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Discussion: Flood plans in England

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Contribution

I would add that there is one key principle to the Reservoirs Act that could be added to Table 1 in the paper, namely that regulation should be proportionate to risk. Section 2A of the Act allowed for the risk designation of reservoirs to provide more targeted regulation of large raised reservoirs with the 'high risk' and 'not-high risk' categories.

An unintended consequence of requiring flood plans for not-high risk large raised reservoirs is to require undertakers to appoint a supervising engineer (SE), if they had not already done so for other reasons, to certify the plan. Although this appointment does not have to 'be at all times' it does require, in my view, a site visit in order to certify the plan on first drafting and when major changes are made. If a not-high risk reservoir does not require an SE for day-to-day safety reasons, why does it (*a*) require a flood plan and (*b*) certification of the flood plan by a Qualified Civil Engineer?

In the final paragraph of the paper, I am not sure section 12AA(3) certificate will provide much useful information on plan maintenance on its own as the pro-forma certificate does not include any information on the reason or nature of the update.

Authors reply – Alan Brown, John Gosden and Andy Courtnadge

1. Regulation proportionate to risk

We agree that regulation should be proportionate to risk, and this is a slightly different expression of principle 3 in Table 1 of the paper. This is also confirmed in the recent ICOLD (International Committee on Large Dams) Bulletin 191 (ICOLD, 2021), which states in section 7.1 that:

> *The overall approach to safety management should take economics and cost into account. This involves balancing the cost of each possible improvement against the added safety benefit it would achieve.*

It is therefore disappointing that the Defra guidance does not provide estimates of costs or the carbon footprint of preparing and exercising the plans, especially 'full site simulations', to justify the frequencies suggested in the Defra guidance. Nor does the guidance allow the undertaker/appointed engineer to determine an appropriate frequency of testing for which the cost is proportionate to the risks at each specific reservoir. This is discussed further below.

2. Need for flood plans for not high risk reservoirs

We agree that it appears illogical and inconsistent with the Reservoirs Act to require an appointed engineer to certify flood plans for not high risk (NHR) reservoirs, when the Reservoirs Act states that a SE is not required for NHR reservoirs.

3. Maintenance of plans

ICOLD Bulletin 191 states in section 3.3: Dam safety assurance:

Safety assurance involves demonstrating that the desired level of safety management has been achieved. This is done by regularly verifying the effectiveness of every stage of the safety management process.

Governments and dam owners both have essential roles in providing assurance of the safety of dams under their control.

We note that the act and direction do not cover how maintenance of flood plans will be assured. We agree that a 12AA(3) certificate provides evidence that a plan has been updated but not what other maintenance of the plan has been carried out. The authors suggest that for high-risk reservoirs the guidance for the content of a SEs annual statement in section D5.2 of the Guide to the Reservoirs Act (ICE, 2014) is replaced by the text in Table 1 of this discussion note, below.

If the requirement for NHR to have flood plans is retained, then a section 12AA(3) certificate should be issued on first preparation to confirm the content of the plan meets the direction. As there is no SE at NHR reservoirs the simplest way for the regulator to monitor the update of plans is for the regulator to periodically ask for a copy.

4. Proportionality of full-scale simulation

The Defra guidance suggests full-scale simulation at one dam every ten years for undertakers with 15 or fewer reservoirs, or every five years for undertakers who own 16 or more dams. This does not take into account the consequence category of the dam, and in many cases the cost is likely to be disproportionate. This is illustrated by the simple sensitivity test in

Table 1. Recommended adjustment to Table D2, section 2.7 in 'Guide to the Reservoirs Act' to accommodate flood plans

Section of act	Action by undertaker	Action by appointed engineer
12AA(3) Certification of flood plan	State action taken last year to update and/or share plan with any organisation	Give date the certificate under section 12AA(3) was last issued
12AA(4) Testing of flood plan	State action taken last year	No direction under 12AA(4) required, unless the testing set out in flood plan is not being implemented
12AA(6) and (7) Updates to flood plan	State action taken last year	As above except for updates

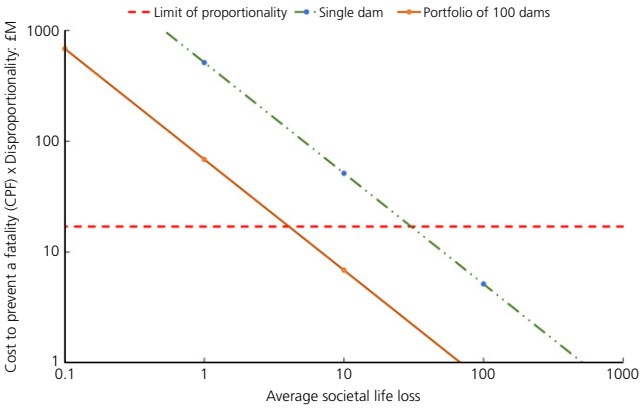

Figure 1. Sensitivity study of when cost of full-site simulation becomes disproportionate

Figure 1, considering two scenarios of an undertaker with a single dam, and one with a portfolio of 15 dams, with other assumptions as shown in Table 2. If a value to prevent a fatality (VPF) of £1.7M, and a disproportionality factor of 10 is used, as per section 10.3 of risk assessment for reservoir safety (RARS) (Environment Agency, 2013), then the cost of a full-scale simulation is disproportionate when the average societal loss of life (ASLL) is less than 50 for a single dam, or 5 for a large (>15 dam) portfolio.

An alternative description is that the cost of carrying out a full-scale simulation on a category D or NHR dams with ASLL of 0.001 or less is equivalent to a minimum of £800 million per life saved, which is clearly grossly disproportionate. At a time of climate crisis, it is also questionable whether the carbon footprint of travel and mobilising equipment for a full simulation is appropriate for these low consequence dams.

Cleary these values would change significantly (e.g. by an order of magnitude) for base values varying from those in Table 2 – for example, if the existing probability of failure was higher or lower than that used in the sensitivity. However, it establishes the principle that full site simulation is unlikely to be proportionate for lower hazard and NHR dams. It also confirms that exercising is worthwhile for dams with an ASLL in excess of 100 lives.

Table 2. Sensitivity test on cost of full-site simulation of flood plan

	Assumed for screening sensitivity	
Parameter	Value	Basis/comment
Cost of a full-scale simulation	£20k	Would require: attendance of undertaker staff, panel engineers and Local Resilience Forum representative, say ten personnel at £500/day. Plus, preparation/washup/feedback say £10k Hire of pumps, include low loader to transport to site say £10k For simplicity, neglect cost of hire of mobile welfare unit, meeting room, consents for discharge to watercourse/closure of PROW/highway along crest and so on Gives equivalent annual cost of £2.000/year for single dam, and £270/year for each dam in a 15 dam portfolio.
Current probability	7E-5 (1 in 15 000)	Median in Figure 15.3 of RARS
Reduction in PoF due to flood plan	9	Step 7 in event tree in RARS (unsuccessful intervention) changes from 'Likely' to 'Unlikely' (table 8.24 of RARS)
Additional reduction due to full-scale simulation	2	Step 7 changes from 'Unlikely' to 'Very unlikely'
Discount factor over 100 years	57	Table 6 of Brown *et al*. (2014)
Property damage	Assume £1M/ASLL	Typical from portfolio risk analysis

Table 3. Possible frequency of exercising flood plans for lower hazard dams (developed from Table 4.14 of the Defra Guide to emergency planning (Defra, 2006))

Flood category	B	C	D, NHR
ASLL (as interim guide to QRA sheet 11.2)	<0.1	<0.01	<0.001
Site attendance – minimum frequency	Annually during S12 inspection	Five yearly	Ten yearly when update plan
Suggested frequency of full-site simulation:			
Single dam	Not required. Rely on simulations and lessons learnt from simulations by other undertakers. May be carried out if concern from the undertaker about the effectiveness of the plan.		
Part of portfolio >15 dams	Five yearly	Not required (as above)	

Based on Figure 14 of Balmforth (2021) full-scale exercising could be disproportionate for up to 50% of UK dams. Hence from this analysis, the authors suggest that a risk-based approach to exercising flood plans could be as set out in Table 3.

5. Summary of key issues

In addition to those in the paper the authors suggest that:

- In implementing and updating the direction and associated documents the regulator takes cognisance of the guidance in ICOLD Bulletin 191.
- The reservoir safety regulator, as part of risk-based regulation, should ensure that lessons learnt from full-scale simulation at high consequence dams are promulgated to undertakers who own low hazard dams.

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