Flood Risk Management:
Modelling blockage and breach scenarios

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Introduction

When assessing flood risk, it is important to consider a range of potential scenarios that may occur during a flood event.

The performance of both structures and defences can significantly affect flow routes, flood extents and depths, and is something that should be carefully considered as part of a flood risk study. Flood water can carry a significant amount of debris which has the potential to cause blockage at structures. Defences reduce risk; however there is also no guarantee that defences will not be overtopped or fail.

This guidance sets out how Natural Resources Wales (NRW) assesses these two variables; blockage at structures and breaches in defences, through hydraulic modelling. The intention of this guidance note is to ensure a consistent approach across NRW. It is aimed at officers in our Flood Risk Analysis teams.

Our Approach

Blockage

Consideration should be given to the possibility of flooding caused by blockage and particular attention given to the potential consequences of such blockage. Hydraulic modelling of flood risk should include sensitivity testing to examine the consequences of blockage.

Whilst it is relatively straightforward to assess the impact of obstruction on upstream water levels; it is more difficult to decide on a credible degree of blockage. The likelihood of material accumulating depends on various risk factors including the type and size of structure and nature of the debris. In order to carry out a hydraulic analysis of blockage, it is necessary to make assumptions about the degree of blockage.

The appropriate proportion of blockage is usually a matter for pragmatic judgement, and often relies on local knowledge; there is no definitive guidance, although some guidance for culverts is available, as shown in Table 1.

Guidance document	Blockage proportion
CIRIA Culvert design and operation guide, 2010 (Table 6.4)	20 to 67% depending on catchment, 100% (blinding or blockage) 5%, 15-25%, 80-100% (for sedimentation of culvert barrel)
EA Trash and Security Screen Guide, 2009 (Table 10.2)	30 and 67% of the screen area, 100% blockage of the screen.

Table 1 – Current culvert blockage guidance

To ensure consistency, the standard figures shown in Table 2 shall be used for modelling blockage at bridges and culverts where no better information is available. These figures are based on the guidance shown in Table 1 and current working practices, with lower figures being applied at bridges, which are less prone to blockage. Local knowledge and engineering judgement will be used to apply varying proportions if considered appropriate.

Blockage Scenario	Culvert blockage proportion	Bridge blockage proportion
Low	30%	5%
Medium	67%	25%
High	100%[1]	80%

Table 2 – Standard blockage proportions

The design events to be considered as a minimum are the 1% AEP (1 in 100 year) plus climate change and 0.1% AEP (1 in 1000 year) events (additional events can be modelled if deemed necessary for a particular location). For simplicity in hydraulic modelling, a blockage is assumed to be in place for the full duration of the flood event.

Breach

Where appropriate, breaching of defences should always be considered and can be significantly influenced by defence type, location, condition and predicted loading. The location of any breach should be agreed with Natural Resources Wales and should generally be located as follows in terms of priority:

1. At any known areas of weakness (e.g. low-spots, the interface between soft and hard defences, outfall structure etc).
2. The location where the defence is closest to the to the development site.

Ultimately any decision on the breach location will need to be guided by local knowledge.

Breach of defences must always be applied if the design event flood level exceeds the crest level of the existing defences or is within the design freeboard of the scheme. Freeboard is not included within flood defence design to account for climate change over the lifetime of the development. This is usually applied to account for uncertainties in hydrology/modelling and settlement over time. It is also recognised that the condition of

[1] Note that a 95% blockage is usually adopted over a 100% in the hydraulic model to maintain a minimum opening and ensure the model remains stable.

flood defence schemes depreciates over time too. Therefore, it is likely that for the majority of cases a breach scenario will be required.

The traditional fluvial freeboard allowances, as described in the former PPS25 Practice Guide[2] (section 6.43), are as follows:

- 300mm for hard defences (such as concrete flood walls)
- 500mm for soft defences (such as earth embankments)

These figures are used as a guide; however, it is important to consider the sensitivity of design flood levels, taking account of model uncertainty and physical processes. For coastal defences, freeboard should also include allowances for wave overtopping.

Breach widths vary depending on the nature of the defence. Table 3 summarises typical breach widths[3]. The figures listed should be used as a starting point (including the freeboard allowances above) unless more appropriate site specific information is available to justify using an alternative value.

Location	Defence type	Breach width (m)
Open coast	Earth bank	200
	Dunes	100
	Hard	50
	Sluice	Sluice width
Estuary / tidal river	Earth bank	50
	Hard	20
Fluvial river	Earth bank	40
	Hard	20

Table 3 – Breach widths by defence type

The duration to be modelled is 3 tide cycles or an appropriate fluvial duration (this is based on an estimation of the time lapse between the initial breach and subsequent repair (even if this is a temporary solution).

The breach can be assumed to be present for the whole event (i.e. is deemed to have occurred prior to the event peak), giving a conservative assumption. Alternatively, breach initiation can be timed to coincide with peak water levels or at the point of overtopping (whichever occurs first). This approach takes into account rapid inundation of areas behind defences. A sudden breach is often an issue for model stability and so defence height may need to be gradually reduced to the base level. The failure mode of a defence will be a function of the defence type.

[2] *Planning Policy Statement 25: Development and Flood Risk Practice Guide*, Department for Communities and Local Government, 2009,

[3] Extracted from *Operational Instruction 303_09 Flood Risk Management: Strategic Flood Consequence Assessment for Wales,* Environment Agency, 2009.

The design events for breach modelling are as shown in Table 4, relating to A1.14 of TAN 15[4];

Type of development	Fluvial AEP	Tidal AEP
Emergency Services	1% and 0.1% plus climate change	0.5% and 0.1% plus climate change
All other development	1% plus climate change	0.5% plus climate change

Table 4 – Design events for breach modelling

[4] *Technical Advice Note (TAN) 15: Development and Flood Risk*, Welsh Assembly Government, 2004.