# Nottingham City Council

# Preliminary Flood Risk Assessment (PFRA)

**Revision History**

| Revision | Author: | Checked by: |
|---|---|---|
| First Draft | Tony Donaldson, Engineer (20th May 2011) | Chris Capewell, Team Leader 25th May 2011 |
| Revision A | Tony Donaldson, Engineer (1st June 2011) | Chris Capewell, Team Leader 6th June 2011 |
| Revision B | Tony Donaldson, Engineer (15th June 2011) | Chris Capewell, Team Leader 15th June 2011 |

# EXECUTIVE SUMMARY

Non-Technical Summary

In recent years parts of Europe including the UK have suffered from significant and damaging flood events that have resulted in economic disruption, people being made homeless and also loss of lives. European legislation has been enacted that requires member countries including the UK to manage the risk of flooding effectively to reduce the damage from future flood events. The first part of this process is for the production of a Preliminary Flood Risk Assessment (PFRA) for all areas of the UK with each unitary or county authority responsible for producing an assessment. The PFRA is based on existing flood risk information and identifies areas that may be at risk of flooding during an extreme rainfall event. It does not mean these areas will actually flood, only that there is a risk of flooding.

Nottingham City Council will use this information as part of their work along with partner organisations to manage the drainage systems within the city and this document will be used to assist the process of prioritising future work. The Surface Water Management Plan for Nottingham is being prepared to take forward the information in the PFRA.

Technical Summary

This report has been produced by Nottingham City Council as a Local Lead Flood Authority[1] (LLFA) in line with responsibilities under the Flood Risk Regulations 2009[2] (Statutory Instrument no. 3042, 2009) and Flood and Water Management Act (FWMA)[3]. LLFA's are responsible for undertaking a PFRA to assess local sources of flood risk, primarily from surface runoff, groundwater and ordinary watercourses. The PFRA is a high level screening exercise required by the Flood Risk regulations 2009 and has involved:

- collecting information on past (historic) and future (potential) floods,
- assembling the data into a preliminary assessment report,
- defining a datum level beyond which previous event or future flood risks may be defined as locally significant.
- using it to identify Flood Risk Areas which are areas where the risk of flooding is *significant*.

The PFRA produced by Nottingham City Council is based on existing and available information and collates information from national and local sources. This data has been obtained from within Nottingham City Council and from key stakeholders. Information from the PFRA process will also feed into other assessments including local flood risk management strategies under the FWMA.

The overall aim of the PFRA documents produced by LLFAs throughout England is to identify Nationally Significant Flood Risk Areas. An area is considered nationally significant if more than 30,000 people, 3,000 non-residential properties, or 150 critical infrastructure locations are at risk of flooding within a particular area. The summation methodology involved clustering

[1] Lead Local Flood Authority as defined by the Flood & Water Management Act 2010

[2] Statutory Instrument no. 3042, 2009: Flood Risk Regulations - http://www.legislation.gov.uk/uksi/2009/3042/contents/made

[3] Flood & Water Management Act 2010 – see http://www.legislation.gov.uk/ukpga/2010/29/contents

1km grid squares that individually had 85 residential properties, 20 commercial properties or 2 critical infrastructure locations within the grid square that were shown to be at risk of flooding to 300mm deep during a 1 in 200 year rainfall event lasting 1.1 hours shown on the Flood Map for Surface Water (FMfSW). This magnitude of storm has been estimated by the Environment Agency as capable of producing a 1 in 100 year flooding event on the ground. The difference between the return periods reflects the capacity of the drainage systems to manage rainfall events to a degree without flooding occurring on the ground.
In addition to the areas identified through the FMfSW, there are some areas considered to be at risk of flooding by Nottingham City Council. In some cases these occupy the same grid square as areas highlighted by the FMfSW however there are also additional areas.

Although there are no Nationally Significant Flood Risk Areas within the City Council, the creation of a PFRA requires the definition and identification of locally significant flood risk. The threshold for locally significant flood risk within Nottingham been set at:

- 20 properties or,
- 2 commercial premises or ,
- 1 critical infrastructure including schools, hospitals, major communication links, substations, telecoms hubs.

Rather than including the total number of properties within a particular grid square or unit of area, the qualification is based on the flood risk location grouped within a particular discrete flooding area. More information on the rationale behind the definition is included later in the report.

Although not required as part of the national PFRA process, Nottingham City Council will use the information gathered as part of this document to identify areas of Locally Significant Flood Risk. Further investigation and modelling can then be focused on these areas in order to fully assess the nature of the risk and evaluate the actions to mitigate or reduce either the probability or consequences of flooding.

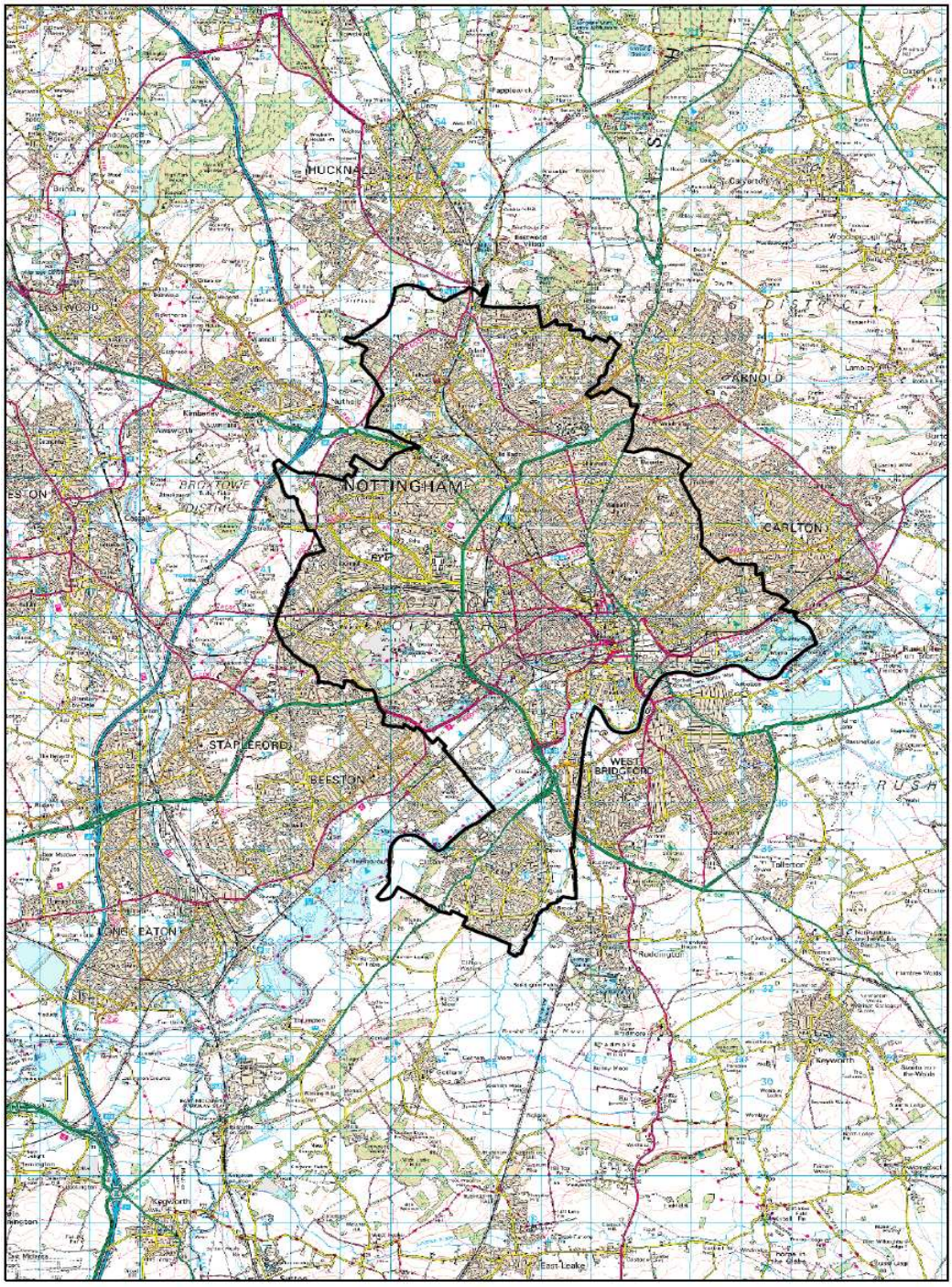



**Figure 1 Map of Nottingham**

## Contents list

**List of Figures**



**List of Tables**

# 1 INTRODUCTION

## 1.1 Scope of the report

Nottingham City Council is a Lead Local Flood Authority (LLFA) and is required by the Flood Risk Regulations 2009 to produce a Preliminary Flood Risk Assessment (PFRA).

The Flood Risk Regulations 2009 established three stages of a flood risk management cycle, scheduled for completion in June 2015 with the aim of achieving the assessment and management of the flood risk to areas within each LLFA administrative area. Lead Local Flood Authorities are higher tier Local Authorities including London Boroughs, County Councils and Unitary Authorities. The PFRA is the first stage in a process that is scheduled to be completed by the end of 2015. The overarching 'driver' behind the Flood Risk Regulations is the European Flood Risk Management directive[4] (Directive 2007/60/EC). The Directive requires Member States to first carry out a preliminary assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding. For such zones they would then need to draw up flood risk maps by 2013 and establish flood risk management plans focused on prevention, protection and preparedness by 2015. The Directive applies to inland waters as well as all coastal waters across the whole territory of the EU. The Environment Agency are responsible for collating and defining the PFRA for main rivers, statutory reservoirs (where the capacity is over 10,000 cubic metres of water that could be released in the event of a failure of the reservoir or for smaller reservoirs where the consequences of failure are severe) and the coastal flood risk. LLFAs are responsible for the assessment of all other sources of flood risk including ordinary watercourses, sewers, and surface water drainage systems

## 1.2 Aims and objectives of the PFRA

The following aims and objectives have been written to guide Lead Local Flood Authorities through the PFRA process.

- The aim of this PFRA is to provide an overview and assessment of local flood risk across the Nottingham City urban area, including information on past floods and the potential extents and consequences of future floods.

### 1.2.1 Objectives

- To collect information on historic and future (potential) floods and flood risk,
- To assemble the information in the PFRA report template and assessment spreadsheets,
- To establish and agree a arbitrary datum for whether an event is locally significant and determine where in Nottingham there are locally significant flood risks based on the probability and the consequence of a flooding event occurring,
- To work with professional partners and stakeholders to communicate information and build an appreciation of the data quality and limitations.

[4] Directive 2007/60/EC – see http://ec.europa.eu/environment/water/flood_risk/index.htm for more information

## 1.3 Introduction to the Study Area

Nottingham City Council covers an area of approximately 74.5 km² with a population of approximately 300,000 people within the city boundary and a further 370,000 people in the surrounding urban area. It is surrounded by the county of Nottinghamshire.

The high population density coupled with the undulation topography has lead to a particularly high density of flood risk within Nottingham and particular challenges in achieving efficient and economic management of the risk whilst balancing a number of competing factors including the need for regeneration and growth. Some of the characteristics of Nottingham are detailed in the flowing points:

- The city area is urbanised with a high proportion of developed areas and relatively few areas of open, vegetated land.
- The topography varies from flat flood plain areas next to the River Trent and lower reaches of the River Leen and Day Brook however most of the city area is undulating around a series of watercourse valleys.
- The former watercourses in many of the valleys have been culverted as Nottingham developed and in many cases the main drainage conduit is a combined sewer operated by Severn Trent Water.
- The surface soils over the northern part of Nottingham tend to be sandy clays and weathered mudstones overlying permeable sandstones and other rocks of the middle coal measures series. In the southern part of Nottingham near to the River Trent, the near surface deposits tend to be sand, gravel and silt. In this respect the infiltration rates for water into the near-surface soils varies widely across the city area. Also the infiltration rate is considerably better in the first 0.5m of surface deposits compared to deeper layers. The infiltration rates may be 10x greater for the near-surface layers due to lower compaction and the action of vegetation reducing the degree of saturation of the soils.

Nottingham is drained through a number of drainage networks:

- Approximately 10km$^2$ (14% of the total) of the city (and some areas of Bramcote and Beeston) are drained to the sewers and minor watercourses that drain into the Tottle Brook in the western part of Nottingham. Tottle brook is a left bank tributary and discharges into the River Trent east of the Lenton Industrial Estate adjacent to Queens Drive.
- Approximately 40km$^2$ (54% of the total) of Nottingham (and another ~80km$^2$ of rural/urban catchments north of Nottingham) drain to the River Leen drainage system. In some cases the 'dry weather' flows are managed through the combined sewers draining parts of Nottingham however intense rainfall events would tend to overload the combined sewers with excess flows being directed via combined sewer overflows (CSOs) to the surface water and fluvial networks.
- Approximately 6.5km$^2$ (9% of the total) of eastern Nottingham drain to a culverted watercourse & combined sewer system flowing down St Anns Well road before discharging into the River Trent adjacent to Trent Lane
- Approximately 3km$^2$ (4.5% of the total) of eastern Nottingham drains to the River Trent via a sewer/watercourse system routed through Colwick park.
- Approximately 4.5km$^2$ (6.5% of the total) of the city centre and Meadows area drains to the combined & surface water sewer system that empties into the River Trent's via CSOs into the Tinker Leen watercourse during high rainfall events.
- Approximately 6km$^2$ (8% of the total) of Clifton and surrounding areas drains via sewer and watercourse systems to the Nethergate and Fairham brooks. The latter is a right bank tributary of the River Trent discharging near to the A52 Clifton Bridge.
- Approximately 1km$^2$ (1.3% of the total) of Wilford and surrounding areas drains via sewer and watercourse systems to the River Trent.

- Approximately 2km$^2$ (2.7% of the total) of the city area lies close to the River Trent. Rainfall in these areas either infiltrates into the floodplain areas or drains to the river.


**Figure 2 Map showing drainage areas**

# 2 LEAD LOCAL FLOOD AUTHORITY RESPONSIBILITIES

## 2.1 Responsibilities

The development of a PFRA is one of the several responsibilities for Lead Local Flood Authorities under the Floods and Water Act 2010. This section provides a brief overview of the responsibilities that Nottingham City Council is obliged to fulfil under their role as a LLFA. The main areas of responsibility are shown in the following table.

**Table 1 LLFA responsibilities**

| Legislation | LLFA Duties |
|---|---|
| Land Drainage Act 1991 | Management of ordinary watercourses.<br>Riparian responsibility for watercourses where the LLFA is the landowner. |
| Civil Contingencies Act 2004 | Emergency Planning Role<br>• Assistance with and preparation of Multi Agency Flood Plans,<br>• Work with Local Resilience Forum<br>• Produce Community Risk Register |
| Flood Risk Regulations 2009 | Production of the Preliminary Flood Risk Assessment<br>Identification of flood risk areas<br>Production of flood hazard & risk maps<br>Production of flood risk management plan |
| Flood & Water Management Act 2010 | Consenting of works that affect ordinary watercourses.<br>Duty to investigate flooding incidents.<br>Sustainable Drainage appraisals, approvals & adoption.<br>Production and maintenance of a register of assets that affect flood risk. Powers to designate 3rd party assets affecting flood risk management.<br>Powers to require and undertake environmental works to reduce flood risk.<br>Powers to designate assets as important in the management of local flood risk and responsibility to coordinate the upkeep of these.<br>Contribute towards the broad aims of sustainable development.<br>Party to the Regional Flooding & Coastal Committee. |
| Highways Act | Responsibility to ensure effective drainage of the highways. |

## 2.2 Governance & Communication

For a number of years flood risk management work has been subject to scrutiny by the Regeneration and Sustainability select committee of Nottingham City Council. Representatives from the Environment Agency and Severn Trent Water have been present at these meetings to inform Councillors of the work they are doing to manage flood risk.

All LLFAs must establish appropriate partnerships to help with the collection and sharing of data, and the effective management of the PFRA process. The importance of working together is reflected in Regulation 35 of the Flood Risk Regulations and Section 13 of the Flood and Water Management Act.

Rainfall and surface runoff do not respect administrative, political or organisational boundaries. Consequently we recognise the importance of working with the adjoining authorities along with all flood risk management authorities within the Nottingham area. This collaborative working helps us to both reduce the likelihood and consequences of flooding, as well as learn from each other how best to manage flood risk.

In order to promote effective partnerships it is proposed to set up a joint Nottingham / Nottinghamshire Strategic Flood Risk Management Board. This Board will operate in a similar manner to those boards already successfully operating in other parts of the Midlands. It is likely that this Board will meet in October 2011.

The objective of the Strategic Flood Risk Management Board is to provide a forum of relevant senior Council officers and Councillors along with senior representatives from the Environment Agency, utility companies, the emergency services, and other flood risk management authorities to develop a strategic approach to drainage and flood management.

The strategic board will not replace any of the existing organisations, but instead work alongside those other bodies with an interest in flood risk management.

The main aims of the partnership are:

- To facilitate the management of flooding risks from all sources.
- To enable Nottingham City Council & Nottinghamshire County Councils to fulfil their responsibilities as Lead Local Flood Authorities.
- To provide strategic advice, overview and direction.
- To enable the Environment Agency to perform their strategic overview role.

Figure 3 below indicates the proposed structure of the Strategic Board in relations to the other existing bodies, and the communication links between these organisations.

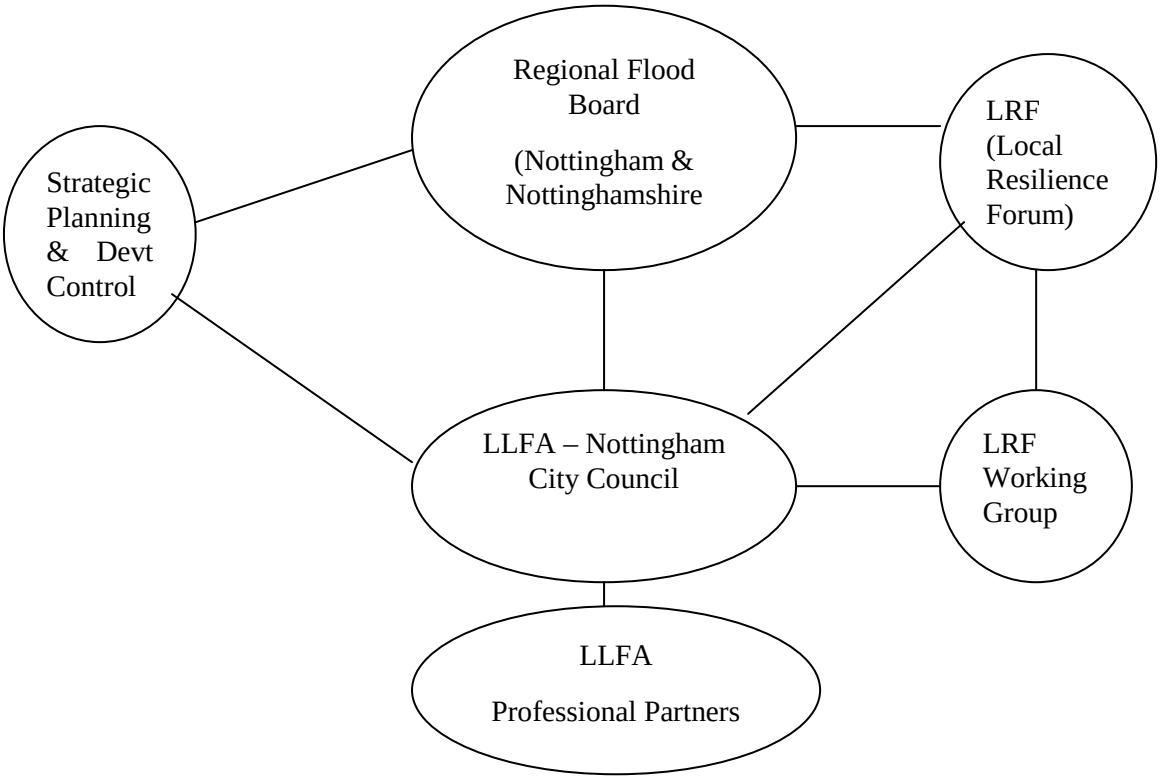



**Figure 3 Communication structure**

# 3 METHODOLOGY AND DATA REVIEW

The purpose of the PFRA document is to identify existing and future areas at risk of flooding. This document has collated information from a variety of sources outlined below:

## 3.1 Information gathered from within the LLFA

In 2009 Nottingham City Council received funding to produce a Surface Water Management Plan (SWMP) in accordance with the Defra SWMP guidance documents. The funding was allocated based upon a perceived risk of surface water flooding to approximately 10,000 residential properties within the city making Nottingham one of the highest numbers of properties at risk in any unitary authority and certainly one of the densest areas of properties at risk per unit of area. The aims of the SWMP process included the assessment of the flooding risks from all sources besides main fluvial watercourses and establishment of a management plan for the future management and reduction of the surface water flood risk within Nottingham.

The main output of this project was a GIS database which brought together all of the existing information on surface water held by Nottingham City Council including local flooding hotspots and the drainage asset information (culverts, pumping stations, intakes/outfalls, ponds) held by the Council. A large part of the project however included the collation of data such as point data on known flooding locations, and the mapping of potential for future flooding by collecting data from other sources described below.

## 3.2 Information gathered from the Environment Agency

As a strategic partner for both the SWMP and PFRA work, the contribution of the Environment Agency into the process of data collection and assessment has been invaluable. Specific data obtained from the EA includes:

- Flood map data for fluvial flood risks – for Nottingham this data is considered to be largely superseded by the 2-D flooding assessments that have been completed as a part of the SFRA projects for the Rivers Trent, Leen and Day Brook.
- Areas Susceptible to Surface Water Flooding (April 2009 version),
- Flood Map for Surface Water (Dec 2010)
- Historic flood record information
- Lidar data for Nottingham at both 1m and 2 m resolution.
- Shapefile data for the SFRA projects that had been completed for the River Trent, River Leen and Day Brook fluvial watercourses. Although fluvial risk from main rivers is excluded from the SWMP and PFRA work, it is nevertheless important to gain an appreciation of where the interaction between fluvial and other drainage systems may create flooding risk problems.
- Areas Susceptible to Ground Water Flooding. Areas Susceptible to Groundwater Flooding (AStGWF) is a strategic scale map showing groundwater flood areas on a 1km square grid. It was developed specifically by the Environment Agency for use by Lead Local Flood Authorities for use in Preliminary Flood Risk Assessment as required under the Flood Risk Regulations.
- National Property database

- National flood risk database showing where a km square meets the threshold for flood risk and also the results of the clustering exercise to establish the overall number of properties and people within the local authority area.

## 3.3 Information gathered from Severn Trent Water

As a strategic partner for both the SWMP and PFRA work, the contribution of the Severn Trent Water into the process of data collection and assessment has been invaluable. Specific data obtained from Severn Trent Water includes:

- The asset record for the STW sewer systems within Greater Nottingham including pipe information, manholes, outfalls and other assets.
- Flooding records where flooding to properties has been recorded on the DG5 register. This information is of limited use due to the lack of detail and specific outcomes of investigations and remedial actions.
- Risk path analysis plans to enable a 'broad brush' assessment of the capacity of the local sewer network. Although not specifically informative towards the PFRA process, the RPA plans are useful as an additional tool in the assessment of flood risk areas using the source-path-receptor methodology. They may also serve as a development control tool to gauge the effect of new development flows on the existing drainage network and highlight where improvements may be required to facilitate development.
- Severn Trent Water have encouraged and enabled close liaison and data-sharing with their term consultant, Mouchel who are involved in a detailed analysis of the Nottingham sewer system.

## 3.4 Limitations with data availability, accuracy, limitations and use

### 3.4.1 Data availability

Flooding information for Nottingham is limited and there are few records of flooding inside properties that can be verified as arising from surface water sources. The reporting of flooding has tended to be subjective with anecdotal records and "flooding" incidences including flooding & waterlogging to gardens, transient flooding of a highway due to a blocked gully and sewers overflowing into back yards, highways and gardens.

### 3.4.2 Limitations due to licensing

The data submitted from both Severn Trent Water and the Environment Agency carries licence agreements that restrict distribution and use outside Nottingham City Council and also for any other uses beyond the SWMP and PFRA projects. These restrictions, whilst understandable in terms of commercial confidentiality, personal data protection and potential property blight are nevertheless a particular problem that restricts the ways in which the data can be used. For instance, where a flooding risk maybe identified on the plans but is not publically available, it is difficult to restrict development as justification for an objection cannot be provided in detail.

One particular problem identified with the Flood Map for Surface Water dataset provided by the Environment Agency is the intellectual property rights (held by commercial organisations that contributed to the datasets) that restrict the release of the data to other professional partners including Severn Trent Water. This particular restriction prevents auditing of the flood zone data by the organisation best equipped to do so and therefore limits the usefulness of the data.

### 3.4.3 Storage of data and security within NCC

The data is stored within two locations within the network servers used by Nottingham City Council. Both are secure and limit use to those with usernames, passwords and authority to access the particular drive on the servers. Sensitive data from 3rd party organisations is further limited to the drainage team only.

The data forms the background to the ArcMap GIS database used by the drainage team for flood risk assessment, asset recording and flood incident recording. In the future, the database tools will include maintenance scheduling and flood incident management and also further detailed flood risk analysis to refine the database.

### 3.4.4 Future updating of data

The PFRA and SWMP reports represent a 'snapshot' of the flooding risk and records based upon the data available at the end of March 2011. The ArcMap GIS database and associated shape files for the flooding risk data will be updated at 6-monthly intervals and will be the responsibility of a particular officer tasked with the control of the data.

# 4 PAST FLOOD RISK

## 4.1 Overview of Historic Flooding in Nottingham

Records of flood events within the city have been collected from the sources identified in Section 3 of this report. Relevant information has been recorded on the ArcMap GIS database used by Nottingham City Council and has also been included within the spreadsheets accompanying the PFRA report.

## 4.2 Definition of Significant Harmful Consequence

The threshold for nationally significant flood risk areas has been set at 200 persons or 20 businesses or 1 critical infrastructure per km grid square where flooding would occur to a depth of 300mm during a 1 in 100 year return period flood. While there have been large fluvial events in the past that would exceed this threshold, there have not been any recorded non-fluvial events that would meet the 'significance' criteria. Guidance from DEFRA suggests that a reduction in the significance thresholds by an order of magnitude may be appropriate for setting a local threshold for a significant flood occurrence.

Using this approach as the basis for creating a workable threshold within the dense urban environment of Nottingham:

15 properties (35 persons) or 2 businesses or 1 critical infrastructure would be deemed an appropriate threshold for a significant flood. For an undulating urban environment such as Nottingham, the situation is further complicated by the heterogeneous nature of the city meaning that flooding events within the same kilometre square may be entirely unconnected with different sources, pathways and other influencing factors. Also the definition of significance is based upon the numbers of people or properties that flood on a 1 in 100 year return period event whereas it may be more appropriate to consider a lower threshold for flooding at greater frequencies.

Risk may be thought of as the product of probability x consequence. In this definition it may be seen that a frequent low-consequence event may attract the same weighting (and therefore attention) as a less-frequent but more severe event resulting in the inundation of many properties or creating adverse outcomes for health, local and individual economic status, environmental damage or pollution and cultural/heritage damage.

- Source – Path – Target: The approach suggested for Nottingham is to consider a smaller number of properties that appear to be flooded from one or more sources but are nevertheless close to or adjacent to one another rather than simply being within a single ordnance survey 1km grid square. Nottingham is a densely populated and extensively developed urban area and areas within the same grid square may be in entirely different catchments or at risk of flooding during very different scenarios. In this respect it is considered to be a more reasoned approach to base the flood risk assessment on the SPR methodology to hopefully create a robust set of data based on a clearly defined approach.
- Threshold criteria: It is proposed to base the threshold for a locally significant risk upon the national criteria but to reduce the number of residential and commercial properties required for qualification as a significant risk as flows: 20 residential properties, 2 commercial properties & one critical infrastructure installation flooding on a 1% annual average probability event. Furthermore it is proposed that a lesser number of properties flooding on a more frequent basis would also qualify subject to meeting the same product value of probability x consequence.

**Table 2 Summary of probability x consequence methodology**

| Annual Average Probability | Residential properties at risk | Commercial properties at risk | Critical infrastructure at risk | Probability x consequence | Does the risk exceed the threshold? |
|---|---|---|---|---|---|
| 1% | 15 | | | 15 | Yes |
| 2% | 8 | | | 16 | Yes |
| 3.5% | 5 | | | 17 | Yes |
| 10% | 2 | | | 20 | Yes |
| 1% | | 2 | | 2 | Yes |
| 2% | | 1 | | 2 | Yes |
| 1% | 10 | | | 10 | No |
| 10% | 1 | | | 10 | No |

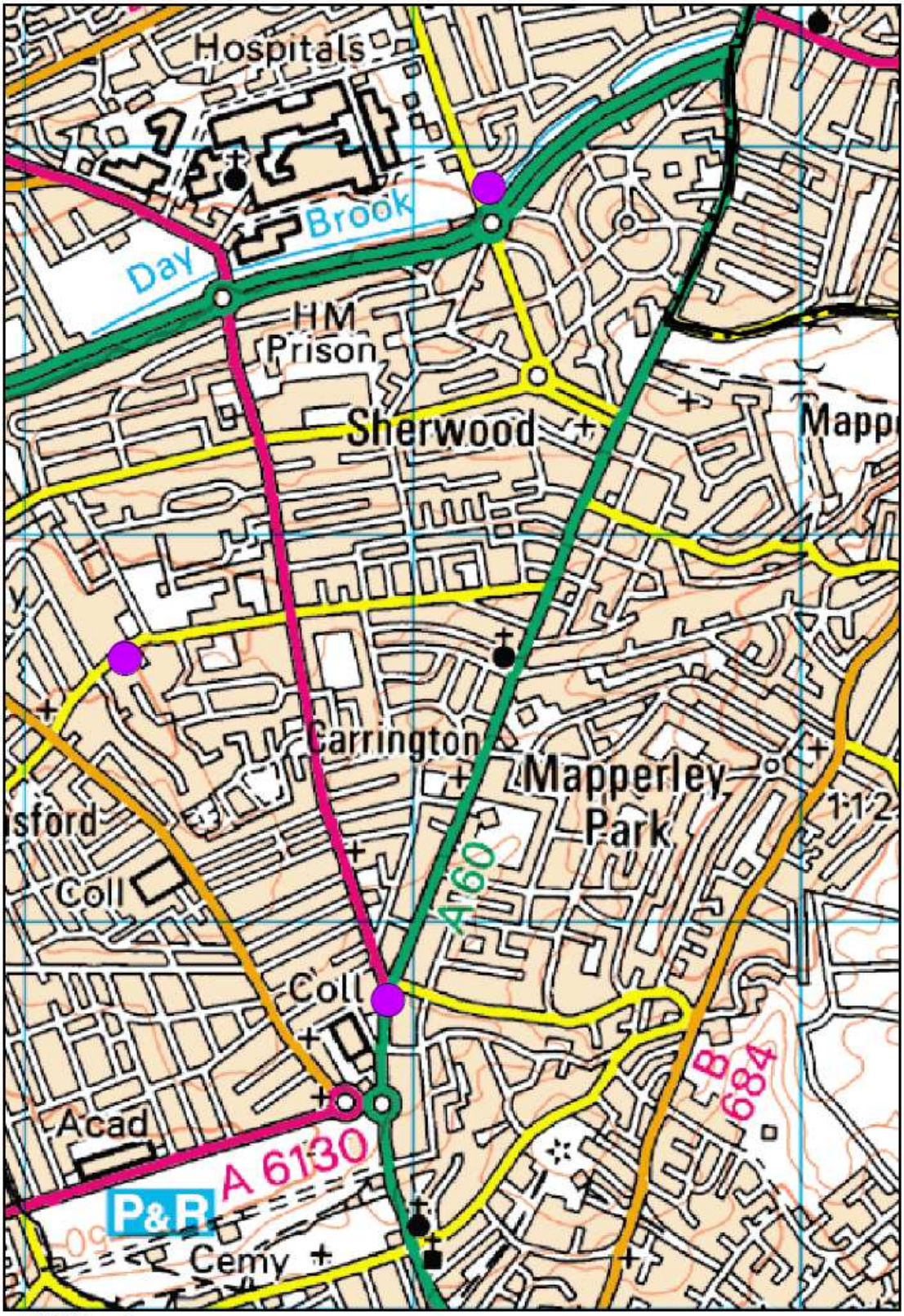
(the example of a 3.5% annual probability event flooding 6 properties describes the 2010 event that flooded properties at Moores Place off Haydn Rd.)

### 4.3 Flooding incidences meeting the locally agreed threshold

There have been very few local flooding incidences that can be considered as significant based on the above criteria. These include:

**Table 3 Flooding incidences meeting threshold**

| **Date** | **Location (address)** | **Location (Grid ref)** | **Residential properties and annual event probability** | **Commercial Properties and annual event probability** | **Source of flooding** |
|---|---|---|---|---|---|
| Summer 2009 | Moores Place, Haydn Rd | 456262, 342686 | 6 properties (return period uncertain) | | Pluvial & highway/sewer |
| June 2010 | Moores Place, Haydn Rd | 456262, 342686 | 6 properties ~3+% | | Pluvial & highway/sewer |
| Summer 2009 | Fiveways Pub, Edwards Lane & Grosvenor Pub, Mansfield Road | 457201, 343878 & 456921, 341817 | | 2 properties (return period uncertain) | Highway /sewer |
| June 2010 | Fiveways Pub, Edwards Lane & Grosvenor Pub, Mansfield Road | 457201, 343878 & 456921, 341817 | | 2 properties 3+% | Highway /sewer |




1:15000 scale.
Lower left corner of map at 456000,341000

**Figure 4 location of locally significant floods**

# 5 FUTURE FLOOD RISK

## 5.1 Locally agreed Surface Water flooding risk information

The PFRA future flood risk areas are based upon:

- Flood Map for Surface Water issued in 2010 by the Environment Agency. Approximately 10,000 properties are shown to be at risk of flooding within the city conurbation using this risk assessment methodology of combining the National Property Dataset issued by the Environment Agency in 2010 and the areas shown to be at risk of flooding to 300mm depth.

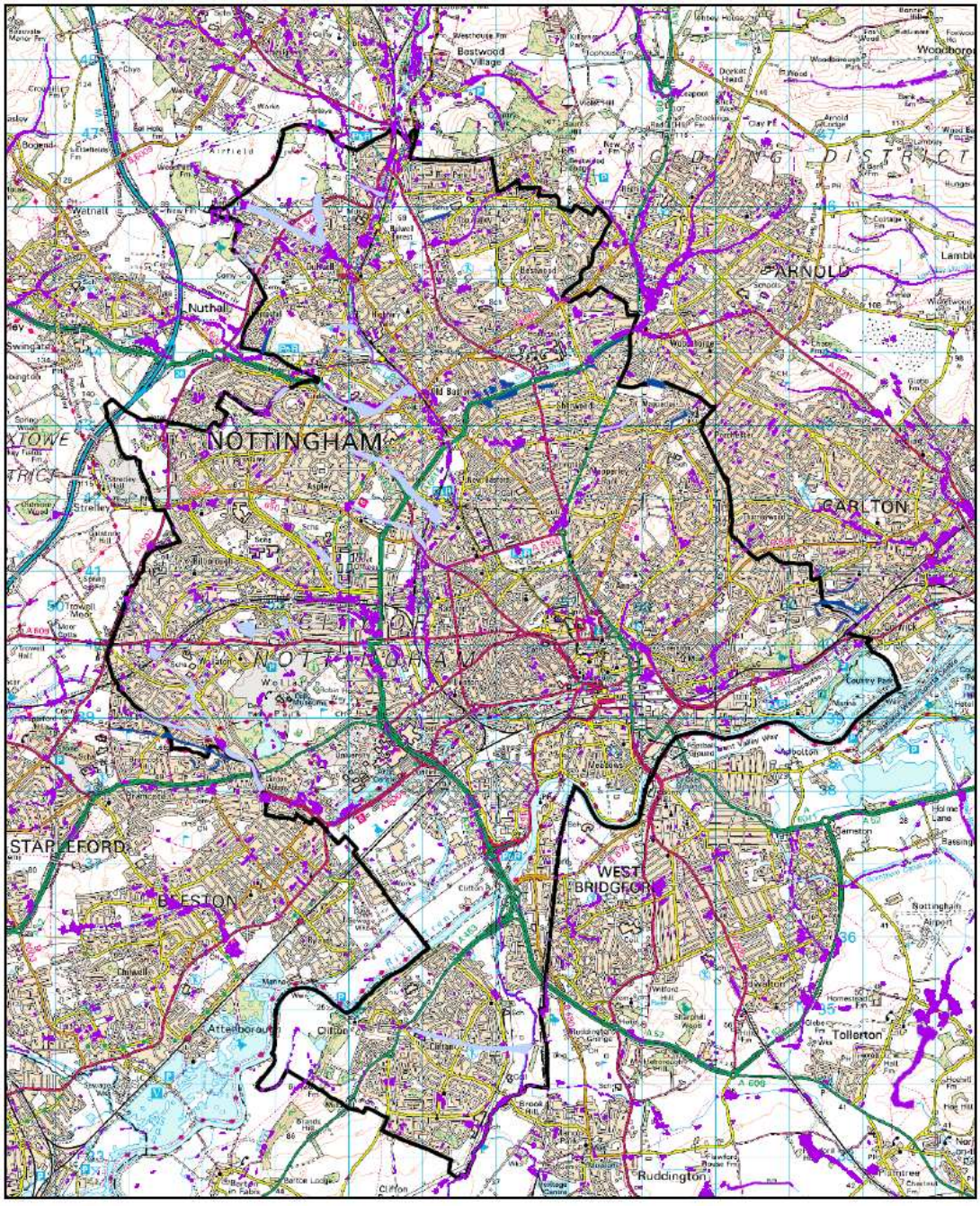



**Figure 5: FMfSW areas (300mm depth zones) and other local pluvial & (small) fluvial risk areas.**

- Outcomes and mapping from the SFRA studies for the River Trent, Leen & Day Brook. Although these are major fluvial sources, they are important to the PFRA as the interactions between the main rivers and other drainage systems, principally through the surcharging of outfalls, can limit the performance of the piped drainage and smaller tributary watercourses.

- Local flood event records, local ordinary watercourse behaviour, knowledge of local topography and pluvial flow behaviour.

Further information on this appropriateness of these sources of data is included within this section.

## 5.2 Local Drainage Capacity

Nottingham has a widespread and effective (based on historical anecdotal experience of the performance during intense rainfall events) surface water sewer system with capacity that appears to be equivalent to at least a 5-year return period rainfall event of 60 minute duration. This is approximately equivalent to a rainfall intensity of 18mm/hour. Recent (lack of) flooding record evidence arising from rainfall events supports this assessment. This level of performance is dependent on regular maintenance of the drainage assets including gully cleansing, sewer & watercourse inspection and maintenance.

## 5.3 Introduction to the Risk Assessment Process

### 5.3.1 Source-Path-Receptor Methodology for assessing flood risk

- The assessment of flood risk is based on a 'source – path – receptor' model where:
- The '**source**' is the catchment of the water that forms the flooding risk therefore an understanding of the behaviour of this in response to a rainfall event is required. The behaviour of the catchment is referred to as the hydrology and includes the amount of run-off and rate of accumulation at a particular point in the catchment. Difficulties that arise in the estimation of the inflows from the source include the need to estimate the amount of rainfall that is attenuated where it falls.
- The '**path**' represents the flow route of the water between the source and the receptor. This includes flow through sewers, open & culverted watercourses, along highways and also across the surface of open areas as 'overland flows'. Defining the 'path' includes a hydraulic assessment of the available flow routes for the floodwater through conduits and channels to identify where flooding might occur and also a detailed assessment of the overland flow routes following flooding from the hydraulic conduit.
- The '**receptor**' analysis includes collating information on the properties in areas at risk of inundation and assessing the flood risk to these in detail under a range of rainfall events. Understanding of the depth of the flooding that might occur is required in order to be able to evaluate the likely damages costs and the benefit:cost ratio of any scheme proposals to reduce the flooding risk in the future.

### 5.3.2 Importance of storm duration and intensity

An important variable with regard to the nature of the flooding risk is the duration of the rainfall event and also the time of concentration of a flooding event as explained in the following bullet points:

- Long duration events are generally lower rainfall intensity events than shorter (thunderstorm) events.
- The longer a rainfall event is, the greater the catchment area that may feed water into a particular point downstream. In the case of Nottingham, with the exception of the River Trent catchment, the drainage areas are quite small therefore the potential flows in the downstream reaches of the small catchments are correspondingly small.

- In this respect, prolonged steady rainfall is not a particular risk to the city as the flows are small and the drainage infrastructure is often able to cope with these flows.
- Conversely, shorter more intense storms are a particular concern as the rainfall intensities combined with the short flow paths and times of concentration through the urban areas can lead to interaction between drainage systems and water from a number of discrete catchments arriving in the same area simultaneously. This has led to flooding on a number of occasions in the last few years.
- Nottingham may be considered at risk from either a long duration rainfall event (low lying areas and floodplains of the Rivers Trent & Leen) or a short violent event (many discrete areas throughout the City) but rarely both.
- There are a few exceptions to this general observation however these are localised areas within the flood plain of the large fluvial sources (Rivers Trent, Leen & Day Brook) that lie adjacent to large capacity sewers or culverted watercourses. One reason for highlighting these at this stage is that the flood risk reduction measures for these areas require greater complexity than for others. As an example of the potential magnitude of the problems due to interaction between sewers and large fluvial watercourses, there are approximately 35 right bank outfalls and 31 left bank outfalls[5] from the Severn Trent Sewer system into the River Leen between the point where it crosses the northern city boundary and confluence of the river with the River Trent. In addition to this there are numerous small private outfalls, highway drainage outfalls and the confluences with small culverted watercourses.

## 5.4 Sources of Flooding

As part of the initial work on the SWMP & PFRA, the project team has considered the various flood risks to the City and evaluated the vulnerability in broad terms to each risk. The list is not exclusive and it is expected that the flood risk areas would be refined in future years as the modelling and prediction information improves. The risks are tabulated below into different categories dependant on the source with a comment on the areas both known to be susceptible to these risks (from historical evidence) and also considered to be vulnerable based on the knowledge of the City infrastructure. The areas at risk from these various sources are shown on Figure 5.

### 5.4.1 Minor Watercourses

There are a number of small watercourses that enter the main rivers as left or right bank tributaries. Unlike the larger watercourses, the flood risk tends to be concentrated around throttle points including:

- intakes/trash screens upstream of culverted sections,
- small bridges and restrictions in the watercourses due to vegetation growth,
- fly-tipping,
- ad-hoc culverting by riparian owners often without knowledge of the capacity requirements.

The watercourses require maintenance on a regular basis to minimise the flood risk although the flooding incidents and problems tend to be limited to a number of discrete locations as described above. Some of the smaller watercourses that enter the River Leen as right bank tributaries (see below) have a base flow from rural areas to the west of the City boundary although the catchment areas are small (a few $km^2$) and the watershed is less than 1km outside

[5] Source: Severn Trent asset records – issued to NCC October 2010.

the western boundary of the City.

The remainder of the flows to these tends to be from surface water sewer outfalls either to the open or culverted sections. The watercourses therefore have a quick response to rainfall events but also tend to convey water quickly as the catchments typically have gradients steeper than 1 in 100.

### 5.4.2 Reservoirs and impounded water[6]

Nottingham has only one reservoir of any size within the city boundary however there are also a number of bodies of water outside the city with the potential to cause flooding to Nottingham..

- Wollaton Lake (GR 452915, 338608) is a large reservoir in the southern part of Wollaton Park and is impounded by an earth dam. The reservoir may contain around 100,000m$^3$ of water and silt. The Reservoir Inundation Map for Emergency Planning[7] indicates that failure of the dam (breach scenario) may result in the inundation of houses immediately downstream of the dam and through Wollaton. The resulting flows of water and debris may pose a threat to life within 200m of the toe of the dam wall due to the high velocities expected if the dam fails.
- There is a drinking water reservoir at Strelley and surface water pond at Nuthall that both have the potential to flood areas of the west of Nottingham if they fail.
- There is a small risk of flooding from the Derwent Valley reservoirs (Howden, Derwent & Ladybower reservoirs) as the floodwater from these would travel along the River Derwent and River Trent watercourses. The distance from the reservoirs to Nottingham means that water would take around 2 days to arrive in Nottingham therefore therefore opportunity exists for warning and preparation and the potential for the flood to exceed the capacity of the flood defences is low.
- The City Council owns and manages a series of impounded lakes at Newstead Abbey to the north of the Nottingham and outside the city boundary. Failure of the dam impounding the Upper Lake may result in localised flooding to properties immediately downstream and furthermore may result in increased water levels and possible flooding risk in the River Leen both inside and outside the city boundary[8]. Flooding risk is shown in Basford, Radford & Lenton on the reservoir inundation map for this particular breach scenario.

### 5.4.3 Flood Risk from Underground Conduits & Sewers

#### 5.4.3.1 Severn Trent Sewers

Nottingham has an extensive network of sewers that are separated into foul, combined and surface water sewers. There are a number of combined sewers that drain older parts of the city and these incorporate combined sewer overflows (CSO) into surface water sewers or watercourses to relieve pressure on the network and reduce the risk of foul effluent flooding onto highways and other areas during intense rainfall events. There are approximately 60 combined sewer overflows within Nottingham and these can pose a pollution risk to

[6] Maps available from the Environment Agency Website: http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683.0&y=355134.0&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=reservoir#x=455014&y=339069&lg=1,&scale=8

[7] Source:Reservoir Inundation Map for Emergency Planning (reference JP3137BH Maximum Flood Extents) issued by the Environment Agency in November 2009

[8] Source:Reservoir Inundation Map for Emergency Planning (reference BP3031BC Maximum Flood Extents) issued by the Environment Agency in November 2009

watercourses that receive the excess effluent during a storm event. Further information on the Combined Sewer Overflows within Nottingham is available from either Severn Trent Water or the Environment Agency as the consenting authority. Although flows through a CSO are undesirable, they do protect other parts of the sewer network from flooding. The combined sewer network exists in the older parts of Nottingham and sometimes receives the flows from the newer surface water networks further upstream as well as the foul flows. In a busy and congested urban environment such as Nottingham, it is inevitably very disruptive and costly to construct new surface water sewers to bypass the older combined networks and in this respect it is unlikely that the number of CSOs operating at the present time or the frequency at which they do will change in the near future. Because of the foul sewage content (itself containing micro-organisms, faecal matter, bacteria and viruses) within combined sewer overflows, flooding incidences from combined sewers are undesirable and also flooding incidences from watercourses that receive significant CSO outfalls upstream of the flooding point. The additional stress and anxiety caused to the victims of flooding from the realisation that they have foul sewage within their gardens and homes following a flooding incident means that efforts to improve the performance of the sewer network are being made continuously. The various contributory factors that influence the magnitude of the risk of flooding from sewers highlights the need for any flood risk reduction policy within Nottingham to be holistic and include measures to reduce the flows at source rather than rely solely on the provision of increased infrastructure capacity or increasing the frequency or volume of combined sewer overflows.

The performance requirements for new sewer systems, as stated in Sewers for Adoption 6$^{th}$ Edition, is for no flooding to occur for rainfall events upto 3.33% annual average probability - approximately equivalent to a 1 in 30 year storm event. OFWAT require water & sewerage companies including Severn Trent Water to reduce the incidences of flooding rather than meet a performance standard as this would possibly involve significant capital outlay from the water companies and a consequent increase in the bills to users of the water supply and sewerage service.

Sewer flooding risks arise from:

- Rainfall events of a severity that exceeds the design performance criteria.
- Older sewer systems that do not meet the performance requirements.
- Blockages and damage that may occur within or to a sewer system. This can include debris or high water levels in watercourses preventing outfalls from functioning correctly with consequent flooding in the upstream sewer system.
- "Urban creep" is a term used to describe the increase in impermeable areas connected to the sewers due to infilling green spaces in urban areas and also the construction of additional driveways, building extensions, conservatories, garages and patios. In localised areas this can add 25% or more to the areas draining to the sewers and poses a serious risk to properties downstream.

Severn Trent Water maintains a register of properties that have reported incidences of sewer flooding to the water company. This register is referred to as the 'DG5' and includes properties that have flooded for events within (and sometimes outside) the required limits of performance of the sewer network. STW have agreed targets with the water industry regulatory body, OFWAT, to reduce the number of properties on the register and undertake capital schemes in each Asset Management Plan period (currently on a 5-year cycle) including schemes to reduce the magnitude of flood risk to residential properties.

**Figure 6 Sewer flooding following intense rainfall**

***Flooding following summer thunderstorm over Nottingham in 2009. Taken from Heart FM building on Manvers Street/City Link junction. Water seen in background issuing from manhole on 1900mm*1500mm combined sewer.***

Within Nottingham, a flooding risk has been identified due to the rapid response time of both the sewer and also the river catchments within & outside (flowing into) the City. The hydrograph shapes and times for the two run-off systems are thought to be broadly similar with the effect that the discharge of the sewers into the rivers and watercourses is compromised as the rivers are already high when the flows from the sewer networks reaches the outfalls. Consulting Engineers (Mouchel) working for Severn Trent Water are currently investigating the interaction between watercourses and the Severn Trent Water drainage systems and the flooding risks arising from these interactions as a part of the Sewerage Management Plan (SMP) being developed for the Stoke Bardolph catchment. Although the study is in the early stages, preliminary results indicate that the volume of flooding from sewers unable to freely discharge into watercourses may be many times greater than for free discharge conditions. In this respect, when surface water and combined sewer overflows are impeded by high water levels in receiving watercourses, it is likely that the numbers of properties thought to be at risk from sewer flooding may increase.

#### 5.4.3.2 Highway drainage

Nottingham has approximately 38,000 road gullies with connections into various types of piped drainage including STW surface water & combined sewers and also into separate highway drainage systems. The performance of the highway drainage system often determines whether properties adjacent to roads flood in heavy rainfall events. Performance of the highway drainage system may be compromised in a number of ways that increases the flood risk as follows:

- Gullies becoming blocked by leaves and other debris or the gully chamber filling with silt and grit from the road surface. Nottingham has many roads that are lined with trees and these pose a particular problem during storm events as the vegetation debris soon covers the gully gratings.
- The gully connections may fail either due to collapse or siltation.
- The highway drainage may have been poorly designed or constructed and is unable to cope with the rainfall. A typical example of this is the spacing and number of gullies on steep gradients as the flow of water in the channel can be rapid and may bypass gullies if it becomes too wide. This then places additional load on gullies further down the hill and may eventually lead to ponding at the base of the hill and possible flooding to 3rd party properties. Another example observed in some Nottingham streets (and corrected where it has been found) are gullies that are not connected to the sewers properly and in some cases simply to one another.
- The highway drainage system is designed to drain the highway areas only. In many instances it has been found that developments off the highway slope towards the carriageway but do not have any intercepting drainage system to prevent flows entering the highway. In some cases this can cause overloading of the highway drainage.

**Figure 7 Highway Drainage**

***Highway drainage on Mansfield Road. Foreground shows silted channels, background shows debris blocking otherwise clear gullies. This area is particularly troublesome due to a large steep catchment, old combined sewer system and development set below the level of the road. There is a possibility in the area of the drainage working in reverse during intense rainfall events with the extensive gully drainage releasing water from overloaded sewers.***

### 5.4.4 Groundwater Flooding Risks

Groundwater flooding is not a particular problem at the present time in Nottingham although there is a risk that it may become so in the future. The underlying geology comprises sandstones and magnesian limestones that are both considered as aquifers however there are also layers of marls and mudstones that act as a barrier to the transmission of water. There are a number of springs within the City Boundary that historically fed watercourses and the former tanning and lace-making industries made extensive use of groundwater within the sandstones under the City.

There is some evidence that groundwater levels are recovering following the decline or cessation of many of the industrial activities that extracted water from under the City – bleaching, brewing, lace-making, chemicals & mining – and the City Council has had a number of reports of groundwater entering the basements and cellars of residential dwellings that have historically remained dry.

Within the area of Basford, the City Council has been involved in prolonged discussions with residents and councillors regarding the possible causes of the localised flooding in cellars and basements and the potential for practical remedial works that might rectify the problems. At the present time, the water that accumulates does not appear to be causing a problem other than as nuisance to the householders that are experiencing this issue and is not considered to be a flooding risk. Because damage has not occurred to the properties affected by the rising groundwater, there is little economic argument for any scheme that might seek to remedy the problem.

### 5.4.5 Surface Water flooding risks

The topography of the western side of Nottingham comprises a series of valleys draining south-east towards a larger north-south valley holding the River Leen. The eastern side of the Principal Urban Area comprises valleys that drain south-west towards the River Leen & River Trent.

The steep valleys within the urban area and the dense development results in a risk of overland flows and surface water accumulation in the base of valleys and hollows. The catchment may be regarded as 'fast-responding' when compared to flatter areas and leaves Nottingham particularly vulnerable to intense, short duration rainfall events including thunderstorms. This situation is exacerbated when other sources of flooding such as sewers and watercourses are able to flow down the steep slopes following the path of least resistance.

The GIS database includes areas of the City where there is a known or suspected risk of overland flow or rainwater accumulation during intense rainfall events. The presence of man-made features including buildings, walls, fences and embankments can interrupt the normal flow of water down a slope and either divert this to other areas or alternatively have an impounding effect creating a localised flood.

The recent (December 2010) issue of the Flood Maps for Surface Water (FMfSW) issued by the Environment Agency have identified a large number of discrete areas within the city boundary at risk of flooding from surface water during a 1 in 200 year rainfall event lasting 1.1 hours.

The FWfSW make a number of assumptions as described in the table overleaf:

**Table 4 assumptions in FMfSW**

| Assumptions used in the modelling | Note on validity |
|---|---|
| The duration of the rainfall event has been limited to 1.1 hours. (The AStSWF mapping issued in 2009 used a 6.5 hour event duration) | Valid: The 1.1 hour storm duration approximates the typical time of concentration of a storm event likely to cause flooding in Nottingham. |
| The impermeability coefficient used for the urban areas is 0.7 | Valid: the dense urban environment within Nottingham coupled with the steep topography would cause a significant proportion of the rainfall to run-off the catchment and accumulate to create a flooding risk. |
| The allowance for the performance of the drainage & sewer network has been made by reducing the rainfall intensity by 12mm/hour to account for the flows removed by the sewers. | Valid: The performance of the drainage network within Nottingham is considered to be good and at least capable of managing a rainfall intensity of 12mm/hr. The lack of regular or even localised flooding in most parts of the City is an indication that the existing drainage network works well. It is possible that the flood areas shown on the FMfSW are pessimistic and the reality would be fewer and/or smaller areas of flooding. |

In this respect the latest issue of the plans may be considered as representative of the approximate scale of the risk if not the actual locations as these would be determined by local factors that could not be included within the models used by the Environment Agency. Overall 10,800 properties are included within the boundaries of the 'severe' mapping (flooding to at least 300mm deep) within the FMfSW. Within the boundaries of Nottingham City Council, there are approximately 2700 discrete areas of surface water flood risk of which approximately 50% lie within residential areas.

## 5.5 Future Climate Change and Long Term Developments

### 5.5.1 The Evidence

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 levels 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.
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.
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%.

### 5.5.2 Key Projections for Humber River Basin District

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 12% (very unlikely to be more than 24%)
- Relative sea level at Grimsby very likely to be up between 10 and 41cm 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 14%

#### 5.5.2.1 Implications for Flood Risk

Climate changes can affect local flood risk in several ways. Impacts will depend on local conditions and vulnerability. Wetter winters and more of this rain falling in wet spells may increase river flooding. 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. Even small rises in sea level could add to very high tides so as to affect places a long way inland. 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.

### 5.5.3 Adapting to Change

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 in the face of some 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.

#### 5.5.3.1 Long Term Developments

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.
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."
In Wales, Technical Advice Note 15 (TAN15) on development and flood risk sets out a

precautionary framework to guide planning decisions. The overarching aim of the precautionary framework is "to direct new development away from those areas which are at high risk of flooding."
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).

**UKCP09 predictions for the East Midlands**[9]
Climate projections are also available for the East Midlands for the years 2020, 2050 and 2080. Table 5-4 shows the projections under a medium emissions scenario and taking the 50% probability level. Further detail including the range of results produced by UKCP09 is available on the Defra website.

Climate projections are also available for the East Midlands for the years 2020, 2050 and 2080. Table 5-4 shows the projections under a medium emissions scenario and taking the 50% probability level. Further detail including the range of results produced by UKCP09 is available on the Defra website.

**Table 5 UKCP09 predictions for the East Midlands**

| | **2020s** | **2050s** | **2080s** |
|---|---|---|---|
| Mean precipitation % | 0 | 0 | 1 |
| Summer mean precipitation % | -6 | -16 | -20 |
| Winter mean precipitation % | 5 | 14 | 19 |
| Mean temperature summer ˚C | 1.4 | 2.5 | 3.5 |
| Mean temperature winter ˚C | 1.3 | 2.2 | 3 |

[9] http://ukclimateprojections.defra.gov.uk/content/view/12/689/

# 6 REVIEW OF INDICATIVE FLOOD RISK AREAS

## 6.1 National Significant Flood Risk Areas

The PFRA documents are designed to be a high level screening exercise to identify areas of significant flood risk across Europe.

Using the Environment Agency criteria outlined in section 4.3 of this document, only ten areas in England qualify as being a national significant "Flood Risk Area". The preliminary flood risk assessment and clustering exercise to group grid squares has identified a large number of properties and people at risk of flooding during a 1% annual average probability event based on the FMfSW dataset however this total number of people and properties fall short of the threshold for denoting as a nationally significant flood risk area. Nottingham City Council consider that the existing numbers may be an overestimate of the true nature of the flood risk therefore are not proposing to add any new 'Flood Risk Areas' for the PFRA.

There appears to be areas within the Nottingham city boundary that are susceptible to flooding from various sources including surface water and are considered "Locally Significant Flood Risk Areas" based upon the local threshold values. Management of these locations should be carried out through the local flood risk management strategies contained within the SWMP for Nottingham produced in 2010/2011. This duty forms part of the new responsibilities required under the Flood and Water Management Act 2010.

# 7 NEXT STEPS

The PFRA produced by Nottingham City Council is a living document and collates existing surface water flooding information held by the Council and other organisations.

Although legislation is now in place to require that the proposals for new development will not have an adverse affect on the local surface water environment and increase flood risk to 3rd party property, the level of growth projected within Nottingham and on the fringes of the city as urban extensions have the potential to produce further locally significant flood risk areas in the future. Secondary legislation is awaited that will require sustainable drainage to become a material consideration for new development applications and will furthermore restrict the discharges from surface water into the sewer systems in favour of more sustainable methods of managing and disposing of surface water run-off. Nottingham City Council will be working closely with developers and statutory partners in the future to manage and reduce the surface water flooding risk where practicable.

Part of the tasks to be undertaken will be to investigate the locally significant flood risk areas and improve local knowledge regarding the nature of the flood risk and likely behaviour of the drainage systems. The PFRA document will be reviewed on a 6 yearly cycle in accordance with the Flood Risk Regulations to take into account this new data.

A part of the future work will include the assessment of flooding risk areas to establish where simple local measures may reduce the flooding risk to vulnerable properties and receptors either by reducing the likelihood of flooding through external measures or reducing the consequence of a flood event through resilience measures. The city council will also pursue this work as part of any flooding investigations that may take place in the future.

The SWMP produced by Nottingham City Council includes an action plan for both short and medium term structural and non-structural measures to improve the management of surface water and reduce the risk of flooding. These are summarised below:

**Table 6 Action Plan**

| **Short term structural measures (within 12 months)** | **Benefits** |
|---|---|
| Increase the frequency of inspections for drainage assets including small watercourses, highway gullies, flood defence measures (balancing ponds, cut-off ditches, bunds etc) | Improve the knowledge of the assets' behaviour over a year and devise a maintenance strategy |
| Collect missing data for small watercourses – position, levels, channel condition | Improve the asset knowledge and enable hydraulic modelling at a later date |
| Procure and implement a CCTV survey for all culverted watercourses and highway drains & culverts in Nottingham. | Produce a condition record and add information to the asset/knowledge database. |
| Inspect all areas suspected of being at risk of surface water flooding. | Verification of risk and increased asset information. |

| Short term non-structural measures (within 12 months) | Benefits |
|---|---|
| Improve the capacity, knowledge and expertise within the drainage team to fulfil the roles of Lead Local Flood Authority | Accord with the demands of the F&WM Act 2010 |
| Design and implement a management structure to implement the SWMP | Accords with the requirements of the F&WM Act 2010 |
| Provide a service to the Planning Strategy & Development Management teams. | Improve the transfer of knowledge, team-working ethos. Reduce future flood risk from inappropriate development. |
| Continue work to produce closer links with other stakeholders and public to assist the management of surface water and flood risks. | Improved SW management and future benefits. |
| Continue to add information to the ArcGIS database and enable this to be used by a number of different users with varying levels of knowledge and expertise. | Improved knowledge transfer. |

| Medium term structural measures (within 48 months) | Benefits |
|---|---|
| Maintenance schemes on all flood defence assets including small watercourses. | Reduced risk of flooding due to improved performance of assets. |
| Design and implementation of flood risk reduction schemes for Tottle Brook, Day Brook and Broxtowe Park Brook. | Reduction in number (approx. 500) of properties at risk of flooding. |

| Medium term non-structural measures (within 48 months) | Benefits |
|---|---|
| Procure hydraulic modelling work for highest risk areas and assess nature of risk and mitigation options. | Detailed objective analysis of high risk areas to define risk and options for reducing risk. |
| Devise/implement management structure & processes as Sustainable Drainage Approving Body (SAB). | Required under F&WM Act 2010 |
| Commence design & performance assessment & adoption of sustainable drainage schemes. | Required under F&WM Act 2010 |
| Perform formal audit to assess progress on SWMP objectives and produce revisions to action plan. | Improvement to service provision under LLFA role & implementation of SWMP |

# 8 REFERENCES


- Environment Agency (2010), Preliminary Flood Risk Assessment - Final Guidance (Report – GEHO1210BTGH-E-E),
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- Nottingham City Council – Strategic Flood Risk Assessments (Greater Nottingham SFRA – updated Oct 2010 and River Leen SFRA 2008) http://www.nottinghamcity.gov.uk/index.aspx?articleid=11469
- Nottingham City Council SWMP Report March 2011