

SAM

System based analysis and management of urban flood risks



BERR | Department for Business
Enterprise & Regulatory Reform



Project tools

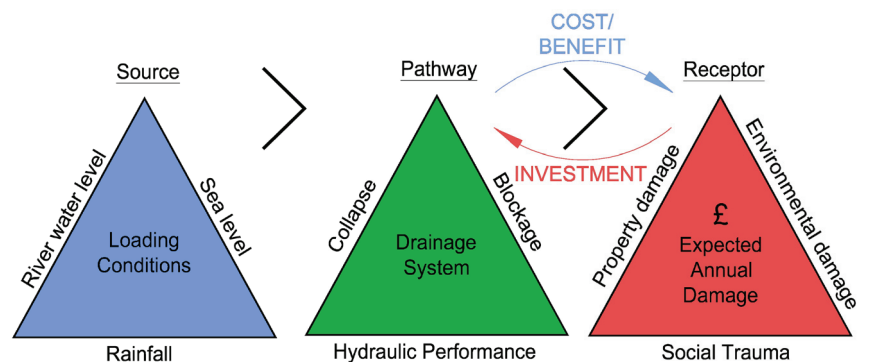
The project produced not only a new procedure for analysis and management of drainage systems, but in doing so also produced the following tools:

- Stochastic rainfall generators for spatially varied rainfall
- Database for assimilating the massive volume of spatial rainfall
- A spatial rainfall event and evaluation processor
- A Rapid Flood Spreading Model (RFSM)
- Integration of a property Damage tool into RFSM
- An integration of InfoWorks with RFSM and the Damage calculation modules (SAM-UMC)
- A Risk shell to run all possible system states and to calculate convergence of Expected Annual Damage (EAD)
- Development of a fast solver for InfoWorks CS
- Modification of FASTNETT to apply the procedure to developing optimised solutions using a genetic algorithm.

Research objective

The DTI SAM project has developed a new procedure and supporting tools for **an integrated analysis of drainage systems using a risk based approach**. The method is based on measurement of flooding and the associated damage costs and attributing these costs to the assets which are the source of the flooding.

The method takes into account not only the probability and consequences of flooding from the system as it is designed to operate, but also considers the probability of assets failing and subsequent flooding consequences. This procedure is a radical change to current best practice where drainage systems are assessed on the basis of the hydraulic performance, not taking into account the consequences of exceedence and failure.



Technical advances

The project addressed many limitations of current practice, including:

- The need to provide a true integrated approach to drainage analysis, both technically and institutionally;
- The problem of using uniform rainfall over large catchments;
- The current lack of explicit consideration of the impact of flooding on people and property in the assessment and management of drainage systems;
- The fact that structural condition is not incorporated in an integrated approach to drainage management assessment which effectively only considers the hydraulic capacity of the system, and
- That the current approach to drainage only considers explicit levels of service rather than all possible events.

The SAM risk based procedure for drainage systems

The procedure is based on three linked packages:

- a drainage network system (Infoworks CS);
- a routing module (RFSM); and
- a damage calculation module.

These three modules are controlled by a separate module (the risk shell) which calculates the Expected Annual Damage (EAD) for each Impact Zone and attributes the damage to the assets. This is illustrated in Figure A.

The risk shell evaluates whether EAD has converged sufficiently at each location, or for the whole system, and launches the next system state and rainfall loading condition. This is illustrated in Figure B.

The procedure can be applied using both design storm events and time series rainfall.

The system states of the network can include blockages and collapses taking into account the probability of failure, and other relevant elements

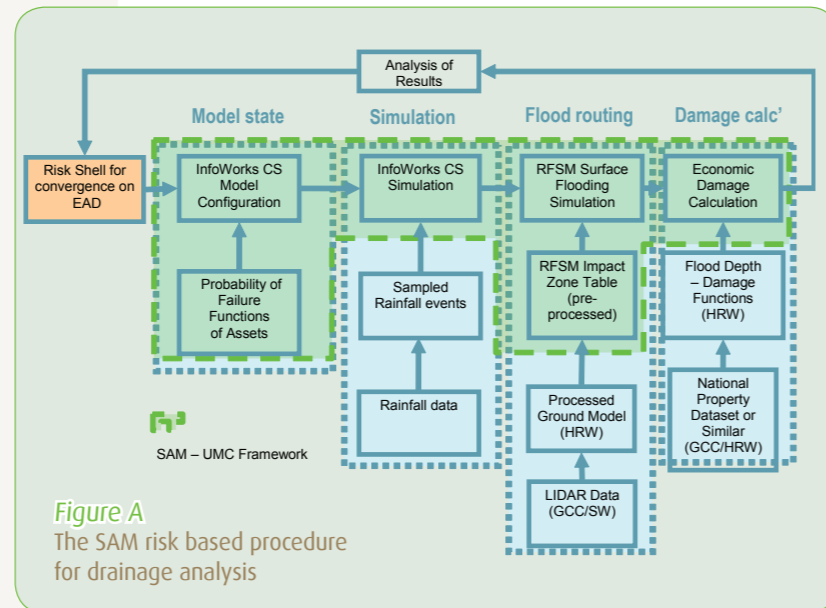


Figure A The SAM risk based procedure for drainage analysis

such as embankments and their risk of failure, can also be represented.

Although the failure probability within the network is very low for any specific location, due to the extent of the system the chance of a failure occurring at some point is relatively high. The inclusion of system failure is therefore an important element in a full risk based approach. However the computing effort needed to consider all system states is illustrated in Figure C. Fortunately convergence can be arrived at before the majority of all the system states are run, due the very low probability associated with multiple failures.

As failure at any location in the system reduces the pipe capacity to zero, this means that all rainfall events (big and small) need to be considered in assessing the impact of flooding.

Figure D illustrates the output in terms of the calculation of EAD across the catchment.

Figure E shows the attribution of flooding to the network to assist with decision making for changing the network.

A value for EAD across the catchment and at any Impact Zone can be computed for any proposed improvement to the system. This allows the drainage engineer to easily assess the cost - benefit for any investment proposal.

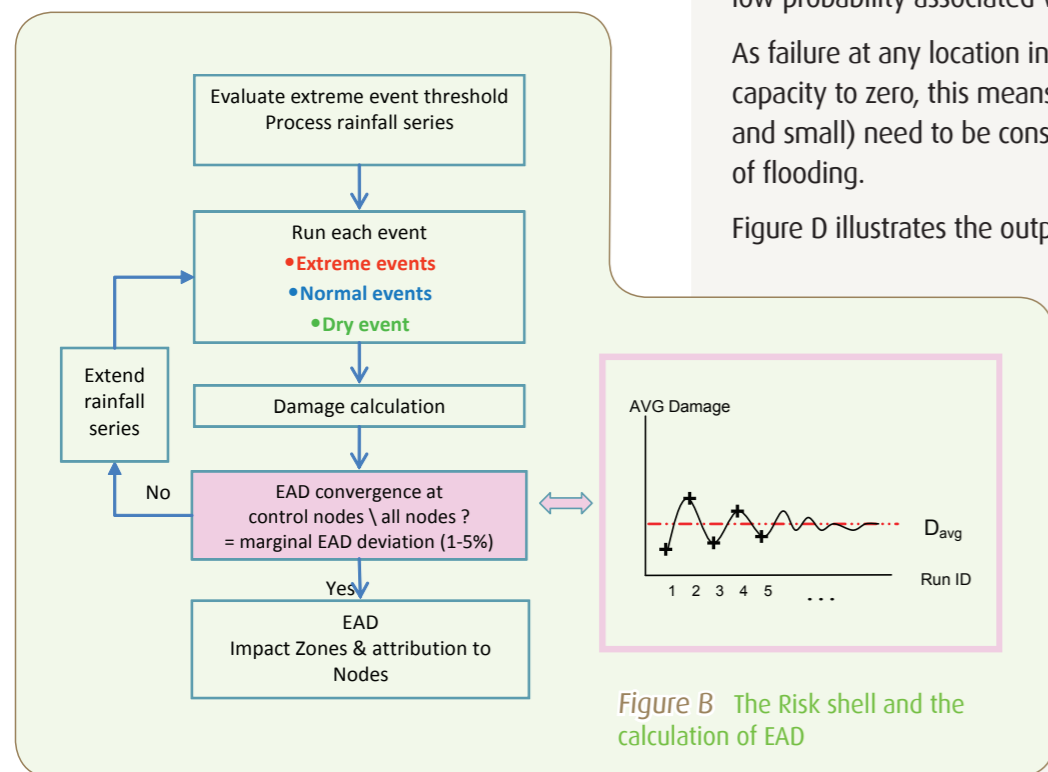


Figure B The Risk shell and the calculation of EAD

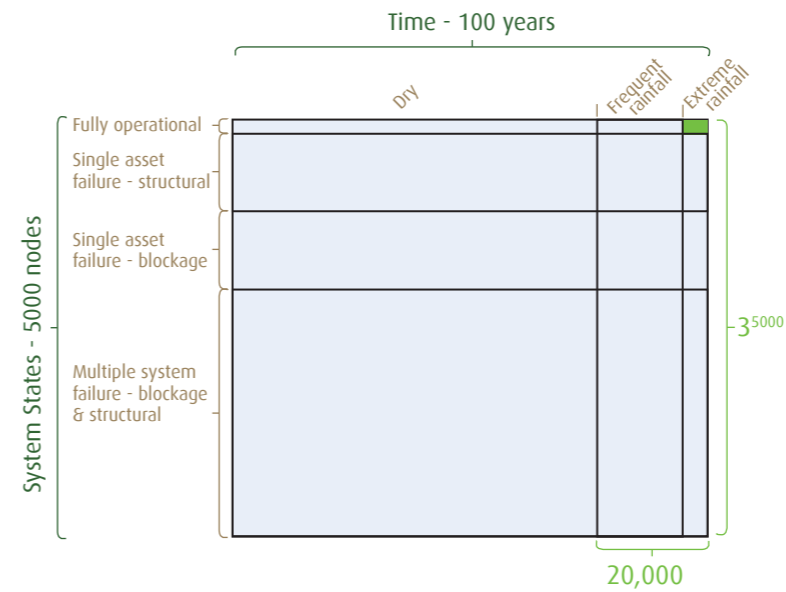


Figure C All possible system states of a drainage system

The Rapid Flood Spreading Model (RFSM) and depth damage assessment tool

The RFSM is a simplified hydraulic model that takes as an input flood volumes discharged from node points or overtopped defences. It then spreads the water over the catchment taking account of topography. The output from the model is a flood depth grid for each cell in each Impact Zone.

The model was specifically developed to provide a very fast solution to the flood spreading problem for use in probabilistic flood risk models that has to consider multiple system states (failures of defences and drainage elements).

The pre-process divides the catchment into areas called Impact Zones. The Impact Zones represent topographic flood collection areas where the water accumulates (Figure F). The flood depth characteristics of the Impact Zones are also generated in the pre-processing stage which also defines the relationship between any Impact Zones and its neighbours. The communication level (CL) of an impact zone defines the level at which water spills into a given neighbour Impact Zones.

The RFSM spreads the flood volumes by filling the Impact Zones adjacent to the input points and spilling the excess to the neighbour Impact Zones. This filling/spilling process is repeated as long as some Impact Zones have volume in excess. When two or more neighbour Impact Zones have the same water level, they are merged into

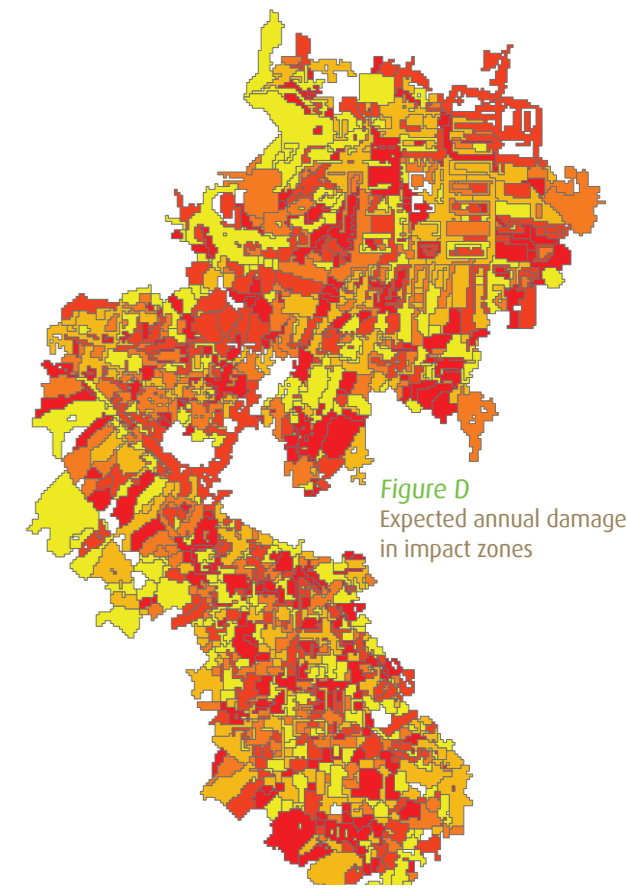


Figure D Expected annual damage in impact zones

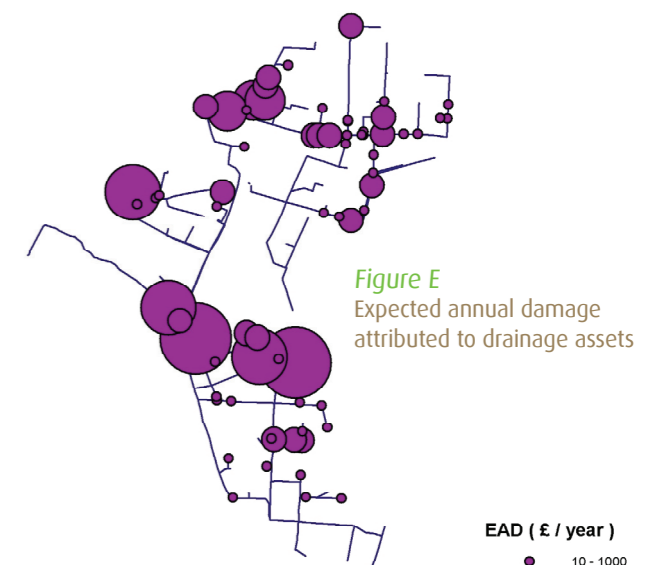
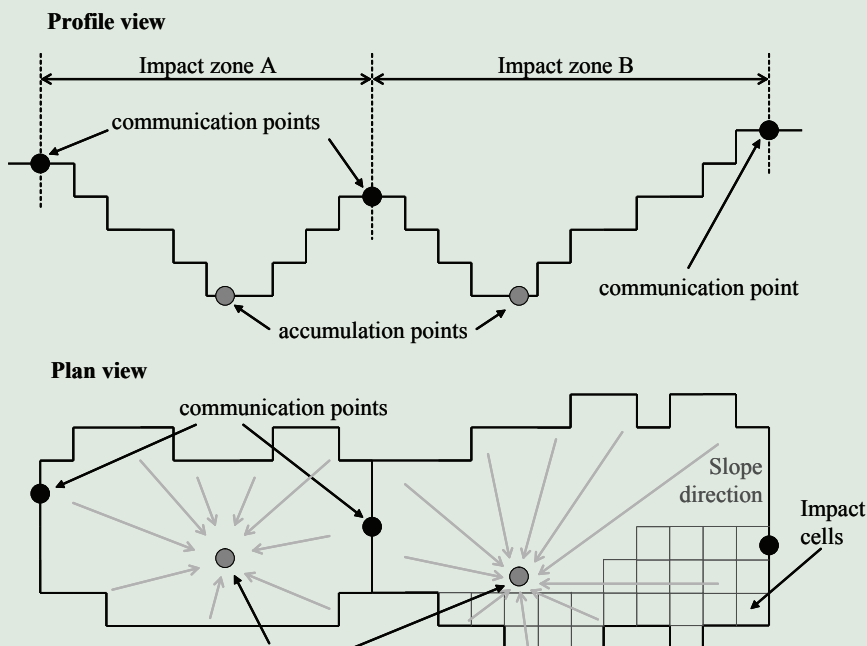


Figure E Expected annual damage attributed to drainage assets

Figure F RFSM and the creation of impact zones and the cells within them



Research partners



Imperial College
London



a unique Impact Zones. When all the input volumes have been spread in the Impact Zones and no Impact Zone has excess volume, it is considered that the flood has reached its final state.

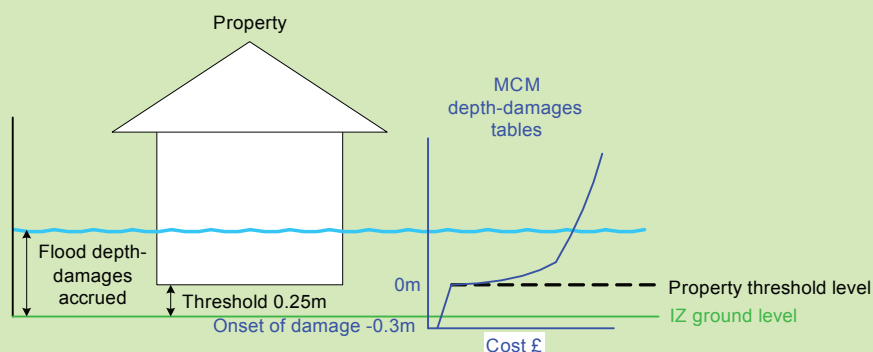
The water level in each cell is then used to assess the depth of flooding against a National Property Database (NPD) of the Environment Agency and information from the Middlesex Multi-Coloured Manual on flood damage. The damage assessment tool includes:

- Average property valuations based on information from the Land Registry Office,
- Floor space and rateable values,
- Flood damage curves for residential and non-residential areas
- Various codes associated with the MCM

This cost is then attributed back on the basis of proportional volume to each asset point from where the flood waters originated.

Figure G

Indicates the basis of the flood damage assessment which is calculated for each cell that is flooded



Industry partners



YorkshireWater

