Gloucestershire County Council

Strategic Flood Risk Assessment

Level 1

Executive Summary

September 2008

Halcrow Group Limited

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Level 1
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This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1	0	Executive Summary – Draft	12/06/08	RD
2	0	Executive Summary – Final	23/09/08	RD

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1 Executive Summary

1.1 Background

In December 2007 Gloucestershire County Council, in partnership with its Local Authorities, commissioned Halcrow to produce a Level 1 Strategic Flood Risk Assessment (SFRA).

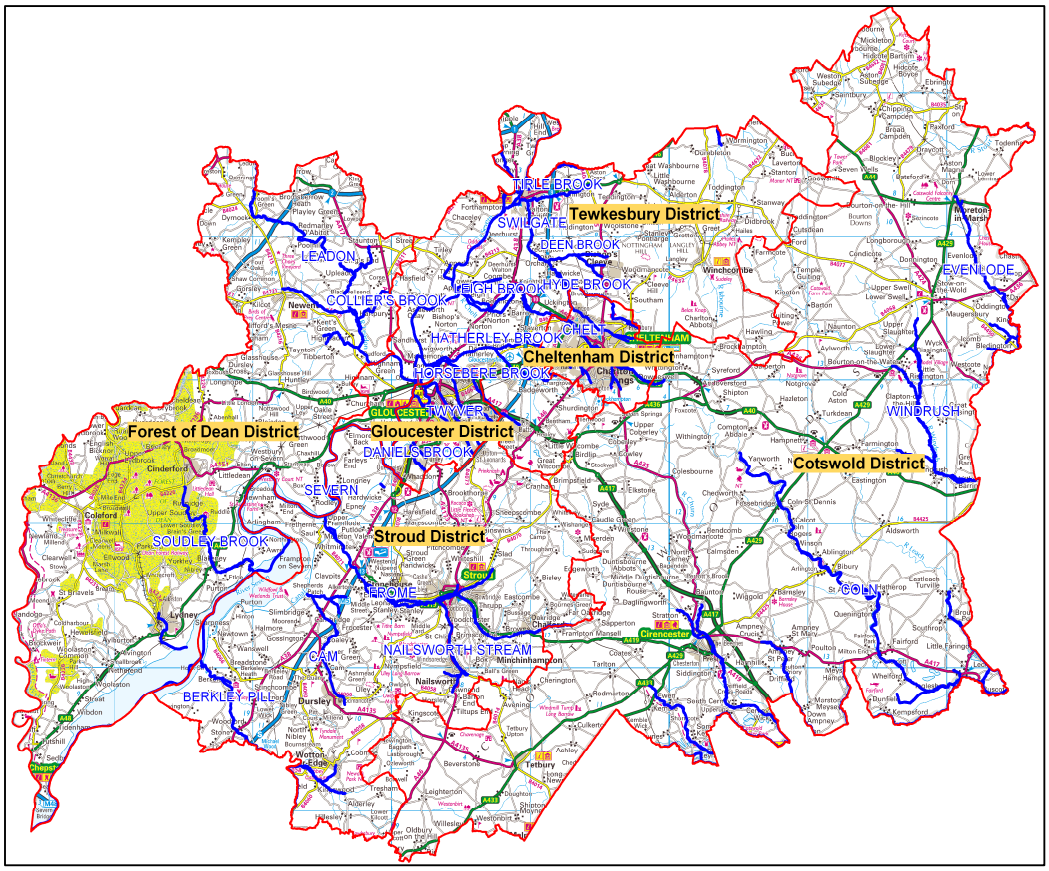

Figure 1: Gloucestershire SFRA Study Area

The SFRA has been prepared to support the application of the Sequential Test (by the Councils) outlined in Planning Policy Statement 25: Development and Flood Risk (PPS25), and to provide information and advice in relation to land allocations and development control.

The SFRA has assessed all forms of flood risk: fluvial (rivers), tidal (sea), surface water, groundwater, sewers and impounded water bodies (reservoirs and canals), both now and in the future given the likely impacts of climate change.

The SFRA includes maps of the flood risks. The strategic flood risk information is also presented as GIS layers, and can be interrogated to gain the associated descriptive information.

1.2 Purpose of the SFRA

The purpose of the SFRA is to:

- Inform the sustainability appraisals so that flood risk is taken into account when considering options in the preparation of strategic land use policies
- Propose appropriate policy recommendations for the management of flood risk within the Local Development Documents (LDDs)
- Determine the acceptability of flood risk in relation to emergency planning capability
- Identify the level of detail required for future site-specific Flood Risk Assessments (FRAs) that support planning applications

The SFRA output is relevant not only to planning and development control, but also site specific FRAs and mapping for emergency planning, alleviation of flood risk within existing development and Surface Water Management Plans.

1.3 Structure of the SFRA

An SFRA document and accompanying set of maps has been produced for each Gloucestershire local authority (Forest of Dean District Council, Tewkesbury Borough Council, Gloucester City Council, Cheltenham Borough Council, Cotswold District Council and Stroud District Council).

For each local authority, the SFRA comprises two separate volumes:

- **Volume 1** contains the technical SFRA report and accompanying executive summary document
- **Volume 2** contains a series of maps

In addition, an SFRA document has been produced for Gloucestershire County Council. This provides the County Council with the necessary information on the application of the SFRA to minerals and waste site allocations, to support the County Council's Minerals and Waste Development Framework (MWDF).

The SFRA is a 'living' document, to be updated as new data becomes available.

1.3.1 Key Sources of Flood Risk Data

The main approach adopted for the SFRA has been to build on previous studies and existing flood risk information. It has therefore been critical to make best use of the significant amount of information which already exists and is held by the various bodies involved in the management of flood risk. Consultation has formed a key part of the data gathering stage of the SFRA. Stakeholders including Gloucestershire County Council and its Local Authorities (which has included information from the public), the Environment Agency, water companies (Severn Trent Water, Thames Water, Wessex Water, and Welsh Water), the Highways Agency, Internal Drainage Boards and British Waterways were consulted so that flood risk data could be gathered. The benefits of adopting a partnering approach (as advocated by PPS25) are significant and have

helped to ensure that the findings and recommendations of the SFRA cover flooding from all sources and are relevant, detailed and robust.

The data gathering process has resulted in a review of:

- Strategically important documents including the Regional Flood Risk Appraisal, the Pitt Report and Making Space for Water
- Historical flooding information from Environment Agency historic fluvial flood outlines and various datasets from water companies, the Councils, the Highways Agency and British Waterways, detailing flooding experienced from 'other sources'
- Environment Agency Flood Zone maps and detailed flood risk mapping outputs, including fluvial climate change outputs
- Information on flood risk management infrastructure, including defences and culverts (supported by information from the Councils and the Environment Agency's National Flood and Coastal Defence (NFCDD) database)
- Existing flood risk management reports including Catchment Flood Management Plans (CFMPs)
- Environment Agency flood warning and flood watch information

1.4 Planning Policy Statement 25: Development and Flood Risk (PPS25)

PPS25 on development and flood risk, published as part of the Governments' making space for water strategy, seeks to provide clear and robust guidance to ensure that current and future flood risk is taken into account at all levels of the planning system.

PPS25 recognises that, although flooding cannot be wholly prevented, its impacts can be avoided and reduced through good planning and management. Flood risk is required to be taken into account at all stages in the planning process to avoid inappropriate development in areas of flood risk and to direct development away from areas of highest risk. This is referred to by PPS25 as the sequential approach. The Sequential Test refers to the application of the sequential approach by a local authority.

1.4.1 The Sequential Test

A key aim of a Level 1 SFRA is provide the necessary information to allow each local authority to guide development towards the area of lowest flood risk using the Sequential Test. This is a process whereby preference is given to locating a new development in Flood Zone 1.

If there is no reasonably available site in Flood Zone 1, the flood vulnerability (see table D3 of PPS25, overleaf) of the proposed development can be taken into account in locating development in Flood Zone 2 (Medium Probability) and then Flood Zone 3 (High Probability).

Table 1: Flood Risk Vulnerability and Flood Zone 'Compatibility' (Table D3 of PPS25)

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test required	✔	✔
	Zone 3a	Exception Test required	✔	✗	Exception Test required	✔
	Zone 3b 'Functional Floodplain'	Exception Test required	✔	✗	✗	✗

Key:

✔ Development is appropriate

✗ Development should not be permitted

Within each Flood Zone:

- New development should be directed away from 'other sources' of flood risk and towards the area of lowest probability of flooding, as indicated by the SFRA maps.
- The flood vulnerability of the development should be matched to the flood risk of the site, e.g. higher vulnerability uses should be located on parts of the site at lowest probability of flooding.

The Sequential Test demonstrates whether there are any reasonably available sites, in areas with a lower probability of flooding, that would be appropriate to the type of development or land use proposed. PPS25 and indeed the SFRA summarises the appropriate uses of each zone, as well as FRA requirements and policy aims for each.

Where it is not possible, or consistent with wider sustainability objectives, for development to be located in Flood Zones of lower probability of flooding, the Exception Test can be applied (in accordance with Table D3 of PPS25). The Exception Test is only appropriate for use when there are large areas in Flood Zones 2 and 3, where the Sequential Test alone cannot deliver acceptable sites, but where some continuing development is necessary for wider sustainable development reasons (the need to avoid social or economic blight and the need for essential civil infrastructure to remain operational during floods). It may also be appropriate to use it where restrictive national designations such as landscape, heritage and nature conservation designations, e.g. Areas of Outstanding Natural Beauty (AONBs), Sites of Special Scientific Interest (SSSIs) and World Heritage Sites (WHS), prevent the availability of unconstrained sites in lower risk areas.

The Exception Test must only been attempted once the Sequential Test has been carried out.

1.4.2 Level 2 SFRAs

A Level 2 SFRA involves a more detailed review of flood hazard (flood probability, flood depth, flood velocity, rate of onset of flooding) taking into account the presence of flood risk management measures such as flood defences. It may also be required to give a more detailed assessment of flooding from 'other sources' in development areas.

1.5 Planning Policy

Flood related planning policy at national and regional levels is detailed in the main reports (Volume 1). This highlights that flood risk is taken into account at every hierarchical level within the planning process. A series of policy recommendations are made, and information contained in the SFRA provides evidence to facilitate the preparation of robust policies for flood risk management (see Section 1.9 of this document for further details).

1.6 Key Findings of the SFRA

The SFRA has assessed all sources of flooding using the information supplied by the consultees mentioned in Section 1.3.1. This section provides a summary of the flood risk issues within the County of Gloucestershire.

The various sources of the data used in this assessment and the relative confidence in these datasets are detailed in the main reports (Volume 1). SFRA flood maps are presented in Volume 2.

1.6.1 Fluvial and Tidal Flood Risk

The Flood Zones used in the SFRA have been derived from a mixture of the Environment Agency Flood Map and detailed modelled information. This encompasses the best available flood risk information at this time. The Flood Zone maps presented in the SFRA show the undefended situation, i.e. the risk posed if all defences did not exist. Undefended maps should be used to carry out the Sequential Test.

The Flood Zone maps show:

- **Flood Zone 1:** This zone comprises land assessed as having less than a 1 in 1000 annual probability of river or sea flooding in any year (<0.1%). While the risk of fluvial flooding is not a concern, flooding from other sources including surface water, groundwater, sewers and impounded water bodies (reservoirs and canals) may still present themselves.
- **Flood Zone 2:** This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year. Flooding from other sources can also occur.
- **Flood Zone 3a:** This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. Flooding from other sources can also occur.
- **Flood Zone 3b** (Functional Floodplain): This zone comprises land where water has to flow or be stored in times of flood (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, including water

conveyance routes). Wherever possible, the SFRA uses modelled information to represent Flood Zone 3b (either by using the 5% (1 in 20 year) annual probability event or a suitable proxy, such as the 4% (1 in 25 year) annual probability event). Where approved modelling of the 5% flood extent has not been undertaken, a conservative approach has been applied in defining the functional floodplain as being to equivalent to land assessed as having a 1% (1 in 100 year) or greater annual probability of river flooding.

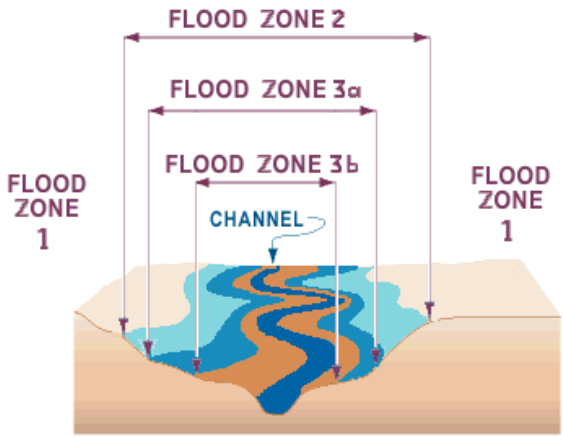

Figure 2: Flood Zones

It should be noted that not all minor watercourses have had Flood Zone maps produced for them (only watercourses with a catchment area greater than 3km² have been modelled by the Environment Agency and, therefore, smaller watercourses as identified on OS maps within Flood Zone 1 may not have Flood Zone information). Any development site located around or adjacent to an unmapped watercourse within Flood Zone 1 should have an 8m development easement from the top of bank applied and a site specific FRA undertaken.

The following summarises the nature of fluvial and tidal flood risk within each Gloucestershire local authority:

Forest of Dean District: Fluvial Flood Risk

- The Forest of Dean District occupies an area of varied topology and geology. Gently sloping lower lying areas near the Severn Estuary are contrasted with steep hills in the West of the District. Catchments can be categorised as large upstream catchments forming large watercourses (the Severn and Wye) and small catchments originating within the general vicinity of the District. All the rivers in the District eventually drain into the Severn Estuary. Within the Lower Severn Valley, flooding can occur from a combination of both tidal and fluvial processes.

- In general, Flood Zone maps in the upper reaches are narrow, confined by steep sided valleys, where catchments can respond quickly to rainfall, increasing the risk of flash flooding. As the watercourses flow towards the coastal floodplains of the River Severn, the Flood Zone maps widen significantly, and extend onto vast areas of flat, coastal floodplain.

- In the lower lying parts of the District the risk of the Severn coming out of bank and flooding some areas during periods of high flows has been substantially mitigated by the presence of defences along the estuary. The remaining small catchments also pose flood risk, depending on the characteristics of any localised storms. The Environment Agency's Flood Zone maps indicate that areas of flood risk from the smaller catchments are small and dispersed, including Parkend, Whitecroft, Drybrook, Cinderford and Newent.

- Tide locking can occur on many watercourses within the District. The main urban area at risk from tide locking within the Forest of Dean District is Lydney, with tide locking also extensive on the Cinderford Streams.

- Tidal Flood Zone maps for the River Severn extend for large distances into the District incorporating a number of properties at locations including: Walmore Common, Rodley, Westbury on Severn, Newnham and Lydney.

Tewkesbury Borough: Fluvial Flood Risk

- The Tewkesbury Borough occupies a low-lying area of the Lower Severn catchment where gentle topography dominates. Nearly all the Borough area drains into the River Severn, with the exception of small portions of the Windrush and Coln catchments in the far east of the Borough which ultimately drain into the River Thames.

- Within the Lower Severn Valley, flooding can occur from a combination of both tidal and fluvial processes. Many of the Main Rivers within the District discharge into the River Severn estuary and as such can be affected to some extent by the tide. However, the predominant flood risk within the Borough is from fluvial flooding. Tidal flooding along the Severn Estuary can lead to flooding to parts of the southern extent of the District by Minsterworth.

- The Rivers Severn and Avon pose the greatest flood risk within the Borough. Where the two watercourses meet at Tewkesbury the topography is flat and the underlying bedrock largely impermeable; as such there is a substantial risk of these rivers coming out of bank and flooding local areas during periods of high flows.

- Smaller catchments within the Borough also pose a flood risk especially in the event of ill-timed localised storms. Flood Zone maps indicate how the risk of flooding along the smaller watercourses is greatest near their confluence with the Severn (or Avon) due to high water levels in these two rivers causing their tributaries to 'back up'. This results in the small residential area of Longford falling within Flood Zone 3 and significant areas of the town of Tewkesbury, which lies on something of a conglomeration of rivers including the Severn and Avon, falling within Flood Zone 2.

Gloucester City Council: Fluvial Flood Risk

- Gloucester City Council is drained entirely by the River Severn, which has both tidal and fluvial influences in the area.

- Flood Zone maps for the River Severn extend for large distances into the Council area incorporating a number of properties. The flood risk to Gloucester is predominantly fluvial as the River Severn channel becomes narrower, providing a restriction to high tides moving

upstream and river flows moving downstream. However, flooding can be a result of a combination of both tidal and fluvial influences.

- The majority of flood risk in the area appears to arise from the smaller catchments. While the Severn is capable of coming out of bank and flooding a large area, flood risk is reduced by the presence of defences. Nevertheless, the Severn may contribute to flooding as the effects of high flows in the smaller streams may be worsened by the elevated levels in the Severn, making it difficult for them to discharge. The main areas at risk are on the Sud Brook around the Tredworth and Linden areas and on the Whaddon Brook around the Podsmead area.

Cheltenham Borough Council: Fluvial Flood Risk

- Cheltenham Borough Council occupies a low-lying urban area of the Lower Severn catchment. The rivers contributing to flood risk are small catchments originating within, or in the vicinity of, the Borough. Of particular relevance is the River Chelt which flows through the centre of Cheltenham, regulated by a flood alleviation scheme.

- The high degree of urbanisation coupled with the small size of the catchments and impermeable underlying rock mean that the greatest flood risk in the area is from high-intensity convective storms more common during the summer season.

- Flood risk in the Borough is influenced by surface water and the overloading of the old drainage system, particularly during intense rainfall events.

Cotswold District Council: Fluvial Flood Risk

- Cotswold District Council occupies the western end of the Upper Thames catchment. The majority of the District drains south east toward the River Thames, with only small areas to the west draining toward the Severn. The steep topography can facilitate flash flooding.

- The greatest area at risk of fluvial flooding is in the south of the District near the River Thames and the Cotswold Water Park. Smaller areas, in towns such as Bourton-on-the-Water and Cirencester are also at risk.

- The underlying bedrock of the District is predominantly limestone which is highly permeable and an excellent aquifer. Percolation of precipitation through to the water table is therefore significant and corresponding runoff in limestone catchments can be relatively slow. However, if the groundwater level is already high and soil moisture deficit very low due to previous rainfall events or prolonged wet weather, then limestone catchments have the potential to respond very rapidly to rainfall, which can result in both fluvial and groundwater flooding. The greatest flood risk in the area is therefore during periods of prolonged wet weather more common during winter months.

- The main locations shown to be at risk from flooding from the River Thames and its main tributaries include: Ewen, Somerford Keynes, a caravan park by Ashton Keynes, Kempsford and Lechlade on Thames on the River Thames; Northleach and Baxter's Farm on the River Leach; Andoversford, Bibury, Quenington, Fairford, and Whelford on the River Coln; Ampney Circus on the Ampney Brook; Cirencester, Siddington and South Cerney on the River Coln and Gumstool Brook.

Stroud District Council: Fluvial Flood Risk

- Stroud District Council occupies an area of diverse landscape character ranging from the steeper upland catchments of the Cotswold escarpment to the flat, extensive floodplains of the Lower Severn Estuary. All catchments in the District drain into the River Severn.
- The topography to the west of the Borough is relatively flat. Drainage within this area is relatively complex and slow. The artificial and much modified channels and drainage networks are, at times, tide locked by high water levels in the River Severn, and often spill into the floodplain after prolonged heavy rainfall. The risk of the Severn coming out of bank and flooding areas during periods of high flows has, however, been substantially mitigated by the presence of defences along the estuary.
- While the Flood Zone maps indicate how the probability of flooding is, in general, greatest near to River Severn due to its tributaries 'backing up', (this particularly happens on the River Frome and Little Avon) the greatest flood risk in the District in terms of both the probability and consequences of occurrence lies in the more built-up areas of Dursley and Stroud. In Stroud, the confluence of the River Frome, Painswick Stream and Slad Brook as well as the Nailsworth Stream a little further west, complicated by the interaction of the Stroudwater Canal, pose a significant flood risk in the relatively steep-sided valleys.
- Although the catchments upstream of this region are small and the underlying limestone largely permeable, the topography is such that intense localised storms on already wet catchments could facilitate flash flooding.
- The Lower Severn Internal Drainage Board (IDB) manages water levels using numerous rhynes, pills and control structures on the Little Avon catchment as it approaches the Severn estuary.

1.6.2 Sewer Flood Risk

Sewer flooding occurs when the drainage networks become overwhelmed and maximum capacity is reached. This can occur if there is a blockage in the network, causing waste water to back up behind it, or if the sheer volume of water draining into the system is too great to be handled. Water companies covering cover the study area were contacted to gain information on areas which have been affected by sewer flooding in the past. However, due to the Data Protection Act, it is not possible to specify the exact locations of past incidents. Instead, data has been received at four-digit postcode level. These postcode polygons outline a series of large geographical areas. Within each postcode area is an indication of how many incidents have occurred. Sewer flood risk has then been classified according to the number of properties flooded from overloaded sewers within each postcode area. The categorisation is as follows:

- Low sewer flood risk: 1 to 5 properties
- Medium sewer flood risk: 6 to 15 properties
- High sewer flood risk: >15 properties

The following conclusions have been drawn:

Forest of Dean District Council: Sewer Flood Risk

- In general the level of flood risk from artificial drainage systems within the District is medium to low.
- The main area known to suffer from sewer flooding is Coleford.

Tewkesbury Borough Council: Sewer Flood Risk

- In general the level of flood risk from artificial drainage systems within the District is medium to low.

Gloucester City Council: Sewer Flood Risk

- In general the level of flood risk from artificial drainage systems within the Borough is medium to high.

Cheltenham Borough Council: Sewer Flood Risk

- In general the level of flood risk from artificial drainage systems within the Borough is medium to low.
- The areas at highest risk are located towards the south west of the Borough by Hatherley, Tivoli and Lansdown; and towards the northern extent of the Borough by St Paul's, Marle Hill, Wymans Brook, Oakley and Lynworth.
- Much of the Cheltenham Central Area Main Sewerage System is over 120 years old and thought to be in a poor structural state. A programme of sewer replacement is being implemented and is thought to involve work beyond the current 5-year Capital Programme. The Chelt main sewer has a large overflow which joins the River Chelt at Arle. It has been recommended by the Environment Agency that any further development within the catchment area of this sewer system deals with surface water appropriately at the surface so that betterment is achieved. An increase in site runoff should not occur as this would increase the sewage flow and would lead to the overflow being used more frequently.

Cotswold District Council: Sewer Flood Risk

- In general the level of flood risk from artificial drainage systems within the Borough is medium to low with the exception of postcode area GL7 5 where there is a high level of risk.

Stroud District Council: Sewer Flood Risk

- In general the level of flood risk from artificial drainage systems within the District is medium to low.

1.6.3 Surface Water Flood Risk

Surface water flooding occurs when excess water runs off across the surface of the land and is usually the product of short duration but intense storms. This type of flooding usually occurs because the ground is unable to absorb the high volume of water that falls on it in a short period of time, or because the amount of water arriving on a particular area is greater than the capacity of the drainage facilities that take it away. Where discharge is directly to a watercourse, locally high water levels can cause back-up and prevent drainage taking place. In each instance the water remains on the surface and flows along the easiest flow path towards a low spot in the landscape. Surface water flooding is often short lived and localised and there is often limited notice as to the possibility of this type of flooding. In addition to general surface water flood risk analysis, the Highways Agency and the County Council provided extensive databases of surface water flooding locations and the following has been found:

Forest of Dean District Council: Surface Water Flood Risk

- Flooding from surface water is a problem within the District, with the geology and topography contributing to increased likelihood of surface water flooding.
- The upper reaches of river catchments within the District, although underlain by permeable limestone and sandstone, are often steep, promoting rapid surface runoff which can lead to localised flooding. In addition, the clays and mudstones found within the Severn Valley lie close to the groundwater table for much of the year and are frequently saturated.
- Areas with an abundance of impervious surfaces are also at risk of surface water flooding, especially when local intense rainstorms occur. Surface water flooding associated with poor urban drainage and backing up within urban drainage systems under high river flows affects Coleford and Lydney in particular.

Tewkesbury Borough Council: Surface Water Flood Risk

- Flooding from surface water is a problem within the Borough, with the largely impermeable geology and gentle topography of the Borough contributing to increased likelihood of surface water flooding.
- Areas with an abundance of impervious surfaces means these areas are also at risk of surface water flooding, especially when local intense rainstorms occur.

Gloucester City Council: Surface Water Flood Risk

- Surface water flooding in Gloucester tends to be associated with poor urban drainage and backing up within urban drainage systems under high river flows. The abundance of impermeable surface can also contribute to surface water flood risk, especially when local intense rainstorms occur.

Cheltenham Borough Council: Surface Water Flood Risk

- Flooding from surface water is a problem within the Borough, particularly in the town due to abundance of impermeable surfaces. In the past the River Chelt was diverted from its natural course to higher ground in order to feed the great mills. The original river valley was

subsequently developed with housing estates, public buildings and industrial development. Consequently, when intense rainfall events occur, runoff follows natural topography and accumulates at the valley bottom, which can flood areas of the town centre.

- The drainage system in the Borough is known to be quite old and there is potential for the drainage systems to overload and exacerbate surface water flooding.

Cotswold District Council: Surface Water Flood Risk

- It is evident that surface water flooding is a problem throughout the District, with reported incidents referring to runoff from hills and drains being unable to cope with storm water.
- During the summer 2007 floods exceptional rainfall was experienced at RAF Fairford resulting in flooding to the airfield and surrounding villages of Whelford, Dunfield and Marston Meysey.

Stroud District Council: Surface Water Flood Risk

- Flooding from surface water is a problem within the District particularly around Stroud. This is due to the combination of steep catchments, combined urban drainage networks, older style properties and an abundance of woodland debris which blocks the urban drainage network.
- Surface water flooding has been identified along the River Frome catchment, mainly due to the steep topography.

A more detailed assessment of surface water flood risk will be required as part of a Level 2 SFRA.

1.6.4 Impounded Water Body Flood Risk

Occasionally, canals can overtop due to high inflows from natural catchments and if overtopping occurs from adjacent water courses. This additional water can be routed/conveyed by the canal which may cause issues elsewhere, not only within the catchment of interest but also in neighbouring catchments where the canal might cross a catchment boundary. Reservoirs with an impounded volume in excess of 25,000 cubic metres (measured above natural ground level) are governed by the Reservoirs Act 1975, though due to high standards of inspection and maintenance required by legislation, normally flood risk from registered reservoirs is moderately low. British Waterways was consulted to gain information on past reservoir breach and overtopping incidents of canals, while the Environment Agency was consulted to gain a comprehensive overview of reservoirs currently held under the Reservoirs Act, and any breach and overtopping information of these reservoirs. However, it should be noted that there is a residual risk of flood risk from all reservoirs and canals, from either breach or overtopping, therefore any development in immediately adjacent/downstream of these areas should be carefully considered and the risks fully assessed. A Level 2 SFRA would be required to determine the risk posed by overtopping or breach of the embankment and to inform appropriate policy and mitigation measures. The Level 1 assessment found that:

Forest of Dean District Council: Impounded Water Body Flood Risk

- There are no canals located within the District.
- There are no records of breaching or overtopping of reservoirs within the District.

Tewkesbury Borough Council: Impounded Water Body Flood Risk

- There is one canal in the Borough, The Coombe Hill Canal. There are no recorded incidents of breaching or overtopping, or any other local flood risk instances associated with this canal.
- There are no records of breaching or overtopping of reservoirs within the Borough.

Gloucester City Council: Impounded Water Body Flood Risk

- One canal, the Gloucester and Sharpness Canal, is located in Gloucester. There are no recorded incidents of breaches or overtopping, or any other local flood risk instances associated with this canal.
- There are no records of breaching/overtopping of reservoirs within Gloucester.

Cheltenham Borough Council: Impounded Water Body Flood Risk

- There are no canals in the Borough.
- A number of flood storage areas are located within or close to the Borough boundary, namely Dowdeswell Reservoir and Cox's Meadow. Dowdeswell is located outside the eastern extent of the Borough (SO 9884 1973) upstream of Cheltenham and has been modified for use from a water supply reservoir to a flood storage reservoir. There are no records of breaching/overtopping of reservoirs within, or in the vicinity of, the Borough.

Cotswold District Council: Impounded Water Body Flood Risk

- There is one canal located within the District. The Thames and Severn Canal is located at the northern extent of the District and runs parallel to the River Frome for much of its length. There are no records of breach or overtopping of this canal in the District.
- There are no records of breaching/overtopping of reservoirs within the District.

Stroud District Council: Impounded Water Body Flood Risk

- There are two canals in the District: the Gloucester and Sharpness Canal and the Stroudwater Canal (also referred to as the Thames and Severn Canal upstream of Thrupp).
- One incident of canal breach on the Gloucester and Sharpness Canal has been recorded within the District in June 1990 at Parkend (SO 7746 1055) as a result of culvert collapse (Saul Junction).
- There are no records of breaching/overtopping of reservoirs within the District.
- It is evident that the Gloucester and Sharpness Canal acts a line of defence, although this is not considered under the Environment Agency's responsibility to operate or maintain. Any failure of the canal could potentially cause or exacerbate flooding problems within the District.

1.6.5 Groundwater Flood Risk

Groundwater flooding is most likely to occur in low-lying areas underlain by permeable rocks (aquifers). These may be extensive regional aquifers (e.g. chalk or sandstone) or localised sands or river gravels in valley bottoms underlain by less permeable rocks. Groundwater flooding occurs as a result of water rising from the underlying rocks or from water flowing from abnormal springs. This tends to occur after long periods of sustained high rainfall. Higher rainfall means more water will infiltrate into the ground and cause the water table to rise above normal levels. Groundwater tends to flow from areas where the ground level is high, to areas where the ground level is low. In low-lying areas the water table is usually at shallower depths anyway, so during very wet periods, all the additional groundwater flowing towards these areas can cause the water table to rise to the surface causing groundwater flooding. Groundwater can take weeks or months to dissipate, because groundwater flow is very slow and water levels take much longer to fall.

However, at this time the areas at risk from groundwater flooding are largely unknown. Although data collected for the SFRA has provided an indication of areas potentially susceptible, the assessment undertaken as part of this SFRA is not exhaustive and the risk and impact of groundwater to all development must be considered. The results of the SFRA can be summarised as follows:

Forest of Dean District Council: Groundwater Flood Risk

- The catchment area of the River Severn contains numerous groundwater springs. These can respond to prolonged periods of rainfall and seasonal variations in climate, impacting on the contribution to flow in adjacent watercourses. In addition, the clays and mudstones of the Severn Valley lie close to the groundwater table for much of the year and as such, are frequently saturated with standing water across the floodplain. This can lead to increased surface runoff and localised flooding, even when the River Severn is not in flood.

Tewkesbury Borough Council: Groundwater Flood Risk

- There are no records of groundwater flooding in the Borough.

Gloucester City Council: Groundwater Flood Risk

- There are no records of groundwater flooding in Gloucester.

Cheltenham Borough Council: Groundwater Flood Risk

- There are no records of groundwater flooding in the Borough.

Cotswold District Council: Groundwater Flood Risk

- The underlying geology of the District contributes significantly to the potential for groundwater flooding to occur. Drift deposits within the District can be found within the Cotswold Water Park towards the south of the District (predominantly sands and gravels associated with the River Thames) and towards the north-east of the District (overlying the Lias deposits). Drift deposits tend to have shallow water tables and are drained by the watercourses running through them. When the levels in these watercourses are high less groundwater can drain away. The drift deposits overlying the Oxford Clays or Lias Clays act as a barrier to the

downward movement of groundwater through the sands and gravels, and as such, the sands and gravels may be poorly drained leading to water-logging and surface flooding. Within the study area there are also aquifers that are confined by the overlying geology. Groundwater within these confined aquifers may be artesian (above ground level) however; the groundwater is prevented from reaching the surface by the overlying geology. Groundwater levels recorded in these artesian boreholes may appear to be above ground level but in reality are not.

- Groundwater flooding has been reported within the District at a number of locations including: areas to the south west of the District around Cirencester (January 2004), Dalingworth (January 2008) and Whitelands Wood (2000, 2003 and April 2004); and towards the north of the District by Shipton Oliffe (June 2007), Cold Aston (July 2007) and Bledington (July 2007).

Stroud District Council: Groundwater Flood Risk

- No records of groundwater flooding were identified within the Borough. However, some valleys in the Cotswold escarpment may show potential vulnerability to groundwater flooding due to the underlying limestone geology and a relatively high water table.

- The catchment area of the River Severn contains numerous groundwater springs which can respond to prolonged periods of rainfall and seasonal variations in climate, impacting on the contribution to flow in adjacent watercourses and the clays and mudstones of the Severn Valley which lie close to the groundwater table for much of the year. Consequently they are frequently saturated with standing water across the floodplain, increasing the risk of surface runoff and localised flooding.

1.6.6 Climate Change Impacts

In its October 2006 publication of the predicted effects of climate change on the UK, Defra described how short duration rainfall could increase by 30% and flows by 20%, and suggests that by 2085 winters will become generally wetter whilst summers, although drier, will be characterised by more intense rainfall events. Changes in sea level could result in tide locking of watercourses draining to the sea and resultant coastal and tidal flooding. Overall, these effects will tend to increase both the size of Flood Zones and the depth of floodwater associated with rivers, and the amount of flooding experienced from 'other sources'. Sites that are currently within Flood Zones 2 and 3 will be subject to more frequent and potentially deeper flooding. Generally, it is anticipated that in flatter areas, the extent of inundation will become bigger, while in narrow floodplains, the depth of the floodwaters will increase. In particularly steep areas the velocity might also increase. This will have a significant impact on the flood hazard. Possible climate change impacts on flood risk in the Gloucestershire local authorities are as follows:

Forest of Dean District Council: Climate Change Impacts

The floodplains in the western upland areas of the District are generally narrow; therefore the depth of flooding is likely to increase here, particularly in the Lyd catchment, mainly at Whitecroft and Lydney. In particularly steep areas the velocity might also increase. In the lower and flatter areas towards the Severn Estuary, flood extents are expected to increase in the Cinderford streams, though the main changes affect the agricultural land in the downstream area of the catchment. The Severn Estuary and its downstream tributaries will be subject to increased storm

surges and wave height future, and the Environment Agency plans to implement managed retreat. Development proposals in this area should be treated with caution. Here, the local authority should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning.

Tewkesbury Borough Council: Climate Change Impacts

Overall, areas currently in Flood Zones 2 and 3 are likely to flood more frequently, to a greater depth. Additionally, the flood extents might also increase due to the low-lying nature of the Borough. The lack of gradient also means that the velocity of flood water is not likely to increase significantly. The increased depth, however, will have a significant impact on the flood hazard. Given these points the local authority should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning. Locations where it might be prudent to do so are along the Severn and Avon floodplains, particularly Tewkesbury town.

Gloucester City Council: Climate Change Impacts

Given the lowland setting of Gloucester, an increase in flood extent is expected, but flood waters might also be deeper. This means that the flood hazard is likely to increase over time, creating increased risk to humans, more damage to property and higher economic damages. Certainly, sites that are currently within Flood Zones 2 and 3 will be subject to more frequent and potentially deeper flooding. Additionally, the tidal section of the Severn might be subject to increased storm surges and wave height. The Severn Tidal Tributaries CFMP states that the most significant changes in flood depth and extent can be seen in the catchments of the Sud Brook and River Twyver, including the industrial area around the Gloucester Docks, through St Paul's, High Orchard, Barton and Tredworth, and south of Coney Hill. There are a few considerable changes in the Wotton Brook catchment, where properties west of the A38 Tewkesbury road and those on the border between Elmbridge and Wotton are expected to flood in the future. There is also an area of agricultural land downstream of the A40 at risk. Slight increases in depth and extent of flooding in areas already at risk of flooding from the Daniels and Dimore Brooks are predicted, but not on the same scale as other areas of the Gloucester Streams. Damages during the one per cent annual probability flood event increase by 17% to £110 million under the 100 year horizon future scenarios. The scale of damage, therefore, remains high. The local authority should therefore consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning.

Cheltenham Borough Council: Climate Change Impacts

Given the lowland setting of the Borough, an increase in flood extent is expected, but flood waters might also be deeper. This means that the flood hazard is likely to increase over time, creating increased risk to humans, more damage to property and higher economic damages. Velocities are not likely to increase significantly, though the upstream section of the River Chelt is steep which may affect velocities. Certainly, sites that are currently within Flood Zones 2 and 3 will be subject to more frequent and potentially deeper flooding. The local authority should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning.

Cotswold District Council: Climate Change Impacts

The floodplains in the District are generally narrow and well defined in the upland areas, where the extent of flooding is negligible under climate change scenario. However, the depth of flooding is likely to increase here. In particularly steep areas the velocity might also increase. By contrast, the lower, flatter areas of the District to the south may be susceptible to an increased flood extent. Along the Thames corridor and its tributaries, the local authority should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning.

Stroud District Council: Climate Change Impacts

The floodplains in the south and east areas of the District are generally narrow, therefore the depth of flooding is likely to increase here, notably in the River Frome catchment. In the lower and flatter areas towards the Severn Estuary and the Little Avon and Cam catchments, especially in Dursley, flood extents are expected to increase. The Severn Estuary and its downstream tributaries will be subject to increased storm surges and wave height future, and the Environment Agency plans to implement managed retreat. Development proposals in this area should be treated with caution. In all these areas, the local authority should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning.

1.7 Future Development

Regional planning policies provide the overarching framework for the preparation of the Local Development Frameworks (LDFs). The Draft South West Regional Spatial Strategy (RSS) provides a broad development strategy for the South West Region up to 2026 and provides a long term land-use and transport planning framework for the Region.

The Northern Sub-Region, of which Gloucestershire is part, will continue to be the main focus for growth in the South West. The area has the potential to continue as a major focus of growth and economic expansion here is likely to be above the national average. Development plans will need to identify strategic employment sites, and provision needs to be made to meet future development requirements at sustainable development locations.

A sub-regional study was completed for Gloucester and Cheltenham and covers wider parts of the SFRA study area. This can be found in Sections 4.2.33 to 4.2.45 of the draft RSS. Table 2 puts forward housing requirements (including panel modifications).

Table 2: Housing requirements for the Gloucestershire (including panel modifications)

	Draft RSS Figures			Panel Modifications		
Gloucester and Cheltenham Housing Market Area	2006-2026 Overall Annual Net Dwelling Requirement	2006-2016 Annual Average Net Dwelling Requirement	2016-2026 Annual Average Net Dwelling Requirement	2006-2026 Overall Annual Net Dwelling Requirement	2006-2016 Annual Average Net Dwelling Requirement	2016-2026 Annual Average Net Dwelling Requirement
Cheltenham	425	425	425	405	405	405
Gloucester	575	575	575	575	575	575
Tewkesbury	525	525	525	730	730	730
Cotswold	300	340	260	345	345	345
Forest of Dean	270	300	240	310	310	310
Stroud	335	435	235	455	455	455
TOTAL	2430	2600	2260	2820	2820	2820

In allocating sites for development, the local authorities will be required to undertake the Sequential Test if promoting any areas that lie within Flood Zones 2, 3a or 3b at any point throughout the life of the development. By applying the Sequential Test the more vulnerable uses of land can be allocated to the lowest risk sites. The SFRA provides the necessary information to allow the local authorities to do this.

Only where there are no reasonably available sites in Flood Zones 1 should the suitability of sites in Flood Zones 2 and 3 be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required. To facilitate the application of the Exception Test, a Level 2 SFRA will be required.

1.8 Flood Risk Management Measures and Potential for Failure

The SFRA has identified existing flood risk management measures such as defences, culverts, flood storage areas and flood alleviation schemes, as well as the existing Flood Warning and Flood Watch service operated by the Environment Agency.

Permanent defences, culverts and storage areas within Gloucestershire have been identified using the Environment Agency's NFCDD and through consultation with the local authorities. As with any flood defence there is a residual risk that it may fail, for example, as a result of either overtopping and/or a breach of a raised defence, or as a result of a blockage or collapse of a culvert. Should such an event occur it may result in rapid inundation of the local community behind or in the vicinity of the flood defence, and may pose a risk to life. This is termed a residual risk area. In the event that allocations are proposed in the vicinity of flood risk management measures, the scope of the SFRA should be extended to a Level 2 assessment.

As a general note, further culverting and building over of culverts should be avoided. All new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit. A number of purpose-built and natural flood storage areas are located within the County. These include a series of natural flood storage areas situated along

the River Severn. It is imperative that any storage areas used as a means of attenuation of flood waters should be maintained to ensure their efficient operation during a flood event.

1.9 Planning Policy Recommendations

Council policy is considered essential to ensure that the recommended development control conditions can be imposed consistently at the planning application stage. A key aim of an SFRA, therefore, is to define flood risk management objectives and identify key policy considerations. It should be noted that it is ultimately the responsibility of the Council to formally formulate these policies and implement them. The SFRA puts forward a number of flood risk objectives which should be taken into account during the policy making process and, where appropriate, used to strengthen or enhance the development control policies also provided in the SFRA. The flood risk management objectives have generally covered the following points:

Flood Risk Objective 1: To Seek Flood Risk Reduction through Spatial Planning and Site Design:

- Use the Sequential Test to locate new development in least risky areas, giving highest priority to Flood Zone 1
- Use the Sequential Test within development sites to inform site layout by locating the most vulnerable elements of a development in the lowest risk areas. For example, the use of low-lying ground in waterside areas for recreation, amenity and environmental purposes can provide an effective means of flood risk management as well as providing connected green spaces with consequent social and environmental benefits
- Build resilience into a site's design (e.g. flood resistant of resilient design, raised floor levels)
- Identify long-term opportunities to remove development from the floodplain through land swapping
- Ensure development is 'safe'. For residential developments to be classed as 'safe', dry pedestrian egress out of the floodplain and emergency vehicular access should be possible. The Environment Agency states that dry pedestrian access/egress should be possible for the 1 in 100 year +20% for climate change return period event, and residual risk, i.e. the risks remaining after taking the sequential approach and taking mitigating actions, during the 1 in 1000 year event, should also be 'safe'.

Flood Risk Objective 2: To Reduce Surface Water Runoff from New Developments and Agricultural Land:

- SUDS required on all new development. As outlined in section 10.3 which outlines appropriate SUDS techniques for the Borough, infiltration systems should be the preferred means of surface water disposal, provided ground conditions are appropriate. Above ground attenuation, such as balancing ponds, should be considered in preference to below ground attenuation, due to the water quality and biodiversity benefits they offer.
- All sites require: Greenfield discharge rates with a minimum reduction of 20%, as required by the Environment Agency and 1 in 100 year on-site attenuation taking into account climate change
- Space should be specifically set aside for SUDS and used to inform the overall site layout
- Promote environmental stewardship schemes to reduce water and soil runoff from agricultural land

Flood Risk Objective 3: To Enhance and Restore the River Corridor:

- An assessment of the condition of existing assets (e.g. bridges, culverts, river walls) should be made. Refurbishment or/and renewal should be made to ensure the lifetime is commensurate with lifetime of the development. Developer contributions should be sought for this purpose.
- Those proposing development should look for opportunities to undertake river restoration and enhancement as part of a development to make space for water. Enhancement opportunities should be sought when renewing assets (e.g. de-culverting, the use of bioengineered river walls, raising bridge soffits to take into account climate change)
- Avoid further culverting and building over of culverts. All new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit
- Set development back from rivers, seeking an 8 metre wide undeveloped buffer strip

Flood Risk Objective 4: To Protect and Promote Areas for Future Flood Alleviation Schemes

- Protect Greenfield functional floodplain from future development (our greatest flood risk management asset) and reinstate areas of functional floodplain which have been developed (e.g. reduce building footprints or relocate to lower flood risk zones)
- Develop appropriate flood risk management policies for the Brownfield functional floodplain, focusing on risk reduction
- Identify sites where developer contributions could be used to fund future flood risk management schemes or can reduce risk for surrounding areas
- Seek opportunities to make space for water to accommodate climate change

Flood Risk Objective 5: To Improve Flood Awareness and Emergency Planning

- Seek to improve the emergency planning process using the outputs from the SFRA
- Encourage all those within Flood Zone 3a and 3b (residential and commercial occupiers) to sign-up to Flood Warnings Direct service operated by the Environment Agency
- Ensure robust emergency (evacuation) plans are implemented for new developments greater than 1 Ha in size

The policy recommendations provided in the SFRA have taken strong direction from the findings of the SFRA on local flood risk issues, PPS25, Making Space for Water, the Water Framework Directive and CFMPs. CFMPs have been critical in informing the SFRA of the Environment Agency's policies for long-term flood risk management of each river catchment in the study area over the next 50 to 100 years. The SFRA advises each local authority of how the relevant CFMP policies will affect their areas and therefore planning decisions.

1.10 Concluding Remarks

The SFRA has established that there are areas within Gloucestershire at risk of flooding. In order to minimise the flood risks posed to all potential development the Sequential Test will need to be applied for all land use allocations. The SFRA provides the necessary information to do this.

The Environment Agency will require a Level 2 SFRA to be carried out in order to provide a detailed assessment of the risk of flooding from non-fluvial sources, in areas where new development is proposed, or where information in the Level 1 suggests there may be a high risk to existing developed areas that warrants further investigation into the source and pathway of flooding. This will particularly assist in Development Control and emergency planning decisions and may also help to identify where Surface Water Management Plans may be necessary.

With regard to fluvial sources of flood risk, a Level 2 SFRA will be required where the need to apply the Exception Test is identified (as outlined in Table D3 of PPS25). This cannot be determined until the Sequential Test has been carried out on all proposed development sites. It is recommended that the Level 2 SFRA approach is agreed with the Environment Agency.

The SFRA underlines the importance of sustainable drainage systems (SUDS). The management of rainfall (surface water) is considered an essential element of reducing future flood risk to both the site and its surroundings. Indeed, reducing the rate of discharge from sites is one of the most effective ways of reducing and managing flood risk within the area. Across the whole of the study area, developers should seek to maximise the reduction of runoff from a site. This is because large increases in impermeable areas contribute to significant increases in surface runoff volumes and peak flows. There are numerous different ways that SUDS can be incorporated into a development to manage surface water drainage to avoid increases in peak flows and volumes, but the appropriate application of a SUDS scheme to a specific development is heavily dependent upon the topography and geology of a site and the surrounding areas.

A number of general issues and resultant recommendations have come forward through the SFRA process. Recommendations have been made within the SFRA which are specific to Council Policy, Environment Agency policy relevant to the Council and Emergency Planning procedures. These recommendations should be taken into account by each Local Authority.