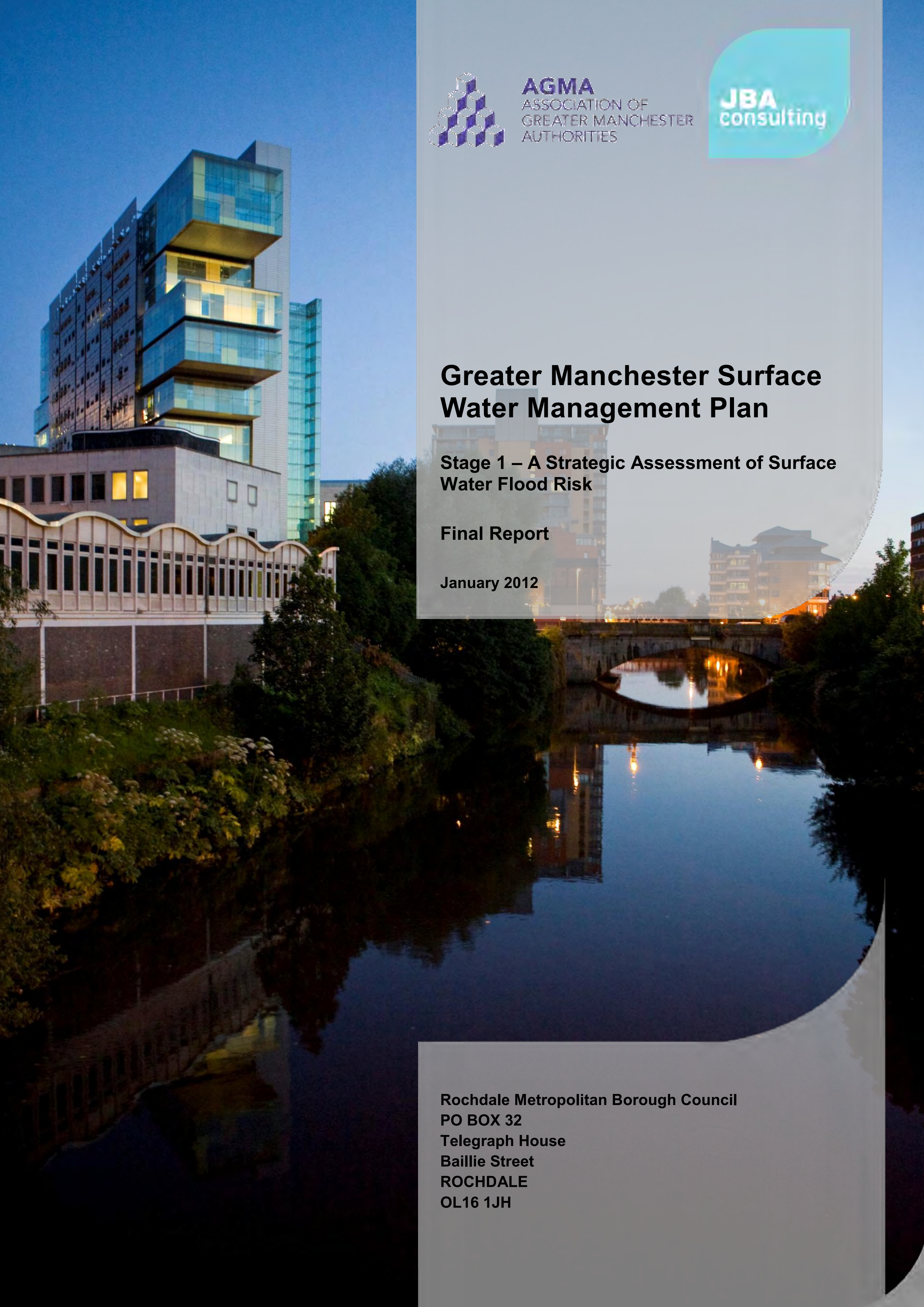

Greater Manchester Surface Water Management Plan

Stage 1 – A Strategic Assessment of Surface Water Flood Risk

Final Report

January 2012

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Contract

This report describes work commissioned by the Association of Greater Manchester Authorities (AGMA) through its nominated lead authority Rochdale Metropolitan Borough Council (MBC) by an email dated 18 Jan 2011. Rochdale MBC's representative for the contract was Francis Comyn. Chris Isherwood and Kevin Keating of JBA Consulting carried out this work.

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Purpose

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Executive Summary

The **Surface Water Management Plan** (SWMP) project is essentially a study of surface water flood risk, recognising the cause and effect of flood hazard between districts and communities in Greater Manchester. In line with DEFRA guidance, the SWMP moves through four stages of delivery, which are

1. **Preparation** – identify need for a SWMP study, its scope and a partnership for its delivery
2. **Risk Assessment** – collect data and undertake various levels of assessment allowing flood risk to be mapped and communicated
3. **Options Appraisal** – identify measures for addressing flood risk, assess and agree preferred options
4. **Implementation and Review** – prepare and publish an action plan, deliver and review

The Greater Manchester SWMP is split between two stages, with this project, **Stage 1**, delivering a **strategic assessment of surface water risk**.

The strategic flood risk assessment focuses on the identification of potential **areas of significant risk,** known as 'surface water hotspots', using

- New strategic surface water modelling hazard outputs across Greater Manchester
- The location of local critical and vulnerable receptors
- Significant flood risk thresholds and weighting
- 500m resolution grid squares

One of the other key outputs of Stage 1 was the development of the Greater Manchester **Strategic Flood Map**, an interactive digital mapping application presenting the modelled surface water flooding outputs, receptor information and derived surface water hotspots, along with other useful flooding related information collected from each LLFA, the Environment Agency and United Utilities. This Strategic Flood Map will be provided to each of the ten districts of Greater Manchester for internal use.

As part of Stage 1, using ranked hotspots and the Strategic Flood Map, LLFAs have identified a **long list of priority areas** to potentially take forward during Stage 2 of the SWMP. The aim of **Stage 2** is to complete as much of the technical process in Defra's 'wheel' diagram as is practical for individual local hotspot.

The decision on how to prioritise the long list of projects for detailed assessment and action planning was a key step within Stage 1. It was agreed that selecting as many areas of highest risk as the budget will allow would only achieve the basic objectives of the SWMP and would not cover the full range of issues facing Greater Manchester districts. Therefore, a more measured approach has been applied, aimed at providing the greatest benefits to all LLFAs by **delivering a good practice toolkit**, which consider partnership and funding opportunities between districts, the Environment Agency and United Utilities.

With this in mind, a **shot list of individual projects** was proposed and agreed through the Planning Officers Group (POG). These projects will be an important component of each district's local flood risk management strategy required under the Flood and Water Management Act and will be a significant tool in delivering the requirements of the PFRA for Greater Manchester required by the Flood Risk Regulations.

This report has been prepared as part of a long term project to deliver what is known as a SWMP. It is targeted at the technical flood risk leads who have been involved in the preparation of the SWMP, such as Planning, Engineering and Emergency Planning officers in each local authority, the Environment Agency and United Utilities, and documents the Stage 1 process undertaken to develop the scope of work for the forthcoming detailed assessment stage of the SWMP.

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Abbreviations

AGMA	Association of Greater Manchester Authorities
AStGWF	Areas Susceptible to Groundwater Flooding
AStSWF	Areas Susceptible to Surface Water Flooding
BLPU	Basic Land and Property Unit
CC	City Council
CDA	Critical Drainage Area
CE	Communication and Engagement
CFMP	Catchment Flood Management Plan
CFRI	Critical Flood Risk Infrastructure
COMAH	Control of Major Accident Hazards
CSOs	Combined Sewer Overflows
DTM	Digital Terrain Model
EA	Environment Agency
FMfSW	Flood Map for Surface Water
FRIs	Flood Risk Indicators
FRISM	JBAs internal Flood Risk Matrix
FRMP	Flood Risk Management Plans
FROG	Flood Risk Officers Group (or AGMA POG)
FRR	Flood Risk Regulations 2009
FWMA	Flood and Water Management Act 2010
GIS	Geographic Information System
HR	Hazard Rating
LDD	Local Development Document
LDP	Local Development Plan
LFRMS	Local Flood Risk Management Strategies
LLFA	Lead Local Flood Authority
LRF	Local Resilience Forum
MBC	Metropolitan Borough Council
NFCDD	National Flood and Coastal Defence Database
NLPG	National Land and Property Gazetteer
NRD	National Receptor Dataset
OSMM	OS MasterMap
PFRA	Preliminary Flood Risk Assessment
POG	Planning Officers Group
PR	Percentage Runoff
RFRA	Regional Flood Risk Assessment
SFRA	Strategic Flood Risk Assessment
SIRS	Sewerage Incident Register System
SUDS	Sustainable Urban Drainage Systems
SWMP	Surface Water Management Plan
T-FROG	Technical Flood Risk Officers Group
UID	Unsatisfactory Intermittent Discharges
UU	United Utilities
WFD	Water Framework Directive
WIRS	Wastewater Incident Register System
WLT	Wider Leadership Team

1 Background and Project Scope

1.1 Target Audience

This report concerns flood risk to Greater Manchester from surface water. The report is part of a longer term project to deliver what is known as a Surface Water Management Plan (SWMP).

This report is targeted at the technical flood risk leads who have been involved in the preparation of the SWMP, such as Planning, Engineering and Emergency Planning officers in each local authority, the Environment Agency and United Utilities. It has been produced for two reasons:

- To support the main product of the SWMP to date, the Greater Manchester Strategic Flood Map, including providing a summary of the methodology and technical aspects.
- To document the process undertaken to develop the scope of work for the forthcoming detailed assessment stage of the SWMP.

Whilst it is intended that it can be understood by those with a non technical background, the primary focus o the report is for those involved with flood risk management. . The wider uses of the Strategic Flood Map are potentially numerous, including planning, emergency planning and flood risk management, including the emerging statutory duties such as the completion of local flood risk management strategies.

1.2 SWMP Introduction

The report assesses surface water flood risk in Greater Manchester at a strategic level and makes future recommendations on what the remainder of the SWMP project should focus on, as agreed by the AGMA Chief Planning Officers Group (POG).

*The quantified combination of probability of flooding and its impact is "**flood risk**"*

The extent, frequency, impact and management of flood risk from surface water is relatively poorly understood. This applies across the UK and is in contrast to that for flood risk from rivers or the sea. But, just like flooding from any source, surface water flooding can cause significant distress, risk to life, and adverse impact on local community and economy. This project was commissioned in order to improve the understanding and management of surface water flood risk across Greater Manchester.

In summary, a good SWMP will enable local government, other organisations, businesses and local communities to make appropriate decisions on the short and long term management of surface water flood risk.

What is surface water flooding?

Defra SWMP Technical Guidance[1] states that it includes:

- ***Surface water runoff (pluvial flooding)*** *- This is water ponding or, due to the capacity of the underground drainage network or watercourse, flowing over ground during high intensity rainfall. Pluvial flooding also includes overland flows from the urban/rural fringe entering the built up area.*
- ***Sewer flooding*** *- This occurs when the volume of rainfall exceeds the capacity of the underground drainage system, resulting in flooding inside and outside of buildings. Note that sewer flooding in 'dry weather' resulting from blockage, collapse or pumping station mechanical failure is not considered here. This is a sole concern of the drainage undertaker (commonly United Utilities).*
- ***Flooding from groundwater****, where groundwater defined as all water that is below the surface of the ground and in direct contact with the ground or subsoil. This includes overland flows resulting from groundwater sources.*

1.2.1 GM SWMP Study Area

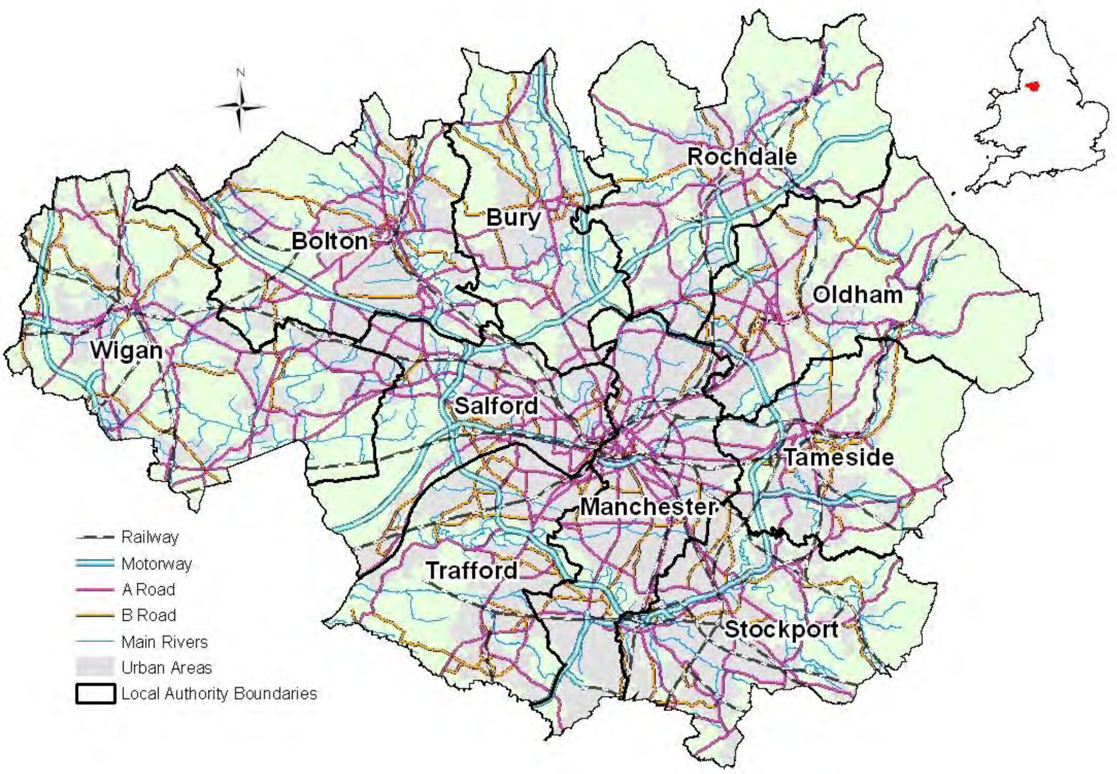
The study area of Greater Manchester spans 1,277 km². There is a mix of high-density urban areas, suburbs, semi-rural and rural locations, but overwhelmingly the land use is urban. It has a focused central business district, formed by Manchester City Centre and the adjoining parts of Salford and Trafford. It is also a polycentric sub-region with a series of major towns in the surrounding districts grouped around Manchester and Salford.

With a population of 2.6 million residents, Greater Manchester is the north of England's largest sub-regional economy and has undergone, and will continue to be a centre of, significant growth, largely concentrated in the Regional Centre and to the south of the sub-region.

Figure 1-1 illustrates the study area of the Greater Manchester SWMP including all ten local authorities within the sub-region. These ten local authorities include:

- Bolton MBC
- Bury MBC
- Manchester CC
- Oldham MBC
- Rochdale MBC
- Salford CC
- Stockport MBC
- Tameside MBC
- Trafford MBC
- Wigan MBC

Figure 1-1: Greater Manchester SWMP Study Area



1.3 Background

The Greater Manchester sub-region consists of a complex hydrological network that interlinks all of the ten councils. Not only natural features such as topography, watercourses and geology affect the hydrology of the sub-region, but also by artificial influences such as canals, reservoirs and the built environment. As a result, the sub-region also has a complex mix of varying and interlinked flood sources and associated risks.

The Pennines rise along the eastern side of the county, through parts of Oldham, Rochdale and Tameside. Black Chew Head is the highest point of Greater Manchester, rising 542 metres (1,778 ft) above sea-level, within the parish of Saddleworth, Oldham.

The principal source of flood risk to the Greater Manchester Sub-Region is from fluvial flooding. A significant amount of information exists for the main watercourses and their tributaries across the four main catchments including the River Irwell, Mersey, Douglas and Glaze Brook. All of these catchments, except for the Douglas, drain into the Manchester Ship Canal, which then flows towards the Mersey Estuary through Warrington. The interaction with the Manchester Ship Canal is important in determining the extent of this flooding.

Superimposed on this "major" drainage system is the drainage from the smaller local urban watercourses and the drains and sewers draining the roads and urban development. There are also a significant number of culverted watercourses in Greater Manchester, which is to be expected in a highly urbanised environment. In addition to the identified culverted watercourses, there are also a number of "Hidden Rivers" or "Lost Rivers" within the sub-region, particularly Tameside, Manchester and Trafford Districts. Excess water from rainfall events, which exceed the capacities of any of these systems or the surface infiltration capacity, can also cause flooding.

1.3.1 Surface Water Flood Risk

The previous understanding of surface water flooding and risk was gained from several sources:

- Ad-hoc historical records
- PFRAs and SFRAs, mainly based on the patchy historical records
- National maps showing potential areas affected by surface water flooding

Historical Records

As indicated above, there are relatively few records of surface water flooding and those that do exist are neither comprehensive nor consistent. Furthermore, until recently the role and responsibilities for managing flood risk were unclear between the ten districts of Greater Manchester, the Environment Agency, United Utilities and other organisations.

The issues of surface water flood risk and organisational responsibility came into sharp focus after the summer 2007 floods, when heavy rainfall resulted in extensive surface water flooding in parts of the UK such as Gloucestershire, Sheffield and Hull causing considerable damage and disruption. Around two-thirds of the flooding was due to surface water flooding.

Although Greater Manchester has not yet experienced a flooding incident of this scale, similar rainfall events across Greater Manchester would result in serious consequences. Indeed, one of the key conclusions of the North West Regional Flood Risk Appraisal (RFRA) was that there is significant uncertainty surrounding surface water flood risk in Greater Manchester

PFRAs and SFRAs

The recently completed Greater Manchester Preliminary Flood Risk Assessment (PFRA) confirmed this. Each District's PFRA was produced to a consistent format and used a common methodological approach, producing a coherent suite of PFRAs across Greater Manchester. They identified over 280,000 properties at risk of surface water flooding across Greater Manchester. 75,000 of these properties are predicted to flood to a depth above 0.3m and this includes 60,000 residential properties[1]. It is expected that climate change will cause more problematic rainfall events and therefore surface water flooding is likely to be an increasing problem for Greater Manchester. It should be noted that the PFRAs were undertaken using the best available information that was readily available, and that the national methodology used gives only a strategic indication of flood risk, and should be treated with some caution in relation to actual flood risk.

The ten Greater Manchester districts have also completed individual or collective sub-regional, Level 1 and Level 2 Strategic Flood Risk Assessments (SFRA) within a coherent Greater Manchester context, in recognition that flooding does not stop at an artificial administrative

[1] Property numbers calculated using the National Receptor Dataset and the Flood Map for Surface Water.

boundary, and that the districts are hydraulically linked through river catchments and other drainage infrastructure.

National and Local Surface Water Flood Maps

In order to improve the understanding of surface water flooding, the Environment Agency carried out a strategic assessment in the form of two national mapping datasets. The Environment Agency released their first-generation national mapping in 2008, Areas Susceptible to Surface Water Flooding (AStSWF). The AStSWF map shows areas susceptible to surface water flow or ponding using three susceptibility bandings for a rainfall event with a 1 in 200-year return period. The Environment Agency adopted a simplified modelling approach, which excluded the underground sewerage, drainage systems, smaller over ground drainage systems and buildings.

The Environment Agency updated their national methodology in 2010 and released their second-generation national mapping, the Flood Map for Surface Water (FMfSW). The revised work had a number of improvements over the AStSWF product including two flood events (1 in 30 and 1 in 200 annual probability), the influence of buildings and the influence of typical sewer systems. The FMfSW also displayed its outputs using two depth bandings (greater than 0.1m and greater than 0.3m).

Local surface water modelling was carried out in 2009 during the Bury, Rochdale and Oldham SFRA and also the Manchester, Salford and Trafford SFRA. This is available in key locations within Bury, Rochdale and Oldham and throughout Manchester, Salford and Trafford. This local modelling developed the methodology of the Environment Agency's first-generation mapping to include local characteristics of rainfall and topography. Together with the Environment Agency's national work, this was the starting point for the new Greater Manchester wide surface water modelling.

1.3.2 Local Responsibilities

Pitt Review and the EU Floods Directive

The Pitt Review drew together the lessons learnt from the 2007 floods. This led directly to the Flood and Water Management Act 2010 (FWMA). Together with the Flood Risk Regulations 2009 (FRR) enacting the EU Floods Directive, they aim to improve both flood risk management and the way we manage water resources.

The FWMA assigns specific responsibilities to 'risk management authorities' including county councils and unitary authorities. Under the Act, local authorities are designated as Lead Local Flood Authorities (LLFAs) and have a number of new statutory responsibilities with respect to local flood risk management, particularly in relation to surface runoff, groundwater, ordinary watercourses and any interaction these have with drainage systems and other sources of flooding including sewers and main rivers.

Local work programmes required include:

- Under the FRR: the production of ten PFRAs (completed[2]), subsequent Flood Hazards Maps and Flood Risk Management Plans (FRMP)
- Under the FWMA: the production of a Local Flood Risk Management Strategy to consider local flood risk.

The efficient integration of these work areas will be challenging. But ensuring that flood risk from all sources can be identified, interactions understood and flood risk effectively managed will be critical in meeting the requirements of the FWMA and FRR. Clearly, the production of an appropriate SWMP can make an important contribution.

Further information on the responsibilities of local authorities can be found on the Defra website: http://www.defra.gov.uk/environment/flooding/legislation/la-roles/

AGMA and the Greater Manchester Districts

[2] PFRAs are expected to be available on or through the AGMA website

The Association of Greater Manchester Authorities (AGMA) was formed in 1986. The most recent milestone for Greater Manchester was when the ten component Local Authorities, variously led by all three major political parties, unanimously agreed to establish the Greater Manchester Combined Authority (GMCA) which was established in April 2011.

At the same time, Greater Manchester's Local Enterprise Partnership (LEP) was also established to provide strategic private sector leadership, complementing the role of the Greater Manchester Combined Authority (GMCA) in driving forward the growth of the Greater Manchester economy.

The goal of achieving sustainable economic growth sits at the heart of the Greater Manchester Strategy and aims to improve the prospects for economic development in Greater Manchester and create the conditions for business investment and growth. Within this context, AGMA is committed to ensuring the provision of the infrastructure necessary to support investment opportunities and provide the 'quality of place' for existing and future residents.

The co-operation across Greater Manchester has continued into this SWMP project. Under the AGMA organisational umbrella, funding from Manchester City Council, Rochdale MBC and Defra was brought together and it was agreed that Rochdale MBC act as lead authority. Following this, JBA Consulting was commissioned to prepare the SWMP in accordance with the Defra SWMP Technical Guidance.

JBA are managed by a Steering Group (the *SWMP partnership*) comprising:

- AGMA
- Bolton MBC
- Rochdale MBC
- Manchester City Council
- Environment Agency
- United Utilities

AGMA POG acts as the senior officer governance and flood risk management board and work with key stakeholders to deliver this role. T-FROG reports into this process as discussed further in Section 2.1.

1.4 SWMP Objectives, Guidance and Stage 1 Scope

1.4.1 GM SWMP Objectives

The objectives of the Greater Manchester SWMP are set out below:

- Using the communication and engagement strategy and through involvement with the technical work, the SWMP should support and be part of the delivery mechanism for the AGMA and unitary level capacity building initiatives.
- Deliver output that can be used to satisfy the requirements of the FRR as far as possible.
- Provide greater detailed understanding of flood risk at identified local hotspots.
- Consider interactions between surface water and other sources of flooding.
- Provide an evidence base that can be used cross-departmentally by all Greater Manchester Authorities, such as ongoing spatial planning and Local Flood Risk Management Strategies.
- Provide an evidence base that can be used by external partners, such as the Environment Agency to feed into their strategy work and local asset systems management planning, and United Utilities to feed into future planning for the AMP6 period through the Period Review process.
- Provide a robust and widely supported SWMP, which can inform, align and deliver public and private investment over the next 10-20 years.

1.4.2 Guidance

The SWMP is essentially a study of surface water flooding, moving through four stages of delivery:

1. Preparation;
2. Risk Assessment;
3. Options; and
4. Implementation and Review.

The first three stages involve undertaking the SWMP study, whilst the fourth phase involves producing and implementing the action plan, based on the evidence gained from the SWMP study. It is based on a widely adopted generic approach to evidence and risk based decision-making.

This full SWMP process is visualised by Defra in the form of a ‘wheel’ (see Figure 1-2 below), which highlights the need to review and continually improve understanding of risk and how it might be addressed beyond the scope of a single specific study and making use of best available data at a given time. For further information on background to SWMPs, please refer to the Defra SWMP Technical Guidance, which can be found at:

http://www.defra.gov.uk/publications/2011/06/10/pb13546-surface-water-guidance/

Figure 1-2: Defra SWMP Wheel

This report mainly relates to the first two stages. Partnerships have been formed, a relatively strategic assessment of surface water flood risk across Greater Manchester has been completed and a plan formed for the remainder of the project. The rest of the project will develop a deeper understanding of surface water flood risk in more critical areas and consider options to reduce risk. Final reporting will draw together the lessons learned and provide an action plan for the AGMA FRM Board and LLFA to take forward during the development of Local Flood Risk Management Strategies.

1.4.3 Stage 1 Scope

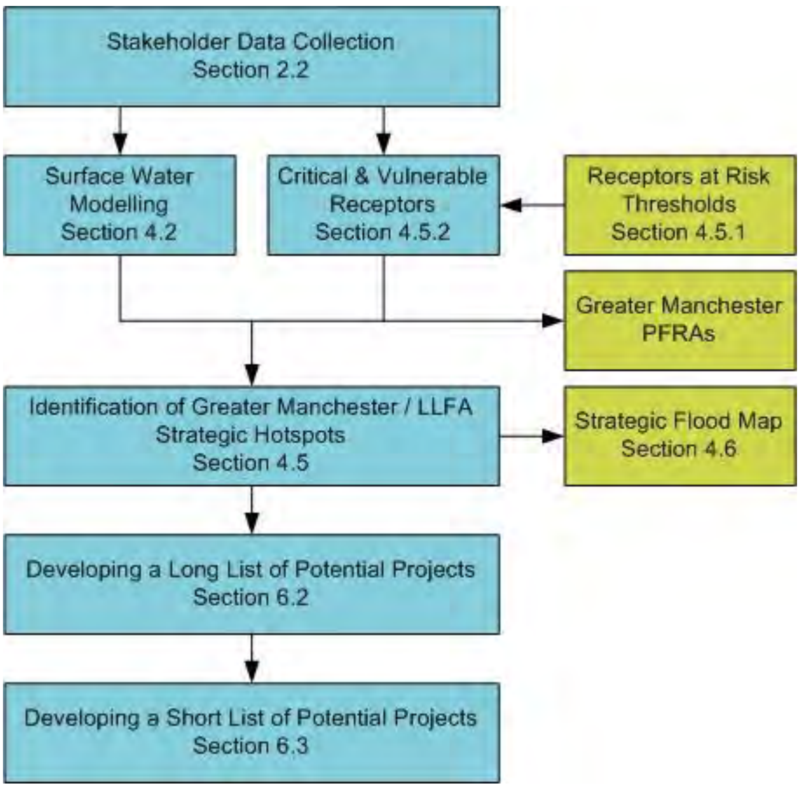
Stage 1 of the Greater Manchester SWMP included:

- The *preparation* of a Communication and Engagement Plan, covering the core partnership as well as wider stakeholder engagement for the successful long-term delivery of the project.
- A *preparation* of data. This was done thorough assessment of available baseline data to identify its quality, consistency and any gaps, which need to be addressed.
- Working as far as possible through the *risk assessment* stage, to identify patterns of flood risk and prioritise "hot spots" for further more detailed work. This includes the production of a Greater Manchester Surface Water Flood Risk Map.
- The production of a PFRA as required under the FRR (a stand-alone output). This included the preparation of Preliminary Assessment Report (PAR) and collection of baseline data for the flood risk and hazard mapping stage of the PFRA.

Through the findings of this stage of the SWMP, a package of semi-independent detailed SWMP studies/sub-projects will be taken forward through the remaining stages of the generic SWMP "wheel" process. These sub-projects were selected in order will provide maximum value to AGMA and each LLFA, supporting the continued process of assessing surface water flooding, effective management and the preparation of LFRM Strategies.

Figure 1-3 illustrates the process taken during Stage 1 of the Greater Manchester SWMP. Section references included relate to the content of this report.

Figure 1-3: Greater Manchester SWMP Stage 1 Flow Chart



2 Governance, Consultation and Data Collection

2.1 Governance and Consultation

Sir Michael Pitt's Review into the summer 2007 floods recommended that local authorities were best placed to bring together all relevant bodies to help manage local flood risk. Since the Review, those with a strong interest or statutory responsibility for managing the various strands of flood risk management have been working more closely together.

More recently, the FWMA formally implements this through the creation of LLFAs, while also recognising the important role district councils, highways authorities, Environment Agency and water companies play. These are referred to as Risk Management Authorities (RMAs). The FWMA enables effective partnerships to be formed. It requires the relevant authorities to co-operate with each other in exercising functions under the Act and they can delegate to each other. It also empowers a LLFA to obtain information needed from others in order to deliver LLFA functions.

The formation of the SWMP partnership (the Steering Group) mirrors this need for co-operation. This comprises the Environment Agency, United Utilities and AGMA / Greater Manchester Districts. Table 2-1 identifies the individual roles and responsibilities of each member. Figure 2-1 presents the wider FRM governance arrangements relevant to the project.

Table 2-1: Stakeholder Roles and Responsibilities

Stakeholder	Greater Manchester SWMP Roles and Responsibility
AGMA	AGMA provided a framework of City Region governance structures and delivery partnerships with key stakeholders for the project. The AGMA Planning Officers Group (POG) and Wider Leadership Team (WLT) provide a hierarchical review process.
LLFAs	Each of the ten districts of Greater Manchester offered key support during the preparation of the SWMP, providing local datasets and local knowledge of areas at risk within their district. Key staff from Rochdale MBC, Manchester CC and Bolton MBC are on the project Steering Group. Rochdale MBC was the nominated lead authority for the SWMP.
Environment Agency	The Environment Agency are represented on the project Steering Group, with the role of providing expert knowledge and guidance particularly relating to Defra's SWMP guidance, the FWMA and the FRR. They also provided key datasets and guidance during the surface water modelling.
United Utilities	A representative of United Utilities is on the project Steering Group, with the role of providing expert knowledge and guidance particularly relating to the risk of sewer flooding, interactions with other sources, key datasets and useful guidance during the surface water and sewer modelling.

As stated in Section 1.4.1, a Communication and Engagement (CE) Plan was developed to support and ensure appropriate engagement from within Greater Manchester districts and to plan for wider stakeholder engagement. The CE Plan establishes the governance and consultation process and should be referred to for additional detail.

The project Steering Group make the main decisions involving detailed methodology and study direction. However, agreement is sought on key issues from POG and the WLT, for study output approval (such as for this report) and permission to proceed with Stage 2 of the project.

Through the development of the project, key contacts in drainage engineering, planning and other relevant service areas within all Greater Manchester Districts have been identified and engaged, through the Technical Flood Risk Officers Group (T-FROG) and various District

Flood Risk Groups. Links to wider networks such as the Greater Manchester Resilience Forum (GMRF) also exist.

The T-FROG forum also provided the opportunity for those involved with the project and LLFA officers to share knowledge – capacity building is an important aspect of the SWMP project. T-FROG also had significant input during the latter stages for the Stage 1 SWMP in reviewing SWMP outputs and contributing to the identification of potential detailed assessment projects.

Figure 2-1: Greater Manchester SWMP Governance and Consultation Process

2.2 Data Collection and Review

An early step of the SWMP process was to identify, collect and collate the requisite data. The Steering Group and LLFAs supplied most of the data. Where relevant, data was sourced and reused from the relevant SFRAs in order to streamline the data collection process.

A project data register was developed, recording all data received throughout the SWMP process. Along with the name of the dataset, the project data register recorded:

- The source of the data including the date received
- The provenance of data
- The format of the data
- Data licences and conditions including limitations of the use of the data

It is important to understand the quality of data so that any uncertainty or perceived weakness is identified and available for consideration during risk assessment and options appraisal stages of the SWMP. A data quality score, as described in relevant guidance[4], was attributed to each data identified as being available. Table 2-2 describes the scoring system used.

Table 2-2: Recording the Quality of Data

Data Quality Score	Explanations	Example
1	No better available; not possible to improve in the near future	High resolution LIDAR River/Sewer flow data Rain gauge data
2	Best replaced as soon as new data are available	Typical sewer or river model that is a few years old
3	Based on limited reliable and readily available technical data combined with professional judgement	Location, extent and depth of much surface water flooding Operation of un-modelled highway drainage 'future risk' inputs e.g. rainfall population
4	Substantially based on professional judgement	Ground roughness for 2D models

Most data requested was good quality and accurate as would be expected. Historical flooding information was generally marked as medium quality as, whilst general locations were normally identified there was often little or no detail behind it identifying the source of flooding. The quality and quantity of historical records also varied across each district.

Fortunately the majority of the datasets could be mapped geographically using GIS software, helping to visualise flooding, flood risk and associated spatial planning issues. Table 2-3 provides a summary of data obtained and processed for this SWMP.

Table 2-3: SWMP Data - Summary of Key Datasets

Data Holder	Data
AGMA / Districts	Greater Manchester Strategic Multi-Agency Flood Plan
	Greater Manchester District Multi-Agency Flood Plans
	Greater Manchester Sub-Regional Strategic Flood Risk Assessment
	Hybrid Strategic Flood Risk Assessments
	Historical flood incident data
	National Receptor Dataset (NRD)
	National Land and Property Gazetteer (NLPG) and other local key infrastructure (receptor) data missing from NLPG / NRD
	Ordinance Survey data
Environment Agency	Flood Map
	Areas Susceptible to Surface Water Flooding (AStSWF)
	Flood Map for Surface Water (FMfSW)
	Areas Susceptible to Groundwater Flooding (AStGWF)
	Historical Flood Map

[4] Flood Hazard Research Centre (2005) The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques

Data Holder	Data
	National Flood and Coastal Defence Dataset (NFCDD)
	Digital Terrain Model - LIDAR
	Catchment Flood Management Plans (CFMPs)
	NW Regional Flood Risk Appraisal (RFRA)
	Hidden Watercourses of Manchester (Pilot Study)
	Preliminary Flood Risk Assessment information
	Medium Term Plan describing future FRM schemes in development
United Utilities	Water supply and sewage treatment infrastructure
	Drainage Areas
	DG5 "At risk register" (Internal & External)
	Extracts from our sewerage incident database
	Hydraulic model results (sewer surcharging during flood conditions)
	AMP5 project details
Electricity North West	Primary electrical infrastructure sites (other sources for this data were unreliable)

2.3 Data Gaps

2.3.1 Historical Flood Incident Data

As mentioned above, the quality and quantity of historical flood incident data across Greater Manchester was variable. Both the Environment Agency and United Utilities provided excellent datasets in their Historical Flood Map (HFM) and sewerage incident databases (SIRS[5] and WIRS[6]) respectively.

Historical flood incident databases maintained by LLFAs were often small or non-existent and depended largely on the quality and scope of their SFRA. However, Wigan MBC, Bolton MBC and Salford CC were exceptions to this trend and provided a large quantity of data identifying the location, date and source of flooding.

2.3.2 National Receptor Dataset

The Environment Agency used the National Receptor Dataset (NRD) during the PFRA process to identify indicative Flood Risk Areas by locating and counting key receptors within their national surface water maps.

During a more local review of this dataset at a Greater Manchester and community level found that NRD did not provide the level of accuracy needed within the SWMP. Whilst the dataset accurately represented the location of residential and commercial properties, it often lacked the accuracy or detail needed when it came to vulnerable or critical infrastructure such as national grid sub-stations, hospitals, water infrastructure and COMAH sites.

In order to improve the NRD, National Land and Property Gazetteer (NLPG) was collected from AGMA, seen as an improved 'local' dataset. A number of datasets were also collected from individual organisations where this was available including national grid sub-station locations from Electricity North West, water infrastructure from United Utilities and Metro link data from Transport for Greater Manchester (TfGM)..

[5] Sewerage Incident Register System
[6] Wastewater Incident Register System

3 Overview of the Stage 1 Flood Hazard and Risk Assessment Process

3.1 Introduction

The aim of the Stage 1 surface water flood hazard mapping work was to identify the sources, mechanisms, frequency and extent of surface water flooding across Greater Manchester. This was achieved through a strategic assessment of pluvial flooding, sewer flooding and flooding from ordinary watercourses along with the interactions with main rivers. The main tool used to generate information was JBAs JFLOW+ software.

JFLOW+ *is a 2D flood-modelling package, developed by JBA to meet the needs of clients who require estimates of flood depth, velocity and extent for a variety of sources of flooding, including fluvial, rainfall and defence/dam breach. The only data inputs required are inflow data, a roughness parameter and a Digital Elevation Model (DEM). It has been successfully benchmarked against other 2D model codes and reference results.*

JFLOW+ solves the 2D Shallow Water Equations and exploits GPU technology. Shallow water based models offer a number of benefits over the diffusion wave approach, as more physics is incorporated into the model including momentum effects. In addition velocity data is directly available, as both depth and velocity are solved by shallow water codes.

Whilst JFLOW+ is a powerful strategic modeling tool, it does make some assumptions as discussed in Section 4.4, and it is recommended that its outputs are not used for detailed assessment purposes.

The output from this modelling work is a set of GIS flood hazards covering nearly all of Greater Manchester. This forms half of the new Greater Manchester Strategic Flood Map.

The second half relates to the mapping of flood risk and the ranking of sites worst affected. This, together with local knowledge and experience from District officers, provided a starting point for the identification of locations for more detailed assessment, known as surface water 'hotspots'. This section provides an overview of the flood mapping and risk assessment process, including the T-FROG consultation and review process.

The work introduced above is documented in the following sections of this report:

- Section 4: Greater Manchester Strategic Flood Map and surface water modelling work completed *(flood frequency, extent and potential hazard)*
- Section 5: The assessment of the impact of surface water flooding (*flood risk*), including ranking problem flood risk locations
- Section 6: Identification of local surface water hotspots and potential detailed assessment projects

3.2 Stage 1 Tasks

The list below outlines the key flood mapping and risk assessment tasks completed:

1. Agree datasets for inclusion, including the assumptions and modelling techniques to produce new surface water data.
2. Carryout strategic surface water and sewer flood modelling across Greater Manchester and develop the GM Strategic Flood Map.
3. Agree with relevant parties the criteria by which “significant” flood risk is defined and re-process flood modelling and receptor data in order to facilitate an assessment against the agreed criteria.
4. Overlay the surface water modelling results with the critical and vulnerable receptors to identify significant Greater Manchester flood “hotspots”.
5. Present findings to T-FROG, allowing all districts to input their understanding of risk and identify those hotspots within their area, which are of particular interest to them

(due to historical evidence, the level of predicted risk, local sensitivities / preferences etc).

6. Draft a short list of potential SWMP sub-projects for consideration in Stage 2 of the project and agree within the Steering Group, T-FROG and AGMA POG.
7. Seek endorsement of the final list of recommended projects.

3.3 Review Process

As shown above, the SWMP risk assessment process has been incrementally developed allowing all stakeholders the opportunity to influence the SWMP methodology, incorporate their own local flood risk knowledge and influence the SWMPs direction of travel in their own local area. This review process has also allowed each stakeholder to:

- Take responsibility for their local surface water issues, to aid them during their local Flood Risk Management Strategy production.
- Establish two way dialogues and long-term relationships with key partners (e.g. commencing "on the ground" dialogue between the LLFA, Environment Agency and United Utilities.
- Clarifying organisational interfaces, roles and responsibilities.
- Share and improve understanding of flood risk, asset ownership, performance, impact of climate change.
- Fundamental development of capacity within the individual districts.

One of the major steps of the review process was for all districts to complete a "Hotspot Assessment Form". The form provided responses on receptor datasets, surface water modelling results and fit with flood history or local professional judgement, and the reasons why they would / would not support a more detailed assessment in that area.

Each district completed the form for a number of their 'priority' hotspots utilising the skills and expertise within different departments such as planners, drainage / highway engineers and emergency planners. Manchester City Council also provided additional suggested hotspot locations developed from Stage 1 work supplemented by local knowledge of potential flood risk. One of the difficulties faced by each district was visualising the scale of surface water flooding modelled. The SWMP deals with extreme rainfall events and in most cases, stakeholders have not experienced these types of events previously.

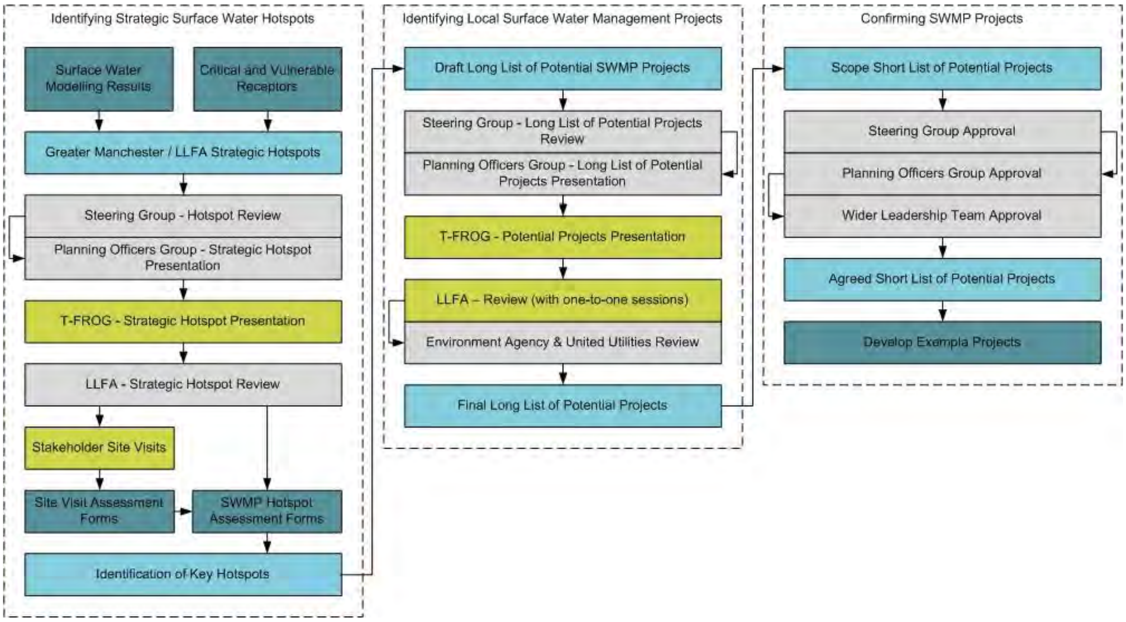
The early T-FROG workshops therefore focused on improving understating of the modelling approach adopted, in order to provide confidence in the results. One-to-one sessions were also held with a number of needed-FROG members.

Site visits were also carried out for most LLFA. The purpose of the site visits were to

- Build relations between districts and the Environment Agency and United Utilities and identify links with other work programmes.
- Extract local knowledge on surface water flood risk issues and historical incidents.
- Ground truth surface water modelling results, including local flood routes.
- Identify key receptors.
- Discuss potential surface water management options.

Figure 3-1 illustrates the overall risk assessment process, from initially identifying strategic hotspots to developing a short list of detailed assessment projects to be taken forward in the SWMP.

Figure 3-1: SWMP Risk Assessment Review and Project Approval Process



4 Greater Manchester Strategic Flood Map and Risk Assessment Methods

4.1 Introduction

The aim of this element of Stage 1 of the SWMP was to identify the sources and mechanisms of surface water flooding through the development of pluvial and sewer flood models. The outputs of the models form the key datasets used in the preparation of the Greater Manchester Strategic Flood Map, including the flood risk assessment process.

The sections below describe:

- The modelling methodologies adopted, assumptions made and the form of outputs produced.
    - Section 4.3 - Surface water modelling
    - Section 4.3 - Sewer surcharge modelling
    - Section 4.4 - Important modelling assumptions
- The methods used in order to assess risk and rank "hot spot" locations by the scale of risk. Section 0.
- The Greater Manchester Surface Water Flood Map, how to analyse the flood risk data and how the map should be used to inform other studies or assessments. Section 4.6.1.

4.2 Surface Water Modelling

Pluvial flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours. In these instances, surface run-off is generated in less permeable or more saturated areas, resulting in water flowing over land.

Within urban areas, rainfall intensity beyond the carrying capacity of drainage systems results in excess water creating flow paths along roads and through developed land, with ponding in low spots. Pluvial flooding within urban areas is typically associated with events greater than a 1 in 30-year rainfall event, the scale of event that has been used as the basis for design of most of our sewerage systems. However, many older sewers may not even offer this standard due to subsequent development and ill-conceived additional sewer connections.

Whilst pluvial flooding from heavy rainfall can occur anywhere in Greater Manchester, there will be many locations where the exact flood routes or mechanisms become complex, including hydraulic interactions between the main rivers, smaller watercourses, surface water run-off and combined sewer systems. It is often difficult or impossible to represent these within strategic scale analysis. Consultation with local knowledge holders was therefore an essential part of the Stage 1 study.

4.2.1 Surface Water Modelling Methodology

The SWMP has undertaken new surface water modelling across Greater Manchester, the outputs of which will be used to identify surface water flood risk hotspots and can also be used for a variety of other local purposes. The new surface water information is considered to provide the best representation of surface water flood risk and should be the 'locally agreed surface water information' across Greater Manchester in preference to previous national and local surface water datasets available.

The additional benefits and technical improvements that the new modelling includes are presented below:

- Use of JFLOW+ provides improved representation of flow across the model domain and permits estimation of reliable flood hazard information (flow depth and velocity)
- Technical improvements such as more locally representative assumptions to account for sewerage system capacity, surface run-off and storm durations

- Additional return periods have been modelled and results provided including allowance for the affects of climate change
- Representing sewer surcharging through am individual sewer model (Section 4.3)

Table 4-1 summarises the key changes in national to local surface water modelling and the reasons behind them including rainfall return periods, storm durations, percentage runoff and drainage capacity. Although some assumptions were made on these variables, they are based on professional judgement and in consultation with the project Steering Group which includes the Environment Agency and United Utilities.

Table 4-1: Greater Manchester SWMP Surface Water Modelling Variables

Variable	FMfSW	GM SWMP	Reasons for Change / Comments
Model Package	JFLOW	JFLOW+	JFLOW+ allows flood depths, velocities and hazards to be produced.
Annual Probability Rainfall	1 in 30 1 in 200	1 in 30 1 in 50 1 in 75 1 in 100 1 in 200 1 in 200 + climate change	Modelling a wider variety of rainfall events will provide a greater understanding of flood risk (e.g. full quantification of economic impact). Climate change will increase rainfall by 30%.
Rainfall Profile	50% summer	50% summer	No change
Storm Duration	1.1 hours	6 hour 1 hour	Both storm durations will be run, with the maximum depth/extent used. 6 hours may be of interest in more rural areas but in urban areas would expect critical duration to be nearer 1 hour.
Percentage Runoff	70% Urban 39% Rural	85% Dense urban 70% Urban 60% Semi rural 39% Rural	Both the national urban and rural values have been kept the same. However, two additional values used to represent city centres and small rural towns/villages. Areas have been defined using MasterMap classes.
Drainage Capacity	12mm/hr Urban 0mm/hr Rural	18mm/hr Urban 0mm/hr Rural	18mm/hr is between 1 in 10 and 1 in 30-year 1 hr rainfall total (after 70% PR is applied).
Manning's 'n' (floodplain roughness)	0.03 Urban 0.1 Rural Buildings were also raised from DTM as unfloodable objects	1.000 Buildings 0.025 Roads & paths 0.050 Rail 0.040 General surface 0.030 Natural envi 0.035 Water 0.035 Unclassified	Manning's is specified based on MasterMap classes. Representing buildings with roughness has advantages when analysing affected properties and reduces post processing time calculating average depths across each building.

The Greater Manchester surface water model was run for a number of rainfall (see above).

Table 4-2 provides a list of surface water modelling outputs.

Table 4-2: Surface Water Modelling Outputs

<table>
<tr><th>Output</th><th>Format</th><th colspan="2">Comments</th></tr>
<tr><td>Extents</td><td>Two flood outlines for each rainfall event have been produced:
• surface water flooding deeper than 100mm
• surface water flooding deeper than 300mm</td><td colspan="2">As rainfall will fall anywhere in Greater Manchester, it is necessary to filter out a certain depth so the whole of the study area is not indicated as flooded. By doing this filtering process, critical surface water flow paths will be more obvious to identify.</td></tr>
<tr><td>Depths</td><td>A GIS depth grid has been produced for each rainfall event, identifying the maximum depth of flooding at a 5m grid size interval / resolution.</td><td colspan="2">For visual reasons it is recommended that, as a minimum, depths below 100mm are not shown when using this dataset</td></tr>
<tr><td>Velocities</td><td>A GIS velocity grid has been produced for each rainfall event, identifying the maximum velocity of flooding in meters per second at a 5m grid size interval / resolution.</td><td colspan="2">For visual reasons it is recommended that, as a minimum, velocities below $0.5m/s^2$ are not shown when using this dataset</td></tr>
<tr><td rowspan="6">Hazards</td><td rowspan="6">A GIS hazard rating grid has been produced for each rainfall event, identifying the peak instantaneous hazard rating calculated using the equation[7]:
HR = d x (v + 0.5)</td><td colspan="2">The following flood hazard ratings should be used[8]:</td></tr>
<tr><td>0 to 0.3</td><td>No Hazard</td></tr>
<tr><td>0.3to 0.75</td><td>Very Low Hazard</td></tr>
<tr><td>0.75 to 1.25</td><td>Dangerous for Some</td></tr>
<tr><td>1.25 to 2.0</td><td>Dangerous for Most</td></tr>
<tr><td>Over 2.0</td><td>Dangerous for All</td></tr>
</table>

4.3 Sewer Surcharge Modelling

Foul sewers and surface water systems are spread extensively across the urban areas with various interconnected systems discharging to treatment works and into local watercourses.

Typically, foul systems will comprise a network of drainage sewers, sometimes with linked areas of separate and combined drainage, all discharging to sewage treatment works. Combined Sewer Overflows (CSOs) provide an overflow release from the drainage system into local watercourses or surface water systems during times of high flows. Surface water systems will typically collect surface water drainage separately from the foul sewerage and discharge directly into watercourse.

Sewer flooding can be caused by several factors: the capacity of the system is exceeded in large rainfall events, the system becomes blocked or it cannot discharge due to a high water level in the receiving watercourse.

Some of the sewers across Greater Manchester will date back to the Victorian times. Since then, the population has grown as the community expanded. More houses and businesses mean increased discharges and less permeable surfaces for rainwater infiltration. Climate change is also leading to longer, heavier periods of rain. These two factors result in the existing sewers and drains not being able to cope at certain times.

Sewers are generally designed to a 1 in 30-year design standard, which means sewer flooding will often be associated with larger events that are less frequent but have a higher consequence. In these situations, sewer inputs from the surrounding land will exceed the

7 The flood hazards formula is based on the Defra (2006) DF2321/TR1 - Flood Risk to People study

8 The original Defra range for very low hazard is 0 to 0.75. The lower threshold has been increased to 0.3 for this SWMP to remove areas with significantly low surface water depths or velocities. For visual reasons, this also allows a better comparison with the surface water flood extents, depths and velocities produced.

sewer system, discharge from manholes and flow across the surface of the land. Overland flows will therefore often follow the same flow paths and pond in the same areas as overland flows identified in the surface water maps.

As part of their ongoing drainage area programme, United Utilities have constructed hydraulic models of many of the main sewer systems through Greater Manchester. A series of design storms representing rainfall events of different return periods (1, 2, 5, 10, 20 & 30-years) were applied to the models with the surcharging volume at individual model nodes (typically manholes) recorded and supplied as a GIS layer. It is this data that has been supplied and analysed.

The methodology adopted takes the sewer-modelling results and routes the flow of water across the model domain using JBAs JFLOW+ modelling package. The same DTM and roughness values within the surface water modelling methodology was used, however only the 1 in 30-year event was modelled which was the largest event available.

The Greater Manchester sewer model was run for the 1in 30-year rainfall event. Table 4-3 provides a list of sewer surcharge modelling outputs. Depth, velocity and hazard grids have not been provided as outputs of the sewer modelling, as it was thought that this was too detailed given the unknown accuracy of the model inputs as discussed below.

Table 4-3: Sewer Modelling Outputs

Output	Format	Comments
Extents	Three separate outlines for the 1 in 30-year event have been produced illustrating a range of depths including: > 0.1m > 0.3m > 1.0m	It must be noted that these flood extents overlap; the 0.1m extent will be included in the 0.3m and 1.0m depth outlines, and the 0.3m extent will be included in the 1.0m depth outline.

4.4 Modelling Assumptions

The JBA team and SWMP partnership has worked hard to ensure that the outputs are as reliable as possible, given the data sources and assumptions needed to produce information appropriate for a cost effective and strategic assessment. It is essential that anyone using the outputs understands the data utilised and are aware of the limitations.

The main **surface water modelling assumptions** are:

- **Drainage Capacity -** The capacity of the drainage system is set to a given value in urban areas. However, the true capacity is variable.
- **Poorly Represented Watercourses -** The capacity of watercourses, canals etc are not accurately represented. In these instances, the predicted extent and depths of surface water flooding along these networks maybe overestimated. The user should refer to the Environment Agency's Flood Map product in such areas.
- **Building Representation -** Buildings have been represented by roughness values (Manning's n). In reality, the ability for flood water to enter buildings is dictated by local factors that cannot be represented in such strategic work. This may lead to unrealistic results if, in reality, key buildings are protected or have high thresholds / ground flood levels.
- **Artificial Structures -** Structures such as roads, railway and motorways, which cross surface water flow paths, are included within the DTM as elevated ground. Where surface water is able to flow underneath these structures (perhaps through culverts or bridge underpasses), the DTM has been edited to allow this. However, the capacity of such structures was not calculated and this will have a significant impact on the accuracy of the results in many locations.

The main **sewer surcharge modelling assumptions** are:

- **United Utilities Hydraulic Sewer Models -** United Utilities supplied all model outputs with the caveat that it was provided without regard to the spatial coverage, age or quality of the background work. Therefore, this dataset will have inconsistencies and inaccuracies but no attempt has been made to assess this by the project team. It is regarded as a reasonable dataset for the strategic purposes of Stage 1 of the project.
- **Sewer Model Coverage** – As stated above, not all urban areas within Greater Manchester have sewer models. Where no JFLOW+ model outputs are shown, this may mean that no sewer model was available rather that the local sewers do not tend to surcharge during flood conditions. The sewer discharge results should always be examined in tandem with the sewer model nodes to ensure that the absence of predicted flooding is not misinterpreted.
- **JFLOW+ Sewer Model** - The model does not allow water, once discharged, to re-enter the surface water drainage system through manholes or highway drains. In this case, the sewer flooding illustrated will be conservative.

It is important to remember, because of these assumptions, that the strategic modelling outputs should not be used for more detailed purposes. The strategic assessment is intended to inform where more detailed investigations should occur and a hotspot identified at the strategic level may turn out not to be so following more detailed investigations and vice versa.

4.5 Identifying Strategic Surface Water Hotspots

A primary purpose for the flood risk assessment in Stage 1 is to signpost and rank areas at risk of surface water flooding across Greater Manchester and individual districts. These strategic hotspots will be used as a starting point in identify potential locations for detailed risk assessments work (discussed in Section 6.1) within the SWMP, as well as provide an important component of each district's Local Flood Risk Management Strategy.

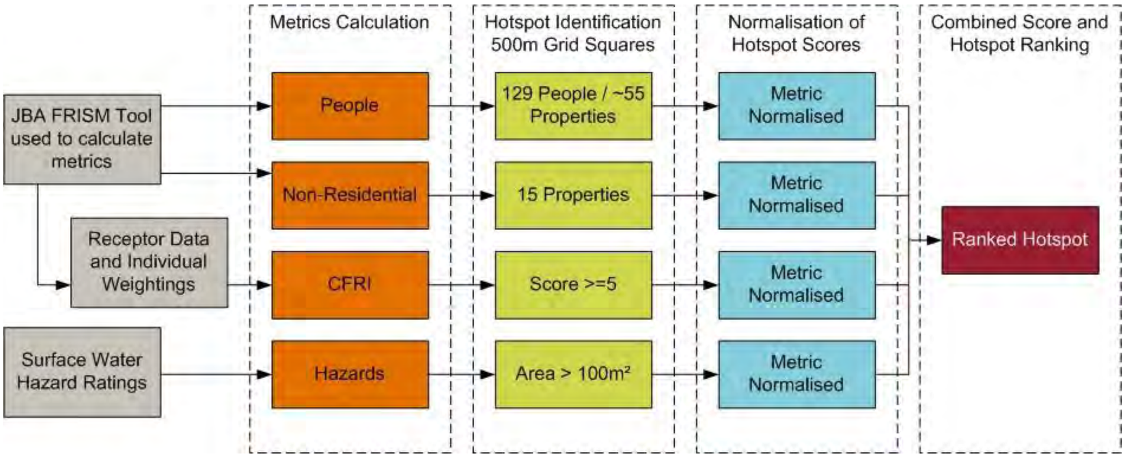
To be able to assess risk strategically over Greater Manchester and within the individual districts, a grid square approach has been adopted allowing local risks to individual receptors to be aggregated to a community or catchment level. The resulting "red flagged" risk squares (or hotspots) allow users to make a quick and consistent assessment of risk. High risk would typically be due to the potential for surface water flooding of highly vulnerable / critical infrastructure or a large quantity of less vulnerable receptors. This approach was also adopted by the Environment Agency during the formulation of "Flood Risk Areas" for the recent PFRA process.

In order to identify these hotspots, the SWMP has:

- Identified areas susceptible to surface water flooding during the 1 in 200-year rainfall event,
- Identified all receptors (including people, property, infrastructure and key services) potentially at risk of flooding across Greater Manchester and defining Flood Risk Indicators (FRI) associated with each receptor grouping,
- Identified an appropriate unit of area (a "grid square") for analysing / collating risk information,
- Identified flood risk thresholds for when a grid square should be "red flagged" as a location where a surface water hotspot may exist, and
- Normalising each FRI score to form a combined score for ranking each hotspot across Greater Manchester.

Figure 4-1 illustrates this process in a useful workflow diagram, identifying each step taken to identify the strategic surface water hotspots. The sections below, describe in more detailed the methodology behind each stage of the process.

Figure 4-1: Flood Risk and Hotspot Assessment Workflow Diagram



4.5.1 Areas at Risk of Surface Water Flooding

Areas predicted at risk of surface water flooding have been identified through the modelling discussed in Section 4.2. The 1 in 200-year rainfall event was chosen to provide the primary scenario to identify hotspots and this was also used during the preparation of the Greater Manchester PFRAs.

The depth grid used to create the 1 in 200-year outline was analysed and all depths below 300mm were removed. The purpose behind this was that this depth was seen as a critical level in which surface water would start to cause significant impact on the receptors.

4.5.2 Flood Risk Indicators

Flood Risk Indicators have been defined for:

- People
- Non-residential properties
- Critical Flood Risk Infrastructure (CFRI)
- Hazards

People Flood Risk Indicator

The people FRI relates to the number of people who are predicted to be affected by surface water for any given scenario, calculated by multiplying the number of residential properties affected by flooding by 2.34. The location of residential properties have been extracted from the National Land and Property Gazetteer (NLPG), with the Basic Land and Property Unit (BLPU) class attributes used to filter data for use in the relevant receptor groups. Table A- 1 (Appendix A) presents the NLPG BLPU categories used to identify residential properties.

Non-Residential Flood Risk Indicator

The non-residential (retail / commercial) receptor data essentially includes all property points obtained from NLPG that could not be identified as having a residential function. Those BLPU codes listed in Table A- 2 (Appendix A) represent those that are present within the NLPG data received for the AGMA region.

Critical Flood Risk Infrastructure (CFRI) Indicator

CFRI receptors contain both particular critical (e.g. motorways) and vulnerable receptors (e.g. residential care homes). An initial list of receptors were identified based upon the national PFRA that were then adapted through discussion with the project Steering Group. CFRI is a combined indicator made up of several 'metrics' that have been individually identified weighted and calculated. This is now described in more detail.

At an early stage of the SWMP, it was identified that relying solely on NRD data as a source for receptor data would create an unrealistic assessment. This is due to the poor quality and omission of some aspects of the NRD when compared at a local and regional level using OS data and local knowledge. Therefore, a process of receptor enhancement was undertaken whereby more accurate data were extracted from NLPG data and local receptor data were available from local authorities and utilities companies.

Where receptors covered large areas, a manual digitisation on polygons was undertaken using OS MasterMap (OSMM) in order to ensure that where potentially flooding of such sites was possible this information was captured. Examples of large area receptors include hospitals, landfill sites and Control of Major Accident Hazards (COMAH) sites. GIS data only included point data for schools (a dot somewhere within the school grounds). Therefore, the decision was taken to buffer this in order to capture their grounds and the immediate wider area (e.g. flood hazard is created near schools due to access and egress issues). The size to which they were buffered was determined by the type of school; pre-schools were buffered to 50m, primary schools to 100m and secondary schools to 250m.

Some data from NRD were retained as they were the best available, including line features representing main road and rail infrastructure and point data such as minor utilities infrastructure. The latter included better electrical substation infrastructure compared to data available from NLPG.

Once a list of appropriate CFRI receptors was compiled, a suitable weighting was associated with each to reflect its criticality or vulnerability to surface water flooding. PPS25 vulnerability classifications were used as a starting point to categorise CFRI weighting. The project Steering Group agreed the final weighting used. This weighting was then used as a factor for identifying surface water flooding hotspots. Although all receptors in this list are critical, the weighting has been used to illustrate the difference in expected vulnerability of the user or infrastructure itself during a significant event. This weighting was then used as a factor for identifying surface water flooding hotspots.

Table A- 3 (Appendix A) defines the type of receptors and data source used to generate the CFRI indicator, which are an amalgamation of point, line and polygonal data sourced from NLPG, the National Receptor Dataset (NRD), local authority sources and utilities.

Hazard Indicator

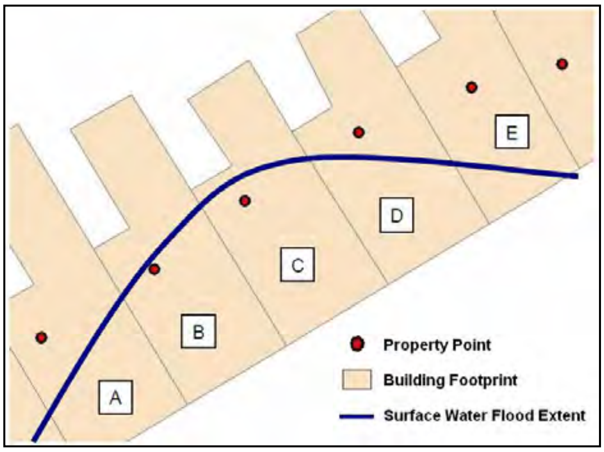
The method for generating hazard information is presented in Table 4-2. Hazard results for the 1 in 200-year event, having a hazard rating of 'Dangerous for Some' and 'Dangerous for All' were converted to a geodatabase feature class and used to generate metrics relating to area of each hazard rating across a 500m analysis grid. For those squares where the area of at least one of the hazard ratings extents exceeded 100m², the values were copied to the main metrics analysis grid discussed in the following section.

4.5.3 Hotspot Identification

In order to undertake a detailed count of receptors located within the modelled 1 in 200-year surface water outline, JBAs internal Flood Risk Matrix (FRISM) tool was used. This helps to query and visualise the results of this analysis.

Firstly, to undertake a count of properties potentially affected by flooding it is necessary to stamp building extents onto the surface water outlines. This approach best represents the number of properties that might be at risk. For example, considering In order to undertake a detailed count of receptors located within the modelled 1

Figure 4-2: Property Count Approach



in 200-year surface water outline, JBAs internal Flood Risk Matrix (FRISM) tool was used. This helps to query and visualise the results of this analysis.

if a 'normal' count was adopted in Figure 4-2 only properties B and C would be counted, however in reality properties A-E would be at risk.

JBA's FRISM tool uses the flood outline and the geometry of the receptor data (point, line or polygon) to count the full number of receptors at risk.

Once the analysis was complete across Greater Manchester, a grid was produced, containing count values for each of the receptor types including all 25 of the CFRI receptor datasets.

The national PFRA grid square analysis approach was used as a starting point for the SWMP, placing a grid of 1km squares across Greater Manchester. Two alternative grid sizes of 500m and 250m were also tested, with the results presented to the project Steering Group.

The 500m grid square was chosen as providing a good resolution for signposting high risk areas, whilst being visible at a Greater Manchester and local community level. For reference, the 1km and 250m grid square analysis results have been provided on the Strategic Flood Map. Whilst the range of hotspot resolution does not particularly help refine the catchment or study area to the user, it does help focus in on the receptors at risk of surface water flooding in order to carry out a local screening.

Once these counts were available for each grid square, it was possible to categorise risk using flood risk thresholds agreed for each of the four metrics used. These thresholds, once exceeded, illustrate when the number of receptors at risk within a defined area (500m²) is significant enough for it to be classified as potential including a surface water hotspot and be considered for more detailed investigation later on in the SWMP or via other flood risk appraisal studies.

The Steering Group was presented with a range of threshold values and the resulting affect on the distribution of hotspots across Greater Manchester. It was observed that the higher threshold values tended to limit the geographical spread of hotspots to Manchester city centre and other very dense urban centres. However, a low value of the threshold made it impossible to identify high-risk areas and geographical patterns of risk across Greater Manchester.

Each flood risk threshold was agreed through consultation with the Steering Group. Table 4-4 presents the four Flood Risk Thresholds used to define a 500m grid square as a hotspot within this SWMP. If a threshold was exceeded for any of the fours FRIs within any given grid square then it was been deemed to be a potential surface water flooding hotspot and "flagged".

Table 4-4: Flood Risk Thresholds

Metric	Approach	Threshold
People	Plotting frequency distribution curve	When **129 people** (≈ 55 properties) or more are at risk within one 500m grid square
Non-Residential Properties	Plotting frequency distribution curve	When **15 properties** or more are at risk within one 500m grid square
CFRI	Steering Group suggested	When the sum of the weighted scored is greater or equal to **5** with one 500m grid square
Hazard	Steering Group suggested	When the area of hazard rating of 'Dangerous for Some' and 'Dangerous for All' is greater than **100m²** within one 500m grid square

4.5.4 Grid Square / Hotspot Ranking

In order to develop the understanding of risk geographically across Greater Manchester and within each district, it was possible to rank each hotspot using their relative surface water flooding probability. Each hotspot has a four scores relating to the number of people and non-residential properties at risk, the sum of the weighted CFRI scores and whether or not the area has an area of hazard rating of ‘Dangerous for Some’ and ‘Dangerous for All’ is greater than 100m².

Each of these scores was then normalised to generate a standard score. A combined score was generated for each grid square by summing the “standard score” for each FRI / metric. These combined scores for flagged grid square / potential hotspot could then be ranked to identified those squares at higher risk, enabling each district to focus their attention to understanding and potentially managing these risks as a matter of priority.

For the highest risk squares, a final task was completed to examine the flagged grid squares and highlight the actual extent of the flood risk problem – scoping the spatial extent of any more detailed work. Strictly, this is the surface water “hot spot” extent but, for brevity, the term is also used to describe the higher ranking grid squares themselves.

4.6 Greater Manchester Strategic Flood Map

The Strategic Flood Map is an interactive digital mapping application presenting the modelled surface water flooding outputs for Greater Manchester, receptor information and derived surface water hotspots, along with other useful flooding related information collected from each LLFA, the Environment Agency and United Utilities.

This Strategic Flood Map enables users to identify areas of high risk of surface water flooding within their area of interest, compare other sources of risk and prioritise future risk assessment or management works.

The Strategic Flood Map has been developed using ESRI ArcReader, a free desktop mapping application that enables users to view, interrogate and explore published maps. ArcReader functionality includes the ability to navigate a map, using zoom and pan tools, select and de-select layers of information and to print desired outputs as required.

Appendix C, Table D- 1 provides a list of all GIS data included on the Strategic Flood Map. The Strategic Flood Map will be provided with a short user guide including disclaimers and FAQs to help users understand the data and its interpretation. Below is a brief summary on key uses of the Strategic Flood Map.

4.6.1 How to use the Strategic Flood Map for Specific Purposes

Land Use Planning

In land use planning, the Strategic Flood Map can be used to highlight where a more detailed study of surface water flooding may be necessary. It will provide the greatest benefit in terms of the identification, management and avoidance of surface water flooding, where the modelled data can be used to inform development allocations within the LDD/LDP and outline the requirements for site level flood risk assessments to be carried out by developers.

The surface water flood outlines, depths and hazards are not appropriate to use as the sole evidence for any specific planning decision at any scale without further supporting studies or data such as locations of historic surface water flooding.

At a strategic level, the Strategic Flood Map can be used to identify areas with critical drainage problems (known as Critical Drainage Areas, CDAs). Some district SFRAs have identified these areas, however, the level of detailed provided on the Strategic Flood Map is better. The Strategic Flood Map includes United Utilities Drainage Areas, flow paths and sewer discharges locations and this can be used to define or refine CDAs, which may currently be broad or indicative.

Local authorities will be able use these CDAs to develop surface water control policies for new development by identifying situations where development through good design can help to reduce risk in these critical areas. Development can also contribute to wider community schemes via CIL/s106.

Site Specific Flood Risk Assessments

Due to the strategic nature of the surface water and sewer modelling used to develop the flood outlines, depths and hazards, it is not appropriate to use the Strategic Flood Map as the sole evidence for any specific planning decisions (such as objecting to a planning application) at any scale without further supporting studies or evidence.

In addition, although the SWMP has used these outputs to calculate the total number of receptors at risk of surface water flooding, the outputs should not be used to identify individual properties at risk.

The Strategic Flood Map can, however, act as a useful tool for developers to check whether they need to consider and when to seek further advice and technical support on surface water flooding and its management within a site specific FRA. Where a site is within an area shown to be at risk, developers should be advised to carry out further investigation (for example check historic records or modelling investigations of surface water flood risk).

Local Flood Risk Management Strategies

LLFAs are required to prepare Local Flood Risk Management Strategies under the FWMA, which will set out how LLFAs will manage the local flood risks in their area.

The strategic modelling, hot spot assessment and the preparation of the Strategic Flood Map have provided a lot of useful information for the preparation of a strategy for each LLFA. Whilst a number of the key hotspots will be taken forward within Stage 2 of the SWMP, there still remains a number of high risk hotspots and areas at risk of surface water flooding across each district. The informational provided in the SWMP should help signpost priorities work in the local strategy.

Flood Risk Regulations Risk and Hazard Maps

Individual PFRAs were completed for each LLFA in Greater Manchester as part of this SWMP. An indicative Greater Manchester Flood Risk Area was identified by the Government as one of ten Indicative Flood Risk Areas (IFRA) in England. Through the PFRA preparation process, it was agreed that the IFRA should be amended so that it only covers the administrative area of nine out of the ten districts (all but Wigan MBC). This means that the next stage of the Regulations have been triggered, with each LLFA contained within the Flood Risk Area having to produce flood hazard and risk maps by the 22nd June 2013 and a flood risk management plan by the 22nd June 2015.

Although LLFAs are awaiting guidance from Defra and the EA, it is likely that the maps will have to include:

- The likely extent (including water level or depth) of possible floods,
- The likely direction and speed of flow of possible floods, and
- Whether the probability of each possible flood occurring is low, medium or high.

It is anticipated that the flood risk data collected, the surface water modelling undertaken and the Strategic Flood Map will provide the majority of information required. However, LLFAs are still waiting on further guidance on what should be included in the flood hazard maps and flood risk maps.

Emergency Planning

The Strategic Flood Map can be used to inform flood related local risk assessments for emergency planning purposes and to assist with developing or updating community / Multi-Agency / Local Resilience Forum (LRF) Flood Plans. Specifically, it can be used to:

- Raise general awareness,
- Support the assessment of surface water flood risk and to produce community flood risk summary sheets / community flood plans,
- Inform LRFs of the model's prediction of flood depth in different locations,
- Prioritise control centre locations and identify existing locations that are in places identified as being at risk of surface water flooding,
- Identify locations of key infrastructure in areas that may be affected by surface water flooding,

- Identify locations of various facilities at risk that are associated with vulnerable people, such as hospitals, schools and care homes, and
- Identify locations likely to be suitable / unsuitable for evacuation routes, safe havens and rest centres.

Green Infrastructure and SUDS

The Strategic Flood Map has generated a series of hotspots where flood risk is potentially significant and a flood management response is likely to be appropriate. These hotspots may be compared against the Water Framework Directive (WFD) targets, as defined in the North West River Basin Management Plan, to identify sections of river where environmental considerations are important or gains can be made as part of any proposed flood management activities.

This will help moving targeted watercourses towards Good Ecological Status/Potential. Synergies with RBMP targets have been reviewed for the rivers covered by the Strategic Flood Map, as presented in Section 5.7.3.

The Strategic Flood Map can also be used within development plans, the Greater Manchester GI Framework and local GI Strategies, which are in development in some cases. The data contained within can be used to identify strategic GI locations or interventions, such as the use and management of existing open green spaces, playing fields, natural floodplains and the locations of possible new assets such as storage solutions.

5 Summary of Surface Water Flood Risk

5.1 Introduction

The aims of the SWMP risk assessment process are presented in Section 4 and a summary of the results of the Stage 1 analysis is presented in this section. This includes the new modelling work as well as other sources of information, such as flood history.

5.2 Surface Water Flood History

Across Greater Manchester, there have been relatively few major surface water flood events that have been identified. The Greater Manchester sub-regional SFRA, carried out a review of significant historical flood events across each district. Table B- 1 lists those which are relevant to this SWMP.

Historical records are often anecdotal and incomplete and it can be difficult to determine accurately the frequency and consequences of events. But any available records can help build a picture of which catchments are susceptible to flooding. By looking into the past, an insight into the sources, seasonality, frequency and intensity of flooding might also be gained.

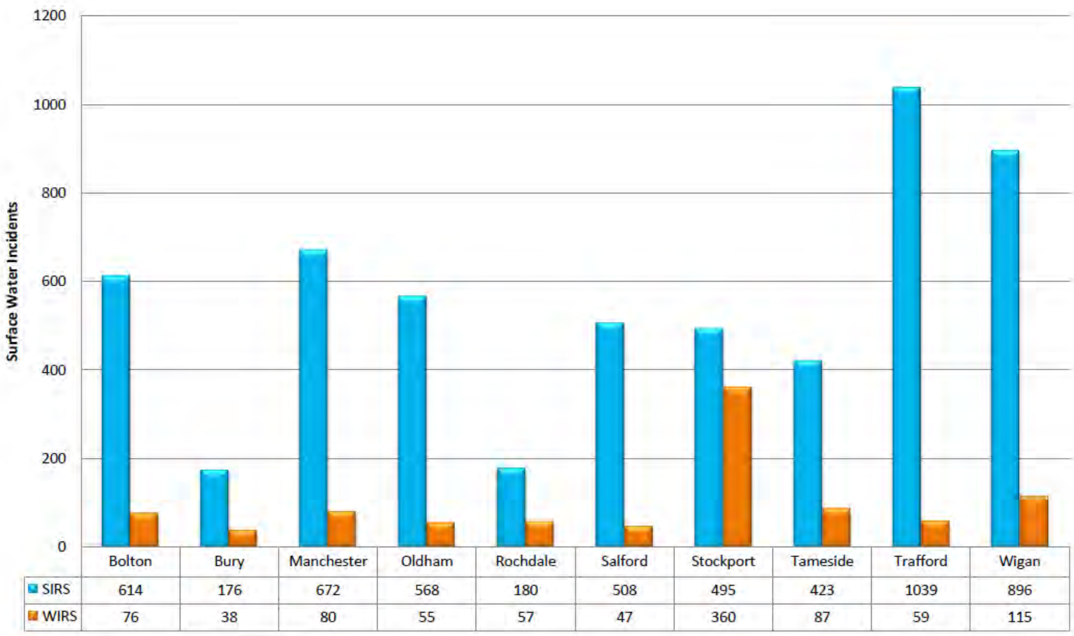
5.2.1 United Utilities SIRS and WIRS

United Utilities provided two main datasets associated with historical flood incidents.

- Sewerage Incident Register System (SIRS)
- Wastewater Incident Register System (WIRS)

These datasets provide a register of all incidents related to United Utilities assets, with the WIRS recording system replacing that of the SIRS in 2008. The SWMP has filtered all incidents, which are not relevant to this assessment. Figure 5-1 illustrates the number of recorded incidents associated with United Utilities assets, which have resulted in surface water flooding of some kind. In the majority of incidents, blockage of the underground system has been the root cause, resulting in surface water flooding to properties and highways.

Figure 5-1: Surface Water Flood Incidents Associated with United Utilities Assets



Trafford and Wigan have had the largest number of incidents records up to 2008, with Stockport having a significantly larger number of incidents post 2008 compared to the other districts.

5.2.2 United Utilities DG5 Register

Water and sewerage providers are obliged to maintain an At Risk Register of all properties in their area that have suffered or are at risk of internal flooding from overloaded public foul or surface water sewers. This is called the "DG5" register.

United Utilities provided "internal" and "external" DG5 records at a property level for use in the SWMP. DG5 records are a dataset of all properties that have suffered internal or external flooding from the sewerage system. It must be noted that the DG5 register supplied is just a "snap shot" in history of those properties on the register at the time it was supplied, and properties may have been added or removed since it was supplied. The DG5 register was provided in February 2011. For a property to be removed from the DG5 register the flooding should be assessed as being no more frequent than 1 in 10 years. An investigation or on the ground works may prompt a properties removal from the register.

Figure 5-2 illustrates the geographical distribution of DG5 records across each United Utilities Drainage Area of Greater Manchester as of February 2011.

Figure 5-3 illustrates the number of properties on United Utilities internal and external DG5 register as of February 2011. Manchester, Trafford and Wigan have the largest number of properties whilst Oldham and Tameside have the lowest.

Figure 5-2: DG5 Register by United Utilities Drainage Area

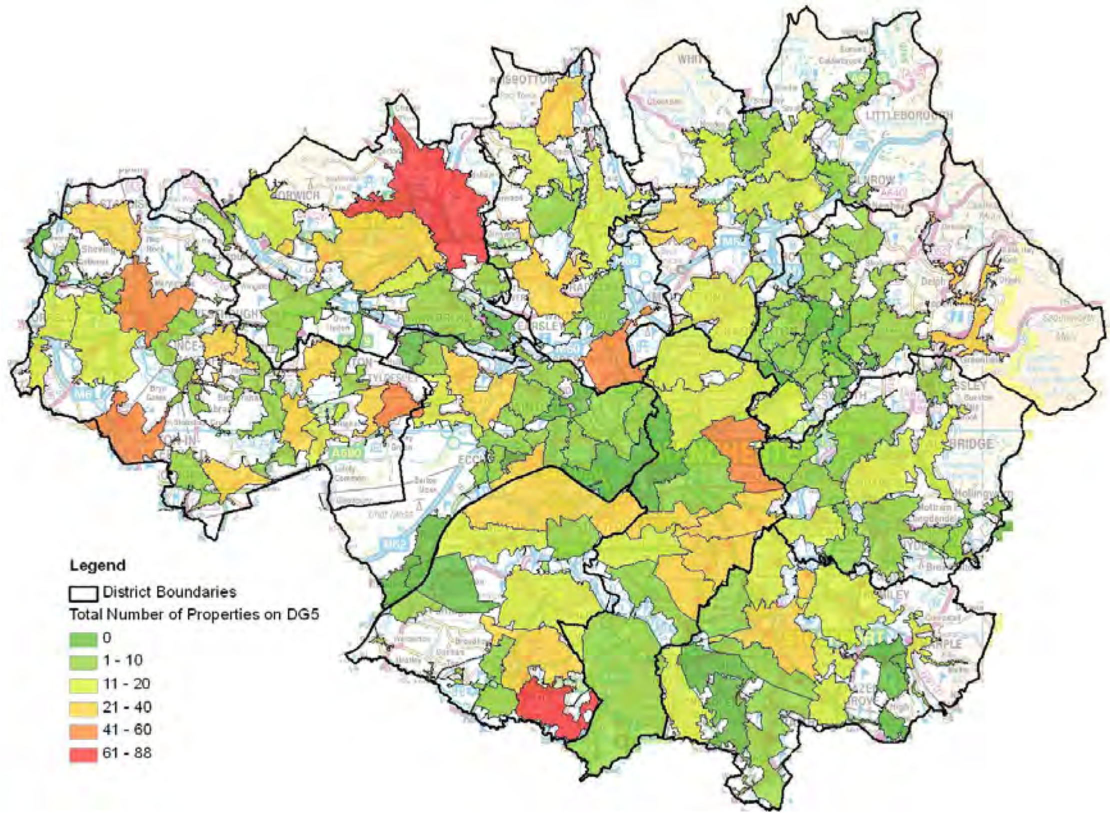
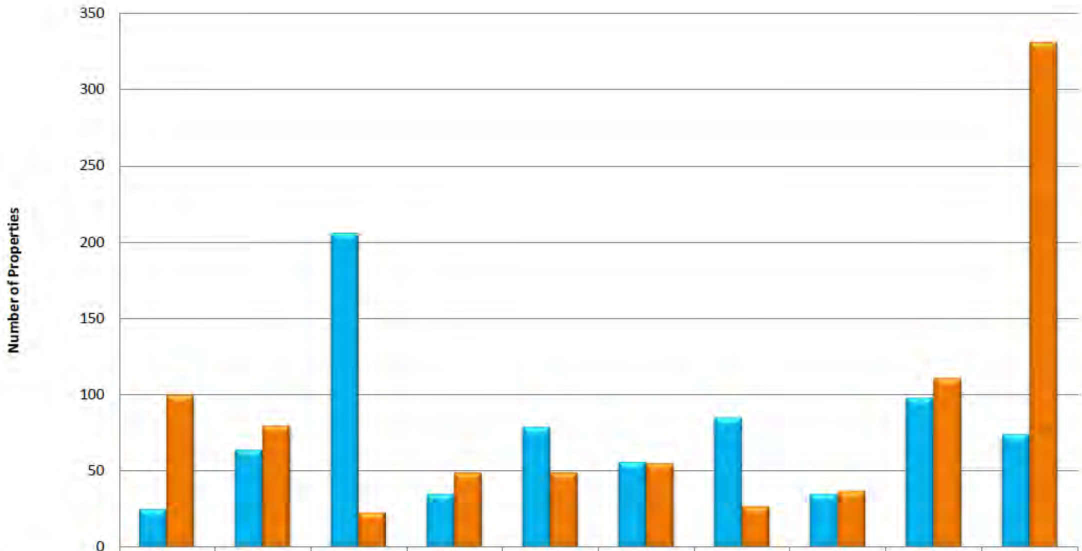


Figure 5-3: Internal and External DG5 Records

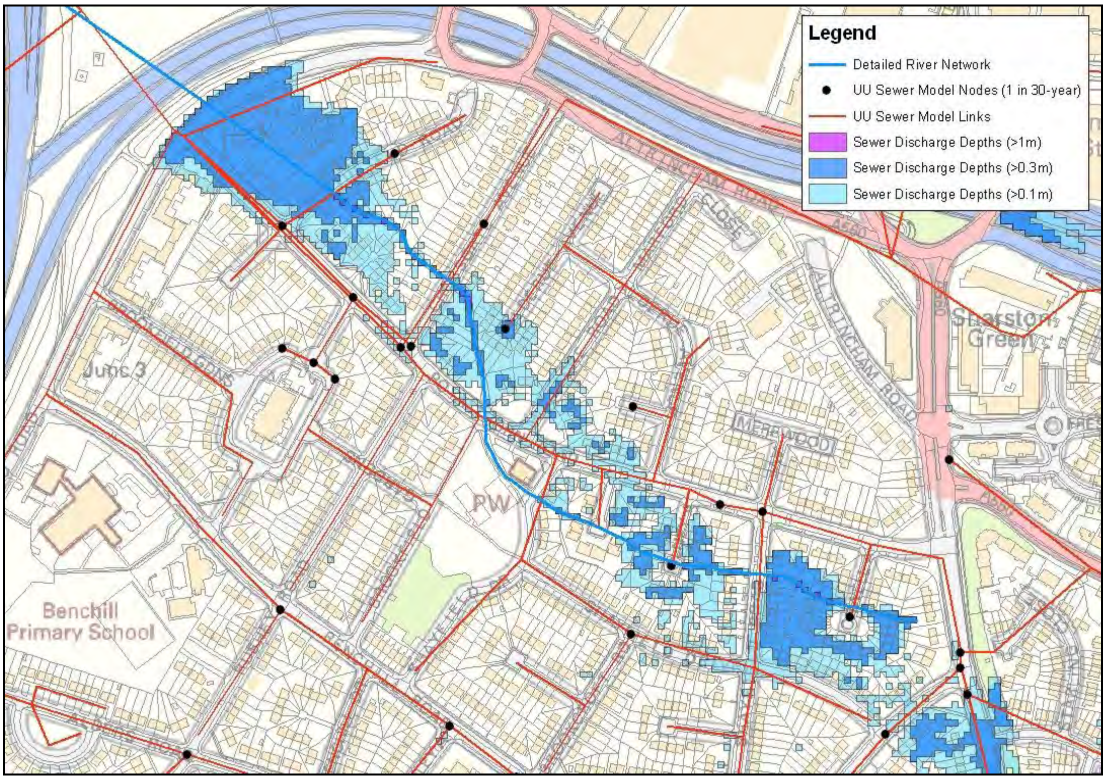


	Bolton	Bury	Manchester	Oldham	Rochdale	Salford	Stockport	Tameside	Trafford	Wigan
DG5 Internal	25	64	206	35	79	56	85	35	98	74
DG5 External	100	80	23	49	49	55	27	37	111	331

5.3 Summary of Sewer Surcharge Modelling Results

The potential for flooding as a result of sewer surcharging has been assessed through modelling the spreading surcharge volumes over land (the method is discussed in Section 4.2). The SWMP strategic model has produced flood extents for the 1 in 30-year rainfall event, which have been disaggregated between the 100mm, 300mm and 1m depth ranges. Figure 5-4 illustrates an example of the sewer surcharge modelling outputs.

Figure 5-4: Sewer Modelling Output Example



Comparing Figure 5-4 with Figure 5-5 shows a very similar flow pattern and extent at risk for both surface water and sewer flooding. This similar correlation is replicated across urban areas in Greater Manchester where data allows a comparison.

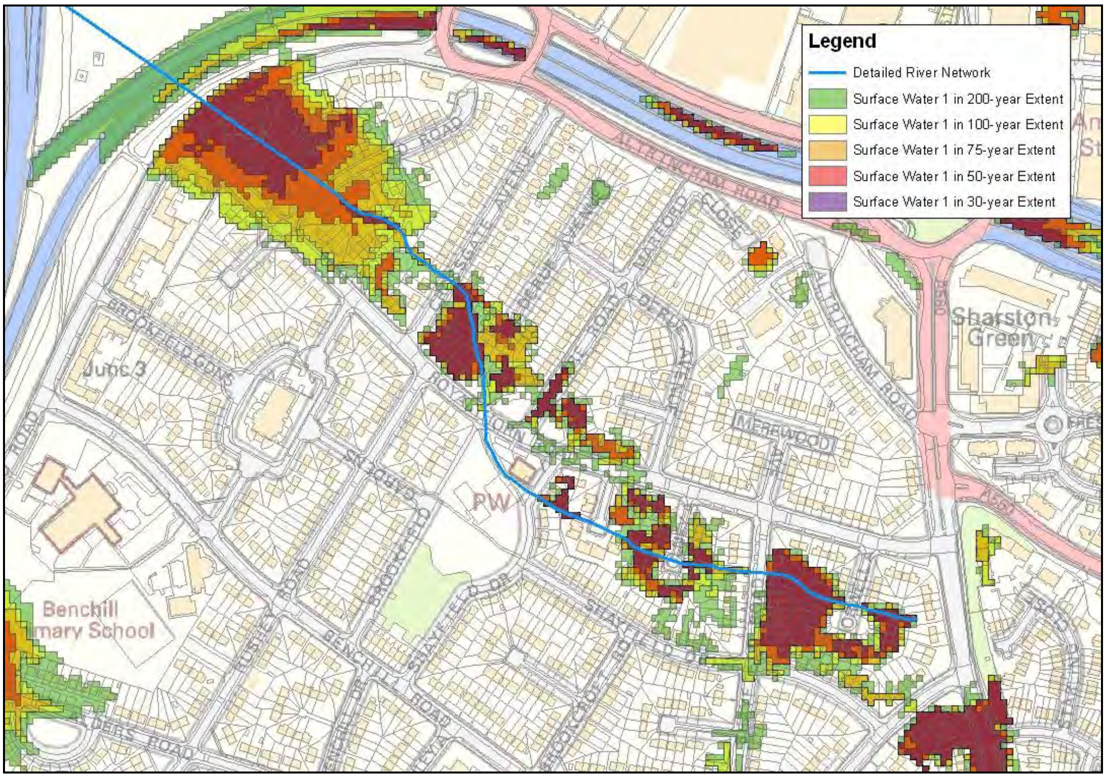
Like the surface water modelling, the sewer model outputs also help identify linkages between different surface water and sewer catchments as water flows over land or is constrained or transferred by roads, railways, rivers and buildings.

5.4 Summary of Surface Water Modelling Results

The potential for surface water flooding across Greater Manchester has been assessed through the development of a strategic surface water model (discussed in Section 4.2), which has modelled flood extents, depths, velocities and hazards for a range of rainfall events.

The range of events help identify those areas which are at higher risk of surface water flooding, due to more frequent flooding or more extreme events. Figure 5-5 helps illustrate the different flood extents with greater rainfall events.

Figure 5-5: Surface Water Modelling Output Examples



In the majority of cases, the surface water flood extents help identify natural flow paths (where main rivers, ordinary watercourses and smaller private drains are located), fitting well with the Detailed River Network GIS layer supplied by the Environment Agency. The surface water flood extents also help to identify culverted watercourses, with surface water flowing overland where the watercourse would naturally flow. This has proved to be beneficial in the heavily urban areas of central Manchester and the identification of hidden watercourses.

The topography and urban nature of Greater Manchester drives the local features of surface water flood risk. The topography of the outlying districts to the north and east such as Bury, Rochdale, Oldham and Tameside is very steep, producing narrow and shallow flow paths. Rapid inundation is noticeable in these areas, with higher velocities and hazards occurring.

A greater number of flow paths can be identified in these upland areas, as surface water flows off the hillsides, collecting in small drains before flowing in to the valley bottom. Known problem locations are often associated with culverts along ordinary watercourses, which can become blocked or exceeded during large rainfall events. Runoff direct from rural land is also an issue in places like Ramsbottom; causing flooding to major road networks and individual properties.

Within the flatter areas of central Manchester, the heavily urbanised flat landscape and the underlying drainage systems drive surface water risks. The extent of flooding can be larger, but due to the presence of buildings and infrastructure such as roads and railway, depths can be much greater. However, because of the flat topography, surface water flooding can often be disconnected, with isolated pools of water developing in and around buildings, as noticed particularly in Manchester City Centre, Levenshulme, Rusholme, Fallowfield and Withington.

5.5 Receptors at Risk of Flooding

Table 5-1 lists the number of key vulnerable and critical receptors at risk of surface water and sewer flooding to a depth of more than 300mm across Greater Manchester for the 1in 30-year, 1 in 200-year and 1 in 200-year plus climate change rainfall events. Not all receptors have been included in the table, but all are available in the Strategic Flood Map.

In half of the districts, the number of receptors at risk of sewer flooding is lower during the 1 in 30-year event when compared to the same event for surface water. However, Bury, Manchester, Salford, Stockport and Trafford all have more residential properties at risk during the 1 in 30-year sewer event.

There is a 25% to 75% in the number of properties at risk when comparing the number of residential properties at risk in the present and future 1 in 200-year rainfall events. Manchester, Salford, Trafford face the largest increases, whilst Rochdale, Oldham and Tameside have the lowest. This pattern will be a result of the topography, with flatter areas being more severely affected (in terms of flood extent) by climate change.

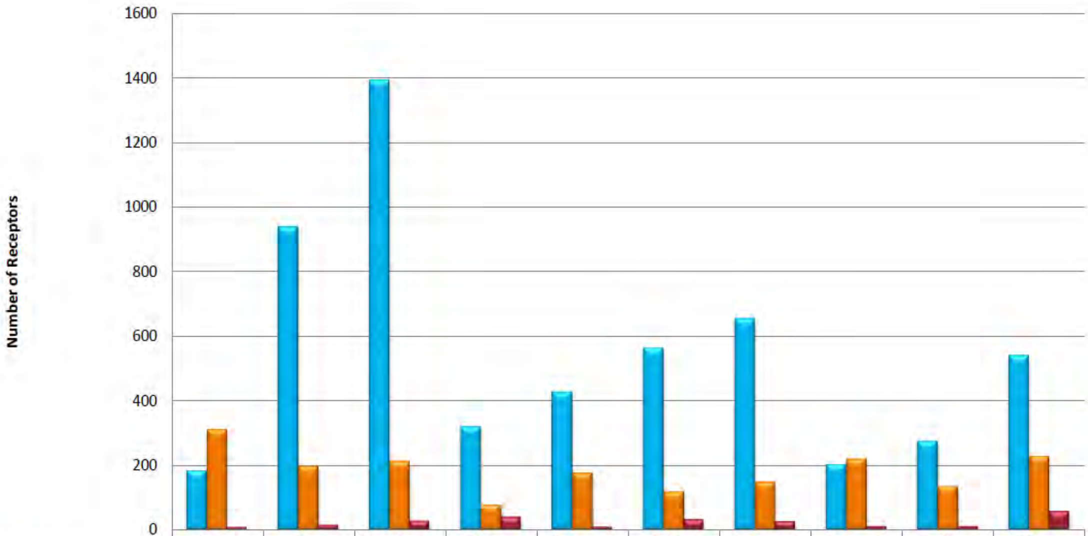
Figure 5-6 and Figure 5-7 illustrate the number of receptors at risk of sewer and surface water flooding for easy comparison across all ten districts. As the number of critical infrastructure receptors at risk is low in comparison to both residential and non-residential properties, these have been combined under one heading.

Manchester City has a significantly larger number of residential properties at risk of surface water flooding (at depths greater than 300mm) than any other district, followed by Oldham, Salford and Wigan. Within Manchester City Centre, this can (in part) be attributed to the large number of apartment blocks in the south of the City Centre,, with some blocks holding around 100 or more apartments. Section 5.6.2 describes this pattern in more detail.

Tameside has the largest number of non-residential properties, whilst Manchester, Salford and Stockport and Wigan have a high number of critical/vulnerable infrastructure assets at risk. The majority of critical/vulnerable infrastructure at risk is associated with schools, telecommunications and utilities infrastructure. The large number of schools identified will be due to the buffering approach taken as described in Section 4.5.2. The number of utilities infrastructure identified at risk mainly relates to the large number of electricity substations provided in NRD. Their size and vulnerability to surface water flooding is however unknown.

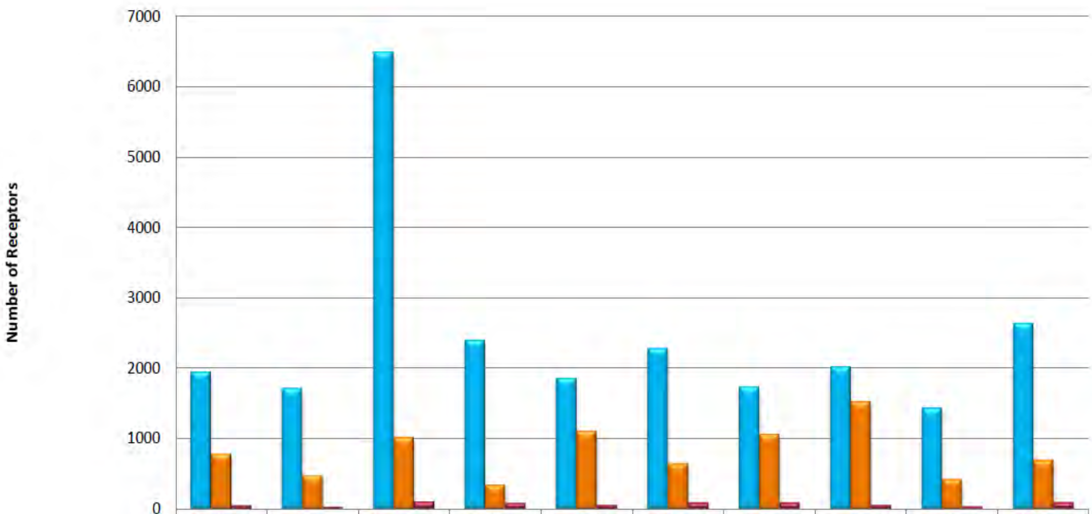
The number of properties at risk from sewer flooding, as identified through the SWMP strategic modelling, should be viewed with caution. As mentioned in Section 4.4 there are a number of assumptions and limitations with the modelling, which could affect the results.

Figure 5-6: Receptors at Risk during 1 in 30-year Sewer Flood Event



	Bolton	Bury	Manchester	Oldham	Rochdale	Salford	Stockport	Tameside	Trafford	Wigan
Residential	184	939	1394	321	428	564	655	204	275	541
Non-Residential	310	197	212	78	176	118	148	219	134	227
Critical Infrastructure	7	14	26	37	8	29	24	10	10	54

Figure 5-7: Receptors at Risk during 1 in 200-year Surface Water Flood Event



	Bolton	Bury	Manchester	Oldham	Rochdale	Salford	Stockport	Tameside	Trafford	Wigan
Residential	1946	1714	6476	2399	1860	2283	1734	2021	1432	2638
Non-Residential	780	476	1014	346	1105	642	1058	1515	427	694
Critical Infrastructure	46	22	91	72	49	80	79	47	30	83

Table 5-1: Vulnerable and Critical Infrastructure at Risk across Greater Manchester

District	Source	Event	Res	Non-Res	Hospitals	Schools	Telecommunications	Emergency Services	WwTW	Pumping Stations	Utilities	ENW Elec. Assets	Waste Sites	COMAH Sites
Bolton	Sewer	30yr	184	310	0	0	5	0	0	0	2	0	0	0
	Surface Water	30yr	702	358	0	5	6	0	1	1	6	0	0	0
		200yr	1946	780	1	12	14	1	1	1	14	1	0	1
		200yr+cc	2563	970	1	13	18	1	1	1	24	2	0	1
Bury	Sewer	30yr	939	197	1	4	0	0	0	2	7	0	0	0
	Surface Water	30yr	531	213	0	5	0	0	0	2	7	0	0	0
		200yr	1714	476	1	5	0	0	0	4	12	0	0	0
		200yr+cc	2266	599	1	7	0	0	0	4	20	0	0	0
Manchester	Sewer	30yr	1394	212	3	20	1	0	0	0	2	0	0	0
	Surface Water	30yr	852	373	4	20	2	0	0	0	5	0	0	0
		200yr	6476	1014	5	51	6	0	0	0	25	3	0	1
		200yr+cc	9497	1441	5	61	8	0	0	0	42	4	0	1
Oldham	Sewer	30yr	321	78	1	29	0	0	0	0	7	0	0	0
	Surface Water	30yr	1226	195	1	33	0	0	1	2	11	0	0	0
		200yr	2399	346	1	44	2	1	1	3	20	0	0	0
		200yr+cc	3022	437	1	47	2	1	1	3	21	0	0	0
Rochdale	Sewer	30yr	428	176	1	3	0	0	0	0	3	0	0	1
	Surface Water	30yr	933	574	0	6	0	0	1	2	17	1	0	1
		200yr	1860	1105	0	8	0	0	1	4	34	1	0	1
		200yr+cc	2395	1413	0	9	0	0	1	4	41	1	0	1
Salford	Sewer	30yr	564	118	0	22	2	0	0	1	3	0	0	1
	Surface Water	30yr	450	170	0	28	6	0	0	1	7	0	0	0
		200yr	2283	642	1	43	12	0	1	2	19	1	0	1

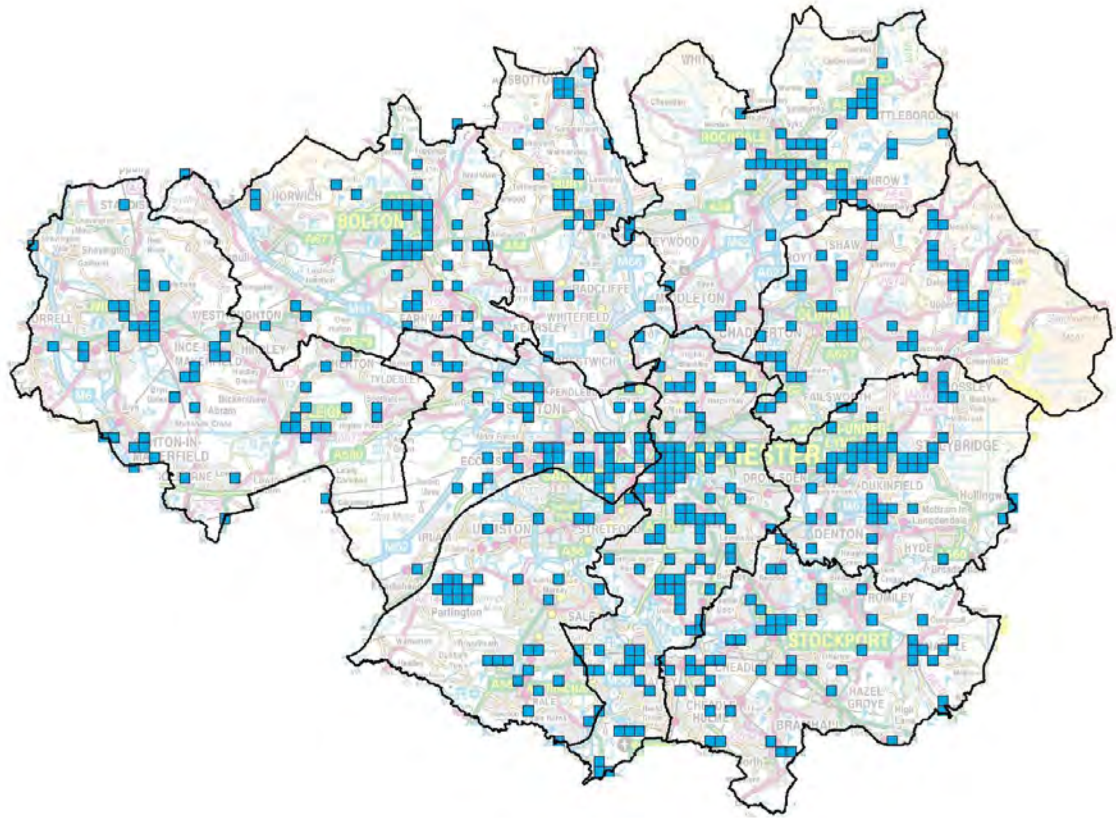
District	Source	Event	Res	Non-Res	Hospitals	Schools	Telecommunications	Emergency Services	WwTW	Pumping Stations	Utilities	ENW Elec. Assets	Waste Sites	COMAH Sites
		200yr+cc	3381	882	1	46	15	0	1	2	24	1	0	1
Stockport	Sewer	30yr	655	148	1	23	0	0	0	0	0	0	0	0
	Surface Water	30yr	312	454	0	28	1	1	0	1	4	0	1	1
		200yr	1734	1058	0	53	8	1	0	2	12	1	1	1
		200yr+cc	2480	1334	2	58	13	3	0	3	15	1	1	1
Tameside	Sewer	30yr	204	219	1	7	0	0	0	1	1	0	0	0
	Surface Water	30yr	762	881	0	13	0	0	0	2	5	0	0	1
		200yr	2021	1515	1	22	3	0	0	2	18	0	0	1
		200yr+cc	2494	1927	1	27	6	1	0	2	27	0	0	1
Trafford	Sewer	30yr	275	134	0	7	0	0	0	1	2	0	0	0
	Surface Water	30yr	227	114	0	5	0	0	0	2	2	1	0	2
		200yr	1432	427	1	13	0	0	0	3	9	2	0	2
		200yr+cc	2520	939	1	13	0	0	1	4	15	2	0	3
Wigan	Sewer	30yr	541	227	2	43	0	0	0	6	2	0	1	0
	Surface Water	30yr	741	226	1	35	0	1	0	4	9	0	1	0
		200yr	2638	694	2	50	0	1	0	7	21	1	1	0
		200yr+cc	3614	908	2	60	0	1	0	11	28	1	1	0

5.6 Surface Water Flooding Hotspots - Results

5.6.1 Strategic Assessment

5,385 500m grid squares cover the ten districts of Greater Manchester. 536 grid squares meet or exceed the thresholds set in Table 4-4. Figure 5-8 illustrates the geographical spread of strategic hotspots across Greater Manchester.

Figure 5-8: Greater Manchester Strategic Hotspots



Two points should be kept in mind when reviewing the hotspot work:

- Not all of the highlighted squares will be at flood risk. Indeed, the actual extent of flooding within a grid square may be a relatively small proportion of the whole square.
- The grid square flagging / hot-spotting process is a strategic screening process and should be used as a starting point. The numerous assumptions made throughout the process means that consistent and reliable quantification of flood risk in one square compared with another is not always present. Further assessment is always needed to confirm the nature and scale of flood risk within any grid square flagged as a hotspot. A key purpose of the analysis is to identify areas worthy of detailed assessment. The exact flood risk "score" should not be relied on in isolation.

There is a geographical spread of hotspots across Greater Manchester and Table 5-2 lists the number of 500m grid squares, hotspots and percentage cover across each district.

Wigan, Rochdale, Oldham are the three largest districts by size. However, the city centre of Manchester and Salford has the largest percentage cover. Manchester has the largest number (105) of hotspots identified within its area. There are some locations, as illustrated in Figure 5-8, where hotspots are clustered together to identify much large areas including central Manchester and Salford, and outlying urban centres of Wigan, Bolton, Rochdale and

Ashton-under-Lyne. Whilst the hotspot approach has led to the identification of these clusters, it is important to assess the actual level of risk at a local level, as there could be many reasons behind such patterns emerging. For instance in Rochdale, Stockport and south Manchester, surface water flows along watercourses joining multiple 500m squares, however in the case of Manchester City Centre there a numerous disconnected areas located in low spots where surface water pools. These can be distributed across each 500m square making it seem that each is hydraulically connected at a strategic scale.

Outside of the urban centres, the distribution of hotspots is much sparser due to the larger areas of open land and more limited density of receptors. Hotspots in these areas tend to focus on large residential communities such as Cheadle (Stockport), Leigh (Wigan), Littleborough (Rochdale), Ramsbottom (Bury), Rusholme (Manchester), Swinton (Salford), Wythenshawe (Manchester) and Uppermill (Oldham).

22 hotspots straddle neighbouring districts. These hotspots could present a challenge given the potential shared issues and responsibilities between districts, which will require collaboration within their local strategies.

Table 5-2: Number of Hotspots across Greater Manchester Districts

District	Number of...		
	500m Grid Squares	"Flagged" Squares / Hotspots	Percentage Cover
Bolton	648	49	8%
Bury	477	37	8%
Manchester	558	105	19%
Oldham	651	60	9%
Rochdale	732	56	8%
Salford	464	63	14%
Stockport	576	58	10%
Tameside	476	57	12%
Trafford	495	42	9%
Wigan	855	53	6%

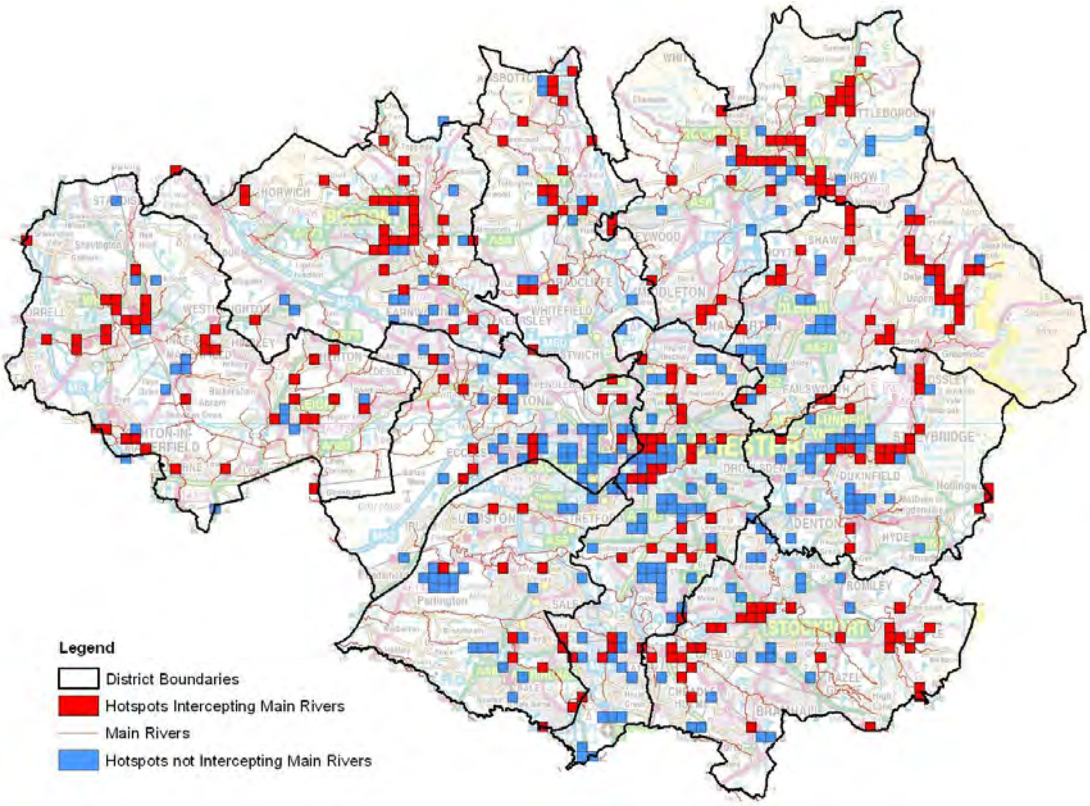
Hotspots help to identify the area at risk, focusing on the receptors rather than where the flood water has come from. This means that whilst the hotspots help identify the effect of flooding in one district, the surface water could originate in another. The impact of flooding within a hotspot may not only be felt locally. Hotspots identified along major road or rail infrastructure could affect multiple districts. For instance, if A-roads in Salford are flooded, it will have major implications of commuters to and from Manchester City Centre.

Within each hotspot, it is important to assess the scale of surface water flood risk against other sources (e.g. from rivers) in order to assess whether surface water risks are the key issue. This comparison is possible using district SFRA information or using the SWMPs Strategic Flood Map, which hold the latest information. For example, once surface water starts to enter to fluvial floodplain, it becomes increasingly more appropriate to use the Environment Agency's Flood Map as it is difficult to assess whether the modelled extent of surface water flooding originates outside of the floodplain or directly from the watercourse itself.

This is noticeable along a number of major and minor river networks throughout the Greater Manchester area. The level of fluvial risk associated with the majority of these networks is well understood as documented in SFRAs, with the majority having detailed models that have contributed to the Environment Agency's Flood Map product (flood zones). Where the surface water modelled outputs overlap with the flood zones it will be important to estimate whether the flood water is flowing into the river (surface water) or flowing out of the river (fluvial) as a result of rainwater entering the system upstream and exceeding channel capacity. Additional data such as depths, velocities, hazards available for each rainfall event can help with this process.

GIS analysis illustrates those hotspots that intercept with main rivers (Figure 5-9). Those hotspots that do not intercept with main rivers are more likely to be associated with surface water flooding.

Figure 5-9: Hotspots Intercepting Main Rivers



5.6.2 Local Assessment (Hotspot Screening)

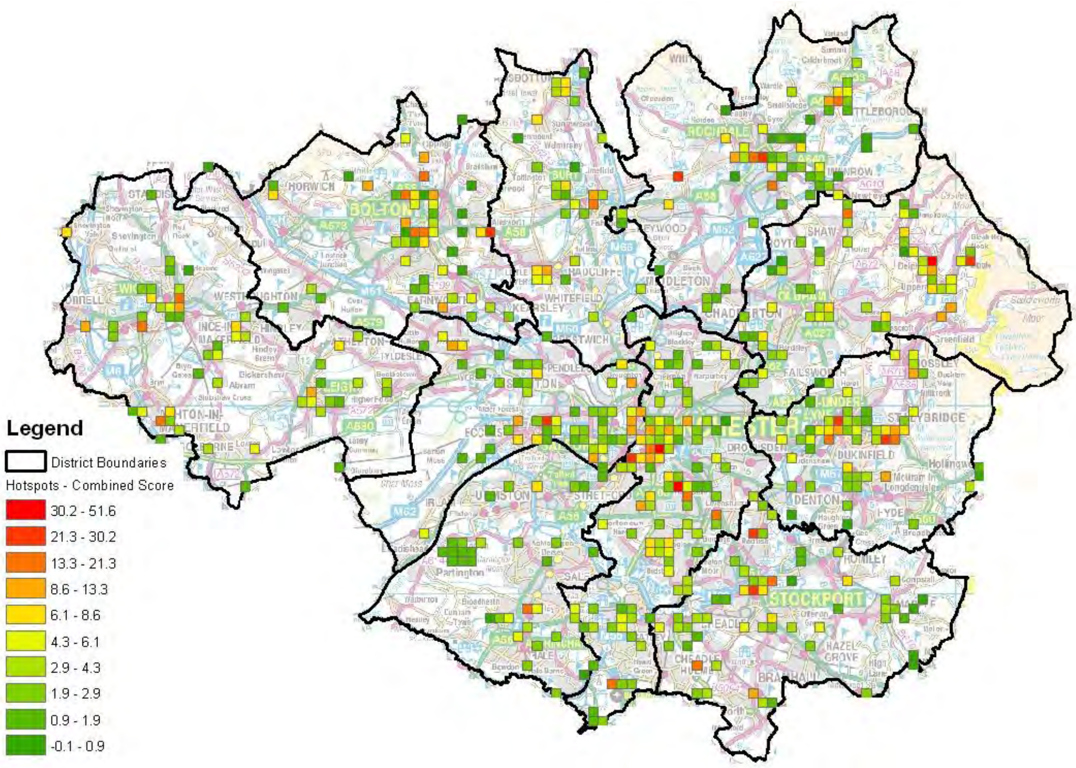
Figure 5-10 illustrates the combined risk score for each hotspot geographically (refer to Section 0 for an explanation of the methodology). It should be noted that this process is essentially a screening process that illustrates the range of risk levels across those hotspots identified.

As shown in Figure 5-10, the majority of higher risk hotspots are located in and around Manchester city centre. Manchester also has a number of higher risk hotspots south of the A57 including Levenshulme, Rusholme and Wythenshawe areas.

Within the city centre, the high-risk nature of these hotspots can be attributed to the large number of residential properties identified with the surface water outlines. Within the Deansgate / Oxford Road area, there are around 1,800 residential properties at risk. This is likely to attribute to the number of apartment blocks in this area, with some blocks holding around 100 or more apartments. As a result, the local receptor dataset used could be skewing the representation of risk in the area. For instance, the majority of these apartment blocks could have car parking or commercial uses located on the ground floor, with little or no actual surface water risks to residences. But there may still be a level of impact to people if they become trapped for long periods. Conversely, if car parking or other use occupies basements of such apartment buildings then this could pose risk to the safety of people and possibly risk to life if flooded suddenly. This quick assessment shows that a local detailed analysis is required to truly understanding the nature of risk in some areas and that the strategic methodology adopted can only be used as a starting point. It is therefore also important that end uses of the SWMP data understand its limitations and stress the importance for a local interrogation of each hotspot using the receptor datasets provided.

This local level validation process is important for all hotspots, not just those within the city centre, as an understanding into the reasons why the thresholds have been exceeded is central in determining whether a hotspot represents a valid area at risk of surface water flooding, or is a result of the methodology and receptor dataset used.

Figure 5-10: Greater Manchester Strategic Hotspots - Combined Score



5.7 Overlaps with other Flood Management Work

As part of the Greater Manchester SWMP, it is important to identify the full range of flood risk management projects / schemes being promoted. Whilst there will be other future funding opportunities such as FDGiA, RFCC, the key sources of information potential work is in the Environment Agency's medium term plan and United Utilities proposed AMP5 / 6 programme. The purpose of this section is to identify potential overlaps between the SWMP and such projects.

5.7.1 Environment Agency Flood Risk Management Studies and Schemes

The Environment Agency provided their Medium Term Plan 2012/13, which is a list of their capital works/bids. The document also contains details of some LLFA surface water bids for schemes. Whilst the Environment Agency has a good indication of what projects have funding, this list has not been officially approved.

Of the schemes put forward in the Environment Agency's **capital** programme bid, only the Irwell refurbishment at Salford has funding with the potential for funding for works at Littleborough. Whilst not all potential schemes have been put forward and received funding, the list of LLFA surface water bids provides a good indication of known high risk surface water problems across Greater Manchester. These problems are likely to be at the top of the local authority's priority list and therefore an opportunity presents itself, to review and potentially take forward such issues within Stage 2 of the SWMP.

Of the list provided by the Environment Agency, only six schemes fall within the Greater Manchester area, three within Salford and three within Rochdale. Table 5-3 lists the location and type of schemes proposed directly copied from information provided by the Environment Agency. These schemes may not have approved funding at this time.

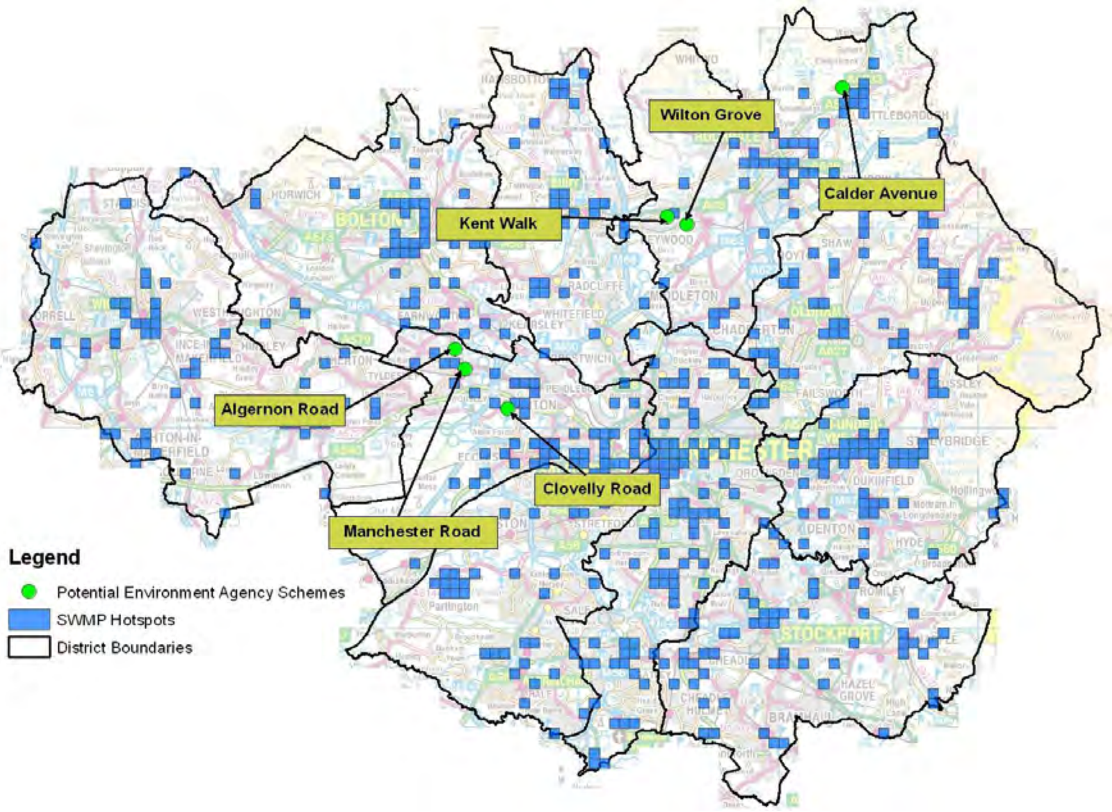
Table 5-3: Potential LLFA Schemes for inclusion in the EA Medium Term Plan

District	Scheme	Brief Description of Problem and Proposed Solution
Salford	Algernon Road, Walkden Surface Water Management Scheme	Surface water flooding has been known to occur around low-lying land. The potential schemes are to investigate potentially redirecting surface water away from properties.
Salford	Manchester Road, Walkden Surface Water Management Scheme	
Salford	Clovelly Road, Swinton Surface Water Management Scheme	Surface water flooding has been known to occur around low-lying land. The potential schemes are to investigate potentially redirecting surface water away from properties and replacement of land drains, which are currently defective.
Rochdale	Calder Brook Culvert Replacement	Around 20 residential properties are regularly flooding at least twice a year. The anticipated project is to be carried out in two phases. Firstly, including the investigation of the problem culvert near Calder Avenue (including survey, CCTC, modelling, excavation and drawings) followed by culvert replacement and installation of an attenuation pond in the second phase.
Rochdale	Wilton Grove Property Level Flood Resilience	Serious flood events have occurred in Heywood in 2001, 2004 and 2006, where surface water runoff has naturally pooled in a low spot. This has resulted in flooding to over 200 properties, with 10 flooding to depths just under 1m on Wilton grove. As an affect of the floods, residents ended up being out of their homes for up to 6 months whilst the drying process was undertaken.
Rochdale	Kent Walk Property Level Flood Resilience	

Figure 5-11 illustrates the location of the above schemes compared to the SWMP hotspots. Of the six schemes proposed, only the Calder Brook Culvert Replacement and Kent Walk Property Level Flood Resilience scheme match directly with hotspots identified in the SWMP. Those schemes put forward in Salford do not overlap directly with hotspots, but are located in close proximity. If the locations of these proposed schemes are assessed at a local level, using the modelled surface water flood outlines, then each location is shown to be at risk.

It must be noted that the possible schemes may have been identified through the old funding system and not the new payments by outcomes approach. Therefore, they may not be representative of the priorities for future funding or illustrative of the main surface water issues in Greater Manchester.

Figure 5-11: Potential LLFA Schemes for inclusion in the EA Medium Term Plan



5.7.2 United Utilities Flood Risk Management Schemes

The four United Utilities Catchment Managers that cover Greater Manchester supplied GIS files showing most of the major network capital investment schemes for their AMP5 period (2010-2015). Their AMP5 is separated between Unsatisfactory Intermittent Discharges (UIDs) and DG5s schemes.

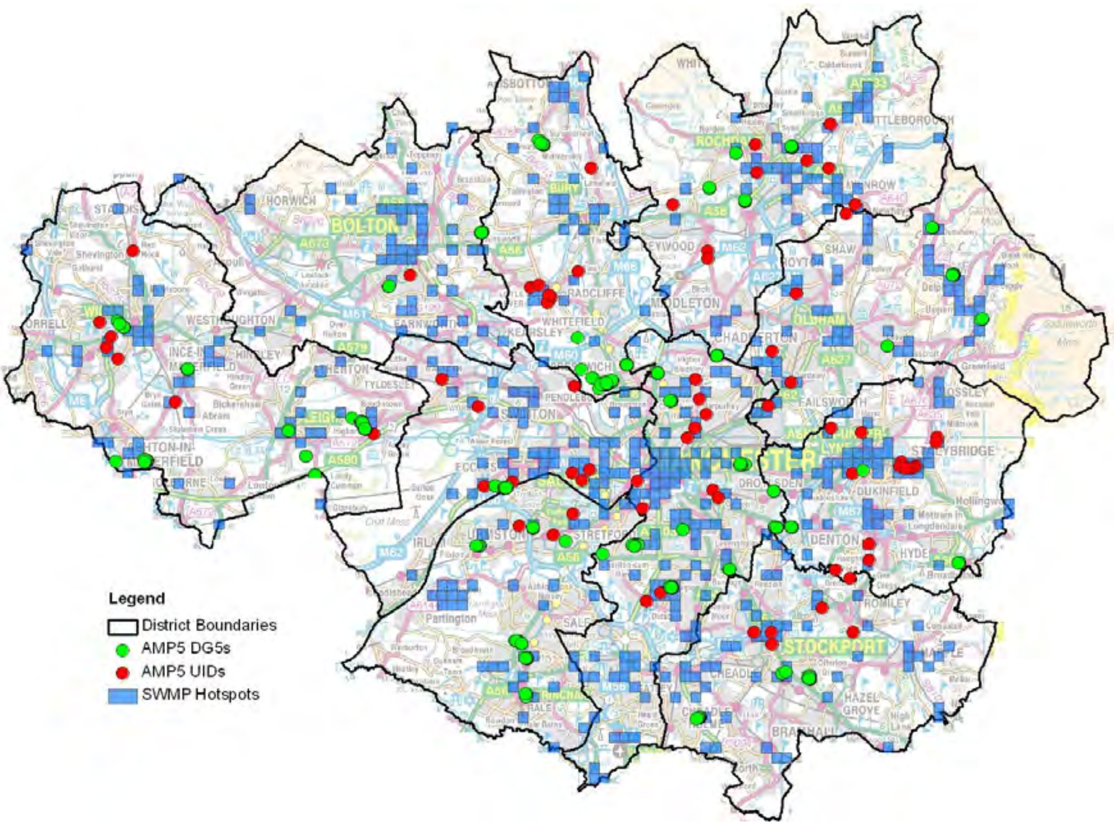
The AMP5 UID projects aim to address combined sewer overflows, which affect water quality or the aesthetic appearance of watercourses. Whilst not directly aimed at addressing flooding, the presence of surface water in the combined sewer network is the key issue driving the need for these projects. These projects are included in the National Environment Programme and therefore have a high likelihood of going ahead.

The AMP5 DG5 projects aim to address areas where the sewer network is hydraulically inadequate leading to the flooding of property. United Utilities prioritise the allocation of funds to projects to deal with flooding based on cost benefit analysis. It is only once a project is fully developed, including relevant assessment studies, that United Utilities can confirm that a flooding project will progress, as it may not be cost beneficial. Because of this, the DG5 programme is under constant review because circumstances can change over time with modelling updates so the locations provided in their AMP5 DG5 GIS files may not have future projects.

At present, United Utilities do not have an AMP6 programme developed for either flooding or unsatisfactory overflows. For the future AMP6 (2015-2020) it seems likely that Ofwat will require Water Companies to base part of their programmes on theoretical flood risk from sewers, not just past flooding recorded on the DG5 Register.

Figure 5-12 illustrates the geographical distribution of schemes across Greater Manchester compared to the location of the SWMP hotspots. There is little correlation between the two. This is because DG5 issues are often associated with local issues or problems with specific systems. However, there is a good correlation between DG5 records with both the modelled surface water and sewer discharge extents, which cannot easily be represented at a strategic scale.

Figure 5-12: Greater Manchester AMP5 UID and DG5 Schemes



5.7.3 Green Infrastructure and WFD

Consideration of Green Infrastructure (GI) and Water Framework Directive related measures have a clear interface with surface water management, including project partnership / funding opportunities. Identifying synergies and constraints is essential, whether it be within this SWMP or in other strategy work. A good example is the joint AGMA and Environment Agency project (August 2011 - March 2012), which is exploring and identifying where Green Infrastructure opportunities can help delivery of the Water Framework Directive (WFD). The key aims of the research are:

- To identify opportunities for GI interventions to deliver key Environment Agency environmental priorities, primarily in relation to the WFD;
- To ensure that the research identifies a series of specific interventions which could be embedded in Environment Agency strategies and programmes and that the scope of the research is restricted to identification of those projects that are likely to receive additional funding (non- Environment Agency sources) and/or involve wider partnerships in delivery;
- More specifically the research provides a key opportunity to understand and embed Environment Agency requirements emerging from the Irwell WFD Pilot (includes Irwell, Croal, Roach, Irk and Medlock catchments) particularly the use of GI to improve the ecological status and potential of water bodies.

Funding opportunities exist for such work following the announcement in April 2011 by Defra of funding to help deliver Water Framework Direct (WFD) objectives covering the four years from 2011-2015. The funding is intended for a range of projects such as habitat improvements and tackling water pollution issues. Part of this funding will be used to establish a Catchment Restoration Fund, which will run initially for three years from 2012/13, and will establish projects from April 2012. Currently much of this money is being directed at projects through river restoration trusts although some projects are being funded and managed by the Environment Agency. Going forward, it will be important that a Greater Manchester flood risk management work programmes explores a range of opportunities for delivering actions that address surface water risk, including less traditional engineering based projects.

6 Identifying Local Surface Water Projects

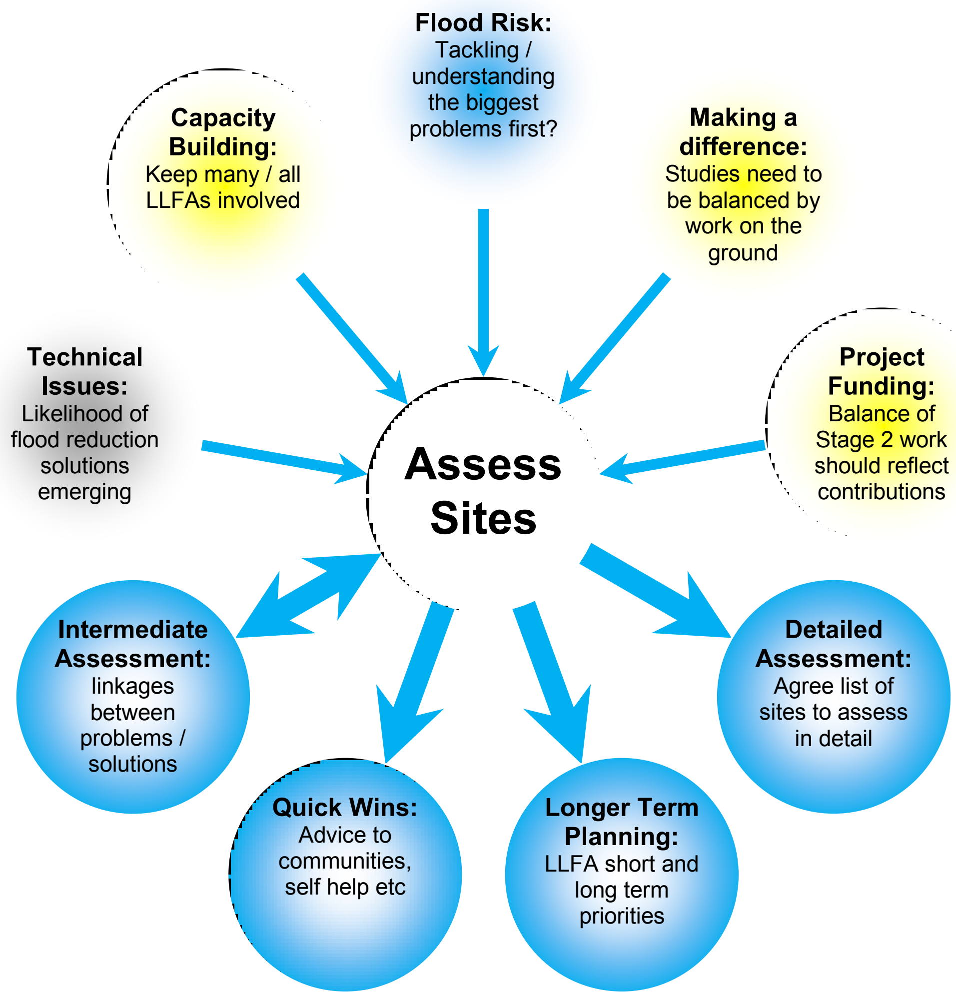
6.1 Introduction

Stage 1 of the SWMP has set out an overview of surface water flood risk based on best available and driveable data. In overall terms, the conclusion was reached by all relevant parties that the scope of Stage 2 should be focussed on understanding and tackling some of the discrete local surface water problems highlighted by the strategic work. But the Stage 1 process has multiple outputs / benefits, only one of which is the selection of sites for the SWMP Stage 2 (detailed assessment). The figure below highlights some of these in blue circles.

Therefore the key aim for Stage 2 is to complete as much of the technical process in Defra's 'wheel' diagram (Figure 1-2) as is practical for each hotspot. However, the overall package also needs to be coordinated to ensure a variety of themes are included that LLFAs may face as they start delivering on their new responsibilities. It is also worth noting that the scope of each project will differ given its own individual starting point along the Defra 'wheel'.

There are numerous considerations when weighing up which studies to take forward. The following figure captures many of the issues.

Figure 6-1: Stage 2 Project Considerations



The following list provides a summary of more detailed specific themes within each potential project:

- Stakeholder engagement:
  - Between LLFAs (including Council departments), the Environment Agency, United Utilities and others, or
  - Neighbourhood planning and local (public) engagement
- Developing the understanding of surface water risks by:
  - Building LLFA capacity
  - Collecting and review currently available information
  - Developing or updating single source models
  - Developing or updating an integrated surface water model
- Identifying potential surface water management options such as:
  - Defining Critical Drainage Areas and associated policies
  - Sustainable Urban Drainage Systems (SUDS)
  - Green Infrastructure led solutions
  - Planning and development led solutions
  - Highway and “soft estate” (grass verges etc) maintenance standards
  - Disconnection of some surface water drainage from the combined sewer network
- Identifying a future direction of travel such as:
  - Stakeholder engagement
  - Funding opportunities and LLFA grant applications
  - Developing an action plan
- Producing standard tools / reporting / body of evidence and key actions for local strategies and new LLFA roles and responsibilities (flood incident register, significant structure register, culvert assessments)

6.2 Developing a Long List of Potential Projects

Each district was asked to identify what type of Stage 2 projects they would benefit from given their own priorities. The starting point for developing a viable package of projects is for each LLFA to consider the ranked list of surface water flooding hotspots across Greater Manchester. The LLFAs were asked key questions for the main hot spots in their area:

- Are the results from our strategic work reasonable?
- Are you aware of any problem locations not identified?
- Which hotspot projects would you most like to see taken forward?

A “Hotspot Assessment Form” has helped each district assess these issues. The result is a “long list” of potential hotpot projects that could form part of Stage 2.

Table 6-1 sets out the location and key issues and characteristics of the hotspots identified. This initial list does not take account of affordability within the SWMP budget, rather than a list of district priorities. The benefits of each potential project were mapped against the issues presented in Section 6.1 and a short list of projects developed.

Table 6-1: Long List of Potential Projects and Key Issues

Hotspot / Project Location	Key Issue
Littleborough, Rochdale	Flood risk attributed to the upstream culvert capacity of Town House Brook (main river) and a partly culverted ordinary watercourse. There is a history of flooding to properties along Calder Avenue. Surface water modelling identifies significant flow paths through Littleborough towards the River Roch.
Heywood, Rochdale	Flood risk associated with surface water pooling and the underlying drainage system unable to cope with extreme rainfall events. This area has a significant flood history with over 200 properties affected. Surface water and sewer modelling results provides a good representation of areas known to be at risk.
Rush Brook (Rusholme), Manchester	Surface water modelling results shows a strong flow path along the predicted line of Rush Brook, a culverted watercourse. Rush Brook is one of Manchester's hidden watercourses and more detailed assessment of flood risk would be beneficial.
Gore Brook (Rusholme), Manchester	Surface water and sewer modelling results show a strong flow path through the area of Rusholme, which could originate from Gore Brook. Flooding could also be associated with Rush Brook to the north.
Levenshulme to Fallowfield, Manchester	Surface water and sewer modelling results show a strong flow path from Levenshulme, west towards Fallowfield. Flooding could be associated with a number of culverted watercourses in the area such as Fallowfield Brook, Cringle Brook, Platt Brook and Gore Brook.
Withington, Manchester	Surface water and sewer modelling results show a strong flow path through Withington. Flooding could be associated with Shaw Brook, a culverted ordinary watercourse. The area includes the Christie Hospital and Withington Hospital.
Wythenshawe, Manchester	Surface water modelling results shows a strong flow path along the predicted line of Mill Brook, a culverted ordinary watercourse. Mill Brook flows close to Wythenshawe Hospital and flooding could have consequences in terms of access and in relation to the neighbouring industrial estate.
Chapel Street, Salford & Manchester	Surface water modelling does not show significant predicted flooding in this area, however the road network are known to flood due to the highway drainage being unable to discharge during periods of high water levels in the River Irwell. Some residential properties in the area have occupied basements.
Manchester City Centre / Oxford Road	Surface water modelling results shows potentially a large impact on asset, infrastructure, and emergency contingency in the city centre given the large flat area. There is a potential for some interactions with other sources, however a large quantity of vulnerable receptors, may be skewing the perception of risk in the area, which should be reviewed.
Gilda Brook, Salford	Surface water modelling results shows flooding along Gilda Brook, a main river that is culverted underneath the M602 before discharging into the River Irwell. The watercourse places a number of properties at risk including Salford Royal Hospital.
Boothstown, Salford	Large residential area at risk of flooding from a number of sources, which are likely to be interlinked. This includes Ellen Brook (main river) and the surface water drainage network.
Alder Forest, Salford	Large residential area at risk of flooding from a number of sources, which have to potential to be interlinked including two main rivers (Worsley Brook and Folly Brook), Old Warke Dam, the Bridgewater

Hotspot / Project Location	Key Issue
	Canal, and the surface water drainage network. A number of the properties in the area have basements with a history of flooding.
Delph to Uppermill, Oldham	Surface water modelling results shows significant flood depths at the bottom of a steep valley surrounding the River Tame. Surface water extents do identify flow paths into the valley floor, but the dominant source of risk is likely to be from the main river itself.
Travis Brow to Carrington, Stockport	The Stage 1 surface water modelling does not show significant predicted flooding in this area, however the road network are known to flood due to the highway drainage/sewers being unable to discharge in a culverted main river.
Cheadle, Stockport	Large residential area at risk of flooding from a number of sources including Chorlton Brook (main river) and the surface water drainage network. Both surface water and sewer modelling results show significant flooding in this area.
Mossley, Tameside	Surface water modelling results shows significant flood depths at the bottom of a steep valley surrounding the River Tame, Micklehurst Brook, Staly Brook and a small reservoir. There is a history of flooding to properties from the reservoir, fed by both Brooks before discharging into the River Tame. Culvert blockage is also an issue in the area.
Ashton-under-Lyne, Tameside	Surface water modelling results shows a significant flood flow path through the town centre, which could be linked to Hurst Brook, which is a culvert ordinary watercourse. There is no known history of surface water flooding in this area.
Horwich, Bolton	The main river (Pearl Brook) runs through the town centre, which is located in a bowl surrounded by steep valley sides. There is a history of flooding to commercial and work units, attributed to a combination of both fluvial and surface water flooding.
Ainsworth Vale Works, Bolton & Bury	Surface water modelling results identifies flooding along a main river Blackshaw Brook. There is a history of Old Wood Lane flooding from overland flow and Blackshaw Brook. The flood mechanisms are linked with main river culvert and highway drainage.
Water Street, Bury	Surface water and sewer modelling results identifies large areas of flooding surrounding residential property and commercial units. Both the Environment Agency and United Utilities know of the issues in this area, attributed to drainage incapacity and interactions with watercourses and canals.
Gypsy Brook, Bury	Surface water modelling results identifies significant flooding along Gypsy Brook, not shown in the main river flood zones. There is a potential for significant consequences if such flooding occurs. There are also sections of the Brook with multiple riparian owners, which has resulted in poor maintenance.
Ramsbottom, Bury	Surface water modelling results identify runoff from rural land flowing into Ramsbottom from the east and flowing towards the River Irwell at the bottom of the valley. Surface water flooding is a known issue in the area, particularly along the A56, causing disruption to commuters. Some mitigation work has been completed but problems still exist.
Timperley Brook, Trafford	Timperley Brook is a main river that flows through a large residential area just north of Altrincham. There are known fluvial and sewer issues in the area, with the Environment Agency and United Utilities carrying out / designing flood risk management schemes. The surface water and sewer modelling results identifies large areas at risk, which coincide with historical records. Infrastructure such as the railway line

Hotspot / Project Location	Key Issue
	and canal also influence flow routes.
Altrincham Town Centre, Trafford	Surface water modelling results shows a small flow path through the town centre. Despite this the risk assessment work shows that There is still the potential for significant consequences, but there is no flood history.
Saddle Junction, Wigan	Surface water modelling does not show significant predicted flooding in this area. However, there is a history of surface water flooding associated with highway drainage being unable to discharge during periods of high river levels. There is future regeneration planned in the area.
Karen Road, Wigan	Surface water modelling results show significant risk associated with Clarington Brook Culvert, classified as a main river in this location.
Bolton Road, Wigan	Surface water and sewer modelling results show a key flow path through a large residential area. The results also match with historical surface water incidents and DG5 records.

Clearly, it is beyond the scope of the SWMP to take all of these projects forward. Therefore, any not taken forward should be considered by each LLFA within their local strategy.

6.3 Developing a Short List of Potential Projects

The decision on how to prioritise sites for detailed assessment and action planning is a key step within the project. As intimated in Section 6.1, selecting as many areas of highest risk sites as the budget will allow would only achieve the basic objectives of the SWMP and would not cover the full range of issues facing Greater Manchester districts. A more measured approach has been applied identifying potential projects that balances the highest ranked risk areas against the need to:

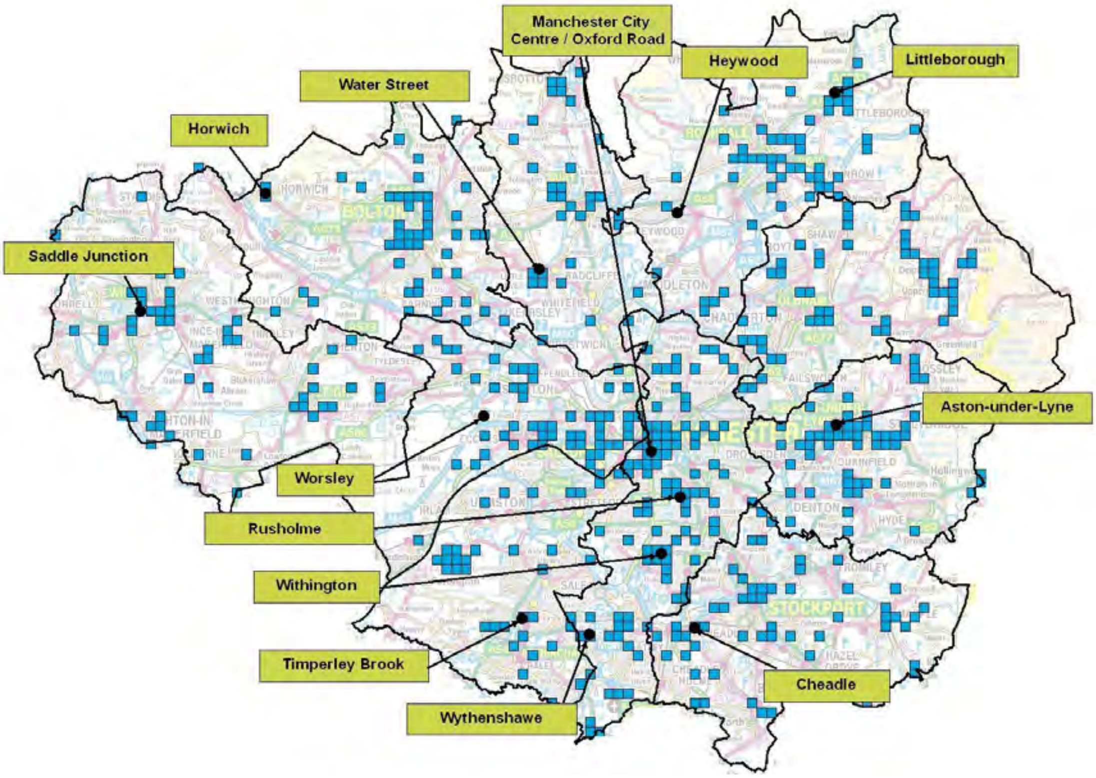
- As far as possible, provide a good representation of each Greater Manchester district and its priority surface water flood risk issues for inclusion in their local strategies
- Represent a range of case studies to create a toolkit of good practice for Greater Manchester and each district
- Provide a strong body of evidence to help deliver the next stages of the FRR i.e. hazard and risk mapping and Flood Risk Management Plans
- Signposting of further work or potential proposals to be taken forward in future Greater Manchester or district work programmes (e.g. local strategy)
- Provide an opportunity for training and capacity building activities
- Develop the important role of partnership working between LLFAs, AGMA, United Utilities and the Environment Agency

6.3.1 Stage 2 Project Scope

Table 6-2 provides the selected short list of projects for Stage 2 based on the longer list in Table 6-1. This has been developed in partnership with the SWMP Steering Group and endorsed within AGMA (by the Planning Officers Group).

The table also summarises the scope of the anticipated project and the key strategic or community benefits. Figure 6-2 illustrates the general location of each project in Greater Manchester along with each initial hotspot identified. The study area of each project will not be constrained by the grid square hotspots. This figure is purely to show the links between the strategic and detailed stages of the SWMP.

Figure 6-2: Location of Recommended Stage 2 Projects



The scope of each project is based around the Defra 'wheel' illustrated in Figure 1-2. These 'ticks', shown in Table 6-2, illustrate how far round the wheel each project should get. For instance, where existing modelling tools exist and the flood risk issue is understood, it is intended that option appraisal will be undertaken, recommended scheme described and in some instances some visualizations prepared.

Where there is little existing data, such as for hidden watercourse locations, the process to get to the identification FRM measures will be much more expensive and so Stage 2 analysis will be more limited, involving a desk based study to improve the understanding of risk (intermediate assessment) and scoping of the next steps. This is also likely to highlight the early actions that the authorities and local community could take in order to manage potential flood risk. Full understanding of flood risk and delivering appropriate long term management solutions will take time in such locations unless economic opportunities over-ride.

An action plan will be prepared for each project, and this can then be integrated within district local strategies.

It should be noted that some districts (such as Manchester and Rochdale) contain more than one listed hotspot, reflecting both the scale of risk and project funding provided by these authorities.

Only one district, Oldham, will not be included directly in the detailed assessment stage. The reason for this is that, on inspection, the larger apparent surface water flood hotspots in Oldham were found to be predominantly fluvial (main river) driven and therefore not within the remit of the SWMP. Oldham MBC will still benefit from other projects across Greater Manchester, particularly those in Rochdale and Tameside, as they share similarities to the surface water problems likely to be experience in their district.

Table 6-2: Short List of Potential Projects and Anticipated Project Scope

LLFA	Hotspot	Issues	Key Project Task	SWMP Wheel – Project Scope: Prep	Risk Assessment		Options		Action Plan	Strategic / Community Benefits
					Inter'	Detailed	Identify	Assess		
Bolton	Horwich	The main river Pearl Brook runs through the town centre, which is located in a bowl surrounded by steep valley sides. There is a history of flooding to commercial and work units, attributed to a combination of both fluvial and surface water flooding.	Detailed flood risk assessment updating the EA main river model to assess impact of surface water flooding	✓	✓	✓			✓	Action plan focused on local community / commercial engagement & local take up of flood resilience measures
Bury	Water Street	Surface water and sewer modelling results identifies large areas of surface water flooding surround residential and commercial units. Both the EA and UU are aware of the issues in this area, attributed to drainage incapacity and interactions with watercourses and canals.	Detailed flood risk assessment and options appraisal using readily available EA and UU hydraulic models	✓	✓	✓	✓	✓	✓	Taking forward EA, UU & LLFA study that has stalled – current study has already identified a long list of options – project required to start momentum and produce action plan to place measures on the ground
Manchester	Rusholme	Surface water modelling results shows a strong flow path along the predicted line of Rush Brook, a culverted watercourse. Rush Brook is one of Manchester's hidden watercourses and little information is available on actual risk.	Intermediate risk assessment using readily available information to identify flood risk sources and potential mechanisms	✓	✓				✓	Project is of strategic & local importance taking the EA's hidden watercourse study forward to identify residual risk & ownership
Manchester	Wythenshawe	Surface water modelling results shows a strong flow path along the predicted line of Mill Brook, a culverted ordinary watercourse. Mill Brook flows underneath Wythenshawe Hospital and flooding could have significant consequences.	Detailed flood risk assessment creating a new hydraulic model of the culverted watercourse	✓	✓	✓			✓	Project is of strategic & local importance required to understand residual risk to hospital, emergency planning requirements & green infrastructure potential
Manchester	Withington	Surface water and sewer modelling results show a strong flow path through Withington. Flooding could be associated with Shaw Brook, a culverted ordinary watercourse. The area also includes Withington Hospital.	Intermediate risk assessment using readily available information to identify flood risk sources and potential mechanisms	✓	✓				✓	Project is of strategic & local importance taking the EA's hidden watercourse study forward to identify residual risk & ownership
Manchester	Manchester City Centre / Oxford Road	Potential high consequences of flooding from multiple source – district centre of regional importance	Detailed flood risk assessment using readily available information and site visits to strategically assess risk to the city centre	✓	✓	✓			✓	Project is of regional importance assess the true nature of surface water risk within the City centre – project will benefit Local Strategies, PFRAs and Flood Risk Management Plans
Rochdale	Littleborough	Flood risk attributed to the upstream culvert capacity of Town House Brook (main river) and a partly culverted ordinary watercourse. There is a history of flooding to properties along Calder Avenue. Surface water modelling identifies significant flow paths through Littleborough towards the River Roch.	Detailed flood risk assessment extending the EA's main river model to include culverted watercourses	✓	✓	✓	✓		✓	Project will contribute to the EA's Roch & LLFA's Local Strategy identifying potential options & FRM ownership / funding
Rochdale	Heywood	Flood risk associated with surface water pooling and the underlying drainage system unable to cope with extreme rainfall events. This area has a significant flood history with over 200 properties affected. Surface water and sewer modelling results provides a good representation of areas known to be at risk.	Detailed flood risk assessment and options appraisal using readily available EA and UU hydraulic models	✓	✓	✓	✓	✓	✓	Project will contribute to LLFA Strategy and UU investment including available funding routes, resilience and green infrastructure

LLFA	Hotspot	Issues	Key Project Task	SWMP Wheel – Project Scope						Strategic / Community Benefits
				Prep	Risk Assessment		Options		Action Plan	
					Inter'	Detailed				
Salford	Worsley	Large residential area at risk of flooding from a number of sources, which have to potential to be hydraulically linked including two main rivers Worsley Brook and Folly Brook, Old Warke Dam, the Bridgewater Canal, and the surface water drainage network. A number of the properties in the area have basements with a history of flooding.	Detailed flood risk assessment updating the EA main river model to assess impact of surface water flooding	✓	✓	✓	✓		✓	Project is of strategic & local importance assess risk from multiple source which are potential interacting including surface water, sewers, rivers, canals & reservoirs
Stockport	Cheadle	Large residential area at risk of flooding from a number of sources including Chorlton Brook (main river) and the surface water drainage network. Both Surface water and sewer modelling results show significant flooding in this area.	Detailed flood risk assessment updating the EA main river model to assess impact of surface water flooding	✓	✓	✓	✓	✓	✓	Project will contribute to the EA's South Manchester & LLFA's Local Strategy assessing the affect of the surface water system on previously consider FRM options
Trafford	Timperley Brook	Timperley Brook is a main river that flows through a large residential area just north of Altrincham. There are know fluvial and sewer issues in the area, with the EA and UU carrying out / designing flood risk management schemes. The Surface water and sewer modelling results identifies large areas at risk, which coincide with historical records. Infrastructure such as the railway line and canal also influence risks.	Detailed flood risk assessment updating the EA main river model to assess impact of surface water flooding	✓	✓	✓	✓	✓	✓	Project will contribute to the LLFA's Local Strategy and EA / UU investment identify holistic solutions from all sources
Tameside	Ashton-under-Lyne	Surface water modelling results shows significant flood flow path through the town centre, which could be linked to Hurst Brook a culvert ordinary watercourse. There is no known history of surface water flooding in this area, so it is purely predictive.	Intermediate risk assessment using readily available information to identify flood risk sources and potential mechanisms	✓	✓				✓	Project will contribute to the LLFA's Local Strategy focused on using model data to identify areas at risk with no historical data
Wigan	Saddle Junction	Surface water modelling does not show significant predicted flooding in this area. However, there is a history of surface water flooding associated with highway drainage is unable to discharge during high river levels. There is future regeneration planned in the area.	Intermediate risk assessment using readily available information to identify flood risk sources and potential mechanisms	✓	✓		✓		✓	Project is of strategic & local importance assessing common highway drainage / main river issues across Greater Manchester

6.4 Next Steps

6.4.1 SWMP Stage 2 Projects

It is important to stress that to get the most effective results and benefit from Stage 2 of the SWMP, each district will need to be fully engaged; facilitating access to local expertise and ensuring appropriate communication and engagement with local Members, communities and other interested parties. Lack of district support or available data may affect the outcome/shape of the final work plan.

Opportunities will be highlighted through the SWMP Communication and Engagement (C&E) Plan and need to be worked up with the co-operation of each district and its local C&E needs/structures/leads. Rochdale MBC are the lead organisation overseeing communications associated with the SWMP and are maintaining a Communications and Engagement Plan.

There are also opportunities to help build capacity within the individual district authorities through officer participation in training and awareness activities delivered through each detailed project in Stage 2, or strategically at T-FROG and Defra / Environment Agency workshops. A detailed training and workshop programme will be developed during the initial phase of Stage 2 and delivered through T-FROG or directly with LLFAs as appropriate.

Consideration will also need to be given as to how the value of this SWMP project can be integrated within other LLFA responsibilities. Primarily these will include:

- Development of Local Flood Risk Management Strategies, as required under the Flood and Water Management Act 2010
- Delivery of the Flood Risk Regulations (FRR) 2009including the development of Risk and Hazard Maps and Flood Risk Management Plan for Greater Manchester (excluding Wigan MBC).

There is large potential overlap between these work streams. Presentation of the data to facilitate this will take place during Stage 2 of the SWMP in liaison with the SWMP Steering Group and the Environment Agency.

It is anticipated that the flood risk data collected and the surface water modelling undertaking in this SWMP will provide the majority of information required. The areas at risk of local flooding across Greater Manchester identified through the LLFA PARs and this SWMP should provide the main focus of the local strategy, especially where the analysis shows an overlap between past flood incidents and future flood risk areas. Other local flood risk studies, such as the Level 1 and Level 2 SFRAs will be building blocks for the delivery of local flood risk management and should be fully integrated into the strategy along with flood management works planned by the Environment Agency and United Utilities.

It must be noted that these hotspots may not represent the priorities for investment by AGMA / LEP and therefore flood risk management actions and local strategies will need to relate to investment opportunities and governance arrangements being established through the Greater Manchester Flood Risk Management Board.

Appendices

A Flood Risk Indicators

A.1 Residential

Table A- 1: BLPU codes used for Residential receptors

LLGP Building Type	LLPG Property BLPU Class	Group
Residential	R	Residential
Residential Dwelling	RD	Residential
Caravans	RD01	Residential
Detached House	RD02	Residential
Semi-detached House	RD03	Residential
Terraced House	RD04	Residential
Bungalow	RD05	Residential
Self contained flat	RD06	Residential
Sheltered	RD08	Residential
Houses in Multiple Occupation	RD09	Residential
Residential Institutions	RI	Residential
Care/Nursing Homes	RI01	Residential
Communal Residencies	RI02	Residential
Residential Education	RI03	Residential

A.2 Non-Residential

Table A- 2: BLPU codes used for non-Residential receptors

LLGP Building Type	LLPG Property BLPU Class	Group
Commercial	C	Commercial
Agricultural	CA	Agricultural
Farms	CA01	Agricultural
Fisheries	CA02	Agricultural
Horticulture	CA03	Agricultural
Community Services	CC	Community Services
Police, Fire and Ambulance Stations	CC01	Community Services
Law Courts	CC02	Community Services
Prisons	CC03	Community Services
Public and Village Halls	CC04	Community Services
Public Conveniences	CC05	Community Services
Cemeteries & Crematorium	CC06	Community Services
Church Halls	CC07	Community Services
Education	CE	Education
Collages	CE01	Education
Nursery/Creche	CE02	Education
Primary, Junior, Infants or Middle School	CE03	Education
Secondary School	CE04	Education
Universities	CE05	Education
Hotels, Boarding & Guest Houses	CH	Hotels, Boarding & Guest Houses
Guest House/B & B	CH01	Hotels, Boarding & Guest Houses
Holiday Let/Other Accommodation	CH02	Hotels, Boarding & Guest Houses
Hotel	CH03	Hotels, Boarding & Guest Houses
Industrial	CI	Industrial
Factories & Manufacturing	CI01	Industrial
Mineral Workings & Quarries/Mines	CI02	Industrial
Workshops	CI03	Industrial
Warehouses	CI04	Industrial
Wholesale Distribution	CI05	Industrial

LLGP Building Type	LLPG Property BLPU Class	Group
Leisure	CL	Leisure
Amusements	CL01	Leisure
Holiday/Camp Sites	CL02	Leisure
Libraries	CL03	Leisure
Museums	CL04	Leisure
Nightclubs	CL05	Leisure
Sport Activities/Leisure Centres	CL06	Leisure
Theatres/Arenas/Stadium	CL07	Leisure
Zoos & Theme Parks	CL08	Leisure
Medical	CM	Medical
Dentist	CM01	Medical
GP Surgeries and Clinics	CM02	Medical
Hospitals	CM03	Medical
Medical Laboratories	CM04	Medical
Animal Centre	CN	Animal Centre
Catteries	CN01	Animal Centre
Kennels	CN02	Animal Centre
Stables	CN03	Animal Centre
Vet	CN04	Animal Centre
Animal Sanctuary	CN05	Animal Centre
Offices	CO	Offices
Offices & Work Studios	CO01	Offices
Broadcasting (TV, Radio)	CO02	Offices
Retails	CR	Retails
Banks/Financial Services	CR01	Retails
Estate Agents	CR02	Retails
Hairdressing/Beauty Salons	CR03	Retails
Markets (indoor & outdoor)	CR04	Retails
Petrol Filling Stations	CR05	Retails
Public Houses and Bars	CR06	Retails
Restaurants & Cafes	CR07	Retails
Shops	CR08	Retails
Betting Offices	CR09	Retails
Transport	CT	Transport
Airports	CT01	Transport
Goods & Freight Handling	CT04	Transport
Railway Assets	CT07	Transport
Stations & Interchanges	CT08	Transport
Vehicle Storage	CT10	Transport
Other Waterway Infrastructure	CT11	Transport
Utilities	CU	Utilities
Landfill	CU02	Utilities
Power Stations/Energy Production	CU03	Utilities
Pumping Stations/Water Towers	CU04	Utilities
Recycling Sites	CU05	Utilities
Telecommunication Masts	CU06	Utilities
Lighthouse	CU07	Utilities
Information	CZ	Information
Tourist Information	CZ02	Information
Military	M	Military
Army	MA	Military
Air Force	MF	Military
Government	MG	Military
Garages	RG	Garages
Lock-up Garages & Garage Courts	RG02	Garages
Unclassified	U	Unclassified
Awaiting Classification	UC	Unclassified
Pending Internal Investigation	UP	Unclassified

LLGP Building Type	LLPG Property BLPU Class	Group
Mixed	X	Mixed
Churches, Mosques, Synagogues, Chapels	ZW	Feature

A.3 Critical Flood Risk Infrastructure (CFRI)

Table A- 3: CFRI Receptor Definitions

Receptor	Description	Critical / Vulnerable	Data Source	Weighting
Railway Stations	Victoria and Piccadilly railway stations manually digitised against OSMM	Critical	OSMM	5
Airports	Manually digitised against OSMM	Critical	NLPG / OSMM	3
Railways	Dataset integrating NRD railway and MetroLink lines	Critical	NRD / Local information	3
Highways (M & A roads)	NRD Roads layer	Critical	NRD	2
Water infrastructure	NRD 'water' layer with waste water related locations removed	Critical	NRD	5
Waste Water Treatment Works		Critical	United Utilities	2
COMAH	Source data received as point coordinates then manually digitised against OSMM	Critical	Local information	5
Landfill	Point locations obtained from NLPG then manually digitised against OSMM	Critical	NLPG / OSMM	1
Hospitals and Hospices	Point locations obtained from NLPG then manually digitised against OSMM	Vulnerable	NLPG / OSMM	5
Minor Utilities infrastructure	Includes sub-stations	Critical	NRD	1
Police, Ambulance & Fire Stations	Point locations obtained from NLPG	Critical	NLPG	3
Prisons	Point locations obtained from NLPG then manually digitised against OSMM	Vulnerable	NLPG / OSMM	0.5
Schools	Point locations obtained from NLPG then buffered	Vulnerable	NLPG	3
Residential Care Homes / Institutions	Point locations obtained from NLPG	Vulnerable	NLPG	5
Hotels	Point locations obtained from NLPG	Vulnerable	NLPG	0.5
Telecommunications	Point locations obtained from NLPG	Critical	NLPG	4
Basement Property	Cellar property dataset provided by United Utilities. Does not distinguish between property types and functions	Vulnerable	United Utilities	0.1
Permanent caravans / mobile homes	Point locations obtained from NLPG	Vulnerable	NLPG	1
Main electricity assets	Primary and grid substations supplied by Electricity North West	Critical	ENW	3
Pumping Stations	United Utilities pumping stations dataset	Critical	United Utilities	5
National Grid (NG) substation	National grid substation data obtained from the NG website	Critical	NG	5

B Significant Historical Surface Water Events

Table B- 1: Significant Historical Surface Water Events

Data	Location	Impact
November 1890	Cheadle, Goyt (Stockport)	Prolonged heavy rainfall leading to local flooding
August 1911	River Mersey, Moss Side and Withington, Fallowfield (Manchester)	Flooded sewage works
Summer 1932	Longdendale Valley (Tameside)	Inundation of property and land
July 1947	Wilbraham (Manchester)	Flooded rail station and line
June 1958	Ardwick, Wilbraham amd Fallowfield (Manchester)	Flooded rail station
June 1959	Whitefield (Bury)	Localised flooding
December 1965	River Mersey, Northenden and Didsbury (Manchester)	Flooded property and evacuations, Sewers burst
December 1965	River Tame (Oldham)	Livestock killed, flooded property and evacuations Sewers burst
December 1965	Mersey , Tame and Goyt Cheadle (Stockport)	Torrential rainfall leading to Livestock killed, flooded property and evacuations, sewers burst
1975	Timperley (Trafford)	Surface water flooding of Newton Road, Timperley
October 1992	Horwich (Bolton)	Localised flooding
December 1992	River Beal (Oldham)	Land, properties and sewers flooded
March 1998	Cheadle (Stockport)	Heavy rainfall leading to Land and property flooded
September 2000	Sale (Trafford)	Flash flooding of doctors surgery
June 2001	Marple Bridge (Stockport)	Intense rainfall leading to localised flash flooding
July 2001	Audenshaw (Tameside)	Flash flooding of homes and gardens
June 2002	Wigan (Wigan)	Sewers flooding 1000 properties
July 2002	Oldham, Medlock (Oldham)	Properties, highways and land flooded
August 2002	Stalybridge (Tameside)	Flooded roads and gardens
July 2004	Flixton (Trafford)	Sewer flooding following intense rainfall leading to highway flooding
July 2004	Hale (Trafford)	Sewer flooding following intense rainfall leading to highway and cellars flooding
August 2004	Ramsbottom (Bury)	Homes and a pub flooded
August 2004	Chorlton Brook, Manchester University and Fallowfield (Manchester)	Flooded halls of residence and homes in Fallowfield
August 2004	Royton, Irk (Oldham)	Homes flooded
August 2004	Heywood (Rochdale)	Over 200 properties flooded in Heywood with up to 900mm of

Data	Location	Impact
		sewage contaminated water for up to 3 hours and around 90 properties had to be evacuated for varying time-spans whilst renovation was taking place
August 2004	Altrincham (Trafford)	Sewer flooding following intense rainfall leading to Internal and external property flooding
2006	Grotton Hollow and Wood Brook (Oldham)	Localised flooding
2006	Trafford (Trafford)	Flooding at Manchester Road and Carrington Road
July 2006	Ainsworth (Bury)	Basements and gardens flooded
July 2006	Bury (Bury)	Sewer flooding causing gardens to flood
July 2006	Heywood (Rochdale)	Over 200 properties flooded in Heywood with up to 900mm of sewage contaminated water for up to 3 hours and around 90 properties had to be evacuated for varying time-spans whilst renovation was taking place
July 2006	Bredbury (Stockport)	Intense rainfall leading to localised flash flooding
January 2007	Bury (Bury)	Surface water flooding causing gardens to flood
July 2007	Summerseat (Bury)	Roads and gardens flooded

C Strategic Flood Map Data Layers

Below is a hierarchical list of the data layers that are in the SFM. Bold represents group layer names rather than data itself.

Table D- 1: Strategic Flood Map Data Layers

Group Layer	GIS Layer
Boundaries	AGMA Boundary
Surface Water Flooding Hotspots	**Ranked grids** • 1 in 200 0.3 m depth 250 m grid Hotspots • 1 in 200 0.3 m depth 500 m grid Hotspots • 1 in 200 0.3 m depth 1 km grid Hotspots **Raw grids** • 1 in 200 0.3 m depth 250 m grid Hotspots • 1 in 200 0.3 m depth 500 m grid Hotspots • 1 in 200 0.3 m depth 1 km grid Hotspots
Hotspot Analysis Grids	• 1 in 200 0.3 m depth 250 m grid • 1 in 200 0.3 m depth 500 m grid • 1 in 200 0.3 m depth 1 km grid
Classified Depth Grids	• 1 in 30 classified depth • 1 in 50 classified depth • 1 in 75 classified depth • 1 in 100 classified depth • 1 in 200 classified depth • 1 in 200cc classified depth
Classified Hazard Grids	• 1 in 30 classified hazard • 1 in 50 classified hazard • 1 in 75 classified hazard • 1 in 100 classified hazard • 1 in 200 classified hazard • 1 in 200cc classified hazard
Classified Velocity Grids	• 1 in 30 classified velocity • 1 in 50 classified velocity • 1 in 75 classified velocity • 1 in 100 classified velocity • 1 in 200 classified velocity • 1 in 200cc classified velocity
Sewer Outlines	• 1 in 30 > 0.1 m depth • 1 in 30 >0.3 m depth • 1 in 30 >1.0 m depth
Receptor Data	• Residential Properties • Non Residential Properties **Critical Flood Risk Receptors (CFRI)** • Emergency Services • ENW Main Electricity Assets • Caravans • Hotels & Guest Houses • Residential Institutions • Telecommunications • Utilities Infrastructure • United Utilities Pumping Stations • United Utilities Waste Water Treatment Works • Water Infrastructure • United Utilities Basement Properties

Group Layer	GIS Layer
	• Motorways & A Roads • MetroLink & Railways • Buffered Schools • National Grid Substation Sites • Major Railway Stations • COMAH Sites • Hospitals • Prisons • Waste Sites • Airports
Historic Flooding Data	**AGMA** • SV0000_nat_hfm_v2_1_0 **Bolton** • Hist_Flood_loc__Point • Wet_Spots__PolyG • BMBC_HFM__PolyG **Environment Agency** • Reported__Flooded_Properties_001 **Manchester** • Manchester_FloodRiskAreas_001 **Salford** • Local_Flood_Hotspots • Culvert_Headwalls **Wigan** • Historical_Flooding • GM_Fire_And_Rescue_Records
Environment Agency	• Main Rivers • NFCDD Defences • Flood Event Outlines (FEO) • Flood Warning Areas • CMFP Units
United Utilities	• AMP5 DG5s • AMP5 Unsatisfactory Intermittent Discharges (UIDs) • Combined Sewer Overflows (CSOs) • Detention Tanks • Internal DG5 • External DG5 • Waste Water Treatment Works (WwTW) • Sewerage Incident Register System (SIRS) • Wastewater Incident Register System (WIRS) • Rising Mains • Sewers • Drainage Areas **Model Data** • Modelnodes • Modellinks • Modellinks
Flood Map (Environment Agency)	• Defences V3.1 • Areas Benefiting from Flood Defences V2.1 • Flood Storage Areas • Flood Zone 3 V4.1 • Flood Zone 2 V4.1
Detailed River Network (Environment Agency)	• SV0000_drnnodes • SV0000_drn • SV0000_drnoffline

Group Layer	GIS Layer
Areas Susceptible to Groundwater Flooding	• Areas Susceptible to Groundwater Flooding
Base maps	• OS_StreetView_grey • OS_VectorMap_grey • OS_250k_grey

D Where to find Other FRM Information

There is a lot of very useful existing flood risk management related guidance, training materials, relevant strategic flood risk assessment reports available already. Much can be gained from absorbing this. The table below provides a summary.

FRM Information	Source
Defra SWMP Technical Guidance	http://www.defra.gov.uk/publications/2011/06/10/pb13546-surface-water-guidance/
Flood and Water Management Act	http://www.legislation.gov.uk/ukpga/2010/29/contents
Defra Flood and Water Management Act fact Sheet	http://archive.defra.gov.uk/environment/flooding/documents/policy/fwmb/fwma-local-authority-factsheet-110721.pdf
Flood Risk Regulations	http://www.legislation.gov.uk/uksi/2009/3042/contents/made
Guidance for Risk Management Authorities	http://www.defra.gov.uk/publications/2011/10/03/pb13640risk-manage-auth/
Defra Capacity Building Strategy	http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/capacitybuilding.pdf
River Basin Management Plans	http://www.environment-agency.gov.uk/research/planning/33106.aspx
Catchment Flood Management Plans	http://www.environment-agency.gov.uk/research/planning/33586.aspx
North West Regional Flood Risk Assessment	http://www.4nw.org.uk/articles/article.php?page_id=485
Greater Manchester Sub-Regional Strategic Flood Risk Assessment	Copies of the 2008 SFRA, GM District Confidence Maps and SUDS Maps from the AGMA Planning and Housing Team. Email: phc@agma.gov.uk
Strategic Flood Risk Assessments	Available on District websites
Preliminary Flood Risk Assessments	Each Districts PFRA will be expected to be available on or through the AGMA website
National Flood and Coastal Erosion Risk Management Strategy	http://www.environment-agency.gov.uk/research/policy/130073.aspx
Local Government Group Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management	http://www.lga.gov.uk/lga/aio/17064046
Environment Agency e-learning website	http://learning.environment-agency.gov.uk/courses/FCRM/capacity/legal/introduction.html
All websites links are correct as of 22 November 2011	

Should you have any queries then the following LLFA and EA contacts should be able to assist.

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