Reservoir Safety - Planning for the Future

IAN HOPE, Environment Agency, Exeter, UK

SYNOPSIS. The Water Act 2003 transferred responsibility for enforcing the Reservoirs Act 1975 to the Environment Agency in England and Wales. It also gave the Government the power to issue a Ministerial Direction to reservoir undertakers (i.e. owners) to produce reservoir flood plans (i.e. emergency action plans).

In his report on the summer 2007 floods, Sir Michael Pitt made a series of recommendations to improve response to flooding. He recommended that inundation maps for reservoirs should be available to the emergency services and the public in order to reduce risk and improve preparedness. He also recommended that there should be a move to a risk-based approach to dam safety as part of proposed legislative change.

Following the Pitt Review, the Department for Environment, Food and Rural Affairs (Defra), the government department responsible for reservoir safety, instructed the Environment Agency to produce simplified inundation maps for all 2,092 large raised reservoirs regulated by the Reservoirs Act 1975. Local Resilience Forums (LRFs) and reservoir undertakers have now received these maps to help them produce emergency action plans. At the same time, Defra and the Cabinet Office have also developed and tested templates and guidance for both on-site and off-site plans.

This paper describes the process for producing inundation maps and their role, together with on- and off-site plans, in the overall emergency planning for reservoirs. It also briefly sets out proposals the Environment Agency is developing for the move to a risk-based approach to reservoir safety.

BACKGROUND

As the enforcement authority, the Environment Agency has responsibility under the Reservoirs Act 1975 (the Act) for assuring the safety of the 2,092 largest reservoirs in England and Wales.

Managing Dams: Challenges in a Time of Change. Thomas Telford, London, 2010

MANAGING DAMS: CHALLENGES IN A TIME OF CHANGE

Reservoir undertakers (owners or operators) are responsible for ensuring safety, compliance with the law and assessing the flood risk posed by their own reservoirs. As described in Hope (2006), it is the Environment Agency's responsibility for ensuring that these undertakers fully comply with the Act, warning and ultimately prosecuting those that do not. The Environment Agency reports to Government on the work it has done to secure compliance with the Act in its biennial report on reservoir safety. These reports have proved to be a valuable vehicle for informing and influencing government policy, and are available on the Environment Agency's website:
http://www.environment-agency.gov.uk/business/sectors/39709.aspx).

Under the Water Act 2003, undertakers will now have to produce flood plans for their reservoirs when the Secretary of State issues a 'Ministerial Direction'. Flood plans are emergency action plans that set out what the undertaker needs to do to delay or prevent the dam failing in an emergency. Defra has produced templates and guidance to help undertakers prepare these plans (Hope & Hughes 2008) and these documents are available on the Defra website:
http://www.defra.gov.uk/environment/flooding/reservoir/flood-plans.htm.

Following the unprecedented flooding of summer 2007 (rated as our largest peace-time emergency due to its scale, impact and duration), the Government asked Sir Michael Pitt to identify lessons that could be learned from the emergency and to make recommendations that would help the country better deal with flooding in the future.

The Environment Agency along with independent dam safety experts gave evidence to the enquiry. This evidence was supported by site visits as the photograph below shows.

Sir Michael Pitt (centre) gathering evidence for his report whilst visiting Venford Reservoir (the subject of a £4 million improvement scheme which included a new spillway).

Two of the recommendations in Sir Michael's final report were particularly relevant to dam safety. Recommendation 57 stated:

> "The Government should provide Local Resilience Forums with the inundation maps for both large and small reservoirs to enable them to assess risks and plan for contingency, warning and evacuation and the outline maps be made available to the public online as part of wider flood risk information."

Recommendation 58 stated:

> "The Government should implement the legislative changes proposed in the Environment Agency biennial report on dam and reservoir safety through the forthcoming flooding legislation."

Defra instructed the Environment Agency to produce inundation maps for all reservoirs under the Act (i.e. large raised reservoirs).

CONSULTATION

Since 2004 the reservoir industry has been periodically informed via a number of channels about the forthcoming need to produce flood plans. This has included presentations at key meetings and events (for example, BDS, ICE, CIWEM, etc.), briefing notes sent to undertakers and panel engineers, and information on the Environment Agency's website.

There is a wide and arguably disparate group of reservoir undertakers. Currently, there are 2,092 reservoirs subject to the Act in England and Wales, with 759 undertakers on the register. However, 75% of these undertakers have only one reservoir. Earlier research by Ipsos MORI on behalf of the Environment Agency, to further improve its communications with the reservoir industry, showed that undertakers range from the expert to non-expert, some with no engineering expertise or in-house capability.

During summer 2009, as part of formal consultation on the draft Flood and Water Management Bill, Defra held a series of seven regional briefings for undertakers and panel engineers across England and Wales. Over 450 attendees received presentations on a range of topics including emergency planning and the preparation of on-site plans, as well as information on the Environment Agency's post-incident reporting system and the joint Defra/EA current research and development programme.

Question and answer sessions took place and the issues raised, together with the feedback from the briefings, was used to improve the specification for on-site plans and further hone the communications strategy.

Regional briefings for Local Resilience Forums (LRFs) were also held in autumn 2009 to improve preparedness and capability of the state to recover.

In January 2010 the Government issued a "Consultation on a Ministerial Direction for reservoir flood plans". It highlighted the need for on-site plans and acknowledged that *"Without a legal requirement, experience confirms that reservoir undertakers are unlikely to prepare such a plan"*. The document consulted on the proposed direction to undertakers of the 100 'higher risk' reservoirs to produce on-site plans from April 2010 with a legal obligation for these to be completed within 12 months. Following further consultation this summer, Defra plans to issue a direction to all other reservoir undertakers this autumn. Following this direction, all remaining on-site plans will have to be completed within a 12 month period. This too would be a legal requirement.

As with all successful major change projects, the Environment Agency has committed significant effort and resource to communicating both externally with reservoir undertakers, panel engineers, government departments and the emergency services as well as internally with its own staff.

In addition to being a Category 1 responder and flood lead at LRFs, the Environment Agency, (comprising 14,000 staff), is also the largest undertaker with 187 reservoirs. Comprehensive briefings, work instructions, training etc. have been provided for both internal and externally facing roles.

RESERVOIR FLOOD PLANS - ON-SITE EMERGENCY PLANS

An on-site plan should ensure that the undertaker is prepared for an emergency at the dam in order to reduce risk. The plan will show how to:

- Prevent the dam failing in an emergency. Make sure that the steps in place can be easily followed, and staff know what to do;
- Delay the dam failing (if it cannot be prevented). The plan should provide as much time as possible to alert and warn people, and reduce the amount of uncontrolled water released. This will also enable work to be done off-site to reduce the potential for loss of life and damage caused.

Undertakers will be able to use the on-site plan to brief staff and subcontractors who are unfamiliar with the dam, set out what steps to follow, and any other information needed to manage an emergency.

The plan will:

- provide useful information about the dam's location, construction, capacity and the operation of its valves and other key equipment;
- provide clear definitions of the roles, responsibilities and actions of each agency at particular stages of the on-site response;
- provide a response escalation procedure and the actions to be taken as part of the incident management from the initial alert, full plan implementation through to stand down;
- set out the links to the off-site plan and the co-ordination and control arrangements for each level of response which should be agreed with the relevant agencies from the Local Resilience Forum;
- specify the way in which information should be communicated to staff and partners in an accessible and consistent way;
- provide contact details to facilitate an efficient call-out of resources.

Defra has produced an on-site template and guidance that outlines the type of information a reservoir undertaker should include in the plan for both large and smaller reservoirs. The current version of these documents can be downloaded directly from Defra's website at:
www.defra.gov.uk/environment/flooding/reservoir/flood-plans.htm

The Environment Agency has also produced a DVD called *'An introduction to producing on-site plans*' to give more technical help and guidance to undertakers. Feedback to date has been limited yet positive, with only one exception. This came from an undertaker who does not have a DVD player. In today's business world we all take access to electronic communication for granted. When communicating with reservoir undertakers we were aware that they did not all have e-mail or access to the internet, but this was another reminder to ensure a thorough approach to communications.

Throughout the consultation process it has been emphasised that the on-site plan is not complex. It covers practical issues such as procurement of emergency pumps, site access during an event, and even questions such as whether there is mobile phone coverage at the dam. We used the following photographs in the presentations to undertakers to prompt them to consider access to their site.

Examples of restricted access


An example of an unplanned response to draw down a reservoir

It is essential that the on-site plan is kept up-to-date. Staff, panel engineers and external organisations that have a role to play in the emergency need to be trained and practice exercising the plan. The on-site plan should set out the training programme for those responsible for managing and implementing the plan. It should outline the level, type and frequency of exercise, where the emphasis is on internal and external coordinated communications and actions. It should also cover externally resourced plant and equipment, and assess the adequacy of this supply chain. Every exercise should include a formal debriefing and lessons learned report, with changes to the on-site plans, where appropriate, as part of continuous improvement. The value of exercising cannot be over-emphasised. A paper ((Brown, Gardiner and Williams, 2010) by reservoir managers representing four of the largest undertakers states: *"The risk to the business should these exercises not be carried out is far greater than the cost of the management of a major incident. Exercising the contingency plans highlights gaps in the knowledge and incident procedures."*

<u>Reinforcing the need for on-site plans</u>

Fortunately the Ulley incident in June 2007 was a 'near miss'. However, it did reinforce the need for on-site plans and highlighted how critical infrastructure could be exposed in the event of a dam breach. This reservoir is also potentially best situated for the management of an incident. The site is served by an 'A' road, has a large car park and office accommodation with welfare facilities. This was used as "Bronze Control". Incident management control centres established are termed bronze (operational), silver (tactical) and gold (strategic) respectively. Generally the bronze control is as near to the site as practical, and gold control in the more established Local Authority Emergency Response Centre. These are equipped with extensive communications infrastructure. An incident may not require silver control to be established. A convenient, well-resourced bronze control is clearly evident from the aerial photograph below.

Bronze control at Ulley Reservoir with “A” road closed and car park accommodating support vehicles from 17 fire brigades

The government review of national preparedness following the September 11 attacks in the US recommended that the fire service across England and Wales be issued with 50 “high volume pumps”. This was implemented as part of the New Dimensions project. Whilst these were mainly intended for de-contamination purposes, they have also been used as a first response to evacuating flood water. For example, six of these pumps were used to reduce the impact of flooding in Carlisle in 2006. At the height of the Ulley incident, 17 fire service high volume pumps, each capable of pumping 7,000l/min., were brought in from across England to commence the process of lowering the reservoir water level. The sheer logistics of such a response at a reservoir need to be accounted for in managing such an incident.

Not all reservoirs have such good access and on-site facilities. Undertakers attending the regional briefings were prompted to consider how the emergency services, temporary pump suppliers, contractors etc. would gain access to their dam. It is encouraging to note that some enlightened undertakers are already conducting exercises and learning from them (Brown, Gardiner and Williams 2010).

Few panel engineers have direct experience of managing a reservoir incident. The demands from “Gold Control” require a rapid response for information, for example “what is the probability of dam failure”, “when will the dam fail” etc. To ensure that panel engineers can confidently lead in this role, the Environment Agency is developing an incident response course that will explain and put incident management in context.

Off-site emergency planning

Off-site emergency planning is carried out under the Civil Contingencies Act 2004. Part 1 of the Act sets out clear expectations and responsibilities for front line responders to make sure that they are prepared to deal effectively with emergencies. It divides local responders into two categories:

a) Category 1 - (for example, emergency services, local authorities, NHS bodies, Environment Agency) - central to most emergencies.

b) Category 2 - (for example, Health and Safety Executive, transport and utility companies) - have to share information and co-operate with Category 1 responders as part of emergency planning.

Category 1 and 2 responders form Local Resilience Forums (LRFs), which help co-ordinate emergency planning, training and exercises locally. There are 47 LRFs across England and Wales, based on police boundaries.

Category 1 responders must carry out risk assessments and produce a Community Risk Register for their area. The National Risk Register provides guidance on risks that can emanate from installations that include: chemical factories, nuclear and major oil process plants. LRF members (county or unitary councils) will now have to assess the need for, and carry out, detailed off-site emergency planning for those reservoirs that pose a high risk in their area.

Unlike the Control of Major Accidents (COMAH) regulations, there is no provision under the Reservoirs Act 1975 for reservoir owners to fund off-site emergency planning. However, the Government set aside £33 million to implement 'Pitt actions', with £2 million of this funding allocated for inundation mapping, and a further £1.25 million allocated for off-site planning. It was clear, therefore, that only a proportion of off-site plans could be funded. The Cabinet Office and Defra developed costs to prepare an off-site plan and established that with available funding between 100 and 120 plans could be produced. The Project Board agreed that this funding would go to the reservoirs that posed the "highest risk" to society.

For the "higher risk" dams, LRFs will have to produce detailed plans that set out local responders' response. This will extend to informing people downstream of the potential risk. For all remaining dams, a generic emergency plan (annually assessed as part of the National Capability Survey) will set out roles and responsibilities of everyone involved, but will not extend to informing the public.

Earlier this year, county and unitary councils were sent a list of all "higher risk" reservoirs in their LRF area in priority order. LRF's have commenced working with neighbouring councils and the Regional Resilience Teams (RRT) as inundation pathways often cross political boundaries.

The Civil Contingencies Secretariat at the Cabinet Office has developed a template and trialed guidance on off-site planning. This was issued to LRFs in summer 2009 and is available at:
www.cabinetoffice.gov.uk/media/312485/feedback-guidance-checklist2.doc.

Risk is a combination of probability and consequence. The inundation maps provide a relatively accurate indication of consequence. Accurately assessing the likelihood of dam failure is extremely difficult and depends on a wide range of variables specific to the site. This extends to the potential for human error whilst operating the dam. In conducting a desk top exercise various algorithms were developed to include dam type, dam age, owner type, etc. In all approaches the results were heavily skewed toward large dams impacting on large communities. By adopting this approach fewer LRFs would be funded to develop 20 to 30 off-site plans and a significant proportion of LRFs would get no funding at all. Arguably the higher probability of dam failure would arise from less well maintained and inadequately monitored smaller dams. The purpose of off site planning is to improve preparedness and no risk ranking calculation will provide an absolute. The project board also considered a number of options including a redistribution/capping process to achieve a more even distribution of funding in order to provide increased preparedness across the country. Every LRF will produce a generic plan which will assist in off-site preparedness.

The need to have and share information was further reinforced in a 'lessons learned' report that followed a major regional flooding exercise by emergency services in December 2006. This exercise included a dam burst in a major northern city. One of the key findings from the report stated that emergency plans 'need to be shared between responding organisations'.

Inundation mapping

Inundation maps show the effects on the downstream catchment of a dam breach. Under the draft proposals for reservoir flood plans produced in 2006, undertakers were to produce inundation maps for their reservoirs as part of their on site plans, when directed by the Secretary of State. But, following the Pitt Review and instruction from Defra, the Environment Agency has now produced these maps for all reservoirs subject to the Act.

To commission an individual inundation map would generally cost between £10,000 and £20,000. In view of the restricted funding available (£2 million from "Pitt" funding), the Environment Agency developed a revised specification in order to afford to complete maps for all 2,092 reservoirs.

The maps produced are for emergency planning purposes and present the "credible worst case scenario".

Trial phase to define the specification for inundation mapping.
Work started in May 2008, with a trial on a number of reservoirs in the North West, supported by Government Office North West. Contractors Mott Macdonald and JBA Consulting carried out the work. A Quality Review Team (QRT) was also appointed, with representatives from the dam community, researchers, Environment Agency and Defra to oversee the trial and pilot phases.

A trial of 13 reservoirs was carried out to test initial proposals and define the specification for national mapping.

To link this trial with Defra's off-site emergency planning activities, there was also consultation with Category 1 and 2 responders. This included exercises to produce off-site plans headed by Cheshire and Lancashire County Councils. Following consultations, maps were produced showing extent, depth and velocity of flood water. Time of travel both for onset and peak of the event were also shown on the maps, together with the hazard rating, produced from HR Wallingford work (Morris 2008). Other variables such as the range of scenarios to be mapped, the level of resolution of the parameters, the level of confidence (uncertainty) in the parameters, and the impact of different flows of water were considered. Emergency planners who would be using the maps felt that they needed to be as clear as possible so they would not be misinterpreted during an emergency. They endorsed the policy that the only scenario to be shown on the maps was the credible worst case. The mapping specification is available on application to the EA.

The trial identified a range of options of varying cost and complexity for the national mapping programme. It set out recommendations for the format of the pilot and for national mapping and produced a detailed inundation mapping specification. The trial also produced a budget estimate and a Project Initiation Document (for financial governance purposes) for national mapping.

Pilot project to test the specification developed under the trial project.
The purpose of the pilot was to:

1. Test if the maps and methods for producing them outlined in the specification were clear.
2. Provide feedback on possible improvements to the specification.
3. To refine cost estimates for the national mapping programme.

The work, coordinated by Mott MacDonald, was carried out by Halcrow in Environment Agency North East Area and Atkins in Environment Agency Yorkshire and Humber Area on 36 reservoirs.

National mapping
As a result of the work carried out during the trial phase and pilot project, the Environment Agency's Reservoir Safety Team commissioned the National Reservoir Inundation Mapping (RIM) Project. This took place in two phases:

Phase 1 (Feb 08 – Oct 09) objectives were to:

- Collect additional reservoir data and update the Environment Agency's reservoir database for all 2,092 reservoirs.
- Produce dam breach hydrographs in accordance with the RIM Trial Specification using the updated database for all 2,092 reservoirs.
- Produce Rapid RIM (JFLOW) for all reservoirs. This is an automated process using SAR data. These have been given to mapping consultants to help the Trial Specification RIM in Phase 2.
- Provide a downstream assessment of risk to life using the Rapid RIM to identify the higher risk reservoirs where more detailed Trial Specification RIM will be carried out in Phase 2. LRFs will also use it when producing emergency plans.
- Provide data and contractual documents to reduce the time, cost and risk to complete Phase 2.

Phase 2 (May 09 – Jan 10) objectives were to:

- Produce Trial Specification RIM for all Category A and higher risk reservoirs identified in Phase 1. This process uses LiDAR data where available.
- Work with Environment Agency Area and Regional teams, LRFs and reservoir owners to effectively hand over Rapid and Trial Specification RIM to LRFs with appropriate guidance.

Mott Macdonald and JBA carried out Phase 1. Following communication with all 759 reservoir undertakers and/or their supervising engineers, they found discrepancies between the data on reservoirs held on the Environment Agency's Reservoir Enforcement and Surveillance System (RESS) and the Prescribed Form of Record. There were also problems with some location references and dam statistics. This was most frustrating because the Environment Agency had already spent a great deal of time and effort

quality assuring the statutory register (generated by RESS) in 2005. Local Authority held data had been checked with statutory inspection reports and all undertakers asked to verify data held.
Phase 2 work was divided into six areas, each containing a different number of reservoirs.

In both phases two types of maps were produced:

- **Outline maps** - showing the maximum inundated area. These are for reservoir undertakers and the public.
- **Detailed maps** - showing velocities, depths of flow, time of arrival and peak and hazard rating. These are for Local Resilience Forums (LRFs) to help emergency planners prepare off-site emergency plans and identify critical infrastructure at risk.

Outline maps were issued during December 2009 to LRFs and all reservoir undertakers. Detailed maps have been loaded on to the National Resilience Extranet and these will be available to LRFs when it goes live in the spring.

Re-categorising reservoirs

The inundation maps have been used to identify people at risk and, in some cases, the flood category of a dam, i.e. A to D (ICE "Floods and Reservoir Safety") will also need to be reviewed. Currently it is estimated that approximately 130 reservoirs would have a higher consequence based on likely loss of life (LLOL) using Reservoir Inundation Mapping outputs. For the enforcement authority, this discrepancy needs to be resolved. Letters will be sent to the relevant undertakers and their supervising engineer, drawing their attention to this discrepancy. He/she will have to consider the information contained in the inundation map and call for a full inspection if it is appropriate. An inspecting engineer would then carry out a review and assess the appropriate consequence class.

Public access to inundation maps and information

A post code search facility is currently being developed that will enable members of the public to view inundation maps on the internet. This is planned to go live in July 2010. The outline maps can already be viewed at Environment Agency Area offices.

To date there has been minimal public interest. Although, as the process of warning and informing develops and the internet search facility goes live, interest in the maps is expected to increase, particularly from the owners of the 1.2 million properties featured in the inundation zones. An extensive joint Cabinet Office, Defra, Environment Agency communications project has been established to ensure an appropriate level of awareness raising.

POST-INCIDENT REPORTING

After Defra consulted with the reservoir industry, the Environment Agency introduced a post-incident reporting procedure in 2007 to raise awareness of incidents and share lessons learned from these incidents. This has been welcomed as a valuable tool by the reservoir industry and is also starting to provide much needed information to inform research and development priorities and provide further evidence for regulatory change (Hope and Warren 2010). However, reporting is still voluntary and the database is still in its infancy. Copies of the most recent post-incident reporting annual reports can be found on the Environment Agency's website:
http://www.environment-agency.gov.uk/business/sectors/37218.aspx

MOVING TO A RISK-BASED APPROACH

Recommendation 58 in the Pitt Review fully supports a move to a risk-based approach to regulating reservoirs. Fortunately, no-one has died as a result of a dam failing in England and Wales since the Reservoirs (Safety Provisions) Act 1930. But, there are a number of incidents each year, where reservoirs have to be drawn down to prevent the dam failing on both large and small raised reservoirs (i.e. those between 10 and 25,000 m^3).

In line with proposed changes in legislation contained in the Flood and Water Management Bill, dam safety arrangements will be extended to reservoirs capable of holding over 10,000 m^3, whilst, at the same time, inspection and supervision of low risk reservoirs will no longer be mandatory (Hamilton-King, Hope, 2009). The process for assessment of "risk" in the regulatory context is still under development and will inevitably be highly influenced by consequence of failure. Dam type will also feature in risk ranking.

As part of the Reservoir Safety Research and Development Programme, the Environment Agency has commissioned a comprehensive Guide to Risk Assessment for Reservoirs. This will provide more accurate methodology for assessment of risk for all types of dam and risk ranking processes for undertakers with portfolios of reservoirs.

Further proposed changes to the Act include mandatory post-incident reporting and receipt of all engineers' statutory statements and reports.

PLANNING GUIDANCE

Inundation maps can also help to make decisions about land use planning policy. Although the likelihood of inundation is low, the following need to be considered:

- safety of people within buildings

- safety of buildings
- safe entry and exit from buildings
- ability of emergency services to evacuate or rescue people from buildings
- location of critical infrastructure.

Inundation maps will provide a vital link between developers, planners and the reservoir undertaker, so that the undertaker is more closely involved in the planning process. This is important because the category of the dam can change as a result of development. If this happens, the undertaker could face significantly higher costs (for example constructing a larger spillway) following the next inspection.

As a result of lobbying by the Environment Agency, flooding from reservoirs has now been identified as a potential flood risk in the recently published Planning Policy Statement 25 (PPS25). Appropriate guidance principles are currently being developed by Defra, Welsh Assembly Government and CLG for both PPS 25 (England) and TAN 15 (Wales).

CONCLUSION

Despite an excellent record of dam and reservoir safety throughout Great Britain over the past eighty years, there is no room for complacency. Following the mapping exercise, it has been calculated that 1.2 million properties are at risk of flooding from dam breach in England and Wales. The untold damage caused by the summer 2007 floods has brought a heightened awareness of the need to be prepared to deal effectively with emergency incidents and to avert dam failure.

From offering expert advice and guidance, to preparing inundation maps for all reservoirs and moving to a risk based approach to managing reservoir safety, the Environment Agency is committed to working with the reservoir industry, Government and the public to reduce risk, improve resilience, raise awareness and improve the long-term safety of reservoirs in England and Wales.

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REFERENCES

Brown, D. Gardiner, K. and Williams, N. (2010), *Exercising of Emergency Drawdown Plans,* in Managing Dams: Challenges in a Time of Change, Thomas Telford, London.

HMSO (2004), *Civil Contingencies Act 2004*, HMSO London

ICE (1996) *Floods and Reservoir Safety Third Edition.* Thomas Telford, London.

Environment Agency (2009) *Reservoir Inundation Mapping – Trial Study*

Hamilton-King, L.J. Hope, I.M. (2009) *Reservoirs Act 1975 – Environment Agency proposals for change* Dams and Reservoirs 2009 19 No.2

Hope, I.M. (2006) *Reservoir Safety in England and Wales – A Time of Change.* ANCOLD Conference, Manly Australia 2006.

Hope, I.M. Hughes, A.K. (2008) *Reservoir Flood Plans – Towards Implementation,* in Ensuring Reservoir Safety into the Future, pp 95-107, Thomas Telford, London.

Hope, I.M. Warren, A. (2010) *Post-incident reporting: the next steps*, in Managing Dams: Challenges in a Time of Change, Thomas Telford, London

Morris, M.W. 2008. *Breaching Processes: a state of the art review.* FLOODsite Report T06-06-03

Pitt, M. 2008 *Learning lessons from the 2007 floods* Cabinet Office

HMSO (1975) *Reservoirs Act 1975*, HMSO, London

HMSO (2003) *Water Act 2003*, HMSO, London