East Staffordshire Borough Council Strategic Flood Risk Assessment

Level 2 Report

East Staffordshire Borough Council

August 2008
Final Report
9S8995/R/Bham/05

A COMPANY OF

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Study Objectives

This Level 2 Strategic Flood Risk Assessment (SFRA) for the East Staffordshire Borough Council (the Council) considers the detailed nature of the flood hazard by taking into account the presence of flood risk management measures and has been undertaken with a principle purpose to facilitate application of the Exception Test. The key objectives of the study are to:

- Review the Flood Zones presented in the Level 1 SFRA, in particular the Functional Floodplain (Flood Zone 3b);
- Review flood defence infrastructure, including its present condition, maintenance and upgrading, consequences of overtopping or failure and the response to climate change;
- Model flood risk across the Flood Zones, including the identification of rapid inundation zones, risk to people behind defences and the effect of increased runoff from developments on flood risk; and
- Analyse site specific flood risk.

In addition guidance notes are provided for the execution of the Exception Test, the preparation of FRAs, Emergency Planning Measures and Dealing with Surface Water Drainage.

Outputs

This report focuses upon the development sites located within Flood Zones 2 and 3, or that potentially pose a risk to unmodelled ordinary watercourses. The existing 1D model for Burton upon Trent was updated to account for the upgrading of the flood defences and a 2D TUFLOW model constructed to review overtopping and breach scenarios. The results of these models are presented in the form of maps and colour-coded tables to summarise the hazard risk posed to each of the development sites.

The defences along Picknall Brook in Uttoxeter were also reviewed and the Flood Zones adjusted to take account of their presence. Breach analysis was also undertaken for the development sites protected by the defences and a review of the results is included in the text.

Where possible, analysis has been based on existing hydraulic studies. For unmodelled watercourses, the analysis has been based on hydraulic calculations using data obtained from site investigations in conjunction with topographic data derived from LiDAR.

Data Sources

The data used within this SFRA was documented within the Level 1 SFRA and updated with the addition of new development sites provided after the completion of the Level 1. Supplementary data was collected during a site visit undertaken at the start of February.

Co-operation

This SFRA was carried out for the Council with the co-operation and support of the Environment Agency, Severn Trent Water, Highways Agency and British Waterways.

GLOSSARY

Brownfield site	Any land or site that has been previously developed.
Catchment	The area contributing flow or *runoff* to a particular point on a watercourse.
Climate change	Long-term variations in global temperature and weather patterns both natural and as a result of human activity, primarily greenhouse gas emissions.
Culvert	Covered channel or pipe that forms a *watercourse* below ground level.
Defacto Defence	Semi-permanent structures which act as a barrier to flow but are not formal defences (e.g. railway embankments, roads etc).
Design flood level	The maximum estimated water level during the *design event*.
Development	The carrying out of building, engineering, mining or other operations in, on, over or under land or the making of any material change in the use of any buildings or other land.
Enmained	Watercourse designated as a *Main River*
Environment Agency	Government Agency charged with the protection of the environment
Exception Test	The final process of the PPS25 Sequential Test (TIERS 3 & 4). It is required when a development application is made for a site within Flood Zones 2 & 3 and no other site of lower flood risk is available.
Flood defence	Flood defence infrastructure, such as flood walls and embankments, intended to protect an area against flooding, to a specified *standard of protection*.
Flood event	A flooding incident characterised by its level or *flow hydrograph.*
Flood Hazard	The potential risk to life and potential damage to property resulting from flooding
Flood probability	The estimated probability of a flood of given magnitude occurring or being exceeded in any specified time period. See also *annual flood probability*.
Flood risk	An expression of the combination of the *flood probability* and the magnitude of the potential consequences of the *flood event*.

Flood risk assessment	A study to assess the risk of a site or area flooding, and to assess the impact that any changes or development in the site or area will have on *flood risk*.
Flood Zones	Flood Zones are defined in Table D.1 of Planning Policy Statement (PPS) 25: Development and Flood Risk. They indicate land at risk by referring to the probability of flooding from river and see, ignoring the presence of defences. The fluvial Flood Zones are usually derived using a two-dimensional hydraulic model called JFLOW, into which a national coarse Digital Terrain Model is fed. However, in some instances, more detailed modelling can be undertaken, using refined information.
Floodplain	Area of land that borders a watercourse, an estuary or the sea, over which water flows in time of flood, or would flow but for the presence of flood defences where they exist.
Freeboard	Vertical distance from the normal water surface to the top of a flood defence or river/canal bank.
Functional floodplain	Land where water has to flow or be stored in times of flood. It includes the land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes.
Greenfield	Previously undeveloped land
Groundwater	Water in the ground, usually referring to water in the saturated zone below the *water table*.
Groundwater flooding	Flooding caused by *groundwater* escaping from the ground when the *water table* rises to or above ground level.
Highway authority	A local authority with responsibility for the maintenance and drainage of highways maintainable at public expense.
Hydrograph	A graph that shows the variation with time of the level or discharge in a *watercourse*.
Local Development Documents	Documents that set out the spatial strategy for local planning authorities which comprise development plan documents.
Local Development Framework	Framework which forms part of the statutory development plan and supplementary planning documents which expand policies in a development plan document or provide additional detail.
Local planning authority	Body responsible for planning and controlling development, through the planning system.

Main River	A watercourse designated on a statutory map of Main rivers, maintained by Department for Environment, Food and Rural Affairs (DEFRA).
Mitigation measure	A generic term used in this guide to refer to an element of *development* design which may be used to manage *flood risk* to the *development*, or to avoid an increase in *flood risk* elsewhere.
Ordinary watercourse	A watercourse which is not a private drain and is not designated a *Main river*.
Overland flow flooding	Flooding caused by surface water *runoff* when rainfall intensity exceeds the infiltration capacity of the ground, or when the soil is so saturated that it cannot accept any more water.
Return period	A term sometimes used to express *flood probability*. It refers to the estimated average time gap between floods of a given magnitude, but as such floods are likely to occur very irregularly, an expression of the *annual flood probability* is to be preferred.
Runoff	Water flow over the ground surface to the drainage system. This occurs if the ground is impermeable or saturated, or if rainfall is particularly intense.
Sequential test	A risk-based approach to *flood risk assessment* in accordance with Planning Policy Statement 25, applied through the use of flood risk zoning, where the type of *development* that is acceptable in a given zone is dependent on the assessed *flood risk* of that zone and *flood vulnerability* of the proposed development.
Standard of protection	The estimated probability of a design event occurring, or being exceeded, in any year. Thus it is the estimated probability of an event occurring which is more severe than those against which an area is protected by flood defences.
Strategic flood risk assessment	A study to examine flood risk issues on a sub-regional scale, typically for a river catchment or local authority area during the preparation of a development plan.
Sustainable drainage systems (SUDS)	A sequence of management practices and control structures, often referred to as SUDS, designed to drain surface water in a more sustainable manner. Typically, these techniques are used to attenuate rates of runoff from development sites.
Watercourse	Any natural or artificial channel that conveys surface water.
Water Cycle Strategy	Provides a plan and programme of Water Services Infrastructure implementation

ABBREVIATIONS

mAOD	Metres Above Ordnance Datum
DPD	Development Plan Document
EA	Environment Agency
FD2320	Flood Risk Assessment Guidance for New Development Phase 2, Framework and Guidance for Assessing and Managing Flood Risk for New Development
FRA	Flood Risk Assessment
FZ	Flood Zone
HEC-RAS	1-Dimensional Modelling Software
iSIS	1-Dimensional Hydraulic Model
JFLOW	2-Dimensional Hydraulic Model
LDF	Local Development Framework
LiDAR	Light Detection And Ranging
LPA	Local Planning Authority
NFCDD	National Flood and Coastal Defence Database
OS	Ordnance Survey
PPS25	Planning Policy Statement 25 – Development and Flood Risk
RSS	Regional Spatial Strategy
SFRA	Strategic Flood Risk Assessment
SUDS	Sustainable Drainage Systems
TUFLOW	2-Dimensional modelling software

1 INTRODUCTION

1.1 Commission Award

Royal Haskoning were commissioned in August 2007 by East Staffordshire Borough Council (hereafter "the Council") to produce a Level 1 and Level 2 Strategic Flood Risk Assessment (SFRA). The Level 1 was completed and approved by the Environment Agency in January 2007. The results and recommendations of the Level 1 report have formed the basis of this Level 2 SFRA.

1.2 Background

This Level 2 SFRA has been carried out to satisfy the requirements of Annex E of PPS25 and in particular paragraphs 2.36 to 2.47 of the accompanying PPS25 Practice Guidance. It corresponds to the 'increased scope' SFRA referred to in paragraph E6 of PPS25 and has the principal purpose of facilitating the application of the Exception Test, as outlined below.

By taking account of the presence of flood risk management measures, such as flood defences, this study considers the detailed nature of the flood hazard. The data held within this Level 2 SFRA can therefore assist planners to better balance risks against the need for development. Although the development of lower risk sites should normally be the preferred option, with suitable mitigation, essential development within high-risk areas is permissible and the Level 2 SFRA is designed to help inform decision makers in these circumstances.

Sequential Test

The Sequential Test is used to prioritise potential development sites in order of probability to flood risk and their acceptability in terms of allocation for development. When allocating or approving land for development in flood risk areas, Councils are expected to demonstrate that there are no suitable alternative development sites located in lower flood risk areas. The flood risk zones are defined in Annex D, Table D.1 as follows:

- Zone 1: Area with low probability of flooding (less than 0.1% in any one year)
- Zone 2: Area with medium probability of flooding (between 1% and 0.1% in any one year)
- Zone 3a: Area with a high probability of flooding (greater than 1% in any one year)
- Zone 3b: The Functional Floodplain – land where water has to flow or be stored in times of flood (probability of 5% or greater of flooding in any year or is designed to flood in an extreme (0.1%) flood)

PPS25, Annex D, p27

When determining future development allocations the Sequential Test is used to direct planners towards the lower Flood Risk Zones in preference to high Flood Risk Zones. The Level 1 SFRA provides the relevant information to aid in the application of this test.

The Exception Test

In accordance with PPS25, the risk-based Sequential Test should be applied at all stages of planning. Its aim is to steer new development to areas at the lowest probability of flooding (Zone 1). It must always be adequately demonstrated that the Sequential Test has been correctly undertaken, that other reasonably available sites in lower flood risk zones have been considered. If however, following the application of the Sequential Test, it is not possible for a development to be located in a zone with a lower probability of flooding, the Exception Test can be applied.

The Exception Test makes provision for sites where flood risk is outweighed by wider sustainability considerations and is designed to ensure that the flood risk posed to such sites is controlled and mitigated to an acceptable level, taking account of climate change, without increasing flood risk elsewhere.

The Council should adopt a sequential approach in order to direct strategically significant growth areas towards locations with the lowest probability of flooding, wherever possible. The Council should demonstrate, in broad terms, that they have applied the sequential approach to managing flood risk as part of their site allocation process.

Where it is necessary, following application of the Sequential Test, to locate new development in Flood Zones 2 and 3, such development should be focussed within areas where the standard of protection afforded by the existing defences is compatible with the land use type proposed. More vulnerable, highly vulnerable and essential infrastructure should being prohibited in those areas of the borough which have been identified as rapid inundation zones, and located instead where the flood forecasting and warning systems, as well as flooding emergency response procedures, are well developed.

For the Exception Test to be passed:

a) it must be demonstrated that the development provides wider sustainability to the community that outweigh flood risk, informed by a SFRA where one has been prepared. If the DPD has reached the 'submission' stage – see Figure 4 of PPS25: *Local Development Frameworks* – the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal;
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; and
c) an FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

PPS25, Annex D, p27

In order to undertake the Exception Test for specific locations as identified necessary in the Level 1 SFRA, the Council needs further information to understand the flood risks at each site and the drainage requirements necessary within the key catchments. It is this information that is provided within this Level 2 SFRA.

1.3 Study Area

The level 1 SFRA identified the potential development sites located in areas of flood risk (i.e. located either wholly or partially within the Environment Agency Flood Zones 2 or 3). All of these sites were located in the towns of Burton upon Trent and Uttoxeter and in the village of Barton under Needwood.

However, following the completion of the Level 1 SFRA, the Council has updated the locations of the potential development sites within Burton upon Trent, increasing their number and re-classifying them under the following headings:

- Greenfield Sites
- Proposed Housing
- Additional Sites for Higher RSS Requirement
- Employment Retain

Although these headings are directed towards the production of the Water Cycle Strategy, they will be retained throughout this report for ease of cross reference. Where the development sites identified in the Level 1 report have not been incorporated in the new classifications, both within and outside Burton, they will be still be reviewed within this report, referred to as Greenfield or Brownfield sites, as appropriate. However, those included in the new plans and re-classified into the groups shown above will be subsequently reviewed under the new headings.

Section 2 of this report involves a comprehensive review of all the development sites and includes updated versions of the concluding Level 1 SFRA report tables to allow continuation into this Level 2 SFRA.

1.4 Scope

The scope for this SFRA is in accordance with PPS25 guidelines (Communities and Local Government, 2006, Planning Policy Statement 25: Development and Flood Risk), Development and Flood Risk a Practice Guide Companion to PPS25, “Living Draft”, and Royal Haskoning’s proposal dated 29th August 2007.

The Council is in the process of preparing its Local Development Framework (LDF) as required by the Planning and Compulsory Purchase Act 2004. East Staffordshire has been identified as a potential New Growth Point by Central Government and, as such, it has ambitions for growth, subject to the statutory regional and local planning process, including:

- An additional 5,000 high quality homes by 2016 and a further 7,000 by 2026.
- Redevelopment of 282 hectares of high quality premium employment land.
- Comprehensive Area Action Plans for Burton upon Trent Town Centre.
- Improvements to key gateways.
- Preserve the rural nature of the Borough through the enhancement of the natural environment, green spaces, canals and rivers.

The majority of the development will be focussed on Burton upon Trent, although Uttoxeter is also expected to grow further. Flood risk is a key consideration in the allocation of land for development especially with the current concerns over climate change. Therefore, to enable the developments to be sited in appropriate locations to

minimise damage to property and threat to life, the Council needs to be informed by the most accurate picture of flood risk possible.

The key aims of the Level 2 SFRA are to consider the detailed nature of the flood hazard by taking into account the presence of flood risk management measures. In particular this study will focus upon the proposed development sites located within zones of medium to high flood risk, Flood Zones 2 and 3 respectively, as identified in the Level 1 SFRA and Section 2 of this report. This Level 2 SFRA will include reviews of: the Flood Zones, in particular the Functional Floodplain (Flood Zone 3b); defence infrastructure, including its present condition, maintenance and upgrading, consequences of overtopping or failure and the response to climate change; Flood risk across the Flood Zones, including the identification of rapid inundation zones, risk to people behind defences and the effect of increased runoff from developments on flood risk; and site specific flood risk. In addition guidance notes are provided for the execution of the Exception Test, dealing with Surface Water, the review of FRAs, Emergency Planning and FRA Procedure.

Using 1D modelling software where available, the Flood Zones for the towns of Uttoxeter and Burton upon Trent have been recalculated, taking into account the presence of flood defences. These models also help identify the possible locations of breaches in the defences. A detailed analysis of flood risk has been undertaken for Burton, with 2D modelling software used to find the maximum flood extents and estimates of likely depths and speed of moving flood water. Using this information Flood Hazard maps have been created, providing an overview of flood risk across the urban area.

Flood Hazard Mapping brings information on flood depth and speed (velocity) of floodwater together to create a hazard rating to people within each area that experiences flooding. The hazard rating used is set out in the report Flood Risk Assessment Guidance for New Development Phase 2, Framework and Guidance for Assessing and Managing Flood Risk for New Development (FD2320/TR2) HR Wallingford (October 2005). Due to the high number of developments falling within high risk Flood Zones, the 'Complex' approach outlined in FD2320 was considered the most appropriate method for assessing the risk to people behind defences in Burton upon Trent.

The hazard rating categorises flood risk in terms of Caution, Danger for Some, Danger for Most and Danger for All, with the hazard becoming dangerous to more people as depths and velocities increase. This is described in *Table 1* and *Table 2*. The equation used to calculate the Flood Hazard Matrix is presented in the *'Flood Risk to People'* project.

Table 1 – Flood Hazard Matrix*

Velocity (m/s)	Depth (m)											
	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.00												
0.10												
0.25												
0.50												
1.00												
1.50												
2.00												
2.50												
3.00												
3.50												
4.00												
4.50												
5.00												

* The green colour code is not specified in FD2320/TR2 and has been employed within this SFRA in order to show maximum flood extent.

Table 2 – Description of Hazard Categories

Degree of Flood Hazard	Colour Code	Description
Low		**Caution**
Moderate		**Danger for Some** Includes children, the elderly, and the infirm
Significant		**Danger for most** Includes the general public
Extreme		**Danger for All** Includes the emergency services

Using the Flood Hazard Mapping we have assessed the flood risk at each specific potential development site. In addition, at Burton upon Trent we have assessed the consequences of a breach in the flood defence at five locations.

Royal Haskoning produced this Level 2 report in close consultation with the Council and the Environment Agency. Input to the SFRA, initially presented in the preceding Level 1 report, was also provided by Severn Trent Water, British Waterways and the Highways Agency.

1.5 Data Used

The data used within this report has primarily been obtained from the Council and the Environment Agency. All information regarding the development site locations and usage were provided by the Council. The fluvial models, original flood zones and information regarding the defence heights and conditions were obtained through the Environment Agency and NFCDD. Data regarding the size and location of culverts along the ordinary watercourses was obtained by Royal Haskoning during visits to the site.

2 UPDATES TO LEVEL 1 RESULTS

2.1 Potential Development Sites

Following completion of the Level 1 SFRA report, the Council released an updated set of proposed development sites for the town of Burton upon Trent and its surrounding villages. Whereas the development sites presented in the Level 1 report are classified into two groups, 'Greenfield' and 'Brownfield' locations, new development sites have also been reclassified into the four groups presented in Section 1 of this report. In some instances these new development sites are duplicates of those in the Level 1 report. However there are also many new additions. Before the relevant new sites can be determined for inclusion in this Level 2 SFRA, they must first be reviewed alongside those presented in the Level 1 report. This is presented as a summary a table in Section 2.2 below. All the developments which have now been put forward are shown, with their new Unique ID reference numbers in *Figures 1, 2* and *3.*

2.2 Fluvial Flood Risk, Climate Change, Flood Risk Management Infrastructure and Flood Warning

Tables 3 to *5* below summarise all the development sites put forward by the Council. The impact of Climate Change is shown by a number index, the key to which is presented at the end of this section, following the tables. The sites highlighted in grey are those located within Flood Zones 2 and 3 and thus requiring further consideration within this Level 2 SFRA.

The letter prefix given for the Unique ID corresponds to the classification of the development sites:

H – *Proposed Housing Site*
RSS – *Additional Sites for Higher RSS Requirement*
GF – *Greenfield Site*
E – *Employment Retain*
U – *Unclassified Brownfield Development Sites (Brownfield development sites presented in the Level 1 report, which have not been included in the new allocation of proposed development sites*

'Defacto' defences are semi-permanent structures which act as a barrier to flow but are not formal defences (e.g. railway embankments, roads etc).

2.2.1 Burton Upon Trent

Table 3a - Proposed Housing Sites

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
H1	GF30	Barton Green, Barton under Needwood	Previously undeveloped Greenfield – village perimeter	5.2	None	4	No
H2	GF29	Mill Bridge, Barton under Needwood	Previously undeveloped Greenfield – village perimeter	19.0	FZ2 & FZ3a (Partially)^	3	No
H3	D33	Hollyhock Lane, Burton upon Trent	Grazing land, not previously developed	15.6	FZ2 & FZ3a	8a	Defacto
H4	D32	Lichfield Lane, Burton upon Trent	Container storage, not previously developed	3.7	FZ2 & FZ3a	3	Defacto
H5	D41	Tatenhill Lane, Burton upon Trent	Open land, previously undeveloped	2.4	FZ2 & FZ3a	3	Defacto
H6	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	3.4	FZ2 & FZ3a (Partially)	12	Defacto
H7	D31	Manor Farm, Burton Upon Trent	Grazing land, not previously developed	2.3	FZ2 & FZ3a	6c	Defacto
H8	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	37.8	FZ2 & FZ3a (Partially)	12	Yes
H9	D30	Bridgford Avenue, Burton Upon Trent	Open space, not previously developed	0.2	FZ2 & FZ3a	6c	Yes
H10	D29	Lynwood Road, Burton Upon Trent	Open space, not previously developed	0.7	FZ2 & FZ3a	6c	Yes
H11	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	10.3	FZ2 & FZ3a (Partially)	12	Yes
H12	D28	Branston Depot, Burton Upon Trent	Potential redevelopment of warehouse	25.2	FZ2 & FZ3a	9	Yes

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
H13	D18	Crown Industrial Estate, Burton Upon Trent	Potential conversion into a commercial building from various employment use	6.3	FZ2 & FZ3a	6b	Yes
H14	D27	All Saints Road, Burton Upon Trent	Potential redevelopment of employment site	0.3	FZ2 & FZ3a	6b	Yes
H15	D24	Queen Street, Burton Upon Trent	Potential redevelopment of warehouse premises	1.1	FZ2 & FZ3a	6b	Yes
H16	D25	Broadway Street, Burton Upon Trent	Potential redevelopment of car repairs garage	0.2	FZ2 & FZ3a	6b	Yes
H17	D26	Blackpool Street, Burton Upon Trent	Potential redevelopment of outbuildings	0.3	FZ2 & FZ3a	6b	Yes
H18	D23	Watson Street (North), Burton Upon Trent	Potential redevelopment of Modern B2	1.8	FZ2 & FZ3a	6b	Yes
H19	*New*	Watson Street (South), Burton Upon Trent	Unspecified	0.5	FZ2 & FZ3a	6b	Yes
H20	GF16	Uxbridge Street, Burton upon Trent	Previously undeveloped Greenfield – within town	0.1	FZ2 & FZ3a	8a	Yes
H21	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	3.5	FZ2 & FZ3a (Partially)^	12	No
H22	D20	Bond Street, Burton Upon Trent	Potential redevelopment of offices	0.7	FZ2 & FZ3a	8a	Yes
H23	*Part of D21*	Bond Street/Green Street, Burton Upon Trent	Potential redevelopment of an employment site	0.3	FZ2 & FZ3a	8a	Yes
H24	*Part of D21 & GF18*	Bond Street/Green Street, Burton Upon Trent	Potential redevelopment of an employment site	0.3	FZ2 & FZ3a	8a	Yes

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
H25	D19	Fleet Street, Burton Upon Trent	Potential redevelopment of a retail warehouse	0.5	FZ2 & FZ3a	8a	Yes
H26	*New*	Shobnall Road, Burton Upon Trent	Unspecified	0.5	FZ2 & FZ3a	2	No
H27	D17	Shobnall Road, Burton Upon Trent	Potential redevelopment of Industrial and B1 site	1.0	FZ2 & FZ3a^	2	No
H28	D16	Shobnall Road, Burton Upon Trent	Potential redevelopment of Industrial and B1 site	2.2	FZ2 & FZ3a^	2	No
H29	*New*	Curzon Street, Burton Upon Trent	Unspecified	0.2	FZ2 & partially in FZ3a	5	Yes
H30	D13	Station Street, Burton Upon Trent	Potential conversion into a commercial building from offices	0.9	FZ2 & partially in FZ3a	8a	Yes
H31	*New*	Millers Lane and Derby Street, Burton Upon Trent	Unspecified	2.1	FZ2	5	Yes
H32	D12	Horninglow Street Middle Yard, Burton Upon Trent	Potential redevelopment of a derelict warehouse, car hire etc	1.5	FZ2 & FZ3a	8a	Yes
H33	D22	Horninglow Street, Burton Upon Trent	Vacant/derelict former PFS site	0.2	FZ2 & FZ3a	8a	Yes
H34	D11	Derby Street, Burton Upon Trent	Potential Redevelopment of an Industrial Premises	2.9	FZ2	5	Yes
H35	*New*	Derby Street, Burton Upon Trent	Unspecified	0.7	FZ2 (partially)	5	Yes
H36	D9	Horninglow Road, Burton Upon Trent	Vacant/derelict factory and land	3.7	FZ2 (slightly)	4	Yes
H37	*New*	Victoria Crescent, Burton Upon Trent	Unspecified	0.9	None	4	No

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
H38	D6	Arthur Street, Burton Upon Trent	Potential redevelopment of an industrial estate	1.9	None*	1	No
H39	D8	Victoria Crescent, Burton Upon Trent	Potential redevelopment of a transport depot	2.3	None*	1	No
H40	D7	Dallow Street, Burton Upon Trent	Potential redevelopment of a workshop	2.6	None*	1	No
H41	*New*	Horninglow Road and Arthur Street, Burton Upon Trent	Unspecified	0.8	None*	1	No
H42	D2	Rolleston Road, Burton Upon Trent	Potential redevelopment of a workshop	0.3	None	4	No
H43	*New*	Redhouse Farm, Shobnall, Burton Upon Trent	Unspecified	15.0	None*	1	No
H44	*Part of GF3*	Outwoods Lane (North), Burton upon Trent	Previously undeveloped Greenfield – town perimeter	41.5	None*	1	No
H45	D1	Forest Edge Way, Burton Upon Trent	Scrub Land, not previously developed	0.8	None*	1	No
H46	*Part of GF2*	Harehedge Lane, Burton Upon Trent	Previously undeveloped Greenfield – town perimeter	6.2	None	4	No
H47	GF6	Lower Outwoods, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	1.1	None	4	No
H48	GF12	Belvoir Road, Burton upon Trent	Previously undeveloped Greenfield – within town	0.2	None	4	.No
H49	*New*	A39, Horninglow, Burton upon Trent	Unspecified	0.3	None*	1	No

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
H50	D3	Horninglow Road North, Burton upon Trent	Potential Redevelopment of a pub garden	0.2	None	4	No
H51	GF27	Redhill Lane, Tutbury	Previously undeveloped Greenfield – village perimeter	8.6	None	4	No
H52	*New*	Wetmore Lane, Burton Upon Trent	Unspecified	0.8	FZ2 & FZ3a	8a	Yes
H53	*New*	Wetmore Road, Burton Upon Trent	Unspecified	0.4	FZ2 & FZ3a	8a	Yes
H54	D5	Wetmore Road, Burton upon Trent	Open land not previously developed	0.8	FZ2 & FZ3a	8a	Yes
H55	GF19	Green Street, Burton upon Trent	Previously undeveloped Greenfield – within town	0.1	FZ2 & FZ3a	8a	Yes
H56	D37	Scalpcliffe Road	Vacant/derelict Ex PFS, now car sales	0.2	None	4	No
H57	D40	Roslison Road, Burton upon Trent	Potential redevelopment of a car repairs and sales centre	0.1	None	4	No
H58	D34	Stanton Road, Burton upon Trent	Potential redevelopment of smallhold/ grazing land	0.3	None	4	No
H59	D35	Model Dairy Farm, Burton upon Trent	Potential Redevelopment of farm buildings & open storage	3.8	None*	1	No
H60	D38	Vancouver Drive, Burton upon Trent	Open space, previously undeveloped	0.7	None	4	No
H61	D36	Scalpcliffe Close	Vacant/derelict workshop	0.4	None	4	No
H62	D39	Berryhedge Youth Centre, Burton upon Trent	Potential redevelopment of a youth centre	0.2	None	4	No

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.

* Adjacent watercourse has not been modelled, so all Flood Zones are based upon the River Trent only.

^ Flood Zone 3b has not been modelled for the adjacent watercourse.

Table 3b - Additional Sites for Higher RSS Allocation

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
RSS1	*Part of GF2*	Harehedge Lane, Burton Upon Trent	Previously undeveloped Greenfield – town perimeter	12.9	None	4	No
RSS2	GF1 (RSS5)	Beam Hill, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	45.5	None	4	No
RSS3	*Part of GF3* (RSS6)	Outwoods Lane (North), Burton upon Trent	Previously undeveloped Greenfield – town perimeter	39.6	None*	1	No
RSS4	*New*	Forest Road, Burton Upon Trent	Unspecified	4.1	None*	1	No
RSS5	GF1 (RSS2)	Beam Hill, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	45.4	None	4	No
RSS6	*Part of GF3* (RSS3)	Outwoods Lane (North), Burton upon Trent	Previously undeveloped Greenfield – town perimeter	25.1	None	4	No
RSS7	GF5 (GF1)	Outwoods Lane (Southwest), Burton upon Trent	Previously undeveloped Greenfield – outside town	28.0	None	1	No

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.

* Adjacent watercourse has not been modelled, so all Flood Zones are based upon the River Trent only.

^ Flood Zone 3b has not been modelled for the adjacent watercourse.

Table 3c - Greenfield Sites

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
GF1	GF5 (RSS7)	Outwoods Lane (Southwest), Burton upon Trent	Previously undeveloped Greenfield – outside town	28.0	None	4	No
GF2	GF7	Henhurst Hill, Rough Hay	Previously undeveloped Greenfield – village perimeter	3.2	None	4	No
GF3	GF8	Postern Road, Rough Hay	Previously undeveloped Greenfield – village perimeter	14.3	None	4	No
GF4	GF10	Henhurst Hill, Rough Hay	Previously undeveloped Greenfield – village perimeter	0.3	None	4	No
GF5	GF11	Forest Road, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	4.8	None*	1	No
GF6	GF13	A38, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	165.3	FZ2 & 3a (Partially)^	12	Yes (Trent) No (Shobnall Brook)
GF7	GF28	Station Road, Barton under Needwood	Previously undeveloped Greenfield – outside village	20.7	None	4	No
GF8	GF23	Dovecliff Road, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	2.3	None	7	No
GF9	GF24	Walford Road (Sports Field), Rolleston on Dove	Previously undeveloped Greenfield – village perimeter	6.0	None	4	No
GF10	GF25	Craythorne Road, Rolleston on Dove	Previously undeveloped Greenfield – village perimeter	1.2	None	4	No

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
GF11	GF22	Forest Road, Burton upon Trent	Previously undeveloped Greenfield – town perimeter	1.3	None	1	No
GF24	GF26	Green Lane, Tutbury	Previously undeveloped Greenfield – village perimeter	15.27	None	4	No

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.

* Adjacent watercourse has not been modelled, so all Flood Zones are based upon the River Trent only.

^ Flood Zone 3b has not been modelled for the adjacent watercourse.

Table 3d - Employment Sites

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
E1	*New*	Central Rivers Railway Depot, Barton Turn, Barton Under Needwood	Unspecified	12.1	FZ2 & partially in FZ3a	12	Defacto
E2	*New*	A38, Barton Turn, Barton Under Needwood	Unspecified	2.6	FZ2 (Partially)	12	Defacto
E3	*New*	A38, Barton Turn, Barton Under Needwood	Unspecified	3.1	FZ2	12	Defacto
E4	*New*	Barton Turn Farm South, Barton Turn, Barton Under Needwood	Unspecified	0.9	FZ2	12	Defacto (Trent) No (Barton Brook)
E5	*New*	Barton Turn Farm South, Barton Turn, Barton Under Needwood	Unspecified	2.2	FZ2 &FZ3 (Partially)^	3	Defacto (Trent) No (Barton Brook)
E6	*New*	Station Road, Barton Turn, Barton Under Needwood	Unspecified	0.8	FZ2 & partially in FZ3a^	3	Defacto (Trent) No (Barton Brook)

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
E7	*New*	Station Road/B5016, Barton Under Needwood	Unspecified	0.6	FZ2	3	Defacto (Trent) No (Barton Brook)
E8	*New*	Rylance Farm, Barton Under Needwood	Unspecified	10.3	FZ2 (Partially)	8b	Defacto (Trent) No (Barton Brook)
E9	*New*	A38 (Lichfield Road), Barton Under Needwood	Unspecified	2.4	None	4	Yes
E10	*New*	A38, Branston, Burton Upon Trent	Unspecified	45.6	FZ2 & FZ3a*	8a	Defacto (Trent), No (Tatenhill Brook)
E11	*New*	Wellington Road, Branston, Burton Upon Trent	Unspecified	5.1	FZ2 & FZ3a	6c	Yes
E12	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	3.5	FZ2 &FZ3 (Partially)	12	No
E13	*Part of GF2*	Harehedge Lane, Burton Upon Trent	Previously undeveloped Greenfield – town perimeter	6.2	None	4	No
E14	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	10.3	FZ2 &FZ3 (Partially)	12	Yes
E16	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	3.4	FZ2 &FZ3 (Partially)	12	Yes
E17	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	2.9	FZ2 & FZ3a	12	Yes
E18	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	3.6	FZ2 & FZ3a	12	Yes
E19	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	16.3	FZ2 & FZ3a	12	Yes

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
E20	*Part of GF13*	A38 'Lawns Farm' Burton upon Trent	Undeveloped Greenfield land	37.8	FZ2 &FZ3 (Partially)	12	Yes
E21	*New*	Wellington Road, Burton Upon Trent	Unspecified	3.6	FZ2 & FZ3a	8c	Yes
E22	*New*	North of Wellington Road, Shobnall, Burton Upon Trent	Unspecified	0.2	None	4	No
E23	*New*	North of Wellington Road, Shobnall, Burton Upon Trent	Unspecified	2.1	FZ2 & FZ3a	8c	Yes
E24	*New*	(Wellington Works), Wellington Road, Shobnall, Burton Upon Trent	Unspecified	10.2	FZ2 & FZ3a	8c	Yes
E25	D15	Shobnall Road (Waste Site)	Potential redevelopment of waste station	1.0	FZ2 & FZ3a	2 & 8c	Yes
E26	*New*	A38, Shobnall, Burton Upon Trent	Unspecified	21.4	FZ2 &FZ3 (Partially)	3	No
E27	*New*	Shobnall Road, Shobnall, Burton Upon Trent	Marston's Brewery	9.4	FZ2 & FZ3a^	2	No
E28	*New*	A38/Shobnall Road, Shobnall, Burton Upon Trent	Unspecified	1.2	FZ2 & FZ3a^	2	No
E29	*New*	A38, Shobnall, Burton Upon Trent	Unspecified	1.6	FZ2 &FZ3 (Partially)^	2	No

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
E30	*New*	Wood Street/Wood Court, Burton Upon Trent	Unspecified	0.4	FZ2 & FZ3a	6b	Yes
E31	*New*	A38/Hillfield Lane, Stretton, Burton Upon Trent	Unspecified	9.4	None	4	No
E32	*New*	Dale Street, Shobnall, Burton Upon Trent	Unspecified	5.8	FZ2 & FZ3a	8a	Yes
E33	*New*	Anglesey Road, Shobnall, Burton Upon Trent	Unspecified	0.7	FZ2 & FZ3a	8a	Yes
E34	*New*	Mosley Street, Burton Upon Trent	Unspecified	5.3	FZ2 & FZ3a	8a	Yes
E35	*New*	Cross Street/Duke Street, Burton Upon Trent	Unspecified	2.3	FZ2 & FZ3a	8a	Yes
E36	*New*	High Street/Meadowside Drive, Burton Upon Trent	Unspecified	2.7	FZ2 & FZ3a	8a	Yes
E37	*Part of D14*	Curzon Street, Burton Upon Trent	Partially: vacant/derelict transport depot and warehouse Rest: unspecified	3.3	FZ2 &FZ3 (Partially)	6a	Yes
E38	*Part of D14*	Curzon Street, Burton Upon Trent	Partially: vacant/ derelict transport depot and warehouse Rest: unspecified	0.6	FZ2 &FZ3 (Partially)	6a	Yes
E39	*New*	Wellington Street, Shobnall, Burton Upon Trent	Unspecified	0.5	FZ2 (Partially)	5	Yes

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
E40	*New*	King Edward Place/ Waterloo Street, Burton Upon Trent	Unspecified	0.8	FZ2 (Partially)	5	Yes
E41	*New*	Borough Road/ Waterloo Street, Burton Upon Trent	Unspecified	2.1	FZ2	5	Yes
E42	*New*	Station Street, Burton Upon Trent	Unspecified	21.7	FZ2 & partially in FZ3a	8a	Yes
E43	*New*	Horninglow Street, Burton Upon Trent	Unspecified	1.3	FZ2	8a	Yes
E44	*New*	Hawkins Lane, Burton Upon Trent	Unspecified	8.1	FZ2 & FZ3a	8a	Yes
E45	*New*	Wetmore Road, Burton Upon Trent	Unspecified	1.3	FZ2 & FZ3a	8a	Yes
E46	*New*	Wetmore Road, Burton Upon Trent	Unspecified	0.5	FZ2 & FZ3a	8a	Yes
E47	GF20	West Yard, Little Burton, Burton Upon Trent	Unspecified	4.3	FZ2 & FZ3a	8a	Yes
E48	*New*	Derby Road, Little Burton, Burton Upon Trent	Unspecified	0.5	FZ2 (Partially)	8a	Yes
E49	*New*	Derby Road, Little Burton, Burton Upon Trent	Unspecified	0.4	FZ2 (Partially)	8a	Yes
E50	*New*	Derby Road, Little Burton, Burton Upon Trent	Unspecified	2.4	FZ2	8a	Yes
E51	*New*	Wetmore Road/Hawkins Lane, Burton Upon Trent	Unspecified	0.4	FZ2	8a	Yes

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
E52	*New*	Hawkins Lane, Burton Upon Trent	Unspecified	0.7	FZ2	8d	Yes
E53	D4	Wetmore, Burton upon Trent	Vacant/derelict industrial site	4.0	FZ2*	8d	Yes
E54	*New*	A5121, Wetmore, Burton Upon Trent	Unspecified	4.9	FZ2 & partially in FZ3a*	8d	Yes
E55	*New*	A5121/Wetmore Road, Wetmore, Burton Upon Trent	Unspecified	2.7	FZ2*	8d	Yes
E56	*New*	A5121 (North), Burton Upon Trent	Unspecified	25.9	FZ2 & partially in FZ3a*	8d	Yes
E57	*New*	Princess Way/Beech Lane, Burton Upon Trent	Unspecified	8.3	FZ2 (Partially)*	8d	Yes
E58	*New*	A5121 (North), Burton Upon Trent	Unspecified	0.8	FZ2*	8d	Yes
E59	*New*	James Brindley Way, Stretton, Burton Upon Trent	Unspecified	10.7	FZ2 & FZ3a	8d	Yes
E60	*New*	James Brindley Way/A5121, Stretton, Burton Upon Trent	Unspecified	0.9	FZ2 & FZ3a	8d	Yes
E61	D10	Dallow Street/Victoria Road, Burton Upon Trent	Potential redevelopment of an employment site	0.5	None	4	No
E62	*New*	Borough Road, Burton Upon Trent	Unspecified	0.3	FZ2 & FZ3a	8a	Yes
E63	*New*	Oxford Street, Burton Upon Trent	Unspecified	0.8	FZ2 & FZ3a	6b	Yes

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.
* Adjacent watercourse has not been modelled, so all Flood Zones are based upon the River Trent only.
^ Flood Zone 3b has not been modelled for the adjacent watercourse.

2.2.2 Uttoxeter

Table 4a - Unclassified Brownfield Development Sites

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
U1	D44	Stafford Road, Uttoxeter	Potential redevelopment of highways depot	1.09	None*	1	No
U2	D43	JCB Sites, Uttoxeter	Potential redevelopment of industrial and open storage	6.79	FZ2, FZ3a & FZ3b (Partially)	10b	Partially (EA and Defacto)
U3	D42	Brookside Road, Uttoxeter	Potential redevelopment of employment site	6.62	FZ2, FZ3a & FZ3b	10a	No
U4	D45	Eastfields Road, Uttoxeter	Potential redevelopment of employment site	1.36	FZ2, FZ3a & partially in FZ3b *	11	No

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.
* Adjacent watercourse has not been modelled, so all Flood Zones are based upon Picknall Brook and River Dove only.
^ Flood Zone 3b has not been modelled for the adjacent watercourse.

Table 4b - Greenfield Sites

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
GF12	GF34	Demontfort Way, Uttoxeter	Previously undeveloped Greenfield – town perimeter	4.12	None	4	No
GF13	GF35	Timber Lane (Track), Uttoxeter	Previously undeveloped Greenfield – town perimeter	3.16	None*	4	No
GF14	GF36	B5013 – Timber Lane, Uttoxeter	Previously undeveloped Greenfield – town perimeter	16.58	None*	4	No
GF15	GF41	Bramshall Road, Uttoxeter	Previously undeveloped Greenfield – town perimeter	6.09	None	4	No
GF16	GF40	A50, Uttoxeter	Previously undeveloped Greenfield – town perimeter	64.76	None	4	No
GF17	GF39	Spath Cottage Farm, Uttoxeter	Previously undeveloped Greenfield – town perimeter	6.47	FZ2 & FZ3a (Partially)^	12	No
GF18	GF38	Eastfield Road, Uttoxeter	Previously undeveloped Greenfield – town perimeter	0.26	FZ2, FZ3a & FZ3b*	11	No
GF19	GF37	Brookside Road, Uttoxeter	Previously undeveloped Greenfield – town perimeter	2.14	FZ2, FZ3a & FZ3b	10a	No

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.

* Adjacent watercourse has not been modelled, so all Flood Zones are based upon Picknall Brook and River Dove only.

^ Flood Zone 3b has not been modelled for the adjacent watercourse.

2.2.3 Rural East Staffordshire

Table 5 - Greenfield Sites

Unique ID	Corresponding Level 1 Unique ID	Location	Current Status	Total Area (ha)[1]	Flood Zones	Impact of Climate Change	Protected by flood defence
GF20	GF42	Northfield Avenue, Rocester	Previously undeveloped Greenfield – village perimeter	2.26	None	4	No
GF21	GF33	Jacks Lane, Marchington	Previously undeveloped Greenfield – village perimeter	1.62	None	4	No
GF22	GF31	Thorny Lanes, Hoar Cross	Previously undeveloped Greenfield – outside village	0.42	None	4	No
GF23	GF32	Knightsfield Road, Hanbury Woodend	Previously undeveloped Greenfield – outside village	0.41	None	4	No

[1] Due to slight adjustments in the shapes of the new development sites put forward, the areas given may differ slightly from those stated in the Level 1 report.

Climate Change Key

NB Any increases in the 100 year flood levels due to climate change do not take into account the effect of breaching or overtopping of the defences.

1 The adjacent watercourse has not been modelled. It is recommended that the existing main river Flood Zone 2 be used to represent Flood Zone 3 with climate change until the watercourse has been assessed in greater detail. As it is outside Flood Zone 2 (1 in 1000 year) risk of flooding is not directly affected by climate change. However, the consequences of the development in terms of additional runoff and increased flood risk elsewhere due to climate change should be considered.

2 Flood level data is not available fort the adjacent watercourse, but as the difference in flood extent between Flood Zones 2 and 3 is minimal, it is recommended that the existing main river Flood Zone 2 be used to represent Flood Zone 3 with climate change until the watercourse has been assessed in greater detail

3 Adjacent watercourse has been modelled with JFLOW. It is recommended that the existing main river Flood Zone 2 be used to represent Flood Zone 3 with climate change until the watercourse has been assessed in greater detail.

4 Outside Flood Zone 2 (1 in 1000 year) and therefore risk of flooding not directly affected by climate change. However, the consequences of the development in terms of additional runoff and increased flood risk elsewhere due to climate change should be considered.

5 Outside the current Flood Zone 3 (1 in 100 year). Therefore an increase in flood height cannot be given. However, a prediction of a Peak Water Level of 45.55m AOD (Burton Economic Study) suggests that the development will be partially affected when compared with the LiDAR, although this does not account for potential flooding from unmodelled adjacent brooks.

6a The current water level for Flood Zone 3 (1 in 100 year) is not provided in the model, therefore approximate increase cannot be calculated. However, a prediction of a Peak Water Level of 45.55m AOD (Burton Economic Study) for that reservoir has been provided and, as the development is already located in Flood Zone 3, it will be significantly affected by this increase.

6b The current water level for Flood Zone 3 (1 in 100 year) is not provided in the model, therefore approximate increase cannot be calculated. However, a prediction of a Peak Water Level of 45.89m AOD (Burton Economic Study) for that reservoir has been provided and, as the development is already located in Flood Zone 3, it will be significantly affected by this increase.

6c The current water level for Flood Zone 3 (1 in 100 year) is not provided in the model, therefore approximate increase cannot be calculated. However, a prediction of a Peak Water Level of 46.62 AOD (Burton Economic Study) for that reservoir has been provided and, as the development is already located in Flood Zone 3, it will be significantly affected by this increase.

7 Approximate increase in the 1 in 100 year flood level of 0.18m (River Dove Strategy Model)

8a Approximate increase in the 1 in 100 year flood level of 0.38m (Burton Economic Model).

8b Approximate increase in the 1 in 100 year flood level of 0.24m (Burton Economic Model).

8c Approximate increase in the 1 in 100 year flood level of 1.1m (Burton Economic Model)

8d Approximate increase in the 1 in 100 year flood level of 0.59m (Burton Economic Model)

9 Approximate increase in the 1 in 100 year flood level of 1.5m (Burton Economic Model). This significant increase should be examined in greater detail in the Level 2 SFRA or a site specific FRA.

10a Approximate increase in the 1 in 100 year flood level of 0.26m (Picknall Brook Model).

10b Approximate increase in the 1 in 100 year flood level of 0.23m (Picknall Brook Model).

11 Approximate increase in the 1 in 100 year flood level of 0.04m (River Dove Strategy Model)

12 No modelled levels have been given. This site will need addressing in greater detail in the Level 2 SFRA or a site specific FRA. The consequences of the development in terms of additional runoff and increased flood risk elsewhere due to climate change should also be considered.

2.3 Summary

Table 6 summarises the number of development sites located in Flood Zones 2, 3a or 3b and thus requiring further analysis within this Level 2 SFRA. These sites are highlighted in grey in the above tables.

Table 6 – Development Sites Located within Flood Zones 2 and 3

	Proposed Housing Sites	Additional Sites for Higher RSS Requirements	Greenfield Sites	Employment Retain	Unclassified Brownfield Development Sites
Burton Upon Trent and Surrounding Areas	39	0	1	57	N/A
Uttoxeter	N/A	N/A	3	N/A	3
Rural East Staffordshire	N/A	N/A	0	N/A	N/A

However, in addition to the sites specified above, there are a number of development sites located in proximity to the ordinary watercourses, which have not been modelled. Although detailed modelling of the Flood Zones for each of these watercourses is beyond the scope of this SFRA, they have been evaluated with regards to the potential flood risk they may pose to the proposed development. The potential increase in flood risk to adjacent areas has also been addressed and the need for detailed surface water discharge systems have been identified.

3 FLOOD RISK IN BURTON UPON TRENT AND SURROUNDING AREA

3.1 Study Area

The area under consideration in this section is shown in *Figure 2*. It consists of the entire town of Burton upon Trent, but also extents as far south as to include the village of Barton under Needwood and north to include the villages of Rolleston on Dove and Tutbury. Most of the sites requiring attention within this Level 2 SFRA are located within the town of Burton, and all except one are located on the west side of the River Trent. However, the affected sites also extend south along the A38 corridor as far as the village of Barton under Needwood. There is also one development site, H2, which is located in the village of Barton and another, H59, which is located in Burton upon Trent, on the eastern, Stapenhill, side of the River Trent. None of the sites located in Tutbury, Rolleston on Dove, or the Clay Mills district of Burton require consideration.

3.2 Overview of Flood Risk

Flood Risk within the Study area is mainly associated with the River Trent. However, the tributary watercourses, such as Shobnall Brook, Tatenhill Brook and Barton Brook also pose a potential flood risk to development sites. In addition, Burton is dissected by a number of smaller Ordinary Watercourses, some of which flow through or have their sources located within, or in proximity to, other development sites. The main brooks which require attention are 'Kitling Greaves Brook', 'Bitham Lane Brook', 'Horninglow Channel', the downstream segment of 'Shobnall Brook' and, on the east side of the River Trent, the upstream, unenmained segment of 'Stapenhill Brook'. The flood risk associated with sewer, groundwater and overland flooding was discussed in the Level 1 SFRA and determined to be of minor risk.

3.3 Flood Risk from the River Trent

3.3.1 Flood Defence Infrastructure

The western side of Burton upon Trent is protected by an extensive flood defence scheme, extending from the railway embankment next to the Riverside Hotel in the district of Branston, in the southern extent of the town, all the way along the edge of development on the western bank of the Trent through the town, as far as the railway embankment to the north of the Clay Mills sewage treatment works. Most of these flood defences are owned by the Environment Agency, although short segments are privately maintained. In 2006-2007, the EA up rated certain sections of the Flood Defences, changing the flood protection standard from 1 in 100 year standard to a 1 in 200 year standard. However the Flood Defences at the Meadowside Centre were not up rated, remaining at a 1 in 100 year standard with limited life expectancy. South and north of the town the railway embankment serves as a defacto defence for some of its length, tying into the formal defence structures.

One formal defence structure is present on the right bank of the Trent, just downstream of Burton Bridge, beside Newton Road (B5008). It only provides a 1 in 100year standard of protection, but, as it does not serve to protect any of the development sites in question, does not require consideration within this report.

Asset Condition

The Environment Agency's National Flood and Coastal Defence Database (NFCDD), contains an estimate of the condition of flood defences, along a 5 point scale, as shown in *Table 7*, below.

Table 7 – Description of Asset Conditions

Grade	Rating	Description
1	Very Good	In good condition, fully serviceable, no remedial work required. Maintenance to continue as present. No significant defect.
2	Good	Minor defects, non urgent. Minor routine maintenance work required In reasonable condition, some increase in maintenance needed, probably no more than 5% affected with slight defect.
3	Fair	Some cause for concern, requires careful monitoring Significant maintenance works required Average condition, some minor repairs needed & moderate 5% - 20% affected
4	Poor	Structurally unsound now or in the near future Major remedial works required and replacement (1-5 years) Extensive repair required in short term. Extensive defect 20% - 50% affected.
5	Very Poor	Completely failed or derelict requires complete reconstruction. Major urgent repairs or replacement needed without delay to avoid failure probably beyond repair. Extensive defect >50%

All of the flood defences through Burton upon Trent have been analysed and their description, location, condition, defence standard and the year they were built have been recorded. The complete record is presented in Appendix B. Unfortunately, the NFCDD has not been updated recently enough to include all of the improvements made during the 2006/7 construction works. As the locations of the improvements are known from a review of the 'As built' engineering plans, they have been assigned a condition of 1 and a defence standard of 200 years. Where these defences consist of an earth embankment rather than a solid masonry, steel pile or concrete wall, they have been assigned '1*' to indicate a degree of uncertainty.

All of the defences within Burton upon Trent have a condition standard of Grades 1-3. Most of them fall within Grades 1 and 2 and are therefore classified as of Good or Very Good standard, with an average Grade of defence throughout the town of 1.4. *Table 8* presents the defences assigned a condition Grade 3. In addition, this table also includes defences not stated as being built to the recommended 200 year standard. All of the defences highlighted in this table are shown in *Figure 4.*

Table 8 – Burton defences in 'Fair' condition or 100 year standard

NFCDD Reference	Unique ID	Asset Description	Location	Condition	Defence Standard	Year Built/ Updated
0330831200102R01	1	Earth ring flood bank in front of twin arched brick culvert	Left bank at coordinates NGR SK2152019620	3	100	1984
0330831200102R02	2	Brick wall cut off to railway culverts	Left bank at coordinates NGR SK2202020320	-	100	1984
0330831200102R03	3	Earth ring bank to cattle underpass	Left bank at coordinates NGR SK2219020510	2	100	1984
0330831200102R04	4	Earth ring bank to cattle underpass	Left bank at coordinates NGR SK2243020830	2	100	1984
0330831610210L11	5	Railway embankment	Left bank at Branston upstream of Old Road	3	200	1961
0330831610210L05	6	Earth floodbank	Left bank in front of Paget School and behind Branston Golf Course	3	200	1961
0330831610209L06	7	Earth embankment	Left bank in front of Blackpool Street, All Saints	3	200	1962
0330831610209L02	8	Masonry floodwall	Left bank in front of Meadowside Centre, upstream of St Peter's Bridge	2	100	1995
0330831610208L20	9	Earth embankment and blue brick floodwall	Left bank across Peel's cut	3	200	1999
0330831610208L02	10	High Ground	Left bank in front of St Modwen's church, Town Centre	3	200	1961
0330831610206L07	11	High ground	Left bank, Wetmore Lane builders' yard	3	200	1961

NFCDD Reference	Unique ID	Asset Description	Location	Condition	Defence Standard	Year Built/ Updated
0330831610206L06	12	Earth embankment	Left bank, upstream of Wetmore Lane between (upstream) NGR SK2553724372 and (downstream) NGR SK2554924399	3	200	2001
0330831610201L03	13	Earth embankment	Left bank, Claymills, between sewage treatment works and railway embankment	3	200	1962
0330831610204R01	14	Natural earth embankment	Right bank downstream of Burton Bridge, beside Newton Road (B5008)	1	100	2003

Future Maintenance and Upgrade

All the defences listed in *Table 8* as being of 100 year standard are located outside of the line of main defences through the centre of the town. Defences 1 to 4 are located to the south of Burton, protecting openings through the railway embankment. As the railway embankment overtops during a 100 year flood event, there is little reason to increase the standard of these defences. However, defences 1, and possibly 2, have a condition of Grade 3. Although satisfactory at the moment, they must be closely monitored and potentially upgraded in the near future to avoid leakage or failure. Defence 14 is the flood bund beside Newton road on the right bank of the River Trent. As this defence is Grade 1, and does not protect any of the new development sites, there is no need to upgrade this defence for the purposes of this SFRA.

Defences 5-13 are of great importance to the protection of the main town of Burton upon Trent and many of the development sites. With the exception of Defence 8, they have all been built to a 200 year standard, but all have conditions of Grade 3. (Defence 8 has a better condition, of Grade 2, but only offers protection to a 1 in 100 year standard). Although they are satisfactory at the moment, these defences will need careful monitoring and are going to require some repair work in the moderate future to prevent leakage, failure or irreparable damage, which could lead to severe flood damage to the properties behind and even risk of loss of life.

3.3.2 Methodology

General

The Level 1 SFRA considered the flood risk to Burton from the River Trent based on the current Environment Agency Flood Zones. It should be noted however that these Flood Zones do not take account the presence of flood defences. Since Burton is protected by a newly upgraded flood defence system, it was considered necessary to undertake additional analysis to identify the "real" flood risk to Burton.

River Trent Model Update

The hydraulic model used to derive the design water levels for the Burton flood defence scheme was supplied by the Environment Agency. The model was constructed using iSIS, an industry approved 1-dimensional hydraulic model. However, the model provided did not include the improvements made to the flood defences in 2007. It was therefore necessary to update the model to include new defence heights, by amending spill heights and cross section extents. The data used to achieve this was obtained from NFCDD and cross referenced with the "As built" drawings of the flood defence scheme.

The model was rerun for the following scenarios:

- 100 year return period with 20% increase in flow to allow for climate change;
- 1000 year return period, present day; and
- 1000 year return period with a 20% increase in flow to allow for climate change

The inflow hydrographs to the models were obtained from the hydraulic model provided by the Environment Agency. It was considered that as the model was sufficient upon which to base the hydraulic design of the flood defences, it would be adequate for the purposes of the SFRA. The modelling report provided with the River Trent model[1] only provided peak flows for the 100, 150 and 200 year extreme flows. The 1000 year flow were therefore based on the extrapolation of these flows as shown in *Table 9*.

Table 9 – River Trent Peak Flows (m^3/s)

Inflow	Return Period (years)			
	100	**150**	**200**	**1000**
River Trent	468	499	522	640
River Dove	199	205	210	238

Reproduced from data presented in "Burton Hydraulic Modelling Report", 2005

The results of the revised model runs were then extracted in order to determine the volume of water spilling over the flood defences and hence the "real" flood risk to Burton.

[1] Fluvial Trent Hydraulic and Economic Study – Burton Hydraulic Modelling Report, Black and Veatch, June 2005

Mapping of "Real" Flood Risk

The iSIS model represents Burton as a series of "reservoirs" interconnected by "spills". This modelling approach allows the representation of flood water filling an area before spilling into a second area, perhaps separated from the first by a raised road for example. This approach however does not represent the flow of water through the town, neither does it give an indication of velocities. It was therefore considered inappropriate for the requirements of a Level 2 SFRA, such as the identification of revised Flood Zones or areas of rapid inundation zones.

It was therefore considered appropriate to model the flow paths behind the defences in greater detail. This was achieved using the 2-dimensional modelling software TUFLOW. TUFLOW represents the town in the form of a grid. The squares of the grid have different elevations based on the topography of the land as defined by LiDAR.

The inputs to the TUFLOW model were taken from the iSIS model, in the form of a stage hydrograph at each section of defence. The volume of water overtopping the defence was determined by the relative levels of the stage hydrograph and the defence height. It was not necessary to simulate the 100 year flood since the flood defence through Burton provides a 200 year (present day) standard of defence, and therefore there is no overtopping.

The resulting flood outlines for the three overtopping scenarios are presented in *Figure 5.*

3.3.3 Breach Analysis

PPS25 requires a Level 2 SFRA to consider the residual risks to developments behind flood defences, both from overtopping and from defence failure. PPS25 recommends that a breach and overtopping analysis should follow the recommendations presented in the report FD2320[2]. FD2320 suggests three levels of complexity in approach, (simple, intermediate and complex). It states that the simple or intermediate approach is usually adequate for the purposes of SFRAs. However, given the importance of the defences in Burton and the number of potential development sites at risk of breaching or overtopping, it was considered that the complex approach should be adopted. The complex approach involves the use of detailed hydraulic modelling to assess a flood hazard based on coincident velocity and depth, as shown in *Tables 1* and *2*.

A number of criteria were adopted in the selection of locations to assess the consequences of breaching, as listed below:

- Breaches have only been considered in defences adjacent to proposed development sites;
- Breaches are assumed to occur in defences with a condition of 3 in the Environment Agency's NFCDD, as shown in *Table 8* in *Section 3.3.1*.

The effects of the breaches were simulated using the "breach" unit in the iSIS model. The dimensions and timings to closure of the breach were taken from Environment Agency guidance, based on an assessment of historic breaching incidents. The

[2] Flood Risk Assessment Guidance for New Development Phase 2, Framework and Guidance for Assessing and Managing Flood Risk for New Development (FD2320/TR2) HR Wallingford (October 2005).

dimensions and time to closure is a factor of the type and material of the defences, as shown in *Table 10*.

Table 10 – Breach Dimensions

Defence Type	Breach Width (m)	Time to Closure (hrs)
Earth Embankment	40	30
Hard	20	18

The iSIS model was used to generate flow hydrographs through the breached defences for the present day 100 year return period. The hydrographs were then used as the input to the TUFLOW model in order to simulate the spreading of the water behind the defences.

Figure 6 shows the five locations where breaching has been assessed and the resulting flood outlines. *Table 11* summarises the details of the breach analysis.

Table 11 – Breach Analysis Details

Breach	Location	Condition	Standard (years)	Material	Cross Section	Dimension
1	Paget School, Branston, Burton upon Trent	3	200	Earth	Burt_Sp1.2	40m (30hrs)
2	Meadowside Centre, Upstream St Peter's Bridge, Burton upon Trent	2	100	Masonry	Burt_Sp2.3b	20m (18hrs)
3	Hay Walk, Meadowside Drive, Burton upon Trent	1	200	Masonry	Burt_sp3.3a	20m (18hrs)
4	Blythfield, Burton Upon Trent	1	200	Masonry	Burt_sp4.1	20m (18hrs)
5	Wetmore Lane Builder's Yard, Wetmore, Burton upon Trent	3	200	Earth	Burt_sp4.3a	40m (30hrs)

The likelihood of defence failure is also a function of the depth of flooding and hence the force exerted on the face of the defence. *Table 12* shows the dimensions of the flood defence at each assumed breach location and the corresponding modelled water levels for the 100 year return period.

Table 12 - Flood Defence Dimensions at Breach Locations

Breach Location	Defence Level (mAOD)	Ground Level (mAOD)	Defence Height Above Ground Level (m)	100 year Water Level (mAOD)	Freeboard (m)
1	48.1	46.5	1.6	47.7	0.4
2	47.0	45.2	1.8	46.4	0.6
3	46.4	44.8	1.6	46.1	0.3
4	46	45.3	0.7	45.6	0.4
5	45.7	43.6	2.1	45.1	0.6

Flood defences are designed and constructed with an additional allowance for uncertainty on top of the predicted design water level. This allowance, as freeboard, allows for uncertainties in the prediction of water levels and also the loadings that could be exerted on the defence. Flood defence guidance, as quoted in PPS25, recommends an allowance of 300mm for fluvial flood defences. *Table 12* shows that during the 100 year flood event the freeboard (the distance between the flood level and the top of the defence) is greater than 0.3 metres at all breach locations. It can therefore be assumed that, were the defences in perfect condition, there would be sufficient allowance in the design to withstand the pressures of the 1 in 100 year flood and that the breach would not fail.

3.3.4 Flood Hazard Analysis

The 'complex approach' presented in FD2320 addresses the issue of flood hazard as a function of flood depth and velocity. *Figures 7, 8, 9* and *10* show the flood depths produced by the TUFLOW model for the 100 year with climate change, 1000 year present day, 1000 year with climate change and breach scenarios respectively. The flood hazard matrix is presented in *Tables 1* and *2* of this report. The results of the TUFLOW model were used to generate colour coded flood hazard maps for the following scenarios:

- 100 year return period with climate change (*Figure 11*)
- 1000 year return period, present day (*Figure 12*)
- 1000 year return period with climate change (*Figure 13*); and
- Breach analysis (*Figure 14*)

The *worst* flood hazard category for each of the proposed development sites within Burton is presented in *Table 13*. It should be noted that his hazard is based on flooding from the River Trent only. Flood risk from other watercourses is considered in *Section 3.4*. The colour code is explained fully in *Table 2* but summarised at the base of each of the following pages.

Table 13 - Flood Hazard Ratings

Site	100 year + climate change	1000 year	1000 year + climate change	Breach
H3				
H4				
H5				
H6				
H7				
H8				
H9				
H10				
H11				
H12				
H13				
H14				
H15				
H16				
H17				
H18				
H19				
H20				
H22				
H23				
H24				
H25				
H29				
H30				
H31				
H32				
H33				
H34				
H35				
H36				
H37				
H38				
H39				
H40				
H41				
H52				
H53				
H54				
H55				
GF6				
E10				
E11				
E14				
E16				

Low Moderate Significant Extreme

Site	100 year + climate change	1000 year	1000 year + climate change	Breach
E17				
E18				
E19				
E20				
E21				
E22				
E23				
E24				
E25				
E26				
E27				
E29				
E30				
E31				
E32				
E33				
E34				
E35				
E36				
E37				
E38				
E39				
E40				
E41				
E42				
E43				
E44				
E45				
E46				
E47				
E48				
E49				
E50				
E51				
E52				
E53				
E54				
E55				
E56				
E57				
E58				
E59				
E60				
E61				
E62				
E63				

Low Moderate Significant Extreme

Access/Egress

In addition to assessing the flood hazard for the development sites, it is also important to review the constraints flooding will place on the access and egress routes to the sites as it may impede evacuation and rescue efforts during a flood event.

Table 14 summarises the availability of access and egress routes during each of the four flooding events mentioned above, taken from *Figures 11* to *14* for the sites identified in *Table 13*. Red indicates that all access roads leading to and from a development site are at risk of flooding during the stated event. Orange indicates that there will be severe restrictions to the access routes, resulting in only one passable road or direction (for sites to which an access road has not yet been constructed). However, it must be noted that this analysis is based upon the major routes identifiable now and may change with development.

Table 14 – Access/Egress Routes Not Affected by Flooding

Site	100 year + climate change	1000 year	1000 year + climate change	Breach
H3				
H4				
H5				
H6				
H7				
H8				
H9				
H10				
H11				
H12				
H13				
H14				
H15				
H16				
H17				
H18				
H19				
H20				
H22				
H23				
H24				
H25				
H29				
H30				
H31				
H32				
H33				
H34				
H35				
H36				
H37				
H38				
H39				
H40				
H41				
H52				
H53				
H54				
H55				
GF6				
E10				
E11				
E14				
E16				

No access/egress routes available

Only 1 access/egress route or direction available

2+ access/egress routes or directions available

Site	100 year + climate change	1000 year	1000 year + climate change	Breach
E17				
E18				
E19				
E20				
E21				
E22				
E23				
E24				
E25				
E26				
E27				
E29				
E30				
E31				
E32				
E33				
E34				
E35				
E36				
E37				
E38				
E39				
E40				
E41				
E42				
E43				
E44				
E45				
E46				
E47				
E48				
E49				
E50				
E51				
E52				
E53				
E54				
E55				
E56				
E57				
E58				
E59				
E60				
E61				
E62				
E63				

No access/egress routes available

Only 1 access/egress route or direction available

2+ access/egress routes or directions available

3.3.5 Rapid Inundation

An important consideration in assessing flood risk, and one that is not adequately addressed in PPS25, is the issue of the speed of flooding. The results of the TUFLOW model were used to calculate the rate of flooding at each of the proposed development sites within Burton. Two specific issues were considered:

- The time taken for water to reach the proposed development site from the onset of flooding (i.e. the first occurrence of overtopping); and
- The time taken for water to reach a depth of 250mm from the onset of flooding at the site

A depth of 250mm was selected as representing the depth below which safe evacuation on foot could be achieved. Rapid inundation has been identified as flooding which reaches a depth of 250mm in half an hour or less. *Table 15* presents the results of this analysis at each of the proposed development sites.

Table 15 shows that a number of sites would experience rapid inundation, with flood levels reaching a significant depth in a short space of time. This issue should be addressed within the planning process when considering the vulnerability of the proposed land use. Preference should be given to sites which would not experience rapid flooding or ensuring that adequate mitigation measures are put in place to alleviate the consequences. As outlined in Section 1.2, more vulnerable, highly vulnerable and essential infrastructure are prohibited in areas identified as rapid inundation zones. In consideration of this, the proposed housing sites highlighted in *Table 15* (H8, H12, H36, H39, H53 and H54) should be relocated outside the rapid inundation areas.

Table 15 – Rapid Inundation Analysis

Site	100 year + climate change		1000 year		1000 year + climate change		Breach scenarios	
	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)
H3	N/A	N/A	33.25	Not reached	15	Not reached	N/A	N/A
H4	7.75	15.75	4.5	11.25	4	7.25	N/A	N/A
H5	15.75	1.5	10.25	1	7.75	1	N/A	N/A
H6	42	2	30.5	1.25	20.75	1	N/A	N/A
H7	N/A	N/A	N/A	N/A	41.25	1.5	N/A	N/A
H8	28.25	0.75	19.5	0.75	14	0.25	N/A	N/A
H9	N/A	N/A	N/A	N/A	31.5	1	N/A	N/A
H10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H12	N/A	N/A	32.25	0.75	15.75	0.5	5.25	2.25
H13	N/A	N/A	N/A	N/A	34.25	7.5	N/A	N/A
H14	N/A	N/A	36.75	Not reached	19.5	10.75	11.25	Not reached
H15	N/A	N/A	N/A	N/A	36.5	Not reached	N/A	N/A
H16	N/A	N/A	42.25	Not reached	22	12.75	N/A	N/A
H17	N/A	N/A	38.25	0.75	20.5	1	12.75	0.75
H18	N/A	N/A	N/A	N/A	35	Not reached	N/A	N/A
H19	N/A	N/A	39.25	2.25	21.75	1.75	13.75	Not reached
H20	N/A	N/A	42	12.5	24.25	7	20	Not reached
H21	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H22	N/A	N/A	N/A	N/A	35.25	3.25	N/A	N/A
H23	N/A	N/A	N/A	N/A	35.25	3.25	N/A	N/A
H24	N/A	N/A	N/A	N/A	35.25	3.25	N/A	N/A
H25	N/A	N/A	N/A	N/A	35.25	3.25	N/A	N/A
H26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H27	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H29	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H30	N/A	N/A	50.25	Not reached	30.75	3.5	N/A	N/A
H31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H32	N/A	N/A	46.75	6	28.75	3.5	N/A	N/A
H33	N/A	N/A	46.75	6	28.75	3.5	N/A	N/A
H34	N/A	N/A	N/A	N/A	34.5	2.25	N/A	N/A
H35	N/A	N/A	N/A	N/A	34.5	2.25	N/A	N/A
H36	N/A	N/A	N/A	N/A	37.75	0.5	N/A	N/A
H37	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Site	100 year + climate change		1000 year		1000 year + climate change		Breach scenarios	
	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)
H38	N/A	N/A	N/A	N/A	47.25	Not reached	N/A	N/A
H39	N/A	N/A	N/A	N/A	38.5	0.25	N/A	N/A
H40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
H41	N/A	N/A	N/A	N/A	47.25	Not reached	N/A	N/A
H49	N/A	N/A	N/A	N/A	47.25	Not reached	N/A	N/A
H53	N/A	N/A	45	0.5	30.25	0.25	14.75	0.25
H54	N/A	N/A	45	0.5	30.25	0.25	14.75	0.25
GF6	28.25	0.75	19.5	0.75	14	0.25	N/A	N/A
E8	33.25	6	19.75	4	8.75	2.75	N/A	N/A
E9	33.25	6	19.75	4	8.75	2.75	N/A	N/A
E10	0	1.5	0	0.5	0	0.5	N/A	N/A
E11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E16	42	2	30.5	1.25	20.75	1	N/A	N/A
E17	42	2	30.5	1.25	20.75	1	N/A	N/A
E18	N/A	N/A	35	Not reached	23.25	4	N/A	N/A
E19	31.5	0.5	22.25	0.5	16	0.25	N/A	N/A
E20	28.25	0.75	19.5	0.75	14	0.25	N/A	N/A
E21	49.5	0.5	35.75	0.5	25.25	0.25	N/A	N/A
E22	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E23	N/A	N/A	45.75	4.25	28.5	2.25	N/A	N/A
E24	58.25	9.75	40.25	1	27	0.5	N/A	N/A
E25	N/A	N/A	N/A	N/A	35.5	0.75	N/A	N/A
E26	N/A	N/A	35.75	1	24.25	0.5	N/A	N/A
E27	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E29	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E30	N/A	N/A	41.75	6	24	3	19.75	Not reached
E31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E32	N/A	N/A	43	Not reached	24.75	8.5	N/A	N/A
E33	N/A	N/A	54.5	Not reached	31.75	2.25	N/A	N/A
E34	N/A	N/A	49	1.5	30	1	N/A	N/A
E35	N/A	N/A	42.75	2.25	24.75	2	20	Not reached
E36	N/A	N/A	35.5	3.75	20.5	4.75	4.75	Not reached

Site	100 year + climate change		1000 year		1000 year + climate change		Breach scenarios	
	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)	Time from onset (hrs)	Time to reach 250mm (hrs)
E36	N/A	N/A	35.5	3.75	20.5	4.75	4.75	Not reached
E37	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E38	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E40	N/A	N/A	N/A	N/A	36	3.75	N/A	N/A
E41	N/A	N/A	N/A	N/A	34.25	0.5	N/A	N/A
E42	N/A	N/A	39	0.5	24.5	0.5	14	2.75
E43	N/A	N/A	70	Not reached	33	3.5	N/A	N/A
E44	N/A	N/A	41.75	1.25	26.25	0.5	21.25	0.75
E45	N/A	N/A	47.5	2.5	29.5	2.75	N/A	N/A
E46	N/A	N/A	53.75	Not reached	33.5	1.75	N/A	N/A
E47	N/A	N/A	43.25	0.5	27	0.25	22.5	0.5
E48	N/A	N/A	60	Not reached	34.5	2.75	N/A	N/A
E49	N/A	N/A	45.25	0.25	28.25	0.25	24.75	1
E50	N/A	N/A	60	Not reached	34.5	2.75	N/A	N/A
E51	N/A	N/A	42.5	0.5	31	0.5	33.75	4
E52	N/A	N/A	46.5	0.5	29.5	0.25	27	0.75
E53	N/A	N/A	48.25	2	31.5	1.5	N/A	N/A
E54	38.5	2.75	31.5	2.25	24	2	N/A	N/A
E55	N/A	N/A	42.5	0.5	31	0.5	33.75	4
E56	N/A	N/A	40.75	1.25	32.75	1	N/A	N/A
E57	N/A	N/A	40.75	1.25	32.75	1	N/A	N/A
E58	N/A	N/A	39.75	1	31.75	1	N/A	N/A
E59	N/A	N/A	43	Not reached	34.25	2	N/A	N/A
E60	43	0.25	34.75	0.25	26.75	0.25	N/A	N/A
E62	N/A	N/A	49	1.5	30	1	N/A	N/A
E63	N/A	N/A	N/A	N/A	32	16.25	N/A	N/A

	Rapid Inundation
"Not Reached"	Depth of 250mm not reached during event
N/A	No flooding from River Trent during flood event

3.4 Flood Risk from Ordinary Watercourses

3.4.1 General

Besides the River Trent, there is a potential flood risk from a number of ordinary watercourses which flow through the town. Since the flood risk from the River Trent is mitigated by the flood defences, it could be argued that the ordinary watercourses pose the most significant risk. As a number of the proposed development sites are adjacent to the ordinary watercourses, there is a potential risk, either of direct flooding from the watercourse itself or of increasing flood risk elsewhere due to increased surface runoff from the newly developed site. This section addresses these issues in relation to the potential development sites only, as opposed to an exhaustive analysis of flood risk at all locations.

Where possible, analysis has been based on existing hydraulic studies. For unmodelled watercourses, the analysis has been based on hydraulic calculations using data obtained from site investigations in conjunction with topographic data derived from LiDAR. The remainder of this section addresses each of the ordinary watercourses with the potential to affect potential development sites within Burton.

3.4.2 Barton Brook

Barton Brook flows through the village of Barton under Needwood before discharging into the River Trent just South of Burton. *Figure 15* shows the proposed development sites within Barton under Needwood.

The Barton Brook has not been previously modelled, therefore it was necessary to base the analysis of flood risk on topographic data. *Figure 16* shows an extract of the LiDAR data, with changes in elevation denoted at 200mm intervals. It is evident from the LiDAR that the land to the east of the A38, south of Barton Brook, is significantly lower than that to the west. To the north of Barton Brook, the land falls away in a north easterly direction. The B5016 Station Road is higher than the surrounding land, with the exception of an underpass next to the canal. Based on land level it is clearly evident that sites H1, H2 and GF7 are not at risk of flooding from the Barton Brook. However, in order to avoid increased flood risk elsewhere adequate provision should be made to accommodate any increase in surface water runoff from the sites.

For the proposed employment sites (E1 to E9) flood risk is dominated by the River Trent. The maximum flood levels were extracted from the River Trent iSIS model at the point where the Barton Brook joins the Trent, as shown in *Table 16*.

Table 16 - Maximum Flood Levels at the Barton Brook Confluence

Return Period (years)	Flood Level (mAOD)
100	48.65
100 + Climate Change	48.87
1000	49.05
1000 + Climate Change	49.35

Figure 17 shows the areas of land below the flood levels.

Figure 15 – Development Sites along Barton Brook

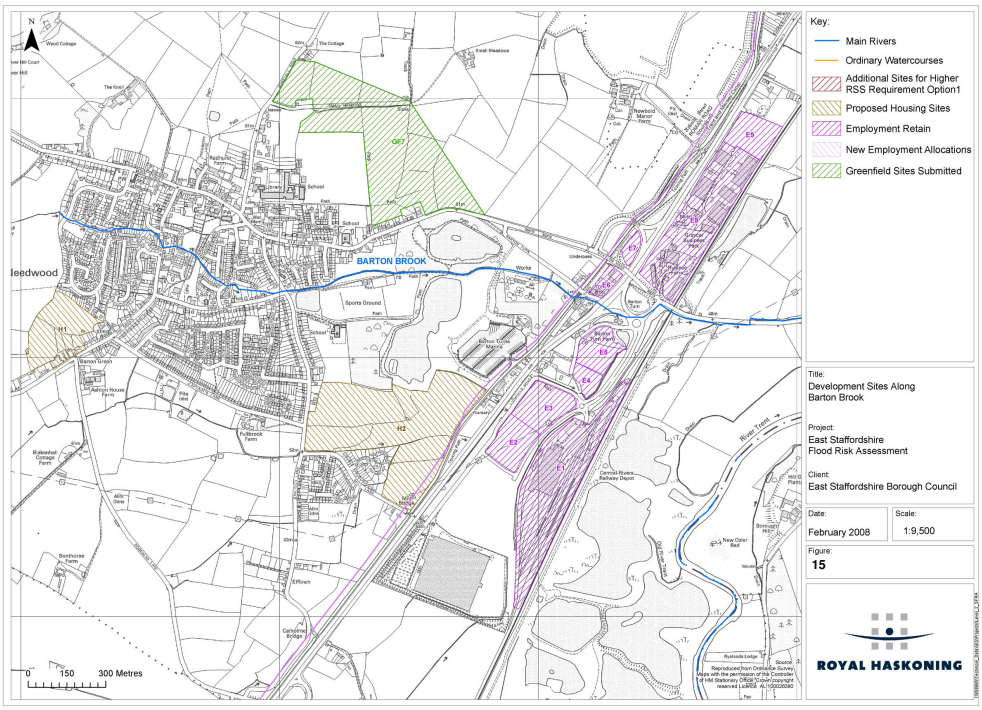


Figure 16 - Barton Brook Topography

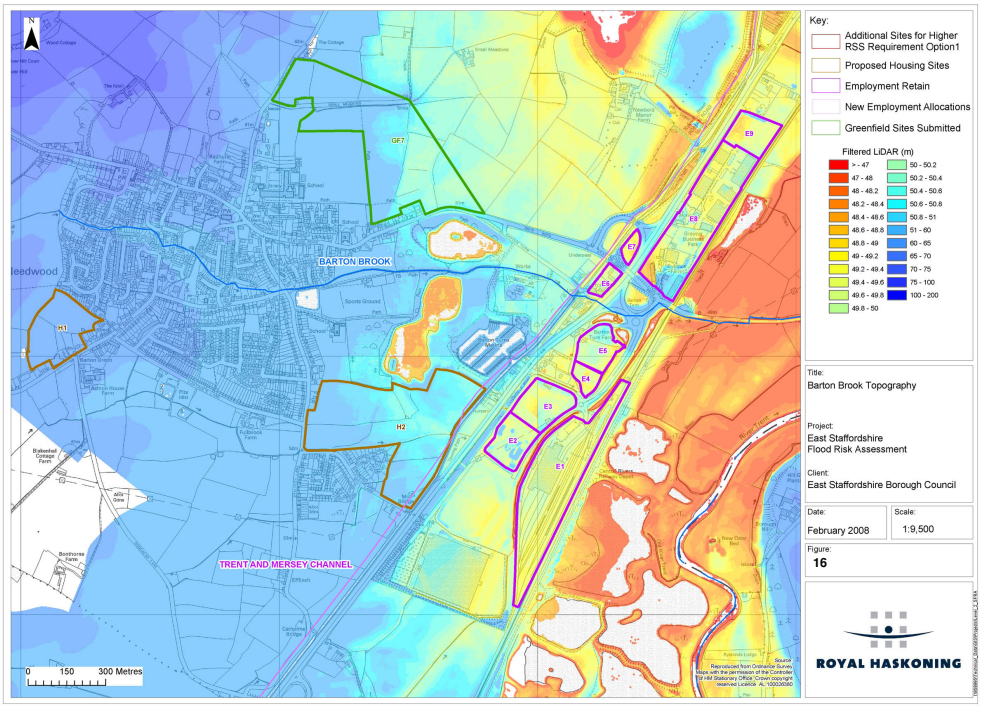
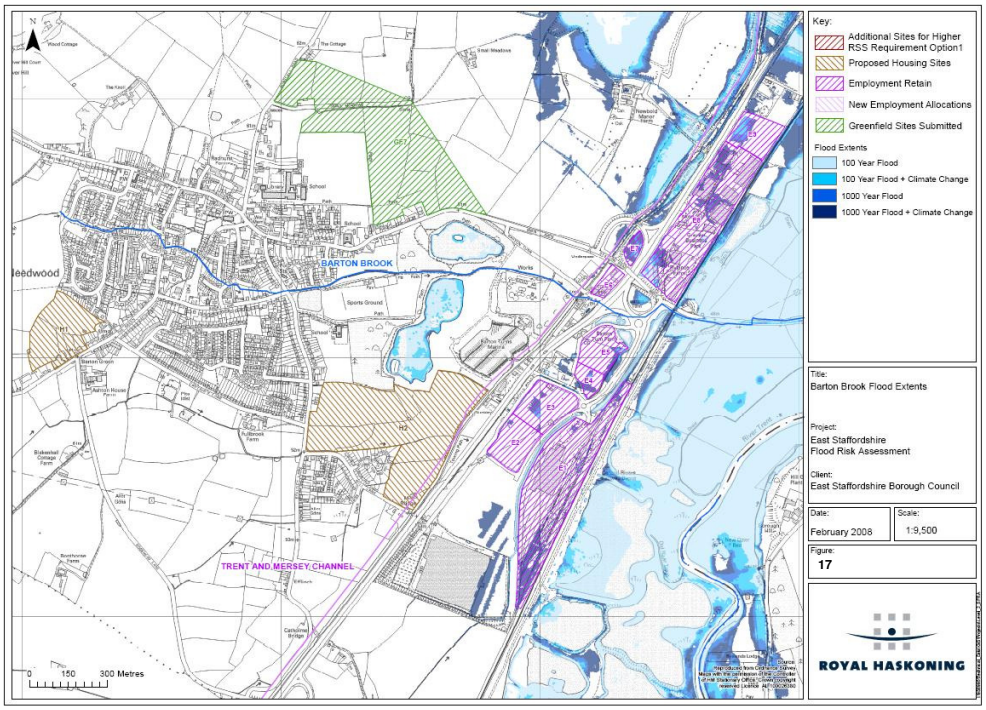


Figure 17 – Barton Brook Flood Extents



It can be seen that areas of E3, E4, E5, E7 and E8 are lower than the modelled flood levels. However, the majority of the sites are elevated above even the 1000 year with climate change level. It would therefore be necessary to consider the opportunity from ground raising to mitigate the flood risk. However, due attention should be given to local drainage issues and the requirement to provide compensatory floodplain storage.

3.4.3 Tatenhill Brook

The development sites adjacent to the Tatenhill Brook are included within the Burton TUFLOW model. *Figure 18* shows the development sites located along the Tatenhill Brook.

The iSIS model of the River Trent gives a 100 year present day flood level of 48.1m AOD. The railway level is approximately 48.0m AOD and therefore will allow flooding to the land behind. In addition, there are a number of railway culverts present which allow flood water to flow through and into the land behind, *before* this level is reached. The LiDAR plot, *Figure 19,* shows a tract of low lying land to the south of Tatenhill Brook, which extends across the A38 and through Branston Water Park. This low lying land which crosses through development site E10 would be the flow route of flood water in extreme events.

Figure 18 – Development Sites Along Tatenhill Brook

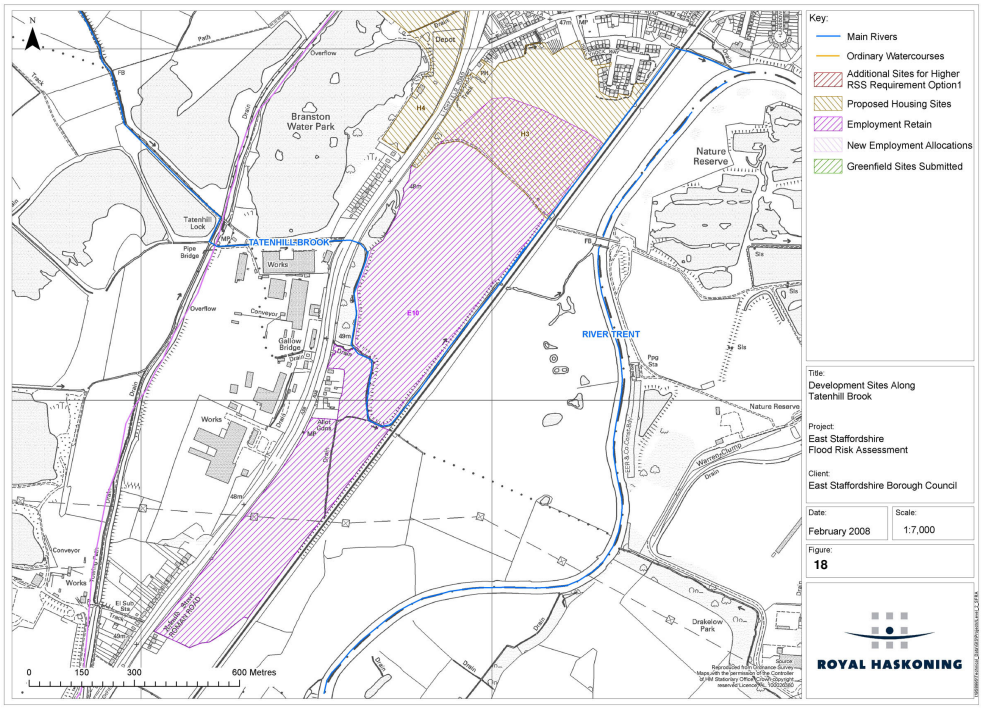
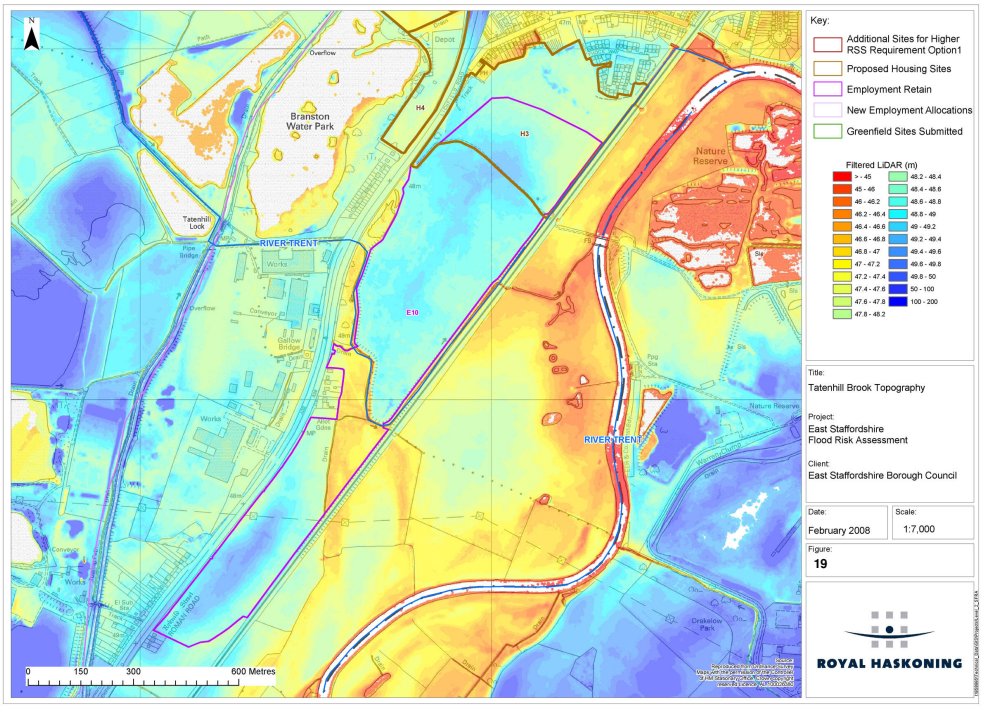


Figure 19 - Tatenhill Brook Topography



3.4.4 Shobnall Brook

Figure 20 shows the potential development sites adjacent to Shobnall Brook

The analysis of Shobnall Brook was based on an existing HEC-RAS model produced for the Council. The model extends from Forest Road Bridge to the outfall of the culvert that starts at Shobnall Road, in front of Marston's Brewery. The model provides the maximum water level and flows for the 100, 200, 400 and 1000 year return periods. It was found that there is a 20% increase in flow between the 400 and 1000 year return periods. Therefore the difference in maximum flood level between the 400 and 1000 return periods was adopted as the allowance for climate change. The resulting maximum water levels were plotted over the LiDAR data in order to generate updated Flood Zone outlines as shown in *Figure 21.*

As can be seen from *Figure 21* development sites GF5 and RSS4 are situated outside the 1000 year flood outline, even with an allowance for climate change. Sites GF2, GF3 and GF4 are upstream of the flood risk from Shobnall Brook. However, it is essential that the runoff fro these sites is controlled through appropriate drainage design.

Figure 22 shows the topography of the sites between the A38 and the inlet to the main culvert.

It can be seen that ground levels fall away from the Shobnall Brook to the north and south. Consequently, water that overtops the Shobnall Brook would drain away form the brook, seeking the lower lying areas. Consequently, development sites E26, E27, E28 and E29 to the south and H26, H27 and H28 to the north are at risk of flooding from the Shobnall Brook. The model results show that the Shobnall Brook overtops in the 100 year flood event even at the present day.

The fact that the existing channel has insufficient capacity demonstrates the importance of drainage from any new developments proposed upstream. In order to proceed with any of the proposed developments adjacent to the Shobnall Brook it will be necessary to upgrade the capacity of the existing watercourse or install drainage source control. However, the EA has stated that, as with most watercourses, it is unlikely that channel improvements can be undertaken on the Shobnall Brook. Development within Flood Zone 3 of this watercourse Is therefore inappropriate.

Figure 20 – Development Sites Along Shobnall Brook

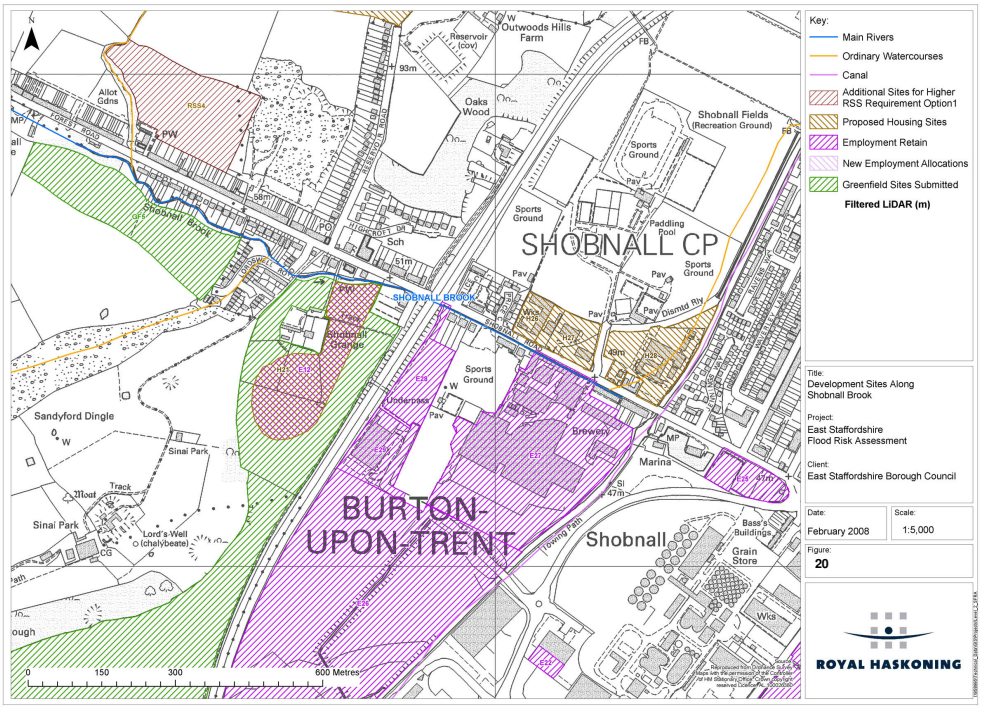


Figure 21 – Amended Shobnall Brook Flood Zones

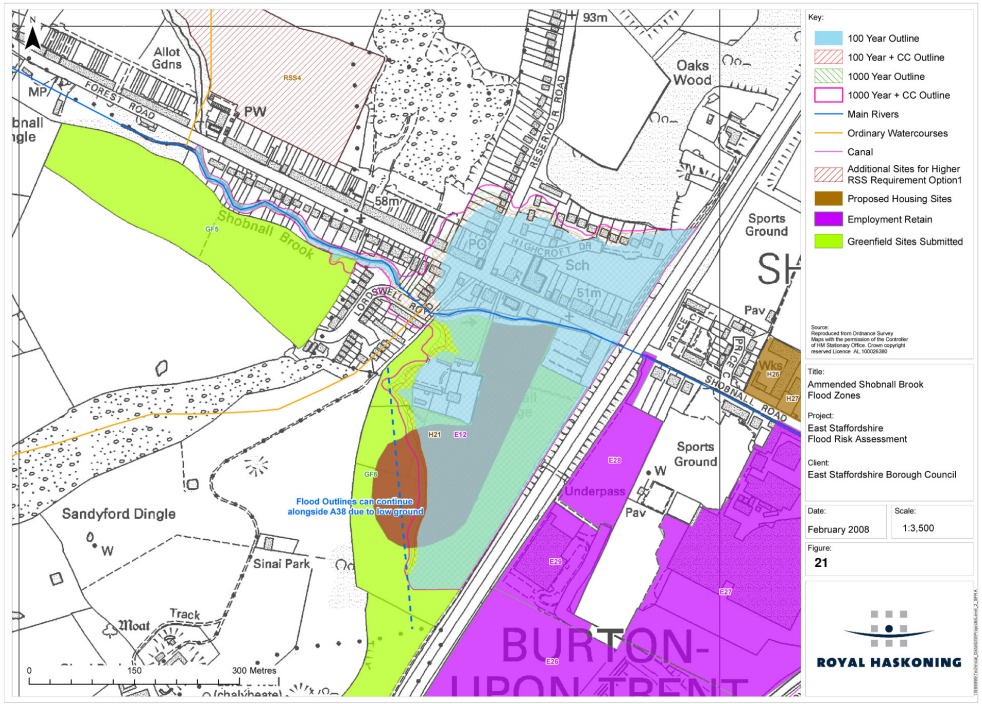
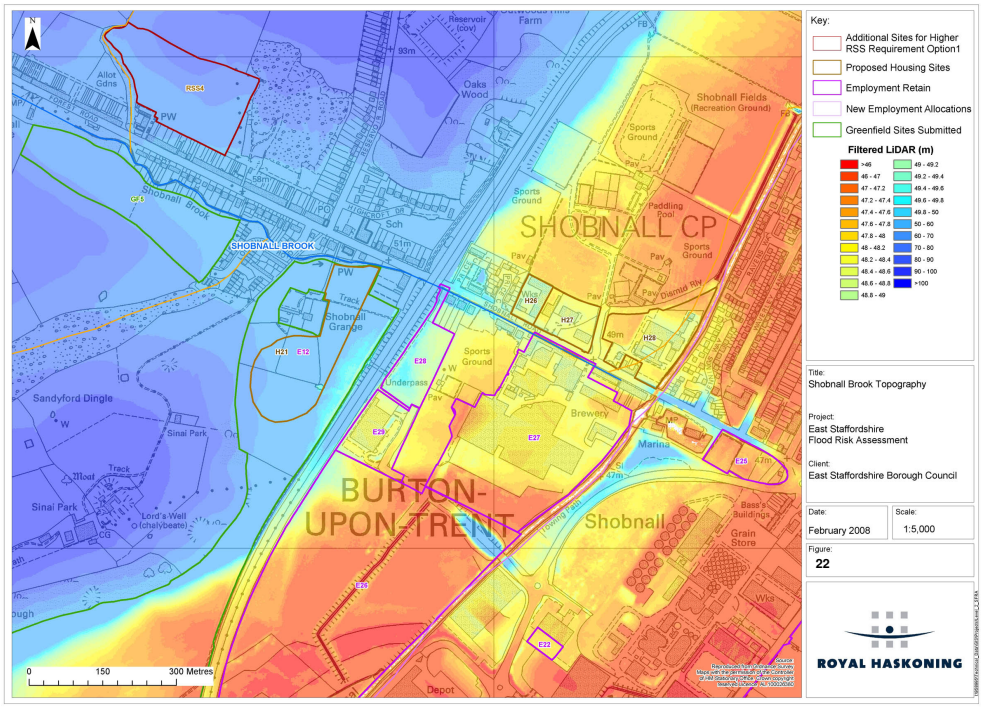


Figure 22 - Shobnall Brook Topography



3.4.5 Horninglow Channel

Figure 23 shows the locations of proposed developments adjacent to the Horninglow Channel. The Horninglow Channel is a wide, heavily canalised watercourse which drains the Horninglow area of Burton. The Horninglow Channel also receives flows from the Shobnall Brook, Kitling Greaves Brook and Bitham Lane Brook. The Level 1 SFRA identified that there have not been historic incidences of flooding directly attributable to the Horninglow Channel.

The LiDAR plot shown in *Figure 24* shows the ground elevations of the proposed housing sites H36 to H41 and site E61 are approximately 47 to 47.5m AOD. This is significantly higher than the land to the east of Princess Way, which has typical levels of between 45 and 46m AOD. This suggests that in the event of overtopping from the Horninglow Channel, sites H36 to G41 would be safe from flooding, with flood water flowing to the east. This would, however, cause water to flow towards the Employment sites to the east.

The Horninglow Channel is included within the TUFLOW model of the River Trent. *Figure 5* shows that sites H36 to H41 are within the flood outline of the 1000 year with climate change. The employment sites E50 to E60 are shown to be within the present day 1000 year flood outline.

Figure 23 – Development Sites Along HorngingloW Channel

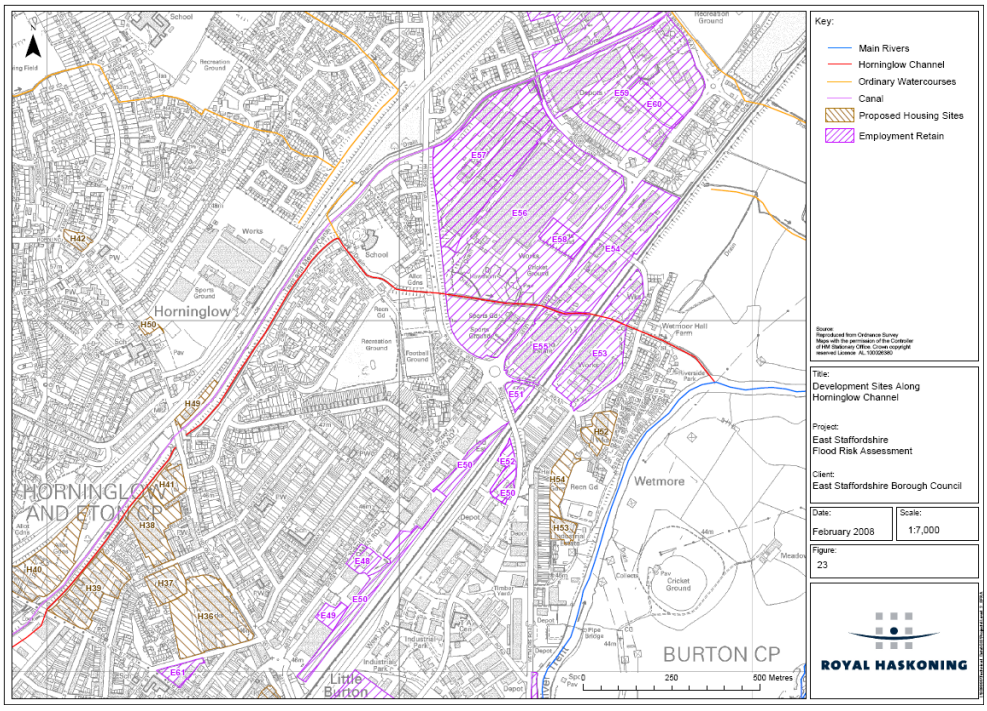
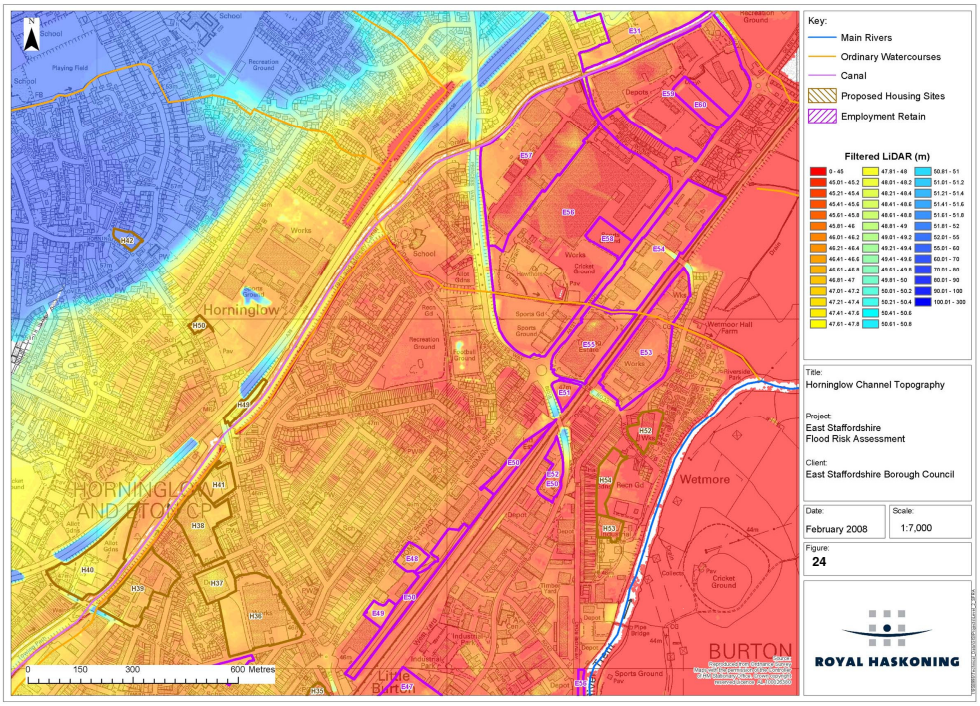


Figure 24 – Horninglow Channel Topography



3.4.6 Kitling Greaves Brook

Figure 25 shows the proposed developments adjacent to Kitling Greaves Brook.

The proposed developments are all located around the headwaters of the Kitling Greaves Brook. The sites are Greenfield, undeveloped land and therefore the development of such areas has the potential to dramatically increase surface water runoff. This would be further exacerbated by the steep topography of the sites, as shown in *Figure 26*, where the construction of roads could have the potential to act as flood routes towards the lower lying land adjacent to the Brook. The Council has advised that the culvert beneath Kitling Greaves Road is already at maximum capacity. It is therefore essential that the development of these sites incorporate adequate source control drainage solutions.

Figure 25 – Development Sites Along Kitling Greaves Brook

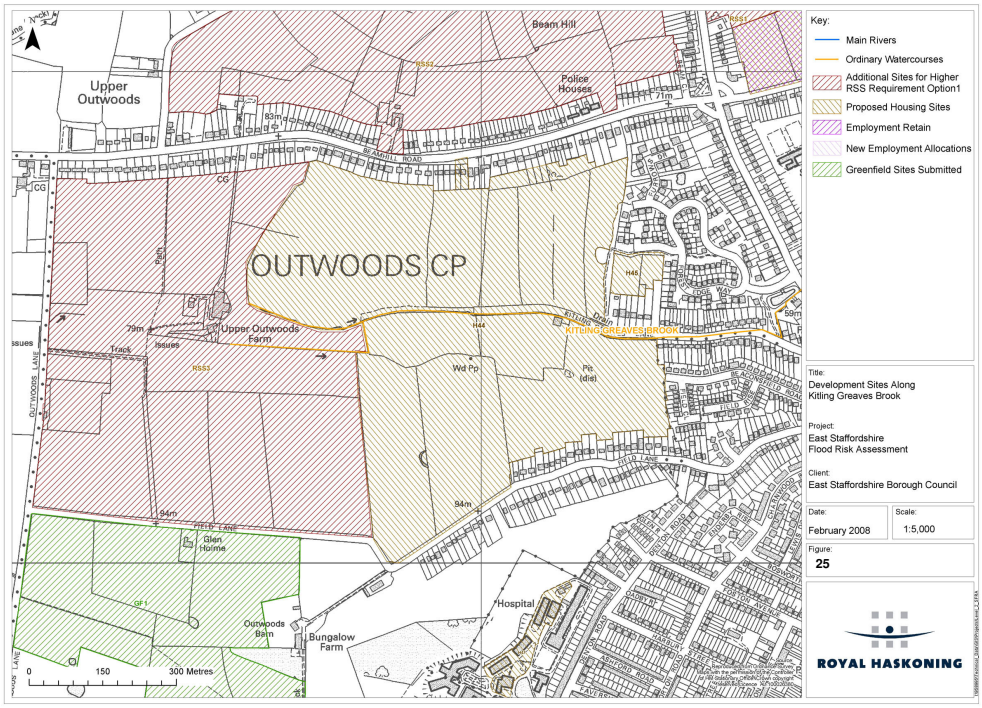
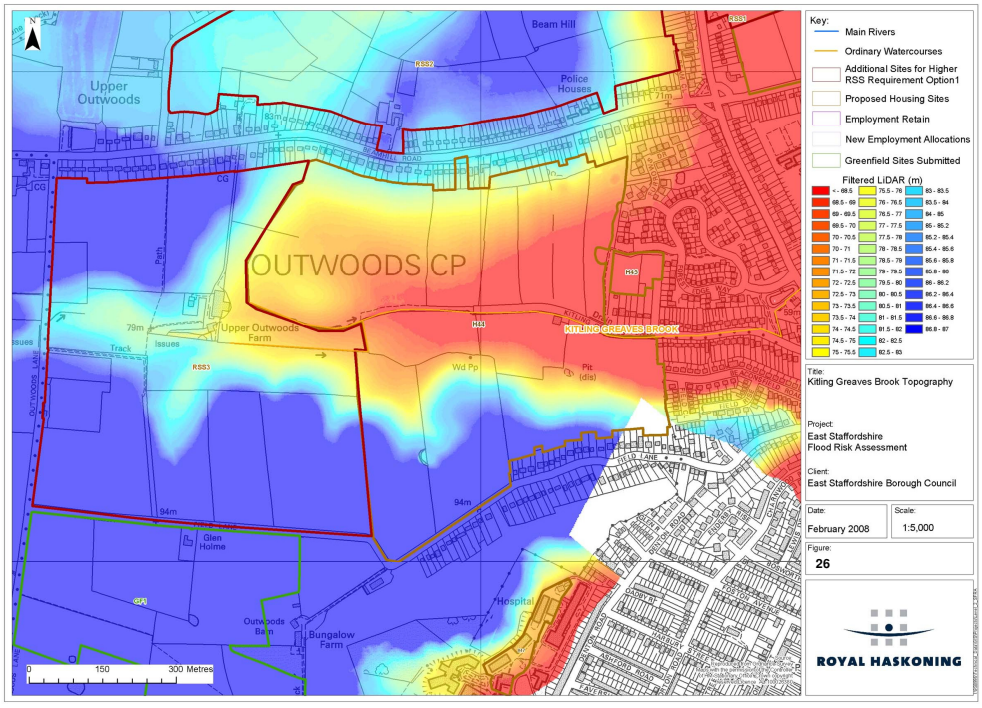


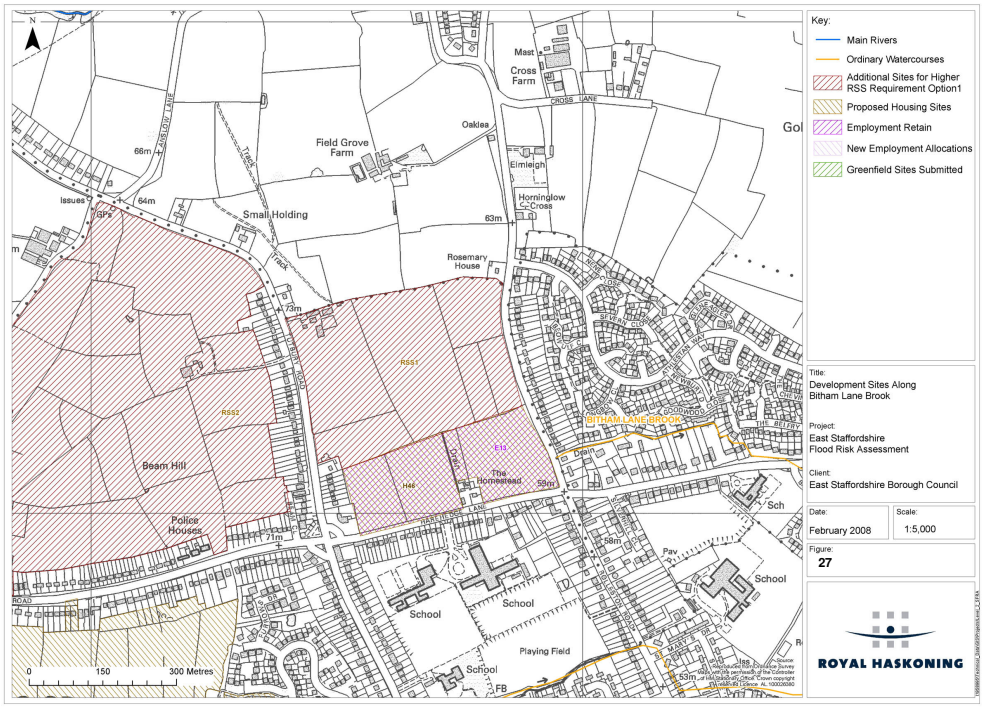
Figure 26 – Kitling Greaves Brook Topography



3.4.7 Bitham Lane Brook

Figure 27 shows the proposed developments adjacent to Bitham Lane Brook. The Brook starts to the east of Rolleston Road, where it flows for a short reach in an open channel before entering a small culvert. From site investigation it is evident that there is no formal drainage from the sites to the west of Rolleston Road and Tutbury Road. It is also evident that the existing drainage system is insufficient to accommodate the additional runoff that would be generated from a site the size of the proposed developments. The development of sites E13, H46, RSS1 and RSS2 would therefore either require source control of all surface water generated by the sites, or a complete overhaul of the Bitham Lane Brook.

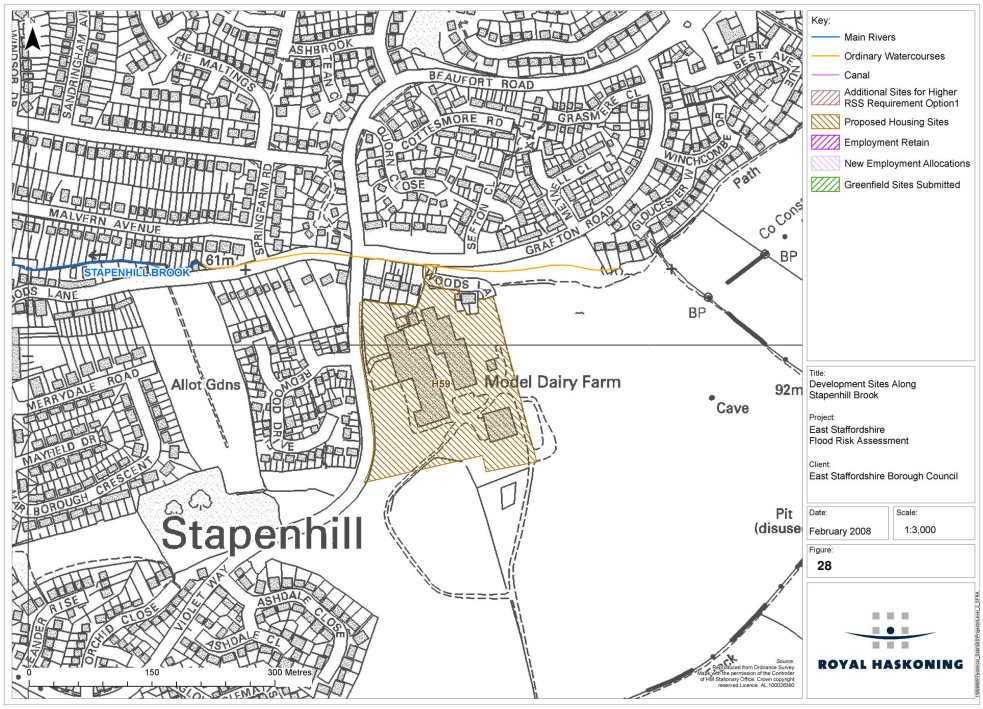
Figure 27 – Development Sites Along Bitham Lane Brook



3.4.8 Stapenhill Brook

Figure 28 shows development site H59, situated near the headwater of Stapenhill Brook. Whilst there is no direct flood risk to the proposed development site from the Stapenhill Brook, it is essential that the runoff from the proposed site does not exacerbate flooding further downstream. This should be addressed through the detailed design of a surface water drainage system for the site.

Figure 28 – Development Sites Along Stapenhill Brook



4 FLOOD RISK IN UTTOXETER

4.1 Study Area

The area under consideration in this section is shown in *Figure 3*. There are very few development sites within Uttoxeter itself, with the main concentration along Picknall Brook, centred around the JCB development site, U2. Along Picknall Brook, with the exception of just one Greenfield site, all are 'Unclassified Brownfield Development'. In addition to the sites located in the vicinity of Picknall Brook, three more sites are located within the Flood Zones of other watercourses. Two are located in the industrial estates to the east of the town within Flood Zone 3 of the River Dove. Both of these sites are also located on the banks of Uttoxeter Brook, which has not been modelled. The third site is located north of the A50 on the left bank of the River Tean, within Flood Zone 2.

In addition to the sites located within the Flood Zones of these major watercourses, there are two Greenfield sites located in proximity to unmodelled watercourses in the 'Balance Hill' area of the town. These will also need consideration, especially with regards to surface water drainage.

4.2 Overview of Flood Risk

Flood risk to the development sites within Uttoxeter is mainly associated with Picknall Brook. However flood risk to the development sites in question are also associated with the River Dove and the River Tean, as mentioned in section 4.1. In addition, a number of smaller, unmodelled watercourses are present within Uttoxeter and may pose a risk of flooding to the development sites along their banks. One of these watercourses is an enmained stream, Uttoxeter Brook, which flows in a south westerly direction from the eastern side of the town, close to the A518, through the industrial estates before joining Picknall Brook east of the race course. The other, ordinary watercourses, in question are all located in the southern, Balance Hill, district of the town. Three of these brooks flow in a northerly direction from the hills south of Uttoxeter, forming a confluence just south of Timber Lane before flowing at one stream, culverted for most of its route, joining Picknall Brook slightly upstream of the JCB factory site.

The flood risk associated with sewer, groundwater and overland flooding was discussed in the Level 1 SFRA and determined to be of minor risk.

4.3 Flood Risk from Picknall Brook

4.3.1 Flood Defence Infrastructure

There is very little raised flood defence infrastructure located on the watercourses around Uttoxeter and all are located along Picknall Brook. There are two Environment Agency maintained defences; upstream of the Hockley Road bridge and downstream of the Highwood Road Bridge. In addition there are two privately maintained flood defences on the left bank of the brook in front of the JCB factory site (development U2). The locations of all of these defences are shown in *Figure 29*. All of these defences are built to a 100 year standard.

Asset Condition

The condition of the flood defences along Picknall Brook are presented in *Table 17* below, as recorded in the NFCDD. The condition levels relate to the Environment Agency scale presented in *Table 7*.

Table 17 – Flood Defences along Picknall Brook, Uttoxeter

NFCDD Reference	Unique ID	Asset Description	Location	Condition	Defence Standard	Year Built/ Updated
0330931090108L01	15	Earth embankment	Left bank, A518 Hockley Road	1	100	1980
0330931090107L08	16	Earth embankment	Left bank, JCB Hockley bridge to change in material behind JCB	3	100	-
0330931090107L07	17	Masonry wall	Left bank, from Pinfold St bridge to change in material behind JCB	3	100	-
0330931090106R08	18	Masonry blue brick wall	Right bank, Highwood road bridge to station road bridge	2	100	1980

Future Maintenance and Upgrade

Both of the Environment Agency maintained defences (15 and 18) are in Good or Very Good condition and as a result should not require maintenance repair work in the near future. However, both of the privately maintained defences are recorded as having a condition of Grade 3, which, although recorded as 'Fair' at present, will require improvement and repair work to be carried out before site U2 can be developed.

In addition, the standard of all of these defences is currently at 100 year standard, which will not withstand the effects of climate change. This must be taken into account when considering the development of areas currently benefiting from the protection of these defences, namely the JCB site, U2. Photographs of the JCB flood defence are included in *Appendix C* and highlight the need for maintenance and upgrade prior to the development of the JCB site behind.

4.3.2 Methodology

The Environment Agency flood zones for the Picknall brook were derived using a computational model. The HEC-RAS model and the accompanying modelling report were provided by the Environment Agency for use in the SFRA.

4.3.3 Flood Zones and Climate Change

Figure 30 shows flood zones 2, 3 and 3b for the Picknall Brook based on the results of the Environment Agency model. *Figure 30* also shows the flood outline for the 100 year return period event with an allowance of 20% to represent climate change. It can be seen that development site U1 is outside Flood Zone 2. Site U2 is shown to be outside of Flood Zone 3b, due to the presence of the raised defences, but at risk from events with a return period greater than 100 years. The development of the JCB site is therefore dependent upon the upgrade and maintenance of the existing flood defence.

Sites U3 and GF19 are shown to be within the functional floodplain (flood zone 3b) of the Picknall Brook. It should also be noted that sites U3 and GF19 are within flood zone 3 of the River Dove to the east and therefore even by mitigating against the flood risk from Picknall Brook the sites would still be at risk.

4.3.4 Breach Analysis and Rapid Inundation Zones

Site U2 is protected by a raised defence with a condition standard of 3 ("Fair") as shown in *Table 16*. It was therefore considered appropriate to assess the risks of a breach in the existing defence. The same criteria were adopted as presented in *Section 3.3.3* in respect to breach width and the time to closure. Since the lowest section of the defence is constructed of masonry, a 20m breach was modelled with a time to closure of 18 hours. The model showed that flooding would reach a depth of 300mm within 30 minutes of the start of the breach. Within three hours water would reach a depth of 1.6m. Based on the Flood Hazard Matrix (FD2320) this would categorise the hazard as "Extreme" and a "Danger for All".

4.4 Flood Risk from River Dove

4.4.1 Flood Defence Infrastructure

There are no flood defences located along the River Dove in the vicinity of Uttoxeter.

4.4.2 Methodology

Analysis of the flood risk from the River Dove was undertaken during the Level 1 SFRA, using the results of a hydraulic modelling study undertaken for the Environment Agency in April 2006.

4.4.3 Flood Zones and Climate Change

The flood extents based on the modelled water levels showed that sites U4 and GF18 are situated within the functional floodplain (Flood Zone 3b) of the River Dove. The hydraulic modelling showed that the 1 in 100 year flood level is expected to increase by 0.04m as a result of a 20% increase in flows to simulate climate change.

4.4.4 Breach Analysis and Rapid Inundation Zones

Since there are no flood defences on the River Dove it is not relevant to consider breach analysis and rapid inundation zones.

4.5 Flood Risk from the River Tean

4.5.1 Flood Defence Infrastructure

There are no flood defences located along the River Tean in the vicinity of Uttoxeter.

4.5.2 Methodology

There is not a specific hydraulic model of the River Tean covering the reach to the north of Uttoxeter. Flood Zones for this reach have therefore been derived using the

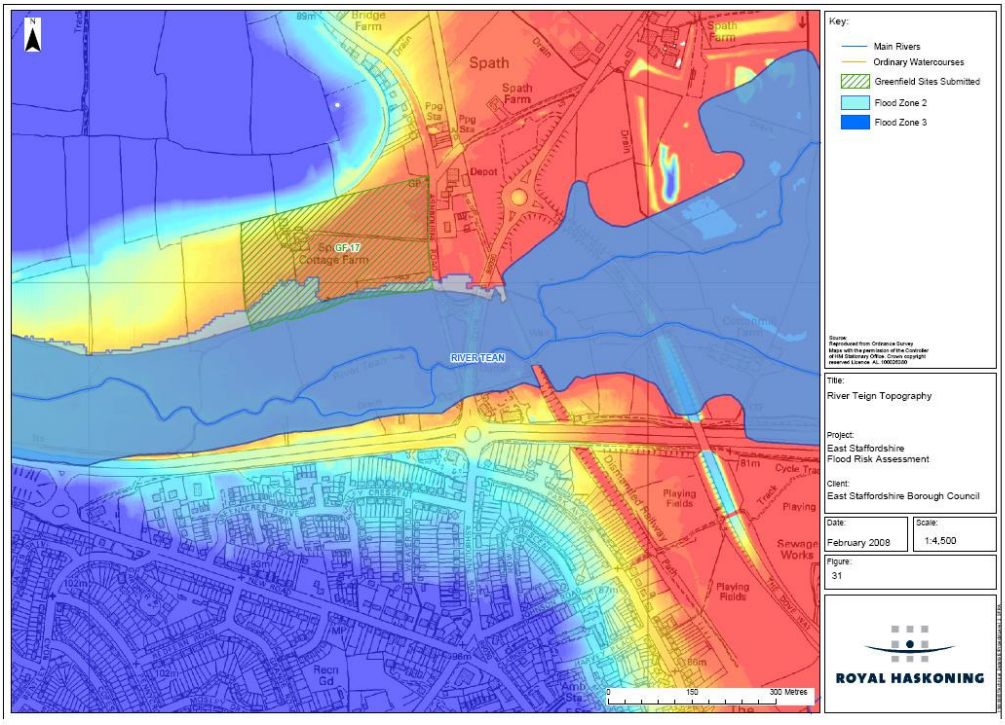
automated JFLOW process. The assessment of site GF17 was based on the JFLOW results and an assessment of the topography of the site based on LiDAR data.

4.5.3 Flood Zones and Climate Change

Figure 31 shows an extract from the LiDAR, the Flood Zones 2 and 3, and site GF17. It can be seen that site GF17 is on the fringe of Flood Zone 3 but partly within Flood Zone 2.

It is also evident that the JFLOW Flood Zone 2 outline seems to bisect the orange shaded area at the location of site GF17. Prior to the development, greater attention should be given to the local variations in topography across the site.

Figure 31 - River Tean Topography



4.5.4 Breach Analysis and Rapid Inundation

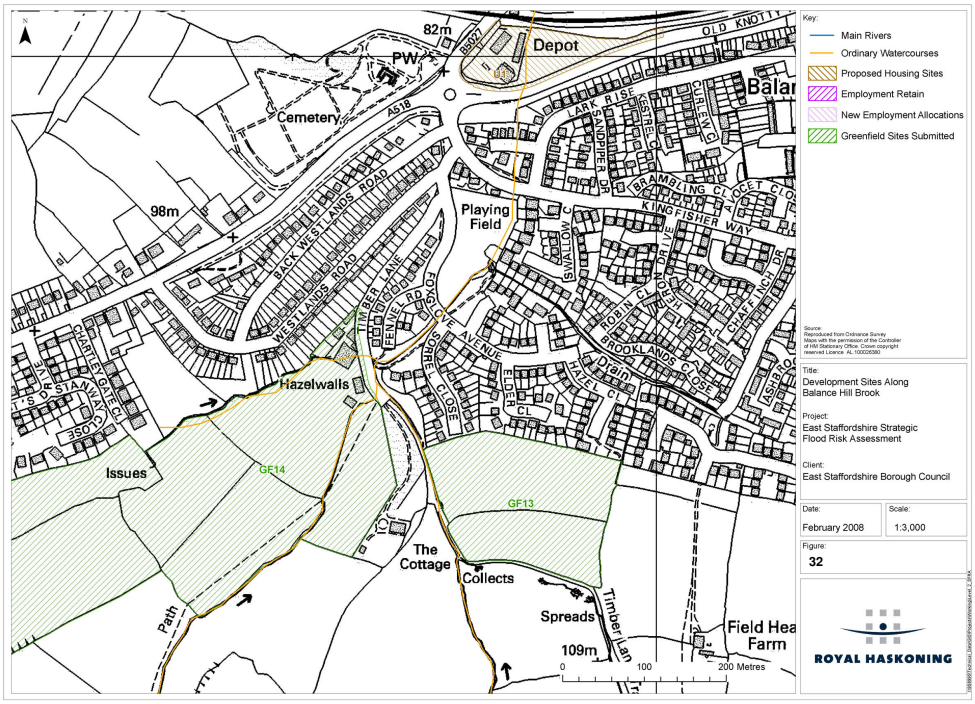
Since there are no flood defences on the River Tean it is not relevant to consider breach analysis and rapid inundation zones.

4.6 Flood Risk from Ordinary Watercourses

4.6.1 General

The remaining potential sites within the Uttoxeter area are located on the fringes of the Balance Hill area of Uttoxeter, (sites GF12, GF13 and GF14), as shown in *Figure 32* Sites GF13 and GF14 are situated on the sub-catchments of three small watercourses, which drain the area to the South of Picknall Brook. The channel of this watercourse is culverted underneath development U1 so poses no flood risk to the site.

Figure 32 – Development Sites Along Balance Hill Brooks



Since these watercourses have a small catchment area, Flood Zones have not been determined by the Environment Agency. The three watercourses combine just upstream of a culvert upstream of the main urban area of Balance Hill. The capacity of this culvert to drain the existing catchment will therefore pose a significant constraint to the proposed development sites GF13 and GF14.

4.6.2 Methodology

The capacity of the Balance Hill culvert was calculated using a methodology presented in the US guidance "Waterway Design". The calculation shows that the existing culvert has the capacity to drain a maximum flow of 0.9m^3/s. An assessment of the design flows to the culvert was undertaken using the "Flood Estimation for Small Catchments" method", (Report No. 124, Institute of Hydrology, June 1994).

The resulting flows are presented in Table 18:

Table 18 – Estimated Flows to the Balance Culvert

Return Period (yrs)						
2	**5**	**10**	**25**	**50**	**100**	**200**
0.53	0.74	0.89	1.12	1.32	1.54	1.79

It is evident that the existing culvert only has the capacity to drain the 10 year flows, but would be surcharged at the 25 year return period event.

This serves to demonstrate the importance of designing a drainage scheme for any new sites upstream, which should ensure that no additional run-off reached the already undersized culvert.

5 GUIDANCE

Throughout this SFRA guidance is given in relation to the development of each of the proposed development sites. Additional generic guidance is presented in *Appendix D* of this report for the following issues:

- The Exception Test;
- Dealing with Surface Water;
- Review of FRAs;
- Emergency Planning; and
- FRA Procedure

6 CONCLUSIONS AND RECOMMENDATIONS

This Level 2 SFRA has assessed the flood risk to each of the proposed development sites within East Staffordshire. The SFRA has shown the reliance of the majority of the existing development and proposed new development on the continued maintenance and upgrade of the Burton flood defences. The SFRA has also shown the significant residual risk of defence failure, either from overtopping or defence breach. It is essential that this residual risk is appreciated and sufficiently mitigated against in the future development of Burton.

The SFRA has also highlighted the need for appropriate drainage design for developments on previously undeveloped sites, in order to avoid increasing the flood risk to properties elsewhere.

ROYAL HASKONING

ROYAL HASKONING

APPENDICES

ROYAL HASKONING

ROYAL HASKONING

Appendix A
Figures

ROYAL HASKONING

ROYAL HASKONING

Appendix B
Burton Upon Trent Flood Defences

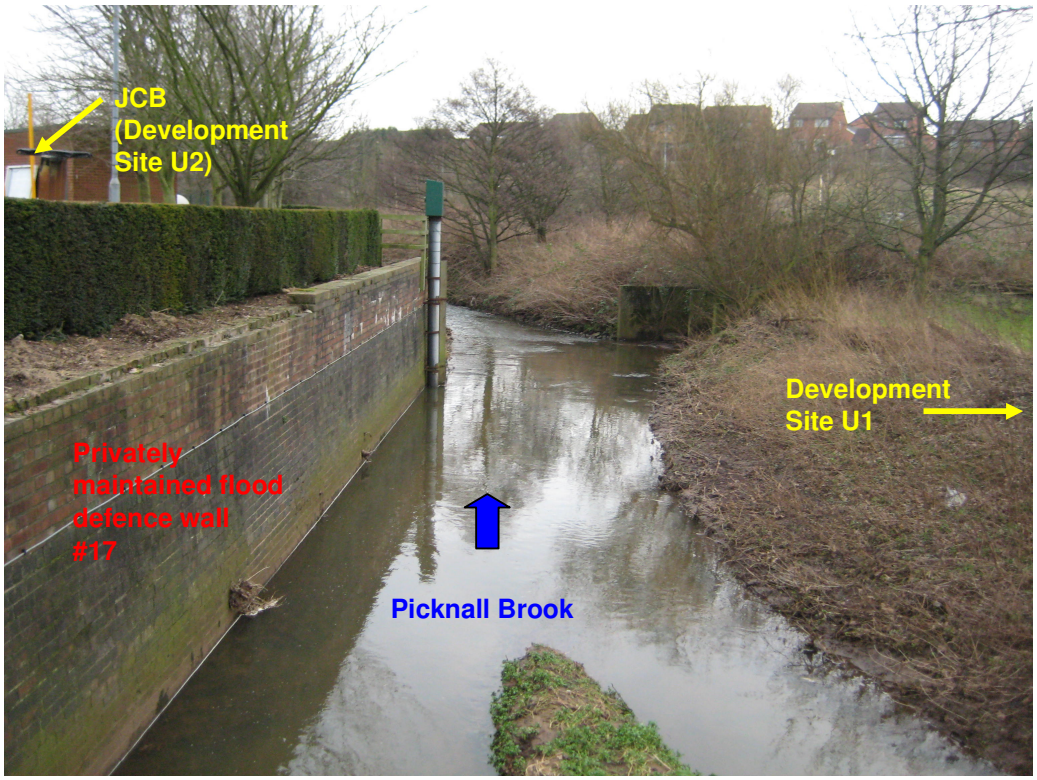
ROYAL HASKONING

ROYAL HASKONING

Appendix C
Site Photographs

ROYAL HASKONING

JCB Private flood defence, Uttoxeter



JCB Private flood Defence, Uttoxeter

ROYAL HASKONING

ROYAL HASKONING

Appendix D
Guidance

ROYAL HASKONING