Gloucestershire County Council

Preliminary Flood Risk Assessment

Preliminary Assessment Report

November 2011

Directorate: Environment

Service: Flood Risk Management

Relevant Legislation: Flood Risk Regulations 2009

Amendment Record:

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1	First draft for scrutiny and internal approval	March 2011	A Cotton
2	Final draft for submission to EA	June 2011	M Parker
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4	Final version for publication on GCC website	November 2011	A Cotton

Executive Summary

Under the EC Floods Directive, which has been transposed into UK law through the Flood Risk Regulations (2009), Gloucestershire County Council must undertake a Preliminary Flood Risk Assessment (PFRA) to assess the harmful consequences of past and potential future flooding, and to identify areas of significant flood risk ('flood risk areas').

As a Lead Local Flood Authority (LLFA), Gloucestershire County Council has responsibility for preparing the deliverables of the Flood Risk Regulations for 'local flood risk' (flooding from surface runoff, ordinary watercourses and groundwater). The Environment Agency has responsibility for preparing the deliverables of the Flood Risk Regulations for flooding from Main Rivers and the Sea.

This report, and associated spreadsheets, has been prepared by Gloucestershire County Council to fulfil the requirements of the Flood Risk Regulations for the PFRA. The methodology for undertaking the PFRA has been based on the Environment Agency's PFRA Final Guidance (December 2010). The principal purpose of a PFRA is to assess past and future floods with significant harmful consequences, and to identify the areas of most significant flood risk across Europe.

The first stage of the PFRA is to assess past floods which have had significant harmful consequences for human health, economic activity or the environment, or could have harmful consequences if they were to occur now. In the wake of the summer 2007 floods a large amount of information on flooded locations was collected by the relevant risk management authorities including the six district councils, the Environment Agency, Gloucestershire Highways, Lower Severn Internal Drainage Board and the water companies. Gloucestershire County Council collated, analysed and mapped this information as part of the pilot Surface Water Management Plan, which was completed in March 2010. This information was reviewed and updated by relevant risk management authorities for the PFRA to ensure it was as up to date and accurate as possible. The key impacts of the July 2007 flooding event were: flooding of over 5,000 residential properties, flooding of over 500 non-residential properties, 135,000 homes being without water for two weeks due to flooding at Mythe water treatment works, 48,000 homes being without electricity for two days, 10,000 people being stranded on the M5 overnight, and flooding at both Cheltenham and Gloucester train stations. The flooding was described as the 'largest peacetime emergency this Country has seen, in terms of complexity, duration and those affected' (Gloucestershire Constabulary, 2007).

The PFRA has also considered the potential risk of future flooding in Gloucestershire. This has been principally based on hydraulic modelling which is able to predict the potential impact of flooding on people, property and the environment. In Gloucestershire the best available information on potential future floods is available from a variety of sources including Surface Water Management Plan mapping, mapping undertaken by Cotswold District Council and the national maps produced by the Environment Agency. This was used to inform an assessment of the numbers of properties in Gloucestershire which are vulnerable to surface water flooding during an extreme rainfall event (similar to that experienced in Cheltenham in July 2007). This analysis has identified that over nearly 17,000 residential properties (approximately 40,000 people), 1500 non-residential properties, and 170 critical services (e.g.) are vulnerable to surface water flooding to a depth of >0.3m during an extreme rainfall event.

The final stage of the PFRA process is the identification of 'Flood Risk Areas'. Indicative 'Flood Risk Areas' have been calculated by the Environment Agency using a threshold defined nationally by ministers at the Department for food and rural affairs (Defra). An indicative 'Flood Risk Area' has been identified where clusters of at least 30,000 people have been identified as being at risk of flooding from local sources. Of the ten indicative 'Flood Risk Areas' which have been identified nationally by the Environment Agency and Defra, none are located in Gloucestershire. Gloucestershire County Council is not proposing to add a new 'Flood Risk Area' for the purposes of the PFRA.

It should be noted that the primary purpose of the Flood Risk Regulations is to identify specific areas at most significant risk across Europe. There may be areas within Gloucestershire which local partners consider to be locally important areas of flooding but are not considered to be a 'Flood Risk Area' for the purposes of the PFRA. Management of locally important areas of flooding should be carried out through the local flood risk management strategies, which Gloucestershire County Council will be developing throughout 2011 as part of new responsibilities provided in the Flood and Water Management Act.

Contents

1 Introduction

1. This report, and associated spreadsheets, has been prepared by Gloucestershire County Council to fulfil the requirements of the Flood Risk Regulations for the PFRA.

2. Under the EC Floods Directive, which has been transposed into UK law through the Flood Risk Regulations (2009), Gloucestershire County Council must undertake a Preliminary Flood Risk Assessment (PFRA) to assess past floods, to assess the possible harmful consequences of future floods, and to identify areas of significant flood risk ('flood risk areas').

1.2 Overview of Flood Risk Regulations

3. The Flood Risk Regulations (2009) outline the roles and responsibilities of the various authorities consistent with the Flood and Water Management Act 2010 and provide for the delivery of the outputs required by the directive. The Regulations:

- Give responsibility to the Environment Agency to prepare Directive deliverables: preliminary assessment report, flood risk maps and hazard maps and flood risk management plans for flood risk from the sea, main rivers and reservoirs.
- Give responsibility to Lead Local Flood Authorities (LLFA) to do the same for 'local flood risk', which includes surface runoff, groundwater and ordinary watercourses.
- Give responsibility to the Environment Agency for collating and publishing the preliminary assessment reports, flood risk maps and hazard maps, and flood risk management plans.

4. The stages of the Flood Risk Regulations are illustrated in Figure 1-1.

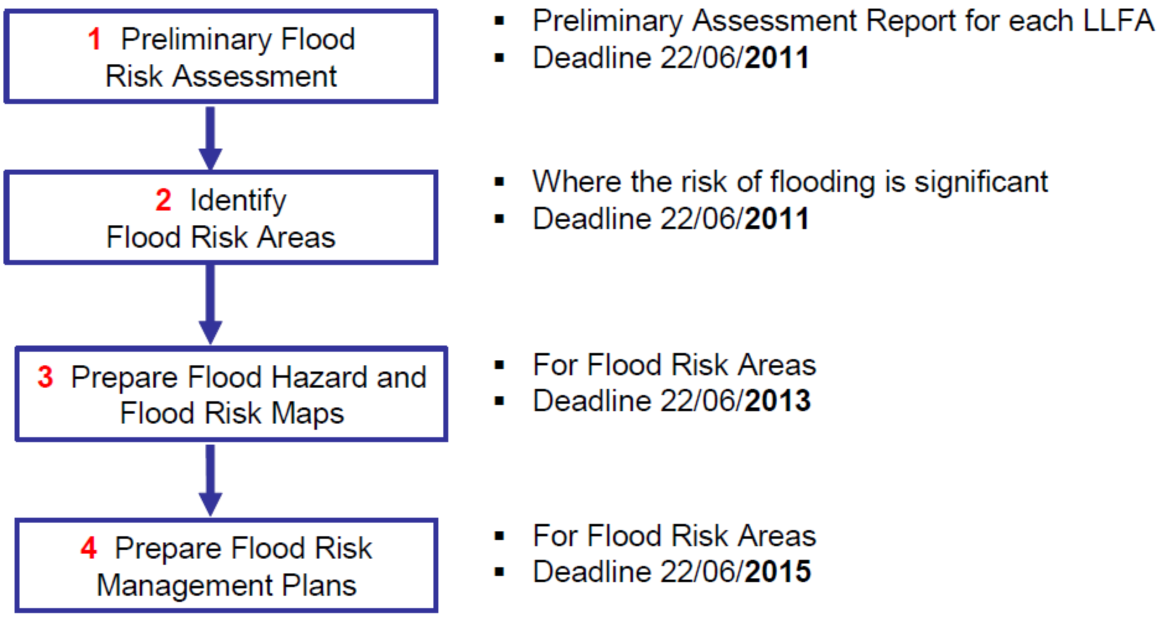

Figure 1-1 Flood Risk Regulations process (taken from PFRA guidance)

1.3 Aims and objectives of the PFRA

5. The PFRA is a high level screening exercise to identify areas of most significant flood risk across Europe. The aim of the PFRA is to assess local flood risk in Gloucestershire with respect to past floods and the potential harmful consequences of future floods.

6. The PFRA has been completed using a four-step process[1]:

- **Assessment of past floods -** the PFRA should assess past floods which have had harmful consequences for human health, economic activity or the environment, or could have harmful consequences if they were to occur now;
- **Assessment of future floods -** the PFRA should assess the possible harmful consequences of future floods, and must take into account topography, watercourses, floodplains, defences, populated areas, economic centres and the impacts of climate change
- **Identification of 'flood risk areas' -** the PFRA should identify 'flood risk areas', which are locations considered to be most significantly at risk of flooding nationally – the Environment Agency has defined criteria for identifying 'flood risk areas' and has provided 'indicative flood risk areas' on a national basis which should be used by LLFAs when undertaking their PFRAs.
- **Preliminary assessment report -** all of the information above should be captured in the preliminary assessment report, which is sent to the Environment Agency for review and publication.

1.4 Study area

7. Gloucestershire commands a predominantly rural setting, with population centred around the main urban areas of Gloucester, Cheltenham, Stroud and Cirencester, though numerous towns and villages exist. The County is drained predominantly by the lower reaches of the River Severn, which flows through the centre of Gloucestershire from the north east to the south west. The Cotswold Hills to the east of the County and the upland areas of the Forest of Dean to the west form the Severn's catchment boundary; areas which are in sharp contrast to the lowland river valley. To the south east of the Cotswold Hills lies the headwaters of the River Thames catchment, draining the majority of the Cotswold District, while the western side of the Forest of Dean is drained by the River Wye, which forms most of the county boundary in this area and meets the Severn Estuary between Sedbury and Chepstow.

8. Further information on the rivers, hydrology, geology and topography within Gloucestershire are provided in the Level 1 Strategic Flood Risk Assessments undertaken for each of the six district authorities. These can be accessed at the following link: http://www.gloucestershire.gov.uk/index.cfm?Articleid=17247

9. A map of Gloucestershire's political boundaries and location of Main Rivers / Ordinary Watercourses are shown in Figure 1-2 and Figure 1-3.

[1] It should be noted that the PFRA should be based on 'available and readily derivable information' (http://publications.environment-agency.gov.uk/pdf/GEHO1210BTGH-e-e.pdf)

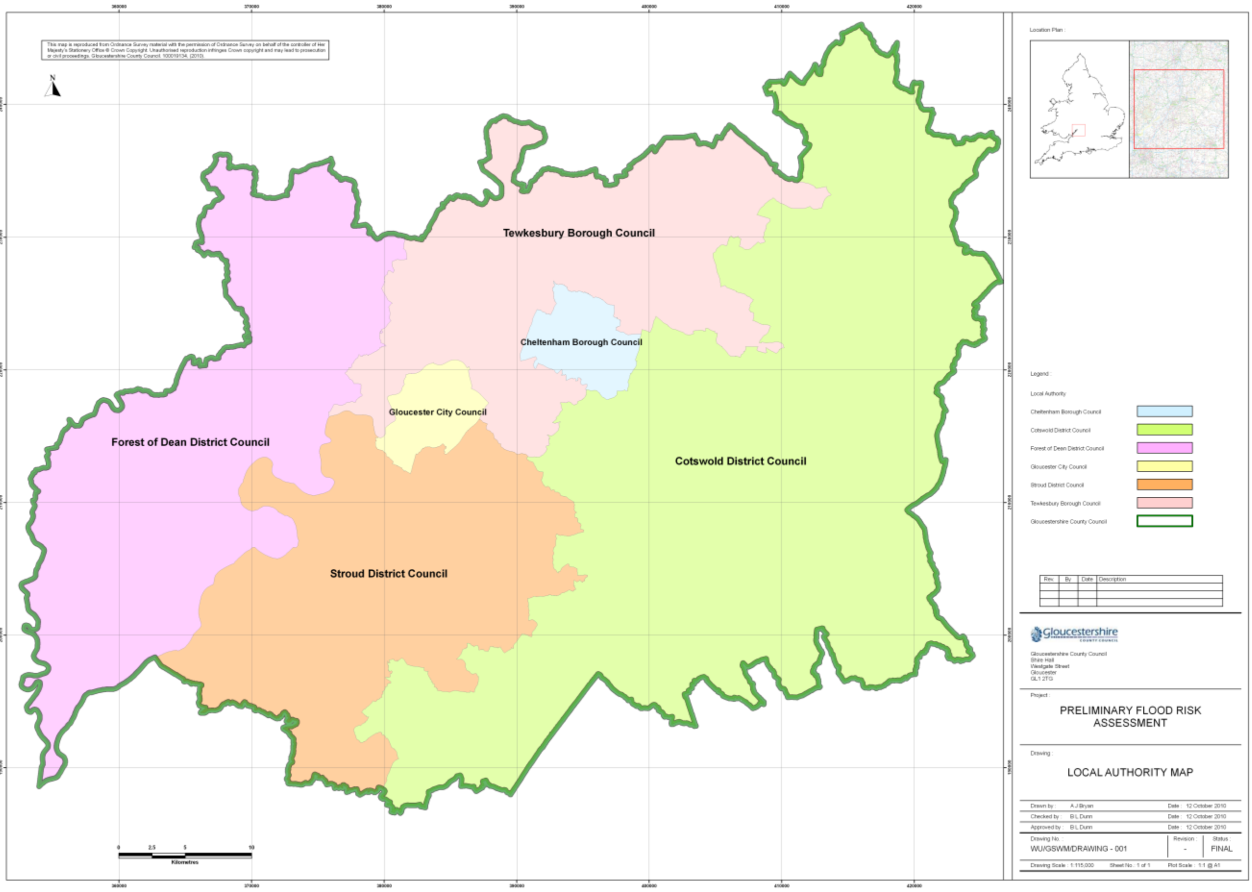

Figure 1-2 **Political boundaries of Gloucestershire**

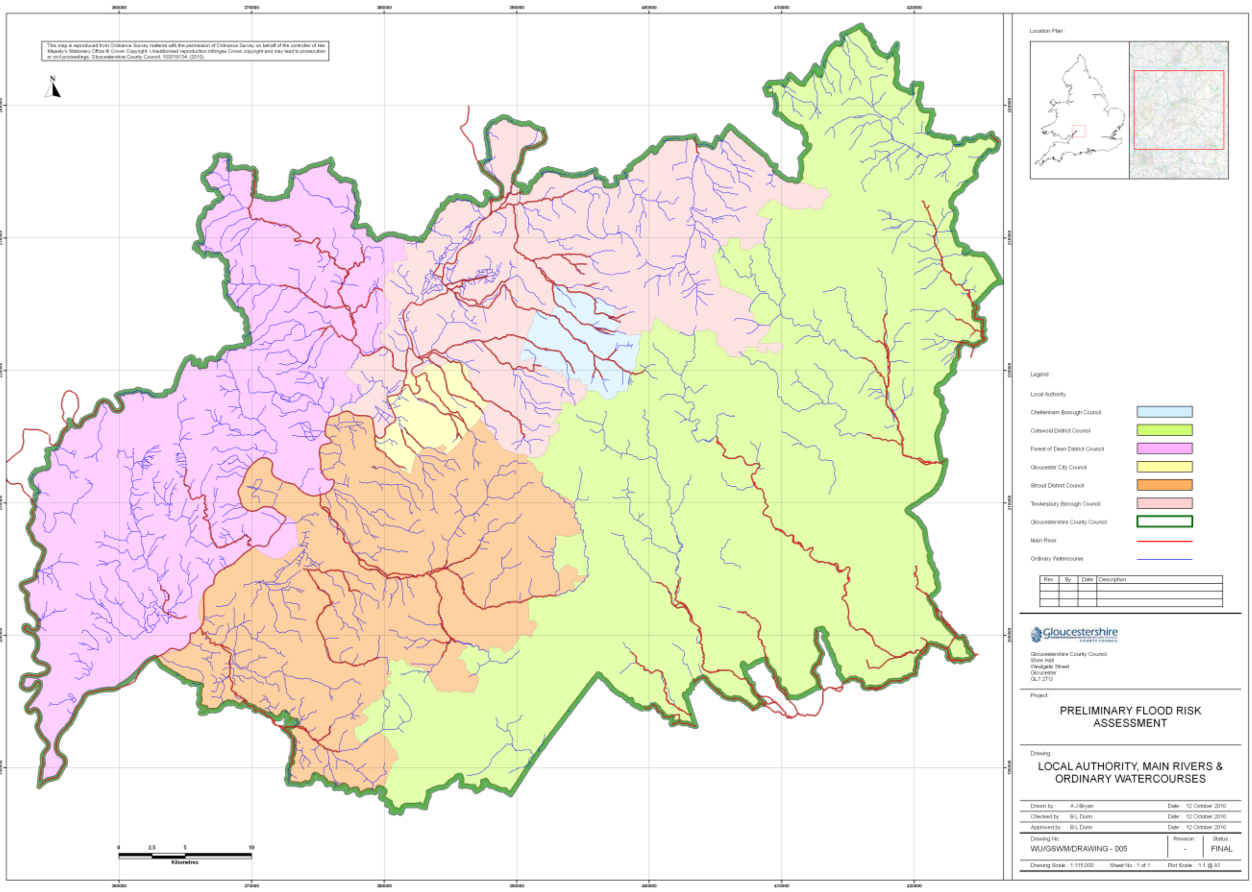

Figure 1-3 **Location of Main Rivers / Ordinary Watercourses**

2 Lead Local Flood Authority responsibility

10. The responsibilities of the LLFA for the Flood Risk Regulations are described in chapter 1 of this report. This section of the report outlines the model for partnership working which has been adopted in Gloucestershire since 2007, and the level of engagement with partners for the PFRA.

2.2 Partnership working

11. A partnership approach is the most efficient approach to co-ordinate local flood risk management activities. Strong local partnerships will enable effective, efficient and integrated flood risk management activities, also allowing for co-ordinated investments. Local flood risks can be complex in nature (i.e. multiple sources and pathways managed by multiple organisations [see Figure 2-1]) therefore working in partnership is essential to achieving optimum understanding of the risks, as well as integrated and efficient mitigation measures where multiple organisations are involved. By working collaboratively we plan to gain an optimum understanding of local flood risks and identify and assess the most suitable risk management measures.

Figure 2-1 **Local Flood Risk Management partners**

12. After the 2007 floods, GCC acted quickly to establish the Gloucestershire Flood Risk Management Group; a multi-agency group that includes representatives from GCC (including Emergency Management Services [EMS], Planning, Development Co-ordination and GH representatives), the Environment Agency, Severn Trent Water, Thames Water, the Lower Severn Internal Drainage Board and all the local Districts. The Terms of Reference for the group are to:

- determine the role of different agencies involved in flood alleviation;

- determine the standards of maintenance set by each organisation;
- undertake risk assessments and identify key infrastructure gaps;
- explore opportunities for joint working to resolve issues;
- agree a process for dealing with requests, complaints and enquiries; and
- agree a process for improving the public's awareness of flooding and their role in flood risk management.

13. The group has been active, countywide, providing a forum for discussing strategic and legislative issues, collaborative working and identifying where multi-agency action can be effective. The relationships that were built early on have helped the progression of joint-funded schemes on a District by District basis, and have included work such as de-silting, culvert improvement and watercourse modelling. In addition GCC has been progressing Surface Water Management Plans (SWMPs) as a tool to better understand and mitigate surface water flooding. As part of these SWMPs (Gloucestershire First Edition SWMP and Cheltenham SWMP), SWMP sub-groups have been formed from the existing Gloucestershire Flood Risk Management Group.

14. With respect to the PFRA, the following process has been adopted to engage with local flood risk management partners:

- a briefing note was prepared to scope the proposed approach for 'determining locally agreed surface water information'[2] – meetings were subsequently held with local flood risk management partners to discuss and agree 'locally agreed surface water information';
- the threshold for defining significant harmful consequences for past floods was discussed and agreed by local flood risk management partners, and;
- district councils were asked to provide GCC with updated records of flood incident data to support the assessment of past floods with significant harmful consequences (see Chapter 5 for further explanation).

2.3 Communication with the public

15. GCC will be progressing SWMPs in areas most vulnerable to surface water flooding, subject to available funding. A SWMP provides a framework to undertake a more detailed assessment of surface water flood risk and to develop an action plan (with short and long term actions) to alleviate flood risk in a given area. As SWMPs provide an enhanced level of detail compared to the PFRA, they provide the optimal platform to communicate surface water flood risk and action plans to the public. Therefore, public consultation and engagement will take place during the progression of SWMPs in high risk locations across Gloucestershire.

[2] The PFRA guidance states 'that LLFAs should: review, discuss, agree and record, with us [*Environment Agency*], water companies, IDBs and other interested parties, what surface water flood data best represents local conditions. This is known as 'locally agreed surface water information'.'

3 Methodology and data review

3.1 Information gathered on 'past floods'

16. The PFRA must include an assessment of past floods which had significant harmful consequences for human health, economic activity or the environment (cultural heritage) or which would have harmful consequences if they were to occur again. The PFRA can ignore floods that are not likely to occur now (e.g. because flood risk management works have been completed). This section of the report describes the key information which was collated to assess past floods within Gloucestershire.

17. The key sources of information to assess past floods were the county-wide Level 1 Strategic Flood Risk Assessment (SFRA), completed in September 2008, and the First Edition SWMP completed in March 2010.

18. As part of the Level 1 SFRA flood risk maps were produced which showed fluvial flood risk and recorded incidents of flooding from 'other sources', which includes surface water and sewer flooding. The available information on surface water flooding was typically skeletal and in most cases the source of flooding was undefined. The first step of the First Edition SWMP was to improve and enhance the information on surface water flooding from the Level 1 SFRA by:

- distinguishing the source of flooding, particularly where the SFRA maps states 'unknown source';
- drawing areas of surface water flood risk which may not be currently shown on the maps;
- enhancing the current information to show wider affected areas if this is the case;
- noting where areas are repeatedly flooding from surface water and areas where the flooding is less frequent/one offs;
- noting where surface water flooding is particularly severe (in terms of depth, velocity, rate of onset) and where it is less so, and;
- giving details of the flood mechanisms.

19. This information was gathered, where available, from local flood risk management partners, including:

- Cheltenham Borough Council
- Cotswold District Council
- Environment Agency
- Forest of Dean District Council
- Gloucester City Council
- Gloucestershire Highways
- Highways Agency
- Lower Severn Internal Drainage Board
- Severn Trent Water
- Stroud District Council
- Tewkesbury Borough Council
- Thames Water

20. Each partner was given a set of SFRA maps for their relevant local authority/area and staff at the 'grass roots' were asked to review the maps and enhance them, including the identification of the severity of the risk and the nature of the flood risk interactions, where possible.

21. Once the data received from the local authorities had been digitised, this was then used in conjunction with the information received from Severn Trent Water, the Internal Drainage Boards (IDBs)

and the Environment Agency, to further identify and enhance risk areas within the individual local authority boundaries.

22. It was recognised that because the process for the SWMP had been completed two years ago, in February 2009, local flood risk management partners may have more up to date and enhanced records of flood incidents. Therefore, the maps and tables were re-distributed to the six district councils, and they were asked to update existing flood incident records (where necessary) and add any new flood incident data which were readily available. In addition the districts were asked to confirm where flood risk management works had been undertaken to alleviate flooding. Despite this process, records of flood incidents were still incomplete in parts, especially with respect to dates of flooding, primary source of flooding and the severity and consequence of the flood incident.

3.2 Information gathered on 'future floods'

23. The PFRA must also include an assessment of the possible consequences of future floods (also known as potential floods). This section of the report describes the information available to assess the possible consequences of future floods, which has been achieved through the use of computer-based modelling.

3.2.1 National mapping

24. At the national scale the Environment Agency has produced two national surface water flood maps:

- Environment Agency 'Areas Susceptible to Surface Water Flooding' national map (AStSWF) – this map, which covers England and Wales, was released in June 2009 to provide a general indication of areas which are more likely to suffer from surface water flooding, and;
- Environment Agency 'Flood Map for Surface Water' national map (FMfSW) – this map, which covers England and Wales, was released in November 2010 and provides a revised approach to mapping surface water flooding including accounting for the presence of drainage systems.

3.2.2 Local mapping

25. As part of the First Edition SWMP for Gloucestershire, intermediate modelling was undertaken for five catchments in Gloucestershire. The intermediate model represented all runoff entering and within the urban area, and included a representation of public sewers and watercourses. The models were simulated using a rainfall event with a 1 in 200 year (0.5%) probability of occurring in any one year, which is a similar rainfall event to that experienced in Cheltenham in July 2007. The intermediate modelling was undertaken for the following catchments (illustrated in Figure 3-1):

- River Evenlode catchment, covering Moreton-in-Marsh;
- Carrant Brook, River Swilgate and Tirle Brook catchments, covering central Tewkesbury Borough and northern Cheltenham Borough;
- River Chelt catchment, covering central Cheltenham Borough;
- Cox's Brook, Broadboard Brook, Hatherley Brook, Horsbere Brook, Queen's Dyke, Wotton Brook, River Twyver, Sud Brook, Whaddon Brook, Daniels Brook and Dimore Brook catchments, covering Gloucester City, a section of south west Tewkesbury Borough and a small section of northern Stroud District;

- River Frome catchment, covering the eastern half of Stroud District, including Stroud town itself.

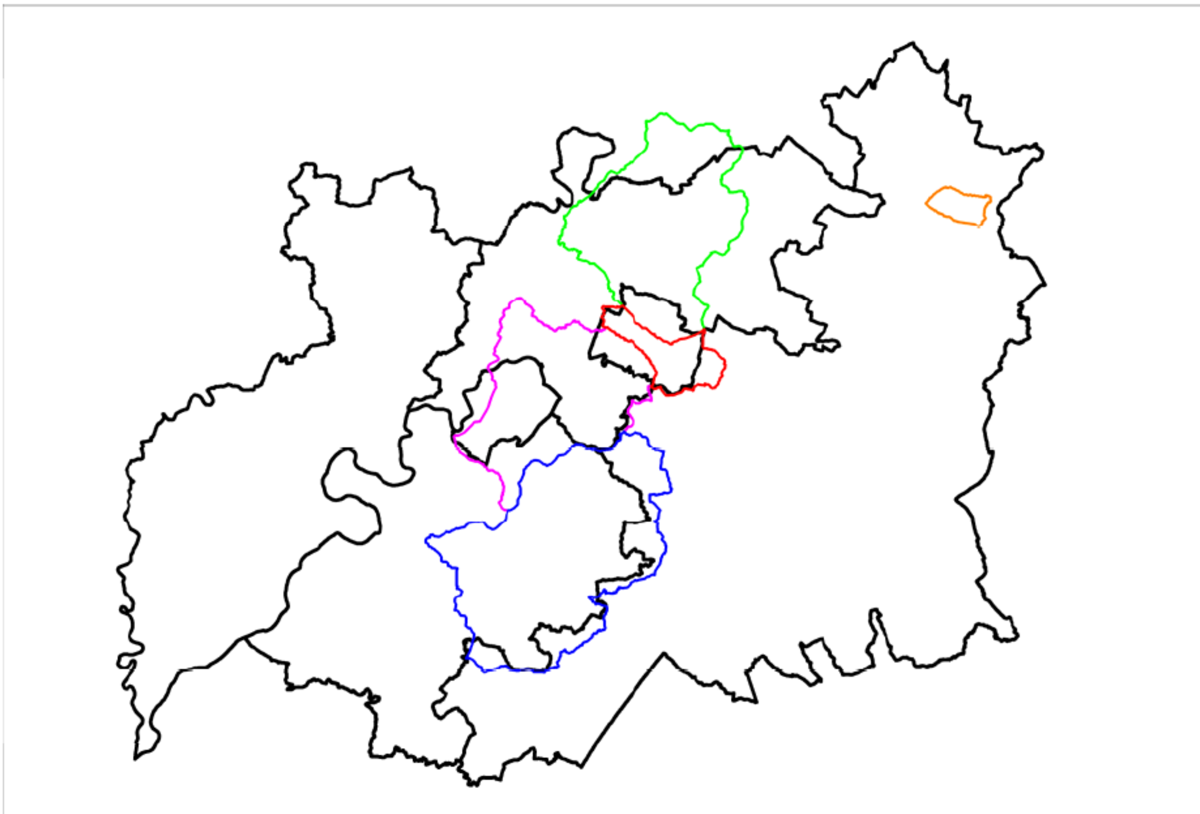

Figure 3-1 Locations of intermediate modelling for the First Edition SWMP

26. In addition to the intermediate modelling for the SWMP there have been a number of flood risk management modelling studies undertaken by Cotswold District Council, including Andoversford, Chipping Campden, Moreton-in-Marsh, Naunton, Willersey, and Weston sub-edge.

27. Further information on which sources of mapping have been used for the PFRA (i.e. 'locally agreed surface water information') for the PFRA is described in Chapter 5.

3.3 Availability of information

28. The annexes to the PFRA guidance state that the Preliminary Assessment Report should include a summary of the availability and limitations of the information gathered, systems used to store the information, and any restrictions on the use of the information. This is summarised below in Table 3-1.

Name of dataset	Availability of dataset	Limitations of dataset	Systems used to store dataset	Security, licensing and restrictions on use
Past floods				
Locally collated flood incident data (from SFRA, SWMP & PFRA)	Dataset has been provided by each of the local flood risk management partners to GCC for use in SWMPs and the PFRA	This is the best available information on past flood incidents. However there is limited information with respect to: • severity & consequence of flooding • no. people, non-residential properties or critical services affected • dates of flood incidents • source of flooding	The data is currently stored as an Excel spreadsheet and as GIS layers GCC are currently developing an online GIS system to capture and store flood incident data	Any information provided by private organisation has been gathered under a confidentiality agreement
Future floods				
'Intermediate' SWMP modelling for 5 catchments	Dataset held by GCC (although the modelling has used data from 3rd part providers)	• Assumes all runoff in the urban environment initially enters the sewer network – in reality during intense storms some runoff cannot get into the sewer network • Buildings not included in the model • Watercourses included as depressions in the model – no structures (e.g. culverts) included	Model files, and model outputs (including maps and GIS layers) are stored by GCC	Modelling has used datasets licensed from 3rd party providers under a confidentiality agreement, therefore release of the modelling outputs is subject to 3rd party agreement
Modelling undertaken in 6 locations in the Cotswolds	Dataset held by Cotswold District Council – flood extents	• Limitations not known	Model files, and model outputs (including maps and GIS layers) are stored by	

	for the 1 in 100 yr plus climate change model run have been provided for the PFRA		Cotswold District Council	
Areas Susceptible to Surface Water Flooding	Dataset available to GCC through the Environment Agency	• Assumes all rainfall is converted to runoff (excludes losses such as infiltration and capacity of drainage systems) • Based on GeoPerspective ground model with accuracy ±1.5m • No buildings, kerb lines or culverts were included in the model • Watercourses included as depressions in the model – no structures (e.g. culverts) included	Flood maps are available in GIS format from the Environment Agency through GeoStore and are held by GCC	The maps have been released by the Environment Agency to GCC under a Non-Commercial license (reference Z10305). Use of the dataset must be in accordance with the terms and conditions outlined in the Non-Commercial license
Flood Map for Surface Water		• Assumes uniform drainage capacity of 12 mm/hr – at a local level drainage capacity may be lower/higher than this • Single figure used to account for losses in urban/rural areas which, in reality, varies locally • Watercourses included as depressions in the model – no structures (e.g. culverts) included		

Table 3-1 Supporting information on data used to assess future floods

4 Assessment of past floods

4.1 Locally agreed threshold for 'significant harmful consequences'

29. The PFRA guidance states that:

30. *'LLFAs only need to record information on floods which had significant harmful consequences. Information on past floods often does not include information on the consequences, or the description is either vague or unreliable. Although no definition is provided in the legislation on what 'significant' means, LLFAs should be mindful of the significance criteria when determining whether past floods are harmful.'*

31. Advice from the Environment Agency indicates that the threshold for past floods with 'significant harmful consequences' should be an order of magnitude lower than the significant threshold for 'future floods' (i.e. clusters of 30,000). Using this criterion would mean that past floods would need to have at least 3,000 people affected to be classified as having 'significant harmful consequences', which is considered to be too high for local flood incidents.

32. Therefore GCC (and other LLFAs in the South West and West Midlands region) have used a lower local threshold for past floods with 'significant harmful consequences'. The local threshold was discussed and agreed by the six districts in Gloucestershire and the Environment Agency. The thresholds are:

- five or more properties flooded internally;
- two or more non-residential properties flooded;
- one or more critical service (e.g. hospital) flooded, and/or;
- a transport link is totally impassable for a significant period.

33. The definition of 'significant period' for transport links to be impassable is dependent on the transport link affected as follows (Highway categories are as set out in Table 1 of the UKRLG Code of Practice for Highway Maintenance).

- Category 1 highways (motorways) and major rail links – 2 hours or more
- Category 2 and 3a highways and other railway links – 4 hours or more
- Category 3b and 4a highways – 10 hours or more
- Category 4b highways – 24 hours or more

34. This threshold is based on the following justification:

- the Environment Agency has split England and Wales into 1km^2 grid cells, and has identified grid cells where 200 or more people, 20 or more non-residential properties, or one or more critical service are at risk of flooding (to a depth greater than 300mm) – these grid cells are known as 'places above flood risk thresholds';
- an order of magnitude lower than the above criteria is 20 or more people (approximately 8 properties assuming 2.34 people/property), 2 or more non-residential properties or one or more critical service at risk of flooding;

- due to the rural nature of Gloucestershire the threshold for the number of residential properties has been reduced to 5 or more residential properties, and;
- The 2-hour period for closure of a motorway or a major railway link is based on a figure suggested by a Highways Agency representative for all parts of the trunk road and motorway network.
- The 4-hour period for closure of a category 2 or 3a highway or other railway link equates to an event affecting one peak period in a working day. (08.00 to 18.00)
- The 10-hour period for closure of a category 3b or 4a highway equates to an event affecting both peak periods in a working day. (08.00 to 18.00)
- The 24-hour period for closure of a category 4b highway equates to an event cutting off small numbers of properties and impacting some rural businesses.
- The difference between major and other rail links has not been specified to avoid being too prescriptive. It is likely that major rail links will have twin tracks carrying several trains per hour in each direction, a number of which will be "through trains" (not stopping at minor stations).

4.2 Past floods in Gloucestershire with significant harmful consequences

35. A summary of past floods in Gloucestershire is provided on a district by district basis below. For the purposes of Annex 1, a screening process was undertaken to determine which flood incidents to record.

- Where the source of the flooding was purely Main River the flood incident was not reported (NB: where flooding was from a combination of Main River and another source of flooding this was reported in Annex 1.
- Where major capital works have been completed since 2007 (e.g. flood protection bund at Bourton-on-the-Water) the flood incident was not reported.
- Where minor capital works have been completed since 2007 (e.g. highway drainage improvements) the flood incident was reported. This is because minor capital works are unlikely to prevent the flooding happening again, although they would reduce the frequency and/or consequences.

4.2.1 Introduction to flooding in Gloucestershire

36. Gloucestershire has a long history of flooding. Based on the Environment Agency Historic Flood Outlines and the data collated for the county-wide Level 1 SFRA there have been the following flood incidents in Gloucestershire:

- Cheltenham Borough – July 1968 and Summer 2007;
- Cotswold District – March 1947, July 1968, August 1977, September 1992, October 1993, April 1998, December 2000, Summer 2007 and January 2008;
- Forest of Dean District - March 1947, July 1968, December 1981, December 2000, Summer 2007;
- Gloucester City – January 1939, March 1947, July 1968, December 1981, January 1990, December 2000, Summer 2007;

- Stroud District – January 1939, March 1947, December 1965, July 1968, December 1981, January 1990, December 2000, Summer 2007, and;
- Tewkesbury Borough - January 1939, March 1947, July 1968, December 1981, 1985, January 1990, April 1998, December 2000, Summer 2007;

37. Due to the scale and impact of the summer 2007 floods, the majority of detailed flood incident records in Gloucestershire are associated with the summer 2007 floods. Annex 1 of this report contains a summary of the total impact of the summer 2007 flooding within Gloucestershire.

38. In the summer 2007 Gloucestershire experienced one of the most significant flood incidents seen in the UK. Following a relatively dry spring the summer was one of the wettest on record. Heavy rainfall at the end of June led to flooding in some areas in Gloucestershire, both from surface water overloading the drainage systems and very high water levels in rivers and brooks. Heavier rain fell in July and on the 20th July the equivalent of two months' rain fell in 14 hours[3]. Resultant severe flooding was experienced across Gloucestershire. A summary of the impact of flooding is provided below:

- **5,000** homes and businesses were flooded (**80%** of properties were affected were overwhelmed by flash flooding);
- **48,000** homes were without electricity for two days;
- Mythe water treatment works was flooded on 22nd July, resulting in **135,000** homes (over half the homes in Gloucestershire) being without drinking water for up to 17 days;
- **825** homes were evacuated resulting in approximately **1,950** people (including **490** children) seeking temporary accommodation;
- **500** businesses were affected;
- **10,000** motorists were stranded on county roads, including the M5 where many people remained overnight;
- **500** commuters were stranded at Gloucester train station;
- over **2,500** people were accommodated in local authority rest centres, many of them commuters from the motorway and rail network, and;
- the estimated cost to repair the county's roads was **£25 million**.

4.2.2 Cheltenham Borough

39. Over 600 properties were flooded in Cheltenham during the summer 2007 floods. Within Cheltenham flooding occurred from a number of sources including fluvial (e.g. River Chelt, Wymans Brook, Hatherley Brook, Mill Stream), surface runoff and exceedance from highway drainage and sewerage systems. Due to the integrated nature of flooding which occurred in Cheltenham it is difficult to separate out the different sources of flooding. The areas which were most significantly affected by the 2007 floods are described below:

[3] In Cheltenham the July 2007 flood was estimated to have a probability of less than 0.8% (1 in 125) chance of occurring in any given year.

- Charlton Kings, including Glynrosa Road, School Road, Sandy Lane, Southfield Manor Park, Oak Avenue, Copt Elm Close, Brookway Road and Langton Place – approximately 70 residential properties were flooded during 2007.

- River Chelt flooding – in July 2007 the River Chelt Flood Alleviation Scheme's design capacity was exceeded, which resulted in approximately 230 residential properties being flooded.

- Hatherley , including the Warden Hill area and further downstream along the Hatherley Brook – approximately 100 residential properties were flooding during 2007.

- Prestbury – flooding occurred due to overtopping of the Mill Stream and surcharging from the Noverton Brook culvert. Locations affected included Mill Lane, Noverton Lane, New Barn Lane, Linden Avenue, Brymore Avenue, Elm Close and Shaw Green Lane – it is estimated that over 70 residential properties were flooded during 2007.

- Whaddon, including Imjin Road, Priors Road, Whaddon Rd, Severn Rd, Thames Rd, Colne Av, Wyman's Rd, Prestbury Road and Cromwell Road – approximately 250 residential properties were flooded during 2007.

4.2.3 Cotswold District

40. Although less densely populated than other local authorities in the county, many people living in towns and villages in the District were affected by severe flooding in the summer of 2007. In total approximately 900 properties were flooded.

41. Following the floods, Cotswold District Council undertook a 'Flooded Homes Survey' which identified the worst affected areas and assessed the mechanisms of flooding within these areas. This included detailed information regarding the source of flooding, location and depth of the floodwaters. The data collected was subsequently reviewed and the top 21 priority areas were identified. In the Cotswold the worst affected areas during the 2007 floods were:

- Chipping Campden where 130 residential properties, 64 non-residential properties and 1 critical service were flooded from surface runoff, exceedance from drainage systems, and surcharging at structures where flow through watercourses is restricted;

- Moreton-in Marsh where approximately 265 residential properties, 3 non-residential properties and 1 critical service were flooded from surface runoff, and surcharging of culverts on the River Evenlode (blocked at Queen Victoria Drive) and the flood relief ditch;

- Fairford where approximately 92 residential properties were flooded although this is largely attributable to fluvial flooding from the River Coln;

- Bourton-on-the-Water where 81 residential properties were flooded, although flood relief works (bunds and improvements to flood relief ditch) have been implemented since 2007;

- Lechlade which suffered from predominantly fluvial flooding from the River Thames (130 properties affected and a caravan site), and;

- Cirencester where 55 residential properties were affected due to a combination of sources of flooding.

42. There were many other settlements in the Cotswolds affected by flooding during the summer 2007 floods.

43. Sewer flooding within Cotswold District was identified at a number of locations, with nine areas where properties were flooded internally (Fairford, South Cerney, Ampney St Mary, Upper and Lower Slaughter, Moreton-in- Marsh, Bourton-on-the-Water and Quenington). Many areas within the District were affected by flooding where sewers cause flooding to gardens and open spaces. In addition, at some locations (e.g. Ampney St Mary and Upper Slaughter) river water inundated the sewer systems making it difficult to distinguish the exact source of flooding (i.e. fluvial or sewer).

4.2.4 Forest of Dean District

44. In comparison to the remainder of Gloucestershire the Forest of Dean was less affected by the summer 2007 floods, and it has been estimated that 93 residential properties were flooded. The areas identified with the highest surface water flooding included:

- Cinderford – overtopping of ordinary watercourses resulted in flooding of 11 residential properties;
- Lydney – approximately 18 residential properties were flooded in Lydney, principally due to overtopping of ordinary watercourses. Locations which flooded include: Lakeside Avenue, Mead Lane, Kimberley Drive and Woodland Rise;
- Longhope – approximately 6 residential properties were flooded at Harts Cove, Longhope Village and Mill Lane;
- Newent – surface runoff affected 10 non-residential properties adjacent to Watery Lane, and;
- Staunton – approximately 10 residential properties were flooded on Gloucester Road, Ledbury Road Crescent and Moat Lane. The source of the flooding is likely to be overtopping of the watercourse due to blockage of the culverted sections.

45. Further locations affected by surface water flooding were identified within the District although these tended to be more rural locations with few properties.

4.2.5 Gloucester City

46. In Gloucester City over 1100 residential properties were flooded during the summer 2007 floods. The areas with the highest perceived risk of surface water flooding include: western side of Gloucester City centre, Quedgeley, Longlevens and Hucclecote. In the majority of cases, the flooding experienced is thought to be a result of culverted urban watercourses which flow through dense, urban areas. These watercourses receive surface water through many thousands of surface water outfalls and when river levels are high, the systems can back-up causing surface water flooding. Areas which experienced the most flooding included:

- Gloucester City Centre – significant flooding occurred throughout Gloucester City Centre (it is estimated that 518 residential properties known to have flooded) due to overtopping of the watercourses and surcharging of the surface water drainage as outfalls to watercourses were blocked due to high levels in watercourses.
- Hucclecote – there were multiple sources of flooding in Hucclecote, including overtopping of Hosbere Brook and Wotton Brook, surface runoff from King George V playing field and backing up of drains. Over 50 residential properties are estimated to have flooded.

- Longlevens – in Longlevens the predominant flooding mechanism was overtopping of the Horsbere Brook, but flooding was also caused by surface runoff and surcharging of storm water drains. Over 270 residential properties are estimated to have flooded.
- Quedgeley – flooding occurred due to overtopping of Daniel's Brook, Dimore Brook and Whaddon Brook, surface runoff from Robin Hill Wood and sewer flooding. 238 residential properties are estimated to have flooded.

4.2.6 Stroud District

47. In Stroud District approximately 200 properties were flooded during the summer 2007 floods. The areas most affected by flooding in 2007 in Stroud were:

- Stonehouse – 87 residential properties flooded;
- Stroud town – 72 residential properties flooded;
- Hardwicke – 26 residential properties flooded;
- Nailsworth – 23 residential properties flooded, and;
- Dursley – 22 residential properties flooded.

48. Other areas within Stroud District which experienced flooding in 2007 include: Berkeley, Bisley, Frampton on Severn, Painswick, and Upton St Leonards.

4.2.7 Tewkesbury Borough

49. The Borough of Tewkesbury is heavily influenced by fluvial flood risk, but surface runoff and insufficient drainage capacity appear to exacerbate the risk. It is worth noting that some properties in Tewkesbury town flooded twice, first from surface water then from rising river levels. In 2007 over 1,800 residential properties are estimated to have been flooded. The main areas of flooding are presented below, although there were a number of other locations which experienced flooding within Tewkesbury Borough.

50. The areas of highest surface water flooding appear to be within Tewkesbury town itself 277 properties flooded in July 2007) around Church Street, Howels Road, Link Road, Oldfield Road and in the Ashchurch area (approximately 63 properties flooded in July 2007). Other key flooded locations in July 2007 included:

- Newtown – 250 residential properties flooded;
- Longford – 107 residential properties flooded;
- Bishops Cleeve – 89 residential properties flooded;
- Northway, Tewkesbury – 79 residential properties flooded, and;
- Winchcombe – 68 residential properties s flooded.

51. For the remainder of the Borough there are a number of recorded flood incidents, but these have generally been in rural locations, affecting highways.

5 Assessment of future floods

5.1 Locally agreed surface water information

52. The PFRA guidance states that:

53. *'LLFAs should: review, discuss, agree and record, with us* [Environment Agency]*, water companies, IDBs and other interested parties, what surface water flood data best represents local conditions. This is known as 'locally agreed surface water information'. LLFAs should determine what 'locally agreed surface water information' means early within the PFRA process.'*

54. To determine the locally agreed surface water information a consultation exercise was undertaken which involved GCC, the Environment Agency and the six district authorities. The consultation provided an opportunity to analyse and review all available sources of surface water flood mapping to determine which were the most representative of known flooding across Gloucestershire.

55. The 'locally agreed surface water information' was a composite of different sources of mapping including SWMP mapping, mapping undertaken by Cotswold District Council, the Areas Susceptible to Surface Water Flooding map, and the Flood Map for Surface Water. A map of the locally agreed surface water information is shown in Figure 5-1.

Local authority boundary	**Summary of locally agreed surface water information**
Cheltenham Borough	Within Cheltenham urban area use the SWMP mapping Outside of Cheltenham urban area use the Flood Map for Surface Water
Cotswold District	Local mapping undertaken by Cotswold District for Andoversford, Chipping Campden, Moreton-in-Marsh, Naunton, Weston sub-edge and Willersey For remainder of District use the Flood Map for Surface Water
Forest of Dean District	Flood Map for Surface Water to be used throughout District
Gloucester City	SWMP mapping to be used throughout Gloucester City
Stroud District	SWMP mapping to be used where available (covers River Frome catchment, covering the eastern half of Stroud District, including Stroud town itself) For the remainder of the District use the Flood Map for Surface Water
Tewkesbury Borough	SWMP mapping to be used where available (covers Carrant Brook, River Swilgate and Tirle Brook catchments), except in Tewkesbury town where the Areas Susceptible to Surface Water Flooding map should be used For the remainder of the Borough use the Flood Map for Surface Water

Table 5-1 Summary of 'locally agreed surface water information'

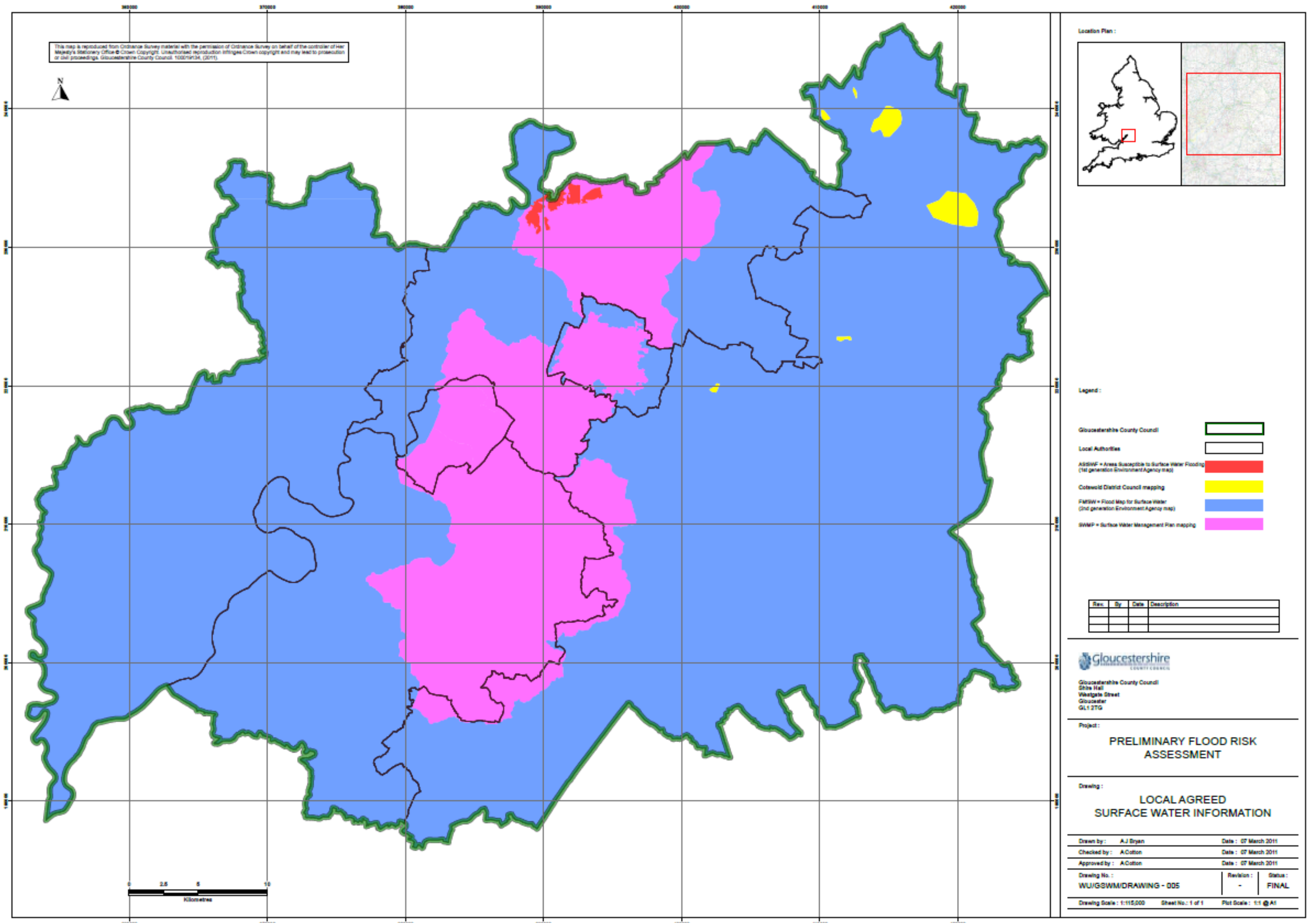

Figure 5-1 Map of 'Locally Agreed Surface Water Information'

5.2 Future floods in Gloucestershire

56. It is essential to consider the consequences of potential future flooding on people, property and the environment. To assess the impact of surface water flood risk within Gloucestershire, the locally agreed surface water information was used in conjunction with the National Receptor Dataset (NRD) (provided by the Environment Agency) and OS MasterMap data (provided by the GCC) to determine the numbers of residential properties, non-residential properties and critical services at risk from surface water flooding within Gloucestershire. It should be noted that this analysis only included predicted flood depths of greater than 0.3m; this will ensure we can identify the highest risk locations and is consistent with the Environment Agency's approach for property counts.

57. The methodology adopted for the property count followed the Environment Agency's 'Flood Map for Surface Water Property Count Method' (Environment Agency, November 2010). This ensured that the counts were consistent with previous work undertaken and followed the latest available guidance. The methodology is described in Section 5.2.1 and 5.2.2 below.

5.2.1 Review of NRD dataset

58. An initial review of the NRD data was undertaken. This was necessary to ensure that any 'non-buildings' (e.g. post boxes, ponds, playgrounds, parks etc) were excluded from the property count. A series of MapInfo queries were run using the OS_Class heading within the NRD dataset to identify the residential and non-residential properties and to remove any unnecessary buildings. Appendix B details the building types that were excluded from the count.

59. The subsequent NRD dataset was then divided into three main categories:

- Residential – including properties identified with an MCM code 1 (Dwelling) or 'blank' OS_Class.
- Non-Residential – including all other categories of property with the exception of those listed in Table A4.1 in Annex 4.
- Critical Services - A review of the OS_Class heading within the non-residential GIS layer was undertaken in consultation with Gloucestershire County Council to identify the Critical Services. Table A4.2 in Annex 4 summaries the OS_Class categories selected as Critical Services.

60. The final property counts were undertaken using these three edited GIS layers.

5.2.2 Property counts based on Locally Agreed Surface Water Information

61. The NRD database itself is comprised of point locations which identify both the centre point of a building and the type of building. For each point location, there may be more than one property associated with the building. This NRD dataset does not however identify the outline of the building itself. As such, when counting properties at risk, using the NRD dataset alone can result in properties whose centre points which fall outside of the flood risk area being excluded from the count.

62. Figure 5-2 demonstrates that when using the NRD dataset alone, whilst point 'B' would have been included within the count, point 'A' would have been excluded as it is located just outside of the flood envelope. However, if the same assessment was made using the OS MasterMap buildings layer, both points 'A' and 'B' are selected, providing a more accurate assessment of the properties at risk.

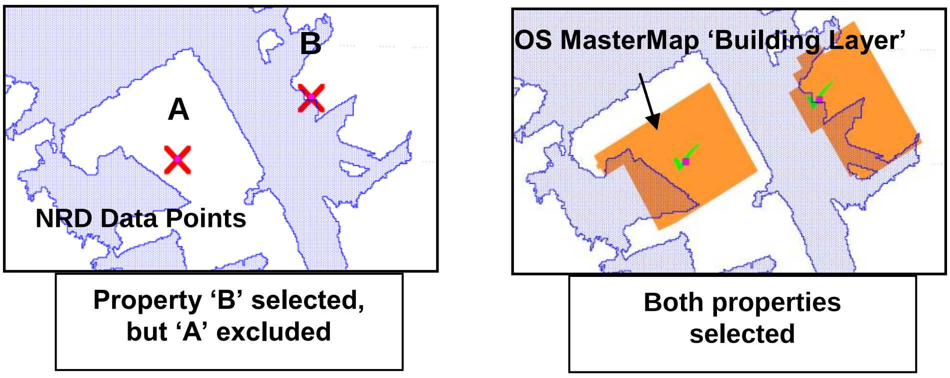

Figure 5-2 **Using OS MasterMap to select properties within the locally agreed surface water information**

63. As such, it was decided that and initial count would be undertaken using the OS MasterMap ‘buildings.’ A MapInfo query was run to identify the buildings that ‘Intersected’ the locally agreed surface water maps and a ‘wetted buildings’ GIS layer produced.

64. The ‘wetted buildings’ layer was then used to relate back to the properties within the filtered NRD layers. A MapInfo query was run to identify the NRD points that were within the ‘wetted buildings’ layer. From this, a final property count was obtained for each local authority area within Gloucestershire, to identify the total number of residential, non-residential and critical services at risk from surface water flooding.

65. Table 5-2 illustrates the number of residential properties (and people), non-residential properties, and critical services at risk of flooding across the County during an extreme rainfall event similar to that experienced in Cheltenham in July 2007.

Location	Number of residential properties	Number of people (no. residential properties x 2.34)	Number of non-residential properties	Number of critical services
County total	**16,753**	**39,202**	**1,486**	**168**

Table 5-2 **Number of residential properties, people, non-residential properties and critical services vulnerable to surface water flooding to a depth of 0.3m or greater, during an extreme rainfall event.**

5.2.3 1km^2 grid square assessment

66. An additional assessment of properties at risk was undertaken to determine the number of properties at risk per 1km^2 area within Gloucestershire. Within MapInfo, a 1km^2 grid was created covering the entire county. The final property counts for residential, non-residential and critical services were then queried to determine the total number of properties at risk within each 1km^2 grid (for an extreme rainfall event) and a GIS layer created summarising the information.

67. Figure 5-3 illustrates the outputs of this analysis, and can be used to identify the locations within Gloucestershire which are at greatest risk of flooding. The grid squares are coloured based on the following: 10-24 properties = light blue, 25-49 properties = darker blue, 50-99 properties = yellow, 100-199 properties = orange, and >200 properties = red. The outputs from this assessment will be further analysed and refined as part of the development of the Local Flood Risk Management Strategy.

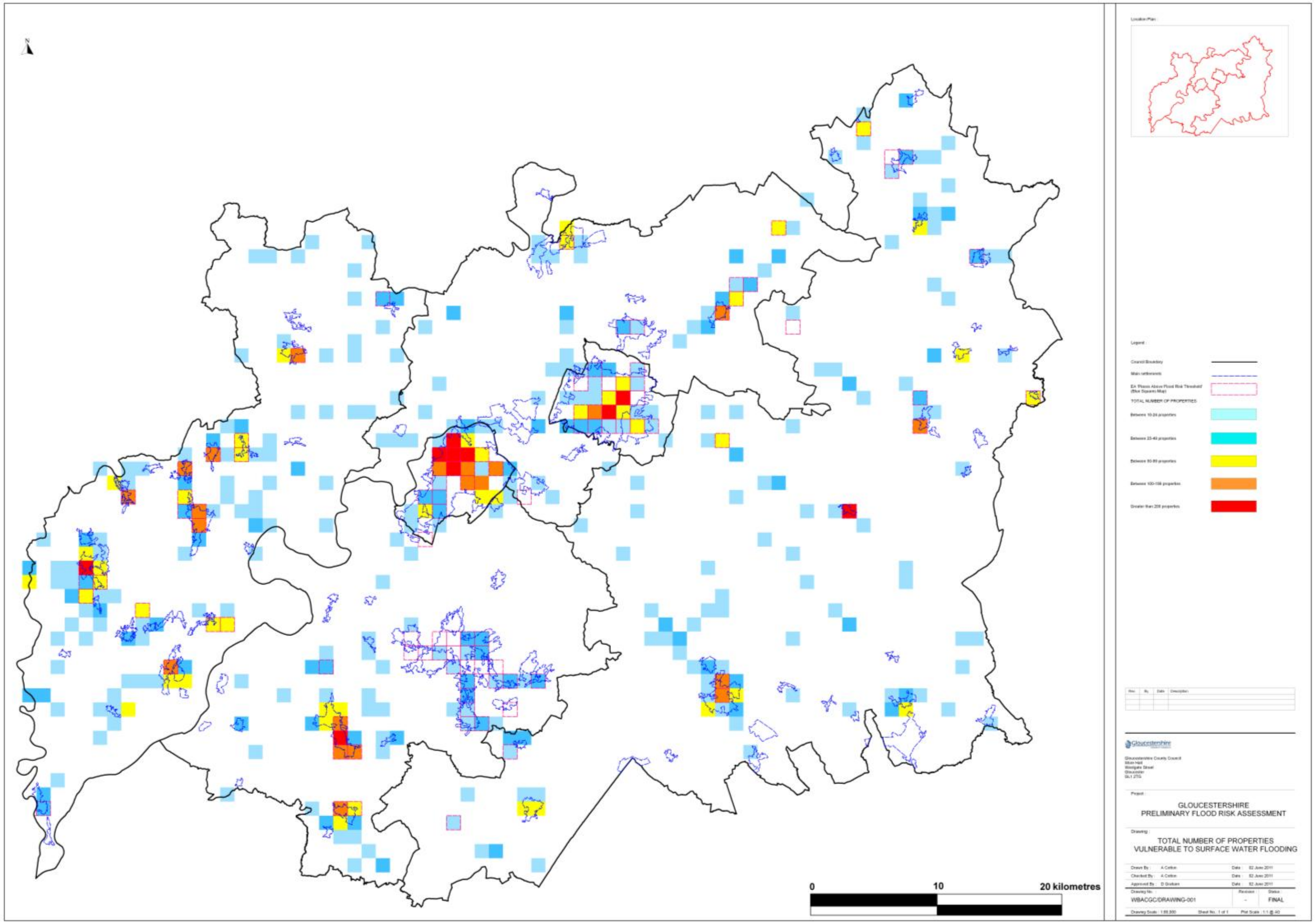

Figure 5-3 **Total number of 'properties' (residential, non-residential and critical services) vulnerable to surface water flooding during an extreme rainfall event per 1km² grid square**

5.3 The impacts of climate change

68. There is clear scientific evidence that global climate change is happening now. It cannot be ignored. Over the past century around the UK we have seen sea level rise and more of our winter rain falling in intense wet spells. Seasonal rainfall is highly variable. It seems to have decreased in summer and increased in winter, although winter amounts changed little in the last 50 years. Some of the changes might reflect natural variation, however the broad trends are in line with projections from climate models.

69. Greenhouse gas (GHG) levels in the atmosphere are likely to cause higher winter rainfall in future. Past GHG emissions mean some climate change is inevitable in the next 20-30 years. Lower emissions could reduce the amount of climate change further into the future, but changes are still projected at least as far ahead as the 2080s.

70. We have enough confidence in large scale climate models to say that we must plan for change. There is more uncertainty at a local scale but model results can still help us plan to adapt. For example we understand rain storms may become more intense, even if we can't be sure about exactly where or when. By the 2080s, the latest UK climate projections (UKCP09) are that there could be around three times as many days in winter with heavy rainfall (defined as more than 25mm in a day). It is plausible that the amount of rain in extreme storms (with a 1 in 5 annual chance, or rarer) could increase locally by 40%.

5.3.4 Key projections for the Severn and Thames River Basin District

71. For the Severn RBD, if emissions follow a medium future scenario, UKCP09 projected changes by the 2050s relative to the recent past are:

- Winter precipitation increases of around 12% (very likely to be between 2 and 26%)
- Precipitation on the wettest day in winter up by around 9% (very unlikely to be more than 22%)
- Relative sea level at Bristol very likely to be up between 10 and 40cm from 1990 levels (not including extra potential rises from polar ice sheet loss
- Peak river flows in a typical catchment likely to increase between 9 and 18%

Increases in rain are projected to be greater at the coast and in the south of the district.

72. For the Thames RBD, if emissions follow a medium future scenario, UKCP09 projected changes by the 2050s relative to the recent past are:

- Winter precipitation increases of around 15% (very likely to be between 2 and 32%)
- Precipitation on the wettest day in winter up by around 15% (very unlikely to be more than 31%)
- Relative sea level at Sheerness very likely to be up between 10 and 40cm from 1990 levels (not including extra potential rises from polar ice sheet loss)
- Peak river flows in a typical catchment likely to increase between 8 and 18%

73. Climate changes can affect local flood risk in several ways. Impacts will depend on local conditions and vulnerability.

74. Wetter winters and more of this rain falling in wet spells may increase river flooding along the Severn and its tributaries. More intense rainfall causes more surface runoff, increasing localised flooding and erosion. In turn, this may increase pressure on drains, sewers and water quality. Storm intensity in

summer could increase even in drier summers, so we need to be prepared for the unexpected. Drainage systems in the district have been modified to manage water levels and could help in adapting locally to some impacts of future climate on flooding, but may also need to be managed differently. Rising sea or river levels may also increase local flood risk inland or away from major rivers because of interactions with drains, sewers and smaller watercourses.

75. Where appropriate, we need local studies to understand climate impacts in detail, including effects from other factors like land use. Sustainable development and drainage will help us adapt to climate change and manage the risk of damaging floods in future.

5.3.5 Adapting to climate change

76. Past emission means some climate change is inevitable. It is essential we respond by planning ahead. We can prepare by understanding our current and future vulnerability to flooding, developing plans for increased resilience and building the capacity to adapt. Regular review and adherence to these plans is key to achieving long-term, sustainable benefits. Although the broad climate change picture is clear, we have to make local decisions uncertainty. We will therefore consider a range of measures and retain flexibility to adapt. This approach, embodied within flood risk appraisal guidance, will help to ensure that we do not increase our vulnerability to flooding.

5.4 Long term developments

77. It is possible that long term developments might affect the occurrence and significance of flooding. However current planning policy aims to prevent new development from increasing flood risk.

78. In England, Planning Policy Statement 25 (PPS25) on development and flood risk aims to "ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Where new development is, exceptionally, necessary in such areas, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall."

79. Adherence to Government policy ensures that new development does not increase local flood risk. However, in exceptional circumstances the Local Planning Authority may accept that flood risk can be increased contrary to Government policy, usually because of the wider benefits of a new or proposed major development. Any exceptions would not be expected to increase risk to levels which are "significant" (in terms of the Government's criteria), but should be recorded here so that they can be reviewed in the future.

6 Review and identification of 'Flood Risk Areas'

80. The PFRA is high level screening exercise to identify the areas of most significant 'flood risk areas' across Europe. To ensure a consistent national approach Defra have identified significance criteria for identifying 'flood risk areas' under the PFRA. Guidance on setting the significance criteria is outlined in Defra's guidance to LLFA's 'Selecting and Reviewing Flood Risk Areas for local sources of flooding'.

81. In England the following process has been undertaken by the Environment Agency to identify indicative 'flood risk areas':

- England has been divided up into a $1km^2$ grid;
- the Environment Agency's 'Flood Map for Surface Water' (>0.3m depth of flooding) has been used to count the number of people, number of non-residential properties and number of critical services at risk of surface water flooding within each $1km^2$ cell;
- where a $1km^2$ cell has more than 200 people and/or more than 20 non-residential properties and/or one of more critical service at risk of surface water flooding the cell is classified as a 'place above flood risk thresholds';
- clustering analysis has been undertaken to identify clusters of $1km^2$ cells which are 'places above flood risk thresholds', and;
- where a cluster contains 30,000 people or more at risk of surface water flooding this has been classified as an 'indicative flood risk area'.

82. Using the Environment Agency criteria stated above there are ten 'Flood Risk Areas' in England, none of which are in Gloucestershire. GCC are not proposing to add any new 'Flood Risk Areas' for the PFRA.

83. There may be areas within Gloucestershire which local partners consider to be locally important areas of flooding but are not considered to be a 'Flood Risk Area' for the purposes of the PFRA. Management of locally important areas of flooding should be carried out through the local flood risk management strategies, which Gloucestershire County Council will be developing throughout 2011 as part of new responsibilities provided in the Flood and Water Management Act.

7 Next steps

7.1 Ongoing work to support future PFRA reviews

84. In accordance with the Flood Risk Regulations the PFRA is to be reviewed on a 6 yearly cycle. As part of their new responsibilities under the Flood and Water Management Act and to support the future reviews of the PFRA, GCC will be:

- developing an online GIS mapping tool to capture, view and edit relevant information on flood risk management, including flood incident and asset data – all local flood risk management partners will be able to access the tool to view, edit and add flood incident and asset data relevant to local flood risk management;
- developing Surface Water Management Plans in the areas most vulnerable to surface water flooding in Gloucestershire, subject to available funding, and;
- continuing to build close partnership working with local flood risk management partners to better understand and alleviate flood risk in Gloucestershire.

7.2 Scrutiny and review procedures

85. The scrutiny and review procedures for the PFRA have been set out in the PFRA guidance provided by the Environment Agency.

86. The first part of the review process for the PFRA is through an internal review by GCC. Within GCC, the PFRA was put before the Environment Scrutiny committee on 15th March 2011.

87. Under the Flood Risk Regulations the Environment Agency has a duty to review, collate and publish all of the PFRAs nationally. The Environment Agency (area review and national review) has reviewed the PFRA to ensure it meets the minimum requirements required by the Flood Risk Regulations and to provide an opinion on the selection/amendment of any 'Flood Risk Areas', and is satisfied that the PFRA meets the requirements of the Flood Risk Regulations. The Environment Agency subsequently made recommendations to the relevant Regional Flood Defence Committee (RFDC) for endorsement. Once the RFDC has endorsed the PFRA a relevant Director at the Environment Agency has signed-off PFRA, after which all PFRAs will be collated, published and submitted to the European Commission in December 2011.

8 References

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Annex 1 Past floods

Annex 2 Future floods

Annex 3 Flood Risk Areas

Annex 4 Supporting information for property counts

OS Base Function	OS Base Function	OS Base Function
ADVENTURE PLAYGROUND	JETTY	POLICE EMERGENCY TELEPHONE
AERATION	KILN	POLO
AGRICULTURAL SHOWGROUND	LANDFILL	POND
ALLOTMENT	LANDING STAGE	PONTOON
APIARY	LEISURE PIER	POST BOX
AQUEDUCT	LIME KILN	PUBLIC CAR PARKING
ARBORETUM	LIMESTONE EXTRACTION	PUBLIC GARDEN
ARMONATIC GARDEN	LOCK	PUBLIC TELEPHONE
ASH DISPOSAL	MAZE	RABBIT FARMING
BANDSTAND	MEMORIAL GARDENS	RESERVOIR
BASIN	METEOROLOGY	ROLLER SKATING
BASKETBALL	MINE	RUGBY
BIRD OBSERVATORY	MINERAL AND FUEL EXTRACTION	SEA FISHING
BMX RACING	MINERAL WATER FACTORY	SEWAGEFILTRATION
BOATING	MODEL BOATING	SEWAGEOUTFALL
BRINE RESERVOIR	MOORING	SEWAGEPUMP HOUSE
BURIAL GROUND	MUSSEL BED	SEWAGEPUMPING
BUS SHELTER	NATURE GARDEN	SEWAGERECYCLING
BUTTERFLY FARM	NETBALL	SEWAGESTORAGE
CHIMNEY	ORNAMENTAL GARDEN	SEWAGETREATMENT
COAL STORAGE	OSIER BED	SHAFT
COMMEMORATIVE GARDEN	OYSTER BED	SHOWGROUND
CRANE	PADDLING	SKATEBOARDING
CRAZY GOLF	PARK	SKIING
CROQUET	PETS MEMORIAL GARDENS	SLAG HEAP
DOCK	PHEASANTRY	SLATE EXTRACTION
DOCK BASIN	PIER	SPOIL HEAP
ELECTRICITY SUB STATION	PIGGERY	TREE NURSERY
EMERGENCY TELEPHONE	PITCH AND PUTT	VAPOUR STACK
FIRST AID POST	PLAY AREA	VINEYARD
FLARE STACK	PLAYING FIELD	WATERCRESS BED
GARDEN OF REST	PO BOX	WATERWHEEL
HYDRAULIC POWER	POINT TO POINT RACING	WEIGHBRIDGE

Table A4.1 Points listed within NRD as a 'property' but excluded from the surface water property count (based on Environment Agency Flood Map for Surface Water Property Count Method)

Critical Services	
AMBULANCE STATION	OIL REFINING
CENTRAL GOVERNMENT OFFICE	POLICE SERVICES
CHEMICAL WORKS	POLICE STATION
CHILDRENS NURSERY	PRE SCHOOL EDUCATION
COUNCIL DEPOT	PRIMARY SCHOOL
CROWN COURT	PRIVATE PRIMARY SCHOOL
ELECTRICITY GENERATING	PUMP HOUSE
FIRE STATION	PUMPING
FIRE TOWER	RADIO COMMUNICATIONS
FIRST SCHOOL	RADIO STATION
FUEL DEPOT	REST HOME
FURTHER EDUCATION COLLEGE	RETIREMENT HOME
GAS REGULATING	SCHOOL
GAS STORAGE	SECONDARY SCHOOL
GOVERNMENT OFFICE	SOCIAL SERVICES
HIGH SCHOOL	SPECIAL SCHOOL
HIGHER EDUCATION	SURGERY
HM COASTGUARD RESCUE	TELECOMMUNICATIONS
HM PRISON	TELEPHONE EXCHANGE
HOSPICE	TELEPHONE RELAYING
HOSPITAL	TELEVISION COMMUNICATIONS
INFANT SCHOOL	UNIVERSITY
LEISURE CENTRE	WASTE DISPOSAL
LOCAL GOVERNMENT OFFICE	WATER DISTRIBUTION
MENTAL HEALTH CENTRE	WATER FILTRATION
MIDDLE SCHOOL	WATER STORAGE
NURSING HOME	WATER TREATMENT

Table A4.2 OS_Class categories selected from the NRD dataset to make up the Critical Services layer