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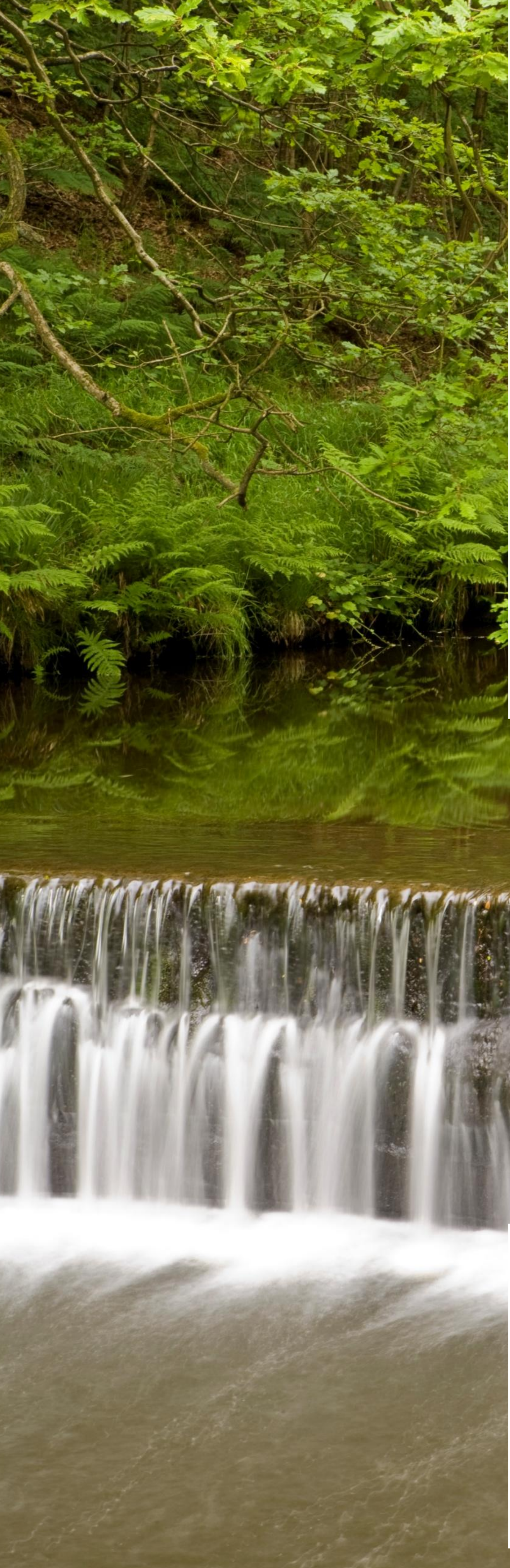

Understanding the Business Case for Surface Water Management Schemes in Comparison to other Flood & Coastal Schemes

Final

Research Report

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Purpose

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Executive Summary

The economics of schemes that address surface water flooding has only recently been described through the publication of the Surface Water Management Plan guidance notes. This has adopted the traditional Benefit Cost Ratio (BCR) approach used for fluvial flood and coastal schemes. These benefit cost ratios, together with Outcome Measures (OMs), are used to decide on the priority for funding when drawing down monies from the national Flood Defence Grant in Aid (FDGiA) budget.

The aim of this research is to provide a baseline analysis on why intervention options for surface water (SW) flooding risk appear to be less competitive than those used for fluvial and coastal flooding solutions. This study focuses on possible reasons why the economic viability of Surface Water Management Plan (SWMP) scheme options are low compared to fluvial and coastal schemes when using the standard Flood Risk Management (FRM) approaches to BCR and cost benefit analysis.

The problem of SW flooding is heavily associated with how urban areas have grown beyond the capacity of originally installed infrastructure.

In 2007/8 Defra commissioned 15 pilot urban drainage projects that aimed to:

- understand the causes of flooding in urban areas and the best ways of managing urban drainage to reduce flooding;
- examine the effectiveness of partnership working
- test the effectiveness of new approaches to urban flood risk management.

The pilots found that models and data are sometimes inadequate and can provide misleading evidence on which solutions to develop. The best solutions may be the most costly, i.e. when town centres and housing must be fully redeveloped.

Understanding the surface water flood risk organisational hierarchy can make partnership working and cross stakeholder improvements difficult to integrate and fund. However, the Flood and Water Management Act 2010 clearly defines roles and responsibilities particularly the lead role for local authorities and this should reduce such barriers. The conclusions drawn upon in this report provide lessons to better communicate the difficulties posed by cross stakeholder working, to better enable more integrated and multi-objective surface water management schemes to be developed.

The work revealed that surface water flooding is more difficult to model accurately because it can include sources difficult to identify and pin-point. Difficulty comes when modelling the topographical data for urban areas accurately.

It is important to point out when identifying surface water risks and mitigation options; site visits, historical and local knowledge from experts such as local drainage engineers can be more valuable than expensive and detailed modelling.

After the 2007 floods and the Pitt Review which recommended that SWMPs should be adopted in areas where surface water risk is high, six First Edition Surface Water Management Plans (FESWMPs) were commissioned to be worked upon in Hull, Leeds, Richmond and Kingston, Gloucester, Thatcham and Warrington.

Four SWMPs have been assessed in detail as part of this study and the two others summarised to support the findings.

In Gloucester, a solution attempting only surface water flood mitigation was not viable without resolving the fluvial flooding problem as well. Green Infrastructure and SuDs were discussed within the Gloucester options appraisal but these were found to be of little potential as there was a lack of available green space within the urban area. Gloucester decided to take forward a holistic solution to be assessed for economic viability. This resulted in a scheme a BCR of 1.84. This means the scheme is beneficial and is also economically sound, but it would be difficult to attract funding as the benefit is comparatively low. It also does not include the cost of works to be undertaken by Severn Trent Water on its sewers and the Environment Agency's work on culverts and main watercourses. The scheme seems to be expensive to implement when it is deemed to provide more protection to fluvial flooding than surface water flooding.

Highlighted in the Leeds pilot is the issue of how the partners work together, in setting objectives and sharing costs and benefits. It explains 'there is a complex legal framework within which the partnership operates to manage surface water, water quality etc. in urban catchments, including the requirements of

the Water Industry Act, 1991, for the maintenance of the sewer system which is carried out by Yorkshire Water'.

The roles of partners are firmly based on regulatory drivers, and could highlight the need for a strategic partnership approach to deliver this Leeds SWMP. The integrated option for controlling surface water flooding would be the best, unfortunately it is difficult to form such partnerships. The pilot concludes that linking partner objectives, working practices and sharing risks in SWMP schemes could be more successful and cost effective, therefore benefits much improved.

The Hull City Council SWMP had many options to improve the catchment area as a whole to mitigate surface water flooding. To test these, two areas of the catchment were considered in detail.

The findings demonstrated that overland flows were a significant contributory factor to surface water flooding. Therefore storage areas above the catchment area were seen as being the best option available to them. One of these options demonstrated a Benefit Cost Ratio of 3.23, and delivered a 1 in 50 standard of protection.

Again in Hull, smaller areas at risk than is common when tackling fluvial flooding results in smaller levels of damage being avoided, however the costs of building these schemes remains high and often higher than fluvial counterparts.

Again the major problem with such schemes is obtaining FDGiA funding because of low BCRs. It also means the many contributing partners involved will be less confident to invest into them. Only with the exception of Thatcham, which came out with an option scoring 6.38, has a strong case for significant levels of FDGiA been demonstrated. Risks avoided to key infrastructure had a significant impact in this example, plus the option reduced risk to 98% of the residential properties flooded in its most major flood event in 2007.

In conclusion, when one compares surface water schemes for relative value for money and approvals with fluvial and coastal schemes they do not appear to compare favourably. This means that surface water schemes may struggle to compete for funding in comparison with fluvial and coastal schemes, and may only attract partial funding under the new Flood and Coastal Resilience Partnership Funding approach announced by Defra in May 2011.

Institutional issues also militate against surface water schemes. These include; the availability and management of data from a range of organisations, existing relationships between the many parties involved in surface water management solutions, and the issue of how one isolates the impact of surface water flooding from fluvial sources.

However, it should be noted that this study looks at only four SWMPs in detail and therefore cannot be regarded as a comprehensive study. With further work and larger sample size a comprehensive research study may be required to obtain more of a representative sample. Early evidence from projects taken forward as part of Defra's Surface Water Early Action grant scheme suggest comparable benefit to cost ratio and cost per property protected metrics are possible with relatively small-scale, targeted capital investments.

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Abbreviations

AADs ....Annual Average Damages
AEP ....Annual Exceedance Probability
AStSWF ....Area Susceptible to Surface Water Flooding
BCR ....Benefit-Cost Ratios
FCERM ....Flood and Coastal Erosion Risk Management
FCRM ....Flood and Coastal Risk Management
FDGiA ....Flood Defence Grant in Aid
FESWMP ....First Edition Surface Water Management Plan
FRM ....Flood Risk Management
IDB ....Internal Drainage Board
IUD ....Integrated Urban Drainage
LAs ....Local Authorities
OM ....Outcome Measures
RFDC ....Regional Flood Defence Committee
SEA ....Strategic Environmental Assessment
SFRA ....Strategic Flood Risk Assessment
SMP ....Shoreline Management Plan
SoP ....Standard of Protection
SSSI ....Sites of Special Scientific Interest
SuDS ....Sustainable Urban Drainage Systems
SWMP ....Surface Water Management Plan
UPM ....Urban Pollution Management

1 Background to Surface Flood Water Management

1.1 Study Aims and Objectives

The aim of this research is to provide a baseline analysis on why intervention options for surface water (SW) flooding risk appear to be less competitive than those used for fluvial and coastal flooding solutions. This study focuses on possible reasons why the economic viability of Surface Water Management Plan (SWMP) scheme options are low compared to fluvial and coastal schemes when using the standard Flood Risk Management (FRM) approaches to Benefit Cost Ratios (BCR) and cost benefit analysis. Current evidence suggests that whilst investment in managing river and coastal flood risk delivers excellent value for money, with Environment Agency's capital programme delivering £13 in long-term (discounted) benefits for each £1 invested, early evidence suggests the investment case for managing surface water risk is more marginal, delivering typically around £2 or £3 in benefit for each £1 of cost[1]. This statement is further explored in section 3.2.7 which summarises the BCRs of the options considered as part of the schemes analysed. There are a number of exceptions however, particularly in the Thatcham scheme with an option generating a BCR of 6.48.

The research has investigated whether fluvial and coastal cost benefit techniques are comparable to surface water management schemes in order to understand the appropriateness of outcome measures when applied to SW projects.

The focus of this study has been to analyse whether the investment case for surface water flood risk management is being restricted using traditional flood defence approaches and economic analysis. The study also considers a number of design philosophies presented in the First Edition SWMPs, i.e. the management of the sources, receptors and pathways.

1.2 Political Drivers and Context

The 2007 floods brought into focus the importance of managing surface water flood risk, but current evidence suggests that whilst investment in fluvial and coastal schemes is excellent value for money, it also suggests that managing surface water risk is of a more marginal benefit, delivering typically £2 or £3 in benefit for every £1 in cost. Surface water flooding is caused by, and influenced by many different factors as we see below. To defend against all these causes can be challenging, and it is difficult to isolate the causes and impacts of the surface water flooding.

1.2.1 Pitt Review and the initiation of Surface Water Management Plans

Figure 1-1. Factors that cause and influence surface water flooding

The Pitt Review lists several factors that can cause and influence the likelihood of surface water flooding:

- Intensity of rainfall: rainwater drains away naturally over long periods of time, but if rain falls in intense bursts the drainage system may be unable to cope. The probability of this type of intense rainfall occurring in the future is likely to increase due to climate change.
- Location of rainfall: the direction of travel of surface water is directly influenced by the topography of an area. Small changes in the location of rainfall can have a significant impact on where the water ends up.
- Capacity and condition of the sewer and drainage system: this can affect the rate at which rainwater can drain away.
- Type of surface material: the permeability of surface material affects the amount of runoff. Urban areas are more susceptible to surface water flooding than rural areas because they are characterised by a significant quantity of impermeable areas.
- Saturation of the ground: if the ground is saturated, or even too dry, any rain that falls will be converted into runoff.

Source - Gloucestershire County Council (2010) Gloucester SWMP [online] http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-gloucester.pdf p13

[1] **http://archive.defra.gov.uk/environment/flooding/documents/policy/fwmb/fwmialocalfm.pdf** p32

1.2.2 Types of surface water risks

The first edition (FE) SWMPs identified numerous causes for surface water flooding.

Sewer Capacity: Sewers are typically designed with capacities up to a 1 in 30 year flood event. Because of this, when there are high levels of rainfall as in 2007, sewers will back up and surcharge onto the surface because the underground system capacity in place has been exceeded.

Backing up of sewers: Sewers can back up when discharge into watercourses is blocked due to high water levels in the receiving system.

Overland Flow: This results when water can no longer infiltrate the ground because its storage capacity has either already been filled due to soil saturation or the ground is impermeable due to natural or man-made processes. Overland flow is particularly common in urbanised areas, because of the high proportion of non permeable materials such as concrete. Surface water flooding events attributed to overland flow is normally felt on the urban/rural fringe due to disconnects between rural and urban drainage systems and changes in permeable surface areas.

Ordinary watercourse flooding: While not 'main' rivers, ordinary watercourses are important mechanisms for understanding surface water flooding and they cover a wide range of origins for flooding. Gloucester SWMP identified this type of flooding as a key issue with historical data showing that flooding frequently occurs from local watercourses because of surface water runoff into them.

Highway drainage: Culverts blocked by debris are not able to work at their full capacity to handle surface water runoff. Culverts have a significant impact on flooding risk. They receive most of their flow from inside urban areas and perform an urban drainage function.

The solutions to surface water flooding are generally limited and costly as identified in the first edition SWMPs - see section 3.2 for the approaches taken in Leeds, Gloucester and Hull. These case examples developed several different solutions to a particular problem. After BCRs had been understood and compared, it was common that only one option presented itself as being practical and cost beneficial.

1.2.3 Is surface water flooding less likely than other types of flooding?

According to the Foresight Future Flooding report of 2004, 80,000 UK properties are at a very high risk of SW flooding, this is set to rise with the increased risk of climate change. Of course these figures are estimates, but the 2007 floods demonstrate that a substantial amount of flood damage can be derived from surface water drains and sewers[2], this was particularly relevant in Hull and its outlying villages. The process of flood damage in many cases was that properties were flooded, firstly by surface water, and then by river water. Areas in Sheffield have demonstrated this situation, where pictures of the flooded city centre showed rivers still within their banks hours before river flooding commenced[3].

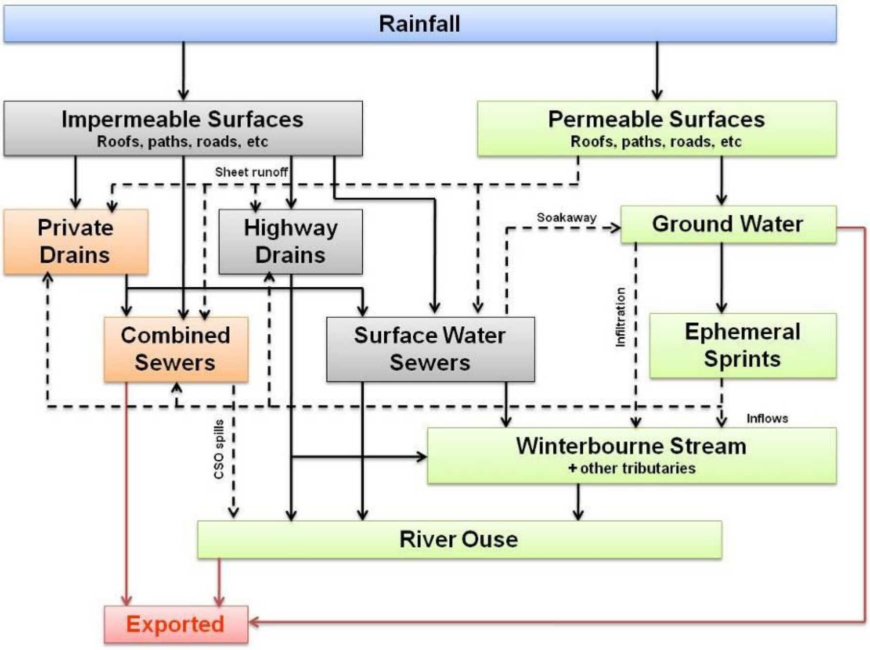
Error! Reference source not found.demonstrates that SW flooding can come from many different sources, making it difficult to pinpoint and prevent against the risk.

In the 2007 floods, it is generally accepted that SW flooding was a much larger contributor to damage than any other type of flooding. However, evidence at the national level is not as yet sufficiently mature to compare expected annual damages from surface water flooding with other types. In general, surface water flooding can be characterised as being more localised, affecting smaller numbers of properties at a time, and being of lesser depths and durations than fluvial and particular coastal flooding, where flood water can be several meters deep and remain in situ for many weeks. Hence, a risk-based (as opposed to probability-based) approach based on current evidence would support the Government's historical focus on fluvial and tidal flood risk.

2 http://publications.environment-agency.gov.uk/pdf/GEHO1107BNMI-e-e.pdf?lang=_e p3

3 http://publications.environment-agency.gov.uk/pdf/GEHO1107BNMI-e-e.pdf?lang=_e p14

Figure 1-2. Drainage processes within the Lewis catchment



Source: Defra (2008) IUD Pilot Summary Report [online] **http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/urbandrainagereport.pdf** p3

1.2.4 Who is involved? Stakeholder map

SW schemes may be costly because of the number of organisations involved in implementation, gaining approvals and meeting legislative criteria. This is possibly more critical than for other FCERM schemes. Table 1-1. Flood and coastal erosion risk management key stakeholders summarises the roles and responsibilities of all organisations in delivering FCERM. In most cases Local Authorities took the lead on SW schemes, a function of the responsibilities highlighted in Table 1-1. Flood and coastal erosion risk management key stakeholders

The Flood and Water Management Act 2010 details a new lead role for local authorities in managing local flood risk (from surface water, ground water and ordinary watercourses) with a strategic overview role for all flood risk given to the Environment Agency. This more clearly defines responsibility boundaries between these organisations. However due to the nature of the schemes, other organisations such as utility (water, sewerage and energy) companies, transport infrastructure companies, emergency response teams, businesses and landowners may be involved and contribute to delivering a SW scheme. Contributions may be other than financial and could include providing personnel skills, equipment or land in-kind. The Environment Agency's appraisal guidance supports the development of multifunctional projects and methods for identifying and working with potential third party contributors through coverage of all sources of flooding and erosion with an intention that organisations work together to manage flood or erosion risk[4].

[4] http://publications.environment-agency.gov.uk/pdf/GEHO0310BSDB-e-e.pdf p13

Table 1-1. Flood and coastal erosion risk management key stakeholders

Responsibility	HM Treasury, Defra, CLG, WAG	Environment Agency	Local authorities and IDBs	Water companies, reservoir owners and transport infrastructure	Emergency services, Met Office
Strategic planning	Policy development, funding, approval of projects (Treasury, WAG, Defra	CFMP, SMP	SMP (LAs), SWMP	Contributor	
Capital and Revenue Investment Planning		Main rivers, sea flooding, coastal erosion, approval of projects	Ordinary watercourses, coastal erosion	Sewer reservoirs	-
Capital Projects Delivery		Main river, sea flooding	Ordinary water courses, surface water, groundwater, coastal erosion	Sewer reservoirs	-
Operational Asset Management	-	main river, sea flooding, (may include riparian owners)	Ordinary watercourses, surface water, groundwater, coastal erosion	-	-
Development control (link to PPS25 and TAN15)	Development of PPS25 (CLG), TAN15 (WAG)	Contributor	Lead (LA) Contributor (IDBs)		
Planning Incident Response Planning	-	Joint lead	Joint lead	Critical infrastructure	
Flood Forecasting & warning	-	Lead	Contributor	-	Contributor (Met Office)
Mapping Flood Risk & Data Management	-	Main rivers, coast	Surface water	-	Contributor (Met Office)

Source: Environment Agency. (2010). Flood and Coastal Erosion Risk Management appraisal guidance [Online] http://publications.environment-agency.gov.uk/pdf/GEHO0310BSDB-e-e.pdf p13

1.2.5 Previous initiatives - IUD Report Findings

Prior to the Pitt Review the need for Integrated Urban Drainage Management approaches to be developed was recognised. The problem of SW flooding is heavily associated with how urban areas have grown beyond the capacity of originally installed infrastructure. It has been noted by others that to fully solve the problem there needs to be complete redevelopment of town centres and housing to 'make space for water'. However evidence suggests that schemes have been much more costly than if an integrated approach had been taken. Essentially the IUD pilots set out to understand the framework that a 'robust and integrated approach' could look like.

In 2007/8 Defra commissioned 15 pilot projects that aimed to achieve three things:

- To understand the causes of flooding in urban areas and the best ways of managing urban drainage to reduce flooding;
- To examine the effectiveness of partnership working between various drainage systems currently and how this partnership can be improved to find solutions to flooding problems, and;
- To test the effectiveness of new approaches to urban flood risk management, including: use of hydraulic models, SWMPs, Sustainable Urban Drainage Systems (SuDS) and the managed routing of drainage exceedance flows[5].

5 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/urbandrainagereport.pdf p3

The driver behind these pilots was the Government's flood and coastal erosion risk strategy, 'Making Space for Water'. It was this that set the framework to move forward approaches which ensure that flood risks are managed more effectively in the future by adopting an holistic, joined-up, and integrated approach. In addition the 2007 floods provided huge impetus for the UK Government to be seen to be working towards better solutions for SW Management in the UK. The Integrated Urban Drainage pilots provided an evidence base which supported the subsequent guidance and initiatives to develop SWMPs.

In summary, the pilots found that models and data are sometimes inadequate and can provide misleading evidence on which solutions to develop. Understanding the SW flood risk organisational hierarchy can make partnership working and cross stakeholder improvements difficult to integrate and fund. The best solutions may be the most costly, i.e. when town centres and housing must be fully redeveloped. In addition there is a skills gap within local authorities who have a key role to play in such schemes.

2 Funding Surface Water Schemes

The SWMP Guidance issued by Defra suggests that the standards used in fluvial and coastal schemes should be used for SW economic assessment. Guidance such as the 'The Benefit of Flood and Coastal Risk Management: A handbook of assessment techniques' assists practitioners on how to measure the impacts of flooding. The inputs to an economic appraisal are:

- Damages – currently SW flood projections contain a high degree of uncertainty compared to fluvial schemes as the modelling techniques are less well developed and the spatial resolution is difficult to achieve for localised flood risk. Flood depths tend to be low, and generate limited damages, which may not reflect; the frequency of occurrence, its impact on the householder and the contamination risks associated with the mix of foul and surface water that inundates the property.
- Scheme costs – SW schemes appear to be complicated, involving many parties in an urban environment compared to fluvial schemes. SW sources and pathways are difficult to isolate and SW schemes will invariably involve tackling ordinary watercourse flood mechanisms etc. A traditional engineered approach is often costly if the proposed standard of service attempts to reach parity with fluvial schemes.

2.1 Cost Benefit Analysis Principles and Government FCRM Funding

If a flood and erosion risk management scheme is to be considered for funding through Government FCRM funding it must have a BCR greater than 1. It is important when meeting funding criteria that the costs and benefits of a particular option are fully understood. This is particularly important when meeting the FDGiA funding requirements; as highlighted in the Environment Agency's FCRM Appraisal guidance.

The FCRM funding pot includes a number of sources, including Flood Defence Grant in Aid (FDGiA) from Defra, Local Levies and general drainage changes (raised by RFDC's) and Internal Drainage Board (IDB) levies. The amount available through FCRM is however not enough to pay for all the schemes that have a cost/benefit ratio more than 1. Therefore the Environment Agency has in recent years used Defra's 'Outcome Measures' (OM) as a framework to help prioritise which projects will be funded. For example the OM scoring includes the following benefits, damages avoided, benefit to local property, businesses, public amenity, local social assets, biodiversity benefits etc. However, OMs do not form part of the individual project appraisal or determination of the preferred option, it aids in developing investment programmes and performance monitoring[6]. The Environment Agency currently uses Defra OM to help develop this, see Table 2-1. **Targets set for 2008-2011**

It is worth noting that during the previous Spending Review period, OM1, 2, 3, 4 and 5 were used explicitly in prioritisation of investment choices. Although OM 1, 2 and 3 are more relevant to SW schemes, predominantly being located in urban areas, it is fair to say that they do not reflect the full range of drivers that can impact on a SW scheme, most notably benefits to utilities (electricity, sewerage), transport (rail/road) and to business/commercial centres.

The benefit to cost ratio is vitally important to the success of achieving funding from FCRM sources. The cost benefit ratio of a proposed scheme is estimated at the time of grant application, however it is important to note this is an estimate, and the whole life cost of a scheme can fluctuate. The whole life cost (the 'cradle to grave' cost) of a scheme may change over time, both through its development (through partner negotiation) and long after the scheme has been constructed, for example due to maintenance cost changes, or modifications to the scheme (more likely for surface water schemes in urban locations). The Environment Agency (through its Contributions Policy) promotes projects with external contributions from the private sector, the public sector (non-FCRM) where joint flood risk benefits can be achieved, such as improvements of national infrastructure or sustainable development. Essentially the contributions policy defines an external contribution as any non FCRM source. It is only through working in partnership that many of these external contributions can be achieved. In many cases funding brings additional benefits in terms of reduced cost to government, and an increase in benefits and therefore an increase of OM Scoring.

With low benefits and high costs the economic case for SW Management schemes will always struggle, this assumption was explored in more detail when looking at the Leeds, Gloucester and Hull FESWMPs section 3.2.

6 http://publications.environment-agency.gov.uk/pdf/GEHO0310BSDB-e-e.pdf p12

Table 2-1. Targets set for 2008-2011

Outcome Measure	Definition	Minimum Target
OM1 Economic Benefits	Average BCR across the capital programme based upon the present value whole life costs and benefits of projects delivering in the CSR07 period.	5 to1 average with all projects having a BCR robustly greater than 1
OM2 Households protected	Number of households with improved standard of protection against flooding or coastal erosion risk.	145,000 households of which 45,000 are at significant or greater probability
OM3 Deprived households at risk	Number of households for which the probability of flooding is reduced from significant or greater through projects benefiting the most deprived 20% of areas.	9,000 of the 45,000 households above
OM4 Nationally important wildlife sites	Hectares of SSSI land where there is a programme of measures in place (agreed with Natural England) to reach target condition by 2010.	24,000 hectares
OM5 UK Biodiversity Action Plan habitats	Hectares of priority Biodiversity Action Plan habitat including intertidal created by March 2011.	800 hectares of which at least 300 hectares should be intertidal
Source: Defra (2009) Investment Targets [online] http://archive.defra.gov.uk/environment/flooding/funding/targets.htm		

2.2 Damages

To understand and map the flood extent and resultant damages of many sources of flooding, extensive 2d modelling is the best method. This is widely used for fluvial sources as reliable results are achievable; it combines fluvial flooding records with well modelled data to produce accurate flood maps. Surface water flooding is more difficult to model accurately because it can include sources difficult to identify and pin-point. Difficulty comes when modelling the topographical data for urban areas accurately.

To identify surface water flooding apart from the use of historical data, new techniques have been developed to identify 'hotspots' of flooding which can be useful for new development in accordance with PPS25. The methods are called rolling ball analysis and direct rainfall methods, which can highlight areas which are susceptible to high rainfall[7]. This has been consolidated by the Environment Agency into their Areas Susceptible to Surface Water Flooding (ASTSWF) map, which can be used as a base by any local council to take on a more detailed assessment of surface water flooding in their catchment, as they can predict areas most at risk. Direct rainfall modelling has shown to be a very effective approach that can provide a preliminary indication of surface water flood risk over wide areas, allowing local councils to focus their resources much more efficiently[8].

Detailed models which have been produced consider surface flows, resulting from drainage exceedance, they also incorporate fluvial flooding which is outlined in the IUD pilot schemes as being the best approach to take to obtain a clearer picture of what solutions should be undertaken[9]. As the SWMP guidance points out however, quantifying current and future flood risk can be demanding and time consuming on computer systems. But it is this that is required to work out Annual Average Damages (AADs) to best inform flood risk option deployment. AADs are used to calculate the benefits of flood alleviation compared with the schemes cost. This method borrows heavily from Defra's appraisal of flood and coastal risk management and is used for fluvial and coastal flooding to decide on the most suitable scheme for a large area. This is however limiting for SW flood risk which cover much smaller areas and chosen for detailed modelling after strategic and intermediate assessments. Defining only small areas and using the AAD will mean that the damages will be relatively less than those from over a large fluvial at risk area i.e. a county being modelled for fluvial flood risk.

There is an economy of scale when dealing with large flood cells, the typical measure being flood protection of properties. In SW schemes it appears that a disproportionate effort is required to reduce the risk for small numbers of properties when compared to much larger schemes. Fixed preliminary costs

7 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp-guidance.pdf p32

8http://www.ciwem.org/media/144588/Broad%20Scale%20Surface%20Water%20Flooding%20Mapping%20Paul%20Eccleston%2007072010.pdf

9 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/urbandrainagereport.pdf p17

such as working within property boundaries, working within the highway, dealing with utility services all can make SW schemes pound for pound much more expensive.

For the actual modelling there are four approaches and as the guidance points out, choosing a method (or methods) is a difficult process and somewhat iterative.[10] It is clear that it is hard to model surface water flooding and it is a costly process involving experienced hydrology modellers, purchasing of data and a lot of time for such models to run.

It is important to point out when identifying SW risks and mitigation options; site visits, historical and local knowledge from experts such as local drainage engineers can be more valuable than expensive and detailed modelling.

The proposed solutions for SW FRM have to date been limited and costly as illustrated by the first edition SWMPs undertaken by local councils. A wide and holistic approach to the solutions was not evident, and this may explain why the BCRs are largely low, except in the instance of Thatcham. The studies demonstrated several different solutions that could be developed, but usually few demonstrated value for money. Solutions were costed and BCRs assessed with little preconceived knowledge of the outcome. A very traditional method was undertaken, with high design standards desired which with hindsight may have been unrealistic. Optimisation on value for money in delivery and design standards and whether a hybrid approach of capital works and resilience would all yield a more viable solution should be explored further. A degree of rethinking how these problems are solved is needed. Engineered solutions at the point of risk are always going to be costly, whilst looking at source control was limited in many of the FESWMPs.

2.3 Mitigation Measures Identification

After the 2007 floods and the Pitt Review which recommended that SWMP s should be adopted in areas where surface water risk is high, six FESWMPs were commissioned to be worked upon in Hull, Leeds, Richmond and Kingston, Gloucester, Thatcham and Warrington. They were instigated by Defra to be carried out from Jan – Oct 2009 to test the living draft SWMP guidance and to provide a working example for stakeholders that can best assist them in their own SWMPs.[11]

For the purpose of this report, four SWMPs have been assessed in detail while the other two have been summarised with the relative evidence taken to support the argument given.

The SWMP guidance states that it is important to classify where the main risk of flooding originates for a given area and to understand how the local authorities could tackle the problems identified. Each of the FESWMPs took an individual and tailored approach, which makes it difficult within this study to make direct comparisons. The pilots are interesting in that they identify the same types of risks, but develop different options and measures to address these. To consider which measures the local authorities should use to protect against SW risks the pilots prioritised the following elements (see Table 2-2. FESWMP Overview of Mitigation Measures).

10 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp-guidance.pdf p46 & 47

11 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp-guidance.pdf Background

Table 2-2. FESWMP Overview of Mitigation Measures

	Classification of flood mechanism	Solving main or watercourse problems	Options looked at integrated approach	SoP selected	Overland flow routing looked at
Hull	Rural run off, available storage in network, urban flow, filling up of drainage network	Mostly looks at the small watercourses, being careful not to select the ordinary watercourses that any of the overland flows would run into so didn't affect the results	Separates different flows to try and highlight the individual causes of surface water flooding, especially the pooling in urban areas	100 year standard of protection was used in the detailed models for each area	Flow routing was looked at as a major solution for the pooling of water in the town
Gloucester	Culverts blocking, fluvial and pluvial contributing to SW flood risk, sewer and watercourse problems	Considered both, evaluating those most SW problems will come from fluvial flooding, thus looking at local watercourses	Gloucester look at a fully integrated approach with fluvial, pluvial and surface water flooding from drain overflow and run off	2-1000 years was modelled for integrated solutions, then SoP 100 was used in the detailed models for the 3 options	Overland flow routing not considered, more emphasis put on fluvial and storage solutions upstream
Leeds	Surface water draining to the combined system, culverts, water flow overland, blockages and failures in sewers and culverts, backing up of water	Looked at the Wyke beck as a source of flooding, as it accounts for the majority of the damages in the associated area	Leeds tried to concentrate on solving the issue of surface water flooding	SoP of 1 in 10 year to 1 in 200 year events to defend against	Flow routing/green infrastructure was the option that was considered in the shortlisted measures
Richmond and Kingston	Fluvial, pluvial, surface water from below ground drainage, excess flows	Considers the fluvial problems in the area	Models an integrated approach with all causes of flooding	SoP of 1 in 25 years, 1 in 100 years and 1 in 200 year events are used	In one of the areas considered, overland flow routing is considered
Thatcham	Sewers, overland flows from urban fringe, urban watercourses, highway drainage, urban green space, rainfall, surface water run off from heavy rainfall	Looks at the problem of the main watercourses	The fully integrated option was considered as being the best way to model all the damages from the sources of flooding	SoP of 5yr, 30yr, 100yr, and 100+CC	Main rural overland flows are considered as being an essential part of surface water flooding in Thatcham and are looked at in 3 options

3 Surface Water Management Planning and Approaches

3.1 Understanding SWMP Modelling Approaches through Case Study Analysis

Gloucester Case Study

The approach taken for the Gloucester SWMP initially modelled the whole catchment area including several watercourses. It focused on using a 1 in 200 annual event approach to find the areas that were most at risk within the catchment. When Gloucester reached what was known as the 'intermediate modelling stage', they divided the catchment into four sub areas. They found that a properly conveyed sewerage system and embankment culverts were helpful in alleviating flooding. They also produced an integrated model to thoroughly test SW flooding, including specific sections of the city where it was felt the need for SW solutions was greatest.

The integrated model combined sewer and watercourse risk. Modelling was undertaken at 60 and 600 minute intervals at SoPs (Standard of Protection) of 2, 5, 10, 25, 50, 75, 100, 200 and 1000 years. The main watercourse that runs through the city, which is not specific to the SWMP guidelines, was included in the modelling work. The resultant risk maps depict the flood risk arising from all sources. It suggests that culverts becoming blocked is one of the main factors that leads to SW flooding.

Hull Case Study

In Hull the SWMP was used to update the SFRA produced to provide a clearer understanding of flood risk in the area. To model this approach, the SW Management planners split the catchment up into six areas for their first round of modelling, which was undertaken using a 1% Flood Event. After they had considered the costs associated with flooding in each area they took two areas forwards for further examination.

3.2 Summary of Schemes

3.2.1 Gloucester First Edition Surface Water Management Plan Measures

"Upon completion of the fully integrated urban drainage model of central Gloucester, the project progressed to the options identification stage, with a view to testing options for surface water flood risk alleviation and subsequently identify a cost beneficial option (or range of options) that would reduce surface water flood risk in the area. It was agreed that a 1 in 100 year standard of protection would be sought"[12].

In Gloucester a 100 year SoP has not been used to develop a surface water management solution. The study found that water companies and highway authorities are generally only willing to protect to a 1 in 10 year standard. This is because if a 1 in 100 year flood event occurred, the main cause would be from fluvial sources and there would be no way of isolating the surface water problem. When modelling was completed:

"it became clear that surface water flooding arises within the study area when flows are greater than the capacities of the watercourses and surface water sewers (with a high degree of interaction between the surface water sewers and the watercourses) or directly from the watercourses as fluvial flooding"[13].

Based on the evidence Gloucester came up with three options, shown below:

- Storage: This option was considered as a prevention measure, storing water as far upstream as possible. This was the lowest ranked option due to the presence of a SSSIs and an upstream designated development site.
- Improve Conveyance: This option looked at increasing the capacity of culverts, to prevent overspill from the two main watercourses in Gloucester designed to prevent fluvial flooding. This option was not ranked highly as Gloucester required an integrated solution.
- Local Defences: This option was impracticable because most watercourses ran behind people's houses, rendering it difficult to erect defences. This option also was deemed not to solve SW flooding.

The Steering Group had major concerns over these options, *"...the options focused on watercourse and sewer improvements. It was questioned whether options should focus on the risk areas outside of the*

12 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-gloucester.pdf p37

13 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-gloucester.pdf p39

fluvial flood map and should not include interventions on main rivers or water company sewers. It was subsequently considered that the surface water risk areas outside the fluvial flood risk map arose due to incapacities in the watercourses and sewers, therefore interventions on main rivers or sewers would be required to provide the drainage capacity to alleviate the risk" [14].

In summary this demonstrates that a solution attempting only surface water flooding in Gloucester is not viable without resolving the fluvial flooding problem as well.

Green Infrastructure and SuDs were discussed within the Gloucester options appraisal, and these were found to be of little potential as there was a lack of green space within the urban area. In addition SuDs retrofitted in an urban environment would not be able to contain a SoP of a 1 in 100 year event. It is suggested that in most cases a SoP of 1 in 100 is too high for SW flooding solutions and would usually concentrate on fluvial flood events and the effects of run-off, instead of isolating the backing up of drains and the problems. SuDs would be most suited to an upstream SW management solution.

Gloucester decided to take forward a holistic solution to be assessed for economic viability. This included interventions on main rivers and the fluvial system rather than the SW system. All partners acknowledged the technical difficulties of trying to artificially separate individual components of the complex flooding mechanisms.

"As with the initial options modeled, it was identified that many elements of the holistic solution included interventions on main rivers and the fluvial system, which had the effect of indicating that the solutions focused on solving fluvial flooding rather than surface water flooding. All partners acknowledged the technical difficulties of trying to artificially separate individual components of the complex flooding mechanisms, which a considerable amount of effort had been used to model holistically" (Gloucester SWMP p42).

As is stated most of the initial options modelled focused on upstream curtailing of fluvial events. This does not help find the best solution for surface water management, especially with costs being so large.

Cost and benefits of the proposed option

The total cost of the preferred scheme put forward for implementation is estimated at £53 million. Using the same intermediate modelling as was used before to calculate damages, the improved option shows a benefit of £97.53 million in terms of damages avoided over the life of the scheme. This gives the scheme a BCR of 1.84. This means the scheme is beneficial and is also economically sound, but it would be difficult to attract funding as the benefits are comparatively low. It also does not include work to be undertaken by Severn Trent Water on its sewers and the Environment Agency's work on culverts and main watercourses. The scheme seems to be expensive to implement when it is deemed to provide more protection to fluvial flooding than surface water flooding. While, as Gloucester found out, it is hard to separate such activities, the fact that Gloucester has used flood defences and culvert control means that it is looking at a wide area, focusing on source control rather than the urban defence.

The problems that they were faced were clear: *"In central Gloucester that meant putting right the mistakes of the 'Victorian past' to reduce the current surface water flood risk will involve significant intervention, made difficult by historic development and space constraints. It was recognised that partial solutions are likely, through new developments, particularly urban regeneration, by applying the principles of PPS25 and Making Space for Water and incorporating source control techniques*. It is understood that *"this is a significant long-term aspiration, unlikely to be realised in the short-term"*[15], this shows that while the optimum solution is to extend drains and sewers, it is not cost effective to consider. It was also found that, *"Time and budget constraints precluded the determination of an optimum holistic solution". It is therefore recommended that future work is undertaken to determine this. In addition, this project has not assessed constraints to the options including Strategic Environmental Assessment (SEA), planning permission and so on, which need to be considered as part of any future cost-benefit analysis or future feasibility study of any aspects of a solution"*[16].

3.2.2 Leeds First Edition Surface Water Management Plan Measures

"Catchment wide damages (total damages and AAD) and the number of properties at risk have been calculated using the 1 in 10 (10%) and 1 in 30 (3.33%) probability events (based on Yorkshire Water Urban Pollution Management (UPM) model outputs routed using JFLOW) and the 1 in 100 (1%) and 1 in 200 (0.5%) probability events based on rainfall routing modelling using JFLOW for both the current and future scenario" (Leeds p19).

14 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-gloucester.pdf p41
15 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-gloucester.pdf p42
16 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-gloucester.pdf p45

Leeds County Council modelled four different probability events with some existing data plus the use of JFLOW. They realised that Surface water flooding was a difficult problem to pick up by itself without any other types of flooding being brought into the model. They also state that*: "The results for the 1 in 10 (10%) and 1 in 30 (3.33%) are known to underestimate risk since they only take into account flood risk from the combined sewer network and not from other sources of flooding, including surface water sewers, watercourses and overland flow, hence there is significant uncertainty associated with these results" (Leeds p20) and also that "The results for the 1 in 100 (1%) and 1 in 200 (0.5%) are likely to be overestimating flood risk since the rainfall routing modelling also picks up properties affected by fluvial flooding in the catchment."* Hence making it difficult to isolate surface water flooding entirely, and also why many of these FESWMPs have options to control watercourses as well as trying to solve the problem of surface water flooding (Table 3-1. Potential measures for reducing flood risk at South Parkway).

Table 3-1. Potential measures for reducing flood risk at South Parkway

Type of measure	Measure proposed	Description
Source control	SuDs retrofit	Retrofitting existing communities with SuDs, such as swales
	Strategic storage in open space	Providing storage in areas of existing open space
Designing for exceedance	Local property level defences	Buds or walls around small groups of houses to divert exceedance flows
	Opening up flowpaths using micro-engineering and green infrastructure	Removing obstructions in the landscape, such as kerb raising, roof or footpath reprofiling and routing through green infrastructure where possible
Sewer separation	Sewer separation	Separating out flows into combined and surface water sewers
	Sewer separation with storage	Separating out flows into combined and surface water sewers and providing storage for surface water
Increasing capacity	Sewers	Increased sewer sizes
	Culverted watercourses	Increased culvert size or opening up culverted watercourses
Other structural measures and non-structural measures	Pipe and overland diversions	Diverting culverted watercourses / sewers away from known flood hotspots
	Flood awareness, forecasting and warning	Flood response and business contingency planning, awareness raising and setting up and maintaining a local surface water flood warning scheme
	Flood fighting and emergency response	Emergency works, using temporary barriers, pumping, rest centres, traffic management and help lines
	Resistance	Property level resistance measures such as floodgates on doors and airbrick covers
	Resilience	Property level resilience measures such as changes to finishes and raising electrics
	Spatial planning and development control	Drainage strategy for redevelopment - this has been considered separately as part of the delivery of regeneration in the area`
Source: Leeds City Council (2009) Surface Water Management Plan [online] **http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf** p29		

These were the options considered to help control surface water flooding in the Leeds area. As is shown in Appendix E of said FESWMP[17], not all these options are viable to take forward, as they are not beneficial in categories such as reducing flood risk, cost beneficence, sustainability and predictability of outcome. As not all these options scored positive marks only a few options are brought forward into the short list for testing (see Table 3-2. Short-listed measures).

[17] http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf

Table 3-2. Short-listed measures

Option	Option proposed
	Do minimum
1	SuDs retrofit
	1a retrofit to 30% of catchment
	1b retrofit to 60% of catchment
	1c retrofit to 90% of catchment
2	Strategic storage in open space
3	Local property level defences
4	Sewer separation with storage
5	Deculverting and storage
6	Opening up flowpaths using micro-engineering and green infrastructure
7	Flood awareness, forecasting and warning
8	Flood fighting and emergency response

Source: Leeds City Council (2009) Surface Water Management Plan [online] **http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf** p30

Once again, some of these options such as local property level defences focus on ordinary watercourses and their role in the wider strategy to reduce flooding in the catchment. In Gloucester it is difficult to ascertain whether surface water flooding is totally responsible for urban flooding by itself, so it is likely that any actions taken within a catchment must focus on an integrated solution.

Highlighted in the Leeds SWMP is the issue of how the partners work together, in setting objectives and sharing costs and benefits stating that, *"there is a complex legal framework within which the partnership operates to manage surface water, water quality etc. in urban catchments, including the requirements of the Water Industry Act, 1991, for the maintenance of the sewer system (which is carried out by Yorkshire Water). The action carried out by the Environment Agency and Leeds City Council is minimal routine and emergency maintenance carried out by both organisations for main rivers (Environment Agency) and ordinary watercourses and the highway drainage network (Leeds City Council) across Leeds"*[18].

The roles of partners are firmly based on regulatory drivers, and could highlight the need for a strategic partnership approach to deliver this SWMP. This is why, although the integrated option for controlling surface water flooding would be the best, unfortunately it is difficult to form such partnerships. But by linking partner objectives, working practices and sharing risks the SWMP schemes implemented could be more successful and cost effective, therefore benefits much improved.

Cost and benefits to the improve options

Leeds took forward their shortlisted measures for economic analysis, and surprisingly it was found only one option had a net present value that was positive and a benefit cost ratio above 1. The Leeds SWMP solutions had a strong Green Infrastructure element but the societal and environmental benefits were not included, which of course have good potential to enhance the benefits of urban SW FRM schemes. This is shown in Table 3-3. Net present value and benefit-cost ratio below:

18 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf p30

Table 3-3. Net present value and benefit-cost ratio

Option	PV of benefits (£)	PV of costs (£)	NPV (£)	Benefit-cost ratio (£)
0: Do mimimum	0	996,411	-996,411	0.00
1a: retrofit to 30% of catchment	1,448,583	4,929,318	-3,480,735	0.29
1b: retrofit to 60% of catchment	1,175,938	6,975,243	-5,799,305	0.17
1c: retrofit to 90% of catchment	2,215,463	9,290,934	-7,075,450	0.24
2: Strategic storage in open space	1,077,941	8,056,448	-6,978,507	0.13
3: Local property level defences	2,659	1,258,079	-1,255,420	0.00
4: Sewer separation with storage	927,842	7,660,891	-6,733,049	0.12
5: Deculverting and storage	594,824	3,489,478	-2,894,654	0.17
6: Opening up flowpaths using micro-engineering and green infrastructure	1,472,199	1,195,449	276,749	1.23
7: Flood awareness, forecasting and warning	351,361	2,150,274	-1,798,913	0.16
8: Flood fighting and emergency response	297,852	2,268,236	-1,970,384	0.13
Source: Leeds City Council (2009) Surface Water Management Plan [online] **http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf p32**				

Even the option that was proposed as being economically viable in the short term, with further testing was rendered as being economically unsound in the future with negative net present values, using the sensitivity of BCR to appraisal period, but this curve projects BCR 100 years into the future. All other options are discounted because costs outweigh the benefits of these measures, and therefore can't be taken forward. For the option that could be taken forward, (open up flow paths using micro-engineering and green infrastructure) it is the lowest cost option (apart from the do minimum, which the SWMP argues should be discounted) and is also environmentally friendly. This option would create a safe flow for exceedance in parts of the catchment, but the SWMP is quick to point out that this should be done with the option to re-examine other measures and possibly use some of these in tandem to produce the most efficient way of defending against surface water flooding.

"This pilot has demonstrated that there is low cost: benefit scores for options to manage surface water flooding. Local determination to 'get things done' following frequent flooding alongside the investment though AMP4 and AMP5 by water companies to reduce flooding to those on the DG5 register need to be explored outside of a standard cost: benefit assessment. Cost: benefit assessment should only be undertaken if it is required."19 As was set out in the methodology for this report, the BCRs for surface water management are comparatively low to fluvial and coastal defences. It is arguable, as is shown in the quote that BCR could be irrelevant in this case as although economically the benefits are low compared to saving thousands of homes from major flooding in fluvial schemes, but it is the surface water that can produce the damage to such things as the electrics in the house, and also cause the people who live within the area a stressful environment to cope with because they will have to protect themselves from flooding. The major problem with such schemes is the funding because of the low BCRs. As they are low, it means the many groups that are involved in such a measure will not be so confident to invest into them. It is noted that *"Legislative changes are needed so that the most sustainable option can be delivered for surface water management in urban areas that can be delivered through appropriate contributions from the local authority, Environment Agency and Water Company"*[20].

3.2.3 Hull First Edition Surface Water Management Plan Measures

Hull City Council had many options to improve the catchment area as a whole to mitigate surface water flooding:

1. Preventing increase in run off by using semi-permeable materials for paving and the introduction of water butts to intercept roof drainage (under investigation for the community as a whole)
2. Increasing the number of road gullies however because of limitations of modelling it is not known whether this would have a positive effect. It would also involve extensive disruption in urban areas through the installation of such gullies.
3. Strategic Interception of Surface Water to be used in conjunction with Storage areas and balancing ponds. The purpose of storage areas and balancing ponds is to delay the entry of

[19] http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf p34
[20] http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-leeds.pdf p35

surface water into the conveyance system releasing stored water slowly once storms have passed. Due to the hydraulics, storage areas need to be formed below the level at which the water is collected i.e. road level. The presence of land suitable for such balancing ponds and storage areas in existing urban areas is often scarce and they can pose a public health risk. Water collected will need to be free of sewage contamination. Stored water may also need to be pumped out into the existing drainage system

4. Soakaways and filter drains to store water below the ground in perforated chambers. Like the problem with gullies, to try and do this in an urban area would cause disruption and is likely to be an expensive choice.

To test these concepts, they decided to look at 2 areas of the catchment, and "*To confirm the finding that overland flows contributed significantly to the flooding problems in Derringham and Orchard Park"* (Hull p30) The findings demonstrated that overland flows were a significant contributory factor to surface water flooding in the town. Therefore Storage Areas above the catchment area were seen as being the best option available to them. This option has been progressed, Defra, the Environment Agency and Hull City Council committing funds for their 'Aqua Greens' project.

Two different storage areas were considered involving, detailed modelling on each to ensure that each would solve the problem. Economic analysis on each followed. In Derringham only one storage option was viable. *"This option would utilise Springhead golf course as a storage area intercepting the major flow paths from Willerby across the golf course. After a storm event had passed stored flows would be released into Sands Dyke which runs through the golf course. This option has a marked influence on flood extent and flooding depths within Derringham with extent, depth and resultant damages being reduced significantly"* and the BCR table is shown below (see Table 3-4. Benefit cost ratio for Option 2 within Derringham)

Cost and benefits of the proposed options

As we can see, this storage option is economically viable, and protecting against the 1 in a 100 year event has the best BCR. Of course these are only estimated figures, done by estimating the cost of the work to carry out these storage areas but as we see the average benefit/cost ratio is low, certainly compared to fluvial and pluvial options. As has been found with the majority of such schemes it is based on a much smaller area than fluvial flooding ones and therefore they are proportionality smaller damages that are avoided, but the cost of building these defences is also higher than the fluvial counterparts.

Table 3-4. Benefit cost ratio for Option 2 within Derringham

Do Nothing	Storage 4% AEP	Storage 2% AEP	Storage 1% AEP	Storage 0.5% AEP
PV costs PVc (incl. Optimism Bias)	0	11,851,284	13,683,906	16,210,911
PV damage PVd	21,323,208	9,300,447	6,915,736	3,096,974
PV damage avoided	0	12,022,760	14,407,472	18,226,234
PV assets PVa				
PV asset protection benefits				
Total PV benefits PVb	0	12,022,760	14,407,472	18,226,234
Net Present Value NPV	0	171,476	723,566	2,015,323
Average benefit/cost ratio		1.01	1.05	1.12
Source: Hull City Council (2009) Surface Water Management Plan and Aqua Green Project [online] **http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-hull.pdf** p37				

Hull ran a model on an option for Orchard Park which had already been identified as an 'Aqua Green' space for storing surface water run off. They proposed that an embankment be built to divert flood water towards the aqua green space so "stored flows would be slowly released into Cottingham drain which runs in culvert along the western boundary of Orchard Park"[21]. This option had the best Benefit to Cost Ratio within a FESWMP of 3.23 for the 2% AEP option, which makes it more appealing to investors, and has been put into operation probably because of this. With surface water solutions, Hull would run into a number of constraints before they could put the option into practice, including a geotechnical review, and archaeological and environmental review and also the usual problem of land ownership, with "the area

[21] http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-hull.pdf p38

West of Orchard Park is divided into a number of plots. Hull City Council own some of this land as do the East Riding of Yorkshire Council with the remainder of the plots being in private ownership"[22].

3.2.4 Thatcham First Edition Surface Water Management Plan Measures

The Thatcham SWMP was broken into three sub catchments to overcome the issues of complex modelling time and resources. They drew up a number of options that could have been pursued, but took forward four options to analyse economically. These were:

- Detention Basins
- A proposed new ditch and swale
- Provision of new surface water sewers to be maintained by West Berkshire Council and Thames Water
- All of the above, plus retro-fitting of resistance measures to residential properties, (98% of the flooding in the 2007 floods was under 300mm).

It became apparent that when modelling the areas there were many places that were a cause for concern with regards to urban flooding and more analysis would be required. Urban analysis and separating the types of flooding proved difficult. Below is the BCR table for the options that Thatcham considered (**Error! Reference source not found.**):

Table 3-5. Results of cost-benefit analysis (£)

	Option 1	Option 2	Option 3	Option 4	Option 5
PV Costs		12,464	18,246	15,314	28,092
PV Damage	181,179	132,638	134,327	139,331	1,846
PV Damage avoided (Benefit)		48,541	46,852	41,848	179,333
Net Present Value, NPV		36,076	28,606	26,534	151,240
Benefit/cost ration (PV benefit/PV cost)		3.89	2.57	2.73	6.38

Notes:
PV = Present Value

Option 1 a do nothing scenario
Option 2 includes 7 new detention basins, 1 new ditch and swale, provision of new surface water sewers in addition to initial recommendations from the 2008 Berkshire Report[23]
Option 3 includes the outlined proposals of the Berkshire Report plus 11 new detention basins, 2 new cut off ditches on major roads, provision of new surface water sewers and upgrading of existing sewer system.
Option 4, same as option 2 plus upsizing of critical sewers.
Option 5 includes Option 2, with addition to retro-fitting resistance measures to residential properties such as flood barriers, air brick caps and sealing of external walls, and a requirement for residents to sign up to an early flood warning scheme[24]

Source: West Berkshire Council (2010) Thatcham Surface Water Management Plan [online] **http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-thatcham.pdf** p43

When comparing Thatcham's solutions with the other SWMPs, the BCRs are significantly higher particularly Option 5 with a score of 6.38. For option 5 whilst the costs for implementation are the highest, it returns high 'damages avoided' mainly as it reduces risk to key infrastructure, such as the hospital. In addition, the majority of the residential property flooding in the 2007 flood (98%) was below 300mm[25], the measures taken in Option 5 would eliminate most flooding risks for this depth. The combinations of measures in Option 5 is seen as being the best way to protect Thatcham from surface water flooding, and this is also projected in the BCR and would significantly reduce the risk in the area.

22 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-hull.pdf p42
23 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-thatcham.pdf p35
24 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-thatcham.pdf p38
25 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-thatcham.pdf p46

For the remaining two FESWMPs (Richmond and Warrington) information presented is much more limited but in all cases the options considered have been summarised, as is BCR information (where possible).

3.2.5 Richmond and Kingston First Edition Surface Water Management Plan Measures

Following site inspections and workshops, the local authority developed a list FRM measures which could be applied to each borough, these included:

Generic Measures Proposed

- Building Resilience and Resistance to surface water flooding (new development)
- Building Resilience and Resistance to surface water flooding (retrofit)
- Land Management (where relevant)
- Building Control
- Development Control
- Flood Warning

Area Specific Measures Proposed

Area specific measures were also developed, aiming to store or divert flows to reduce flooding in the areas indicated to be most at risk. These were:

- Storage Areas - at four locations were considered. After scenario modelling was carried out, there was found to be no significant impact on reducing flooding. [26]
- Road Flow Diversion - While this would lessen the flooding in Kingston Town Centre it would exacerbate the problem elsewhere, therefore not considered further.
- Control Runoff from Richmond Escarpment - High velocity flows from the runoff of steep slopes are dangerous to people and properties within the area, therefore fringe interception and diversion where possible have been considered.

The SWMP at Richmond and Kingston supports a relatively small area approach with specific measures; generalised options have been only produced for broad scale areas. It was also noted that the economic case for development should be considered alongside engaging and achieving stakeholder buy-in. [27]

3.2.6 Warrington First Edition Surface Water Management Plan Measures

The SWMP in Warrington highlighted the need for an integrated approach to finding a solution to surface water flood risk. It points out that because of all the stakeholders involved in these decisions, it would be pretty difficult to present such a unified integrated solution. Instead Warrington Council agreed that a compromise was needed and the different bodies involved would need to carry out their own separate works. The lack of working between the separate bodies clearly highlights the issues of joint collaboration. A fully integrated solution usually is the best solution but because of legal restrictions and reluctance to spend money on another stakeholders assets, we find that *"In the short term at least (the next 5 years) it is difficult to see how any new projects identified in the SWMP regarding current flooding problems will be implemented through the existing capital and operational planning frameworks of the project partners. This is because the integrated urban drainage process is still in its infancy and current capital and operational programmes have to a large degree been already determined, in part with appropriate external Regulators."*[28] Warrington also found major problems with the funding of such schemes, noting the cost of surface water flooding defences, and also the maintenance and technical upkeep of the SWMP options. It is possible that it will become an exceedingly expensive operation for local authorities: *"resourcing will be likely to be a long term issue for local authorities given their intended pivotal role in the SWMP process."*[29]

26 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-richmondkingston.pdf p53

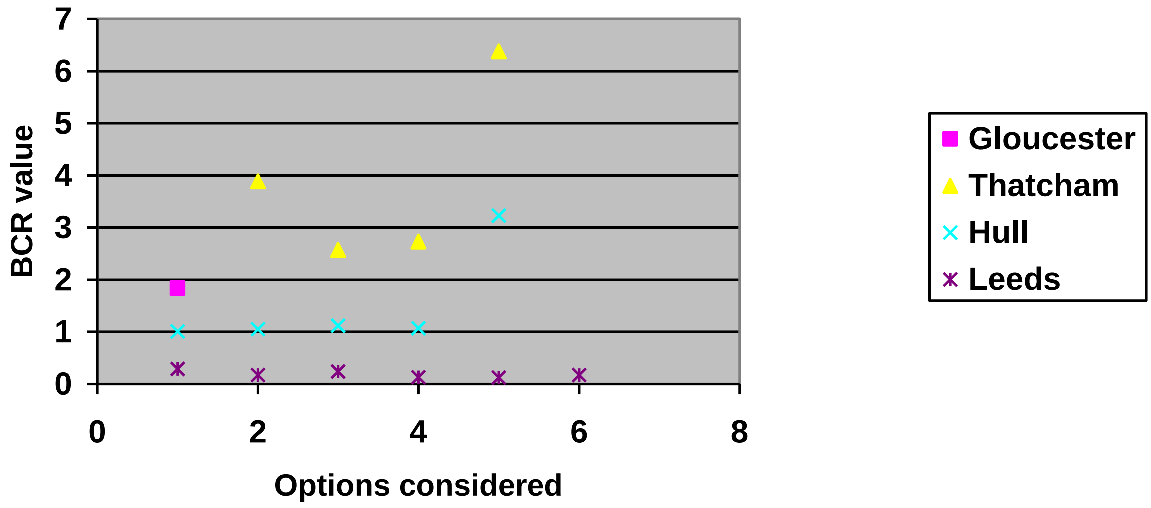
27 http://archive.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-richmondkingston.pdf p72

28 http://www.defra.gov.uk/envirooding/documents/manage/surfacewater/swmp1-warrington.pdf p27

29 29 http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/swmp1-warrington.pdf p29

3.2.7 Summary of options and BCRs

Figure 3-1. First Edition Surface Water Management Plan benefit cost ratio histogram



The histogram clearly shows that the BCRs of schemes identified are comparatively low. There is a recurrent theme within surface water schemes, the cost of implementing such defences is expensive when compared to that of a fluvial defence which normally provide reduced risk over a much larger areas and include many more properties.

3.3 Coastal Scheme Comparison

The coastal scheme in Redcar has been used as a comparative study to examine further why the benefit to cost ratio is typically much better for a fluvial or coastal scheme than found for surface water management schemes.

The Redcar coastal scheme has a preferred standard of protection is 1 in 300 (0.33% Annual Exceedance Probability (AEP))*" (p6) with "978 residential and 209 commercial properties within the flood risk area. If emergency repairs to the existing defences were to cease, it is estimated that erosion would take place at an average rate of 0.6m per year and a further 184 residential and 98 commercial properties would be at risk from erosion within the 100 year appraisal period"* (p5). This demonstrates the high numbers of properties and in addition highway and sewerage infrastructure is also at risk from coastal flooding.

The cost of the coastal schemes such as Redcar is generally high due to the engineering required and was more than many of the surface water management schemes that presented in the FESWMPs, for example the cost of the sustainable option in Leeds was valued at £1,195,449, and the storage option at Derringham in Hull valued at £18m. However the benefits or damages avoided is drastically different from that of the Redcar example. Coastal schemes such as Redcar with typically BCRs of 5.2 have large benefits, £147m in the case of Redcar. In contrast the favoured option for Derringham, Hull only has benefits of £20m. The coastal scheme includes Redcar and surrounding area, its modelled area is much more extensive and is much easier to accomplish than the modelling for the SWMP's. A larger areas this coincides with more properties at risk, and also includes the cost to such things as SSSIs and habitat erosion neither not normally available in urban areas. Urban areas may have more dense residential and business properties locations but no large habitats or biodiversity interests which can be included in a benefit cost analysis for a coastal scheme. It is also hard to reduce costs of schemes that combat surface water management when they are often technically more difficult to build or introduce than coastal defence such as at Redcar. The Redcar Outcome Measure prioritisation figure stands at 2.53. The Outcome Measures are calculated by taking into account the following:

1. Overall benefits - This will show the benefits of flood and coastal erosion risk management activities in monetary terms. Where possible, aspects of the natural historic environment and social benefits will be included. In time the costs and benefits of protecting properties, infrastructure, transport links. The environment and so forth will be identified separately as well as the total benefits.

2. Household at risk - The number of households at risk from flooding or from coastal erosion will be shown by this measure. Households at risk of flooding will be in one of four bands which describe the probability of flooding (very significant, significant, moderate or low). For households at risk of erosion, the time before the property is expected to be lost to erosion will be used. The number of households in each of four time bands will be counted, from the short-term (erosion likely within 10 years) to long-term (erosion likely between 50 and 100 years).

3. Deprived households at risk - This measure will enable the level of flood and coastal erosion risk reduction to the most deprived communities to be targeted. It will use an established ranking of deprived areas (the Index of Deprivation rank for Super Output Areas), combined with the risk bands for flooding and erosion described above to indicate the risk to deprived communities.

4. Nationally important wildlife sites- This measure will record, through liasion with Natural England, the delivery of flood, water level and coastal management remedies which contribute to the government target to have 95% of Sites of Special Scientific Interest in favourable condition by 2010.

5. UK Biodiversity Action Plan habitats - Flood and coastal erosion risk should improve the natural environment as well as reducing the risks to people and property. This measure will record the overall increase in Biodiversity Action Plan habitat achieved through flood and coastal erosion risk management activities.

6. Flood warning (flood risk only) - Flood warning allows those living and working in areas that can flood to take action to reduce risks, particularly to people. This measure will record the proportion of households and businesses in high risk areas that are offered the Flood Warnings Direct service and have registered to receive warnings. There is no equivalent measure for coastal erosion.

7. Contingency Planning (flood risk only) - The Environment Agency works with other bodies in Local Resilience Fora to plan for different types of emergency. This measure will show the percentage of Local Resilience Fora emergency response plans that are considered by the Environment Agency to satisfactorily address flood risk. There is no equivalent measure for coastal erosion.

8. Inappropriate development - This will show the number of households covered by planning consents which have been granted despite Environment Agency objections on flood risk grounds. A similar measure for coastal erosion will be used when national maps showing erosion risk are available.

9. Long term policies and action plans - For the next few years this measure will ensure that sustainable, high-level plans for managing flood and coastal erosion risks are developed. It will show the percentage of Catchment Flood Management Plans and Shoreline Management Plans that have been signed off by Environment Agency Regional Director.

None of the FESWMPs have added an Outcome Measures table, but considering the above it is clear few of the options proposed deliver outcomes beyond households at risk. At the smaller scale of localised surface water planning matters such as damages and disruption to local businesses and other local community facilities is important but not recorded in the present nationally based OMs.

4 Conclusion

In conclusion, SW schemes do not appear to compare favourably in terms of relative value for money and approvals with fluvial and coastal schemes. Fluvial and coastal schemes tend to protect higher numbers of households for a given cost, and can routinely save millions of pounds in damages.

In addition to the relative economics of SW schemes institutional issues mitigate against SW schemes. These include; the availability and management of data from a range of organisations, existing relationships between the many parties involved in surface water management solutions, and the issue of how one isolates surface water flooding from fluvial sources. The FESWMPs appear hindered by the lack of historical data, which was often incomplete and out of date and sometimes third party sharing agreements stood in the way of producing this data.

Many of the schemes brought forward in the FESWMP's leant towards an integrated solution. As seen in Gloucester, this approach looked at solving main watercourse problems to reduce the chance of surface water flooding. However, integrated solutions require the involvement of a number of stakeholders who have to agree to share in the work.[30] Restrictions from Local Authority boundaries can prevent the progression of options, this was experienced in Gloucester. Recommendations put forward by the Flood and Water Management Act (FWMA) which came into effect in April 2010 should be adopted here. The Act takes forward a number of recommendations from the Pitt Review into the 2007 floods, promoting collaborative and partnership working and places new responsibilities on the Environment Agency, local authorities and property developers (among others) to manage the risk of flooding.

Under the new Flood and Coastal Resilience Partnership Funding approach, capital FDGiA is available to SW schemes on an equal basis to tackling fluvial and coastal flooding. However, due to the comparatively low benefits and numbers of households protected, SW schemes may only qualify for partial funding in most cases. Furthermore, a low BCR significantly affects investment opportunities from all sources, not simply FDGiA. It significantly reduces confidence in a scheme, particularly from the water and sewerage companies and the local councils who now have responsibility for surface water management. Budget cuts across the board are likely to put further pressure on schemes, and the importance to achieve high BCRs.

4.1 Further work

More research is still required to fully understand why SW schemes have relatively low BCRs. The study points to issues of spatial scale reducing damages avoided, with SW spatial scales being an attribute of complexity and modelling capacity.

In addition the full impact of Defra's Flood and Coastal Resilience Partnership Funding approach for SW schemes should be investigated further, based on some case study examples.

30 **http://www.defra.gov.uk/environment/flooding/documents/manage/surfacewater/urbandrainagereport.pdf** p10

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