3. CURRENT DEVELOPMENT AND FLOOD RISK

This Chapter summarises the best available knowledge with regard to general current sources of flooding and flood risk within the SFRA study area. Flooding can arise from a variety of sources, not just fluvial floodplains. The autumn 2000 Flood Report [1] from the Environment Agency reported that some 42% of flood reports in 2000 arose from sources other than fluvial, namely:

- General land drainage and surface water
- Groundwater
- Highway and urban sewer systems

The July 2007 flooding within Herefordshire also substantially arose from sources other than fluvial floodplains, in particular general surface water runoff, which was characterised by the rapidity of the rise in floodwater. Some 65% of the national flooding reports of July 2007 arose from overwhelmed drains, culverts sewers and ditches [2].

3.1 Environment Agency Data Sources

3.1.1 Environment Agency Flood Maps

A foremost source of flood-risk identification will always be the Environment Agency generated Flood Zone Maps [3]. These Flood Zone Maps are published by the Environment Agency and are available online from the Environment Agency's website, http://www.environment-agency.gov.uk/floodmap.

The Flood Map is revised and updated 4 times yearly, and updated Flood Maps are issued in electronic form to all Local Planning Authorities (LPAs) for planning purposes. The Flood Map is designed to raise awareness among the public, local authorities and other organisations of the likelihood of flooding, and to encourage people living and working in areas prone to flooding to find out more and take appropriate action.

The Flood Map can also be used by anyone who wants to apply for planning permission in England and Wales to see whether the site they plan to develop is in one of the Flood Zones specified by the government's planning policy.

3.1.2 Historic Flood Maps

The Environment Agency also periodically issues to LPAs Historic Flood Maps for many locations. These are compilation maps which show the extent of major historical floods in combination with groundwater and/or tidal flooding. These extents may be more or less than the extent of the 1% probability floodplain maps depending on the magnitude of the historical flood. Historic flood events should be taken into account for all development sites. Where a historic flood event has affected a proposed development site, flood resistance and resilience should be incorporated into the site design. The historic flood maps are held by Herefordshire Council IT Department as GIS layer **NAT_HFM_1_xx** where xx is a version number.

3.1.3 Environment Agency Flood Zones

Flood Zones, also known as floodplains, are areas of land which could be affected in the event of flooding from rivers or the sea. Flood zones are mapped ignoring the presence of existing flood defences, since defences can be 'overtopped' if a flood occurs which is higher than that which defences are designed to withstand.

A recent example is the overtopping of The Stank at Hampton Bishop during the July 2007 floods.

Evidence Map 3-1 shows the Environment Agency Flood Zones 2 and 3 for the entire SFRA study area. In essence, there are 3 defined Flood Zones as set out under Table D.1, PPS 25 [4]

Flood Zone 1 – Low Probability
This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or tidal flooding in any single year (< 0.1%).

All uses of land are appropriate in this zone.

Flood Zone 2 – Medium Probability
This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of fluvial flooding in any single year (1% - 0.1%), or between a 1 in 200 and 1 in 1000 annual probability of fluvial flooding in any single year (0.5% - 0.1%).

Essential infrastructure, water compatible, less vulnerable and more vulnerable uses of land may all be appropriate in this zone. Generally, subject to the Sequential Test being applied, highly vulnerable uses of land are only appropriate if the Exception Test has been passed. See Chapter 4.

Flood Zone 3a – High Probability
This zone comprises land having a 1 in 100 or greater probability of fluvial flooding (> 1%) or a 1 in 200 (> 0.5%) probability of tidal flooding in any single year.

Generally, only water compatible uses or more vulnerable and essential infrastructure subject to the Exception Test would be permitted in Zone 3a. Highly vulnerable uses should not be permitted. Less vulnerable development is considered an appropriate use of land, subject obviously to the appropriate sequential tests and compliance with 'safe' development criteria.

Flood Zone 3b – Functional Floodplain
This zone comprises land where water has to flow or be stored during flood events. Generally this land is defined as having a probability of flooding in any

single year of 1 in 20 (> 5%) OR land which is designed to flood at a probability of 0.1%.

In general no development other than water compatible uses would be permitted in this zone.

3.1.4 Environment Agency Flood Defences

The published Flood Map also gives the location of raised flood defences such as embankments and walls, as well as land designated and operated to store flood water.

Areas that would normally benefit from flood defences during a major flood are also shown on the Flood Map. Because defences are in place, these areas can be expected to flood less often. Not all areas that benefit from flood defences are currently shown, but the map is regularly updated as the Environment Agency obtains further information from ongoing studies.

We consider the current Environment Agency Flood Defences map to be outdated (version 2.2). This SFRA has updated notable defence schemes in the study area, in particular those of the Lugg at Leominster, the Wye at Hereford, and the Rudhall Brook at Ross-on-Wye, see **Evidence Map 3-1**.

3.1.5 Environment Agency Historical Reports

The Environment Agency regional offices at Cardiff, Tewkesbury, Monmouth and Shrewsbury hold varying degrees of valuable historical and anecdotal flood information. All of these offices were visited to obtain as much data as possible on historical flooding. A substantial and useful collation of various historical flood reports is held at the Monmouth office, and much of this has been incorporated into the database developed for this study.

Much of the Environment Agency data and information is not held in easily accessible electronic form, largely ad hoc spreadsheets and paper records. The cost and time of collating this information into more useable formats (principally GIS layers and databases) was very substantial, and it is a recommendation of this SFRA that the appropriate departments of the Environment Agency and Herefordshire Council work more closely together in future to maintain and update the substantially improved databases that have been delivered as part of this Strategic Flood Risk Assessment.

A specific **Flood Incident Report Form** has been developed as part of this study for improved reporting and data collation.

3.1.6 National Flood and Coastal Defence Database (NFCDD)

The Environment Agency hosts and maintains a powerful web based database and Geographic Information System which is accessible to Local Planning Authorities. This is known as the National Flood and Coastal Defence Database (NFCDD v. 3.3).

The NFCDD is accessible on-line via:

https://nfcdd.environment-agency.gov.uk/nfcdd

A User Account and password are required to access the system. To our knowledge, although NFCDD has been available for some time, Herefordshire Council has not made use of this valuable resource. To this end the SFRA team has set up the Herefordshire Council account.

The NFCDD support desk can be reached at 08708 506506.

The NFCDD operates on a layered approach, similar to a GIS, whereby the user can select from a wide range of data types (including O.S. Map backgrounds, flood infrastructure, flood warning systems, standards of defences flood reports etc.). The example overleaf is a screen-shot of Leominster, detailing the various flood defence infrastructure at the Sports Centre.

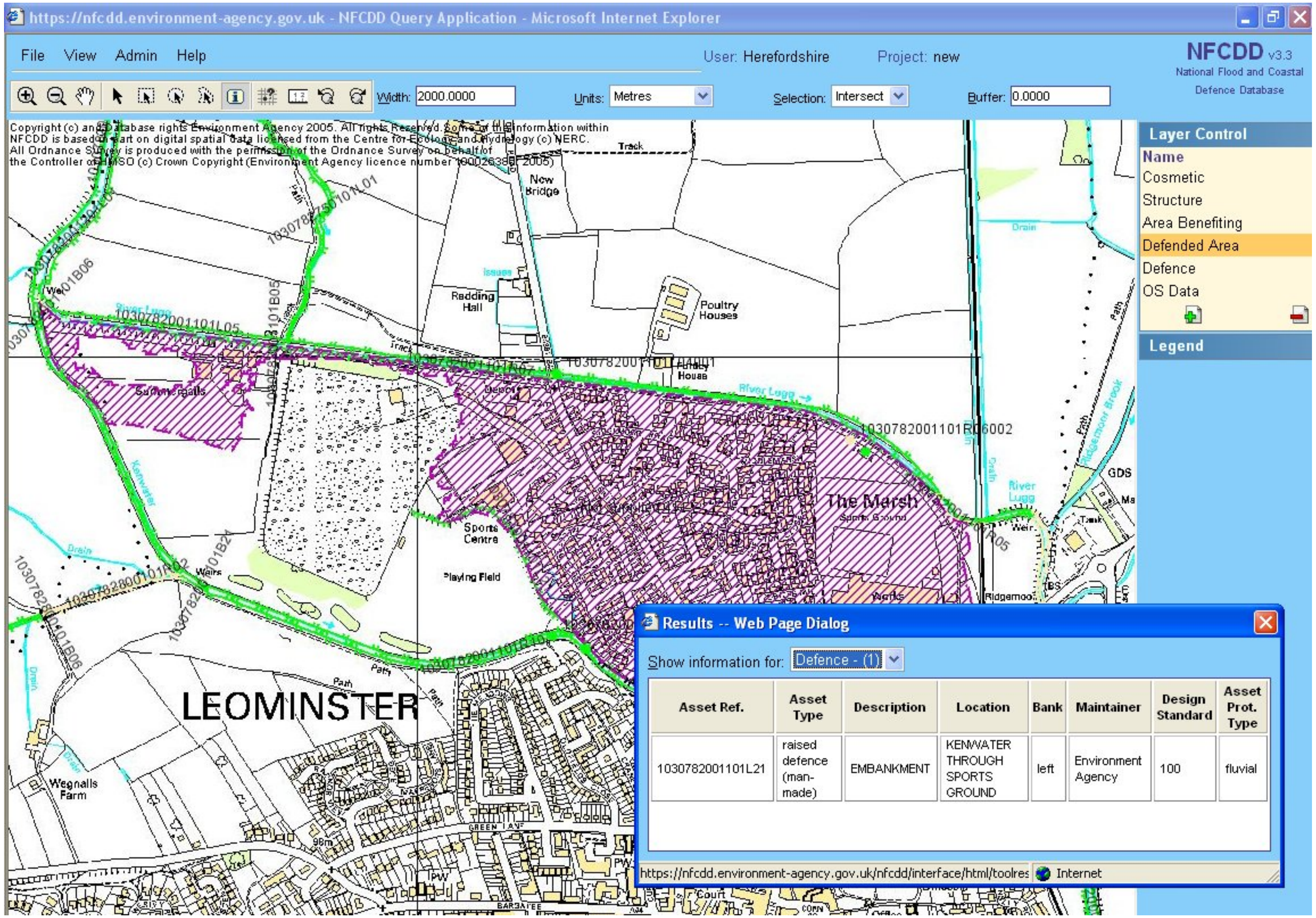
Figure 3-1 – Example Output of NFCDD for Local Authority Use

This example shows the flood defence assets in the centre of Leominster, with various data layers selected, including Structures, Areas benefiting from Defences, Defended Areas and Ordnance Survey background.

Any object layer can be queried, in this case to identify the flood defence bank around the playing field, and to establish its standard of flood protection.

Please note that NFCDD does not currently function with Internet Explorer v7.0. Version 6.x or earlier must be used.

Source: Environment Agency, NFCDD



3.2 Functional Floodplain Assessment

3.2.1 Definitions

The functional floodplain is expressly addressed under PPS 25 Table D.1 which is defined as *"land where water has to flow or be stored in times of flood".* Arguably this might be extended to any floodplain but this is not the strict intention of the definition. The functional floodplain should be identified within SFRAs so that active water conveyance routes (flood pathways), or areas of relatively frequent storage are preserved, and where possible even recovered from previous uses.

Specifically, the functional floodplain is 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 (e.g. washlands and/or strategic storage zones), or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes. This zone is often approximated in SFRAs, or possibly identified from detailed hydraulic modelling.

The functional floodplain is of importance to current and future development because only the water-compatible uses and the essential infrastructure listed in Table D.2 that has to be there should be permitted in this zone. It should be designed and constructed to:

- remain operational and safe for users in times of flood
- result in no net loss of floodplain storage
- not impede water flows
- not increase flood risk elsewhere.

Essential infrastructure in this zone should pass the Exception Test.

3.2.2 Outputs

For consistency with the other general flood outlines provided by the EA national generalised floodplain model (i.e. the 0.1%, 1% and 1% + climate change outlines) as part of this SFRA, specific runs were commissioned of this model to generate the 5% flood outlines for all of the Herefordshire region. This included the River Wye and all its tributaries between Hay-on-Wye and Ross-on-Wye, and the River Leadon and its tributaries.

The River Teme was excluded from the analysis because only relatively small areas of the Teme catchment fall within Herefordshire, lesser still when identifying potential development sites.

This floodplain outline is included in the GIS outputs as the **HSFRA Functional Floodplain** layer.

It is evident that the Functional Floodplain layer is very extensive in many areas, comparable to the extent of the 1% AEP flood extent. This is the result of using a relatively conservative metric (i.e. the 5% annual probability flood) to define the 'functional floodplain'. The Generalised Model used to generate the functional floodplain (the same as the Environment Agency's Flood Zone Maps) does not distinguish between passive storage and active conveyance within floodplains because it simply inundates all land at the projected flood level, irrespective of whether or not this water is actually moving.

In practice many river engineers consider that, dedicated storage zones aside, the truly functional floodplain is only that which has moving water within it, as opposed to areas where water is additionally stored until such time as the flood level drops. The **HSFRA Functional Floodplain** shows the latter scenario, and therefore is highly conservative with respect to 'functionality'.

In reality, the truly functional floodplain (i.e. that which is required for conveyance) can only be determined by sensitivity testing of a hydraulic model to demonstrate the minimum head (flood level) to convey the appropriate peak flow for the design event in question. Once this level is attained, additional flow volumes will simply move sideways into storage.

For the purposes of this SFRA, it is recommended that the functional floodplain map is regarded as indicative, not definitive. The presence of a potential development site within Flood Zone 3b (functional floodplain) should act as a trigger for a more detailed site level hydraulic analysis. In many instances, this analysis is likely to show that the functional floodplain is very much less than indicated by the Strategic Flood Risk Assessment.

It should be noted that in some areas (e.g. Hereford city), the functional floodplain map is inconsistent with the 1% probability flood outlines prepared by the Environment Agency (as of October 2008). This is because revisions to the flood maps derived from sources other than the Generalised Model have superseded the published zones incorporated in this study. This is particularly so of the Yazor and Eign Brook within Hereford.

3.3 Herefordshire Local Flood Data Sources

3.3.1 Highways and Parish Surveys

Up to 2007, the principal source of flood information held within Herefordshire Council was restricted to ad hoc reporting of Highways flooding. This data is not held in any systematic format, and is largely on paper, including annotated maps. Whilst these data sources were investigated, and as far as resources permitted, information was processed by the SFRA team into electronic format, it is likely that perhaps only 50 – 60% of persistent highway flooding is logged in the database and GIS.

In July 2007, following the massive property and highway disruption of the summer flooding, the Highway Maintenance Department of Herefordshire Council commissioned a simple questionnaire based survey of flood reports of all Herefordshire Parish Councils. This survey had an excellent response, and provided quality information throughout the County on localised flood reports.

This survey was supplemented by a parallel investigation of Parish Councils, managed by the Economic Regeneration Department of Herefordshire Council. Unfortunately these two surveys overlapped substantially, whilst still including important separate information. It was a disproportionately expensive exercise attempting to resolve and extract data from the two databases.

The great importance of maintaining central, efficient databases for this type of purpose cannot be over-emphasised, as the cost of collating the information at a later date from a variety of ad hoc sources becomes prohibitively time consuming and expensive.

3.3.2 HSFRA Flood Reports Database

One of the central undertakings of the SFRA has been to create a **HSFRA Flood Reports** Database and GIS layer that incorporates all of these 2007 reports, but also includes as far as could be readily determined, other historical and anecdotal flood reports throughout the County from a wide range of sources, including local knowledge, the Environment Agency flood reports cited in 3.1.4 above, BBC News reports, and Consultant studies.

It is undoubtedly the most complete reference for historical flood reports available, and is one of the foundation evidence bases of the Strategic Flood Risk Assessment. It includes to date some 552 separate records, incorporating approximately 920 individual flood reports, but it is at a best estimate only 70% complete.

In compliance with PPS25 ‘best practice’, the HSFRA Flood Reports database gives a comprehensive insight into the exact locations and mechanisms of flooding for each record (where these have been recorded). As Figure 3-3 shows, as well as mapping every recorded flood incident, (which provides a powerful aid to the spatial assessment of flood risk under the Sequential Test), the database records a number of key fields, including the relevant watercourse, nearest settlement, the type of flooding under four categories (Property, Highway, Amenity or School), the general location, the District Postcode, and upto three dates of flooding to account for multiple reports. Where depths and/or flood levels are reported, these can also be recorded. Crucially, the probable source of flooding is also recorded, so this is invaluable when identifying flood risks outside the Environment Agency Flood Zones 2 & 3. 8 source types of flooding have been classified, and it is possible to search by this type of flooding for any location within Herefordshire

In common with all relational databases, it is therefore possible to query the GIS Flood Reports layer by any attribute to identify specific flood risks. For example, a query can be set to identify all flood reports within a particular locality, either by postcode district e.g. HR8 1 or name e.g. Bosbury.

Simple relational queries can also be made. For example, with the GIS layers **HSFRA Flood Reports** and **HSFRA All Catchments** added, it is possible to identify all flood reports of source "land drainage" arising in sub-catchment "Lower Leadon".

Rapid 'point and click' assessment of any flood report can be obtained via the GIS Info Tool. In the example of Figure 3-2, there are two properties with a flood report at Kingstone in June 1985, external to the fluvial flood zones.

Figure 3-2 - Screen-shot of MapInfo® Info Tool query

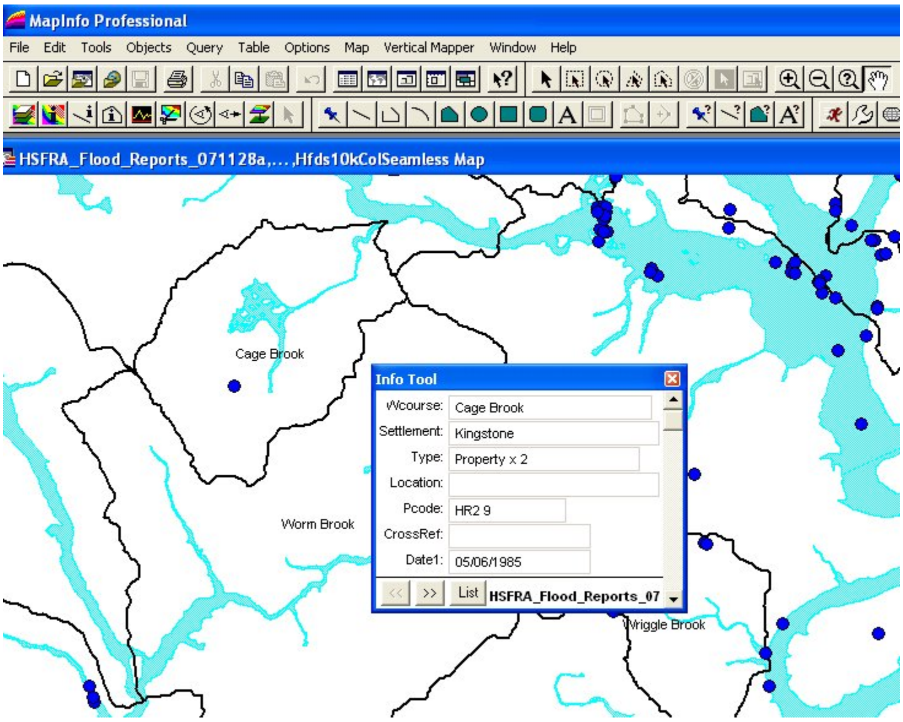
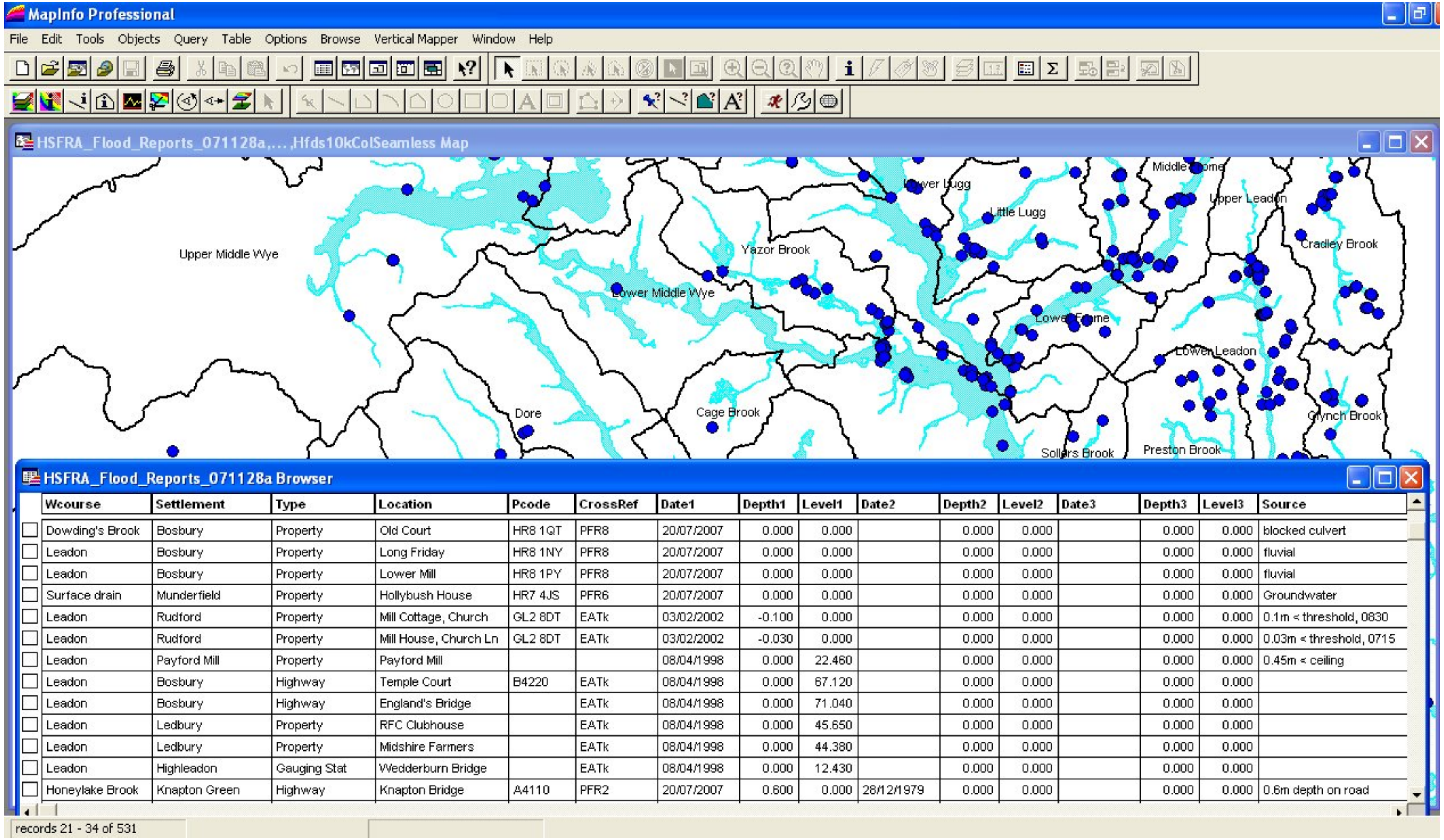


Figure 3-3 – Example Output of HSFRA Flood Reports Database and GIS Layer



Wcourse	Settlement	Type	Location	Pcode	CrossRef	Date1	Depth1	Level1	Date2	Depth2	Level2	Date3	Depth3	Level3	Source
Dowding's Brook	Bosbury	Property	Old Court	HR8 1QT	PFR8	20/07/2007	0.000	0.000		0.000	0.000		0.000	0.000	blocked culvert
Leadon	Bosbury	Property	Long Friday	HR8 1NY	PFR8	20/07/2007	0.000	0.000		0.000	0.000		0.000	0.000	fluvial
Leadon	Bosbury	Property	Lower Mill	HR8 1PY	PFR8	20/07/2007	0.000	0.000		0.000	0.000		0.000	0.000	fluvial
Surface drain	Munderfield	Property	Hollybush House	HR7 4JS	PFR6	20/07/2007	0.000	0.000		0.000	0.000		0.000	0.000	Groundwater
Leadon	Rudford	Property	Mill Cottage, Church	GL2 8DT	EATk	03/02/2002	-0.100	0.000		0.000	0.000		0.000	0.000	0.1m < threshold, 0830
Leadon	Rudford	Property	Mill House, Church Ln	GL2 8DT	EATk	03/02/2002	-0.030	0.000		0.000	0.000		0.000	0.000	0.03m < threshold, 0715
Leadon	Payford Mill	Property	Payford Mill			08/04/1998	0.000	22.460		0.000	0.000		0.000	0.000	0.45m < ceiling
Leadon	Bosbury	Highway	Temple Court	B4220	EATk	08/04/1998	0.000	67.120		0.000	0.000		0.000	0.000	
Leadon	Bosbury	Highway	England's Bridge		EATk	08/04/1998	0.000	71.040		0.000	0.000		0.000	0.000	
Leadon	Ledbury	Property	RFC Clubhouse		EATk	08/04/1998	0.000	45.650		0.000	0.000		0.000	0.000	
Leadon	Ledbury	Property	Midshire Farmers		EATk	08/04/1998	0.000	44.380		0.000	0.000		0.000	0.000	
Leadon	Highleadon	Gauging Stat	Wedderburn Bridge		EATk	08/04/1998	0.000	12.430		0.000	0.000		0.000	0.000	
Honeylake Brook	Knapton Green	Highway	Knapton Bridge	A4110	PFR2	20/07/2007	0.600	0.000	28/12/1979	0.000	0.000		0.000	0.000	0.6m depth on road

3.4 Consultant Studies and Modelling

A significant number of hydraulic, hydrological and Flood Risk investigations have been conducted within Herefordshire in the last 20 years. Copies of most of these detailed technical reports are held by the Environment Agency for reference, but there may be licensing, copyright and confidentiality issues associated with obtaining data from these studies. A number of these studies have been carried out for Herefordshire Council itself, in which case data would be available to third parties.

The majority of the studies have been commissioned by Environment Agency (Wales) under its Strategic Flood Risk Management (SFRM) Framework Agreement.

Herefordshire Council and developers should be aware of all such studies in the SFRA area, as the data and knowledge held within these reports with respect to flood risk represents an important asset to the County which has entailed significant technical and financial resources over the years.

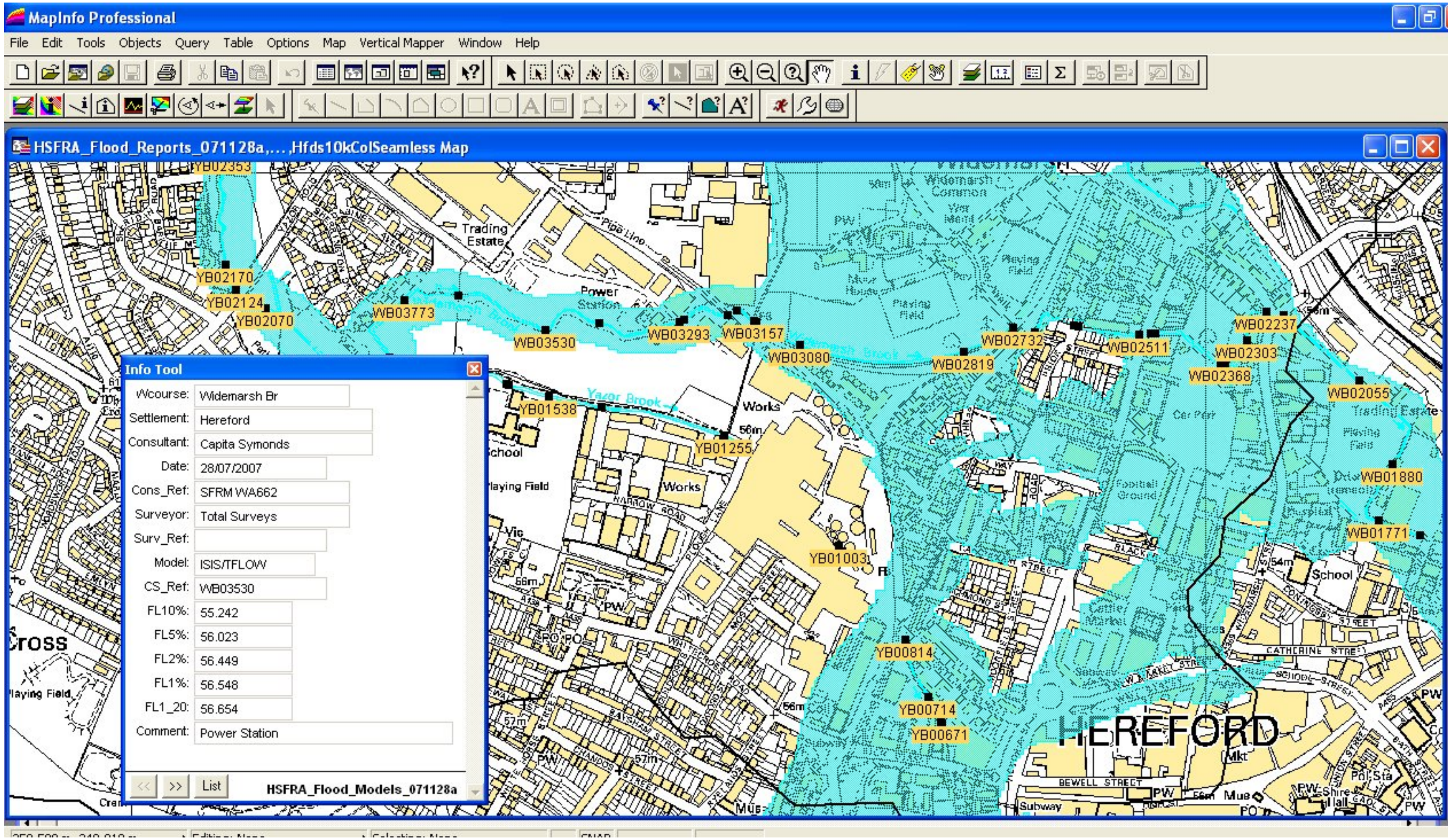
A substantial evidence base has been prepared that identifies as far as possible every modelled cross-section within Herefordshire. The database and GIS layer **HSFRA Flood Models** incorporates detailed information on each hydraulic model, including the consultant, the date, cross-section identifier etc. The purpose of this evidence base is to provide further detailed hydraulic information on flood levels, flood depths and velocities, which may be required of more detailed Flood Risk Assessments under PPS 25, especially those requiring the Exception Test.

Figure 3-4 illustrates how GIS layer **HSFRA Flood Models** can be used to quickly identify the hydraulic information relating to any particular modelled location. In this example the Zone 2 floodplain is superimposed on the Widemarsh area of Hereford. Model cross-section nodes are identified as a label, and a query with the Info Tool can rapidly ascertain that in this example for model node WB03530, the data derives from a Capita Symonds study in July 2007, and the currently estimated 1% AEP flood level for this location is 56.548 mAOD, rising to 56.654 mAOD with climate change effects.

Evidence Map 3-3 summarises the precise location of every modelled cross-section within Herefordshire from the various studies identified below, superimposed on the Environment Agency Flood Zone 2 layer. Each record contains data similar to that demonstrated in Figure 3-4.

IN GENERAL, USE OF DATA FROM THESE MODELS WILL REQUIRE THE AGREEMENT OF THE ENVIRONMENT AGENCY, AND CHECKS SHOULD ALWAYS BE CARRIED OUT TO CONFIRM IF THE MODEL DATA HAS BEEN IMPROVED OR SUPERSEDED.

Figure 3-4 – Example Output of HSFRA Flood Models Database and GIS Layer



3.4.1 Studies and Hydraulic Models near Hereford

River Wye at Bredwardine
Section 105 Floodplain Mapping – Modelling Report, WS Atkins, August 2000
This hydraulic study was prepared as part of the national Section 105 (Floodplain Mapping) Framework Contract, and incorporates 5.5km of the River Wye between The Bunch of Carrots PH and Bredwardine upstream of Hereford. DOC Ref: AW5798.050.

River Wye, River Lugg and River Frome at Hereford
SFRM Wye Lugg Confluence Modelling – WS Atkins, March 2006
This major study completed in 2008 extends between Ballingham on the River Wye to Warham west of Hereford, (a modelled distance of 21km), and includes 5.2km of model of the River Lugg from the Wye confluence, and 1.0km of the River Frome from the Lugg confluence. The ISIS based model incorporates various previous studies by WS Atkins, including those prepared for the Environment Agency and Herefordshire Council.

In particular this model has been used to identify design criteria for the Hereford Flood Defence Scheme, floodplain issues at Rotherwas, and standards of protection at The Stank for Hampton Bishop.
DOC Ref: 5029863.70DG06-R2

Hereford Critical Ordinary Watercourses (Yazor, Eign, Widemarsh Brooks)
Hereford COWs SFRM Modelling – Capita Symonds, August 2007
The key objectives of the study were a hydrological assessment of the Yazor Brook and Widemarsh/Eign Brook catchments, development of an ISIS-TUFLOW hydraulic model of approximately 3 km length of the Yazor Brook from Three Elms Road Bridge to the outfalls into the River Wye and approximately 3.9 km of the Widemarsh/Eign Brook from the Yazor Bifurcation to the outfall on the River Wye.

Extensive river channel and structure survey was collected for the study and a Digital Terrain Model (DTM) developed from Environment Agency LiDAR data.
DOC Ref: WA662

Edgar Street Grid Regeneration Area (Yazor, Eign, Widemarsh Brooks)
Edgar Street Grid Strategic Flood Mitigation Options Appraisal Report – Capita Symonds, December 2007

As a result of recent detailed flood risk studies carried out by the Environment Agency, the proposed regeneration area of the ESG site in central Hereford has been shown to be at significant risk of frequent flooding. Capita Symonds was commissioned by ESG Herefordshire Ltd. to assess strategic options for flood mitigation for the proposed redevelopment of the Edgar Street Grid.

This report identifies a range of flood mitigation options and appraises their feasibility, appropriateness and risks. The study utilised the base hydraulic model prepared for the SFRM study above, but extended it significantly

upstream. It has not been possible to identify the additional sections within the current Flood Models database.
DOC Ref: None

River Wye General Hydraulic Model
Wye and Usk Catchment Flood Management Plan – Capita Symonds, April 2008

As part of the general investigations of the Environment Agency CFMP, a coarse ISIS-TUFLOW hydrodynamic model is being prepared for the entire length of the River Wye, which will assist in examining aspects of storage effects and floodplain management. Details of this model were not available to the SFRA team.
DOC Ref: Scoping Report

Lower Bullingham, Withy Brook and Red Brook
Preliminary Flood Study – WS Atkins, November 2004

This hydraulic study incorporates 32 cross-sections on the Red Brook and 42 cross-sections on Withy Brook. The HEC-RAS model was used to assess flood risk problems in and around Bullingham and Watery lane, a persistent flood prone area. The analysis concluded that flood levels in the 1% AEP for both watercourses are dominated by high tailwater levels in the River Wye. Cross-section data could not be obtained for the Strategic Flood Risk Assessment.
DOC Ref: 5012593/70/DG/10

3.4.2 Studies and Hydraulic Models near Ross-on-Wye

River Wye at Ross-on-Wye
River Wye: Ross-on-Wye Section 105 Floodplain Mapping – Modelling Report, WS Atkins, August 2000
This hydraulic study was prepared as part of the national Section 105 (Floodplain Mapping) Framework Contract, and incorporates 7km of the River Wye between Weirend and Backney Bridge with some 55 sections. The Rudhall Brook is also modelled with approximately 18 sections as far as the Ashburton Industrial Estate.
DOC Ref:

Rudhall Brook at Ross-on-Wye
Ross-on-Wye Flood Alleviation Study, Halcrow, July 2002
Following the significant flood damage of the 2000 event, a hydraulic model and study was commissioned to examine flood alleviation options. The ISIS model utilised the cross-section data of the above study, but added a further 19 sections on the Rudhall Brook upstream of the A40.
DOC Ref:

River Wye at Goodrich
Interim Hydraulic Modelling Report, WS Atkins, May 2003
This HEC-RAS study was undertaken as part of the Flood Risk Mapping National Framework Contract, and extends for 2.9km between Kerne Bridge and Pencraig, with 21 cross-sections.
DOC Ref: AK4020.100, May 2003.

3.4.3 Studies and Hydraulic Models near Leominster

River Lugg at Leominster

Section 105 Floodplain Mapping – Modelling Report, WS Atkins August 2000

This major HEC-RAS study was undertaken as part of the Flood Risk Mapping National Framework Contract, and extends for 3.7km downstream of Leominster as far as Ford, and 8km upstream to Lugg Bridge at Kingsland. A total of 300 cross-sections are included, and the Marsh Cut flood relief channel to the north of the town is also modelled.
DOC Ref: AW5798/130/DRN/120.20672

River Arrow at Eardisland and Pembridge

River Arrow at Eardisland – Section 105 Floodplain Mapping – Modelling Report, WS Atkins, May 2000

Eardisland is a heavily flood-prone area, and encountered particularly severe flooding on 8 January 1986, with other major floods in October 1998 and December 1979. This study development a HEC-RAS model between Arrow Bridge at Arrow Green 2.4km downstream of the village, to New Mills at Pembridge, 5.6 km upstream. 200 channel and floodplain sections were modelled, and this study is a valuable reference source for future development in this area.
Doc Ref: W5624.242/SW

3.4.4 Studies and Hydraulic Models near Ledbury

River Leadon at Bosbury

Bosbury Flood Alleviation Study, Initial Feasibility Report, Babtie, Brown & Root, August 2003.

Bosbury has a significant history of flooding. The March floods of 1998 damaged 25 properties, and the October 1998 and December 2000 events damaged up to 12 properties. This study prepared a HEC-RAS model of the River Leadon between Lower Mill and England's Bridge, 1.30km and 16 sections. Flooding of the village also arises from Dowding's Brook at the confluence with the Leadon, and this was also modelled.

A Flood Alleviation Scheme for Bosbury was completed in November 2006, but appears to have been only partially successful, as several properties were flooded again in July 2007.
DOC Ref: S49X 7009.

River Leadon at Ledbury

River Leadon Main River Survey, Severn Trent Water Authority – Lower Severn Division, November 1983

A major channel survey of the River Leadon extending for 26km from the Leadon – Severn confluence to England's Bridge at Bosbury was carried out by the Severn Trent Water Authority. A full set of 1:2500 scale drawings are held at the Environment Agency Tewkesbury office. No hydraulic modelling was carried out with these sections, but they represent a valuable resource for future studies.

Ledbury RFC – Hydraulic Model Build and Calibration, Hydrologic Ltd, May 2005,
This study prepared a HEC-RAS model of the River Leadon adjacent to the Rugby Football Ground for FRA purposes, incorporating 19 sections between the A449 and A438 roundabouts of the Ledbury Bypass. This model was subsequently used by Halcrow for further investigations at Lower Road in 2006.
DOC Ref:J2156/Hyd

Flood Risk Assessment - Lower Road Industrial Estate, Ledbury, Halcrow, November 2006
The Lower Road area of Ledbury has encountered significant recent flooding, especially in the March and October 1998 events, and December 2000. The Ledbury Bypass was flooded in December 2000. This study used the model of Hydrologic Ltd to examine flood risks at the Lower Road Industrial Estate. Both the Hydrologic and Halcrow studies were unable to obtain satisfactory calibrations of the hydraulic model, compared to historically recorded levels.
DOC Ref: WELLRF\1000.

3.4.5 Studies and Hydraulic Models near Kington

River Arrow at Kington

Development & Flood Risk at Kington - Hydraulic Model Study, HR Wallingford, May 1995
This study developed an ONDA model of the Arrow at Kington, extending between Downfield Farm 1.0km downstream of the Kington Sewage Treatment Works, to 2.9km upstream of the STW at Hergest Mill. The model includes 85 cross-sections. The model was developed primarily to assess the potential floodplain impacts of development of land on the left bank of the Arrow upstream of the A44 Bypass Bridge. The model will still be of use for future studies.
DOC Ref: EX 3217

3.4.6 Other Important Hydraulic Studies

River Lugg at Presteigne

Flood Risk Mapping – Final Hydraulic Modelling Report – WS Atkins, April 2003
Flood defences along the left bank breached in 1998 causing flooding of properties in Ford Street near Lugg Bridge. This study was undertaken as part of the Flood Risk Mapping (Section 105) National Framework Contract. The study extends for 1.6km between Brink Lane and Boultibrooke Bridge, including 13 cross-sections. Although Presteigne falls outside the Herefordshire boundary, it is relevant to the SFRA scope.
Doc ref: 5010639/100.

River Wye at Hay-on-Wye

River Wye at Hay-on-Wye – Final Modelling Report, WS Atkins, May 2003
This study was undertaken as part of the Flood Risk Mapping (Section 105) National Framework Contract. 36 cross-sections are modelled, from Bronydd 2.2km downstream of the town STW, to Llowes 4.5km upstream of Hay Bridge.

This study identified that the STW is at risk in all flood events. The A438 near Llowes is also reported as flooding.
DOC Ref: 5010639.300

River Dore at Peterchurch

River Dore at Peterchurch – Final Report, Capita Symonds, June 2006
This study was undertaken as part of the Flood Risk Mapping (Section 105) National Framework Contract, and incorporated 28 sections between Poston Court Farm and Hinton Hall upstream, 2.6km length.

The reach from Hinton Bridge to Horsepool Bridge is a flood risk area and benefited from a flood alleviation scheme in 1980's.
DOC Ref: WA625

Dulas Brook and River Dore at Pontrilas

Dulas Brook and River Dore at Ewyas Harold – Flood Risk Mapping Interim Hydraulic Modelling Report, WS Atkins, April 2001
Lying at the confluence of the River Dore and Dulas Brook, Pontrilas has a long history of flooding, as does Ewyas Harold upstream on the Dulas Brook. This study was commissioned as part of the Flood Risk Mapping (Section 105) National Framework Contract. The largest flood occurred in May 1931, other major floods in November 1980, October 1998, and December 2000. Flooding of storm sewers is also frequently reported.

The model incorporates 18 sections on the Dulas Brook from the Dore confluence to the Ewyas Harold Post Office, and 8 sections on the River Dore.
DOC Ref: AK4040.200/DG

River Teme from Knighton to River Severn

Flood Risk Mapping, Capita Symonds, 2009
An ISIS model of the River Teme has been in existence for some years, and is currently undergoing a major update. This is due to be ready in early 2009. The model is being supervised by West Area EA Midlands Region.

3.5 BBC Local News Reports

BBC and local newspaper reports generally carry useful photographs and records of recent flood incidents, and these local resources have been extensively searched to supplement the **HSFRA Flood Reports** database where locations could be identified.

3.6 Strategic Appraisal of Current Flood Risk

3.6.1 Summary of Sources of Flooding

Table 3-1 summarises the entire **HSFRA Flood Reports** database by source of flooding where it is known.

Table 3-1 – Summary of Flooding Reports by Source

Flooding Source	Number of Reports	Most reported Postcode	% of total
Fluvial	136	HR2 6, HR6 9, LD8 2, SY8 4	25%
Land Drainage	62	HR6 0, HR6 9, HR81, HR8 2, SY8 4	11%
Groundwater	2	HR7 4, LD8 2	<1%
Storm Sewers	5	HR2 6, HR4 9, HR8 1	1%
Foul Sewers	2	HR2 0, SY8 4	<1%
Highway Drainage	21	HR1 3, HR6 9, HR9 5,	4%
Culvert	8	HR3 5, HR4 8, HR6 8, HR9 7, WR6 5	2%
Unknown or “ “	237		43%
TOTAL	552		

Table 3-1 indicates that fluvial flooding is the largest single source of flooding within Herefordshire. However, land drainage also features strongly. The high level of unallocated or unknown sources reflects the poor quality of reporting of past flood incidents, which could be rectified by use of a Standard Flood Incident Report Form. Anecdotally, it is thought there is approximately a 50/50 split between fluvial and land drainage sources of those unidentified.

Since the **HSFRA Flood Reports** database can be used in a relational way, it is of course possible to query the data by any field against another. For example, it is possible to determine how many instances there of ‘fluvial’ flooding within Postcode HR6 9 etc

3.6.2 General Fluvial Flooding

Evidence Map 3-1 illustrates the Flood Zone 3 and 2 extents for Herefordshire. These maps are a primary resource to identify existing property at risk of flooding.

The Wye and Usk CFMP currently estimates that there are some 6498 people at risk of fluvial flooding between Hay-on-Wye and Monmouth in a 1% AEP flood event. For the 0.1%AEP, this figure rises to 26,640.

3.6.3 Analysis of Fluvial Flood Risk by Sub-catchment

Quantitatively, risk is defined as:

Total Risk = Impact of Hazard x Elements at Risk x Vulnerability of Elements

Hazard is "a threatening Event, or the Probability of occurrence of a potentially damaging phenomenon within a given time period and area". Vulnerability is "Degree of loss resulting from a potentially damaging phenomenon" (UN, 1992)

Consequently, for risk to be present, there must indeed be a potential hazard (river, floodplain or impermeable catchment), but there must also be an element present (properties and roads) that has vulnerability if it is flooded.

The HR Wallingford Report [5] determines Risk broadly as "a combination of the chance of a particular event (Probability), with the impact that the event would cause (Consequence) if it occurred. Flood hazard therefore only becomes a risk when there is an element or consequence arising. Hence the presence of a floodplain does not in itself present a risk, only when properties or assets are included can true risk be determined.

With the benefit of the ADDRESS-POINT® dataset held within Herefordshire Council, the SFRA has undertaken a major reassessment of properties at risk within the Flood Zones 3 and 2, by combining the EA Flood Zone data and the OS Address Point data (see Figure 3-5).

Uniquely for this SFRA, this analysis has been sub-divided by the 47 target sub-catchments of the Strategic Flood Risk Assessment. Hence it is possible to identify in a ranked or hierarchical way the sub-catchments most and least at risk of fluvial flooding and extreme flooding in terms of properties at risk i.e. hazard x consequence. The high risk catchments are summarised in **Table 3-2** and the full analysis is summarised in **Table 3-3**.

Figure 3-5 – Example Output of ADDRESS-POINT Query in Flood Zone 3

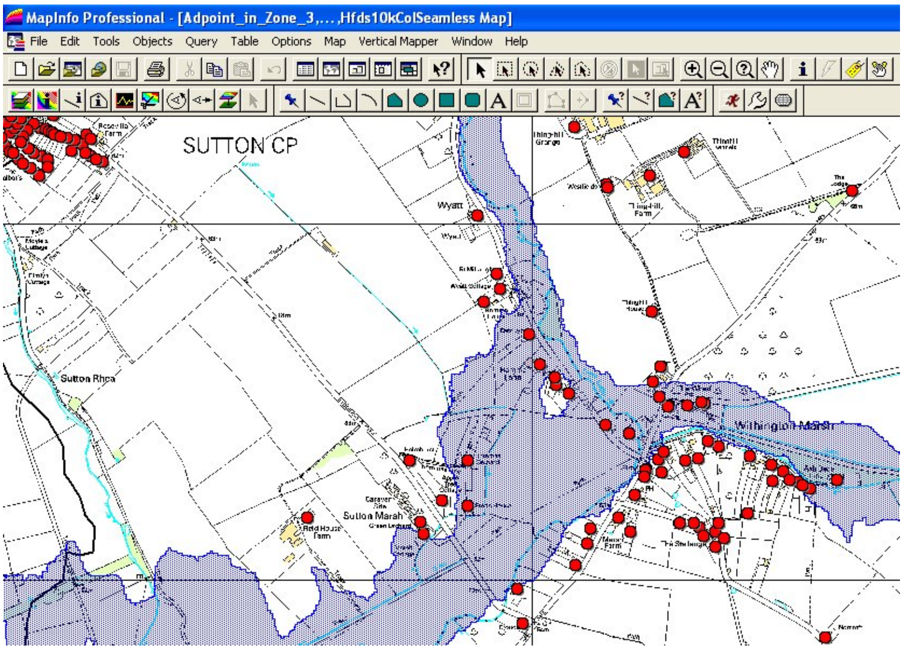


Table 3-2 – Summary of Highest Flood Risk Sub-catchments

Sub-catchment	Fluvial Flood Risk Rank	No of Properties in Flood Zone 3	Total No Of Properties	% of total
Lower Wye	1	1253	23,678	5.3%
Yazor Brook	2	688	10,377	6.6%
Pinsley Brook	3	443	2,703	16.4%
Lower Lugg	4	273	7,714	3.5%
Upper Mid Wye	5	227	2,413	9.4%
Upper Lugg	6	202	1,191	17.0%
Middle Arrow	7	144	1,227	11.7%

No account has been taken of flood depths or property levels etc, it is simply assumed that if an address point lies within the flood zone, it is effectively at risk, and the analysis differs from the Environment Agency figures in that TOTAL number of properties has been taken into account, not just residential property.

From Table 3-2, the sub-catchment with the greatest current fluvial flood risk (hazard x consequence) is the Lower Wye sub-catchment, extending along the River Wye between Belmont and Monmouth. 1253 properties are at risk in a 1% AEP flood event. However, the catchment with greatest <u>proportional</u> flood risk (properties as % of total) is actually the Upper Lugg, where 17% of properties are at risk. This is closely followed by the Pinsley Brook at 16% of total.

An assessment of the relative sensitivity of individual sub-catchments to climate change or extreme floods (< 1% AEP) can be made by comparing the rank of the 1% AEP column (Flood Zone 3) to the rank of the 0.1% AEP column (Flood Zone 2) i.e. the difference in number of properties affected between the two flood zones. Generally the rank of the catchment for the 0.1% AEP is similar to that of the 1% AEP, but there are some subtleties. The Lower Wye is the most sensitive to the change in zone (greatest increase in number of properties affected, followed by the Middle Lugg, followed by the Yazor Brook).

This analysis gives unprecedented insight into flood risk within Herefordshire at a very detailed scale. The property counts lying within the Food Zones 3 and 2 have been explicitly extracted into three GIS layers (**HSFRA All Catchments**, **HSFRA Addpoint Zone 3** and **HSFRA Addpoint Zone 2**. Hence it is possible to combine data of Table 3-3 with many other flood hazard attribute layers provided as part of the Strategic Flood Risk Assessment.

For example, property counts by sub-catchment can be compared to the **HSFRA Flood Timing** layer to compare the sensitivity of the properties at risk to the degree of flood warning available.

The priority catchments listed above in Table 3-2 will require particular attention with regard to new development in the floodplain, emergency planning and civil contingency preparedness.

Table 3-3 – Summary of Hierarchical Fluvial Flood Risk by Sub-catchment

Catchment	Properties at risk 1% AEP	Risk Rank	Properties at risk 0.1% AEP	Risk Rank
Redlake Brook	2	40	6	37
Mid Teme	86	11	108	12
Sapley Brook	4	38	4	39
Cradley Brook	16	24	16	27
Upper Leadon	1	42	1	43
Lower Leadon	25	20	31	24
Preston Brook	12	27	17	26
Kempley Brook	0	46	0	46
Glynch Brook	1	42	1	43
Ell Brook	11	28	12	31
Afon Llynfi	0	46	0	46
Upper Middle Wye	227	5	378	6
Letton Lake	16	24	41	21
Middle Wye GS55002	25	20	79	15
Cage Brook	4	38	4	39
Yazor Brook	688	2	1063	2
Upper Lugg	202	6	241	7
Hindwell Brook	30	19	35	23
Middle Lugg	45	13	479	4
Ridgemoor Brook	43	15	50	19
Cheaton Brook	5	36	6	37
Pinsley Brook	443	3	481	3
Upper Arrow	54	12	175	10
Back Brook	25	20	102	14
Middle Arrow	144	7	170	11
Stretford Brook	8	32	9	34
Lower Arrow	11	28	15	28
Humber Brook	6	34	9	34
Wellington Brook	40	16	70	16
Little Lugg	32	17	42	20
Upper Frome	2	40	3	41
Bromyard Brook	1	42	1	43
Middle Frome	44	14	66	18
Lodon	5	36	7	36
Lower Frome	10	30	10	32
Lower Lugg	273	4	394	5
Wriggle Brook	6	34	14	29
Sollers Brook	7	33	13	30
Rudhall Brook	133	8	235	8
Bailey Brook	31	18	69	17
Garren Brook	16	24	41	21
Lower Wye	1253	1	4404	1
Upper Monnow	23	23	23	25
Honddu	1	42	2	42
River Dore	94	10	108	12
Worm Brook	9	31	10	32
Lower Monnow	124	9	187	9
TOTAL	4238		9232	

3.6.4 Urban Sewerage and Flash Flooding

Flash flooding occurs when the ground becomes saturated with water that has fallen too quickly to be absorbed. The runoff rapidly flows downhill and collects in low-lying areas. This is particularly of concern in towns and cities where, because of the built environment, the ground has little capacity to absorb rainfall. In a flash flood drainage and sewerage systems, generally at best designed to take a 30 year storm, are overwhelmed causing flooding in vulnerable areas.

It has been particularly difficult to establish sources of flooding from external Agencies. Welsh Water – Dwr Cymru (WWDC) does not keep extensive records of surface flooding arising from sewers, although such data should be readily available from the OFWAT DG5 Standard of Service Reporting sewer flooding returns. WWDC was not prepared to divulge any further information than that listed below.

Table 3-4 – Recorded Urban Locations at Risk of Sewerage Flooding

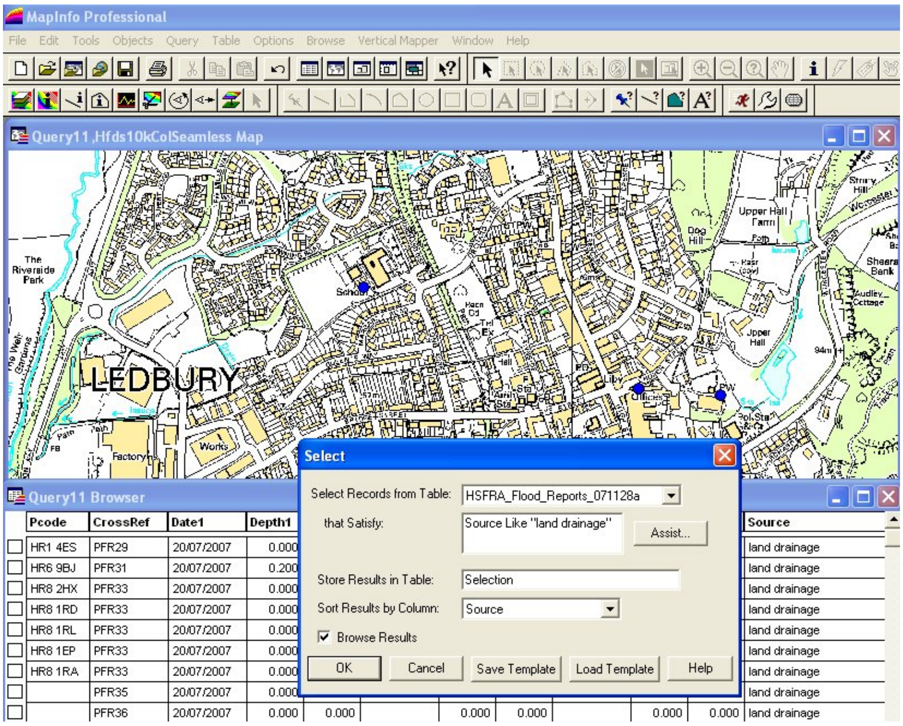
Settlement	Postcode	Number of Properties	Comment
Hereford	HR1	14	DCWW
South west Hereford	HR2	11	DCWW
North Hereford	HR4	13	DCWW
Leominster	HR6	8	DCWW
Bromyard	HR7	1	DCWW
Ross-on-Wye	HR9	9	DCWW
Ewyas Harold	HR2 0	?	SFRA
Ledbury	HR8 1	?	SFRA

A key task for the future will be to liaise more effectively with Welsh Water to prepare more informative registers of sewerage flooding within Herefordshire.

The **HSFRA Flood Reports** database however attempted to identify sources of flooding for every record. This was occasionally not possible due to the poor quality of the source data. However, 60 reports identify ‘land drainage’ as the source of the flooding. Not all of these will have originated from urban sewers, but those in urban areas are likely to be indicative of such a source. The query functions of the MapInfo GIS can be used to identify these locations for further investigation.

An example query of how the GIS database can be queried to search, list and map for any particular type of flooding is given below in Figure 3-6.

Figure 3-6 – Example Flooding Source Query from MapInfo



3.6.5 General Groundwater Flooding

As for urban flooding, it was particularly difficult to identify confirmed sources of groundwater flooding. Since the extent of aquifers within Herefordshire is somewhat limited, groundwater flooding is not expected to be a significant issue. The **HSFRA Flood Reports** database identifies only two reports of confirmed groundwater flooding as opposed to land drainage or surface water, see Table 3-5.

Table 3-5 – Recorded Reports of Groundwater Flooding

Settlement	Postcode	Number of Properties	Data Source
Combe	LD8 2	1	SFRA
Munderfield	HR7 4	1	SFRA

3.6.6 Flood Risk and Flood Defences – Hereford

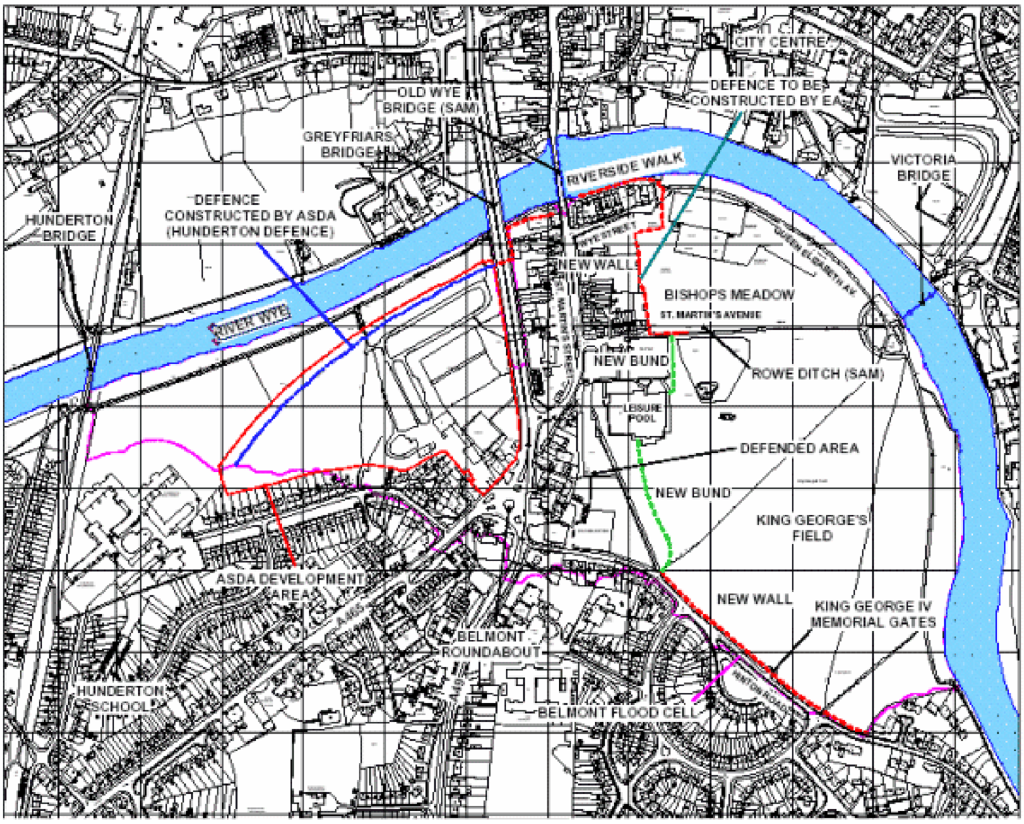
Evidence Map 3-2 shows the current Flood Zone 3 and Flood Zone 2 extents for Hereford city. Particularly notable is the Zone 3 inundation extent around the Blackmarstone area south of Greyfriars Bridge (due to be protected by the Hereford FDS). The Widemarsh and Eign Street areas in the city area are also notable Flood Zone 3 areas.

Observed flood reports are particularly concentrated around the Greyfriars Bridge area (Greyfriars Avenue and St Martins Street), Widemarsh (Edgar Street and Newton Road), and the Lower Bullingham area (Holme Lacy Road and Watery Lane). Further information on the precise type of flooding (dates, postcode, and depths) is contained in the supporting GIS database **HSFRA Flood Reports**.

In the last eight years alone, there have been 6 notable flood events in Hereford, at least 4 of which have caused significant damage to properties, disruption to traffic, financial loss to businesses, and tension, stress and anxiety to those affected by flooding.

Currently in progress, the Hereford (Belmont) Flood Defence Scheme will reduce the likelihood of flooding to 196 properties, including 25 listed buildings, as well as the main trunk road running through the centre of Hereford, particularly around the Belmont Roundabout, a frequently inundated area. The standard of the defences will be to provide 0.5% AEP protection (1 in 200).

Figure 3-7 – Proposals for Hereford Flood Defence Scheme



Source: Environment Agency

Evidence Map 3-2 also shows parts of The Stank flood defence protecting Hampton Bishop. Some 131 properties are protected by this major defence, which is ancient in origin, but has been periodically reconstructed and repaired. There were major breaches of The Stank during the 1960 flood, creating significant damage to Hampton Bishop, and most recently in July 2007, when the defences were overtopped by record flood levels, due to coincidences of the Rivers Lugg and Frome. People had to be evacuated from the village in the 2007 flood.

The Stank is regarded primarily as an agricultural defence, and hence may be sub-standard in some places with respect to protection of property. In fact according to the WS Atkins study of 2006, the average freeboard to the defences above the 1% AEP flood event is 0.48m, but this reduces to as little as 0.04m in specific locations.

A report is awaited from the Environment Agency on the causes and lessons learned from the failure of the defences in July 2007 [7].

3.6.7 Flood Risk and Flood Defences – Ross-on-Wye

Evidence Map 3-3 shows the current Flood Zone 3 and Flood Zone 2 extents for Ross-on-Wye. Much of the town is elevated above the River Wye; consequently the Wye has limited flood impact. However, excess flows from the Rudhall and Chatterley Brooks from the east interact with high tailwater levels in the Wye and severe flooding to parts of the town centre have occurred in recent years.

Flood reports from the database show only flooding in Brookend Street and the Broadmeadows Industrial Estate, but this is primarily due to a lack of recorded reports from the Environment Agency and Herefordshire Council.

In particular, Brookend Street, Station Street and Millpond Street are affected, as is the Broadmeadows Industrial Estate. Particularly notable is the Zone 3 inundation extent running west-east from the River Wye to the intersection with the A40 which crosses the Rudhall Brook on the eastern edge.

Following particularly severe flooding on 8 December 2000, the Ross-on-Wye Flood Alleviation Scheme was promoted, and is due for completion in 2008. The scheme entails a combination of flood relief siphon, improved culvert and channel capacities, and storage of excess flood water upstream of the town. The scheme is intended to provide 1% AEP standard of protection to the shaded area of Evidence Map 3-3.

During periods of high flow in the Rudhall and Chatterley Brooks the excess water will be diverted away from the Greytree Road culvert into a new tunnel between the Kings Acre and Homs Road car parks. Further excess flow will be stored by an earth bund east of A40 (the Marsh Farm bund, marked as a flood defence in Evidence Map 3-3). Later, as downstream flow levels reduce the stored water will pass back into the Chatterley Brook and on to the River Wye.

3.6.8 Flood Risk and Flood Defences – Leominster

Evidence Map 3-4 shows the current Flood Zone 3 and Flood Zone 2 extents for Leominster, which are very extensive, particularly on the north side. Leominster lies at the near confluence of two major river systems, the Lugg and the Arrow. Some 654 km² of catchment therefore drains towards Leominster, and it is not surprising that it is a flood prone area.

Significant flooding at Leominster has occurred in recent decades, although until 2007 there were few documented reports.

Flood defences in Leominster comprise a flood alleviation channel that runs west-east from Summergalls Farm along the northern edge of the town to join the Ridgemoor Brook upstream of Ridgemoor Bridge. In combination with this flood alleviation, the original course of the River Lugg through the town centre was improved, and excess floodwater is stored in the sports centre playing field adjacent to Leominster Town FC. The scheme is believed to have been constructed post 1979, to provide a 1% AEP standard of protection. The area benefiting from defences within Leominster on the left bank of the River Lugg amounts to 0.44 km², serving in excess of 250 properties.

The current scheme is designed only to the 1% standard however, with no allowance for freeboard or climate change.

The July 2007 event was noteworthy in Leominster because a significant number of flood reports arose from flash flooding and lack of general drainage capacity rather than direct fluvial flooding. The Southern Avenue Industrial Estate area was particularly affected in July 2007, with the Leominster Ambulance Station being severely flooded.

Photograph 3-1 – Leominster Flood Alleviation Channel

Source: © B Faulkner 2008

3.6.9 Flood Risk and Flood Defences – Bromyard

Evidence Map 3-5 shows the current Flood Zone 3 and Flood Zone 2 extents for Bromyard, which are relatively narrow and confined away from the urban area. Bromyard does not have a significant history of flooding. However, the 20 July 2007 event was exceptional in its severity and onset. The Linton Park Caravan Site (A44, Petty Bridge) was primarily affected, with the majority of the residents having to be evacuated.

The rate of onset of the flooding was one of its most noteworthy factors, and has initiated a significant demand by local residents for an improved flood warning scheme.

The Environment Agency has advised that a flood warning gauge has now been installed in 2008, but that it will require 2 years of data collection to establish the usefulness of the gauge warnings.

Photograph 3-2 – Evacuation from Linton Park, Bromyard

Source: BBC, © Jeff Johnson 2007

3.6.10 Flood Risk and Flood Defences – Ledbury

Evidence Map 3-6 shows the current Flood Zone 3 and Flood Zone 2 extents for Ledbury. The River Leadon is characterised by a relatively very narrow floodplain throughout its length, and property is relatively unaffected by Zone 3 and Zone 2 fluvial extents. However, Ledbury in general exhibits a tendency to flash flooding, as evidenced by floods in the town centre during July 2007.

Flash flooding due to excessive surface water runoff from the Ledbury hillside has been reported in the Church Street area, the Newbury Park Road area, and the western ends of Lower Road and Little Marcle Road.

There are also numerous reports of surface water flooding throughout the Leadon catchment, as evidenced by the **HSFRA Flood Reports** Database This can be largely attributed to higher than average soil impermeability.

Photograph 3-3 – Flash Flooding near Church Street, Ledbury

Source: BBC © Ed Ashley 2007

3.6.11 Flood Risk and Flood Defences – Kington

Evidence Map 3-7 shows the current floodplain extents for Kington. The town can be potentially cut off from the north and south if the Arrow and Back Brook flood simultaneously. Kington was severely affected by flooding on 10th January 1986, as was Eardisland downstream. Floods were described as being of 'exceptional intensity'. 22 properties flooded in Eardisland, 21 in Kington. There are currently no defences for Kington, and it lies at the confluence of two relatively sharply responding catchments.

3.7 Interactions with EA Catchment Flood Management Plan

This study has identified that there are approximately 4328 properties within the 1% AEP flood outline within the SFRA area, which broadly covers the Lower

Wye area of the CFMP. This figure is substantially more than the CFMP figure of 2902, and these discrepancies should be resolved.

The forthcoming CFMP should take account of the detailed sub-catchment breakdown presented in the SFRA, and coordinate flood management policy measures with Herefordshire Council particularly with regard to the high risk catchments of the Lower Wye, Pinsley Brook, Yazor Brook, Lower Lugg, Upper Middle Wye and the Upper Arrow. These are priority areas for flood risk management, particularly with regard to emergency planning, evacuation and critical infrastructure assessment.

3.8 Evidence Based Statements

1) A foremost source of flood-risk identification will always be the Environment Agency generated Flood Zone Maps. These Flood Zone Maps are published by the Environment Agency and are available online from the Environment Agency's website. The Flood Map can also be used by anyone who wants to apply for planning permission in England and Wales to see whether the site they plan to develop is in one of the Flood Zones specified by the government's planning policy.

2) We consider the current Environment Agency Flood Defences map to be outdated (version 2.2). This SFRA has updated notable defence schemes in the study area, in particular those of the Lugg at Leominster, the Wye at Hereford, and the Rudhall Brook at Ross-on-Wye.

3) A specific **Flood Incident Report Form** has been developed as part of this study for improved reporting and data collation.

4) A key evidence base of the SFRA is the **HSFRA Flood Reports** Database and GIS layer that incorporates numerous historical and anecdotal flood reports throughout the County from a wide range of sources.

5) A significant number of hydraulic, hydrological and flood risk investigations have been conducted within Herefordshire in the last 20 years.

6) Fluvial flooding is the largest single source of flooding within Herefordshire. However, land drainage also features strongly. The high level of unallocated or unknown sources reflects the poor quality of reporting of past flood incidents, which could be rectified by use of a Standard Flood Incident Report Form.

7) The SFRA has undertaken a major reassessment of properties at risk within the Flood Zones 3 and 2, by combining the EA Flood Zone data and the OS Address Point data. Uniquely in this SFRA, the analysis has been sub-divided by the 47 target sub-catchments of the Strategic Flood Risk Assessment. Hence it is possible to identify in a ranked or hierarchical way the sub-catchments most and least at risk of flooding and extreme flooding in terms of properties at risk.

8) The sub-catchment with the greatest current fluvial flood risk (hazard x consequence) is the Lower Wye sub-catchment (including Hereford), extending along the River Wye between Belmont and Monmouth. 1253 properties are at risk in a 1% AEP flood event. However, the catchment with greatest proportional flood risk (properties as % of total) is actually the Upper Lugg, where 17% of properties are at risk. This is closely followed by the Pinsley Brook at 16% of total.

9) Other sub-catchments within the highest flood risk category include the Yazor Brook, Upper and Lower Lugg and the Middle Arrow.

10) Groundwater and sewerage flooding are not thought to be significant issues within Herefordshire, but this may be due to the poor quality of reporting in past events.

11) Surface water/land drainage flooding is a particular issue on the eastern side of the SFRA area and was widespread in July 2007. Flash flooding has been reported in Ledbury and Brimfield.

12) Settlements with a significant history of flood disruption include Bosbury, Eardisland, Ewyas Harold, Hampton Bishop, Hereford, Kington, Leintwardine, Leominster and Ross-on-Wye. Emergency planning and future development proposals should take particular account of these settlements with regard to avoidance of increased flood risk.

3.9 Evidence Based Recommendations

3) It is a strong recommendation of this SFRA that the appropriate departments of the Environment Agency and Herefordshire Council work more closely together in future to maintain and update the substantially improved databases that have been delivered as part of this Strategic Flood Risk Assessment. Foremost amongst these is the HSFRA Flood Reports database. The great importance of maintaining central, efficient databases for this type of purpose cannot be over-emphasised, as the cost of collating the information at a later date from a variety of ad hoc sources becomes prohibitively time consuming and expensive.

4) The Flood Incident Report Form prepared as part of this study should be made available from the Herefordshire Council website to facilitate future reporting and recording. Any flood incident, whether from highways or property should be properly logged and added to the database.

5) Herefordshire Council and developers should be aware of all the major hydraulic models within the SFRA area, as the data and knowledge held within these reports should be used wherever possible to corroborate and reinforce further site specific Flood Risk Assessments (FRAs).

6) It has been particularly difficult to establish sources of flooding from external Agencies. Welsh Water – Dwr Cymru (WWDC) does not keep extensive records of surface flooding arising from sewers and a key task for the future will be to liaise more effectively with Welsh Water to prepare

more informative registers of potential sewerage flooding within Herefordshire. In this context DCWW will have to recognise its responsibilities arising from the recommendations of the Pitt Report.

7) The forthcoming CFMP should take account of the detailed sub-catchment breakdown presented in the SFRA, and coordinate flood management policy measures with Herefordshire Council particularly with regard to the high risk catchments of the Lower Wye, Pinsley Brook, Yazor Brook, Lower Lugg, Upper Middle Wye and the Upper Arrow. These are priority areas for flood risk management, particularly with regard to emergency planning, evacuation and critical infrastructure assessment. Discrepancies between the SFRA and CFMP 'numbers of properties at risk' should also be resolved.

3.10 References and Additional Resources

The following published or web-based documentation has been referred to in the following sections, and may provide useful further reference material for the Local Development Framework.

1. **Lessons Learned – Autumn 2000 Floods** (Environment Agency, 2000) http://www.environment-agency.gov.uk/commondata/acrobat/126637

2. **Review of 2007 Summer Floods** (Environment Agency, December 2007) http://www.environment-agency.gov.uk/subjects/flood/1867303/

3. **Understanding Flood Risk – Using Our Flood map** http://www.environment-agency.gov.uk/commondata/acrobat/floodmapeng_1368736.pdf

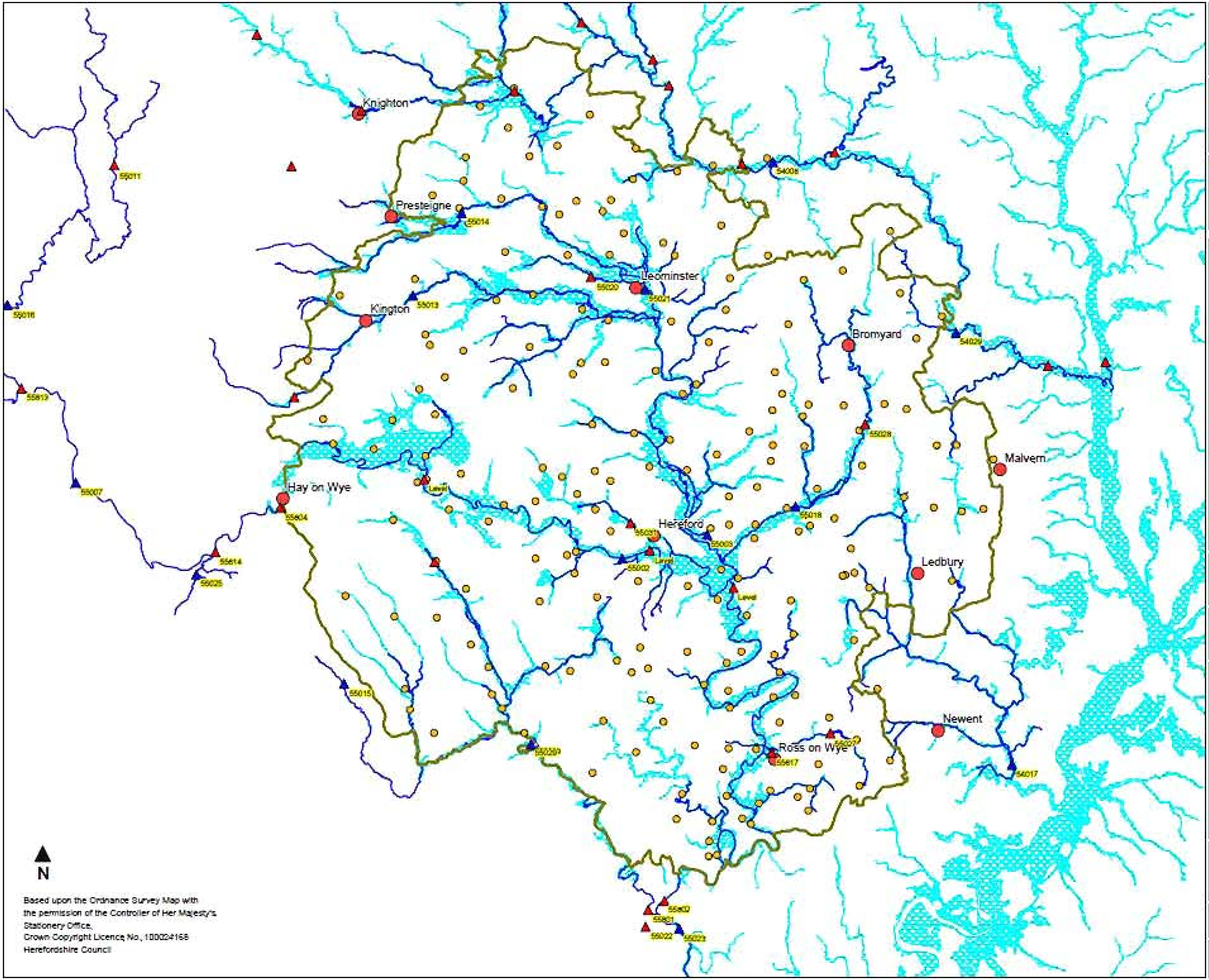
4. **Planning Policy Statement 25 (PPS25): Development and Flood Risk** (DCLG, December 2006) http://www.communities.gov.uk/publications/planningandbuilding/pps25floodrisk

5. **Risk Performance and Uncertainty in Flood and Coastal Defence – A Review** (HR Wallingford, 2002, SR587)

6. **Guide to the Management of Floodplains to Reduce Flood Risks – Stage 1** (HR Wallingford, 2003, SR599) http://books.hrwalllingford.co.uk/acatalog/floodspage.html

7. **Failure of the Hampton Bishop Flood Defences, July 2008** (Environment Agency, Report awaited)

Evidence Map 3-1 – Environment Agency Flood Zones



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Key

- Wye Catchment
- Herefordshire
- Principal Rivers
- Main Town
- Village
- EA Flood Zone 2
- EA Gauging Station
- EA Level Warning Station

Client

Herefordshire Council

Scheme

Strategic Flood Risk Assessment

Drawing

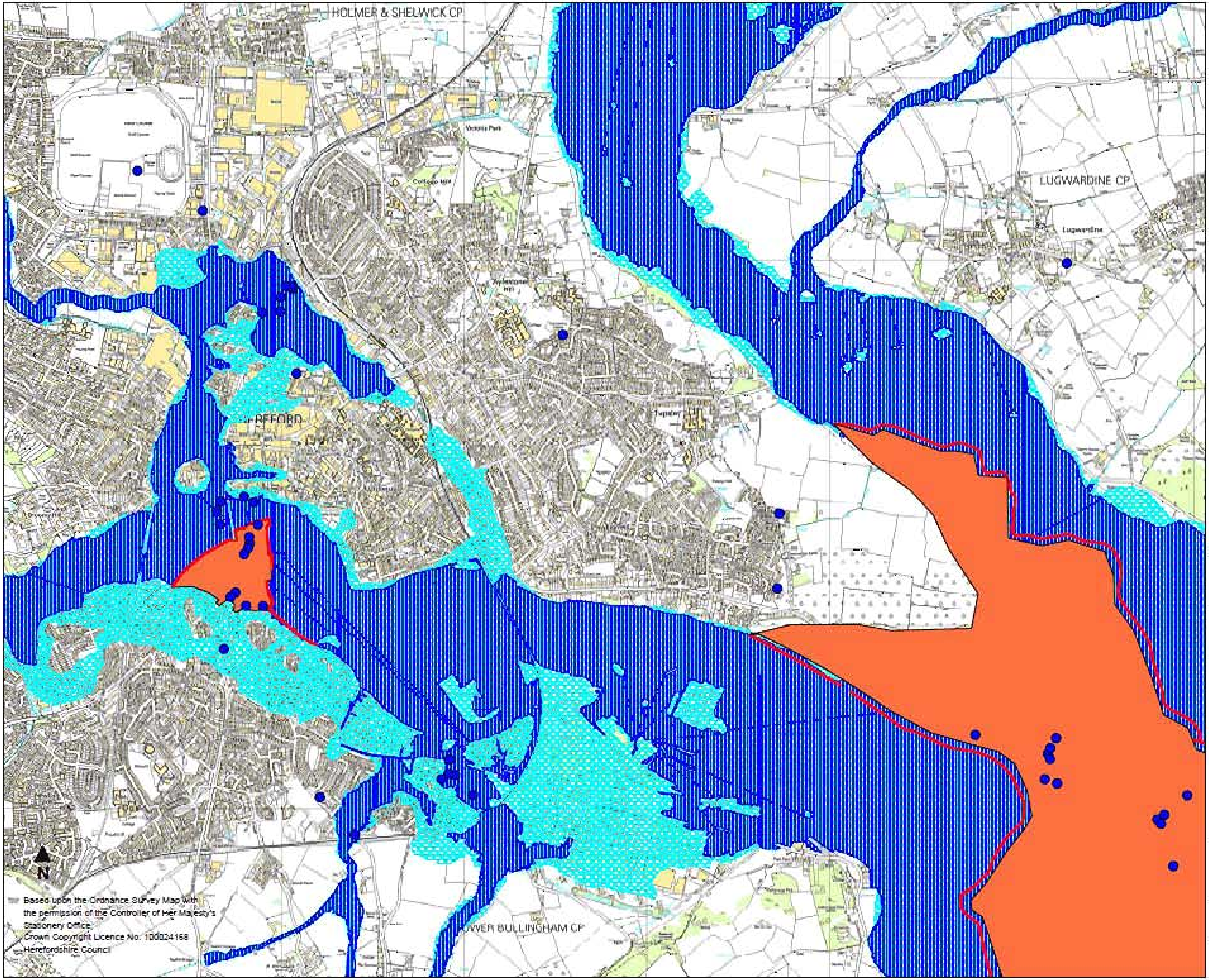
Title	EA Flood Zones
Subset	Flood Zon 2
No.	1110/EB/3-1/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:NTS

Evidence Map 3-1

Evidence Map 3-2 – Environment Agency Flood Zones Hereford



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Key

- County Boundary
- Wye River Basin
- Principal Rivers
- Main Town
- EA Flood Zone 3
- EA Flood Zone 2
- Flood Defences
- Areas Benefiting from Flood Defences
- Observed Flood Report

Client

Herefordshire Council

Scheme

Strategic Flood Risk Assessment

Drawing

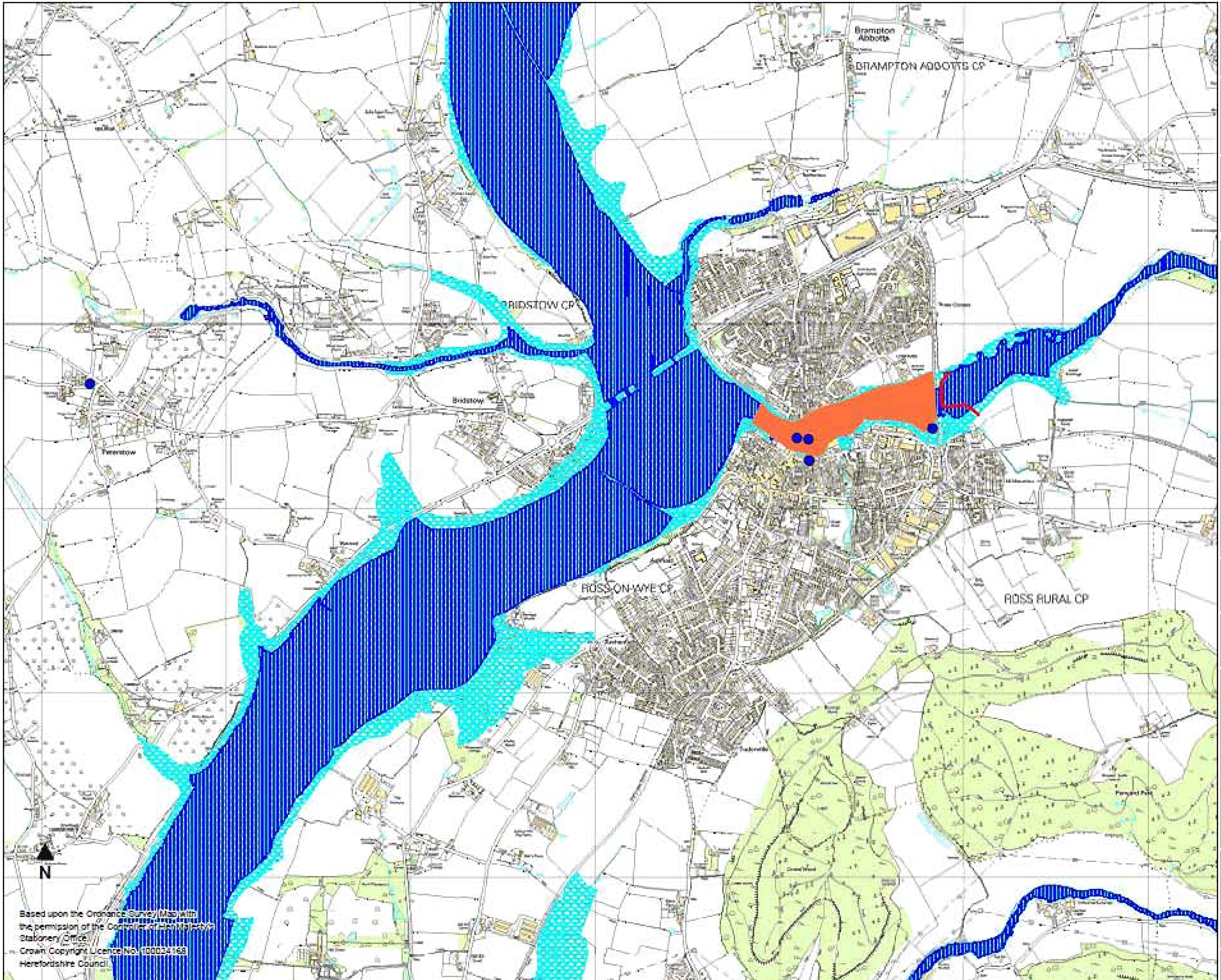
Title	Flood Risk, Flood Reports & Flood Defences
Subset	Hereford
No.	1110/EB/3-2/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:20 000

Evidence Map 3-2

Evidence Map 3-3 – Environment Agency Flood Zones Ross-on-Wye



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Key

	County Boundary
	Wye River Basin
	Principal Rivers
	Main Town
	EA Flood Zone 3
	EA Flood Zone 2
	Flood Defences
	Areas Benefiting from Flood Defences
	Observed Flood Report

Client
Herefordshire Council

Scheme
Strategic Flood Risk Assessment

Drawing

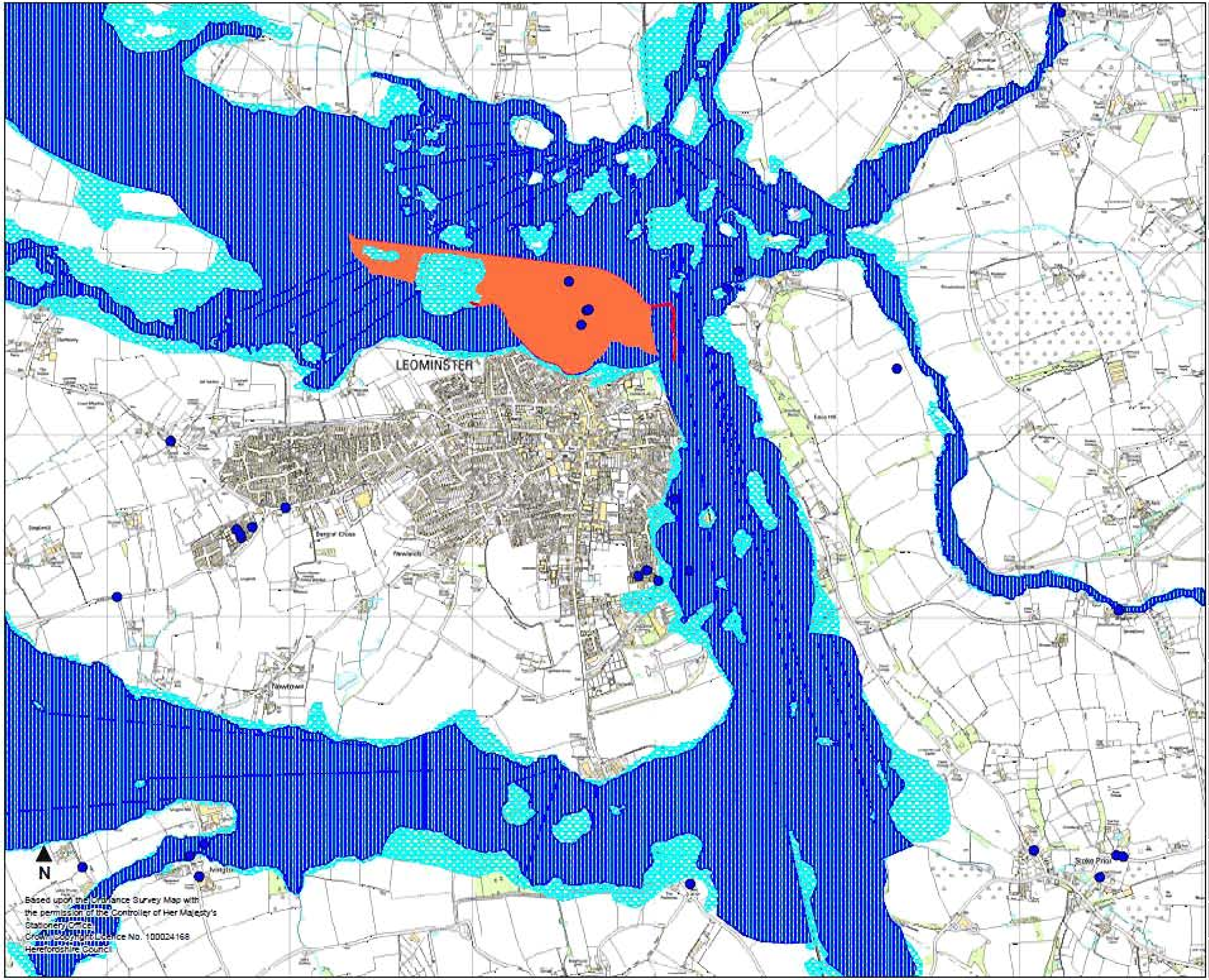
Title	Flood Risk, Flood Reports & Flood Defences
Subset	Ross-on-Wye
No.	1110/EB/3-3/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:20 000

Evidence Map 3-3

Evidence Map 3-4 – Environment Agency Flood Zones Leominster



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Key

- County Boundary
- Wye River Basin
- Principal Rivers
- Main Town
- EA Flood Zone 3
- EA Flood Zone 2
- Flood Defences
- Areas Benefiting from Flood Defences
- Observed Flood Report

Client

Herefordshire Council

Scheme

Strategic Flood Risk Assessment

Drawing

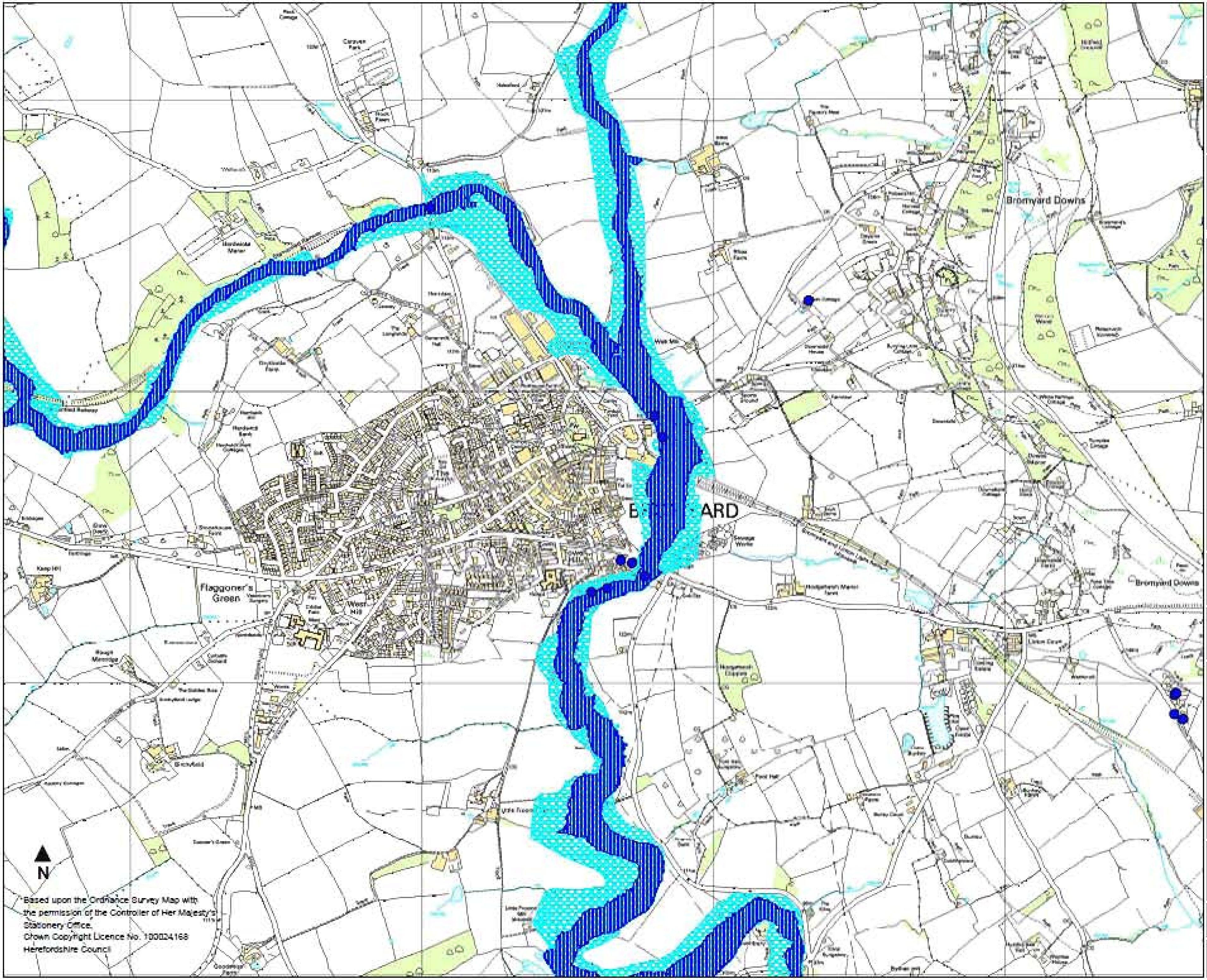
Title	Flood Risk, Flood Reports & Flood Defences
Subset	Leominster
No.	1110/EB/3-4/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:20 000

Evidence Map 3-4

Evidence Map 3-5 – Environment Agency Flood Zones Bromyard



HEREFORDSHIRE COUNCIL

amey

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Key

- County Boundary
- Wye River Basin
- Principal Rivers
- Main Town
- EA Flood Zone 3
- EA Flood Zone 2
- Flood Defences
- Areas Benefiting from Flood Defences
- Observed Flood Report

Client
Herefordshire Council

Scheme
Strategic Flood Risk Assessment

Drawing

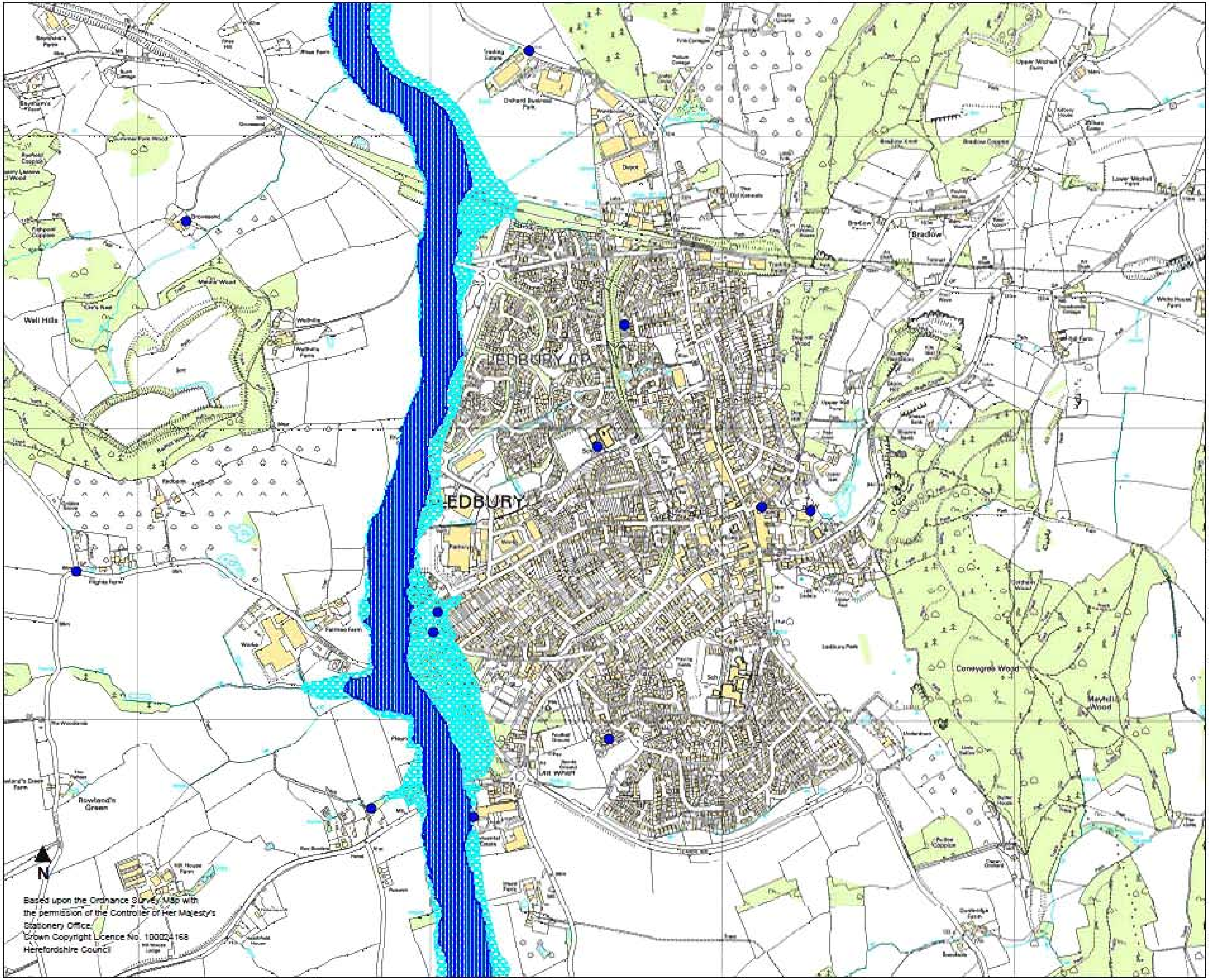
Title	Flood Risk, Flood Reports & Flood Defences
Subset	Bromyard
No.	1110/EB/3-5/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:12 500

Evidence Map 3-5

Evidence Map 3-6 – Environment Agency Flood Zones Ledbury



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Key

- County Boundary
- Wye River Basin
- Principal Rivers
- Main Town
- EA Flood Zone 3
- EA Flood Zone 2
- Flood Defences
- Areas Benefiting from Flood Defences
- Observed Flood Report

Client

Herefordshire Council

Scheme

Strategic Flood Risk Assessment

Drawing

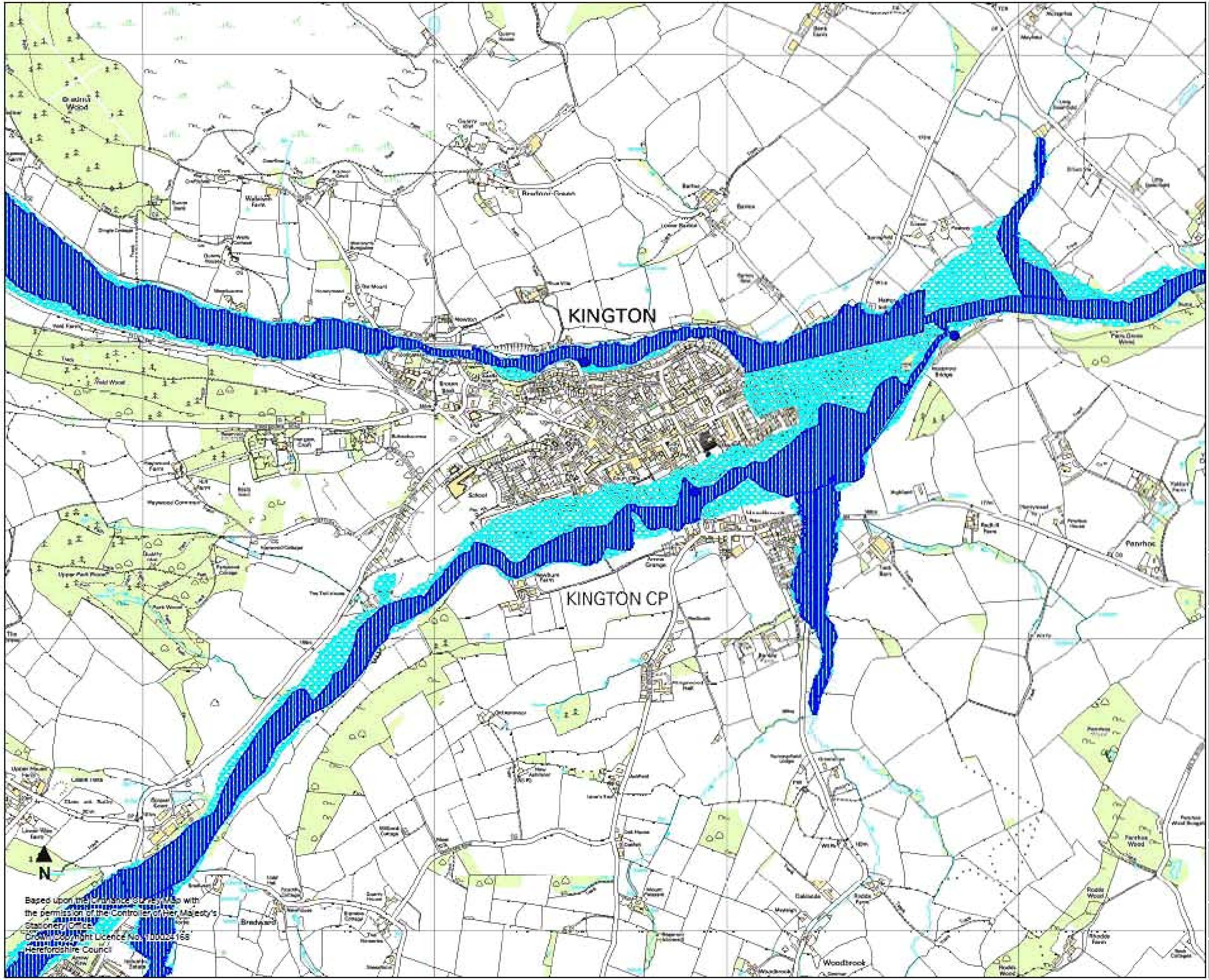
Title	Flood Risk, Flood Reports & Flood Defences
Subset	Ledbury
No.	1110/EB/3-6/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:12 500

Evidence Map 3-6

Evidence Map 3-7 – Environment Agency Flood Zones Kington



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Key

- County Boundary
- Wye River Basin
- Principal Rivers
- Main Town
- EA Flood Zone 3
- EA Flood Zone 2
- Flood Defences
- Areas Benefiting from Flood Defences
- Observed Flood Report

Client

Herefordshire Council

Scheme

Strategic Flood Risk Assessment

Drawing

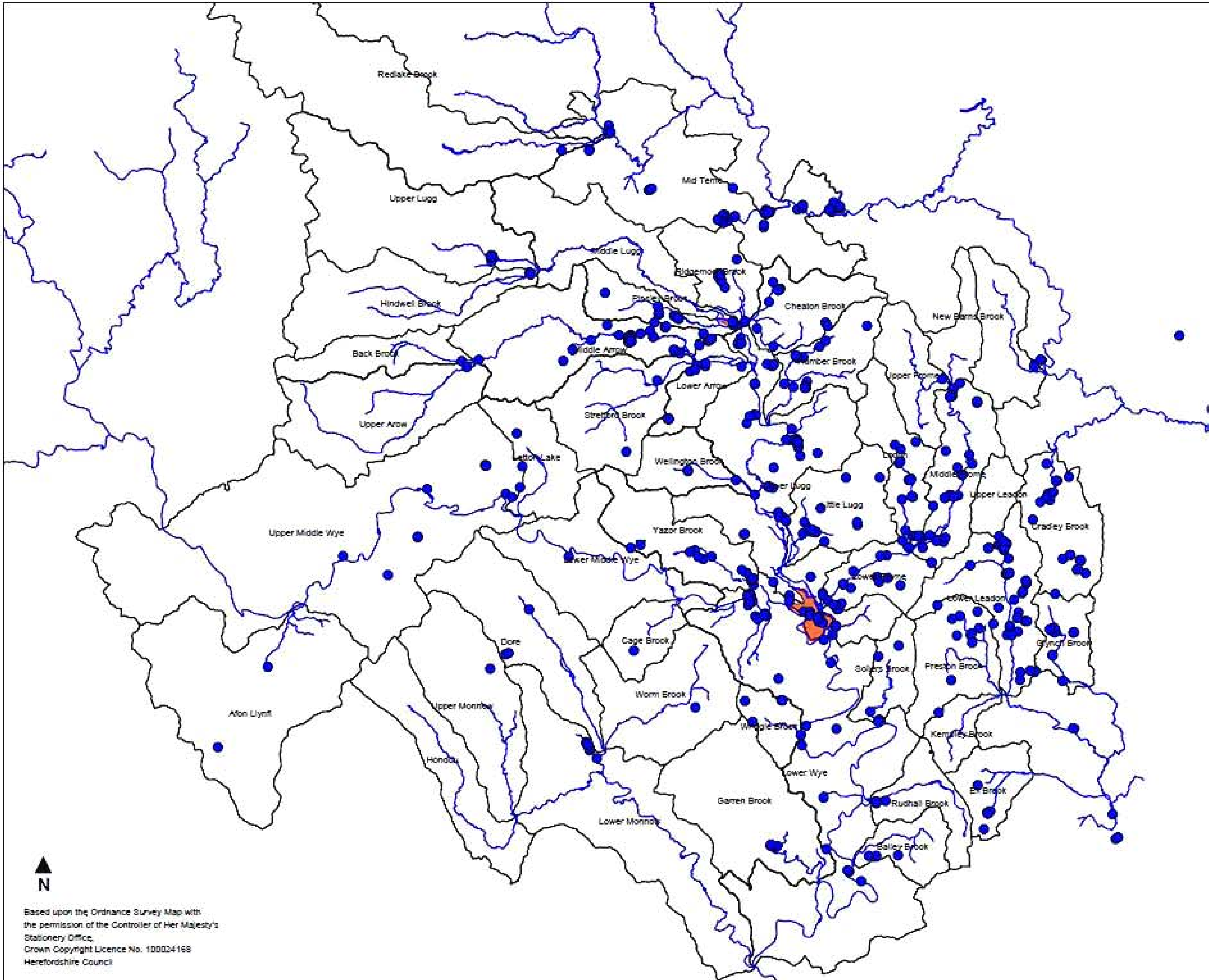
Title	Flood Risk, Flood Reports & Flood Defences
Subset	Kington
No.	1110/EB/3-7/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:12 500

Evidence Map 3-7

Evidence Map 3-8 – Historical Flood Reports By Sub-catchment



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Key

- Wye Catchment
- Herefordshire
- Principal Rivers
- Main Town
- EA Flood Zone 3
- EA Flood Zone 2
- Flood Defences
- Areas Benefiting from Flood Defences
- Observed Flood Report

Client
Herefordshire Council

Scheme
Strategic Flood Risk Assessment

Drawing

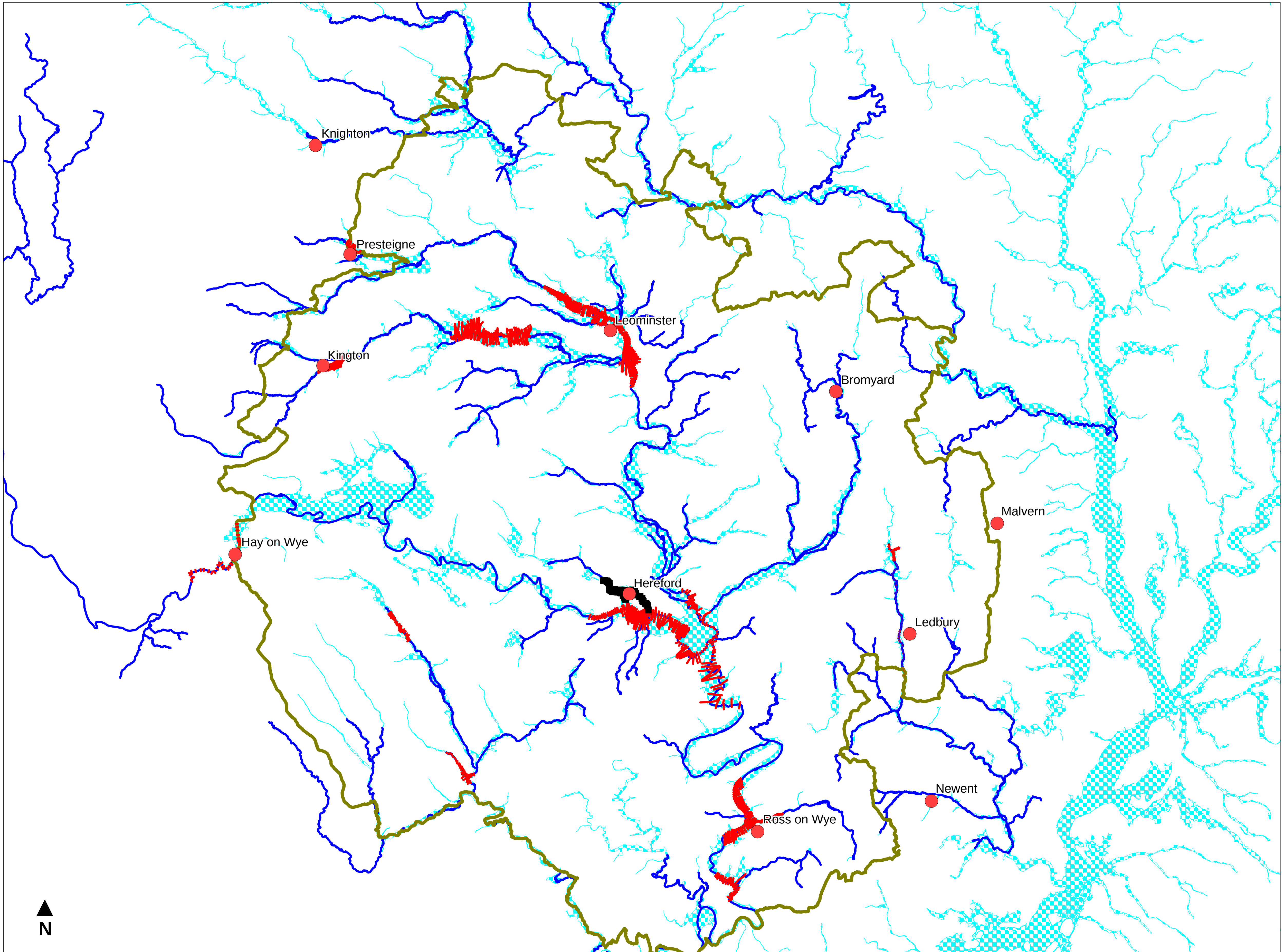
Title	General Flood Reports
Subset	By sub-catchment
No.	1110/EB/3-8/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:NTS

Evidence Map 3-8

Evidence Map 3-9 – Location of Hydraulic Models and Cross-sections



HEREFORDSHIRE COUNCIL

amey

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Key

	Wye Catchment
	Herefordshire
	Principal Rivers
	Main Town
	EA Flood Zone 3
	EA Flood Zone 2
	Models with Cross Sections

Client
Herefordshire Council

Scheme
Strategic Flood Risk Assessment

Drawing

Title	Hydraulic Models & Studies
Subset	Cross-section data
No.	1110/EB/3-9/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:NTS

Evidence Map 3-9

4. FLOOD HAZARD AND FLOOD RISK INDICATORS

4.1 Catchments as the Source of Flooding

Possibly unique amongst UK SFRAs, this study has attempted to develop a set of generalised but quantifiable catchment flood hazard and risk Indexes, based on the essential hydrological components of 47 policy specific identified sub-catchments.

The indexes focus on catchments, not rivers, as rivers are but one source of potential flood risk. The summer floods of 2007 clearly showed that significant flood damage to numerous properties and infrastructure can arise from general surface runoff and groundwater.

It was concluded that one of the most useful measures that a LPA could have at its disposal when sequentially testing land and development type allocations within the Local Development Framework would be a set of systematically derived indices that would compare sub-catchments on a like for like basis. Such a measure would greatly simplify:

- Where alternatives are available, the allocation of a development area to a lower category of flood risk, in compliance with the Sequential Test approach of PPS 25.
- Identification of future increased flood risk by comparison of development pressures in relation to the existing flood potential index.
- Identification of catchments most vulnerable to flash flooding
- Identification of the highest risk catchments where improved flood warning, or critical infrastructure resilience may be required

4.1.1 Catchment Flood Hazard Parameters Explained

In essence, the indexes attempts to objectively classify sub-catchments into a flood hazard potential class, derived from a comparative ranking of each sub-catchment with regard to a specific flood creating attribute (see Table 4-1).

A ranking of 1 denotes the highest relative level of flood hazard for that particular attribute. The selection of these attributes is subjective, and could be the subject of further refinement in the future if the method is found useful, but the principles are founded on sound science as explored in ongoing research [5]. The primary flood hazard attributes considered are discussed listed below, and explained in more detail in the Technical Appendix – Chapter 11.

As a general guide only, a single composite index known as the **Catchment Flood Hazard Index** has been derived for each sub-catchment, based on the average ranking of the following parameters:

- Proportion of time that Soil Moisture Deficit (SMD) was less than 6mm
- Standard Percentage Runoff (SPR)
- Time to Peak (Tp(t)) of the FEH Unit Hydrograph
- Number of Recorded Flood Reports / Divided by Catchment Area

This overall combined ranking is the average rank of the 4 attributes listed above for every sub-catchment, and is defined as the **Catchment Flood Hazard Index** (CFH Index). The CFH index has been explicitly incorporated into the **HSFRA All Catchments** GIS layer and database.

Table 4-1 also presents a range of other potentially useful relevant flood hazard potential parameters that have NOT been used to derive this composite index, but which may also individually be of use when assessing various aspects of development allocation under the sequential test. The technical background is presented in Technical Appendix A.

Foremost amongst these is the 'Adpoint' rank. This summarises the number of properties known to be at risk of flooding within a particular sub-catchment in the 1% AEP event. This individual parameter has been extracted for use in the Sequential Test as the **Fluvial Flood Risk Index** (FFR Index) and has been explicitly incorporated into the **HSFRA All Catchments** GIS layer and database. The Index is simply derived from GIS queries on how many properties are located in the floodplain, each catchment then ranked.

If a development site is unavoidably to be located within Flood Zone 3a, use of the FFR Index would help to locate the site in a catchment where there is a lesser number of properties in the same flood zone. The argument is that this sequential test at least minimises the increased pressure on potential emergency and evacuation resources for example.

A further index has used the hydrograph time to peak (Tp(t)) rankings to derive a general **Flood Timing & Evacuation Index** (FTE Index). The higher the rank of the catchment, the shorter is likely to be the flood peak timing; hence there is greater possibility of flash flooding, reduced flood warning time, and/or capacity of emergency services to respond to emergencies.

For example, if a specific development is considered vulnerable in terms of flood warning (emergency access is difficult, risk of being cut off etc.) flood warning time may be considered a critical issue for that site. Table 4-1 can be used to assess the sensitivity or ranking of the associated sub-catchment under that particular hazard and the SEQUITIR tool (see **5.7**) applied to find alternative reasonably available sites with a longer flood warning lead time. This would theoretically permit a greater period of time for flood warnings to be identified and issued, for a safe evacuation to be conducted or for emergency services to reach the site. Hence a lower level of risk can be identified for an alternative site, thereby complying with the stipulations of PPS 25.

The alternatives are readily assessed from **Table 4-1**. The FTE Index has been explicitly incorporated into the **HSFRA All Catchments** GIS layer and database.

The tabled parameters of Table 4-1 can also feasibly be applied in any combination. For example, if two comparative sites are being considered for development, both beyond the Zone 3 and 2 floodplains, but both on higher, steeper ground, the respective ranking of the parameters SPR and Tp(t) could be averaged to estimate the site potentially least susceptible to flash flooding.

Table 4-1 – Fluvial and Catchment Flood Risk Indices

					FFR Index						FTE Index				CFH Index	
Catchment	Area	Rank	SAAR	Rank	Adpoint	Rank	PROPWET	Rank	SPR	Rank	Tp(T)	Rank	Reports	Rank	AVG	Rank
Redlake Brook	167.6	3	996	5	2	40	0.48	11	33.60	30	7.70	25	1	43	27	41
Mid Teme	148.1	5	909	12	86	11	0.39	14	23.50	40	10.05	39	109	7	25	31
Sapley Brook	39.4	26	722	26	4	38	0.32	32	37.70	10	6.34	15	2	32	22	21
Cradley Brook	47.9	24	698	37	16	24	0.32	32	34.70	23	6.92	20	21	16	23	23
Upper Leadon	15.3	47	694	41	1	42	0.32	32	37.60	12	5.15	5	0	44	23	26
Lower Leadon	60.1	20	686	43	25	20	0.32	32	37.90	8	9.41	33	63	2	19	6
Preston Brook	46.1	25	693	42	12	27	0.33	21	35.60	21	8.07	27	12	22	23	23
Kempley Brook	17.6	45	695	40	0	46	0.33	21	35.80	20	6.51	17	0	44	26	34
Glynch Brook	24.7	39	681	45	1	42	0.33	21	32.00	33	6.04	12	14	11	19	12
Ell Brook	27.0	37	709	35	11	28	0.33	21	33.90	27	5.52	7	14	15	18	4
Afon Llynfi	149.6	4	999	4	0	46	0.54	1	30.70	35	5.81	9	8	31	19	9
Letton Lake	37.7	29	720	27	16	24	0.49	5	36.50	18	6.79	18	1	37	20	13
Upper Middle Wye	318.1	1	1100	2	227	5	0.48	11	34.70	23	13.75	44	14	33	28	42
Cage Brook	23.4	42	716	28	25	20	0.33	21	38.00	7	7.28	23	2	30	20	15
Middle Wye GS55002	79.9	12	825	16	4	38	0.49	5	37.80	9	16.25	45	1	42	25	33
Yazor Brook	51.0	21	686	43	688	2	0.32	32	38.30	6	7.44	24	27	14	19	9
Upper Lugg	116.8	8	988	6	202	6	0.49	5	30.60	36	5.94	11	19	24	19	9
Hindwell Brook	78.1	15	977	7	30	19	0.49	5	33.80	29	6.06	13	2	38	21	19
Middle Lugg	73.6	16	935	10	45	13	0.27	47	22.09	43	9.79	37	11	25	38	47
Ridgemoor Brook	34.5	31	715	29	43	15	0.32	32	30.60	36	7.76	26	11	18	28	43
Cheaton Brook	38.8	27	713	33	5	36	0.32	32	37.00	17	8.14	28	12	19	24	29
Pinsley Brook	23.7	41	734	21	443	3	0.33	21	30.20	38	9.12	32	13	13	26	37
Upper Arrow	84.2	11	968	9	54	12	0.49	5	35.30	22	5.87	10	19	23	15	2
Back Brook	32.9	33	973	8	25	20	0.49	5	33.40	31	4.77	2	1	35	18	5
Middle Arrow	86.4	10	887	13	144	7	0.39	14	31.90	34	9.72	35	49	12	24	28
Stretford Brook	60.6	19	714	32	8	32	0.34	18	37.70	10	9.89	38	2	34	25	31
Lower Arrow	25.2	38	887	13	11	28	0.45	13	33.40	31	9.72	35	24	4	21	17
Humber Brook	38.2	28	715	29	6	34	0.32	32	37.50	14	8.26	29	25	8	21	17
Wellington Brook	27.1	36	698	37	40	16	0.32	32	37.60	12	6.90	19	3	28	23	23
Little Lugg	48.7	23	658	47	32	17	0.32	32	39.60	4	9.47	34	46	5	19	6
Upper Frome	33.1	32	727	24	2	40	0.32	32	37.30	16	7.11	22	1	36	27	40
New Barns Brook	20.6	44	730	22	1	42	0.32	32	38.70	5	7.02	21	0	44	26	34
Middle Frome	50.2	22	710	34	44	14	0.32	32	40.02	1	11.36	41	58	1	19	6
Lodon	37.4	30	696	39	5	36	0.32	32	40.00	2	8.49	30	16	17	20	15
Lower Frome	28.5	35	699	36	10	30	0.32	32	33.87	28	12.60	42	28	3	26	39
Lower Lugg	136.4	7	791	17	273	4	0.34	18	34.50	26	16.66	46	88	9	25	30
Wriggle Brook	17.4	46	729	23	6	34	0.33	21	14.50	45	4.61	1	5	21	22	20
Sollers Brook	22.7	43	681	45	7	33	0.33	21	28.80	39	6.14	14	7	20	24	27
Rudhall Brook	30.2	34	715	29	133	8	0.33	21	13.80	46	5.33	6	26	6	20	14
Bailey Brook	24.4	40	748	19	31	18	0.33	21	12.90	47	5.69	8	3	27	26	36
Garren Brook	91.0	9	762	18	16	24	0.33	21	14.90	44	10.64	40	8	29	34	46
Lower Wye	225.5	2	725	25	1253	1	0.38	16	23.40	41	25.13	47	129	10	29	44
Upper Monnow	79.4	13	1083	3	23	23	0.54	1	34.70	23	5.02	4	1	41	17	3
Honddu	63.0	18	1206	1	1	42	0.54	1	22.70	42	4.80	3	0	44	23	22
Dore	78.8	14	875	15	94	10	0.51	4	39.90	3	6.36	16	10	26	12	1
Worm Brook	73.5	17	744	20	9	31	0.34	18	37.40	15	8.89	31	1	40	26	37
Lower Monnow	139.3	6	932	11	124	9	0.38	16	36.10	19	12.82	43	3	39	29	45
Sum or Average	3173		801		4238		0.38		32.61		8.49		19.36			

4.1.2 CFH Index as part of the Sequential Test

The CFH Index or other individual Indexes can be used directly by the LPA to demonstrate that where feasible, it has located development sites in the lowest possible areas of general flood risk (as opposed to fluvial flood risk), thereby complying with the Sequential Test. This test could be either on the basis of the general CFH Index OR against a specific parameter from within Table 4-1 if this parameter was considered individually more relevant to the site.

So as not to over-sensitise the analysis, it is recommended that sub-catchments are grouped into categories of flood hazard potential, with the 5 most hazardous catchments being described as Category 1, the next 5 as Category 2. After the first 10 catchments are allocated, it is suggested that Category 3 includes the next 10 ranked catchments, and thereafter no further distinction is drawn as the Index will be sufficiently coarse as to make divisions somewhat arbitrary.

- **Category 1** – Ranks 1 – 5 sub-catchments with highest relative flood hazard potential
- **Category 2** – Ranks 6 – 12 sub-catchments with average to high relative flood hazard potential
- **Category 3** – Ranks 11 – 20 sub-catchments with lower to average flood hazard potential
- **Category 4** – Ranks 21 - 47 sub-catchments with least flood hazard potential

Table 4-2 below summarises the categorised flood hazard catchments.

Table 4-2 – Flood Hazard Potential Categories by Sub-catchment

General Flood Hazard Category	Identified Sub-catchments (listed by rank)
Category 1 Highest Flood Hazard Potential Ranks 1 – 5 (5 catchments)	Dore, Upper Arrow, Ell Brook, Upper Monnow, Back Brook
Category 2 Average to High Flood Hazard Potential Ranks 6 – 12 (8 catchments)	Lower Leadon, Little Lugg, Middle Frome, Upper Lugg, Yazor Brook, Afon Llynfi, Letton Lake, Glynch Brook
Category 3 Lower to Average Flood Hazard Potential Ranks 13 – 20 (8 catchments)	Cage Brook, Rudhall Brook, Lodon, Lower Arrow, Humber Brook, Hindwell Brook, Sapley Brook, Wriggle Brook
Category 4 Least Flood Hazard Potential Ranks 21 – 47 (26 catchments)	Wellington Brook, Honddu, Cradley Brook, Preston Brook, Upper Leadon, Sollers Brook, Cheaton Brook, Middle Arrow, Stretford Brook, Lower Lugg, Mid Teme, Middle Wye, Bailey Brook, Kempley Brook, Bromyard Brook, Pinsley Brook, Worm Brook, Upper Frome, Lower Frome, Redlake Brook, Upper Middle Wye, Ridgemoor Brook, Lower Wye, Lower Monnow, Garren Brook, Middle Lugg,

For direct use in the Sequential Test approach, the **Catchment Flood Hazard Index** has been added to the GIS Layer **HSFRA All Catchments**.

4.2 Identifying the Key Flood Risk Areas

Risk driven plans and strategies such as SFRAs and CFMPs should target policy and resources at the highest risk areas. It is requirement of these plans that the Environment Agency and LPA should engage and agree which areas within the catchment are the highest at risk and what polices should be adopted to control this risk [1].

This SFRA has provided a wealth of evidence to support the LPA in this priority task, and the outputs are likely to be somewhat more detailed than those considered in the CFMP. Nevertheless, there should be broad agreement between regulatory authorities which villages, localities and catchments should receive active intervention to reduce flood risk (i.e. Policy Options 4 and 5 under the CFMP framework).

Within the SFRA framework, the highest risk areas that are identified for urgent active policy consideration are based on the following objective measures:

- The five highest ranking catchments in terms of fluvial flood risk i.e. existing flood-risk defined by property counts within the 1% AEP floodplain
- The five highest ranking catchments in terms of generalised flood hazard as defined by the Catchment Flood Hazard Index of this study
- The five highest ranking catchments in terms of number of reported flood incidents.
- Specific settlements where there has been repeated severe flooding and where strategic options may be necessary in the future.

Where catchments fall into more than one of these categories, these can be considered to be even higher priority candidates for active policy intervention.

Development pressure is ignored in these criteria, precisely because through the Sequential Test, the LPA will have to demonstrate that it has sought to locate developments in alternative areas. Hence, development allocation is an output from the risk assessment, not an input.

Current risks are identified in **Evidence Map 4-1 Principal Flood Risk Areas** which also includes the EA flood warning areas.

4.2.1 Five Highest Risk Catchments by Fluvial Flood Risk

Table 4-3 summarises the highest fluvial flood risk areas as defined by the FFR Index.

Table 4-3 – Five Highest Fluvial Flood Risk Catchments

Catchment	Localities affected	Watercourses	Risk Measure
Lower Wye	Hereford	Wye, Red Brook, Withy Brook,	Rank =1 under FFR Index
Yazor Brook	Hereford	Yazor Brook, Widemarsh Brook	Rank = 2 under FFR Index
Pinsley Brook	Leominster	Pinsley Brook, Lugg	Rank = 3 under FFR Index
Lower Lugg	S. Leominster, Bodenham, Hope-under-Dinmore, Hampton Bishop, Mordiford	Lugg, Cherry Brook, Pentaloe Brook	Rank = 4 under FFR Index
Upper Middle Wye	Eardisley, Winforton, Whitney-on-Wye	Wye	Rank =5 under FFR Index

4.2.2 Five Highest Risk Catchments by Flood Hazard

Catchment Flood Hazard is defined in **4.1.1** as the average of the rank of each catchment with respect to long-term percentage runoff, soil moisture deficit, time to peak and number of flood reports. This is a general indicator of potential surface water flooding, and as expected there is no overlap with the FFR Index as these are measuring quite different flood impacts (one flood hazard, the other fluvial risk). The five highest ranking catchments are summarised in Table 4-4.

Table 4-4 – Five Highest General Flood Hazard Catchments

Catchment	Localities affected	Watercourses	Risk Measure
Dore	Dorstone, Peterchurch	Dore	Rank =1 under CFH Index
Upper Arrow	Kington	Arrow	Rank = 2 under CFH Index
Upper Monnow	Michaelchurch Escley, Clodock, Longtown	Escley Brook, Olchon Brook,	Rank = 3 under FFR Index
Ell Brook	Aston Ingham	Ell Brook	Rank = 4 under FFR Index
Back Brook	Kington	Back Brook	Rank =5 under FFR Index

4.2.3 Five Highest Risk Catchments by Flood Reports

Irrespective of the theoretical indicators, account should also be taken of where actual flooding has been record in the past. Historical flooding can be a useful pointer to future flood risk, because the causes of the flooding are likely to persist. It is possible to query the database directly to ascertain the total number of flood reports by catchment, and this output leads to Table 4-5.

Table 4-5 - Five Highest Catchments by Flood Reports

Catchment	Localities affected	Watercourses	Risk Measure
Lower Wye	Hereford, Lower Bullingham, Hampton Bishop	Wye, Red Brook, Yazor Brook	Rank =1 under Reports Index
Mid Teme	Leintwardine, Orleton, Brimfield	Teme, Brimfield Brook, Little Hereford	Rank = 2 under Reports Index
Lower Lugg	S. Leominster, Stoke Prior, Hope-u-Dinmore, Bodenham, Marden, Sutton St Nicholas, Withington Marsh, Hampton Bishop, Mordiford	Lugg, Cherry Brook, Pentaloe Brook	Rank = 3 under Reports Index
Lower Arrow	Barons Cross, Ivington, Knapton Green	Arrow, Honeylake Brook,	Rank = 4 under Reports Index
Middle Frome	Bromyard, Bishops Frome, Five Bridges, Stretton Grandison	Frome	Rank =5 under Reports Index

4.2.4 Summary Flood Risk Map

The overall flood hazard, flood risk and flood report indicators discussed above are summarised in **Evidence Map 4-1** and is held as GIS layer **HSFRA Flood Risks**. **HSFRA Flood Risks** can be used in combination with numerous other GIS layers to identify development pressures, flood warning deficiencies, and critical infrastructure impacts.

There is a reasonable association between theoretical Category 1 Flood Hazard catchments and observed flood reports, suggesting that the Index is useful in identifying potential flood hazards, for example in the Dore catchment (Ewyas Harold), Back Brook and Upper Arrow (Kington), and in the Ell Brook (Aston Ingham).

The Flood Risk Map basically confirms that the greatest fluvial risks to existing property lie along the main corridors of the Lugg and the Wye, where there is the greatest concentration of property. Development in these areas must be located outside the zone 3 and 2 floodplains otherwise this will place an increased burden on emergency services and civil contingency planning.

There are a significant number of observed flooding hot-spots. The most persistent include Kington, Leominster and Hereford in the main towns, and Leintwardine, Eardisland, Orleton, Ivington, Bodenham, Stretton Grandison, Sutton

St Nicholas, Bosbury, Hampton Bishop and Ewyas Harold among the villages. Strategic solutions may be needed for these places in future.

4.3 Interactions with the EA Catchment Flood Management Plan

The EA is asked to take note of the methodologies used to ascertain flood hazard and flood risk in the SFRA area, and establish if this information can be incorporated usefully into the CFMP.

There is a requirement for the EA and Herefordshire Council to be in agreement about where exactly the greatest existing flood risks are located, and to make provisional plans and policies for their protection.

Table 4-1 indicates that currently there are 4238 properties at risk in the 1% AEP event in the SFRA area, which loosely corresponds to the Lower Wye part of the CFMP. This is significantly more than the CFMP figure of 2900 properties for the same region. The EA should check and confirm its calculations.

4.4 Evidence Based Statements

1) Possibly unique amongst UK SFRAs, this study has attempted to develop a set of generalised but quantifiable catchment flood hazard and risk Indexes, based on the essential hydrological components of 47 policy specific identified sub-catchments. The indexes focus on catchments, not rivers, as rivers are but one source of potential flood risk. The summer floods of 2007 clearly showed that significant flood damage to numerous properties and infrastructure can arise from general surface runoff and groundwater.

2) It was concluded that one of the most useful measures that a LPA could have at its disposal when sequentially testing land and development type allocations within the Local Development Framework would be a set of systematically derived indices that would compare sub-catchments on a like for like basis.

3) The CFH Index or other individual Indexes can be used directly by the LPA to demonstrate that where feasible, it has located development sites in the lowest possible areas of general flood risk (as opposed to fluvial flood risk), thereby complying with the Sequential Test. This test could be either on the basis of the general CFH Index OR against a specific parameter from within Table 4-1 if this parameter was considered individually more relevant to the site.

4) Risk driven plans and strategies such as SFRAs and CFMPs should target policy and resources at the highest risk areas. It is requirement of these plans that the Environment Agency and LPA should engage and agree which areas within the catchment are the highest at risk and what polices should be adopted to control this risk [1].

5) This SFRA has provided a wealth of evidence to support the LPA in this priority task, and the outputs are likely to be somewhat more detailed than those considered in the CFMP. Nevertheless, there should be broad agreement

between regulatory authorities which villages, localities and catchments should receive active intervention to reduce flood risk (i.e. Policy Options 4 and 5 under the CFMP framework).

6) There is an observed association between Category 1 Flood Hazard catchments and observed flood reports, suggesting that the Index is useful in identifying potential flood hazards, for example in the Dore catchment (Ewyas Harold), Back Brook and Upper Arrow (Kington), and in the Ell Brook (Aston Ingham).

7) The Flood Risk Map basically confirms that the greatest fluvial risks to existing property lie along the main corridors of the Lugg and the Wye, where there is the greatest concentration of property. Development in these areas must be located outside the zone 3 and 2 floodplains otherwise this will place an increased burden on emergency services and civil contingency planning.

8) There are a significant number of observed flooding hot-spots. The most persistent include Kington, Leominster and Hereford in the main towns, and Leintwardine, Eardisland, Orleton, Ivington, Bodenham, Stretton Grandison, Sutton St Nicholas, Bosbury, Hampton Bishop and Ewyas Harold among the villages. Strategic solutions may be needed for these places in future.

4.5 Evidence Based Recommendations

1) The EA is asked to take note of the methodologies used to ascertain flood hazard and flood risk in the SFRA area, and establish if this information can be incorporated usefully into the CFMP.

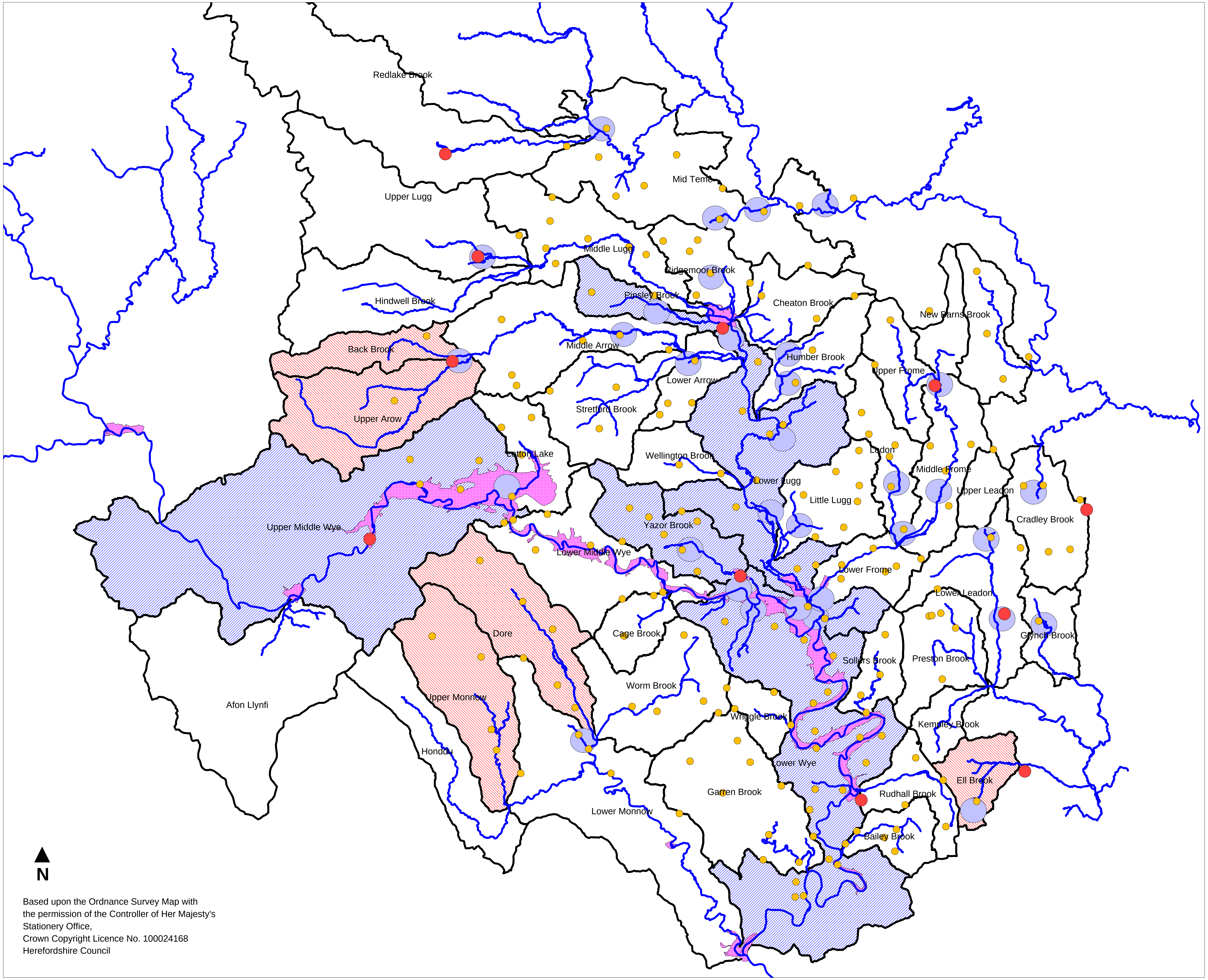
2) There is a requirement for the EA and Herefordshire Council to be in agreement about where exactly the greatest existing flood risks are located, and to make provisional plans and policies for their protection.

3) Table 4-1 indicates that currently there are 4238 properties at risk in the 1% AEP event in the SFRA area, which loosely corresponds to the Lower Wye part of the CFMP. This is significantly more than the CFMP figure of 2900 properties for the same region. The EA should check and confirm its calculations.

4) Specific flood management plans and policies should be prepared for the high fluvial risk catchments of the Pinsley Brook, Lower Wye and the Lower Lugg.

5) Specific flood management plans and policies should be considered for the persistent flood risk areas of Leintwardine, Eardisland, Orleton, Ivington, Bodenham, Stretton Grandison, Sutton St Nicholas, Bosbury, Hampton Bishop and Ewyas Harold among the villages. Strategic solutions may be needed for these places in future.

Evidence Map 4-1 – Principal Flood Risk Areas



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Key

- Wye Catchment
- Herefordshire
- Principal Rivers
- Main Town
- Village
- Flood Warning Area
- Category 1 Flood Risk Area
- Category 1 Flood Hazard Area
- Extensive Flood Reports

Client
Herefordshire Council

Scheme
Strategic Flood Risk Assessment

Drawing

Title	Principal Flood risk
Subset	By sub-catchment
No.	1110/EB/4-1/a
Date	24-1-2008
Check:	BF

Revisions

Scale : 1:NTS

Evidence Map 4-1