Noble House, Capital Drive, Linford Wood, Milton Keynes MK14 6QP
T +44 (0)1908 669898 **F** +44 (0)1908 669899 **E** harrisjt@rpsgroup.com **W** www.rpsgroup.com

Mansfield
District Council
Creating a District where
People can Succeed

STRATEGIC FLOOD RISK ASSESSMENT

TECHNICAL REPORT

JUNE 2008

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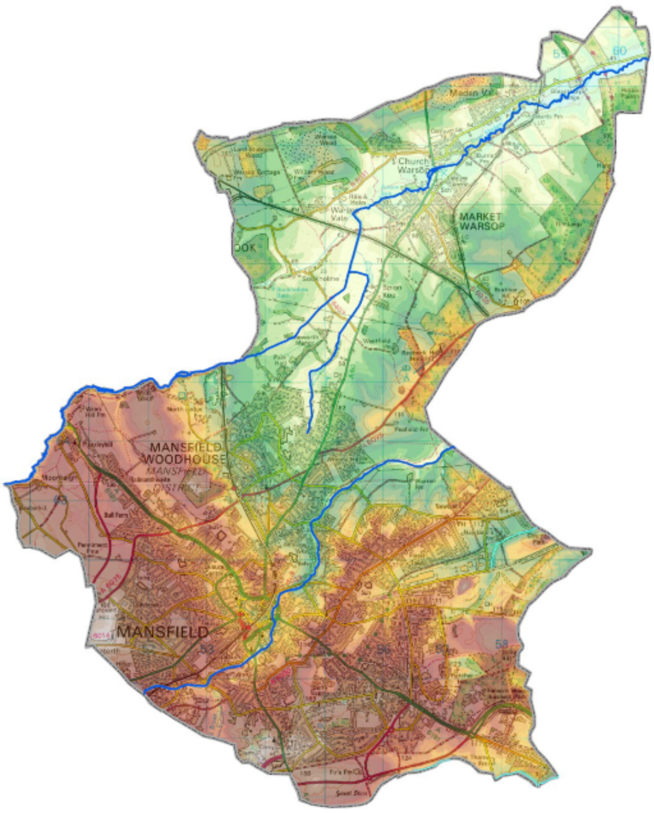

RPS Planning and Development Ltd Registered in England No. 02947164
Centurion Court, 85 Milton Park, Abingdon, Oxfordshire OX14 4RY
A member of the RPS Group plc

STRATEGIC FLOOD RISK ASSESSMENT

TECHNICAL REPORT

For

Mansfield District

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For and on behalf of RPS Planning and Development

Prepared by:		J. Harris	*Principal Engineering Hydrologist*
Checked by		K. Limbrick	*Principal Hydrologist*
		H. Phillips	*Associate Planner*
Approved by:		K. McEvaddy	*Associate*

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APPENDICES

1 INTRODUCTION

1.1 Background

1.1.1 The Mansfield District Council SFRA covers an area of 76.7km^2 as shown in Figure 1.1 below. The River Maun and River Meden flow across the district and later join the River Idle; the River Maun dissects Mansfield town centre and the River Meden flows to the north of Market Warsop. **An overview of the physical features within Mansfield district are shown in Appendix B.**

1.1.2 Despite their prominence within the study area, the relatively steep topography means that flooding from rivers and streams only impacts on a small portion of the district. Flooding from surface water run-off, sewers and groundwater are equally important factors and are therefore considered in this study.

Figure 1.1 – Mansfield District

1.1.3 The River Maun Flood Risk Mapping study was commissioned by the Environment Agency and was completed in March 2007. This document is the key source of information relating to fluvial flooding in the River Maun. There is no detailed flood mapping of the River Meden, although this is scheduled for completion in 2008.

1.1.4 This Strategic Flood Risk Assessment (SFRA) takes account of the guidance contained in the following documents:

- *Strategic Flood Risk Assessment: Midlands Region Interim Guidance (March 2006), Environment Agency;*
- *Planning Policy Statement 25: Development & Flood Risk (December 2006), DCLG;*
- *Planning Policy Statement 25: Development & Flood Risk Practice Guide (June 2008), DCLG;*
- *Maun Valley Action Plan (May 2000), Baker, Shepherd, Gillespie.*
- *River Trent Catchment Flood Management Plan – Final Draft (2007), Environment Agency*

1.2 Project Brief

1.2.1 Planning Policy Statement 25: Development and Flood Risk (PPS 25) requires local planning authorities to demonstrate a risk-based approach to the preparation of local development plans and consideration of planning applications through the application of a Sequential Test and where appropriate the Exception Test.

1.2.2 The key objectives for the undertaking of the SFRA are outlined below:

- *Inform the preparation of the emergent Local Development Framework*
- *Assist in assessing the long-term development potential of the District*
- *To steer new development towards areas of the lowest risk of flooding and inform the application of the Sequential Test.*
- *Maximise the reuse of accessible Brownfield land by understanding possible constraints imposed by flooding.*
- *Enable policies to be developed that aim to minimise and manage flood risk, enhance the biodiversity of the watercourse and address water quality and resource issues.*

1.2.3 Each of these objectives needs to be met within the principles defined by PPS 25 and associated guidance. It is vital that the adopted approach accounts for the Environment Agency's flood risk management strategy for the area, as outlined in the River Trent Catchment Flood Management Plan.

1.2.4 The key components of the Strategic Flood Risk Assessment brief are summarised below:

- *Consolidated flood maps detailing the fluvial flood risk associated with the River Maun, River Meden and tributaries indicating the flood outline for specific design events.*
- *Consolidated flood maps detailing possible sources of flooding.*
- *An appraisal of the protection provided by natural and man-made flood defences, if any.*
- *Identify key locations where culverts could be reinstated as open channels for improved biodiversity.*

- *An appraisal and Code of Practice for sustainable surface water management. To include advice on the use of SUDS in agreement with Severn Trent Water and other relevant parties.*
- *An appraisal of areas where surface water run-off generated by new development may assist to replenish low flow watercourses for biodiversity and water quality benefits.*
- *Guidance on the required content of site-specific Flood Risk Assessments, based on the risks associated with the general location of the site.*

2 METHODOLOGY

2.1 Strategic Flood Risk Assessment

2.1.1 A strategic approach to flood risk assessment requires consideration of current and future flood risks within the study area. The precautionary risk based approach covered by the Sequential Test in PPS 25 seeks to encourage sustainable land allocation practices. The Sequential Test is an evidence-based exercise carried out by decision makers to appraise the reasonable availability of sites for development. This prioritises low flood risk areas, and then considers higher flood risk areas where alternative sites are reasonably available. This aims to match the vulnerability of proposed development with severity of flood risk.

2.1.2 Completion of the SFRA is achieved through a four stage process. Stage 1 uses the Flood Zone Maps published by the Environment Agency as a starting point. Stage 2 reviews these Flood Zone Maps to establish whether they depict a realistic risk, based on the presence (or absence) of flood defences and other structures. This information is combined with other known sources of flooding to create the indicative flood risk maps. Stage 3 considers the residual risk of fluvial flooding. Stage 4 then considers appropriate practices for the management of surface water and opportunities to enhance the biodiversity. The full details of which are discussed below.

Stage 1: Identification of Flood Zones

2.1.3 The identification of sites in relation to Flood Zones 1, 2 and 3 enables the broad evaluation of sites based on the fluvial flooding risk, (Low, Moderate and High). The identification of appropriate development for each of the flood zones should be made with reference to Table D.1 and D.3 of PPS 25.

Stage 2: Determine Indicative Flood Risk

2.1.4 The indicative flood risk gives a more detailed assessment of the fluvial flood risks to a site, and includes the flood outlines generated from detailed modelling and enables identification of possible flood depths at broad locations and the likelihood of structures being overtopped.

2.1.5 Other possible flood risks are identified to enable a precautionary approach. In general, all land identified to be in Flood Zone 1 is appropriate for development. Where additional sources of flood risk are identified, development may still be acceptable, but must be accompanied by a detailed Flood Risk Assessment which addresses these risks in greater detail and where appropriate makes provision for suitable mitigation measures.

Stage 3: Review Residual Flood Risk

2.1.6 Within the Mansfield District, the Residual Risk is generally considered to be associated with extreme fluvial flooding with a 0.1% annual probability of occurrence (1 in 1000-year event).

Stage 4: Determine Best Practice for Surface Water Management and Enhancement of Biodiversity

2.1.7 With sites evaluated in terms of flood risk, the final stage considers opportunities for biodiversity enhancement. This includes the best practice for the management of surface run-off such as:

- *Priority sites for Green SUDS*
- *Priority sites for soakaways*
- *Priority sites for direct discharge to low flow areas*

2.2 Biodiversity Enhancement Strategy

2.2.1 In addition to the strategic flood risk component, this document also considers opportunities to improve the biodiversity of the river environment through opening up culverted sections of the rivers and streams and restoring the natural flow character of streams suffering from low flow conditions without increasing flood risk. This component is termed the Biodiversity Enhancement Strategy (BES) and is integral to the overall flood risk management strategy.

Summary

2.2.2 The holistic approach encompassed in this assessment enables land allocations to consider both the strategic impact on flood risk and the opportunity to enhance the biodiversity.

3 STRATEGIC FLOOD RISK ASSESSMENT

3.1 Assessment Procedure

3.1.1 In order to support the Sequential Test described within PPS 25, the following assessment processes have been completed:

3.1.2 **Identification of Flood Zones**
Flood zones are related to fluvial flooding only and are defined assuming the absence of flood defences. Thus in defended areas the zones may exhibit an outline not necessarily indicative of the actual level of flood hazard.

3.1.3 **Categorisation of Indicative Flood Risk**
The indicative flood risk gives due consideration to possible flood risks from rivers, surface run-off, sewers, and groundwater. Indicative flood risk accounts for the presence of flood defences and makes allowance for the impact of climate change.

3.1.4 **Review of Residual Risk**
Review of residual risk identifies the remaining risks, which cannot be eliminated using flood defences alone. This seeks to identify those areas at risk from more severe storm events than those assessed for the derivation of the indicative flood risk. This section also recognises the anticipated increase in storminess associated with climate change and its unpredictable nature.

3.1.5 The Sequential Test should also consider the impact of surface water discharges and identify areas at risk from surface water flooding.

3.2 STAGE 1 – Identification of Flood Zones

Introduction

3.2.1 Flood Zones classify the flood risk based on the annual probability of flooding. Broadly speaking, these Flood Zones are derived from computational models based on design rainfall events. The definition and detail of these flood zones depends on the detail of the hydraulic modelling. PPS25 identifies distinct areas of flood risk as follows:

Table 3.1: Flood Zone Definition

Flood Zone	Risk Description	Return Period	Annual Excedence Probability
1	Little or no risk	< 1000 year	< 0.1%
2	Low to medium risk	100 – 1000 year	0.1% – 1.0%
3a	High risk	20 – 100 year	1.0% – 5.0%
3b	The Functional Floodplain	> 20 year	> 5%

3.2.2 The Flood Zones ignore the effect of flood defences, such that in areas benefiting from defences the zones will show an outline that is not necessarily associated with the real level of flood risk.

Environment Agency Flood Zone Mapping

3.2.3 Within Mansfield District Council, the Flood Zone Mapping is based upon historic flood events, the River Maun Flood Mapping Study, 2007 and the Environment Agency National Flood Model. At the time of this report being published, the River Meden flood outline was generated from the national model while the River Maun has been produced from the more detailed Flood Mapping Study. These modelled outlines would be superseded by historic flood outlines where a historic flood event had a flood outline greater than the modelled outline.

3.2.4 The Flood Zone Maps ignore the benefit of flood defences. Consequently the Flood Zone Maps illustrate the possible flood extent should there be a failure of the defences, or where there are no defences they provide a reasonable indication of the indicative risk to a site. The maps are therefore a useful tool for emergency planning and for steering new development to more sustainable sites that do not depend on the maintenance of flood defences.

3.2.5 It is understood that the currently available Flood Zone Map (version 3.5) for the River Meden is based on the national model and does not consider historic flood outlines or detailed hydraulic modelling. The Flood Zone Map for the River Maun is based on detailed hydraulic modelling as described in Sections 3.2.6 & 3.2.7. It is observed from the existing Flood Zone Map that the floodplain associated with the River Maun and River Meden is generally narrow, with the difference between the Flood Zone 2 and Flood Zone 3 being relatively minor, reflecting the generally steep topography which categorises the Mansfield District. **The Flood Zone Map is included in Appendix D.**

River Maun Hydraulic Modelling

3.2.6 The River Maun Hydraulic Model was completed by JBA Consulting in March 2007. This flood mapping study has produced flood outlines for a range of different return period flood events, including the 25-year, 100-year, 100-year plus climate change, and the 1000-year return period flood events. In accordance with PPS25, the 1 in 20-year return period event should be used to define the Functional Floodplain. In the absence of this information, the Environment Agency agreed that the 25-year event can be used to define the functional floodplain. **The modelled flood extents are presented in Appendix E.**

3.2.7 The modelled flood extents are generally greater than the existing flood zone outlines, particularly at Field Mill Pond and in the town centre in the Bridge Street area. Despite this, the flood extent remains localised with only small areas falling within Flood Zones 2 and 3. Further discussion of the River Maun hydraulic modelling is included in Stages 2 and 3 of the SFRA.

River Meden Hydraulic Modelling

3.2.8 The River Meden flood risk mapping has been undertaken by JBA Consulting in 2008. The draft output was made available in June 2008 for the purpose of this study. **The River Meden flood outlines generated by this modelling are incorporated in the indicative flood risk maps presented in Appendix F.**

3.3 STAGE 2 – Indicative Flood Risk

Introduction

3.3.1 The next step is to identify the ‘Indicative Flood Risk’. This involves an assessment of the risk of flooding allowing for the presence of flood defences. There are however considered to be no extensive defences in Mansfield such that this has been omitted from the scope of the SFRA. The identification of risk includes the identification of flood mechanisms, and the preparation of plans which place land into categories reflecting the key flood mechanisms present (e.g. flooding from blockage of drainage systems or local surface water flooding etc).

Historic Flooding

3.3.2 The identification of historic flood events provides a useful reference point for the identification of indicative flood risks. The location and nature of the flooding is considered against known infrastructure upgrades and developments. Particularly pertinent to this assessment was the flooding which occurred in June 2007, providing a current calibration of the flood risk throughout the Mansfield District. The June 2007 event resulted in widespread flooding across the district, affecting properties and infrastructure, as shown below. A more detailed **photographic account of the June 2007 flooding is included in Appendix C.**

Figure 3.1: Flooding at Field Mill Dam and Nottingham Road, Mansfield (taken from www.chad.co.uk)

3.3.3 The best available rainfall data for the June 2007 flood event was from the Gleadthorpe tipping bucket rainguage at Grid Reference SK59126991. This raingauge can measure the rainfall intensity for short durations. The annual exceedance probability of the June 2007 rainfall event is estimated from the DDF Modelling function within the Flood Estimation Handbook, as summarised in Table 3.2. FEH provides statistical rainfall data for the whole of the UK, the DDF Modelling function therefore gives a general statistical estimate of probability. The short duration rainfall on the 25th June 2007 does not on its own correspond to a particularly severe rainfall event, with the 24 hour rainfall equivalent having an estimated annual probability of 4.5%. However, consideration of the preceding days indicates a more sever storm with an annual probability of excedence equivalent to 1.5%.

Table 3.2: June 2007 Rainfall Data, Gleadthorpe

Duration	Peak Rainfall	Estimated Annual Probability
1 hour	10.0 mm	50.0%
3 hours	23.6 mm	25.0%
24 hours	69.6 mm	4.5%
2 days	82.0 mm	6.0%
3 days	91.6 mm	5.0%
4 days	120.0 mm	1.5%

3.3.4 Saturated soil conditions followed by moderately high rainfall on the 25th June 2007 led to widespread flooding within the Mansfield District.

3.3.5 A rainfall event of a particular return period will result in different depths of rainfall, for example a 100 year design rainfall event may be characterised by a 1 hour storm in which there is 46mm of rainfall, or a 2 day storm in which there is 118mm of rainfall. The physical characteristics of a river and its associated catchment mean that the water level in a river will respond differently for different storm durations. Consequently, for a 100-year rainfall event, the river level will respond differently, depending on the storm duration. The rainfall duration which causes the greatest response from a river (and the most severe flooding) is described as the critical storm duration. The critical storm duration for Mansfield District as identified in the River Maun Flood Mapping study is as follows:

- 3.75hrs for the upper reaches of the River Maun to Bath Lane
- 7.5 hours downstream of Bath Lane

3.3.6 At these storm durations the return period of the June 2007 flooding is considered to be relatively low (less than the 1 in 20-year storm).

3.3.7 The Environment Agency's gauging station at Quarry Lane recorded a peak flood level in June 2007 of 109.50mAOD. The closest model node to the gauging station is 31454 which has a modelled design flood level of 109.55mAOD for a return period of 50 years. This is more severe than suggested by the short term rainfall data. Furthermore, the hydraulic model is considered to indicate elevated levels over the crest of the Field Mill Pond embankment, it is expected that the recorded flood level may therefore be attributed to a higher return period event. The severity of the June 2007 flooding is attributed to the saturated soil conditions as a result of the prolonged rainfall in the preceding days. The saturated soil conditions will have exacerbated the severity of the rainfall event, with the percentage run-off being significantly increased.

3.3.8 **The location of key flooding events in June 2007 are shown in Appendix F.** It is important to note that much of the flooding was away from the rivers and can not be attributed to fluvial flooding, in particular the flooding along the Mansfield-Ashfield Regeneration Route. The Citizens Panel undertake a quarterly questionnaire to over 1000 participants within the Mansfield District. Eight flood related questions were placed in the September 2007 questionnaire as follows:

Q1. Were you directly affected by the flooding?
Q2. If so, please state how you were affected by the flooding?
Q3. And roughly how deep was the flooding?
Q4. In particular where was the flooding that affected you?
Q5. How long did the flooding last for at this location?
Q6. In your general opinion, what do you think caused the flooding at this location?
Q7. Have you witnessed flooding at this location in the past?
Q8. If so, please state how often this has happened over the last 5 years?

3.3.9 700 responses were received, representing 67% of the total panel. The results therefore provide a useful gauge of public perception of the flooding and help to identify the extent and severity of flooding experienced in the district. 11% of the panel were directly affected by the flooding, of which 57% were affected by road closures and 3% experienced flooding in their home. The cause of flooding was generally perceived to be associated with excess surface water and insufficient capacity of the drainage system, with 20% of the flooding associated with streams and rivers. **A full summary of the Citizens Panel results is included in Appendix A**

Figure 3.2: Flooding along the MAR Route (taken from www.chad.co.uk)

Table 3.3: Historic Flooding
(adapted from River Maun Flood Mapping Study, JBA, 2007)

Date	Description of Flooding
08/1858	Flooding reported to have occurred in the Mansfield area on a similar scale as that which occurred on 30th May 1912.
25/08/1873	At Mansfield rain was reported to be sudden and heavy as to burst the drains.
07/03/1889	A rainfall observer at Mansfield noted “snow and rain, yielding 1.25 inches, followed by extensive floods”.
30/05/1912	A hail and rainstorm of “unusual violence” broke over Mansfield soon after 3pm on the 30th May. When the storm was at its worst the volume of water in Westgate was so deep it was reported to have reached up to a man’s thighs. A rainfall observer at Mansfield noted a cloudburst, when 1.26 inches of rain fell in 40minutes and 1.54 inches in an hour, causing severe flooding. Many shops and business premises were flooded and near the parish church the water spread the full width of the road and was 18 inches deep.
06/08/1922	At Mansfield the local rainfall record registered 4.34 inches of rainfall over the 2days and many homes were flooded in Retford.
18/07/1968	Brimful after 24hours of incessant rain, the River Maun in Mansfield burst its banks, flooding Bridge Street and bringing ruination to shops, houses and licensed premises.
26/10/2001	Flash floods caused havoc on roads across the Mansfield and Sutton in Ashfield area. The heavy rain “turned roads into rivers, drains failed to cope with the floods and some homeowners had to wade in water in their living rooms”. Homeowners in Meden Vale suffered mud up to 2inches thick over their gardens. Torrential rain caused runoff from farm fields off Rotherham Road, New Houghton and into business premises, ruining property in the process.
07/08/2002	Thunderstorms brought flash floods to the Mansfield and Sutton in Ashfield area. At Glapwell (Bath Lane) the floodwaters were reported to be more than 12 inches in depth. Bilsthrope was among many villages across the area to suffer as a result of the storms, with Maid Marian Avenue and Valley Road being badly hit.
18/08/2006	Torrential rain across the Mansfield area caused up to 18 inches of water to settle in parts. Mansfield Council and Severn Trent Water disagreed over the cause of the flash flooding.
25/06/2007	Moderate rainfall fell from 22/06/07 followed by 69mm of rainfall on 25/06/07. The saturated ground conditions resulted in high levels of run-off from the rainfall on 25/06/07. Carter Lane and Church Road in Warsop Vale were flooded. Sections of the Marr route flooded. The Field Mill Dam overtopped and flooded Nottingham Road. In Pleasley the River Meden flooded forcing the road to be closed. In Sookholme Road (Spion Kop) surface run-off from the old coal tip caused localised flooding.

Fluvial Flooding

3.3.10 The River Maun hydrodynamic model is the only detailed model within the Mansfield District. This model is the main data source for the detailed assessment of fluvial flooding. This model does not consider the River Meden which flows in the northern part of the District. However, the EA is currently in the process of preparing a detailed model of this section of the River Meden; this information was however not available at the time of this report. The fluvial flood risk associated with the River Meden is therefore based on the available Flood Zone data, a review of key hydraulic structures and observations during the June 2007 flood event.

3.3.11 The blockage risk of structures along the River Maun was discussed with the Environment Agency and Mansfield District Councils engineers. All structures along this reach were considered in accordance with the likelihood of blockage and proportion of blockage that would be expected. Blockages were considered as, minor (25% blocked), moderate (50% blocked), and major (75% blocked). Possible blockages at Rock Valley, Bridge Street, Bath Lane and Sandy Lane were dismissed as unlikely to provide any significant obstruction. Two structures were identified as having a notable blockage risk, namely:

- *Hermitage Pond Culverts – Minor Blockage*
- *Field Mill Pond Culvert – Moderate Blockage*

3.3.12 The blockage at these structures was considered for the 100-year flood event with and without consideration of climate change. Interestingly it was found that the blockage would have a negligible impact on the peak flood level as modelled in the River Maun Flood Mapping study due to the naturally low capacity of these structures in relation to the high flows during flood conditions. The modelled level in the Flood Mapping Study is therefore considered to appropriately represent the blockage risk at these structures.

3.3.13 The flow area of key structures has been reviewed throughout the Maun and Meden rivers. A full summary of these structures is provided in **Appendix G.** It is noted that many of the structures with capacity limitations were subject to overtopping during the June 2007 flooding. This included the following structures:

Table 3.4: Structures liable to overtopping

Location	Structure	Watercourse
Access Bridge at Quarry Lane	Culvert	River Maun
Field Mill Pond Main Culvert	Culvert	River Maun
Bath Street Road Bridge	Arch Bridge	River Maun
Culvert at Church Lane	Culvert	River Maun
Access Bridge at New Mill Lane	Rectangular road bridge	River Maun
Spa Lane Road Bridge	Arch road bridge	River Maun
Bridge Street Culvert	Culvert	River Maun
Rock Valley Culvert	Culvert	River Maun
Pleasley Square Road Bridge	Weir & Arch Opening	River Meden
The Carrs, A60 Road Bridge	Arch opening	River Meden

3.3.14 With consideration of the flood outlines generated in the River Maun Flood Mapping Study, a total of 2.1km^2 of Mansfield district lies within Flood Zone 3, (the 1 in 100-year floodplain), equivalent to 2.7% of the total district area. A total of 2.5km^2 lies within the 1 in 1000-year floodplain, equivalent to 3.2% of the district.

3.3.15 The presence of flood defences in Mansfield reduces the risk of flooding to sites that the River Maun Flood Mapping Study considers to be within Flood Zone 3. In particular:

- *Embankments and walls to the south of Field Mill Pond will provide some protection to the industrial units in this area.*
- *Between Bath Street and Rock Valley, the majority of the river is defended against flooding from events up to the 1 in 100-year event.*

3.3.16 It is noted that the flow through the culverts at Bridge Street and Rock Valley give a low conveyance capacity through the structure and consequently a high afflux. This is discussed in greater detail in Section 6.7.1 of the River Maun Flood Risk Mapping Report, where alternative modelling techniques result in lower flood levels. RPS has verified the different modelling techniques and considers that the model used to generate the 100-year flood outline is particularly conservative and that a lower peak flood level should be considered in this area. The river Maun Flood Mapping Study considers two flood levels for the 100-year event; 100mAOD from the ISIS modelling and 96.83mAOD using HEC-RAS modelling. A 3.2m difference in flood level will have a missive impact on the peak flood level in the town centre. It is considered that the HEC-RAS model provides a more accurate representation of the conveyance capacity of the Rock Valley Culvert.

3.3.17 For the purposes of the SFRA, the 100-year peak level at the upstream end of the Rock Valley culvert is conservatively considered to be 97.75mAOD; similar to the 5-year level in the ISIS model. At this peak level, the area immediately upstream of Section 30212 (between Bridge Street and St Peters Way) is considered to be protected against fluvial flooding. The Environment Agency does not have flood defences between Bridge Street and the Rock Valley Culvert. It is therefore considered that there is a considerable flood risk in this confined area.

3.3.18 **In general the indicative risk of fluvial flooding is considered to be low for most areas. With a moderate to high risk being associated with specific structures.**

Climate Change

3.3.19 Annex B of PPS 25, provides detailed guidance on how climate change should be considered within the context of new development. Planning has an important role to steer development towards sustainable sites which avoid unnecessary risk to people and property with consideration of the future impact of climate change. In accordance with the Practice guide, that accompanies PPS25, an appropriate allowance for climate change should be included over the lifetime of the development in question. Table 3.5 is an extract from PPS 25 and should be applied to all proposed development to ensure that proposed drainage schemes take appropriate account of increased rainfall, and that sites are elevated outside the future floodplain with consideration of climate change.

Table 3.5: Recommended Consideration of the Impact of Climate Change (PPS 25)

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Peak Rainfall Intensity	+5%	+10%	+20%	+30%
Peak River Flow	+10%	+20%		

Sewer Flooding

3.3.20 Severn Trent Water is responsible for the operation and maintenance of the sewers within the Mansfield District. The sewer network comprises a system of combined foul and surface water sewers with a design capacity ranging from the 1 in 5-year return period rainfall event for the older sewers to an optimum capacity of 1 in 40-year return period rainfall event for some of the newer sewers.

3.3.21 Incorporated in the sewer network is a series of online retention tanks which is understood to include a 5m diameter storm relief culvert. These tanks and relief culverts form part of the on-going upgrade to Severn Trent Water's sewers.

3.3.22 There have been reported incidents of sewer flooding within Mansfield itself, most recently during the June 2007 flooding when manholes surcharged in Bridge Street.

3.3.23 Due to the Data Protection Act, Severn Trent are unable to identify specific locations where there has been an incident of sewer flooding. They are also unable to identify the design standard of specific sewers. However, Severn Trent Water has stated that all known sewer flooding incidents are resolved within the 5 year AMP period such that they consider there are no long term issues of sewer flooding within the Mansfield District. On this basis, this assessment considers **the indicative risk of sewer flooding to have an annual probability of occurrence between 2.5% and 20% based on the design standard of the public sewers**.

3.3.24 Without access to the network analysis, it is difficult to identify the primary locations at which sewers will become surcharged in the event of capacity excedence, and where pluvial flooding risk is greatest. It is also not appropriate to speculate where the pluvial flood risk is greatest. It is however reasonable to consider that widespread ponding and surface water run-off would occur during higher return period flood events which exceed the design capacity of the sewer network. Urban flooding would be expected when the sewer capacity is exceeded (i.e. for events greater than the 5 to 40 year return period design standard). In this instance the following flooding mechanisms would be expected:

- ***Pluvial Flooding*** *– flooding is caused directly from the surcharging of sewers which results in surface water flowing out of the sewer network.*
- ***Ponding*** *– rain water collects in depressions in the ground unable to drain into the sewer system due to capacity excedence.*
- ***Surface Run-off*** *– rain water flows overland in accordance with the slope of the ground. The surface water run-off will bypass the drainage gullies due to insufficient capacity in the sewer network.*

Surface Run-off

3.3.25 The risk of surface water run-off is generally associated with large areas of impermeable or low permeability surfaces, or saturated, frozen ground conditions. The likelihood and severity of surface run-off is increased where topography tends to concentrate flows, such as natural valleys or at the base of hills. Even areas that are considered to be positively drained through the sewer network may be subject to a risk of surface run-off when the drainage capacity is exceeded. The Mansfield District is categorised by undulating topography such that the risk of flooding from surface run-off requires due consideration. There are several sources which contribute to an increased risk of flooding from surface run-off. These are discussed below:

Densely Urbanised Areas

3.3.26 Densely urbanised areas will lead to an increased risk of surface run-off. The flooding risk is further exacerbated where urban creep occurs such that grassed gardens and verges are replaced for paving. This can lead to additional pressure on the public drainage network and increased volumes of surface water run-off.

Highways

3.3.27 As with densely urbanised areas, highways present an impermeable surface which must be properly drained to minimise the risk of flooding from surface run-off. Highways have been separated out from urbanised areas since they usually have a dedicated drainage system. In the case of the new Mansfield Ashfield Regeneration Route, there have been incidents of flooding on the western side of Mansfield, close to the junction of the MARR with Chesterfield Road North at Pleasley. This flooding may be attributed to insufficient capacity of the highway drainage to convey the large volume of surface run-off which was exacerbated by run-off from the adjacent fields which have been identified to comprise low permeability soils.

Disused Coal Tips

3.3.28 The spoil from old mine workings is found in several coal tips throughout the district. These clay capped spoil heaps often rise above the surrounding areas and are considered to be a potential source of flooding within the district. The tips would usually incorporate drainage at the toe of the tip, with the drainage typically designed with sufficient capacity for rainfall events up to the 1 in 10-year return period event. As discussed in Section 3.5, a surface run-off risk will be apparent once the capacity of the drainage has been exceeded. A particular flooding risk is associated with the coal tip at Meden Vale which has caused recurrent incidents of flooding from surface run-off.

Low Permeability Soils

3.3.29 Soil formations with high clay content or naturally high groundwater conditions will generate increased volumes of surface run-off. While the majority of the district consists of freely draining soils, there are also some extensive areas of the of low permeability clayey soils associated with the Middle Permian Marl formation, which stratigraphically overlies the limestone in the western region of the district. Such areas include the south western area of the town of Mansfield, the northern area of Mansfield and the area to the south of Sookholme which is located towards the northwest of the district.

Summary

3.3.30 Table 3.6 provides an estimation of the surface water run-off rates from the impermeable surfaces based on calculations for Greenfield run-off from the Institute of Hydrology Report 124, Flood Estimation for Small Catchments (IOH 124) and for developed areas using the Modified Rational Method with catchment descriptors taken from the Centre for Ecology and Hydrology, Flood Estimation Handbook (FEH), version 2. This information is intended for comparison with the peak discharge rates calculated in the detailed drainage design for proposed developments. **These rates should not be relied upon for design purposes.**

3.3.31 The run-off from a high permeability soil has been included, this would be characteristic of the run-off from the permeable sandstone and limestone based soils which dominate the district. It is important to note that the run-off rates and volumes are derived from the Standard Percentage Run-off (SPR) characteristics of the different surface types.

Table 3.6: Indicative Peak Surface Water Run-off rates

	l/s/ha	*l/s/ha*	*l/s/ha*
Urbanised Areas & Highways	190	340	440
Disused Coal Tips	6	12	17
Low Permeability Soils	4	9	13
High Permeability Soils	2	4	6

NB This table is for guidance only and must be verified by detailed calculations and agreed with the EA.

3.3.32 An estimation of the total volume of run-off is presented in Table 3.7. This has been calculated using the DDF rainfall modelling function within FEH, with appropriate percentages applied in accordance with the Standard Percentage Run-off for the appropriate surface. The soil permeability is derived from the National Soil Resources Institute data. All rainfall is based on a 1 hour intensity storm, which may not be the critical rainfall event for the site. This information is intended for comparison with the discharge volumes and attenuation storage calculated in the detailed drainage design for proposed developments. **These volumes should not be relied upon for design purposes.**

3.3.33 Where the topography is particularly steep, or soils are frozen or saturated due to prolonged periods of rainfall; the run-off from the soil will be significantly increased. In this instance the run-off from Greenfield sites may even exhibit run-off characteristics similar to impermeable surfaces such as that represented by urbanised areas and highways.

Table 3.7: Indicative Surface Water Run-off Volumes

	%	*m^3/ha*	*m^3/ha*	*m^3/ha*
Urbanised Areas & Highways	100%	124	310	449
Coal Tips	50%	62	155	225
Low Permeability Soils	40%	50	124	180
High Permeability Soils	15%	19	47	67

NB This table is for guidance only and must be verified by detailed calculations and agreed with the EA

Groundwater Flooding

3.3.34 The potential impact of flooding from groundwater includes flooding of residential or commercial properties located in typically dry valley areas or potential spring lines. Where hydro geological conditions are appropriate rising groundwater levels can lead to the emergence of ephemeral streams in such dry valleys which may only flow for hours or days. In addition, even where there is no obvious signs of flooding on the surface, rising groundwater levels may impact basement structures leading to potential property damage.

3.3.35 Groundwater conditions can vary significantly even on a local scale depending on the hydro geological conditions and in accordance with PPS 25 a site specific assessment should always be made of the potential for groundwater flooding.

3.3.36 Groundwater flooding within the UK is most likely to occur in low lying areas underlain by permeable rocks such as sandstone, chalk and limestone where rapid changes in the water table can occur. Groundwater levels rise and fall naturally with the seasons with groundwater levels generally rising during the wet winter months and falling through the summer. In addition, long term patterns in groundwater levels can occur where successive dry years can lead to a general lowering of groundwater levels and conversely a series of wet years leading to a general rise in groundwater levels.

Geology

3.3.37 The solid and Superficial Geology has been interpreted from British Geological Survey map sheets 112, Chesterfield and 113 Ollerton, Solid and Drift editions.

3.3.38 The solid geology underlying the district predominantly comprises limestone and sandstone. The western part of the district, which includes the western half of the town of Mansfield and Mansfield Woodhouse, is dominated by the Permo-triassic Lower Magnesian Limestone. This is a magnesium rich dolomitic limestone with subordinate mudstone, dolomitic siltstone and sandstone beds. This formation is likely to be up to approximately 100m in thickness across the district. A small localised area of the Middle Permian Marl, which stratigraphically overlies the limestone, is present across the western region of the district. Such areas include the southwestern area of the town of Mansfield, the northern area of Mansfield and the area to the south of Sookholme which is located towards the northwest of the district.

3.3.39 The eastern part of the district, which includes the eastern half of Mansfield and Market Warsop, is underlain by the Sherwood Sandstone Group, which stratigraphically overlies the Middle Marl and Limestone Formations identified to the west of the district. The Sherwood Sandstone Group comprises the Lower Mottled Sandstone, a band of which outcrops in a north to south orientation through the centre of the district, and the Pebble Beds which outcrops across the eastern area of the district. These formations are likely to be approximately 50m in thickness.

3.3.40 Superficial deposits are not widespread across the district. An area of Glacial Sand and Gravels and Glacial Till (Boulder Clay) is identified to the southwest of Mansfield Town. A small area of Glacial Sand and Gravel is identified to the south of Sookholme. Deposits of alluvium are identified along the River Meden and its tributaries and the River Maun. Such deposits are likely to be relatively shallow and as such not likely to contain significant bodies of groundwater with respect to the potential for groundwater flooding.

Hydrogeology

3.3.41 Environment Agency Groundwater Vulnerability Map, sheet 18, Nottinghamshire indicates that the geology underlying the district is classified as Major Aquifer. Small areas of Non-Aquifer relating to the Middle Permian Marl outcrops are identified. A Non–Aquifer is described as containing insignificant groundwater but these areas are likely to be underlain by the Major Aquifer.

3.3.42 The Sherwood Sandstone Group and Lower Magnesian Limestone Group are both classified as Major Aquifers. Major Aquifers are described as highly permeable formations usually with a known or probable presence of significant fracturing.

3.3.43 Groundwater level hydrographs have been requested from the Environment Agency relating to both the Magnesian Limestone and Sherwood Sandstone aquifers. The two limestone hydrographs indicate a seasonal variance in groundwater levels up to 6 m; however the overall level over the identified monitoring period (1973 – 2003) does not appear to have significantly changed. The two hydrographs indicate that maximum recorded groundwater levels are in excess of 6 and 10 m bgl.

3.3.44 The three hydrographs associated with the Sherwood sandstone show a relatively stable seasonal groundwater level although all three indicate a significant fall in groundwater levels over time which is likely to be caused by over abstraction. All three hydrographs indicate that the maximum recorded groundwater level is approximately 30 m bgl, however recent groundwater levels have been recorded at levels of up to 8m less than this.

3.3.45 The current over abstraction of the sandstone aquifer as identified in the Environment Agency's Idle and Torne CAMS may result in groundwater rebound (i.e. groundwater recovery from a lower level to a previous level or higher). However, in the future, if abstraction rates subside, the available information suggests that it is unlikely that such rebound will have a significant impact on the district.

3.3.46 Institute of Geological Sciences, Hydrogeology Map of the Northern East Midlands, 1:100 000 scale indicates that groundwater in the region flows towards the northeast. Groundwater levels across the majority of the district are indicated to be in excess of 10 m bgl.

Conclusions

3.3.47 Due to the presence of highly permeable bedrock across the district, seasonal and interseasonal groundwater level fluctuations may be significant. Should groundwater levels be close to the surface locally then groundwater levels may rise above ground level and cause/exacerbate flooding. Based on the identified relief of the district such areas are likely to be limited to valley floors where fluvial flooding would remain the dominant mechanism. In this district valley floors typically have a river present and as such flooding from groundwater is unlikely to pose a significant risk on its own but may exacerbate the occurrence of fluvial flooding locally.

3.3.48 Groundwater conditions can vary significantly even on a local scale depending on the hydro geological conditions and in accordance with PPS 25 a site specific assessment should always made of the potential for groundwater flooding. This is particularly the case where basement structures are proposed.

Summary of Indicative Flood Risk

3.3.49 The indicative flood risk to areas within the Mansfield District are presented in Table 3.8. Where information exists these are shown spatially in **Appendix F.**

Table 3.8: Summary of Indicative Flood Risk within Mansfield DC

Source of Flooding	Potential			Comments
	High	*Med*	*Low*	
Fluvial *(Rivers)*	☐	☐	☒	Extent of flooding generally localised and minor. High risk is apparent near structures with limited capacity.
Pluvial (drainage system)	☐	☒	☐	Expected that capacity exceedance will occur during moderate rainfall events.
Surface Run-off	☐	☒	☐	Isolated incidents of high risk, while overall risk remains moderate due to topography and dense urbanisation
Groundwater	☐	☐	☒	Risk of GW flooding generally low, with the risk increasing proximate to streams and spring lines.

3.4 STAGE 3 – Residual Flood Risk

Introduction

3.4.1 The assessment of residual risk identifies the impact of flood events of greater magnitude than those identified for the derivation of the 'Indicative Flood Risk' categories. This will highlight locations that might be sensitive to large magnitude flood events where the consequences may require rapid evacuation of large numbers of people or where people would be exposed to hazardous situations with little warning. This is consistent with the precautionary approach to flood risk.

Extreme Fluvial Flooding

3.4.2 The residual flood risk considers the flood extent during an extreme fluvial flooding event (0.1% annual probability). The extreme flood extent ignores the benefit of flood defences and assumes inhibited flow through key structures. The River Maun Flood Mapping study considers the flood extent without the benefit of flood defences. In addition, conservative modelling techniques are employed which generally give a low estimation of flow through key structures such as bridges and culverts. It is particularly noted that the flow through the culverts at Bridge Street and Rock Valley give a low conveyance capacity through the structure and consequently a high afflux. This is discussed in greater detail in Section 6.7.1 of the River Maun Flood Risk Mapping Report, where alternative modelling techniques result in lower flood levels. RPS has verified the different modelling techniques and considers that the model used to generate the 1000-year flood outline is particularly conservative and therefore gives a useful representation of the extreme flood outline in Mansfield city centre.

3.4.3 The residual flood extent is included in **Appendix F,** defined as the extreme flood. In general, the extreme fluvial outline is not significantly greater that the 100-year flood outline. However, the flood depth is significantly increased due to the generally narrow floodplains. For the localised areas that are subject to flooding, the residual hazard is significantly increased.

Other Residual Risks

3.4.4 King's Mill Reservoir has a capacity in excess of 400,000m^3 with an embankment height of 9.5m. The reservoir is therefore subject to The Reservoirs Act, 1975. The Reservoirs Act requires regular inspections to ensure the reservoir is maintained at a good standard and does not present an unacceptable hazard. The reservoir should generally be designed to withstand the probable maximum flood, or the 1 in 10,000-year return period flood event if overtopping is tolerable. It is therefore considered that the integrity of the Kings Mill reservoir is safeguarded to a standard significantly higher than is considered within the residual risk.

3.5 Data Sources and Reliability

3.5.1 The River Maun flood risk mapping study provides a conservative representation of the fluvial flood risk along the River Maun. In accordance with the specification, the mapping ignores the benefit of flood defences and undertakes a particularly conservative modelling approach to the flow through key structures which might otherwise reduce the extent of flooding along individual reaches of the River Maun.

3.5.2 Restricted access to data from Severn Trent Water means that the risk of flooding from sewers cannot be reliably established, particularly for lower return periods.

3.6 Summary of the SFRA

3.6.1 The indicative flood risks within the Mansfield District are generally considered to be low, with 2.7% of the district within Flood Zone 3. In accordance with the Sequential Test, there is no reason in terms of flood risk why the majority (if not all) of the LDF allocations should not be located outside of Flood Zone 3.

3.6.2 Due to the high proportion of land at low risk of flooding within Mansfield DC, land allocations should generally avoid areas considered to be at high risk of indicative flooding. These areas are identified using **Appendix F**, with specific reference to the following:

- *All development within Flood Zones 2 and 3*
- *All development adjacent to the recorded historic flood incidents*
- *All development prone to a high risk of surface run-off*

3.6.3 All development along the River Meden in Flood Zones 2 & 3 will require a supporting flood risk assessment, the detail of which needs to be proportionate to the flood risk and vulnerability of the proposed development / land use.

4 BIODIVERSITY ENHANCEMENT STRATEGY

4.1 Introduction

4.1.1 The Mansfield Strategic Flood Risk Assessment seeks a holistic approach to flood risk and the management of surface water. Consequently, the SFRA also considers ecological issues and in particular the potential to improve biodiversity through reinstating the natural character of watercourses. This considers the following:

- *The potential for improving the connectivity of the open watercourse environment;*
- *The opportunities for providing open watercourses to enhance areas of existing or potential biodiversity interest.*
- *Opportunities and benefits of restoring flow to low flow watercourses.*

4.1.2 Baseline information required for this appraisal included:

- *Mapping of the existing open and culverted watercourses.*
- *Areas of existing open space of biodiversity value (or areas where such space could potentially be created through policies in the Mansfield District Local Plan and emerging Mansfield District Local Development Framework).*
- *Records of relevant protected riparian species (particularly water vole Arvicola terrestris, otter Lutra lutra and white-clawed crayfish Austropotamobius pallipes).*

4.1.3 Culverted watercourses have been assessed according to the potential for improving connections between existing watercourses (with highest priority being afforded to those watercourses which would extend the potential habitat for protected species), for improving existing open space, and for contributing to the value of open space likely to be brought forward as part of development projects.

4.1.4 This assessment will enable resources to be targeted so as to achieve a cost effective strategic approach to watercourse reinstatement, with due regard being given to the potential for funding through development. The extent to which reinstatement could contribute to the following Nottinghamshire Local Biodiversity Action Plan 'Habitat Action Plan for Rivers and Streams' targets has been considered:

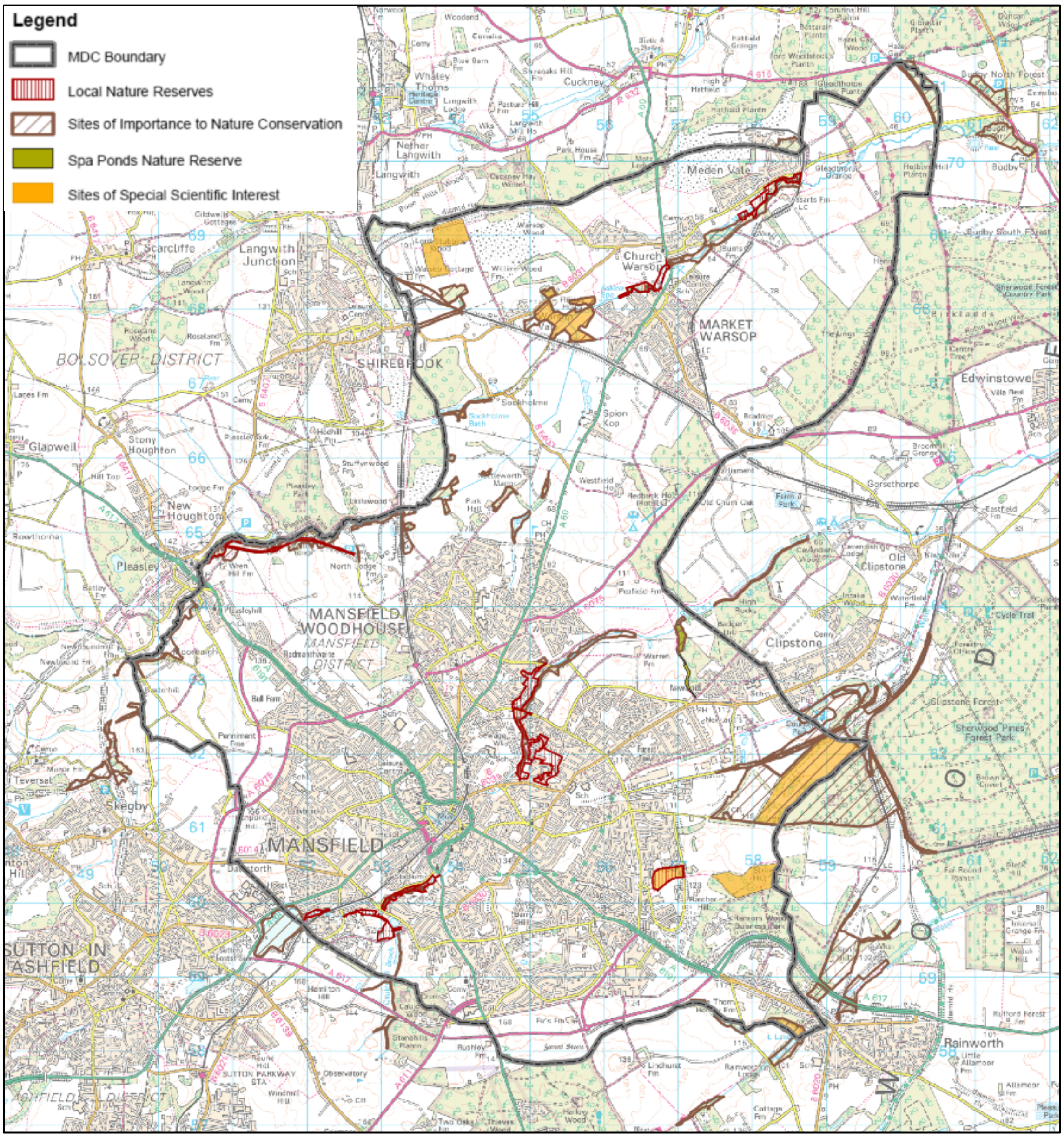
- *"Maintain and enhance the existing habitat and species diversity of rivers and streams.*
- *Enhance, through sensitive management and habitat creation schemes, the habitat and species diversity of at least 100km of the main river by 2010.*
- *Restore natural flows, in terms of water level and flow characteristics, to rivers and streams wherever possible."*

4.2 Sites and habitats

4.2.1 Watercourses and their associated habitats are of high biodiversity value since they often support continuous and semi-continuous habitats that provide valuable wildlife corridors. Wetland habitats of national and local importance (BAP priority habitats) in the district include: lowland wet grassland, wet woodlands (woodland carrs), eutrophic standing waters, reed beds, ponds, swamps, marshes, fens and rivers and streams. A majority of these habitats are associated with statutory sites (SSSIs and LNRs) and local wildlife sites (Sites of Important Nature Conservation or SINC’s), although some may be located outside these designated areas.

4.2.2 Two main rivers flow through Mansfield District, the River Maun and the River Meden. Key sites and habitats, including statutory and non-statutory designated sites, associated with the watercourses and wetlands within Mansfield District are described below by catchment. Information on sites and habitats of biodiversity interest were obtained from Mansfield District Council, Nottinghamshire Wildlife Trust and Natural England. The key sites within the study area are shown in Figure 4.1; a more detailed plan is given in Appendix I.

Figure 4.1: Biodiversity Sites within Mansfield District



River Maun

4.2.3 Within Mansfield District the River Maun extends from Kings Mill Reservoir in the southwest through the District to Clipstone in the east. Caudwell Brook and Vicar Water are both tributaries of the River Maun.

Maun Valley Park LNR

4.2.4 The park is large and has the River Maun running along its length. It contains amenity grassland, an ancient woodland dominated by oak, and wet woodland, designated as a UK Biodiversity Action Plan (UKBAP) priority site. Along some of its length the river has been canalised to prevent flooding. The river is flanked by willow and hawthorn scrub. Surveys for both water vole and white-clawed crayfish have proved negative but the site has over 100 species of birds recorded including kingfisher *Alcedo atthis*, marsh tit *Parus palustris*, willow tit *Parus montanus* and reed bunting *Emberiza schoeniclus.* Waders such as ruff *Philomachus pugnax*, green sandpiper *Tringa ochropus* and common sandpiper *Actitis hypoleucos* are seen during autumn passage.

Oakham LNR

4.2.5 Oakham LNR comprises a wide assortment of habitats ranging from unimproved grassland to wetland habitats adjacent to the River Maun. The northern section of the reserve contains mainly wetland habitats with a small area of wet willow carr woodland, a UKBAP and Local Biodiversity Action Plan (LBAP) priority habitat. Grey heron *Ardea cinerea*, kingfisher and dipper *Cinclus cinclus* have all been recorded. There is an exceptionally high population of water voles using both the river and the man-made scrapes. There is also a colony of white-clawed crayfish in the nearby Cauldwell Brook.

Quarry Lane LNR

4.2.6 At Quarry Lane LNR the River Maun meanders through the reserve eventually entering Field Millpond. The Millpond contains eutrophic standing water, a National and Local Biodiversity Action Plan Habitat, and attracts a wide variety of bird species including great crested grebe *Podiceps cristatus* and little grebe *Tachybaptus ruficollis.* The area holds a thriving population of water voles both along the river and around the edge of the millpond. The river is flanked by mature woodland dominated by ash *Fraxinus excelsior*, beech *Fagus sylvatica* and oak *Quercus robur*. It supports kingfishers and attracts feeding bat species.

Hermitage LNR

4.2.7 The site is an old disused millpond of the River Maun containing eutrophic standing water and reed beds, both UKBAP and LBAP priority habitats. Water enters the site from the overflow from Kings Mill Reservoir and also via an outfall from Ashfield Sewage Works and exits through culverts situated at the east of the site. The pond is surrounded by mature deciduous woodland and supports foraging bat species. A total of 46 bird species have been recorded on site with 42 having bred including grey heron, pochard, kingfisher, willow tit and reed bunting.

Spa Ponds Nature Reserve (Nottinghamshire Wildlife Trust)

4.2.8 A nature reserve managed by Nottinghamshire Wildlife Trust, the site comprises a mixture of dry acidic grassland, heathland and wet woodland with a series of ponds fed by a spring. These are designated as UKBAP and LBAP priority habitats. The River Maun runs adjacent to the reserve. The wetland flora is diverse and the reserve supports species of dragonflies, kingfisher and little grebe.

Site of Importance for Nature Conservation

4.2.9 There are several SINC’s along the River Maun corridor, this includes; sites of zoological importance associated with White Clawed Crayfish habitat; the Maun Woodlands, described as deciduous acidic woodland, and the Maun scrub and acidic grassland. The culvert between Cauldwell Brook and the River Maun is also denoted as a Crayfish habitat, with the upstream end of Cauldwell Brook is described as being a noteworthy botanical community.

River Meden

Hills and Holes and Sookholme Brook, Warsop SSSI

4.2.10 A site of significance for its wetland habitat of limestone and base-rich flush plant communities consisting of calcareous grassland and rock surface plant communities developed on soils, spoil and rock derived from limestone.

The Carrs LNR

4.2.11 This LNR lies alongside the River Meden between *The Bottoms LNR* and *Hills and Holes and Sookholme Brook SSSI.* The area has a high diversity of habitats including wet willow carr and wet grassland (LBAP priority habitat) and dry grassland. The site contains two Sites of Importance for Nature Conservation (SINCs) - the millpond and island to the east and a small crack willow woodland in the west. These are linked by the River Meden that flows from west to east through an area of amenity grassland. This stretch of the River Meden supports water voles and a low population occurs in the millpond SINC. Bird species including goosander *Mergus merganser* and osprey *Pandion haliaetus* have been recorded on the site.

The Bottoms LNR

4.2.12 The River Meden meanders through the LNR flanked by low-lying wetlands either side of the river. The area regularly floods during the winter months providing habitat for a host of bird species. The site contains native wet broadleaved woodland (UKBAP and LBAP priority habitat) and supports a small population of water voles even though the predatory American mink *Mustela vison* have occasionally been recorded on site. The extensive wetlands on site support newts and grass snakes as well as bird species including little grebe, grey heron, teal *Anas crecca*, water rail *Rallus aquaticus*, kingfisher, marsh tit, willow tit and over wintering waders.

Site of Importance for Nature Conservation

4.2.13 There are numerous SINC's along the River Maun corridor primarily with a botanical interest; this includes various grasslands, wet woodland and deciduous woodland.

Other

Rainworth Lakes SSSI

4.2.14 Rainworth Lakes lies partially within the Mansfied District. It is a site of importance for its examples of base-poor marsh and open water plant communities. These habitats are associated with a series of ponds and small lakes lying along streams. Additional interest is provided by areas of scrub and wet and dry broadleaved woodlands, which provide habitat for a variety of breeding bird species.

Rainworth Water LNR

4.2.15 Rainworth Water lies east of Mansfield District. Once part of Rufford Colliery, the site is a unique landscape created as colliery spoil was piled steeply around the watercourse forming a giant bowl. Large areas of planted broadleaved and mixed woodland occur on site along with valuable wetland habitat consisting of pools, shallows and meanders with adjacent marshy areas. Dragonflies, damselflies and bird species occur on site.

Site of Importance for Nature Conservation

4.2.16 Rainworth Lakes are considered to be fine base-poor marshes and open-water plants. The country park along Foul Evil Brook is host to several SINC's, including acidic flora, dry acid heathland, and a good butterfly habitat.

4.3 Protected Species

4.3.1 Protected species, in particular records of otters, water voles, white-clawed crayfish and birds associated with the watercourses and wetlands within Mansfield District as identified in the desk study are described below by species. Protected species records were obtained from Nottinghamshire Wildlife Trust, Nottinghamshire Biological and Geological Record Centre and the Environment Agency and are shown in Appendix I.

European otter

4.3.2 No records of otters were obtained for the study area. Otters are believed to have disappeared from the County of Nottinghamshire in the 1970s, although their return is being encouraged by the restoration of suitable habitat.

White-clawed crayfish

4.3.3 Nine records of white-clawed crayfish at Caudwell Brook and Caudwell Dam were identified for Mansfield District. The white-clawed crayfish, once widespread in Britain, has been in decline since the 1980s. Populations have been reduced by crayfish plague, habitat modification, predation, disease and competition from introduced North American signal crayfish. The white-clawed crayfish is protected under Schedule 5 of the Wildlife and Countryside Act (1981), and is a UK Biodiversity Action Plan Priority Species and a Priority species in the Nottinghamshire Biodiversity Action Plan.

4.3.4 The freshwater white-clawed crayfish is the UK's only native crayfish species. It grows up to 12cm in length and is native to a variety of freshwater habitats in England. The crayfish favours clear, relatively hard oxygenated water found in small streams, brooks, rivers and lakes. They can be found hiding in the crevices between rocks and under the tree roots along riverbanks.

4.3.5 Loss of appropriate habitat through canalisation and sedimentation of waterways have affected the white-clawed crayfish. A general decline in water quality, including the introduction of chemical pollutants and sewage, has also had a damaging effect on the crayfish. Where crayfish occur in a watercourse, they are not uniformly spread along the channel. The population can be highly localised, occupying only favourable sections of a river. The crayfish may also be localised within a channel cross-section. For example, the animals may be found mainly in the margins and may be sparse or even absent in the mid-channel. Table 1 below summarises crayfish habitat preferences.

Table 4.1: Crayfish habitat preferences

Crayfish preferences	*Crayfish tend to avoid*
Slow-flowing sections of stony rivers	Uniform clay channels
Boulder riffles in chalk or clay streams	Areas of deep or soft silt
Submerged tree roots	Dense filamentous algae
Debris dams	Narrow fast-flowing channels
Crevices in old or damaged submerged brickwork, stonework, cracked concrete or rotten wooden structures	Areas of sand and gravel, or bedrock, which are lacking in cobble or boulder (though they may feed or walk through these areas)
Un-mortared stone revetment which protects banks form erosion	Pebble or cobble shingle regularly exposed by changing river levels
Stands of submerged and emergent aquatic plants	Areas of armoured bed, where the substrate is compacted by the river flow
Old gravel workings and chalk pits	Acidic streams or ochreous drainage
Good water quality	Poor water quality or salinity

Peay (2000)

4.3.6 White-clawed crayfish eat a wide range of food including fallen leaves, aquatic vegetation, dead fish, aquatic invertebrates including snails and caddis-fly larvae, and other crayfish. They have a wide range of predators; juveniles are eaten by fish, birds and invertebrates whilst adults are taken by large predators such as heron, mink and otters. To avoid predation crayfish hide in refuges by day and are active at night.

Water voles

4.3.7 Fifty-four records of water voles were identified for Mansfield District on the River Maun, Caudwell Brook, Vicar Water and the River Meden. The water vole receives legal protection through its inclusion of Schedule 5 of the Wildlife and Countryside Act 1981 (as amended April 2008). The water vole has received this protection in recognition of the significant decline that the species has undergone in recent decades. The water vole is a UK Biodiversity Action Plan Priority Species and a Priority species in the Nottinghamshire Biodiversity Action Plan.

4.3.8 Water voles are herbivores, primarily feeding on the leaves and stems of a wide variety of waterside plants. Over winter the roots and bark of woody species such as willow or sallow are eaten, together with rhizome, bulbs and roots of herbaceous species. Each vole utilises a series of burrows comprising many entrances, inter-connecting tunnels, food storage, nest chambers and bolt holes. Occasionally the animal will weave a nest into the bases of sedges and reeds as a large ball of vegetation. Above ground, the water vole's activity is largely confined to runs in dense vegetation within 2-5m of the water's edge. Water voles exhibit strong habitat preferences for sites with grass tussocks and emergent plants while avoiding sites heavily grazed, trampled or over-shaded by dense scrub.

Birds

4.3.9 Although no specific records were received from consultees, citations for the sites and habitats described above contained observations on a significant number of bird species associated with watercourses and wetlands within the district. Of the bird species identified, the kingfisher *Alcedo atthis* is probably the most notable resident species and the most closely associated with watercourses. Kingfishers live around streams, slow-flowing rivers, ponds and lakes and feed on aquatic insects and small fish such as sticklebacks. They hunt from riverside perches, occasionally hovering above the water's surface and make burrows in sandy riverbanks. The burrow consists of a horizontal tunnel with a nesting chamber at the end and usually is about a metre long. Kingfishers are a vulnerable species to hard winters and habitat degradation through pollution or unsympathetic management of watercourses. Kingfishers are listed on Schedule 1 of the EC Directive on the Conservation of Wild Birds and Schedule 1 of the Wildlife and Countryside Act 1981 (as amended).

4.3.10 Other significant resident bird species associated with watercourses and wetlands within the district include reed bunting *Emberiza scoeniclus* and willow tit *Parus montanus*, both UK BAP Priority Species.

4.3.11 A discussion of the ecological benefits of restoring culverts to open watercourses will therefore focus on benefits to the sites and habitats described above, to water voles, white-clawed crayfish and bird species, in particular kingfisher.

4.4 Fish Stocks

4.4.1 The River Maun and Meden have an abundance of fish stocks. Table 4.2 gives a summary of the fish stocks within the Mansfield district as surveyed between July 2003 and June 2007. In addition to supporting piscivorous species, the maintenance of a good water habitat which will support the fish stocks is considered important to local anglers, with fishing being a popular recreational activity within the district. The maintenance of good water quality and dry season flows is important to support an appropriate habitat for fish.

Table 4.2: Fish Stocks

	Church Warsop		**Houghton**		**Meden Vale**		**Cavendish Bridge**		**Whitewater Bridge**		**Total**	
	Meden		**Maun**		**Meden**		**Maun**		**Maun**			
	08/07/2003		22/06/2006		12/06/2007		17/07/2003		07/06/2007			
	SK57336, 68771		SK68078, 72839		SK58321, 69626		SK58648, 64876		SK66468, 70574			
	SK57405, 68840		SK68199, 72859		SK58342, 69724		SK58737, 64911		SK66453, 70645			
	Count	%	Count	%	Count	%	Count	%	Count	%	**Count**	**%**
	18	38%			2	7%					**20**	**2%**
			19	17%	4	14%			21	28%	**44**	**5%**
	3	6%	1	1%	12	43%			6	8%	**22**	**3%**
	2	4%	34	31%	1	4%	4	100%	5	7%	**46**	**5%**
	7	15%			2	7%			17	23%	**26**	**3%**
			1	1%					1	1%	**2**	**<1%**
	17	36%	56	50%	7	25%			25	33%	**105**	**13%**
Total	**47**		**111**		**28**		**4**		**75**		**265**	

4.5 Restoration of open watercourses

Biodiversity benefits

4.5.1 The two main ways in which the restoration of culverts to open watercourses could benefit biodiversity are through the linking of fragmented populations and increased riparian habitat.

Linking of fragmented populations

4.5.2 The restoration of watercourses could be used to provide linkage between fragmented and isolated populations. This is particularly applicable to water voles since long lengths of culvert may act as an impermeable barrier to the voles.

4.5.3 There is little available information relating to the length and design of culverts which act as barriers to water voles movement. However, relatively short culverts, under single carriageway roads for example, are known to be regularly used by water voles. Culvert design which includes a ledge linking the banks of the watercourse on either side of the structure and culverts which are large and box-shaped in cross section are also thought to be beneficial in facilitating the movement of water voles, as well as other species such as otters.

4.5.4 Culverts do not appear to provide a major problem to the movements and dispersal of water voles. However the following basic principles have been considered in the assessment of culvert use by water voles to inform Section 4.5.

4.5.5 The more headroom above the water and the more light entering the culvert the better to encourage the through movement of water voles. Box culverts are therefore preferable to small pipe culverts and do not suffer from a diminishing airspace as the watercourse floods;

4.5.6 Ledges within the culvert may be useful as these allow the upstream movement of animals at times of high flow (provided they are not submerged);

4.5.7 Diameter of culverts may be an important consideration- the greater the diameter the more likely water voles will pass through the culvert;

4.5.8 Length of culverts may restrict water voles in their daily movements and/or dispersal. For example, an 18m culvert under a standard B-road carriageway is unlikely to prohibit the connectivity of habitats for water voles given that the typical home range for a water vole is about 50m linear length.

4.5.9 There is little available information relating to the length and design of culverts which act as barriers to white-clawed crayfish movement. White-clawed crayfish have occasionally been recorded in culverts and it is likely they will use them as daytime shelter. However in a study of signal crayfish movements in America (Light, 2003), culverts acted as barriers to crayfish passage and the crayfish did not occur in sites of optimum habitat upstream of culverts.

4.5.10 Culverts can also potentially affect fish passage. Culverts with steps or very smooth surfaces may restrict fish passage under normal flow conditions. The restriction of fish movement will also indirectly adversely affect piscivorous species (species which feed mainly on fish) including otters and kingfishers.

Increased riparian habitat

4.5.11 Re-instating culverts to open watercourses will inevitably result in an increase in riparian habitat including banks, bankside vegetation, marginal vegetation and aquatic vegetation. This increases habitat available to riparian species such as water voles and kingfisher in the form of additional lengths of banks for burrowing. The increase in vegetation also provides extra food and cover for water voles and could help to ensure healthy fish populations. This will directly benefit fish species and indirectly benefit piscivorous species. Increased riparian habitat will result in increased foraging opportunities for white-clawed crayfish in the form of additional plant matter, fish and invertebrates. The benefits associated with increased riparian habitat due to the reinstatement of open watercourses are only likely to be minor with short culverts but could be significant with longer culverts.

4.6 Prioritisation of culverts for restoration

4.6.1 The evaluated culverts are shown in **Appendix I**. Species and sites of ecological interest in the vicinity of the culvert as identified in the desk study exercise are listed and the benefits of restoring the culvert to open watercourse is classified as low, medium or high potential to benefit biodiversity together with a brief rationale of this classification.

4.6.2 The majority of the culverts within the Mansfield District are situated under essential infrastructure such that there removal is not considered feasible in engineering terms. There are however four particular culverts which may present opportunities for removal in part or along the whole length. The presence of buildings along the route of the culvert has been ignored. These are included in Table 4.3 below.

Table 4.3: Possible Culverts for removal

Culvert ID	Location	Description	Ecological Interest	Potential biodiversity benefits of reinstatement to open watercourse
C5	Cauldwell Brook	Major culvert	Water voles, white-clawed crayfish	**High**: Restoration in whole or part could link water vole populations and increase habitat for white-clawed crayfish
C7	Field Mill Pond Outfall	Spill units linked to rectangular culvert	Water voles, white-clawed crayfish	**Moderate**: Culvert may act as a barrier to water vole and crayfish passage. Not feasible to link to suitable habitat or other populations
C13	Rock Valley	Single culvert varying in shape and dimensions	Minimal	**Moderate**: Minor benefit to diversity. Restoration of natural channel will improve general amenity and quality of environment.
C14	D/S of Rock Valley	2 x rect. culverts into 2 arch culverts	Minimal	**Moderate**: Minor benefit to diversity. Restoration of natural channel will improve general amenity and quality of environment.

Low potential biodiversity benefits

4.6.3 When considering which culverts to reinstate to open watercourse in order to benefit biodiversity, the obvious areas to consider are those north and south of the main urban conurbation of Mansfield. Within the conurbation the structure of the River Maun and its water quality are predominately influenced by urbanisation. From the King's Mill Reservoir to Tichfield Park the river flows in artificial channels. Downstream of Tichfield Park the river flows through a network of culverts, tunnels and artificial channels. No protected species records or designated sites exist within the main conurbation between the Field Mill Pond Outfall and Bath Lane Road. Restoration of watercourses within this much urbanised environment is likely to be impractical and of low biodiversity value.

Moderate potential biodiversity benefits

4.6.4 Culverts **C7, C13 and C14** may present realistic opportunities for restoring natural channel conditions. The impact on diversity may only be minor since the restoration of the channel at these locations will not lead to the linkage of significant habitats. However, the naturalisation of the channel at these locations could potentially lead to the establishment of new habitats and could lead to the enhancement of the urban area through the creation of open space and a significant public amenity.

High potential biodiversity benefits

4.6.5 Culvert **C5** is a major culvert connecting Caudwell Brook and the River Maun which poses a significant barrier to water vole and white-clawed crayfish passage. The culvert runs parallel to a factory fence line with dense scrub and then enters the factory compound. Restoration of the culvert in whole or part could increase the habitat of water voles and white clawed crayfish within Caudwell Brook and provide greater connectivity with the River Maun, potentially linking existing water vole and crayfish populations. There is potential to improve biodiversity at Oakham LNR. The additional benefits described in 4.6.3 will also apply.

Other culverts

4.6.6 Anecdotal evidence of white-clawed crayfish in a disused culvert just north of Tichfield Park has been obtained. The provision of in-channel boulders or other refugia would ensure the loss of the culvert has no adverse effects on the white-clawed crayfish present.

Flood Risk Issues Associated with Culvert Removal

4.6.7 Of the four culverts identified for possible removal, the majority can not be opened along their full length as this is impractical in engineering terms, consequently sections of the culverts will need to remain in place. The Maun hydraulic model includes culverts C7, C13 and C14, at each of these structures the model considers there to be insufficient capacity for high return period flows such that the river may back up causing flooding upstream. At Field Mill Pond, the limited capacity of the culvert results in overtopping of the embankment and overland flooding of the land downstream, between Field Mill Pond and Tichfield Park.

4.6.8 The removal of sections of culverts is likely to reduce the risk of flooding upstream, and with the exception of Field Mill Pond could increase the risk of flooding downstream due to the improved conveyance. The risk of flooding downstream could be mitigated through the incorporation of increased flood storage and carefully designed flow control structures. With this in mind, the restoration of the channel could provide opportunity to mitigate the fluvial flood risk in Mansfield and provide a long term solution for the sustainability of development within these areas.

4.6.9 The grassland between Old Mill Lane and New Mill Lane could be utilised as additional flood alleviation storage to compensate for the removal of culverts upstream on the River Maun. The utilisation of this grassland is unlikely to benefit Mansfield directly, but could prevent an increased risk of flooding to downstream areas as a consequence of culvert removal.

Summary

4.6.10 In order to benefit biodiversity, the reinstatement of open watercourse should include ‘wildlife-friendly’ provisions such as re-profiling of the banks, introduction of aquatic and bankside vegetation, fencing of buffer zones along the watercourse in order to allow the establishment of vegetation and the design and implementation of appropriate habitat management plans.

4.6.11 The possible removal of culverts should carefully consider the potential impacts on flood risk upstream and downstream. However, if appropriately designed, the restoration of natural channel could provide flood mitigation benefits in addition to the biodiversity improvements.

4.7 Low Flows

Background

4.7.1 Low flow areas have been identified within the Mansfield District at Vicar Water, Rainworth Water and Foul Evil Brook, all tributaries of the River Maun. While these tributaries are towards the edge of the study area, the contributing catchment is largely within the Mansfield District and occupies 19% of the total Mansfield District area as shown in Appendix H. The low flow conditions observed in Vicar Water and Rainworth Water have two primary impacts:

- *The biodiversity is threatened through loss of water habitat.*
- *Longstanding surface water abstraction agreements can no longer be sustained through extended dry periods.*
- *Lack of water to dilute pollutants entering the watercourses and damaging the aquatic environment.*

Impact on Biodiversity

Low flows can affect biodiversity through the following means:

Effects on riparian vegetation

4.7.2 Flow reduction can affect the growth of water plants. As well as directly impacting the value of the aquatic flora, it also indirectly affects fauna which use the vegetation for food, cover and breeding purposes such as water voles, white-clawed crayfish, fish, dragonflies, damselflies and newts;

Exposure of riparian fauna

4.7.3 Low flows fully expose aquatic fauna and their habitats. The exposure of water vole burrows makes the voles particularly vulnerable to terrestrial predators such as stoats *Mustela erminea* and weasels *Mustela nivalis*. Low flows also leave crayfish fully exposed to a range of predators including heron and mink;

Siltation and Pollution

4.7.4 Flow reductions can alter siltation and pollution levels. This could affect aquatic flora and fauna and has potential to significantly impact fish species and white-clawed crayfish, which are particularly vulnerable to decline in water quality.

4.7.5 It should be noted that although the restoration of low flows is generally considered beneficial to biodiversity, high water levels and flooding could also be detrimental, particularly to water voles. During periods of high water levels or flood conditions, refuge areas for water voles are essential. Many brooks and streams suffer from wild fluctuations in depth in response to rainfall, especially where rapid run-off occurs as a result of agricultural land drainage improvements and urban development. Suitable refuges for water voles may be present in the form of high banks or backwater pools. Water level management through increased flood storage capacity by way of on-line pools and additional ditch channels may alleviate the worst of the flooding as well as providing flood refuge areas for water voles.

Low Flows in Mansfield

4.7.6 Vicar Water, northeast of the Mansfield conurbation, supports water voles and should therefore be a priority site for the restoration of water levels.

4.7.7 There are two statutory designated sites on Rainworth Water on the south-eastern boundary of the District. Restoration of water levels at this location could potentially increase the biodiversity.

4.7.8 ***Restoration of flows to Vicar Water and Rainworth Water is considered to present a significant opportunity to enhance the biodiversity at these locations.*** To maximise the environmental benefit of the restored flows sensitive engineering to re-profile banks, remove excess silt and clear excessive scrub from the dry bed should be included. This will encourage the recovery of aquatic vegetation and maintenance of water depth. It is critical that the restoration of low flows be managed in a fashion that does not lead to rapid fluctuations in water depth.

Sustainable Practices

4.7.9 The Catchment Abstraction Management Scheme, CAMS (March 2007), for the Mansfield area identifies that both the Lower Magnesian Limestone and Sherwood Sandstone are considered to be over abstracted i.e. the potential for groundwater may be depleted over time by pumping of groundwater. In particular, there are a number of surface water and groundwater abstractions within the Sherwood Sandstone. These abstractions are considered to have a direct impact on the low flow conditions observed in Rainworth Water and Vicar Water. While the Environment Agency will not award any further abstractions in this area, those abstractions in place will continue to be honoured. It is therefore crucial that replenishment of the groundwater and surface water resources take place in order to prevent continued degradation of the low flow areas and ultimately to restore natural flow conditions. It is strongly advised that sustainable drainage practices be adopted throughout the Mansfield District, the recommended sustainable drainage practices are as follows:

- *Prioritise the use of soakaways throughout the district and especially in areas over the Sherwood Sandstone.*
- *Minimise surface water discharge into combined sewers which drain surface water away from its natural catchment.*
- *Maximise opportunities for contolled discharge into Vicar Water, Rainworth Water and Foul Evil Brook.*

The application of these proposals is discussed further in Section 4.8.

4.8 Sustainable Drainage Systems

Introduction

4.8.1 In accordance with the holistic approach of this strategic assessment, the application of sustainable drainage systems is considered for both the sustainable management of surface water and the biodiversity benefits. The CIRIA guide, C697 – The SUDS manual, provides extensive advice on the best practice in the design of Sustainable Drainage Systems. The recommendations made in this section should be considered in conjunction with this practice guide.

Biodiversity Benefits of SUDS

4.8.2 The implications of Sustainable Urban Drainage Systems for wildlife have not been extensively studied. However since SUDS offer a network of diverse and contiguous habitats and corridors, in many cases connecting to existing habitats, there is great potential for the systems to benefit wildlife.

4.8.3 Potential benefits for sites and species of biodiversity value including water voles, white-clawed crayfish, bird species, newts (in particular great crested newts) and invertebrates might include:

- *Extension of existing habitat;*
- *Creation of feeding habitat;*
- *Creation of breeding habitat;*
- *Creation of linkages and suitable corridors between existing fragmented habitat;*
- *Protection of enhancement of water quality.*

4.8.4 The table below summarises potential wildlife habitats within a Sustainable Urban Drainage System.

Table 4.4 – Biodiversity Benefits of different SUDS systems

SUDS feature	Description	Habitat	Ecological significance
Sub-surface attenuation	Sub-surface storage with controlled discharge	None	Low
Retention Pond	Storage facility with permanent water	Pond/Small lake	Wide range of wildlife habitats
Wetland	Retention basin with significant numbers of water-purifying plants	Marsh/bog/reed	Wide range of wildlife habitats, improved water quality
Soakaway	Trench or pit filled with a large void ratio allowing water storage and infiltration	None	Low
Infiltration Basin	Similar to a pond but all stored water infiltrates into the underlying soil	Seasonally wet grassland/wet woodland/carr	Valuable wildlife habitat
Grassed Swale	Shallow, flat grassed ditch allowing storage and infiltration	Ditch with grassland	Valuable wildlife habitat and corridor

Priority areas for Green SUDS

4.8.5 Green SUDS is considered here to be systems which have a notable ecological benefit through the creation of wildlife habitats. This therefore excludes sub-surface systems such as soakaways and storage tanks which have a low ecological significance.

4.8.6 Priority areas for SUDS within Mansfield District should include areas adjacent to Caudwell Brook since the habitats described above are likely to be of significant value to white-clawed crayfish and the systems could help to protect or enhance the quality of run-off entering the brook which is essential for the survival of the crayfish population.

4.8.7 Other priority areas in which SUDS should be considered are areas in which the associated habitats might provide a link between existing fragmented water vole populations, in particular along the following stretches of watercourse:

- *Stretch of the River Maun between Kings Mill Reservoir and Caudwell Brook*
- *Stretch of the River Maun within Maun Valley LNR*
- *Stretch of the River Meden between Hills and Holes and Sookholme Brook SSSI and The Carrs LNR*

Soakaways

4.8.8 The underlying hydrogeological conditions of the district are likely to favour the use of soakaways. Localised areas, such as where glacial till is present, are unlikely to favour the use of soakaways. Such soakaways should only be used in consultation with the EA. Local restrictions on the use of soakaways may be advised by the EA to ensure the protection of the quality of groundwater resources. Where source protection zones are present the EA are likely to restrict/object to the use of soakaways. The EA's Policy and Practice for the Protection of Groundwater details the relevant policies and likely restrictions which may be placed. In addition where developments are proposed on brownfield sites a contamination assessment should be undertaken in the areas where soakaways are to be located to ensure that any contamination present would not be mobilised into the underlying aquifer and hence potentially cause deterioration in groundwater quality.

Source Protection Zones

4.8.9 Environment Agency mapping indicates that the entire eastern section of the district, which is underlain by the Sherwood Sandstone Group, is designated as Zone 3 (Total Catchment) of a source protection zone. Three Zone 1 (inner protection zone) areas are identified within the district boundary; all are located along the A617 between Mansfield and Rainworth. The western most is located close to the centre of Mansfield centred at national grid reference SK541 608, another is located approximately 3 km southeast of this at SK566 594 and the final is located in Rainworth at SK588 588. Each of these is surrounded by a Zone 2 (Outer protection zone) of up to 2 km in area. These areas are identified in **Appendix J.**

4.8.10 Two Zone 2 source protection areas are present where the abstraction is located outside of the district boundary. An area of Zone 2 protection zone is present to the extreme east of the district to the south of Clipstone, this is less than 1 km in area. The second which is much larger in area, approximately 10 km, is present to the northeast of the district and includes part of Market Warsop and Meden Vale.

4.8.11 According to the Policy and Practice for the Protection of Groundwater the Environment Agency is unlikely to permit the discharge of potentially polluting effluent within or outside of source protection zone 1. The document does however indicate that other than inside of SPZ 1, the Environment Agency will support the use of sustainable drainage systems for new discharges provided that an appropriate level of risk assessment demonstrates the groundwater conditions to be suitable. In addition, there should be adequate protective measures for groundwater and arrangements for effective management and maintenance of the system. The relevant guidance documents including Groundwater Protection: Policy and Practice (2007) and The Water Framework Directive (2000) should be consulted on a site specific basis.

4.8.12 The incorporation of soakaways should be prioritised for all new development in accordance with recommendations made by the Environment Agency. Soakaways may not be suitable where sites are:

- *Contaminated*
- *Situated on low permeability soils*
- *Located within Flood Zone 3*
- *Within Groundwater Protection Zone 1*
- *Proximate to Low flow areas*

Appendix J and Appendix D should be used to help identify the above restrictions.

Surface Water Attenuation

4.8.13 In accordance with SUDS principles, surface water run-off should be controlled at source. The general approach in accordance with PPS 25 and the EA standing advice is to manage surface water in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development, while reducing the flood risk to the site itself and elsewhere, taking climate change into account. This should be demonstrated as part of the site specific flood risk assessment.

4.8.14 A slight relaxation of this approach is recommended for areas adjacent to the low flow areas. Where sites are sufficiently close to Vicar Water and Rainworth Water, discharge could be permitted up to the peak run-off rate from the existing site during a 2-year return period rainfall event. The maintenance of existing run-off rates is not necessarily required at these locations. Surface run-off from events in excess of the 2-year event should be controlled as described above to prevent the risk of fluvial flooding during severe rainfall events. Where direct discharge into Vicar and Rainworth Water is possible, the use of soakaways should be discouraged, in order to maximise the volume of water discharging into these streams, albeit at controlled rates.

4.9 Summary of Biodiversity Enhancement Strategy

4.9.1 The conservation of biodiversity of catchments within the Mansfield District should protect habitats and species where they have been found to occur and encourage them to expand into suitable adjacent habitat. Much of the former wet margins, backwater ditches and water meadows have already been lost throughout the catchments. The restoration of large swathes of bankside vegetation and the creation of additional wetland habitats including pools, ponds and interconnecting ditches, within and adjacent to existing populations are key to the protection and enhancement of biodiversity within the District. The widespread use of soakaways should be encouraged to replenish the groundwater and the incorporation of other Sustainable Drainage Systems should be promoted as ecological habitats, improved amenity and as good flood risk management practice.

4.9.2 Floodplains which have lost wetland habitats are less able to adapt to fluvial flooding; where they do exist the wetland habitat will act as natural Green SUDS and therefore provide an important link between biodiversity and flood risk management.

4.9.3 Consideration should be given to the removal in part or whole of culverts which may present a barrier to the expansion of biodiversity within the Mansfield District. As well as providing an ecological benefit, the creation of naturalised watercourses provides improved amenity and could help alleviate flood risk in key urban areas.

5 APPLICATION OF THE MANSFIELD SFRA

5.1.1 Full details on the implementation of the Mansfield Strategic Flood Risk Assessment and Biodiversity Enhancement Strategy are provided in the Guide for Planners and Developers which accompanies this technical report.

6 CONCLUSIONS

6.1.1 The Strategic Flood Risk Assessment is a co-ordinated response to the flood risk and biodiversity concerns within the Mansfield District. The technical information gathered through this assessment informs the accompanying Non-Technical Guide for Planners and Developers which accompanies this report. This accompanying document provides guidance to help steer development away from areas of high risk in accordance with the Sequential Test in PPS 25. Key opportunities to enhance the biodiversity are highlighted through the Biodiversity Enhancement Strategy. Sustainable drainage systems (SUDS) are proposed to suit the local environment and to assist with the overall water management strategy.

6.1.2 In general the Mansfield District is considered to be at low risk of flooding. There are however specific locations where flooding is a concern and should be addressed through appropriate LDF allocations and good water management practices. In addition to the fluvial flood risks, there have been historic incidents of flooding from surface run-off which remain unresolved.

6.1.3 The River Maun Flood Mapping Study completed in March 2007 is considered to incorporate a conservative modelling approach. While this approach may overestimate the extent of flooding for a given return period, it does nonetheless identify bands of risk which should inform the Sequential Test. It is therefore considered that the mapping study does not materially affect the overall conclusions about flood risk.

6.1.4 The current Low Flow conditions observed in Vicar Water, Foul Evil Brook and Rainworth Water could be alleviated through appropriate implementation of SUDS. Soakaways should also become a mandatory planning requirement where ground conditions permit, in accordance with the proposed SUDS code of practice. The widespread application of SUDS will help to cap and even reduce the risk of flooding from sewers and surface run-off.

6.1.5 All proposed LDF allocations should be reviewed in accordance with the SFRA. It is considered that there is sufficient land available in areas of low risk to prevent the need for extensive development within Flood Zones 2 or 3. The generally steep sides of the river channel and associated floodplain means that in many areas, land adjacent to the rivers may be considered to be at a low risk of fluvial flooding.

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