Managing Adaptive REsponses to changing flood risk

Flood Risk Management Planning - Don Valley Sheffield

Sheffield City Council in collaboration with the partners of the MARE project

List of stakeholders

The stakeholders should be listed against the standard list. However the terms in the standard list should be used within the case study in order to enable readers to more easily understand

Ref. No.	Stakeholder	Developers		Long term ownership		Interest																									
						Regulators										Planning bodies										Knowledge development					
						Wild life		Heritage		Environment		Water quality		Water quantity		Emergency plannning		Strategy planners		Development control		Building control		Road/Transport		Initiators		Create state of the art knowledge		knowledge maintenance	
		A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D
	Public authorities and water utility organisations																														
	Sheffield City Council				X											X	X	X	X	X	X	X	X	X	X						
	Environment Agency									X	X	X	X	X	X																
	Yorkshire Water				X							X	X	X	X																
	Citizens, organisations and communities																														
	Wicker Traders Group memberss		X		X																										
	Forgemasters		X		X																										
	British Land		X		X																										
	Royal Mail		X		X																										
	Irwin Mitchell solicitors		X		X																										
	Home Office		X		X																										
	Aizlewood Mill business centre		X		X																										
	River Stewardship Company																														
	Groundwork																														
	Interest groups																														
	Sheffield and District Afro-Caribbean Community Association			X																											

	South Yorkshire African and Caribbean Business and Enterprise Training Centre			X																											
	Kayak Club			X						X		X		X																	
	SPRITE (Fishing organisation)			X		X				X		X		X																	
	Knowledge institutions																														
	University of Sheffield																										X		X		X	

Contents

1 Introduction

The process of forming and managing Flood risk management plans in England, with Sheffield as a typical example, has been influenced by many factors and is still a 'work in progress' for many cities. For main river flooding, for which Sheffield is particularly vulnerable, there is an unclear shift in roles. For many places severe flooding has been very infrequent with a resultant lack of attention both from the Environment Agency, as responsible body for main river and from the city as custodian of it's people's living and working environment. This lack of flooding and absence of water in daily lives has meant Flood Risk Management Planning has been poorly addressed in the past.

The 2007 floods were so severe in Sheffield that a generational change has occurred. Specific spatial vulnerability has stimulated the municipality to lead on actions as the impacts are economic as well as social. In this respect reactive projects have ensued whereby wider more considered comprehensive Flood risk management planning for the city is emerging. Although this is perhaps not ideal it is understandable as the driver was not evident /real previously. If Sheffield City Council were a wealthier authority it may have had the foresight to plan Flood risk management irrespective of how frequently such events were likely to occur.

The Environment Agency's responsibility for main river has meant ownership of many of the issues has not been with the municipality. Knowledge levels of FRMP and capacity to build them have been very low in the municipality in terms of priorities and perceived needs. The privatisation of the water supply and sewerage services in 1989 has further spread out knowledge and reduced the chance of coordination and joined up thinking, for example sewer/surface water flooding and river interactions. In effect responsibilities are shared by many.

Nevertheless an iterative process is underway whereby pieces of the FRM jigsaw are becoming clearer. Some are being put in place because of a pragmatic need for urgent improvements and are by their nature realisable (see case study Sheffield Central Area Flood Protection). Others are more difficult requiring long-term feasibility and interagency negotiations and indeed are therefore less likely to be realisable, e.g. cost benefit ratios being unfavourable or changes in functions being new to business remits. This uncertainty highlights a fundamental characteristic of FRM Plans in England. They should be viewed as an ever-changing iterative processes because responsible bodies are not necessarily in possession of all information, resources and permissions etc to allow delivery of one harmonised version of a programme. Activities also take place at different scales. So for example, large scale activity interactions with local activity. As is the focus of MARE , climate change provides an additional uncertainty that needs to be accommodated in FRM so that provision is made for adaptation into the future.

This report describes the plans and developments for flood risk management for the Lower Don Valley in the City of Sheffield, South Yorkshire and its context within Sheffield. It is essentially focussed on river flooding but references some work on surface water interactions. In June 2007, there was a major incident with flooding from the rivers in the River Don catchment and from other sources in Sheffield. Since then, Sheffield City Council (SCC) and other stakeholders have been developing flood risk management plans

that will address this flooding. As part of this process, measures have been implemented in several places because high levels of flood risk have been affecting the welfare of local communities.

This report describes the comprehensive approach to managing flooding throughout the entire Lower Don Valley.

1.1 Aims and objectives

The aims are twofold:

- To reduce and manage the risk of river flooding and the associated flooding from other sources within the high risk flood zone within the Lower Don Valley
- To use the focus of the Lower Don as a stimulus to Sheffield wide FRM
- To demonstrate the application of the MARE toolbox in the analysis and assessment of current and future flood risk and the development and selection of appropriate risk treatment options

The specific objectives are:

- To engage with affected communities and to seek their financial support for flood risk management
- To determine the exact nature of flood vulnerability
- To determine the levels of protection (Boundary condition) for the communities that are achievable in the funding climate in relation to damages
- To begin to determine alternative solutions to flood risk management beyond traditional defences in line with the MARE climate proof toolbox

1.2 Background

Sheffield, with a population of half a million, is the most western of the South Yorkshire urban communities and borders and indeed forms part of the Peak District National Park. Founded on the water power opportunities provided by the steep rivers, Sheffield was a key player in the agricultural revolution in providing tools for this purpose. It then evolved to become the world centre for cutlery and a large steel producer. Although globalisation has changed Sheffield's commerce, it remains a specialist in steel related industry, much of which is still within the original riverside environment.

The river Don in Sheffield can be divided by the more rural upper reaches from the Pennine headwaters to the centre of Sheffield, characterised by steep narrow channels and upland reservoirs and the lower reaches being heavily urbanised (Fig 1). The River Don within Sheffield is little more than a large stream as its response time is a matter of hours, limiting the effectiveness of temporary flood protection measures. In the aftermath of the 2007 flood, the decision to prioritise the Lower Don Valley for mitigation measures was driven by the need to sustain the economic and regeneration processes in the area. Flood risk management is led by Sheffield City Council (SCC) as Lead Local Flood Authority in close collaboration with the Environment Agency (EA), the body with a strategic function and responsibility for main rivers in England and Wales. There is also close contact with the residential and business communities within the Lower Don Valley and the private sewerage operator, Yorkshire Water Services Ltd.(YWS).

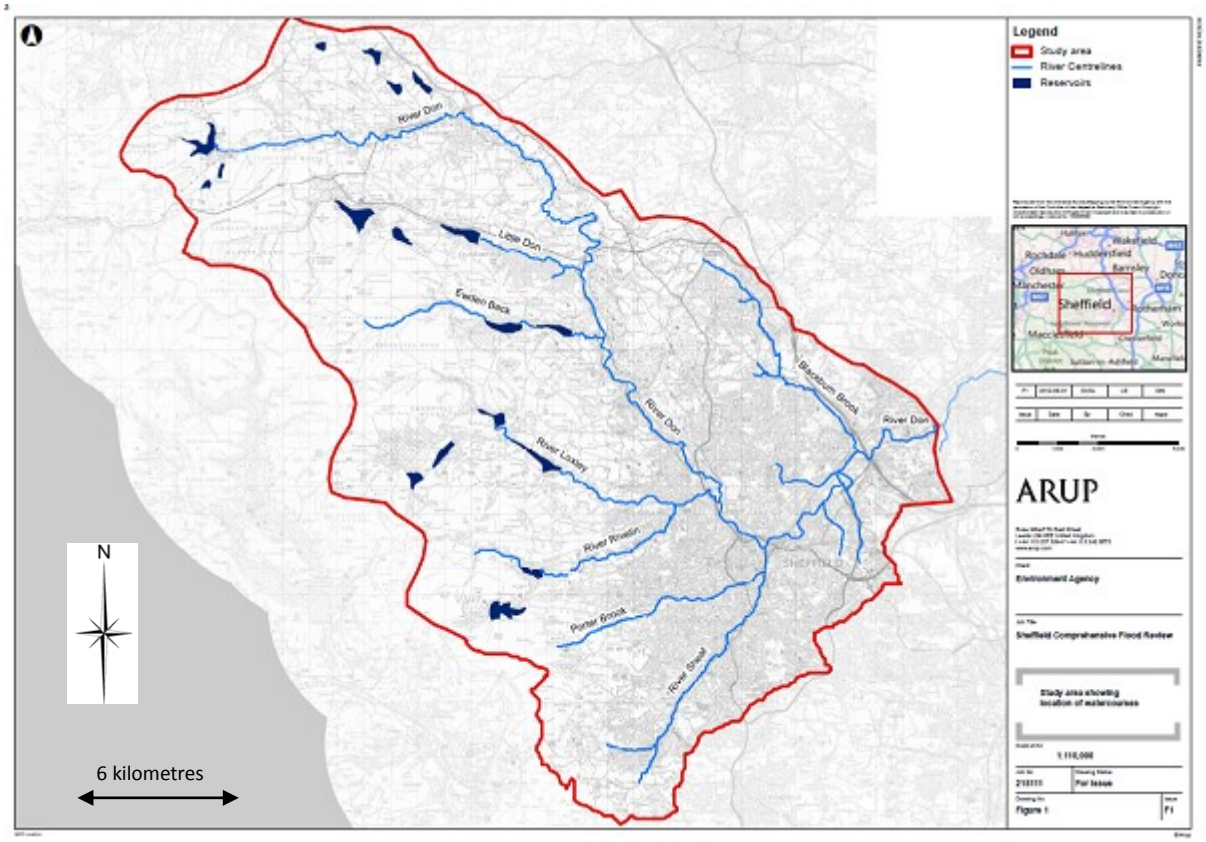


Figure 1: River Don and its tributaries within Sheffield – Sheffield Comprehensive Flood Review, Arup 2012

Major flooding within the River Don catchment in Sheffield, is not a frequent occurrence in terms of the memories of current stakeholders, including the Environment Agency, although much of the Don Valley is termed as susceptible to flooding. 1965 is regarded as the most recent severe flood, although levels were 1 metre below the 2007 event. The consequence of this is that a culture of flood awareness has not featured amongst individuals, residents, professionals, businesses and others. Prior to 2007, devastating flooding had not been experienced within living memory and therefore was not seen as a high priority. Even though the Lower Don Valley was identified through flood maps as vulnerable, it was not until the flood event that actions were undertaken. A desire to satisfy a mixture of community demands within the area and with the need for broad city regeneration and protection of the City's economic heartland were seen to depend in part on flood alleviation. This required a partnership approach to enable a more creative mix of funding to be accessed than available from a single source. The responses following the flooding in 2007 were not guided by an overarching flood risk management strategy,

as this was not in place at that time despite the plethora of Strategic Flood risk assessments and high level plans.

The redefining of roles and responsibilities between the key stakeholders; Sheffield City Council (SCC), Environment Agency and Yorkshire Water following the flooding and inquiry recommendations[1] have galvanised actions and as a consequence everyone involved is participating in a learning process about how best to deliver FRM strategies and measures.

Fig 2 Flooding in 2007 Lower Don Valley

[1] Pitt M (2008). Inquiry into 2007 floods in England.

In 2007, there was only limited capacity and knowledge about flood risk management within SCC, and it was necessary to improve this situation. However, since that time there has been a continuous process of change in legislation, guidance, standards, planning and practice affecting flood risk management within the city. This means that the learning process for SCC and the wider community has been one of iterative development rather than a straightforward journey from A to B. Although this work was already in progress prior to the implementation of the EU Flood Directive within England, the Directive has emphasised that the requirements laid down in national standards are necessary and appropriate to ensure water safety for the citizens of Sheffield.

The other main change in external circumstances during the period considered here has been the economic crisis. This has had a major impact on local government in England, with the loss of many skilled and experienced professionals, not least from SCC, where the entire drainage team (amongst others) have left. Fortunately the team has been replaced, although the new staff have had to learn quickly about the management of flood risk and the particular circumstances to be dealt with in the River Don valley catchment. Because of the severe financial constraints, the focus of FRM in Sheffield has been on managing current risks. Potential future climate change effects have been considered in the design of alleviation measures but may not be possible to include on cost grounds.

The Lower Don Valley area involves a wide range of businesses, some of national significance, such as Forgemasters, British Land and Royal Mail. Others are small scale such as those around the Wicker area, the focus of the Central Area Flood Protection. These businesses have been engaged through business and community focus groups.

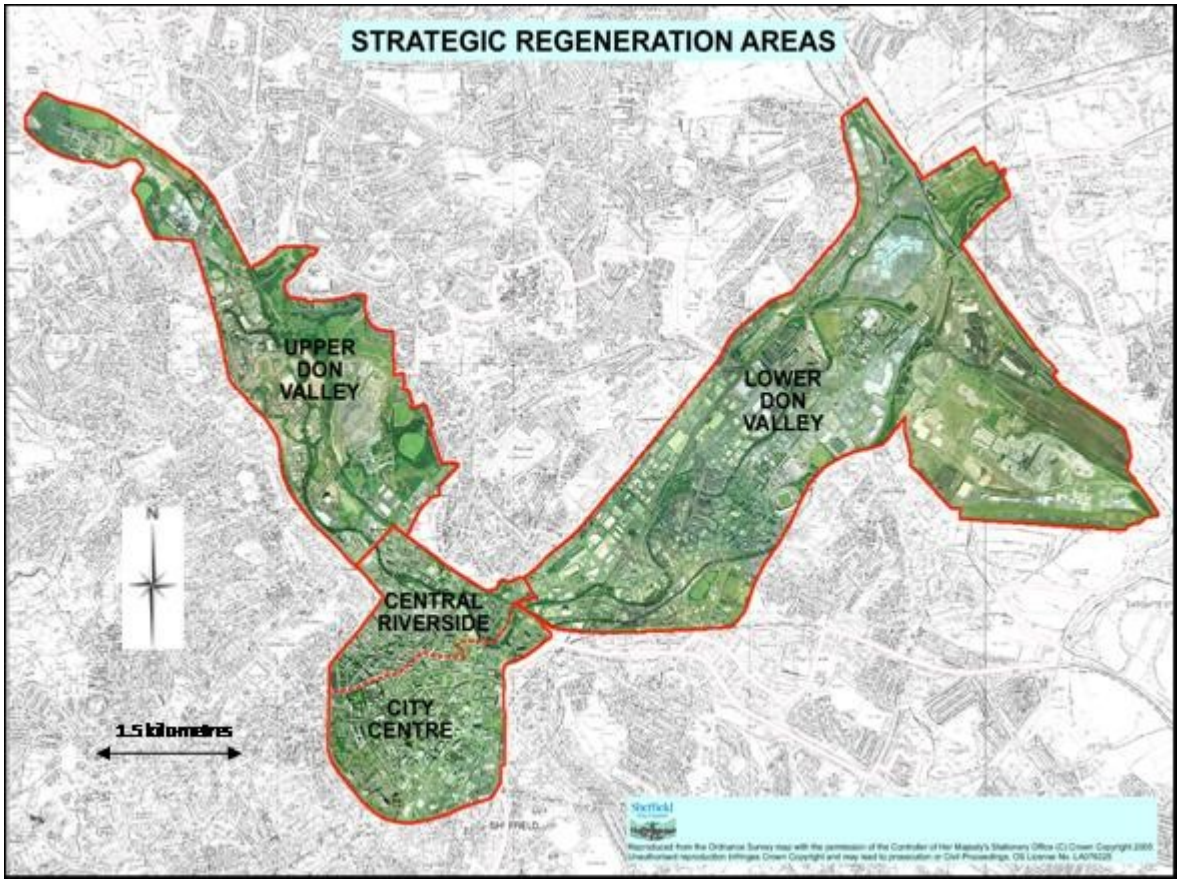


Fig 3 Strategic Regeneration areas. Central riverside being the location of the Sheffield Central Area Flood Protection scheme - the subject of the case study report

The main flood risk management authorities involved are Sheffield City Council and the EA. Within each of these organisations there are multiple facets of engagement, for example the EA is simultaneously a funder, regulator and Flood Risk manager. SCC is concurrently a regeneration agent, planning regulator and development promoter, highway authority, land drainage authority and funder. It also has officers charged with developing a climate change adaptation strategy. Emerging from this process and coincidentally timing with government legislation is an increasing role for the council as Flood risk manager being formalised during this project as Lead Local Flood Authority (LLFA), a designation given to all unitary and upper tier municipal authorities in England.

The process of addressing the flood risk in this and other areas of Sheffield was and is facilitated by a regeneration team with support from the flood risk manager within the council.

Knowledge base participants included the MARE partner, the Pennine Water Group, the URSULA project (both University of Sheffield), the latter a nationally funded research project looking at multi-value regeneration from

urban rivers and the Interreg VALUE project. Interest groups on the river were the Kayak club and a fishing organisation, SPRITE. MARE has facilitated the formation of the Don Catchment Learning and Action Alliance and Yorkshire and Humber LAA that have allowed the changing picture of responsibilities and approaches to flooding to be shared both within the Don catchment and also across the region.

Other significant local players associated with flood risk in this area are the River Stewardship Company who are taking a role in managing the river and riverside environment and Groundwork, a national charity, who are working alongside the Environment Agency on flood awareness.

The Don Partnership has been established as a pilot catchment for implementing Water Framework Directive aims. The importance of flow management in relation to ecological potential in the heavily modified water body of the Don is highlighted through this process. This work will contribute to the River Basin Management Plan – the key response to WFD.

2007 has promoted improved working between bodies so the culture has shifted from siloed working to one of joint learning through alliances (MARE WP1).

1.2 Regulations, procedures and standards

There is no statutory requirement for the British Government to protect property against the risk of flooding. Aside from this, the Government recognises the importance of safeguarding the wider community and, in doing so, the economic and social well being of the nation. Municipalities, however have a duty to promote health, welfare, security and quality of life.

Since 2007 there have been a number of significant changes, especially to the way in which local flood risks are managed in England, with the passing of the Flood and Water Management Act in 2010 and related instruments, including the Flood Risk Regulations 2009[2]. Under the new legislation, the main parties in flood risk management are outlined below.

- The Environment Agency, which for Sheffield is covered by the Yorkshire and North east Region, has the overview function and specific duties with respect to rivers and large streams. Overview is partly guided by the Catchment Flood Management Plan (Fig 4) which was commenced in 2006 and completed in 2010. This sits under the National Strategy for Flood and Coastal Erosion Risk Management. An 'integrated approach working in partnership' is their vision for the Sheffield area. Broadly the Environment Agency predict that flood areas in Sheffield will change little as a result of climate change but that flooding depth and regularity will increase. The Plan identifies the need for a Sheffield Strategic Flood Risk Management Plan. EA regulate any activity within 8 metres of main river channels. In addition they lead on the formation of the River Basin Management plan that addresses WFD requirements. This is now progressing through a partnership.

[2] Great Britain. Parliament, 2009. SI 2009 No. 3042 Environmental Protection. The Flood Risk Regulations. London The Stationery Office.

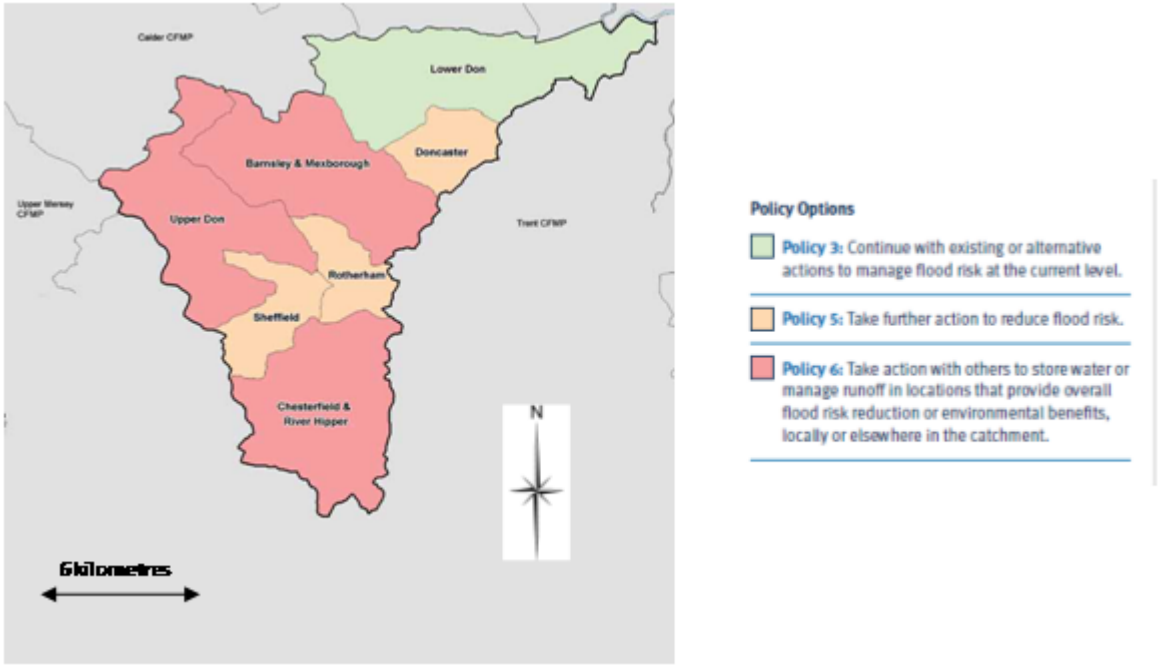


Fig 4 Map of Catchment Flood Management plan policies – showing Sheffield urban and Upper Don much of which is Sheffield rural.

- the Regional Water and Sewerage Undertaker which is responsible for effectually draining urban areas, i.e. sewer related flooding, water supply, treatment and reservoir management

- the Lead Local Flood Authorities (LLFAs) such as Sheffield City Council has local responsibilities for all other types of flooding. As a result of the Flood and Water Management Act 2010 the LLFA needs to produce and manage a Local Flood Risk Management Strategy with other risk management authorities. A key focus of this process is to develop communication strategies around FRM. The LLFA is required to investigate incidents of flooding and has a responsibility to address surface water and ordinary/smaller watercourse flooding. Under the Flood Directive these sources of flooding have also been investigated to determine where significant problems exist and to respond with proposals for their management. In Sheffield's case few significant flooding problems were identified, although climate change modelling was not incorporated into investigations.

- SCC provides the planning regulation role. The key tools in this respect are the Planning and Policy statements PPS 25 Development and Flood Risk and PPS 1A Planning for Climate Change. These have now been replaced with the National Planning and Policy Framework which highlights climate change as a consideration, for example Local Plans needing to take account of long-term flood risk. The Sheffield City Council Local Development Framework provides guidance to the range of land uses across the city and considers flood risk in designations as to how land may be developed.

In 2011 a number of strategic guidelines and directions related especially to local flood risk practice and funding were published; encouraging co-funding partnerships for flood risk management[3] in England. These recognise the synergies, interactions and opportunities for managing flood risks as part of normal urban planning processes, for which Sheffield CC has control. The result of this is that the approach has moved from one of addressing individual problems on an ad hoc basis to one of a phased implementation of a catchment based flood risk management plan addressing flood risk alongside business continuity, inward investment and other urban development issues.

[3] Defra/EA (2011) Understanding the risks, empowering communities, building resilience. The national flood and coastal erosion risk management strategy for England. www.official-documents.gov.uk.

1.3 Timeline and flow diagram

Year	Events
2007	Major flood event 25th June
2008	Review of Strategic Flood Risk Assessment for Sheffield SFRA2 for Sheffield Central Area
2009	Completion of Catchment Flood Management plan and river basin management plan
2010	Commence construction of Sheffield Central Area Flood Protection scheme (SCAFP)
2012	Completion of Sheffield Central Area Flood Protection Lower Don Valley FRMP feasibility study Completion of Sheffield Comprehensive Flood review Commence upstream reservoir study
2013	Reservoir study
2014	Implementation of main Lower Don alleviation

2 Details

2.1 Analysis and assessment

2.1.1 Flooding

June 2007 was the wettest month on record in Sheffield since 1882 with a total rainfall of 285mm. Two periods of heavy rain occurred - 13th -15th June when 135mm fell saturating the catchment uplands and filling reservoirs and 24th-25th June (the day of the flood) when there was 87mm of rain. Although these two events were around 1 in 25 year return period the interaction with the catchment and reservoirs meant the resultant river flow was 1 in 200 year return period. As the river flows through mainly commercial areas, more than 1000 businesses were affected. However 1275 homes were also subject to flood damage and two people lost their lives. Previously there have been less severe flooding events and there has been small scale defence work completed at vulnerable points by the Environment Agency. As the Sheffield Central

Area Flood Protection (SCAFP) scheme was the first project as a reaction to this, it was also the first to take into account a greater depth of analysis of the flooding vulnerability in the City than had been done before. However, the resourcing identified for this area meant detailed analysis of economic impacts was not a requirement as is needed for the higher investment alleviation further downstream for the remaining part of the Lower Don Valley. The key information that has informed the Municipality's flood maps is from the Environment Agency. This information has been refined by further studies by Sheffield Council in specific areas of vulnerability and change

Summary of Flood studies undertaken

2.1.1.1 Sheffield Strategic Flood Risk Assessment SFRA1

Effectively the formation of this document was built upon previous flood maps provided by the Environment Agency and Sheffield City Council. This happened after the 2007 floods and helped define the flood zones for Sheffield to help with planning of land uses in the different high, medium and low risk zones.

Zone 3b Functional Floodplain

Areas of the region susceptible to flooding within which "water has to flow or be stored in times of flood" (PPS25).

Zone 3a High Probability

Land assessed as having a 1 in 100 or greater annual probability of river flooding in any year.

Zone 2 Medium Probability

Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding in any year.

Zone 1 Low Probability

Land assessed as having a less than 1 in 1000 annual probability of river flooding in any year.

2.1.1.2 More detailed studies Sheffield Central Area Flood Protection (SFRA) 2 July 2008 Jacobs

Modelling has taken place across Sheffield's rivers over a number of years prior to and post the 2007 floods to determine flow and depth. Some has been carried out to improve the flood mapping for planning purposes, others driven by the need for improved flood alleviation. The SCAFP project as a first intervention received its own focussed modelling to improve flood risk knowledge for planning as well as more detailed analysis for alleviation options.

2.1.1.3 Sheffield Comprehensive Flood Review

A more strategic approach, the Comprehensive Flood Review, spearheaded by the Environment Agency, is bringing together disparate and unconnected computational (hydrological and hydraulic) river flow models of the Sheffield River Don catchment (see fig 5) . It has also incorporated national changes in flood estimation and now provides a consistent model to develop flood risk management in the future. These models are being used to evaluate the current and future flood risk and appropriate risk treatment options, and within the context of the MARE project to demonstrate the application of the MARE toolbox (CPT) to ensure the vitality of the City of Sheffield in areas that are at risk of flooding from the River Don. This new model for Sheffield has come mid way through activities to address the first flood alleviation in the SCAFP project. Although not ideal in the sequence of activities this new model has allowed confirmation of the design work for the SCAFP project.

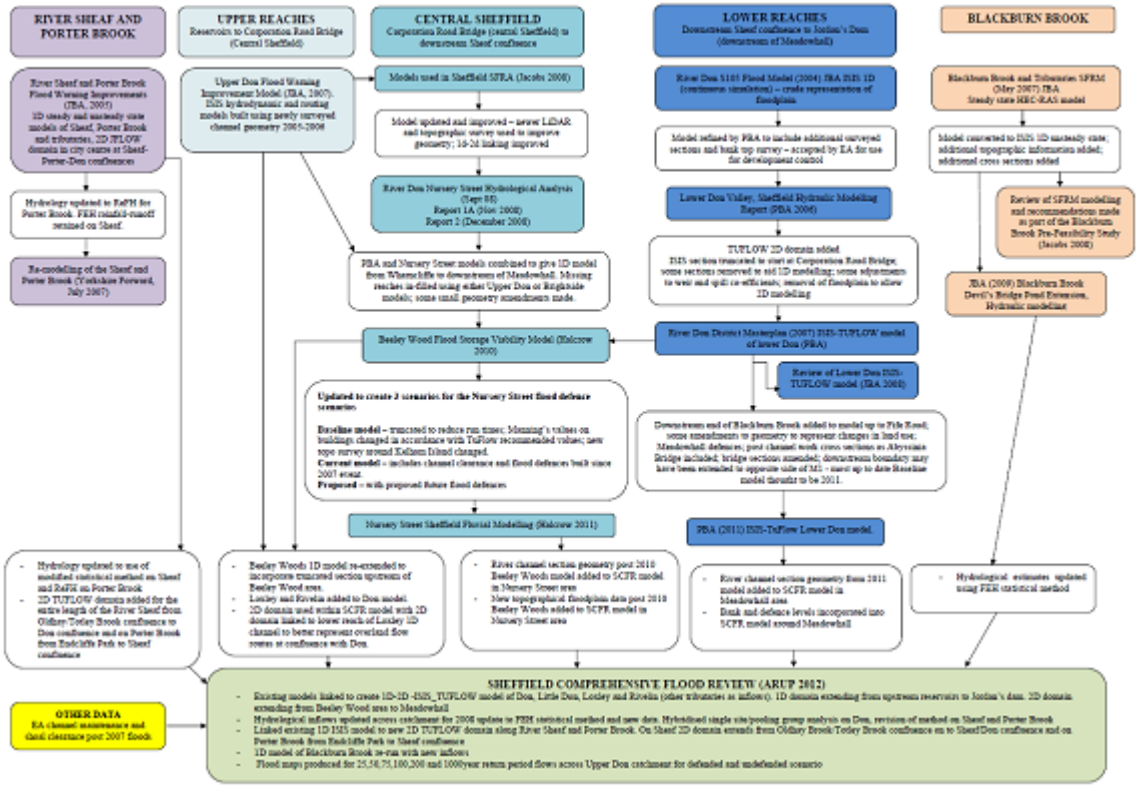


Fig 5 Model collation for the Sheffield Comprehensive Flood Review, Arup 2012

Summary of Sheffield Comprehensive Flood review methods

- Digital terrain modelling merging previous filtered and unfiltered LIDAR data sets (0.25m resolution) with ground inspection
- Target flows for 25, 50, 75, 100, 200 and 1000 year return period for each of flow estimation points
- Reflecting recent channel clearance by EA post 2007 floods
- Simulating return periods in defended and undefended scenarios – giving flood depths and extents and standards of existing flood protection service (See fig 6 for existing defences)
- Validation with flood event experience
- National receptor database combined with ordnance maps and flood extents to determine level of flood risk to: Residential, Critical infrastructure, Transport network and Emergency services.
- Noted that sparse flood gauges and blockages make accurate flow estimation not possible therefore modelled flows will not always correspond with observed levels.

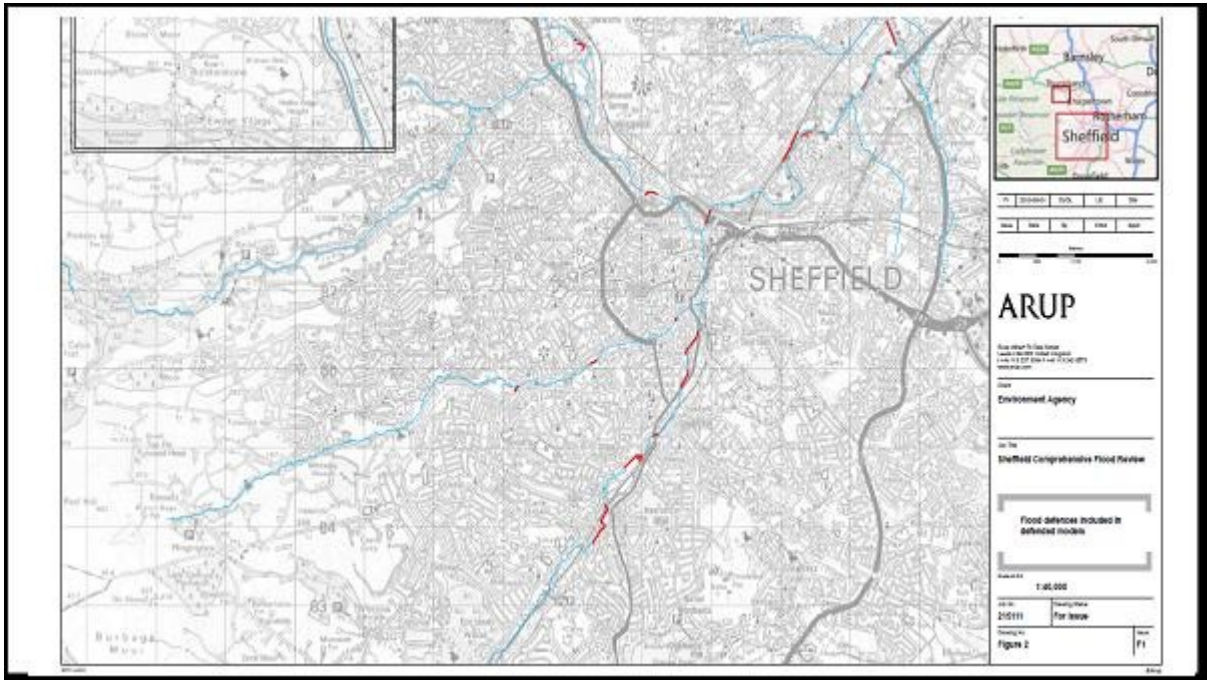


Fig 6 Plan of existing defences in Sheffield

Results

- Number of properties benefitting from existing defences: 223 residential and 166 non residential in 1in 100 year event.
- Critical infrastructure vulnerable in both defended and undefended – One substation vulnerable to 1 in 50
- 2007 event 259m3/sec 1 in 220 year return period.
- Overland flows cause considerable proportion of flooded areas
- Extensive areas vulnerable to a 1 in 25 year event in the Lower Don as illustrated in figs 7 and 8
- Considerable floor area of businesses affected in Lower Don Valley (fig 9)
- Flooding mechanism is via a number of key points which give rise to overland flow along valley bottom on roads this mainly on the left bank for the Lower Don

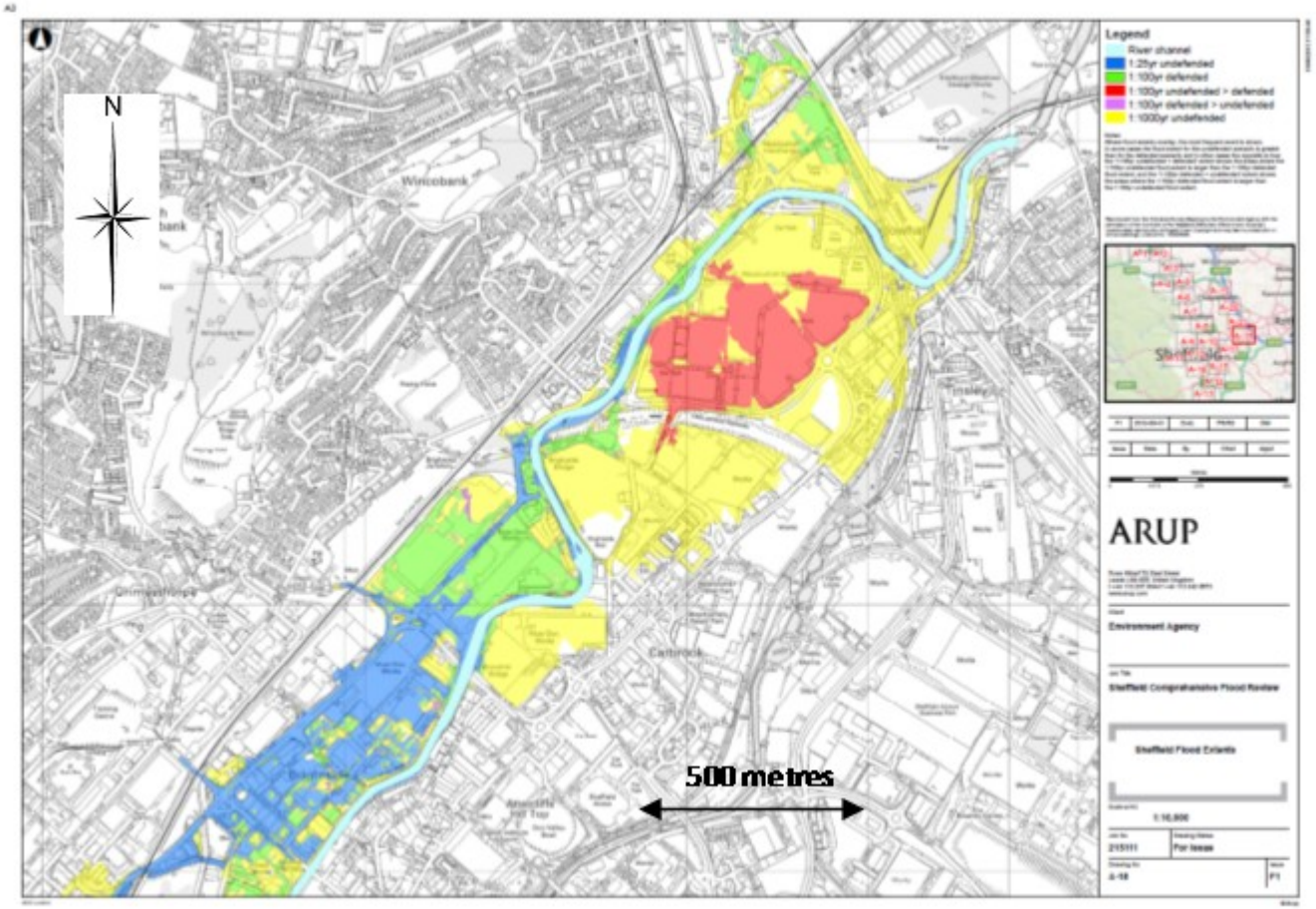


Fig 7 Flood maps for Lower Don Valley North - Sheffield Comprehensive Flood Review, Arup 2012

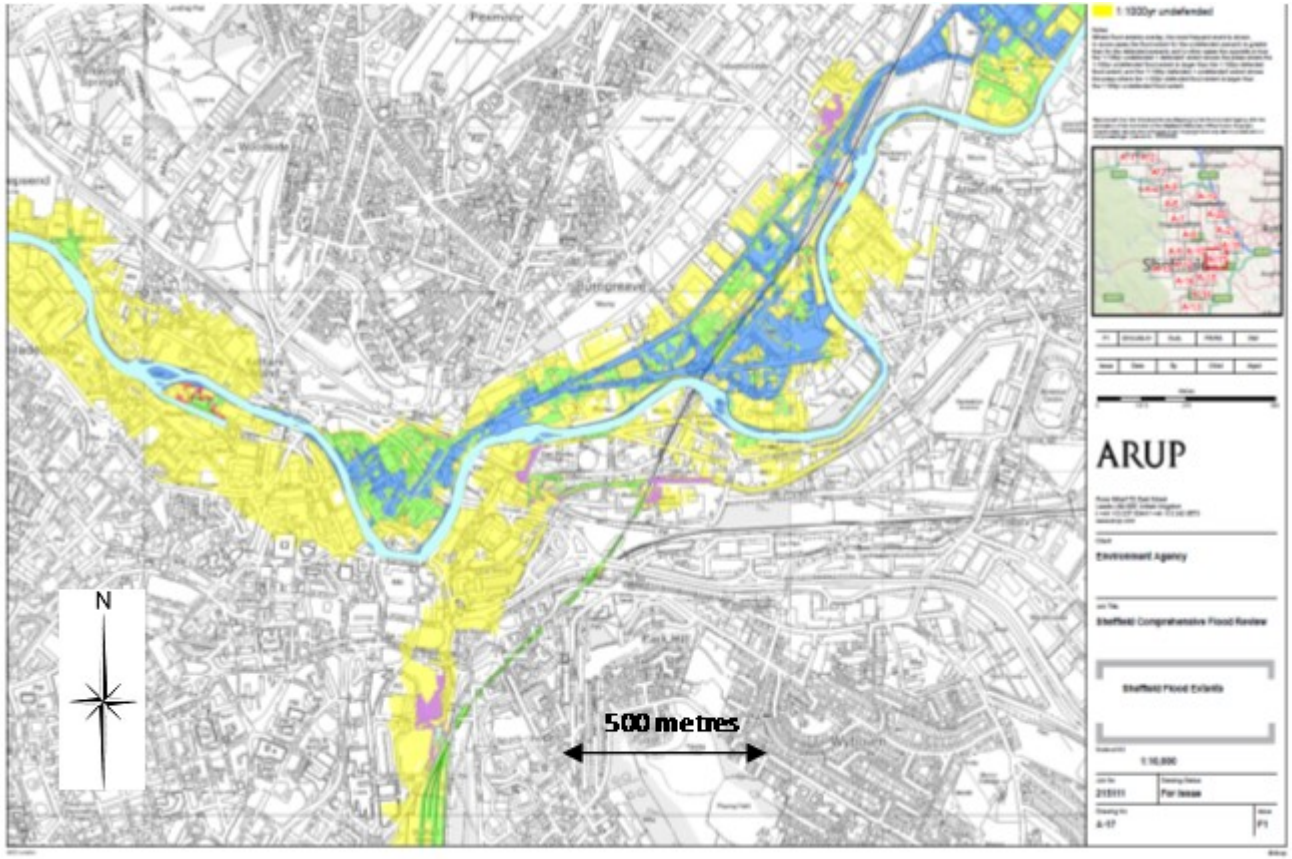


Fig 8 Flood maps for Lower Don Valley South - Sheffield Comprehensive Flood Review, Arup 2012

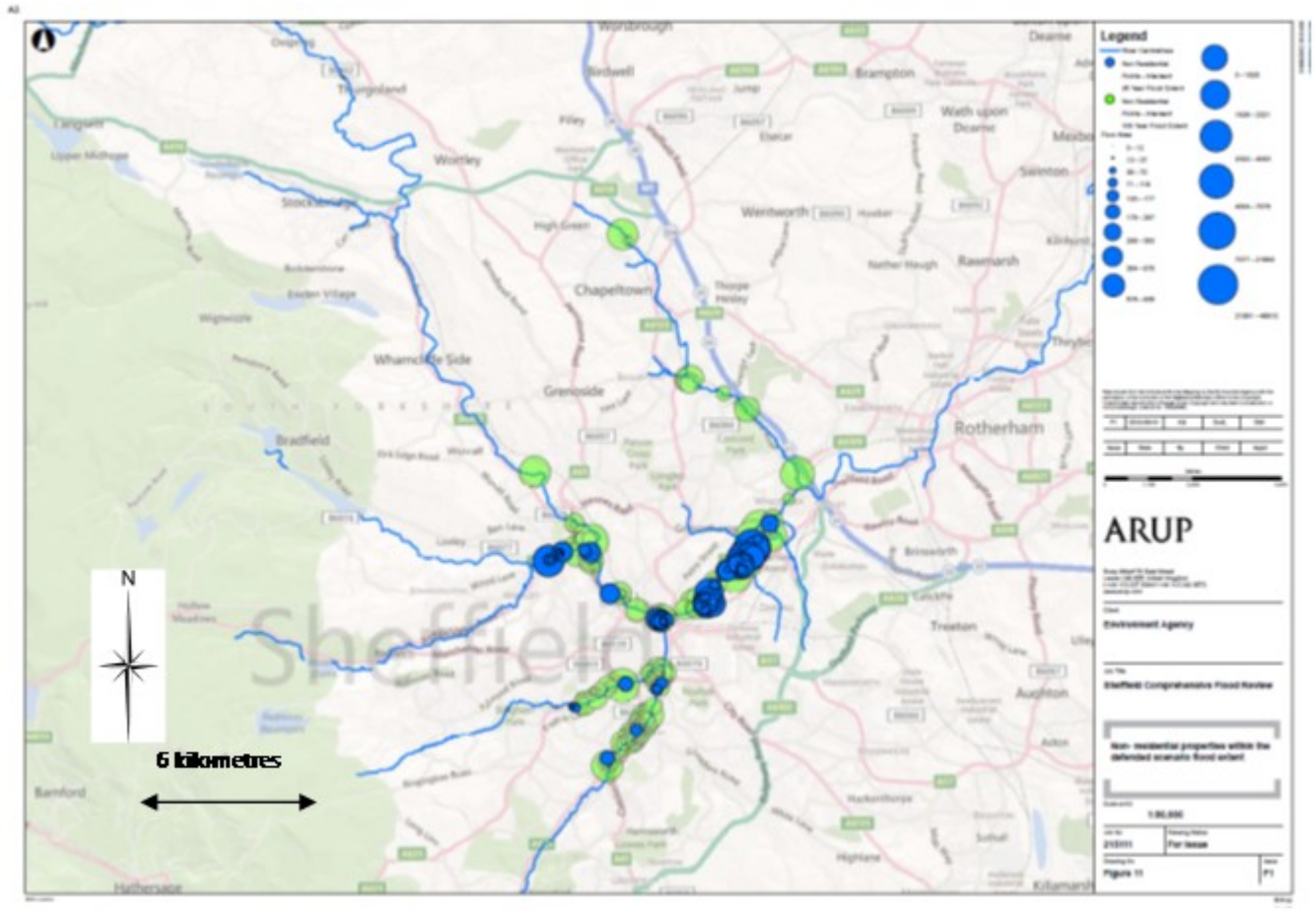


Fig 9 Floor area affected by flooding in 1 in 25 and 1 in 100 for non-residential properties Sheffield Comprehensive Flood Review Arups 2012

2.2 Problem definition

The delivery of improved flood risk management to these areas from both adjacent flooding from banks and from overland flows along the valley floor throws up a number of questions at different scales. The problem of the actual flooding is relatively simple in terms of understanding its processes, although blockages of bridges can significantly compromise channel modelling predictions. The key judgement facing Sheffield is how to tackle this problem bearing in mind:

- Needing to be seen to take action and protect communities and business within an acceptable timeframe
- Uncertainty over aspects of possible actions as part of a multifaceted approach because of a lack of information
- Uncertainty over future funding for example where a phased approach is being taken

In addition there are other questions:

- Ensuring no exacerbation of unattended flooding elsewhere as a result of an intervention?
- How can any responses provide for adaptation in the future?
- How can responsibilities for various aspects of the FRM be allocated for example channel management?
- How can we ensure the river remains an asset to the city?
- Are the skills and capacity available to deliver this work?

2.3 Options considered

A number documents highlight thought processes both within the EA and the municipality considering both structural and non-structural approaches. Some are high level and others cover high level to local. Some options were instigated rapidly on the back of the 2007 floods whilst others are ongoing or as part of future work. There are structural and non structural measures.

2.3.1 Sheffield Central Area Flood Protection Feasibility study Sheffield City Council 2008

This study was produced to address action for the Sheffield Central Area. Through localised requirements wider issues were explored. It necessarily explored the range of options in FRM suggesting many that were valuable approaches but that on their own were not sufficient. Options then focussed on localised alleviation. (see SCAFP)

2.3.2 High level Options and considerations

The response to the 2007 flood event reflects the historical and understandably low priority placed on Flood Risk Management for Sheffield by the Council and EA. SCC sought action based on regeneration concerns (SCAFP) which led to localised alleviation. The EA carried out extensive channel clearance work which had not been addressed for a number of decades and will be necessarily carried out into the future despite this being the responsibility of landowners. In addition, during this period, the EA progressed the Catchment Flood Management Plan for the Don, a high level document highlighting basic principles for how to manage flood alleviation in the different regions of the Don. This was followed by the EA's Don Strategy that established the need for a Sheffield specific study, the first phase, a baseline model, which is now complete. This will be followed by modelling to explore the use of a number of upland non-supply water storage reservoirs in the Don catchment, owned by YW for additional storage and

attenuation of flows during severe weather events.

The options considered are reviewed in terms of the 4As[4] of FRM:

- Avoidance: of flood through e.g. planning and standards
- Alleviation: through 'best practice' and use of technical guidance
- Assistance: to those at risk (also see 'Awareness')
- Awareness: of flood risk through better risk information and warning systems

2.3.2.1 Avoidance

A major aspect of this project has been the need to encourage urban regeneration in the areas at risk of flooding as illustrated by the inundation in 2007. Therefore the formal planning processes and their relationship to what and how regeneration continues are important.

All development in England has traditionally been subject to Planning policy Statement 25 (since 2005). This national policy required planning authorities to ensure appropriate development within the different flood zones. The project being in designated high risk Flood Zone 3A would not have allowed residential development in the area until 2017, a date set nationally. However, as has been demonstrated in particular cases, this constraint can be overthrown on regeneration grounds. Exceptionally developer applicants have sought to demonstrate that there are no other suitable sites for their development within a predetermined radius of the site. If no sites are found a further test is carried out to assess whether or not development can go ahead. This process has underpinned the management of land use in the flood vulnerable areas for the last 7 years, but is more of a reactive tool to review development applications. It has not engaged in debate about urban infrastructure in relation to choices about managing future standards of protection.

After the Government changed in 2010, the English Department of Communities and Local Government (DCLG) began a process of deregulation, implementing the Localism Act[5] and with the department of Business Innovation and Skills, the Penfold Review[6]. Together these initiatives are reducing planning guidance (deemed to comply standards) from more than 20 documents comprising more than 1000 pages to one document with some 60 pages. Thus rendering the former flood risk management planning guidance obsolete. As yet, the replacement as regards how development is considered in terms of flood risk within formal urban planning approvals is unclear, but is likely to be locally defined, rather than nationally based as formerly.

In Cities such as Sheffield, much of the land is already developed and many issues relate to the protection of existing properties in the face of changing external circumstances.

Flood zoning is independent of flood alleviation activity as any defences etc are regarded as

[4] Scottish Government (2007) Flooding Issues Advisory Committee (FIAC) and Flood Resilient City project

[4] http://www.communities.gov.uk/documents/localgovernment/pdf/1896534.pdf

[5] http://www.communities.gov.uk/documents/localgovernment/pdf/1896534.pdf

[6] http://www.bis.gov.uk/assets/biscore/better-regulation/docs/i/11-1413-implementation-of-penfold-review

subject to potential mismanagement and communities are still vulnerable to overtopping.

2.3.2.2 Alleviation

The process of alleviation can involve multiple activities at different scales in space and time. For example:

Riverside wall based defences as new constructions or modified existing ones	Deliverable and immediate measureable impact based on known modelling
Spillways to divert flows thus avoiding blockage vulnerable bridges	Few situations would benefit from this approach. The option to have built a spillway/ culvert short-circuiting the Wicker bend in the river and avoiding Lady's bridge (Figure 4) during the construction of the inner relief road prior to the flood was seen by the design team as an important missed opportunity.
Flood routing	Overland flow through the Don valley is a feature of the mechanism of flooding. Whilst there may be merit in exploring this the difficulties in accommodating these flows within the urban context make this a less preferable choice.
Upstream storage either as newly constructed features or in adapting existing reservoirs in the way levels are managed	Complexities make this a long-term option but with possible considerable parts of catchment benefitting. From the initial studies, led by the Environment Agency, the creation of new online storage 2km upstream at Beeley Wood (Figure 10) has been shown not to be cost-beneficial. However, this potential project may be revisited in the future. Presently the use of reservoirs for upstream storage is being explored.
Upland land management changes for example in reducing grazing intensity or replanting woodland	A more incremental process both in space and time and delivering less distinct results. However, regarded as an important part in building better resilience by reducing speed of run-off from steep catchment. This will be seen as a long term approach through moorland and farmland management plans. Sheffield's close proximity to its rural catchment and coverage through its governance means attention to rural land use is very much in its interest.
Channel modification	Removal of weirs may have considerable benefits in some circumstances on flood levels, in addition they provide a barrier to fish movement. However there historic value to Sheffield and contribution to water retention within the river channel mean removal would be controversial.

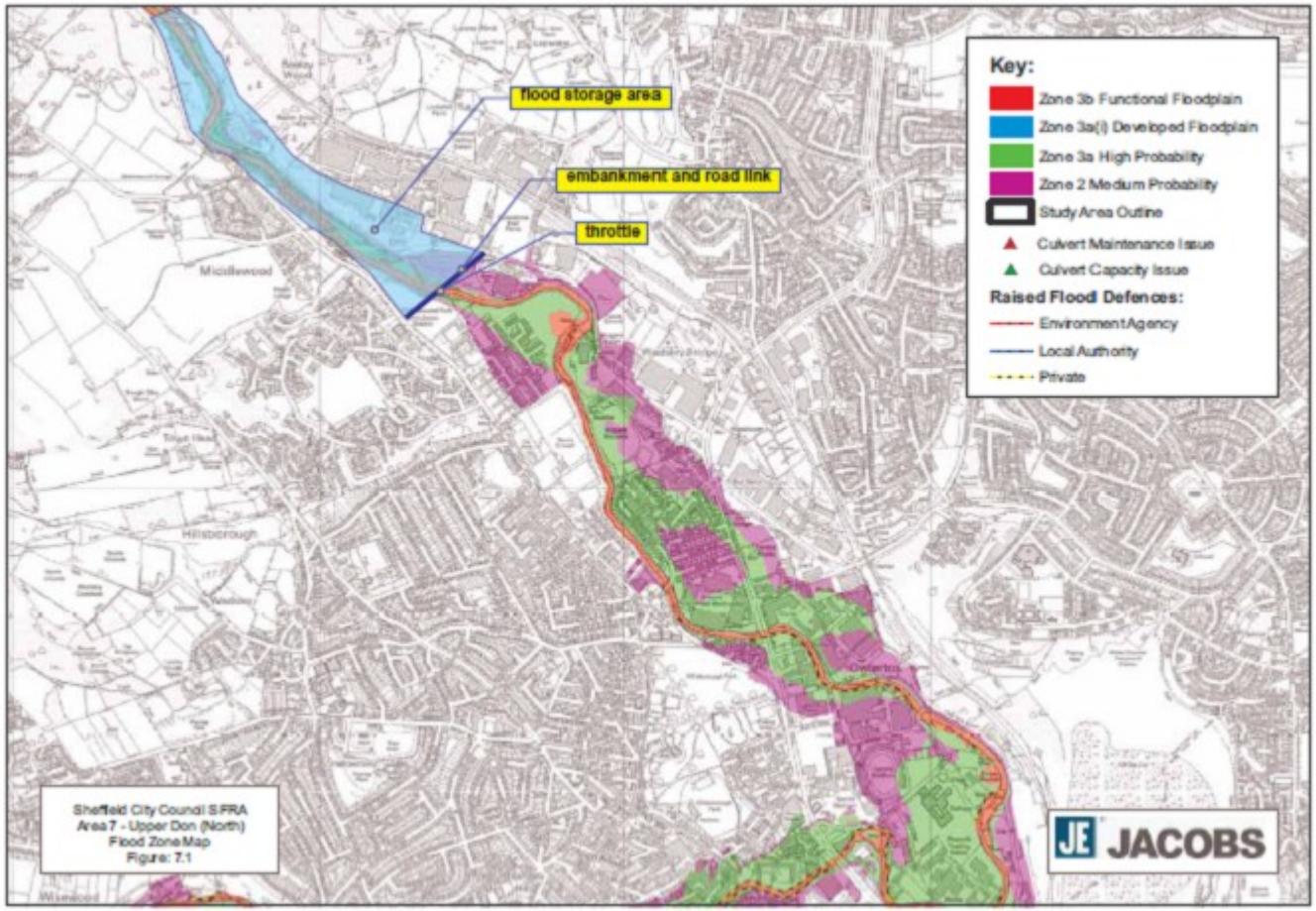


Figure 10 Potential floodable area at Beeley Wood

Making room for the river – washlands	In the upper catchment this is not possible due to the steep topography. Sheffield Lower Don Valley historically would have been a flooded landscape but any effective management of flood levels would need considerable parts of the Lower Don Valley, the economic heartland of Sheffield, to be sacrificed for the benefit of downstream communities beyond Sheffield.
Bridge removal	Although bridges do cause potential considerable problems through blockages from debris, when managed they are not causing a considerable constriction. Some of the more vulnerable to blockage bridges are also of historic importance.

Channel management to ensure reduced debris that causes blockages and optimum cross sections for flood level management	Knowledge of the processes of build up of sediment within the channel is poor but neglect for decades has resulted in a choked channel with large deposits of gravels and establishing tree stands. Clearance by the EA post 2007 to ensure improved flow was shown through modelling to reduce flood levels

2.3.2.3 Awareness and assistance - Building resilience and flood warning

Guidance to inform how future developments should ensure safety such as appropriate ground floor uses, safe access and egress, is delivered through the town planning process. This is done for all areas within the flood plain irrespective of the presence of riverside defences. In addition the Environment Agency is starting to explore providing support for local resilience for existing buildings in the event of flooding, including overtopping of defences through the Local Resilience Forum. Owners/tenants are encouraged to sign up to the EA flood warning system. Voluntary groups such as Groundwork also help facilitate these processes.

2.3.3 Discussion

Capacity to fully coordinate between the four 'A's within Sheffield is limited and there is still learning to be achieved. Avoidance through planning appropriate development is consistently applied but would not be updated as other management tasks are undertaken as the Flood Zones remain as defined irrespective of other interventions. Individual development application Flood Risk Assessments however can make the case that defences are under reliable management responsibility and therefore persuade Sheffield Council of wider regeneration benefits, for example city living in attractive riverside environments. There has been little challenge to this in exploring resilient building within flood vulnerable areas where defences are not pursued. Allowing parts of the city to deliberately flood and adapting development accordingly was not seen as an option particularly as flood cells are large and urban turnover slow and hazard from flooding high. Nevertheless development has to

demonstrate how residual risk, i.e. overtopping behaves and what design considerations have taken this into account.

Awareness raising of flood risk in communities has been initiated through the Local Flood Risk Management Strategy. It is recognised by the EA that warning systems could be improved with better monitoring of river levels. Both these activities also need to reference other improvements in flood protection but be mindful of any alleviation having its limits, i.e. in overtopping (MARE 3) .

The need for assistance measures will undoubtedly be affected by improved flood protection, for example the Lower Don not affected adversely by a 1 in 100 event. Improving understanding of these activities will allow services to be tailored to requirements.

Many of the 'manage and cope with flooding' options were considered possible only over an unacceptably long timescale. It was considered important to re-create a sense of security and demonstrate strong action following the 2007 flooding in order to engender business confidence and continue encouraging private investment in the regeneration process. Alleviation was therefore seen as a priority.

Activities to improve flood vulnerability can be tangibly delivered through alleviation therefore decisions focussed on which methodologies were best employed at the different scales. Although many of the approaches in the above table were available, solutions either were not having sufficient impact in relation to the disbenefits, for example removing bridges, or were too long-term and therefore unpredictable or were accumulative and therefore hard to quantify. Nevertheless these latter activities were seen as too important not to pursue as part of a more resilient strategy. A major consideration was the need for properties to be eligible for insurance cover necessitating a 1 in 75 year standard of protection as a minimum. Building resilience within the community was not considered an option as most of the existing buildings in the areas considered could not easily be adapted to withstand flooding.

2.4 Selected option

2.4.1 Summary

Whilst developments of a strategy for the whole Sheffield Don River system is in progress, individual alleviation interventions, for example in the Lower Don valley areas were deemed appropriate and necessary given the risks and expected time delays for a full Sheffield catchment plan. Awareness raising, for example through the Local Flood Risk Management Strategy and improved streamlining with emergency services is ongoing and application of planning rules continued.

The progression in deciding how best to manage flood risk in Sheffield has been an iterative process with many of the partners finding they had new/changed roles[7] during the process and that new guidance, standards and expectations emerged from Central Government. In summary, flood risk management is now being pursued through a combination of alleviation through flood defences and upstream storage, ongoing planning of the types of development in flood vulnerable areas and an increase in the engagement of communities, businesses and in understanding flood risk through local fora and the provision of flood warning systems.

[7] As a result of new legislation, especially the Flood Risk Regulations 2009 and the Flood and Water Management Act 2010

Although a range of alleviation options were considered, the economic and regeneration driver led to a focus on bankside alleviation as a relatively quick measure to visibly reduce flooding and its resultant effects. [8]. In addition much flooding within the Don Valley leads to overland flows further down river on to the road network. Thus alleviation through wall based defences were considered important, and effectively the key strategy for strategic flood risk management as these would keep the river contained in its' channel. Aesthetic or access considerations were considered to be subordinate to providing a reduced probability of flooding, i.e. only flooding frequency was considered in the decision process, not vulnerability or impacts although these played a part in making a case for resourcing. However, a good quality environment was also deemed important. Hence the approach was not one of simply using flood walls.

More consideration needs to be given to co-design, embracing multiple land uses and benefits and this is now encouraged by Government guidance and standards for shared funding that make a multi-beneficial approach (MARE 1) mandatory. However, it is crucial that in regenerating areas, business confidence is maintained and this is most easily done by constructing visible and 'we know it works' hard infrastructure defences (alleviation). Changing mindsets (awareness) to accept floodable areas, risking loss of valuable land for development, being willing to be flooded even every 100 years or so, are all excellent aspirations, but in the short term, a pragmatic and more traditional approach is unfortunately essential in Sheffield otherwise business funding and acceptance will not be forthcoming.

2.4.1.1 Standards of protection and Climate change

The standard of service or boundary condition, as identified in the MARE Climate Proof Toolbox, that is typically sought is for the 1 in 100 return period (MARE 2). 1 in 75 is quoted as the minimum in terms of insurance. Standards above this, for example the 1 in 200 as was experienced in 2007, may be sought but this can involve costs that are sometimes not achievable (MARE 3), in addition funding bodies may reduce scoring for funds for higher return periods. Damage curves, however, may illustrate that damages significantly increase post 1 in 100 (MARE 3) thus arguments could be made for higher standards of service or boundary conditions.

The most recent computer modelling has shown that defences for the Wicker scheme (Sheffield Central Area Flood Protection) exceeding a 1 in 100 year standard of protection will cause upstream flooding by backing up which would require further alleviation in upstream areas. Limited funding means that it was necessary to avoid a scheme that would impact over a wider area with additional costs. Because of this, any allowance for Climate Change requiring higher defences (typically 20% increase in future flows as defined by the EA), has not been possible to accommodate, as this would further exacerbate upstream water levels and the need for more extensive defences. It has also meant that some local communities may not be defended against a flood equivalent to 2007 (although this is hard to prove as the effects of bridge blockages causing localised river level increases are difficult to quantify during an event) especially as in 2007 much of the problems

[8] this is an agreed protocol between the UK Government and the Association of British Insurers and expires in 2013 (when it will no longer be valid).

were caused by debris trapped at the bridge inlets.

The development of the overall Lower Don Valley flood protection scheme has been based on the lower 1 in 100 year (without an allowance for climate change) to keep costs at a level that are in line with the cost benefit ratios required by funders, for example as related to the numbers of jobs protected and damage impacts[9]. However, the business community in the Lower Don Valley understandably want to be confident that they are protected to at least withstand what was witnessed in 2007, and although debris blockages of bridges may have exacerbated local flood levels there is a view that there will be a need for additional protection. The more recent modelling through the Comprehensive Flood Review is suggesting that damage impacts may be more post the 1 in 100 year threshold. Thus defences may be argued on the basis of 1 in 100 year plus 20% addition for climate change which is equivalent to the 2007 event approximately 1 in 200 . Upstream storage in these circumstances could be regarded as providing additional flexibility over the climate change allowance on a 1 in 100 defence or adaptability for climate change over a 1in 200 defence.

With regard to managing the impacts of climate change, the following options can be pursued as part of the forward strategy, but as yet are not determined:

- Adaptable defences allowing standards of protection to be maintained for individual flood cells (i.e. river reaches)
- Upstream storage - Recent considerations suggest that the use of reservoirs in the uplands immediately above Sheffield may be the best way to effectively provide this additional protection. Thus providing a higher standard of protection than the 1 in 100 year or 1 in 200 year or at least maintain the standard of protection of 1 in 100 year or 1 in 200year as climate change impacts on rainfall. (MARE2)
- Planning for increased overtopping associated with a reduced Standard of protection, for example directing out of channel flood water along pre-planned (blue infrastructure) pathways, redeveloping with resilience. (MARE3)

The latter is as yet unexplored as the focus has predominantly been on protection. If upstream storage proves not possible and raising defences appears not practical, for example because of cost or urban design requirements, then an allowance may be needed for reduced standards of flood protection.

Uncertainty over percentage increases in river flows associated with uncertain climate create a key challenge as is defined by the MARE toolbox. On the one hand one could suggest that by adding extra height in defences we have chosen a predict-then-adapt approach and are then vulnerable to future climate scenarios overriding present scenarios. The 1 in 100 year is based on historic data. The 20% increase does give a level of headroom but for how long would this buffer before the boundary condition of 1 in 100 is no longer achievable? In the case of Sheffield's defences there may be more facility available in the form of upstream storage and catchment management

[9] This was traditionally set at benefit to costs of 6:1 based on direct damage alleviated. In 2011 this was amended to include a much wider range of potential benefits, including ecosystem services (see footnote ref. 2) but this came too late for the scheme outlined here.

improvements giving flexibility into the future to account for uncertain climate change.

The alternative of using the Adaptation Tipping Point presumes there is headroom before the boundary condition is no longer achievable. In the case of the Don there is no headroom as there are no defences that deliver the 1 in 100 year boundary condition. In this respect, the project is seeking to establish the 1 in 100 year boundary condition through investment as it is seen as essential. It is hoped that publicly led investments and private ones through development, will achieve this across Sheffield. However, even as this is being built in theory, the boundary condition is being exceeded, where defence heights have no percentage addition, as climate change is already having an impact. In this situation decisions to let boundary conditions lower would be needed, for example a review every ten years with resultant modelling determining the new standard of protection. So for example, if this was to drop below 1 in 75(the insurance threshold) then new investment etc would be needed.

Using damages to assess thresholds is an alternative

Present predicted damages are known for the Lower Don Valley at a variety of return periods. Policy decisions on levels of damage that are acceptable, are yet to be determined. Damage curves are smooth so there are no present rapid uplifts associated with particular events. Correspondingly there are no sudden changes with percentage uplifts that might inform interventions in the future.

In summary, without points at which damages increase at an extreme rate it may be that intervention occurs as a result of thresholds in standards of protection being exceeded (MARE 3).

2.4.1.2 Channel conditions and Bridge throttles

Without ongoing river bed maintenance the channel cross sections assumed within the computational models will start to change, with a likelihood of deposition causing cross sectional area reduction and reduced standards of protection.

Accretion of gravel and silt deposits within the channel as shoals has occurred in the past as a result of a lack of maintenance. Under English law the riparian landowner is responsible on each side up to the middle of the river and for ensuring the river flows freely. In practice this is not recognised or acted upon particularly in cities where the perception is that the Environment Agency or council would be responsible. Hence there is a dereliction of awareness on the part of those legally responsible. Successive organisations and incumbents, seen as responsible for FRM, such as the EA, have failed to make those responsible aware of this. It is expected that at some time in the future, as flooding incidents increase in frequency and impact, insurance companies will endeavour to pursue riparian owners who are derelict in their duties to maintain rivers and watercourses for compensation. Until this happens, the current situation will prevail and municipalities and the EA will be those who undertake the river and watercourse maintenance required under permissive powers that allow them to do the work but with inadequate funding. The River Stewardship Company (Fig 11) was established as a vehicle to address this disjointed situation where riparian owners could contribute towards an operational organisation who had the expertise. The removal of debris also has positive visual benefits for the river, so in effect the RSC is an example of MARE 1, where food risk management processes can have multiple

benefits in terms of quality of the river environment.

Bridges in the area act as throttles in flooding conditions, potentially lifting flood levels, this is increased when openings are completely submerged. Debris deposited within the channel further exacerbates this problem, for example the build up of fallen tree trunks. These openings have been carefully modelled computationally to better understand their potential effects. Removal of trees within channels has taken place since 2007 by the EA with the aim of reducing these sources of blockage. Bridges with multiple piers will need regular maintenance to ensure maximum cross sectional area is maintained during high flows. This will be raised with the Highways department who will also want to ensure clear bridges from a structural loading point of view.

Fig 11 River Stewardship Company with volunteers

The subject of channel clearance has required considerable joint working (WP1) between bodies to ensure reduced conflict over operations. The removal of huge numbers of trees has taken the channel from a verdant shaded corridor to one of a channel with low level vegetation. Although there have been lessons learnt regarding the need for more sensitivity to these operations there has been an increase in understanding regarding the special case of rivers in cities and the flooding problems caused by debris in the channel (Fig 12).

Fig 12 Ladys Bridge is vulnerable to blockage but is an historic feature of the city and has recently been renovated

2.5 Implementation

Whilst the delivery of Flood risk management work is supported through a number of means such as climate Adaptation strategy work for the city, emergency planning and the management of a Local flood risk management strategy, distinctly active work has been through the alleviation work discussed above.

The Phase 1 Sheffield Central Area Flood Protection (see separate report) has now been completed providing a 1 in 100 year standard of protection to the immediate communities. Recent modelling using the Comprehensive

flood review has shown that downstream impacts, through reducing out of channel flows, has also been achieved through this local scheme.

The remaining Lower Don Valley alleviation planning is in feasibility stage with scheme definition being finalised via testing through the comprehensive flood review model. The final scheme is likely to involve numerous bankside interventions with new defences, raising existing defences and the inspection and potential rebuilding of existing structures that will, under a protected scenario, become functioning defences having previously not been involved during high water events.

The resourcing of this scheme is through a combination of funding, some from central government (DEFRA) via the EA and some from Europe via the Department of Communities and Local Government. The remaining gap in funding is to be raised through a Business Improvement District (BID). All these funds have their own complexities. EA funding for flood defence is traditionally focussed on protecting residential properties. The Lower Don flood zone is almost totally made up of businesses so arguments ensue regarding the strategic economic benefits, such as key national industries. The low scoring of non-residential protection schemes in funding applications has been raised at ministerial level as other municipalities are struggling for the same reasons in raising funds from this source.

The ERDF requires sufficient economic drivers to warrant investment. Although the damages are being determined from the equivalent event to the standard of protection proposed through mapping land uses etc, ERDF requires more positive economic outputs such as removing barriers to investment and encouraging floor space use of unoccupied development.

The BID process appears to be the first use of this mechanism to raise funds for flood defence in England. This is a legally bound mechanism where affected businesses vote to support a business case focussed on flood protection. If 50% of businesses and 50% of total rateable value of businesses support the proposal then a levy is introduced on them through an uplift in their rates over a five year period. Included in this will be the capital works and maintenance monies to ensure the channel is maintained.

2.5.1 Surface water flooding

In 2010 a surface water flooding assessment was commissioned by the Sheffield City Council. This was resourced by central government in response to the 2007 events that purported to be significantly from surface water sources. This allowed identification of problems areas and provided the majority of work needed for the Preliminary Flood Risk Assessments required under the National Flood Regulations (EU Flood Directive). The summary of this study is that there were no significant areas of flood risk through surface water in Sheffield. The main problems were associated with culvert screen management.

However, during the feasibility study for the Lower Don river flood works it was decided to look at river/ surface water flooding interactions and to determine if solutions could be found to low point accumulations of surface water in the river flood areas. It was deemed logical to address both sources of flooding at the same time. Using the EA surface water flood maps and flood incident records, investigation has started into 9 key locations where actions could be taken.

Unfortunately due to the lack of historical joint working with Yorkshire Water, examination of

local sewer capacity issues is not taking place hence this work solely focuses on issues such as overland routing to the river. (Note that this is not required under the EU Directives)

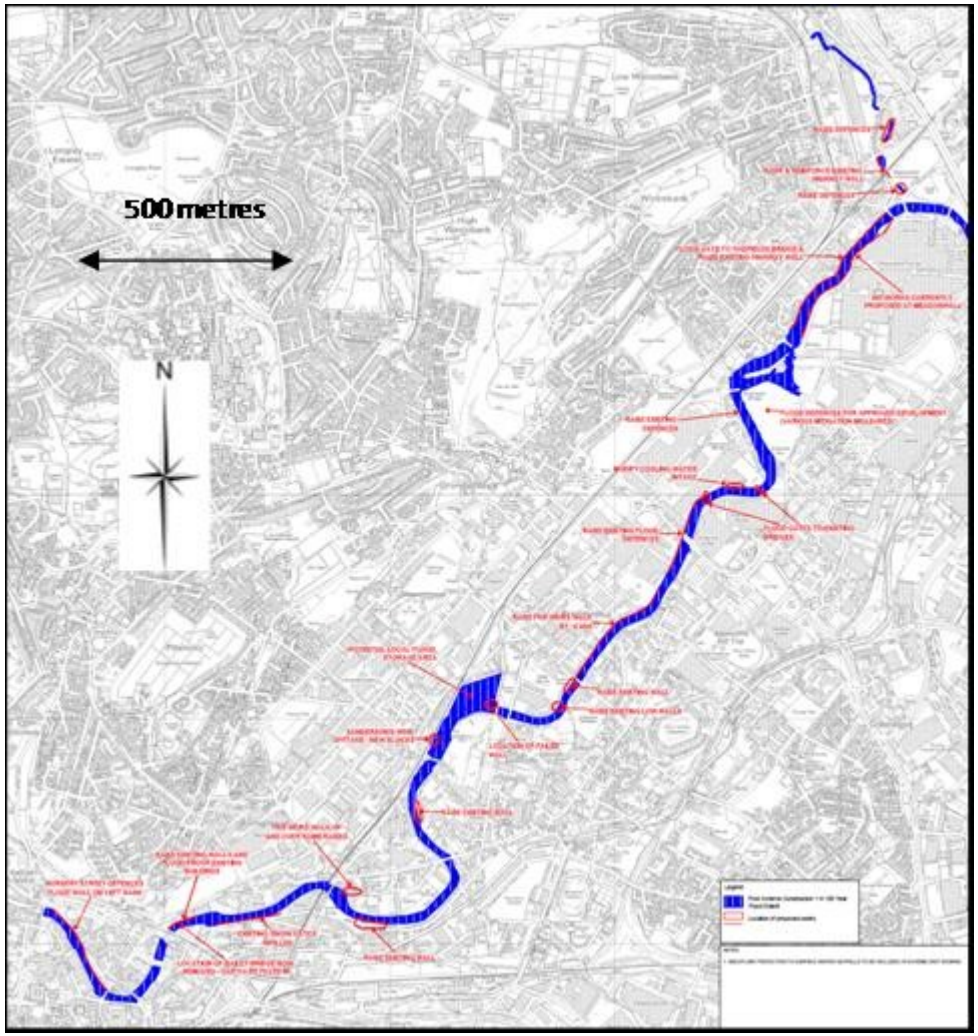
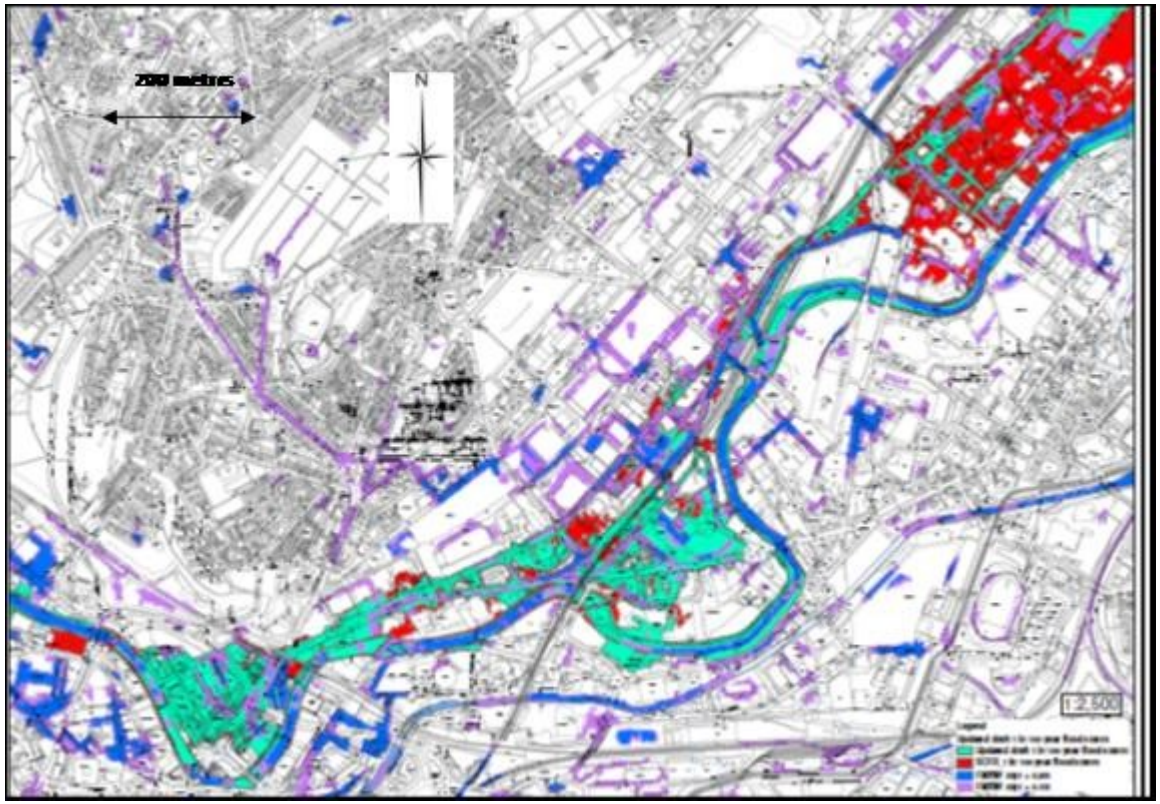


Fig 13 Plan of the Lower Don Interventions



Plan showing potential surface water flooding (purple and blue) (Source EA)

2.5.2 Reservoirs

The exploration of the use of reservoirs is being instigated now that the Sheffield Comprehensive Flood review has generated a Sheffield wide computer model. This study will seek to determine the range of storage volumes that would be beneficial down river. This information will be passed to Yorkshire Water who own and operate the reservoirs and who will determine the risks they will be subject to as a result of managing the freeboard on the top of the reservoirs. It may be concluded that storage should be permanently available and that compensation storage should be provided elsewhere. Cost benefit analysis will determine whether the damage reduction benefits warrant this level of expenditure. Bringing a new use in for the reservoirs on top of water supply and sustaining ecological base flows in rivers will require parliamentary approval as this would be a business change for a water company. Issues such as operational management responsibility and funding will also need to be resolved.

2.6 Performance and effects of selected option

As most of these interventions are yet to be built, actual onsite performance is yet to be determined. Calibration post flood events will be carried out to confirm modelling practice.

2.7 Difficulties encountered

Loss of knowledge within Sheffield Municipality associated with local government cuts has meant this project has suffered from a gradual reduction of expertise during design for flood risk management. This may have had an impact on continuity of input etc, for example in model changes impacting on design leading to difficult discussions with the community around lower standards of protection.

Existing infrastructure for example services, archaeology causing problems with design with numerous iterations and prolonged feasibility.

3 Review

3.1 Discussion

The Lower Don Valley flood risk management work associated with alleviation has been indicative of the partnership's strong focus on action after 2007. Rather than developing methodologies in assessment and decision making for measures to be rolled out over a number of years, the partnership has chosen to deliver schemes that provide obvious benefits. Although in hindsight this may mean missed opportunities or over investment, the realisable nature and immediacy of impact drove these interventions.

The schemes are understandable reactions to the need for addressing flooding in the context of Sheffield being in the upper catchment where rapid deep flows in valley bottoms occur. Towns further down the catchment have had to live with a different dynamic of flooding where defences are part of the everyday landscape. Reducing the flow within river is restricted to the limited level areas of the surrounding valleys which are predominantly already occupied with reservoirs so making room for the river through washlands is not something that Sheffield has as an opportunity to utilise.

Future strategies for flood risk management in Sheffield dealing with climate change impacts are likely to continue to look at maintaining standards of protection. The alternative of living with water in the city as a result of overtopping of defences and reduced standards of protection and adapting development accordingly is as yet not considered a viable option. Decisions to do this will be influenced by the short duration of flooding – deliberately designed flow paths may be preferred to wholesale urban infrastructure change. This living with water may become more of an issue if upstream storage proves not to be feasible. The present focus of limited resources is on giving protection to communities to today's 1 in 100 year and perhaps 1 in 200 year flood events. Although it is expected that residual risk is examined when building flood defences and that designs of buildings should cater for this, the Multi Level safety approach and the coordination needed associated with it is still in its infancy in Sheffield. The awareness of residual risk and the concept of overtopping is recognised in development circles, but this does not mean that it is a recognised in the wider community who naturally expect total protection when defences are proposed. This aspect of flood risk management and the potential for it to increase as a result of climate change is to be addressed through the Local Flood Risk Management Strategy.

3.2 Learning points

The development of Flood Risk Management strategies in Sheffield is iterative and consequently not necessarily perfected. Processes are influenced by unknown funding availability, incomplete information and scenario testing and variable drivers such as localised regeneration. In Sheffield like much of England this has been complicated by changes in responsibility which in part were stimulated by the considerable floods in 2007.

A lack of resources within Local Authorities and historic lead from the EA have meant integrated thinking about how urban areas will adapt in the future to increased flooding associated with Climate change is in its infancy. Putting in simple defences has been a huge learning exercise in itself for Sheffield. The lack of historic flooding events in living memory has reduced the awareness at all levels within all aspects of society including the Council. Hence it is still of low importance.

There is as yet no clear platform for decision making regarding maintaining standards of protection in the face of Climate change (MARE2). The outcome of the reservoir study will have considerable influence on this as it will lead to either management rules over reservoir levels for flood alleviation or a balancing act between lifting walls and accommodating more water in the city in exceedance (MARE3) if reservoirs prove not be a viable option.

Although resourcing for flood defence has been reduced, this can create opportunities for diverse funding sources delivering different integrated aspects of a scheme. This in turn can help to win arguments for long-term resourcing as the beneficiaries and value of benefits can be raised.