A flow of good ideas - designing for exceedance

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Abstract

Recent research on climate change has shown that current approaches to managing urban flood risk are likely to be unsustainable in the longer term. In an innovative approach to the problem, CIRIA is currently producing guidance on how flows that exceed the capacity of urban drainage systems might be better managed by improving the interface between drainage systems and the built environment. This includes the design and use of above ground flood pathways for conveyance. The authors explain how the design approach is being developed in the context of a risk management approach and how the diverse views of stakeholders are incorporated into practical solutions.

The need for a change in urban drainage design philosophy

It is inevitable that as rainfall events become more extreme, flooding from drainage systems will become more common place as their capacity is exceeded. This ‘period of exceedance’ occurs when the rate of surface runoff exceeds the drainage system capacity or when the outfall capacity is restricted. As a result of this exceedance, various parties (e.g. sewerage undertakers) face an increased exposure to litigation and complaint. Traditional solutions such as increased conveyance capacity or additional storage will become more and more expensive to the extent that they may become unsustainable.

Urban drainage flooding has social, economic and environmental impacts that need to be considered in a holistic framework (ICE 2001). The social impact of flooding and the damage caused to property is a small element of the real human impact. The implications of flooding can be made worse where foul sewage is involved and where property is flooded internally. The stress and trauma associated with the loss of personal possessions, the clean up process and living in temporary accommodation should not be underestimated.

Research on climate change (UKWIR 2004) has shown that short duration rainstorms could increase in intensity by up to 40% and that this will have a direct impact on sewer system performance. The potential changes that can be expected by 2080 are shown in figure 1.

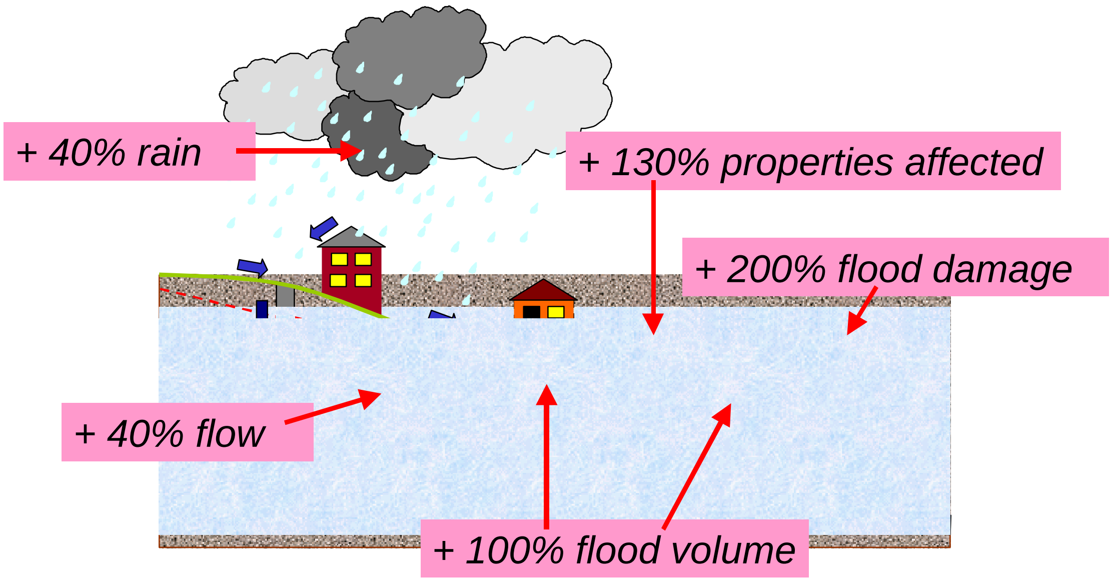

Figure 1 The potential impacts as a result of climate change on the urban drainage system.

The recent Foresight Programme (Evans et al 2004) indicated that compared with storage, conveyance solutions become relatively more cost effective for the more extreme events, especially when climate change is accounted for. However, increasing conveyance capacity of the piped drainage system is likely to be too expensive and very disruptive. The only practical solution appears to be better management of surface conveyance during extreme events.

In new developments, Sewers for Adoption 5th Edition (Water UK and WRc 2001) recommends that no flooding should occur in any part of a new site for a 1 in 30 year return period design storm unless other standards are used by the sewerage undertaker. It identifies that when flooding does occur an adequate level of protection for internal property flooding should be achieved. In addition above ground flow paths should be identified and the possible impacts of flooding determined if exceedance occurs. However, no specific guidance as to how this should be achieved is provided. A key driver for the better management of urban flood risk is the insurance industry which is now looking for a 200 year level of protection from internal flooding to effect flood insurance at normal premium levels.

In the recent consultation document 'Making Space for Water' (Defra 2004) minor highways are identified as potential flood conveyance routes. However, there is a need to take consultation further and make use of a wide variety of conveyance mechanisms and storage options such as green space networks and corridors (Evans et al 2004) which could be utilised if above ground flows are to be actively managed. If this is achieved, urban flood risk may be reduced.

CIRIA RP699: Designing for exceedance in urban drainage systems

Currently a research project led by CIRIA with MWH, HR Wallingford and Imperial College is developing best practice guidance for the design and management of urban drainage systems to reduce the impacts that arise when flows occur that exceed its capacity. The main aim of the guidance is to improve engineers, planners and designers understanding of how to design systems that safely and sustainably accommodate periods of exceedance. It also aims to improve the users appreciation of the flood risk associated with urban drainage systems to facilitate management of risks and reduce the impacts that exceedance may have on people and property.

PPG25 'Development and Flood Risk' identifies that during extreme events the capacity of the urban drainage system can be exceeded and flooding can occur on a local scale. The resolution of such flooding can only be achieved on a site specific basis. Conveying exceedance flow on the surface clearly offers potential for flood risk management. However, current knowledge is lacking on how this might best be achieved. The guidance aims to address this gap in knowledge by providing information that can be used to manage and control exceedance flows sustainably.

Stakeholder consultation

The guidance recognises the very important role of stakeholder participation to achieve sustainable and cost effective solutions to flooding challenges. During the first phase of the project (Spring 2004) a consultative stakeholder workshop was held to discuss and identify current and future practice in designing for exceedance. The workshop also provided the opportunity for delegates to share and exchange views on the needs of different stakeholders, to ascertain guidance requirements.

The workshop was run in two main sessions. The first identified practices that were currently used and the key challenges to be considered in the future. The key findings were:

- Uncertainty about responsibility for the maintenance of the above ground structures?
- A need to understand the risk of using above ground pathways and storage areas
- Integrated solutions that include building detail, roadway design, drainage design, above ground pathways, storage areas and downstream impacts
- Education of the general public of the risks of exceedance flows
- Health and safety of the general public must be maintained and is an essential part of any guidance developed.

The second session identified the barriers to implementation of the future practices. The most common barriers were:

- Understanding the diversity of responsibilities for urban flood management
- Complex interaction between stakeholders during a development project
- Mechanisms for protecting above ground pathways from future change
- Methodology for robustly modelling overland flows and designing conveyance pathways

The workshop highlighted that currently there is a lack of information available to adequately design for exceedance flows and provided support for the development of the guidance, and its aims and objectives.

An introduction to the guidance

The output from this project will include easy to read good practice guidance on designing for exceedance. It is designed to engage a target audience that includes drainage engineers, planners, consultants developers, architects, landowners and insurers.

The guidance will be divided into the following parts:

- Stakeholder interaction.
- Run-off
- Natural drainage
- Drainage of developed areas
- Interaction between the major and minor system
- Developing a risk assessment
- Designing for surface conveyance
- Designing for surface storage
- Building layout and detail
- Impact on downstream systems

Part 1 will be an overview aimed at developers, planners, architects etc who do not necessarily require detailed guidance. Part 2 includes the detail needed to deliver specific designs. Part 3 will include illustrative case studies.

Interaction between the major and minor system

Central to the guidance is a risk management approach. To achieve good risk management, understanding the interaction between the major and minor system is important.

The mechanisms of interaction between the major and minor drainage systems are complex. The formal (or designed) drainage system (piped or SUDS) is referred to as the **minor system** whereas the system of above ground flood pathways are known as the **major system** and is an integral part of the built environment. The guidance describes the mechanisms and sources of exceedance flow. To be able to understand the interaction between the systems, the cause of exceedance conditions needs to be identified. This may be due to:

1. Flooding from manholes and other connections from the minor system as a result of inadequate hydraulic capacity in the minor drainage system, or blockage, collapse or other service defects. This can generally be calculated if the connections between the major and minor system are adequately modelled.

2. Excess surface run-off that cannot enter the minor system due to the limited capacity of drainage inlets. This may be at a variety of inlets including road gullies, yard drains and roof gutters.
3. Surface run-off from pervious areas that have no direct connection to the sewerage network. The amount of surface run-off can be significant during extreme events and contribute a substantial flow. It can be a major cause of flooding.

The guidance proposes three levels of detail depending upon the needs of the work and complexity of the catchment. The level of assessment is also linked to the perceived level of flood risk and this is briefly described below:

Level 1. *Design of new drainage in small and simple development areas*. It is not suitable for existing systems.

Level 2. *Analysis / design of medium to large or complex drainage systems* where the major and minor system are modelled. Full interaction is not replicated.

Level 3. *Analysis / design of large and complex drainage systems*. The major and minor system, and the interaction between the two systems are modelled.

Risk assessment

The risk assessment uses the flows calculated during the three level approach above. Risk is calculated in the classical manner as a combination of probability and consequence. More consequences are considered as the level of assessment increases. This replicates the level of complexity that is required to deal with different levels of risk. The designer would not normally begin at level 3, starting instead at a level 1 or 2 as appropriate and working up detail to level 3 in specific areas as required. The consequences considered for each level of assessment are described below:

Level 1. Damage to property due to depth.

Level 2. Damage to property due to depth and loss of facility for the downtime of a business or reduced level of service.

Level 3. As level 2 plus damage to property, pedestrians, vehicles and drivers using a combination of depth and velocity.

The information used to assess the consequences is being collected from a wide number of sources in the UK and overseas. For example, the relationships used to develop guidance on the ability for a person to safely move in exceedance flow uses research undertaken at Helsinki University (Helsinki University of Technology 2001). Figure 2 shows that the ability to withstand the flow is dependent on the conditions. Good conditions include a non-slippery surface to walk on with no obstacles, the water has no debris and has good visibility, you are of good health, have no extra load and have good light. Poor conditions are the opposite of the good condition points.

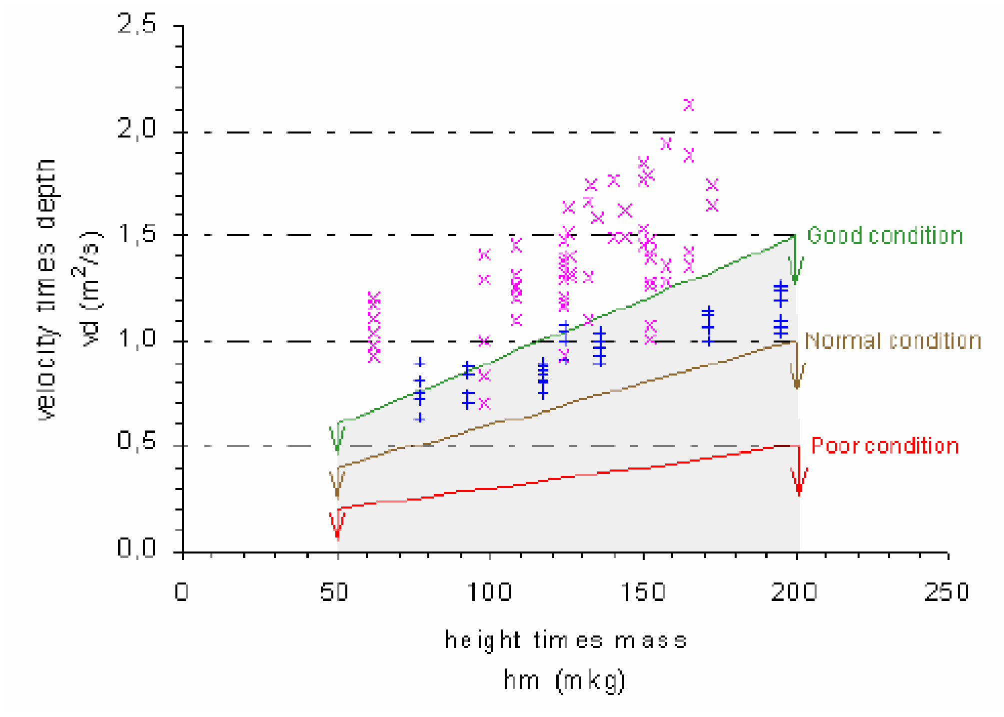

Figure 2 Recommendations for human stability in flowing water (from Helsinki University of Technology, 2001)

Conclusions

The concept of explicitly managing surface flood pathways as a means of controlling flood risk has arisen because recent research has shown that traditional solutions to flooding may become unsustainable if more extreme conditions and/or climate change are to be accounted for. CIRIA Project RP699 aims to move surface flood conveyance in the major system from an unmanaged to a managed process. It recognises that current legislation does not facilitate this and gaining voluntary agreement between stakeholders affords the best option in the short term. By providing strategic and detailed advice, the guide is aimed at a wide range of users to deliver more cost effective means of managing urban flood risk.

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