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Sustainable Water Management in the City of the Future

Integrated Project
Global Change and Ecosystems

DELIVERABLE TASK 2.2.3a: EVALUATION OF DECISION-MAKING PROCESSES IN URBAN STORMWATER MANAGEMENT

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SWITCH Deliverable Briefing Note for Deliverable 2.2.3a

SWITCH Document: **Evaluation of Decision-Making Processes in Urban Stormwater Management**
Audience: This deliverable is targeted at urban stormwater managers who are involved in decision-making processes where the diverse views of multiple stakeholders need to be considered. It is also of relevance to all SWITCH partners who have an interest in how the optimal drainage design for their selected city can be achieved taking into account the different interests of important stakeholders.
Purpose: The objective of this deliverable is to identify the decision-making processes which currently operate in urban stormwater management and to highlight the opportunities and problems for diverse stakeholder engagement in this process.
Background: The principal barriers to the implementation of sustainable integrated urban drainage and surface water management in different parts of the world have been identified as being related to decision-making processes associated with a number of key areas: • identification and clarity of roles and responsibilities in terms of organisational management of surface water drainage • lack of clarity in legislation, regulation and funding arrangements • lack of adequate technical knowledge and tools in essential areas such as flood exceedance, sewer quality modelling, BMP/SUDS performance etc. • insufficient and poor quality data and monitoring capabilities • lack of public perception of, and engagement in, urban drainage These represent the core issues facing the municipal decision-making structures although their severity and balance varies between different cities and individual national circumstances. Unfortunately, examples of best practice and critical success factors are not always transferable, and in many cases the existence of barriers is used as a reason to prevent further progress towards achieving integration rather than being seen as a problem which can be surmounted given appropriate motivation and leadership
Potential impact: A vision statement for urban stormwater management has been developed which for the Birmingham Eastside demonstration area is based on eight primary criteria: • flooding and flood risk • receiving water quality • receiving water ecology and stream health

• urban land use planning • regulation and funding regimes • technical and scientific issues • stakeholder participation • need for coherent, integrated approaches The final and fully developed vision statement provides a basis for stakeholder engagement to develop and implement acceptable strategic management approaches and frameworks.
Recommendations: The decision-making process in urban stormwater management can be regarded as comprising a series of iterative, step-functions involving separate but interlocking action spaces which need to be coherently integrated in terms of strategic objectives and administrative support. This in turn needs active and full cooperation between the various organisational levels and groups e.g. from central government to regulatory bodies to local authorities to other stakeholders and presents numerous challenges. The developed vision statement provides a basis for developing a generic technical and organisational systems map for sustainable surface water management in the wider context of a sustainable city onto which different institutional maps could then be overlaid. In turn, this facilitates the description and identification of differing modelling approaches for surface water management and contributes to overcoming the problem that BMP/SUDS drainage options represent a "bundle" of technologies which are often selected by differing countries in relation to differing issues.

1. INTRODUCTION

The SWITCH Deliverable for Task 2.1.2 "*Database Showing Threats/Uncertainties to Stormwater Control*" for the selected demonstration cities of Belo Horizonte (Brazil), Birmingham (UK) and Hamburg (Germany) clearly identified the principal issues, risks and barriers to the successful achievement of future sustainable surface water drainage management in urban catchments (Ellis *et al*., 2008a). The deliverable demonstrated the commonality of issues and risks associated with the implementation of sustainable integrated urban drainage and surface water management in different parts of the world. The principal barriers were related to decision-making processes associated with a number of key areas:

- identification and clarity of roles and responsibilities in terms of organisational management of surface water drainage
- lack of clarity in legislation, regulation and funding arrangements
- lack of adequate technical knowledge and tools in essential areas such as flood exceedance, sewer quality modelling, BMP/SUDS performance etc.
- insufficient and poor quality data and monitoring capabilities
- lack of public perception of, and engagement in, urban drainage

Whilst the severity and balance of these key barriers varied between the three demonstration cities and individual national circumstances, they identify common core issues facing the municipal decision-making structures. Unfortunately, examples of best practice and critical success factors are not always transferable, and in many cases the barriers are used as reasons to prevent further progress towards achieving integration rather than barriers which can be surmounted given appropriate motivation and leadership (Digman *et al.*, 2006a).

In the European context (as well as in North America, Japan and Australia/New Zealand), where there is an established legislative and regulatory framework contained for example in the EU Water Framework Directive (WFD) or the US Clean Water Act (CWA), the emerging priority success factor is that of multi-stakeholder engagement and partnership (Newman *et al*., 2008a). This factor is frequently characterised by organisational leadership and high-level "buy-in" to provide a clear strategic and operational framework for lower-level consultation and decision making. In addition, the importance of source control and BMP measures involving public participation to manage the driver-response process of urban flooding and pollution in a more resilient manner is becoming increasingly apparent (Newman *et al*., 2008b). Sustainable urban drainage is no longer based solely on levels of service measured by equivalent greenfield runoff rates and extreme flood control standards limiting external flooding to 1:30 or internal flooding to 1:100 year events. Source control and BMP/SUDS treatment are now additional sustainable criteria to provide a more complete measure of drainage system performance. In many respects it can be argued that there is a basic crisis in governance mechanisms rather than technical, legislative or climatic conditions or even economic instruments which presents the major issue for future integrated urban stormwater management (IUSM). The central issue is concerned with a changing balance in the "power process" for decision-making between stakeholders with a generalised move away from single functional actions and centralised institutional arrangements.

In developing countries such as Brazil, the priority is directed more towards the technical problems associated with providing a basic effective urban drainage infrastructure for fluvial flood control, with surface water (pluvial) management playing a subsidiary supporting role to this main objective particularly in terms of diffuse pollution. Nevertheless, public participation in decision-making on budgetary distributions for sewage, stormwater management and other urban infrastructure investment is beginning to play a more significant role in municipal policy formulation (Nascimento *et al.*, 2008). However, local community preferences tend to be strongly in favour of conventional drainage systems with BMP/SUDS systems, especially in terms of diffuse pollution control, being largely unknown and untried, with the possible exceptions of detention basins and wetlands

The objective of this current task (Task 2.2.3a) is to produce a deliverable which identifies the decision-making processes for urban stormwater management currently operating within selected demonstration cities and to highlight the opportunities and problems for diverse stakeholder engagement in this process. Some general issues related to the complexity of drainage processes, especially for the identification and management of extreme events, are initially discussed together with generic issues associated with public perception of, and participation in decision-making structures and planning approaches for urban surface water management. A vision statement for each demonstration city is then developed to help identify those primary indicators of relevance to the achievement of integrated urban drainage management for the city-of-the-future and which form a prime basis for driving the decision-making process and structures.

2. COMPLEXITY AND INTERACTIONS IN URBAN SURFACE DRAINAGE.

The challenge of delivering long term integrated urban drainage is inevitably difficult where the sources of and responsibilities for the flood, pollution, drainage management and controlling legislation or other limiting parameter cannot be readily identified. The difficulty is exacerbated where the management responsibility for these individual parameters are distributed between varying contributing sources and organisational groups.

It is now generally acknowledged that urban flooding and pollution are frequently the result of multiple urban land use sources associated with a combination of overland flow, sewer surcharging and receiving watercourse overloading. These hydraulic and associated geochemical processes follow basic principles, but their operational scales and detailed mechanisms will differ depending on the type, nature and activities associated with specific urban land uses and planning decisions. These mechanisms will also vary between as well as within different wet weather events, which further complicates the flow and quality interactions and outcomes experienced in the drainage system.

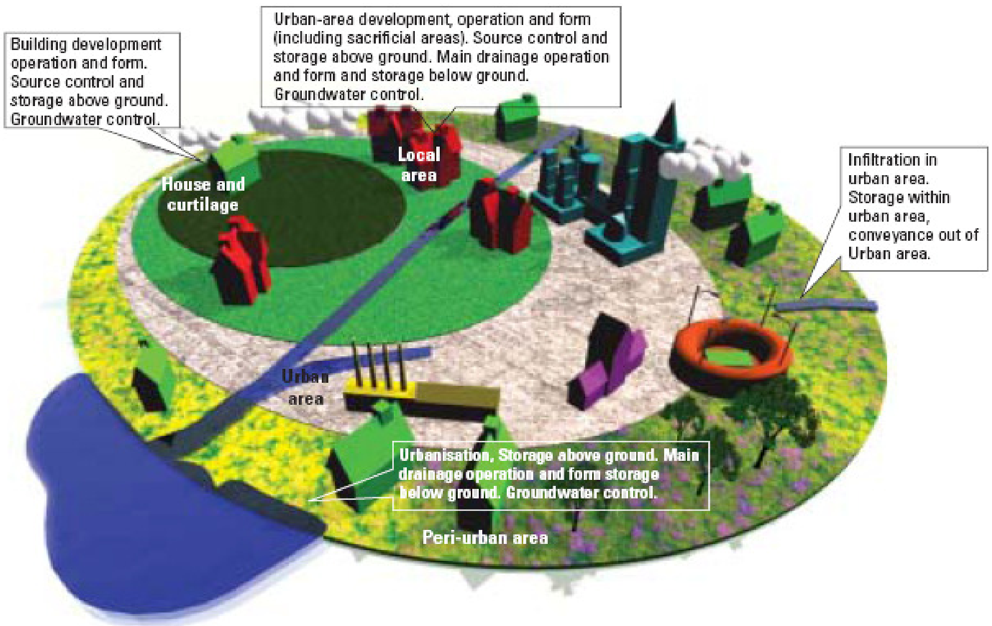

Figure 1 Sources and scales of flooding and responses **(From: Evans *et al*., 2004)**

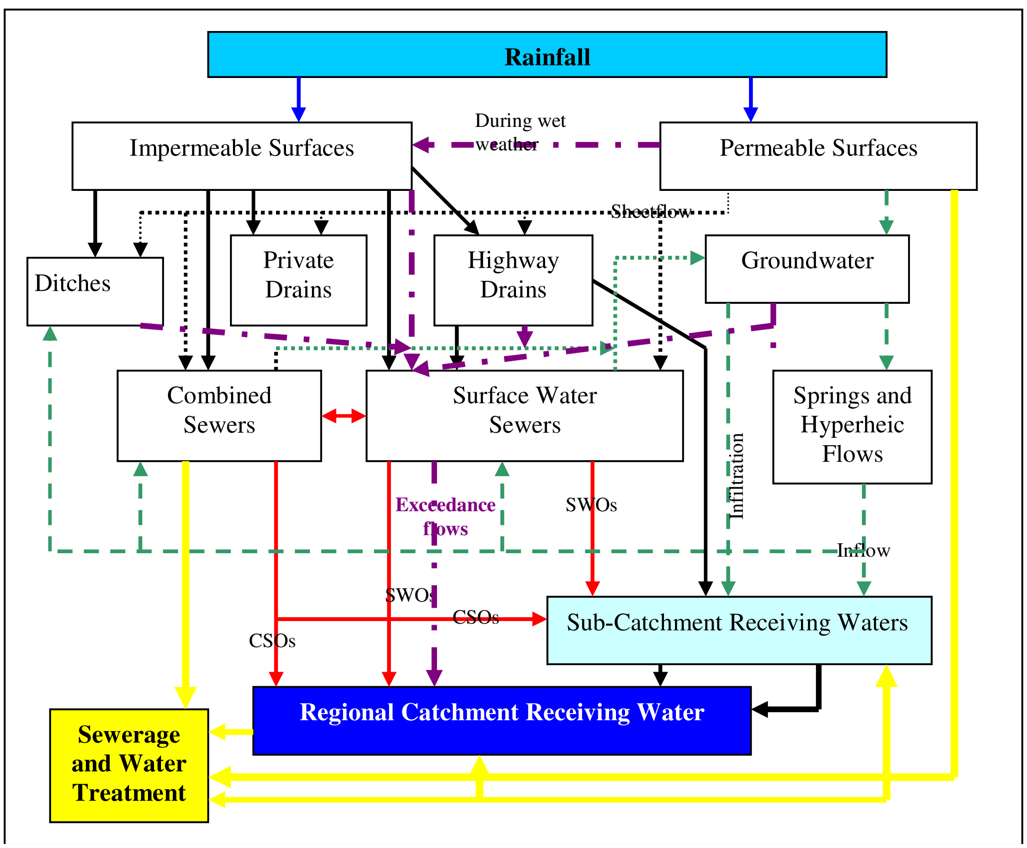

Figure 2 Interactions Between Urban Drainage Sources, Pathways and Receptors.

Figure 1 shows that the intra-urban response to flooding will operate through various process mechanisms and acts on differing spatial scales, combining above and below ground systems, storage facilities and flow routes. Figure 2 provides further detail on the sources, pathways, receptors and return flows for the urban drainage system which emphasises the complexity of interactions between the various above and below ground sources. Four individual but interlinked drainage systems can be identified from Figure 2:

- a foul (combined) sewerage system with combined sewer overflows (CSOs) discharging to the receiving water,
- a separate surface water sewer system with surface water outfalls (SWOs) to the receiving water,
- the receiving water (normally "heavily modified")
- and exceedance surface flows during extreme wet weather conditions.

Interconnections, including system cross- (or mis-) connections, infiltration and inflow pathways as well as system abstractions further complicate the process interactions. The interactive nature of these urban drainage systems therefore requires a fully integrated, nested modelling approach to replicate the real flooding and pollution situation during extreme events (>1:30 RI).

Potential responses to the flood and associated pollution driver mechanisms must take into consideration this complexity of sources and scales of operation. Control and management approaches should therefore consider the level of the individual building (and curtilage), through the plot, site and sub-catchment levels as well as interactions with the surrounding peri-urban region. The key control interaction is the ability to discharge excess flows away from the development site to control surface flooding and to capture the majority of small scale events (<1:1 RI) for quality control. In many cases, it will be most effective to resolve local flooding problems through addressing and disentangling sources, changing the volume and pattern of surface runoff (e.g through disconnection, infiltration etc.) and/or by increasing available storage capacity. In addition, above-ground flood routes and temporary storage for extreme events need to be delineated rather than seeking to expand or enlarge traditional below-ground conveyance systems given the prohibitive costs of system rehabilitation and enlargement.

The complexity can be further illustrated by reference to the July 2002 floods in Glasgow, Scotland where post-flood modelling studies attributed the discrete catchment flood volumes to the three specific sources mentioned above (Adshead, 2007). Pluvial overland runoff from impervious surfaces was considered to contribute over one-third (34%) of the total flood volume with sewer surcharging accounting for 23% and watercourse (fluvial) overspill some 43%. The recent Pitt review of the summer 2007 UK floods attributed some two thirds of the flooding to inadequacies in the current capacity of surface water drainage systems (Pitt, 2007).

One aspect of concern is that the operational efficiency of surface water outfalls (SWOs) becomes seriously affected when the receiving water channel runs close to bank full capacity. Surface flooding caused by backing-up and surcharging from the stormwater pipe can become a substantial problem under these hydraulic conditions. This situation was cited in the Defra pilot integrated urban drainage (IUD) study of the upper River Rea as being a major contributory cause of surface flooding in the suburban regions of Birmingham (Birmingham City Council, 2008). Figure 3 illustrates the complex hydraulic interactions between major and minor drainage systems that can occur under exceedance flow conditions during a storm event which can lead to "coincident" flooding. The varying storm design standards shown for the differing parts of the sewer system further illustrate how the hydraulic capacity of the minor system is readily overcome during extreme events with roadside gully chambers, normally designed to a 1:1-1:2 RI capacity, being rapidly drowned out and contributing to exceedance flows in the highway cross-section. Urban surface flooding during such extreme events can be further exacerbated by source contributions from groundwater and overflows from local ditches.

A number of recent reviews within the UK have now reported on the challenges presented by complex flooding and diffuse pollution mechanisms (Balmforth *et al.*, 2006; Dignam *et al.*, 2006a; Pitt, 2008). The final Pitt review (2008) of the UK

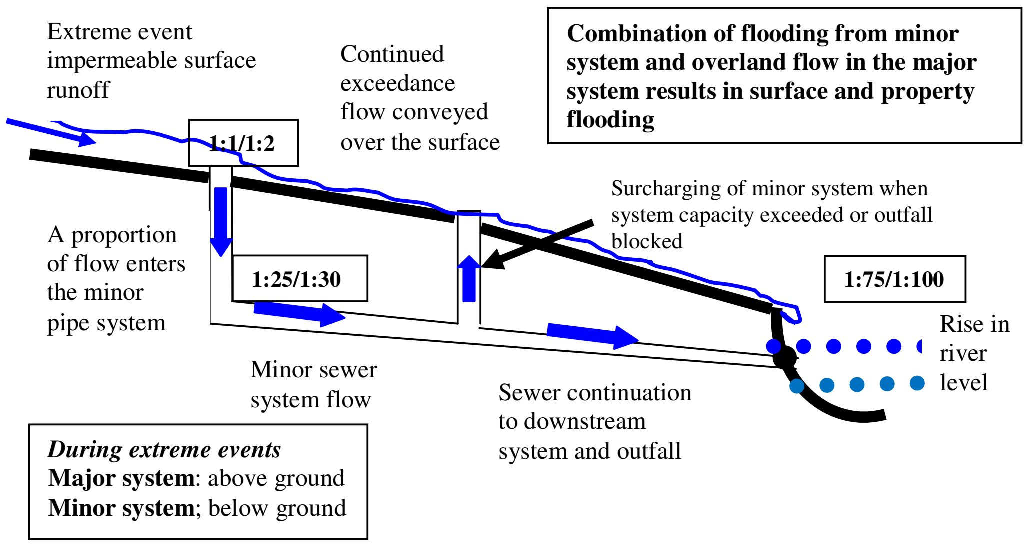

Figure 3 Urban Drainage System Extreme Event Interactions (Based on Digman *et al.*, 2006b)

summer 2007 floods drew attention to the need for more information and modelling tools to accurately assess urban flood risk. The majority of current modelling approaches for surface water flooding are based on 2D overland routing of an assumed uniformly distributed rainfall event (or "blanket" approach) which significantly overestimates the extent of flooding, but which is suitable for initial, high-level screening analysis. A decoupled 1D sewer model with 2D overland routing produces a much better estimate of the spatial extent of flooding as shown in Figure 4. The red line indicates the actual extent of flooding experienced in the urban catchment compared to the modelling output of the flooding shown in solid blue. The 2D "rolling-ball" routing algorithm tracks flood flow paths from flooded gullies and manholes along highway "channels" as seen on the decoupled modelling in Figure 4, and which replicates the actual physical process of surface flooding (Hankin *et al.*, 2008), based on ground topography of the road and containing kerbs, walls etc.

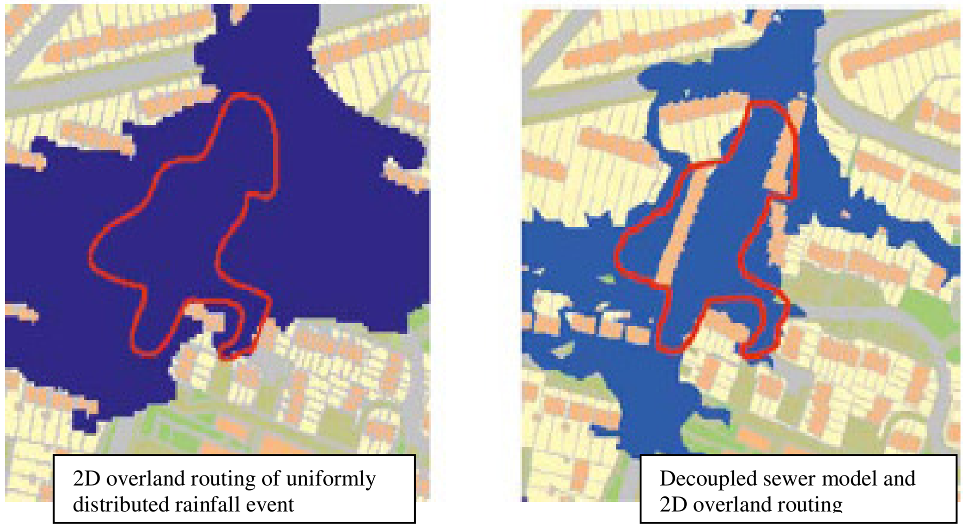

Figure 4 Modelling Approaches to 1:30 RI Extreme Storm Event. (From: Pitt, 2008b)

Figure 5a illustrates simulated surface flood pathways for a 1:10 storm event in the Brent catchment in N London using a decoupled model using digital elevation data as applied to a GIS base and routing the flood volumes from over 1000 manholes and gully chambers. This approach overestimates the actual flood ponding as it actually occurs on the ground as it does not allow for surface flows to return back into the below-ground system. A coupled sewer modelling approach provides for a more realistic interchange of flows between the various types of drainage system as well as taking into account receiving water (fluvial) flood effects as shown in Figure 5b for a different part of the Brent catchment. An interactive 3D virtual planning approach to

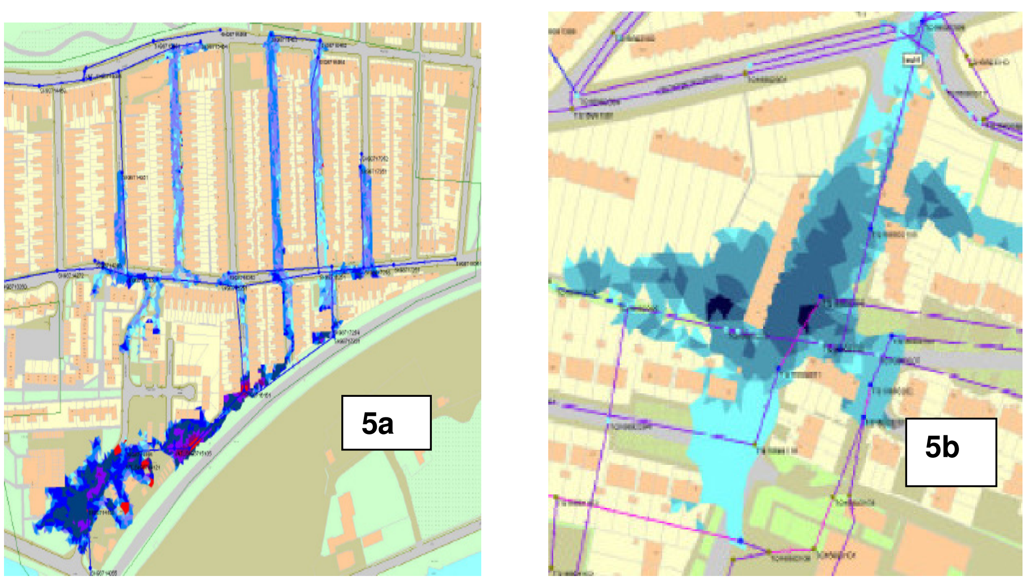

Figure 5 Surface Flow Paths During an Extreme Event. (From Gill, 2008)

help visualise the real time effects of combined pluvial and fluvial urban flooding has recently been developed under EU INTERREG III funding (www, veps3d.org). Urban flood simulations can be carried out on-line to help stakeholders understand the implications of planning decisions in flood risk areas, although the individual contributing flow sources to the final flood outcomes are not distinguished in the modelling simulations.

In the River Rea Defra IUD pilot study in Birmingham, the adopted modelling approach assumed a scenario in which the below-ground system (surface water and combined sewers) was completely filled with simulated surface runoff and identified ponding locations based on applying the 2D surface model to all subsequent rainfall-runoff from the extreme event i.e a non-nested approach. Figure 6 thus shows a "worst-case" scenario of the extent and depth of surface flooding associated with a 1:100 event for the sub-catchment.

Figure 6 Predicted 1:100 RI Surface Flooding for the Upper Rea, Birmingham. (From: Birmingham City Council, 2008)

Such integrated modelling, being based on the inter-connectivity of the different sources of urban drainage and their effect on intra-urban flooding and pollution, will provide a much firmer strategic foundation for risk management. This philosophy has been the basis for the 15 Defra Integrated Urban Drainage (IUD) pilot studies in the UK (http://iudpilots.defra.gov.uk; 1 October 2008). The real-time, surface and sub-surface hydraulic modelling techniques allow the flow complexity to be spatially and temporally analysed and provide a much better understanding of the extreme event problem and the management of potential solutions including the location of sacrificial flood storage areas (Bamford *et al.* 2008) based on source contributions. However, such modelling requires detailed data on the geo-located flooding and the generating rainfall event, which is not always available or requires considerable effort and cost as well as "ground truthing" (Gill, 2008). One particular problem relates to the accuracy of the digital elevation model (DEM) used in the modelling algorithms as walls, fences, alleyways, driveways (and sometimes bridges, flyovers etc.) are not always represented in the DEM. Unless they are removed from, or taken into account in the data set, such common urban features can lead to apparent shortcutting and/or blocking of surface flow routes within the model results (Boonya-aroonnet *et al.*, 2007). However, recent work on automated "barrier" detection to surface flow path analysis has suggested that utilising LiDAR data representation based on recognition of elevated map features (such as bridges, crossings etc.), can provide the possibility of much more effective flowpath mapping (Evans, 2008).

Nevertheless, such risk mapping is only likely to be cost-effective for flood "hotspots" of high vulnerability and/or damage costs and will require careful "ground truthing". The hydraulic modelling also requires a supporting tool to identify appropriate locations for and types of BMP/SUDS that might be retrofitted and dimensioned for flow and quality control. Such a tool is being developed concurrently within the SWITCH programme and its structure and performance capabilities have been outlined elsewhere (Viavattene *et al.*, 2008; Ellis *et al.*, 2008a).

There are additional pressures on this spatial and process complexity associated with climate change, future urban development and urban creep. Climate change is predicted to increase winter rainfall by 10 – 30% in the UK by the 2080s with rainfall intensities increasing by up to 20%. Up to 3 million new dwellings are scheduled to be built in England alone by 2016 and "urban creep" from paving of previously pervious areas will collectively increase significantly the surface water flood risk. This is being addressed to a certain extent by the introduction of new legislation that will require local authority planning permission for driveway paving and a requirement to use permeable materials. However, it is not clear how this regulation will work in practice and how it will be enforced.

The UK government Foresight report (Evans *et al.*, 2004) estimated that the number of properties at risk of flooding could be up to 0.5 million by the 2080s. It is estimated that two-thirds of the 57,000 flooded homes during the recent summer 2007 extreme events were inundated by surface water drainage with damage estimated at about £3 billion (Crichton, 2007), In principle this provides a considerable stimulus to facilitate the availability of robust and accurate modelling techniques for assessing the real-time risk of such complex pluvial conditions. The availability and implementation of fully integrated coupled models for urban drainage will enable decision-makers to identify the likely severity of flood and pollution impacts as well as to select and locate compensatory storage and/or infiltration controls (Diaz-Niets, 2008).

However, like the gradually subsiding waters following a flood, the lessons learned from extreme wet weather events tend to seep away despite many of the fundamental problems and driving mechanisms being well known and documented. This may be mainly due to competing priorities and agendas which arise in the intervening periods, as well as because identified response/action plans are in many cases an addendum to core institutional and organisational responsibilities. With additional staffing and other resource constraints, organisations find themselves unable to commit to ensure that approved plans and training are introduced. In addition, terminology of flood risk management such as the 1 in 100 year flood event, is easily misunderstood by both the general public and politicians and can lead to inter-flood event apathy.

3. PUBLIC PERCEPTION OF AND PARTICIPATION IN URBAN DRAINAGE DECISION-MAKING

The concept of integrated urban stormwater management (IUSM) involves stakeholder engagement at the interfaces of engineering, science, governance and socio-economics. The interfacial processes in turn involve attempts to bridge and/or integrate data and knowledge, experience and opinion across the various stakeholder communities on matters such as surface water management plans (SWMPs) or the introduction of source control technologies. It is almost inevitable that the boundaries of perception between the major stakeholders will be characterised by significant discontinuities over issues such as:

- sources, meaning and relevance of data/information on which to base protocols, priorities and actions
- the value and validation of processes and control/management "responses"
- acceptable level of risks and their apportionment
- notions of performance effectiveness and efficiency, especially under changing climatic and demographic conditions

IUSM requires an understanding and management of these interface issues and engagement processes, but whereas some stakeholders will actively seek specific solutions e.g technical controls, others seek more pragmatic multiple-issue agendas and approaches. For example, excessive water use to some may simply mean insufficient supply whereas others would seek solutions in rainwater harvesting and stormwater re-use as well as consumer constraints. These two stakeholder attitudes would lead to very different policy implications and management outcomes. Although the introduction of structural BMP controls such as detention basins have been recognised as beneficial for flood and pollution control, communities surveyed in Belo Horizonte, Brazil perceived that such structures often led to higher crime and vandalism and favoured channel widening and lining controls (Nascimento *et al.*, 2008). This mismatch of problem identification and policy agenda has been addressed in various ways including system theory, active learning and adaptive management approaches (Thevenot, 2008).

The underlying issue is that the urban water environment provides multiple functions to multiple stakeholders and communities, and that both function and "community" change over time and space with changing preferences and priorities. It must also be recognised that there are no "solutions" *per se* to flood and pollution risks under future climate, urban and demographic change. It has been suggested that "response" rather than "solution" is a better term under these circumstances (Ashley *et al.*, 2008), with policy and actions developed to respond at intervals to changing external drivers and pressures and as drainage assets deteriorate with time. Thus more flexible, adaptable, resilient and abandonable approaches are needed under this scenario which frequently will not require engineering solutions. Such policies and approaches will rather require changes to life style patterns, public engagement and empowerment mechanisms with effective, open collaboration between agencies and stakeholders at all levels. Such a re-appraisal and re-alignment of professional, institutional and public involvement in future IUSM is a radical concept that will not be easy to achieve.

Problem prescription and intervention is therefore a function of contemporary perception and diagnosis often resulting in a "forced" common understanding. In this respect integrated approaches are essentially concerned with the evolution of acceptable policy guidance based on creating more effective, efficient systems. However, these systems are likely to remain unpredictable, unstable and difficult to manage as well as lacking true social equity. As the franchise for engagement in urban water management has increased, so have the stakeholder perceptions, perspectives and aspirations; particularly amongst articulate, higher-income "self-interest" groups. Thus expecting wider and more meaningful community engagement, interaction and participation to inevitably generate widely acceptable and successful outcomes is a risky strategy. The benefits of multi-stakeholder participation in IUSM might well be more transitory and costly than expected. The concept of stakeholder participation in decision-making processes as part of "civil society" has become a core concept of urban sustainability. However, stakeholder participation is still very much a generalised "umbrella" concept embracing a variety of institutional interests having varying, and frequently limited powers. It is also the case that when applied to urban water management it only includes limited sectors of the public, being normally an aggregation of vested, self-interest groups or individuals having little, if any structured hierarchy. In this respect, stakeholder participation can often fall short in terms of both the concept and delivery of public equity.

The transition from traditional to adaptable, resilient IUSM requires capacity building at technical, institutional and social levels in order that participating stakeholders can both understand the context of the "responses" and the functioning of the responses themselves. There is a need to develop and foster a shared understanding of the systems and challenges to these systems. If stakeholders have limited capacity then they will not be able to understand why a certain "response" may be appropriate and therefore capacity building becomes the key limiting factor in the selection of appropriate solutions. Such capacity building is concerned with the creation of an enabling environment including the development of appropriate technical, institutional and local delivery frameworks having appropriate structures, processes and procedures within which individuals, groups and agencies can perform effectively. The EU WFD requires "dweller" engagement as an essential aspect of sustainable water management and equivalent Brazilian policy formulation likewise demands public participation in municipal decision-making on urban flood and pollution control. Such requirements theoretically draw the public into the IUWM arena as equal stakeholders in the identification of **r**esilient, **a**daptable, **f**lexible approaches, **n**ot **e**ntailing **e**xcessive **c**osts. This RAFNEEC approach complements the BATNEEC philosophy underlying BMP/SUDS drainage systems, and together with the 4A's legislation and regulatory agency champions forms the basis for new urban drainage management approaches that are being currently introduced in Scotland (Newman *et al.*, 2008b).

The 4A philosophy is based on the assertion that for new technologies or response initiatives to be successfully implemented, reform approaches need to be designed from the enduser or recipient's point of view. It is argued that the value of this receptivity concept is that it assists with identifying the types and structures of policy mechanisms needed to improve practice (Brown *et al.*, 2007). The 4A receptivity attributes assume that individuals, agencies and organisations:

- should be aware of a problem and need for a "solution" (or response) i.e ***a****wareness*
- can relate sufficiently to the potential benefits to commit effort to implement "responses" i.e ***a****ssociation*
- have requisite skills and resources to implement and support solutions i.e ***a****cquisition*
- have appropriate incentives to promote response implementation i.e ***a****pplication*

Table 1 illustrates some of the social, institutional and other variables underpinning the concept of receptivity and the 4A philosophy which have been tested within the

Table 1 Assessment Variables for 4A's Receptivity

AWARENESS	ASSOCIATION	ACQUISITION	APPLICATION
- available data and information - awareness of urban drainage system - visible flood and/or pollution problems - environmental and social damage and/or costs - lack of opportunities for participation in decision-making process	- community perceptions - stakeholder commitment - potential social amenity - potential environmental outcomes - potential public health outcomes	- technical feasibility - professional knowledge - government/agency policy - regulations and approvals - stakeholder commitment - costs - property access - management arrangements	- implementation timescales - effective institutional arrangements - stakeholder commitment

context of flood risk management in Scotland (Scottish Government, 2008a) as a basis for delivering future sustainable flood management in a fair and equitable manner. The 4A criteria and variable listing provides a useful generic template for the assessment of potential participatory effectiveness, although it may be difficult to derive appropriate and objective scores for each of the variable indicators. A tentative scoring allocation is outlined in Annex B of the Scottish Government (2008a) flood risk management document but a number of indicators e.g stakeholder commitment, government/agency policy etc., could be interpreted and scored in very different ways to influence the end outcome. The most common issues arising from the consultation exercise on flood risk management in Scotland revolved around the process and accountability of stakeholder participation and implementation funding (Scottish Government, 2008b). The development and promotion of "joined-up" thinking in terms of regulations and institutional responsibilities were also considered to be essential requirements for effective cooperative participation and adaptive resilient management.

An adaptive management approach involving active learning can provide inherent flexibility and reversibility as well as avoiding closing-off options which are essential in the light of responses to future climate changes. Table 2 defines stages in the process of a well-designed adaptive management programme that could be applied equally to both individuals/groups (and their institutional settings) and the physical systems for urban flood and pollution risk management. Whilst such adaptive management allows for feedback from observation to better inform management decision-making, it is not a replacement for economic, social or political inputs to the decision-making process, nor does it attempt to resolve differences in values between stakeholders.

Table 2 Stages in an Adaptive Management Programme for Urban Stormwater Drainage

STAGES	COMMUNITY/INSTITUTIONAL	PHYSICAL SYSTEM	STAKEHOLDERS
Assess system and define hypotheses	Governance and institutional structures, frameworks and processes; delivery mechanisms for urban surface drainage; are they fit for purpose? Define active learning options	Surveying, modelling flowpaths and pollutant fates, vulnerability and impacts; attribution of sources of flood and water quality risks; system operation and maintenance (O&M)	Little public involvement; mainly high-level institutional stakeholders
Design actions or responses to achieve specific objectives	Manage and adapt institutional systems, behaviour and partnerships i.e organisational culture change. Establish champions and working relationships with learning alliances	Set targets, including an adaptation approach. Define range of potential structural and non-structural responses, including "housekeeping" controls and O&M needs	Joint stakeholder studies with limited (selected?) public engagement. Consultations on administrative and legislative changes as necessary. Forum meetings with local/regional Liason or Advisory groups. Definition of likely cost burdens.
Implement actions and/or responses at demo or full scale	Engagement and joint meetings/workshops at all levels. Implement active learning and non-structural controls that require stakeholder action	Implement above options and approaches.	Main issues likely to be those of funding and identification of lead organisation/group. Definition of emergency response measures.
Monitor actions and/or responses	Monitor effectiveness of active learning process and learning alliances. Monitor both structural and non-structural measures introduced.	Continuously monitor changes in flood and water quality risks and system performance	Principally intermediate level stakeholders at municipality and/or regulatory agency level. Active learning in place for all stakeholders
Evaluate responses with respect to initial hypotheses	Are engagement processes working? Are active learning and learning alliances effective?	How well are actions and/or responses working? Were original attributions correct?	Identification of effective institutional and individual capacities. Identification of appropriate levels of stakeholder responsibility. Emergence of new champions at differing levels
Adjustment of management actions to achieve objectives more effectively based on improved shared stakeholder understanding	Refinement of active learning and learning alliances process and structures. Adjustment to more realistic levels of risk acceptability	Design and implement appropriate next stages of intervention in adaptation steps to meet declining performance standards and/or revised objectives	Central government and regulatory agency stakeholders in legislative and administrative improvements. Government led consultation on revised options

A prime requirement for collaborative stakeholder participation is that there should be an appropriate institutional capacity framework within which IUSM can be delivered effectively. Most recent approaches to institutional capacity building assessment (Brown *et al*., 2006) have used nested models of inter-related capacity spheres with links from each sphere to possible capacity building interventions as illustrated in Figure 7. The figure illustrates some general characteristics of "good" capacity that need to be in place within organisations in order to develop coherent IUSM strategies and to deliver sustainable future urban drainage "responses".

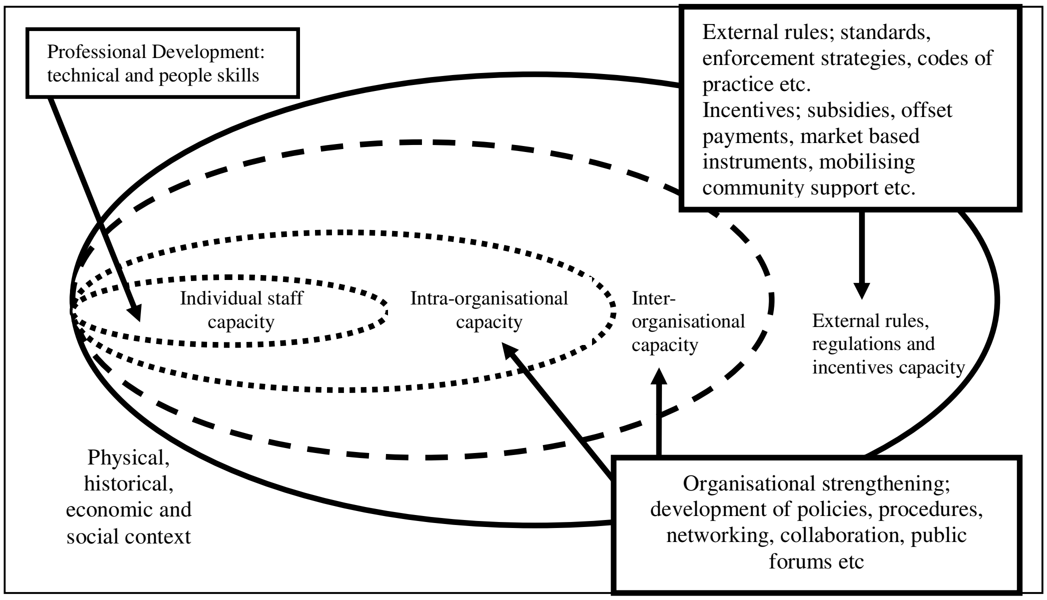

Figure 7 A Framework for Institutional IUSM Capacity Building.

Whilst statutory plans required under prevailing national/federal planning and environmental legislation include clear drivers for public participation in IUSM, there are other policy tools available to local government which are also crucial to promote and support IUSM. These additional tools and approaches include growth strategies, structure plans, SWMPs, engineering standards, land development codes of practice (such as PPS25 in the UK on flood risk management for urban development) as well as various BMP/SUDS design guidelines (see SWITCH Deliverable Task 2.1.4, Ellis *et al*., 2009) The development and promotion of these tools largely sit outside the formal national legislative framework and could be referred to as supporting strategic influences on the core legislative capacity. Whilst many of these tools may be generally developed outside formal public policy processes, they can be given later statutory effect through the regional, local and district planning process.

Local government is being given much firmer and clearer mandates through national/federal legislation to ensure that communities identify and address their ecological, social, economic and cultural aspirations. This depends on an integrated institutional approach in the delivery of outcomes to be successful. A necessary first step to facilitate low-impact, urban water management is to understand and model the critical phases of policy development as they relate to implementing agreed or approved BMP/SUDS approaches and to be more proactive in identifying and scoping the use of the full range of available policy and guideline tools. Such modelling approaches must recognise that local authorities will be at different stages in the change (or power balance) process, and as a consequence their needs in terms of capacity building will be different. The final critical step in capacity building is to ensure that the various development policy tools support each other and are integrated in ways that strengthen the implemented outcomes. This may occur through organisational protocols and practices to ensure that decisions are properly aligned and are compatible and reinforcing across different organisational levels and units.

Critical to this integrated cross-institutional policy development process, is securing the commitment from politicians, developers, regulatory agencies and communities. Without a sufficient commitment (and concomitant resources) for change, any attempts to strengthen or re-direct the policy framework will be less effective.

The capacity building framework illustrated in Figure 7 incorporates three key elements:

- human resource capacity: equipping individuals and groups with the understanding, skills and access to knowledge and information to enable them to perform more effectively
- organisational capacity: improvement of management structures, processes and procedures both within (intra-) and between (inter-) organisations.
- external institutional rules and incentives: regulatory and administrative initiatives with appropriate facilitating incentives (and penalties) to promote and improve adoption.

These key components provide the basic conceptual framework for effective capacity building for the implementation of IUSM.

Table 3 summarises the principal attributes that can be ascribed to the intra- and inter-institutional capacity and external spheres shown in Figure 7 and which are needed to foster and promote stakeholder trust. In order to achieve successful intra- and inter-institutional trust and effective working relationships, significant attention needs to be paid to developing these organisational attributes and understanding their drivers,

Table 3 Criteria and Attributes Associated with Sphere Domains Identified in Figure 7.

Individual Capacity Sphere	Intra-organisational Capacity	Inter-organisational Capacity	External Rules and Incentives Capacity
- Technical knowledge, communication and community engagement skills - Ability to work with other professional disciplines - Availability of specialist “champions” and possession of broad environmental understanding - Staff motivation and commitment - Recognition that sustainability is critical to work ethic	- Organisational culture focussed on sustainability and supportive of staff innovation, active learning and promotion of “champions” - Clear direction and plans for implementation - Embraces adaptive management and active learning approaches - Continuous evaluation and improvement of staff resources, skills and organisational development - Top-down leadership and support management styles - Effective and efficient resource/revenue costing	- Establishment of both formal and informal relationships between organisations at different levels (central and local government, regulatory agencies, NGOs etc.. - Organisational relationships founded on the principle of open collaboration - Receptive to productive stakeholder engagement - Open and transparent communication between organisations - Willingness to share data and information in participatory forums	- Need for appropriate mix of regulatory and inventive-based approaches - Clearly defined roles with statutory responsibilities and powers to enable coordinated participatory IUSM - Acceptance that stakeholder and community engagement will underpin IUSM decision-making - Availability of adequate and consistent technical and financial resources - Policy and action-based “responses” are coordinated across administrative and catchment boundaries

[After: Van de Meene, 2008]

constraints and operational limitations. However, experience would suggest that not all the listed attributes would be accepted or weighted in the same way within all organisations and in particular many would feel constrained by resources and a lack of technical capacity to effectively review innovative urban drainage solutions. Undoubtedly each organisation would identify different barriers that might prevent some (or even all) of the attributes being realised. These impediments are probably predominantly located in the intra- and inter-institutional capacity spheres which might suggest that these areas should be prioritised in capacity building initiatives.

In the context of UK urban drainage however, many organisational barriers are associated with external legal constraints related to the definition of a "sewer", acceptance of surface discharges to sewers, BMP/SUDS adoption and funding arrangements, incentive charging etc., in addition to definition of clear boundaries and powers of organisational responsibility. The UK Environment, Food & Rural Affairs (EFRA) Select Committee on "*Flooding*" (HMSO, 2008) noted that additional barriers were related to how agreed stakeholder forum "responses" were translated into implemented actions on the ground. They asserted that statutory regulation needs to be in place to ensure that coordinated outputs are actioned by identified responsible organisations. This requires a clear steer on which authorities/agencies should take a lead in coordinating agreed stakeholder action and management strategies. The experience of stakeholder participation forums such as those involved in the previous UK Department of Environment, Food & Rural Affairs (Defra) IUD pilots in Birmingham and Leeds/Bradford, would suggest their value perhaps lies less with identifying and implementing "solutions", rather than in the benefits gained from the exploration of the processes and barriers to collaboration. Future urban drainage management systems are likely to have complex governance arrangements consisting of multiple organisations located at different levels, which will further emphasise the need for intra-and inter-organisational capacity. Focussing on one area of capacity without others is unlikely to result in permanent or widespread change. The links between capacity spheres also need to be considered as these are usually complex and context dependent.

Thus the major impediments and barriers to IUSM are not technology dependent but rather institutional and social, neither of which have been well addressed to date given the emphasis on technology and planning issues within the water industry which are frequently driven by legal and market-led targets. Inertia related to a combination of legal, regulatory, administrative, skills and resource constraints are widespread but many studies would suggest that institutional acquisition barriers comprise the most embedded and difficult to reform (Rauch *et al.*, 2005; Brown and Farrelly, 2008). The development and implementation of key demonstration projects and associated training programmes would serve as useful policy interventions to build greater trust and confidence in both technical BMP/SUDS performance as well as institutional and stakeholder participation protocols. The implementation of local demonstration sites within the context of stakeholder networks having clear working management objectives has been shown to be successful in forging better and more integrated organisational links within the UK, Brazil and Australia (Todorovic *et al.*, 2008; Nascimento *et al.*, 2008 ; Heslop and Hunter, 2007).

4. THE DECISION MAKING FRAMEWORK FOR THE MANAGEMENT OF SURFACE WATER DRAINAGE IN BIRMINGHAM

Full detail of the organisational structures and frameworks for the management and delivery of effective urban stormwater drainage within the Birmingham area has been given in a previous SWITCH deliverable (Task 2.2.1a. *Evaluation of Current Stormwater Strategies*. J B Ellis, L.Scholes and D M Revitt. May 2007). The deliverable provided detailed information on the legislative, strategic and planning structures for the regulation and management of urban surface runoff and the major stakeholders involved in the decision-making process. The key institutional organisations involved in surface water management in the Birmingham region were also identified in Section 1.2.2 of the SWITCH deliverable under Task 2.1.1b (*Database Showing Threats and Uncertainties to Stormwater Control Which Exist in Selected Demonstration Cities Together with Their Predicted Major Impacts*. Edits: J B Ellis, L Scholes and D M Revitt. July 2008). This deliverable also outlined the principal organisational powers and responsibilities for surface water drainage and the major barriers to achieving IUSM in terms of future threats and uncertainties (Section 4.1.2.5). Organisational roles and responsibilities for the governance of sustainable urban water management in the UK and Birmingham region are also described in detail in the scoping study on institutional mapping contained in the SWITCH deliverable Task 6.1.2 by Green *et al* (2007). This deliverable stressed the organisational difficulties and deficiencies arising from the overlapping of linked legislative, administrative and planning "action spaces" within which UK urban surface water management is currently located. Without effective cross-collaboration and enabling legislation and organisational arrangements, the implementation and integration of sustainable drainage options into catchment management will not be possible according to Green *et al* (2007).

A number of recent pilot field studies, consultation and review reports covering urban surface water management and associated flood/water quality risks and impacts have been produced at national level in the UK over the past few years. These include the Defra pilot IUD projects which included the Birmingham River Rea project, reported and reviewed in SWITCH deliverable Task 2.1.2 (Ellis *et al*., 2008b). Central government long term strategy ("*Future Water*"; Defra, 2008a) for the overall UK water sector was published in February 2008 and both the Pitt Review ("*Learning Lessons from the 2007 Floods*"; Pitt, 2008) and the EFRA Select Committee inquiry ("*Flooding*"; House of Commons, 2008), stressed the need for new and/or amended institutional and legislative arrangements in order to achieve effective surface water management. Defra complemented these two central government reviews with a consultation document seeking views to a potential range of alternative new structures and institutional frameworks for urban surface water drainage (Defra, 2008b). A summary of responses to this consultation document was published in September 2008 (Defra, 2008c). Concurrent with the issue of the consultation document, the government announced that in future, local authorities would take the lead responsibility for surface water management and the production of SWMPs (as advocated by both Pitt (2008) and the EFRA Select Committee (House of Commons, 2008). Six UK local authorities have been funded to develop "first-edition" SWMPs as a basis for future national guidance. The regulatory Environment Agency (EA) will retain the strategic policy overview and direction for both flood risk and pollution control including responsibility for the production of catchment management plans (CMPs) and river basin management plans (RBMPs) as required under the EU WFD regulations.

All the above reports have identified common barriers to the achievement of an effective decision-making process and framework for the management of urban surface water drainage and the implementation of sustainable drainage options. The principal limitations have been summarised in the Introduction to this deliverable and were also developed in previous SWITCH deliverables Task 2.2.1a (Section 5.1) and Task 2.1.1b (Section 4.1.2.5). Table 4 lists these principal barriers and limitations which have been identified in the various official government reports and SWITCH deliverables mentioned above, together with comment on how they are being, or are likely to be, addressed at various institutional and administrative levels. There has clearly been a substantial central government response to the various reviews and reports on urban flood risk which will bring about substantial change to the current situation in the UK regarding surface water management. The changes involve a mixture of legislative, administrative, institutional and structural actions which should evolve in terms of improved practice and institutional reform over the next five years. However, as indicated in the final comment column of Table 4, there remain various questions over the adequacy and clarity of the proposals as well as their outcomes in practice. A considerable reliance is likely to be placed on the strength and direction

Table 4 Barriers and Responses to UK Surface Water Drainage Management.

DECISION-MAKING BARRIER/LIMITATION	MANAGEMENT SOLUTION OR RESPONSE	COMMENT
Lack of clear, strategic responsibility for surface water flooding	EA will be given full responsibility for national strategic overview and monitoring of fluvial and groundwater flood risk.	EA intended to ensure coordination and integration of flood risk planning at national/regional level. EA overview role needs clear specification in terms of responsibilities and functions. Requires legislative backing from forthcoming Floods & Water Bill.
Lack of clear identification of institutional leadership and responsibilities for local surface water flooding (especially for wet weather exceedance pluvial flooding)	Local authorities (LAs) will have leadership role and responsibilities for pluvial (exceedance) flood risk. Required to establish new partnership and administrative arrangements to effectively undertake these responsibilities. Boundaries to, and exact powers associated with, these responsibilities to be explored with EA and central government agencies (Defra, DCLG etc.)	LAs need clear understanding of role and boundaries to their powers and responsibilities. Issues relating to 2 tier authorities and how responsibilities will be shared. Relationship and responsibilities for flooding between LAs and EA need to be fully defined and articulated with clear lines of accountability. How will the new partnerships be formed, operated, funded and how will approved decisions be implemented? Lack of both administrative and legislative structures and processes to bring all stakeholders together. LA flood authority and powers require new legislation (Floods & Water Bill). How will consistency in practice and harmonised standards between LAs be ensured? Use of risk-based approaches.
Coordination and integration of planning process in relation to flood risk	LAs, DCLG, EA and other stakeholders such as water/wastewater companies, highways agency, NGOs etc., to establish regional seminars and workshops on stakeholder coordination and integration for PPS25 "*Development & Flood Risk*" policy. On-going review of PPS25 implementation and review of "call-in" planning decisions	Not clear who will take lead in this exercise and whether it will be a "one-off" campaign. Not clear whether it will mandatorily involve any substantial public participation. Not clear how the process and outcomes will lock into the development of local

	where LAs over-ride EA or other major stakeholder recommendations. Local Resilience Forums (LRFs) will be established regionally to enhance local flood warning capabilities and post-flood emergency coordination capabilities	and regional planning framework documents.
Information and data sharing between stakeholders.	LAs required as part of their new surface water remit to cooperate and share information between stakeholder organisations in future flood risk partnerships.	Supporting administrative and organisational structures to implement data sharing still to be worked out and tested. No clear pathway or structural frameworks whereby LAs as lead organisation, will be able to "demand" stakeholder information sharing especially on sensitive issues involving private/corporate organisations e.g water/wastewater companies.
Responsibility for modelling and mapping extreme wet weather pluvial (exceedance) flooding	EA will have responsibility for undertaking and developing 2D/1D modelling and mapping for urban flood risk Local Resilience Forums (LRFs) to review areal susceptibility to surface water flooding (in high risk areas). Development of partnership approaches e.g between local/district councils, EA and water companies etc., on integrated urban drainage modelling pilot studies such as Torbay Council and SW Water. Joint EA and Met Office centre to develop storm modelling forecasting capability.	Such flood modelling detail required anyway under EU Floods Directive (by 2013). How will this local/district modelling focus be integrated into regional and catchment scale modelling required for EA CMPs/RBMPs? Modelling capabilities long way from being realised in practice at all levels.
Lack of local/regional surface water management plans (SWMPs)	LAs will be required to produce SWMPs and undertake mapping/review of drainage assets and production of public register as basis for tackling surface water problems. EA/Defra developing initial guidance for SWMPs to produce national template. Supporting £5M allocated for development of early SWMP guidance template.	Restricted to 50 identified priority areas. How will compatibility between SWMPs (LAs having lead role) and CMPs/RBMPs (EA having lead role) be ensured? Requires new legislation (Floods & Water Bill). How will LAs obtain input from private/corporate organisations and how will SWMP production, work for tiered authorities? How will quality assurance of SWMPs be ensured?
LA resource capabilities and organisational capacity	Defra and Local Government Association (LGA) to undertake capacity and resource review as basis for ensuring threshold institutional capacity. LA national network (LANDFORM) established within CIRIA to support/share knowledge and skills on surface water drainage.	Adequate technical and resource capabilities lacking in many LA organisations to deal with lead roles and powers for surface water management. Awaits new major funding arrangements and administrative structures. New enabling legislation and funding required.
Lack of capital and maintenance funding to establish and implement coordination and partnership proposals as well as introduction of alternative planning and drainage systems	£34.5M set aside for implementation of Pitt Review recommendations. Expected £60M expenditure for overall flood risk management over next 2/3 years with majority (£27M) allocated to LAs (under Revenue Support Grant and/or Comprehensive Spending Review, CSR07) to support LA technical capabilities.	Suggestion by EFRA Select Committee that total funding budget will be inadequate to meet recommendations and meet flood risk management objectives. No clear indications or steer on how funding will be distributed internally within LAs and what specific projects, administrative structures and processes will receive priority. Where and how will funding be allocated and how will it be accountable? Ofwat should consider introduction of surface water charge and rebates.
Adoption of BMP/SUDS drainage systems	LAs to be responsible for adopting and maintaining new and re-development BMP/SUDS on both highway and public realm drainage systems. Model adoption agreements as described in "*Interim Code of Practice*" (National SUDS Working Group, 2004). Design guidance, working practice and	Issues of 2 (or more) tiered organisations having split or shared responsibilities for urban drainage. Need for local, district, county and highway authorities to work closely on BMP/SUDS ownership and maintenance issues. Effective collaboration cannot be

	protocols, codes of practice including PPS25 Practice Guide (DCLG, 2008) as well as guidance provided by CIRIA; ABI; Environment Agency; Highways Agency etc.	ensured given that government intends to give formal adoption responsibility to county and unitary authorities. Does not refer to BMP/SUDS retrofit drainage in existing sewered urban areas. No binding legislation requiring that BMP/SUDS drainage be implemented for urban drainage. Presumption in favour needs to be formally included in Planning Bill. Requires new enabling legislation. Need for good quality demonstration sites having well-formed local stakeholder frameworks to serve as regional templates.
Definition of "sewer" and inclusion of BMP/SUDS within standard definition. Restriction on sewer design levels and standards	Central government review of sewer design standards especially for surface water sewers. OFWAT to re-consider definition of "sewer" in relation to alternative drainage systems. Introduction of EA maintenance programme of flood prevention assets.	Need for new enabling legislation but no provision for upgrading design for existing surface water sewers and SWOs. Review needed of what constitutes reasonable levels of flood protection in terms of public expectations.
Right-to-connect to public sewer system for new urban development.	Unconditional right to connect surface water drainage to the public sewer system to be amended in future Floods & Water Bill.	Proposals are for amendment to existing legislation rather than complete removal of right.
Extension of impermeable surfaces and urban "creep"	Ban (under Town & Country Planning Act) on non-permeable paving (>5m^3) for front gardens, with possible extension to back gardens and commercial premises. Prescription against building on high flood risk areas in accordance with PPS25. LAs required to take flood risk into account in preparation of LDFs and individual planning applications. DCLG to publish practical guidance to support delivery of policy.	Developers to fund flood mitigation works including BMP/SUDS drainage. No basic formula for such funding yet agreed. Procedure for "paving" approvals under householder permitted development rights yet to be worked out, as well as procedures (and penalties) for non-compliance.
Lack of community perception and awareness of flood risks	Central government commissioned review of public attitudes, behaviour and knowledge awareness to flood risk. Expectation that LA (county/district/local) will work with EA, Highways Agency and other major stakeholders in promoting local community awareness. Formation of Local Flood Liason Forums (LFLFs) for surface water flood risk management. Enhanced EA public outreach capabilities on flood prevention and mitigation measures. Possible inclusion of flood/sewer searches in Home Information Packs (HIPs) for future property sales. Local Resilience Forums (LRFs), FloodLine warnings and websites to be enhanced.	How will local stakeholder partnerships be linked to strategic policy decision-making? No formal structures proposed to facilitate or underpin partnerships. No clear funding arrangements to support partnership formation.

taken by the legislation which will be developed in the forthcoming Floods & Water Bill. This guiding national legislation will re-organise the structural framework and delivery mechanisms for future flood risk management and a major stated intention is to clarify roles, responsibilities and inter-relationships between regulatory agencies and organisational levels.

The large majority of the proposals and responses alluded to above have been directed at the flood risks associated with urban surface water management with very little concern for or attention to the related water quality risks of impermeable surface discharges. Water quality regulation, whether it be related to receiving watercourses or impermeable surface runoff, remains the responsibility of the EA. However, responsibility for effective drainage of sewered discharges lies with the LAs and water companies and remediation of polluted SWOs requires effective coordination between the LAs, EA and water companies. No regional coordinated strategy to fulfill these responsibilities is currently in place in the UK although future SWMPs might help to address this issue assuming they include reference to water quality. Thames Water has introduced partnership arrangements with the EA and Greater London LAs to develop a regionally coherent surface water outfall strategy for its drainage area and the liason has been shown to be productive (Dunk *et al*., 2007). The adopted management approach lies outside formal legislative requirements and administrative frameworks but illustrates that motivated partnerships (with expert overview scrutiny committees) can be highly effective when focussed on specific drainage problems of vested interest to the stakeholders. In this case the main driver has been the desire of Thames Water to fully achieve its Asset Management Planning (AMP) targets to satisfy Ofwat and EA requirements for receiving water quality.

The emerging institutional decision-making structure for urban surface water management likely to result in the UK from the various responses and actions noted in the second column of Table 4, will function on at least four distinct levels. Whilst the emerging structure as shown in Figure 8 may appear similar to the existing

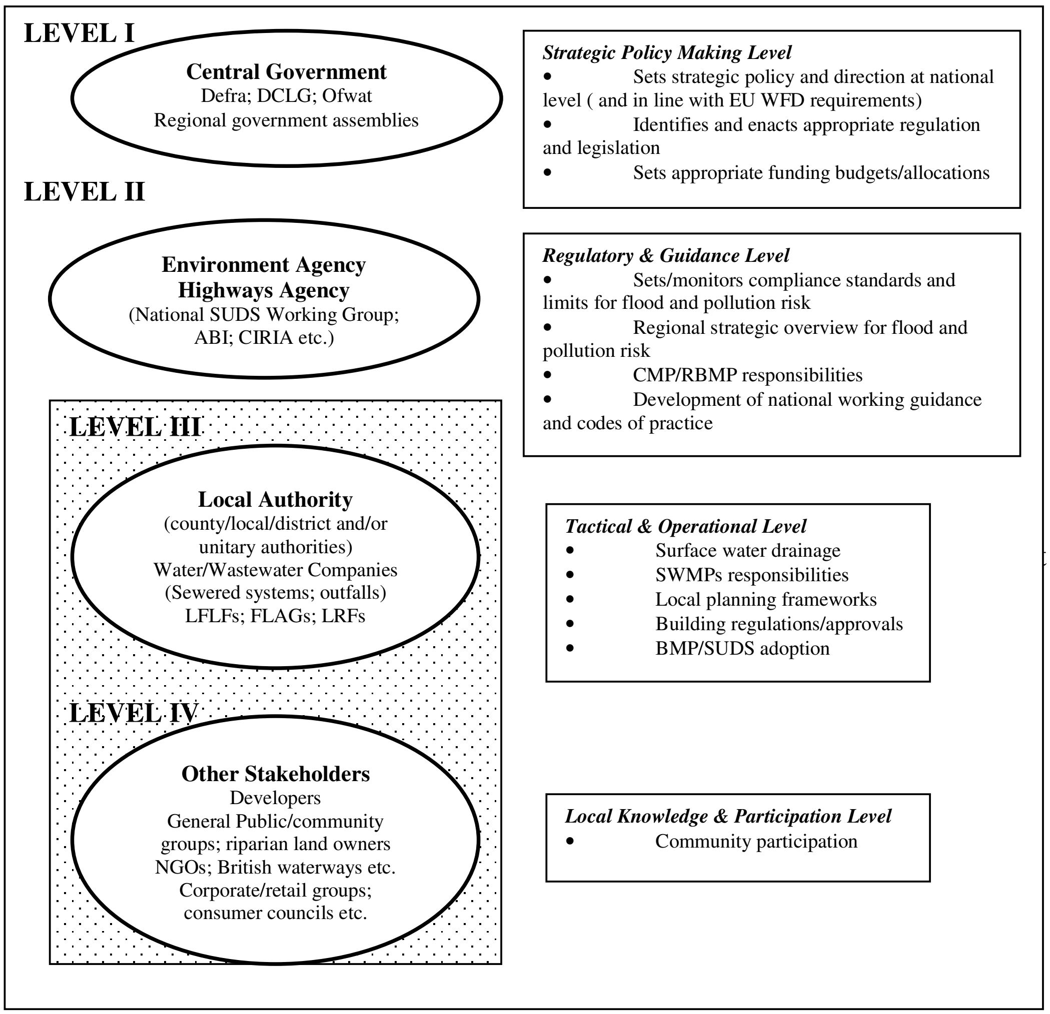

Figure 8 Emerging Institutional Structures and Administrative Levels for Surface Water Management.

organisational framework, there are a number of fundamental and significant differences. The organisational agencies, groups and functional responsibilities lying within the shaded box will require new (or amended) legislation, administrative and funding arrangements in order to be effectively undertaken. In addition, there will be a need to ensure vertical consistency and compatibility of functions and actions between different levels e.g making clear separations between SWMP and CMP/RBMP delivery roles and functions whilst at the same time ensuring integration of objectives and outcomes at local and regional scale.

The institutional arrangements and framework structure illustrated in Figure 8 demonstrates that the decision-making system for surface water management will continue to operate strongly in a "top-down" approach. This continues a traditional propensity in the UK for higher-level management decision-making in the water sector with a reluctance to actively engage with stakeholders at the local Level IV (Ashley *et al*., 2008). Thus, there is likely to be a continued issue of commitment in engagement and empowerment of Level IV stakeholders and in developing alternative non-structural responses to flood and pollution risk. The key here is in developing and implementing appropriate communication systems and tools. The relevant tools will be those that enable the different participants to have more effective and articulated discussion. Establishing appropriate participatory frameworks and active-learning cultures in the decision-making process within the institutional hierarchy of Figure 8 will be a major challenge. It may be best achieved through the formation of local/regional alliances supported by appropriate demonstration sites and a re-appraisal of skills and professional needs (i.e capacity building) of Level III organisations.

5. A VISION STATEMENT FOR THE MANAGEMENT OF SURFACE WATER DRAINAGE IN BIRMINGHAM EASTSIDE

The UK government set out a template of its long term strategic vision for the water sector in the Defra (2008a) "*Future Water*" document. A summary of the proposed actions in relation to the surface water component of this national vision is given in Table 5 which provides a generalised outline of aspirations rather than any intended guiding action. The Defra vision statement was paralleled by individual strategic

Table 5 UK Government Vision for Future Surface Water Management.

Surface Water Drainage	Receiving Water Quality	Regulatory Framework
More adaptable drainage systems delivering reduced flood risk, improved water quality and decreasing burden on the sewer system. Better management of surface water drainage: • Increased capture and re-use of water • slower absorption through the ground • increased above-ground storage • routing of surface water separately from the foul system . Better public appreciation of causes and	Establish good ecological and chemical status Maximising sustainable use and amenity benefits of the water environment. Maximise resilience to climate change and sustain biodiversity. Tackle problems of diffuse pollution (including impervious surface runoff). Increased flexibility in management of flood storage.	Strategic framework for the UK water industry with incentives, innovation and sustainable demand. Long term planning with short term efficiency. Effective risk-based regulation. Efficient, flexible UK water industry to meet challenges of pollution and climate change.

consequences of surface water runoff and actions that can be taken to minimise risks.		

direction statements covering the 2010 to 2035 period by a number of wastewater companies including Severn Trent Water (STW). Its vision identified a number of key strategic intentions (KSIs) to meet the challenges of future climate and demographic change as well as future environmental and societal demands (Severn Trent Water, 2007). Table 6 provides a summary of this strategic vision in respect of surface water management, with most KSIs being broadly compatible with the Defra "*Future Water*" drivers and aspirations. The STW 25 year vision focusses on more sustainable approaches, with increased ownership of planning objectives and targets and a commitment to involve a wider stakeholder group. Whilst key drivers to the

Table 6 Severn Trent Water Future Strategic Vision for Surface Water Management.

Key Strategic Intention (KSI)	KSI Benchmark	Management Options
KSI 1: Safe, reliable water supply	Promote water efficiency programmes and water re-cycling for consumers and business.	Commissioning of trials: • rainwater harvesting for non-potable use for all new commercial property • retrofitting of rainwater harvesting on existing commercial properties • greywater re-use schemes (especially for industry).
KSI 2: Effective dealing of wastewaters	Improved sewer network and hydraulic capacity to cope with all but most extreme wet weather events. No "customer" community to be subjected to internal sewer flooding Improved sewer network to ensure no serious pollution incidents.	Improved and increased separation of surface water and foul wastewater flows Promotion of SUDS with installation of trial projects Monitoring (and rehabilitation) of SWO discharge and quality. Enhanced sewer cleaning programme to prevent blockage, siltation and pollution Public educational campaigns on fats, oil disposal to sewers.
KSI 5: Lowest possible charges	Assessed property charges.	Incentives for surface water disconnection and/or storage Impermeable surface water connection charge.
KSI 6: Right skills for delivery	Develop internal organisational capacity building and professional skills. Develop leadership and training roles with local communities being served.	Address and champion specific skill shortages. Deliver people and community engagement programmes.
KSI 8: Promote effective regulation	Encourage innovation, better planning and development of long term, sustainable solutions.	Risk-based management approaches. Improved communication and cooperation with stakeholders involved in the legislative and administrative management of the regional water sector. Setting and monitoring appropriate levels of water quality and standards and ensuring cost-effective delivery.

vision are climate change and increased sewer network resilience to flooding and pollution risks, a primary response is to future consumer expectations. However, consultation on the strategic vision document made clear that STW cannot make decisions on their asset strategies in isolation from other agencies including local/district authorities and regulatory agencies. The STW strategic approach to sewer separation, SUDS and water re-use is likely to be opportunistic in nature, with step-changes in urban drainage introduced gradually in cooperation with developers, local planning authorities and regulatory agencies. The STW consultation also highlighted a major difference in attitude between their vision aspirations and those of the public on the issue of receiving water quality. This received little consumer support in comparison to the perceived priority as required under the EU WFD legislation. This may simply reflect a public remoteness and lack of awareness of the problem, in addition to the high costs of pollution control against public willingness-to-pay. The STW vision addresses areas of perceived corporate vulnerability and exposure to potential market threats and uncertainties as well as attempting to identify effective strategic management options. A partnership approach is essential to actioning the visioning exercise given the disparate and often competing "consumer" concerns,.

The Birmingham SWITCH Learning Alliance also undertook its own visioning exercise on integrated urban water resource management (IUWRM) at their fourth meeting on 16 October 2007. The workshop meeting objective was to create a joint stakeholder vision for the future water landscape of the Birmingham region based on scenario-building to explore a range of potential strategies, planning horizons and solutions. A further meeting held during 2/3 March 2008 discussed a vision statement which included specific reference to urban surface water management, and which considered the relative merits of using measurable indicators in benchmarking progress towards achieving vision aspirations and objectives. It was recognised that in practice such a vision statement would need to capture both narrative and numerical indicators for identified criteria, and that it might be difficult to objectively compare the utility and value of these two benchmarking techniques.

A final Learning Alliance meeting held on 26 August 2008 clarified the structure and format of this vision statement together with the identification of alternative benchmarking approaches. The approach to, and outcomes of, these visioning workshops have been reported in the SWITCH deliverable D6 for WP6.2 (Chlebek and Sharp, 2008). A summary vision statement for Birmingham 2050 provided the conclusion to the SWITCH Learning Alliance report. However, this concluding vision sets out aspirations and "desired-situations" for the wider water sector rather than any detailed analysis of enablers and processes involved in surface water management. Nevertheless, the vision statement aids the learning process through core "messages" of intent, aspiration and direction. This first visioning stage must be backed-up by clear ownership and championing of strategic responses and the evolution of a collaborative approach between Level III/IV stakeholders together with a designation of response responsibilities, time schedules and funding allocations. A cross-stakeholder scrutiny or liason steeering group is also needed to ensure the vision "messages" are targeted and progressed in an acceptable prioritised manner with appropriate reference to Level I/II drivers.

The various Learning Alliance visioning meetings did enable a final draft to be completed of the 2030 vision statement for urban stormwater management in the Birmingham Eastside demonstration area, based on eight primary criteria:

- flooding and flood risk
- receiving water quality
- receiving water ecology and stream health
- urban land use planning
- regulation and funding regimes
- technical and scientific issues
- stakeholder participation
- need for coherent, integrated approaches

The range of potential indicators and benchmarking techniques for these primary criteria was then tested over the period August to December 2008 by visits and group discussion with Learning Alliance members resulting in the production of a final draft of the vision statement on urban surface water management which is given in Table 7.

It is considered that this vision statement provides a first-step in engaging the full range of Birmingham Learning Alliance stakeholders in scenario-based, participatory decision-making for urban surface water management. The vision statement provides a basic first step procedure in identifying priority targets and objectives for the achievement of a sustainable urban drainage strategy for the Birmingham demonstration area. It can be used as a basis for stakeholder engagement to develop acceptable strategic management approaches and frameworks in order to achieve differing elements of the vision. In this respect the decision-making process can be regarded as comprising a series of iterative, step-functions involving separate but interlocking action spaces which will need to be coherently integrated in terms of strategic objectives and administrative support. This in turn will need active and full cooperation between the various organisational levels and groups noted in Figure 8 and will undoubtedly present many challenges for the individual stakeholders.

It may be possible to use the vision statement as a basis to develop a generic technical and organisational systems map for sustainable surface water management in the wider context of a sustainable city onto which different institutional maps could then be overlaid. In turn, this might enable the description and identification of differing modelling approaches for surface water management. One problem with BMP/SUDS drainage options is that they represent a "bundle" of technologies which are being picked-up by differing countries in relation to differing issues:

- green roofs are frequently being considered in relation to city heat island effects and energy conservation as well as comprising elements of a more resilient dwelling fabric
- rainwater harvesting is often viewed in relation only to supplementing available water supplies for secondary use
- permeable paving is sometimes primarily considered in terms of reducing traffic surface noise
- retention storage and wetlands are frequently adopted because of perceived benefits in ecology, biodiversity and/or social amenity

- all BMP/SUDS options are considered to provide towards an overall abatement of flooding and pollution.

Mapping the connections between these various functions and their supporting organisational and decision-making structures and governing mechanisms within different national and regional contexts might be useful in terms of the wider definition of the sustainable city concept. In addition, such mapping might also identify differing mechanisms and structures by which BMP/SUDS implementation might be more easily and effectively achieved.

Table 7 Birmingham Eastside Urban Stormwater Management: Vision for 2030. The City-of-the-Future.

FLOODING	WATER QUALITY	ECOLOGY & STRAM HEALTH	TECHNICAL & SCIENTIFIC	PLANNING	STAKEHOLDRRS	LEGISLATION AND FUNDING	INTEGRATED APPROACHES
- Reduced flood risks and frequency; i.e no surface water flooding for <M75-60 extreme storm event in line with ABI property insurance guidelines. -Improved knowledge and modelling capability for extreme event exceedance flows; real-time flood risk maps for urban areas - Flood peak attenuation to at least pre-development levels and establishment of an improved urban water balance - Decreased burdens on both surface water and combined sewer systems e.g > 20% reduction in annual O&M costs; introduction of impermeable surface "tax" (>5m^2.); - Increased retention, harvesting and re-use of rainfall-runoff e.g equivalent to initial 5mm of effective rainfall-runoff - Increased use of local, small-scale infiltration	-Achievement of "good" chemical quality (GQA 2/3) status irrespective of any initial WFD derogation for urban watercourses - Ensure elimination of all illicit cross-connections to the surface water system; introduction of CCTV drain survey under property conveyance requirements -Elimination of dual manhole mixing for wet weather sewer flows - Implementation of BMP/SUDS measures for impermeable surface water flows on all new commercial, retail and industrial premises to eliminate/reduce toxic pollutant and organic discharges; financial incentives for retrofit measures - Development, testing and application of robust, reliable sediment quality standards for urban receiving waters	- Improved urban ecosystem health and biodiversity; achieve "acceptable ecological status" under WFD requirements - Eliminate faecal coliform and pathogen species from SWO outfall discharges - Improved benthic and channel habitats; annual (or 3 year survey) improvements in biodiversity scores - Development of "green corridor" approaches and "daylighting" of culverted ditches and streams; introduction of sinuous flow paths in straight engineered river channels - Use of public open space, parks, playing fields etc., for extreme flood storage (>1:30 RI events with maximum storage depth of ~200mm and minimum 60 -120 minute durations. - Undertaking of bankside shrub and tree	- General availability of reliable, accurate and robust technical tools/models for BMP design, selection and pollutant retention/degradation for given storm event properties and land use - Availability of flexible LID approaches for greenfield and inner urban retrofit surface drainage schemes - Mandatory availability and "ownership" of appropriate and systematic O&M procedures for surface water drainage - Availability of user-friendly tools for prediction of BMP/SUDS performance levels for given flow design parameters - Target uptake levels for BMP/SUDS measures as related to development e.g	- Identification and establishment of single-authority oversight for planning and management of surface water drainage - Development and application of integrated surface water management plans (SWMPs) based on identified and agreed stakeholder priority issues and acceptable risk levels - Development and application of adaptable mitigation measures for flow volume, water quality and stream health to address issues and pollutants of concern - Assessment of (and improvement to) organisational capacities to implement and resource remedial and mitigative actions. - Robust planning for flood risk with policies and codes to restrain flood plain development; M75 -120 minimum protection level of service; limits	- Identify appropriate stakeholders; clarify boundaries of responsibilities and powers - Clear leadership and oversight responsibilities and powers for surface water drainage - Implementation of multi-stakeholders into integrated decision-making framework - Development and implementation of formal procedure and enabling structure(s) for agreement and approval of objective setting and performance standards - Identification of community knowledge, awareness, attitudes and expectations to support approved objectives and stormwater management vision; testing of willingness-to-pay -Organisation and delivery of stakeholder stormwater fairs, signage campaigns, interpretive boards/pamphlets etc. - Commitment to implement outcomes of	- Resolution of issues relating to "right-to-connect", sewer definitions and sewer asset management. - Identification of, and compatibility between, district, council, county/state and national legislation and planning processes for surface water drainage including coherence of SWMPs, CMPs and RBMPs - Establishment of integrated, multi-stakeholder decision-making framework and Codes of Practice for surface water drainage - Development and implementation of appropriate framework of social, economic and environmental costs and benefits for surface water drainage - Sensitisation of water industry to incentives, innovation and sustainability demands for integrated sustainable surface water drainage	- Stronger interface between engineering/science of catchment health and ecosystem functioning with municipal and national planning and policy decision making - Availability of sustainable integrated strategies for urban surface water management which considers plot, site and regional level scales. - Availability of adequate resources and funding with long term commitment - Availability of information database and performance monitoring - Availability of appropriate benchmarks for adaptive integrated ecosystem health and management

(incl. porous surfacing) systems where appropriate and where not prejudicial to groundwater quality - Disconnection (partial??) of impervious areas from the surface water sewer system for all new build and infill development; financial incentives/discounts for voluntary disconnections -Introduction of flood resilient building for all new build and infill development in flood prone properties	- Improved knowledge of catchment dynamics and water quality impacts from both acute and chronic pollutant discharges; wider intermittent wet weather standards for acute surface water discharges - Improved knowledge of sediment dynamics, biodegradation products and fates; monitoring of priority pollutants - Insertion of "dragons teeth", weirs etc., to provide improved channel aeration	planting schemes - Introduction of "soft green" street landscaping and bioretention features	required annual uptake targets for new implementation and retrofitting	to urban "creep" and extension of impermeable surfacing for residential and commercial properties - Coordination of SWMPs with EU WFD RBMPs and with regional/local development plans. -Building regulations to include appropriate flood proofing and sustainable building materials - BCC and local council bye-laws and SPD statements to support consistent decision-making -Introduction of area-wide strategic sustainability planning for Eastside development - Introduce presumption against culverting in drainage infrastructure planning	participatory stakeholder consultation exercises	- Implementation of impervious (or other surrogate) stormwater charge - Requirement to implement BMP/SUDS drainage for new and infill development unless severe technical or other difficulties are encountered. - National source control procedures e.g emission controls, product substitution etc..	

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7. ABBREVIATIONS/ACRONYMS

ABI: Association of British Insurers
AMP: Asset management planning
BCC: Birmingham City Council
BMP: Best Management Practice
CCTV: Closed circuit television
CIRIA: Construction Industry Research and Information Association (UK)
CMPs: Catchment management plans
CSO: Combined sewer overflow
CWA: Clean Water Act (United States)
DCLG: Department of Communities and Local Government
Defra: Department of Environment, Food and Rural Affairs (UK)
DEM: Digital elevation model
EA: Environment Agency
EFRA: Environment, Food and Rural Affairs (UK Select Committee on Flooding)
FLAG: Flood Liaison Action Group
GIS: Geographical Information System
GQA: General quality assessment
HIP: Home information pack
HMSO: Her Majesty's Stationery Office (Publisher of legislation in the UK on behalf of the government)
INTERREG: Inter-regional cooperation programme funded by the European Union.
IUD: Integrated urban drainage
IUSM: Integrated urban stormwater management
IUWM: Integrated urban water management
KSI: Key strategic intervention
LA: Local Authority
LANDFORM: Local Authority Network on Drainage and Flood Risk Management (operated under the auspices of CIRIA)
LDF: Local Development Framework (a folder of local development documents that outlines how planning will be managed in different areas in the UK)
LFLF: Local Flood Liaison Forum
LGA: Local Government Association
LID: Limited impact development
LiDAR: Light detection and ranging
LRFs: Local Resilience Forums
Met Office: Meteorological Office (UK)
NGO: Non-governmental organisation
O & M: Operation and maintenance
Ofwat: Office of the Water Services Regulation Authority (UK)
PPS25: Planning Policy Statement 25 (UK Government policy document on development and flood risk)
RAFNEEC: Resilient, adaptable, flexible approaches not entailing excessive costs
RBMPs: River basin management plans
RI: Return interval
SPD: ???????
STW: Severn Trent Water
SUDS: Sustainable Drainage Systems

SW Water: South West Water
SWMPs: Surface water management plans
SWO: Surface water outfall
WFD: Water Framework Directive (European Union)