

The development of reservoir safety management plans

A L WARREN, Mott MacDonald

M HEWITT, Mott MacDonald

P D DOWN, Mott MacDonald

D SCOPES, Mott MacDonald

SYNOPSIS The national reservoir safety review in 2021 indicated a need for high-risk statutory reservoirs to have in place a reservoir safety management plan (RSMP). The intent was that this plan should set out what surveillance, monitoring and maintenance is required at a reservoir and how it is to be operated, together with the frequency of each element, how it is to be delivered and by whom. Drawing on research for the Environment Agency, the paper discusses:

- The basic requirements of a RSMP in line with international practices and guidance
- How the scope of the RSMP for any given reservoir might be informed through legislation and site-specific studies
- The responsibilities of stakeholders in preparing and managing the plan
- How development of RSMP's might change the current provisions for reservoir record-keeping.

INTRODUCTION

The Reservoir Review (the Review) in 2021 (Balmforth, 2021) proposed that high-risk statutory reservoirs in England should have a Reservoir Safety Management Plan (RSMP). The Review stated:

“All high risk reservoirs should have a reservoir safety management plan (RSMP) in place. This should set out what surveillance, monitoring and maintenance is required at a reservoir and how it is to be operated, together with the frequency of each element, how it is to be delivered and by whom. It would be in addition to and sit alongside an on-site emergency plan, and be appended with a record of all surveillance, operational and maintenance activities together with associated data, measurements and other information, which should be kept up to date.”

The Review also stated that the Supervising Engineer should review and approve the RSMP annually and to certify that the owner's actions have been carried out in accordance with the plan.

Mott MacDonald was commissioned by the Environment Agency (EA) to consider the elements required of a RSMP, how its development would affect the current statutory safety records (Prescribed Form of Record), the responsibilities of key stakeholders in managing the

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RSMP and how the scope might vary according to new hazard class designations. The development of RSMPs will be driven through further research and development and industry consultations so the final arrangements, terms and details brought into legislation and guidance are likely to differ from those presented in this paper.

INTERNATIONAL GUIDANCE ON RESERVOIR SAFETY MANAGEMENT SYSTEMS

There are several ICOLD bulletins which cover the key elements of good reservoir safety management. These include Bulletin 138 (ICOLD, 2009), Bulletin 154 (ICOLD, 2014), Bulletin 158 (ICOLD, 2019), Bulletin 168 (ICOLD, 2017) and Bulletin 180 (ICOLD, 2018). As part of the research, consultations were made with several leading UK and international dam operators to capture examples of the best reservoir safety management practices.

Some of the key points of guidance from the research relevant to the requirements of a sound reservoir safety management system are as follows:

1. Records should include all basic physical information for the reservoir.
2. Dam owners have a 'duty of memory' to fulfil, i.e. information on the original design and construction, studies, investigations, surveys, monitoring, remediation and improvement records, incidents and matters of concern should be carefully preserved and passed on to new owners when appropriate.
3. Effective safety management should include for performance assessment through visual inspections (surveillance), monitoring and the testing of safety-critical equipment such as gates and valves.
4. Monitoring and surveillance activities should be tailored to reflect failure modes and the history of the reservoir.
5. Monitoring equipment must be maintained through planned activities (i.e. pro-actively) as well as through corrective maintenance.
6. Surveillance should be carried out continuously and in a professional manner by trained personnel.
7. The scope and frequency of monitoring, surveillance and testing should be adaptable to the life cycle of a dam.
8. Special activities should be carried out following unusual events to verify performance.
9. Management systems should include an emergency action plan.

DEVELOPMENTS FOR A NEW REGULATORY DAM SAFETY MANAGEMENT SYSTEM

Defra and the EA are currently leading research into many of the recommendations of the Review including how reservoirs might be re-designated and how the regulatory controls for individual reservoirs might be introduced according to the hazard posed by each reservoir. A significant issue for the UK is that high hazard reservoirs are owned and operated by a very diverse group of reservoir owners ranging from water companies through to private individuals. Accordingly, there is considerable diversity in the knowledge, skills and financial resources that can be directed to the promotion of reservoir safety. All reservoir owners have a responsibility for the safety of the downstream communities and those communities have a right not to be disadvantaged on account of the financial and technical resources of the reservoir owner. Upholding this principle without placing intolerable requirements on

reservoir owners poses one of the greatest challenges in developing new legislation and guidance.

The recent research by Mott MacDonald proposed a safety management system as shown in Figure 1.

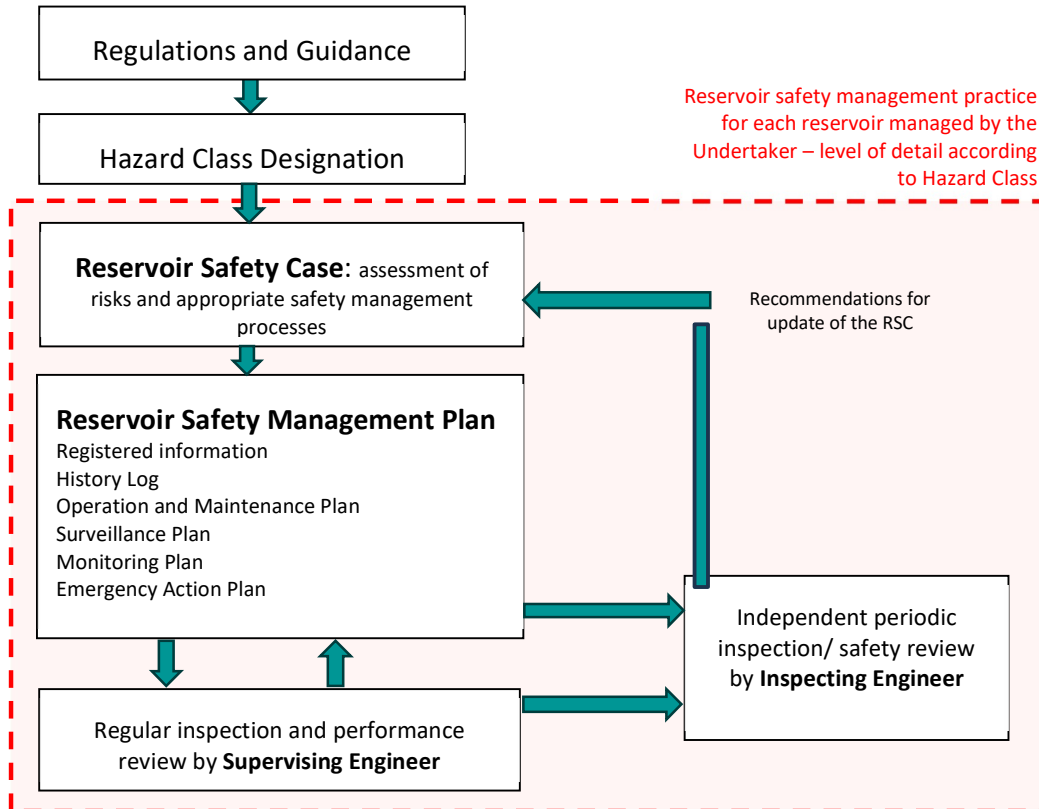


Figure 1. Outline of a new reservoir safety management system.

New regulations would define the hazard classes. All statutory reservoirs will need to be re-designated according to the new class definitions. To set out the minimum requirements for specific reservoirs it is proposed that there would be a ‘reservoir safety case’ (RSC). The scope of the RSC, how it would be completed and by whom has yet to be developed. Responsibility for preparing the RSC is likely to be with the Undertaker but clearly many Undertakers will require professional assistance in preparing it, as has been the case with Flood Plans. The RSC should evaluate the form and function of the reservoir structures and safety-related equipment (dams, tunnels, gated outlets etc) and consider the history of the reservoir and the modes of failure. It should aim to set out the minimum provisions for the reservoir in terms of surveillance, monitoring, competencies and training. It will therefore shape the reservoir safety management processes which are then developed further in the various parts of the RSMP. The minimum requirements for the RSC could reflect the reservoir hazard category. It would appear appropriate that the RSC should be reviewed periodically by the inspecting engineer who could make recommendations for amendments.

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The RSMP would replace the current provisions set out in the Prescribed Form of Record and Flood Plan (emergency on-site plan). It is proposed that the RSMP should have six key elements which are described in the sections below.

The role of the Supervising Engineer and Construction/Inspecting Engineer is not proposed to substantially change in scope. These roles and responsibilities will need to be adjusted but fundamentally they would be very similar to the current provisions.

PRESCRIBED FORM OF RECORD

Currently the reservoir safety records comprise sixteen parts of the Prescribed Form of Record (PFR) and the Flood Plan. The research proposed that the PFR need not be retained in future legislation as all the information can be captured by the RSMP parts described below. The research also proposed renaming the 'Flood Plan' as an 'Emergency Action Plan' which better aligns with international terminology.

REGISTERED INFORMATION

A digital database should be made available by the enforcement authority to store basic information on the reservoir, typically including the information contained in Parts 5-8 of the PFR. Some information is already stored by the EA. It is essential that there is common agreement on key data pertaining to the reservoir and that the EA maintains an overview of national data on reservoirs.

The Review recommended that the public should have greater accessibility to information on reservoirs that may affect their safety. Accordingly, it is possible that the public would have access to some parts or all the digital database. The information available could potentially include details of whether the Undertaker is in receipt of any directions to make improvements in relation to their statutory obligations. This would help to make Undertakers more accountable to downstream communities and bring greater transparency to the workings of the legislation.

HISTORY LOG

The PFR provides for recording past statutory reports, unusual events, drawings available etc. Greater emphasis should be placed on the value of retaining and recording key information relating to the history of a reservoir in terms of its design, construction, performance, remediation and improvement. ICOLD Bulletin 138 (2009) refers to owners having a 'duty of memory'. Drawings, investigation reports, changes in equipment, incidents etc can be lost over time and information may not be fully transferred when the ownership of a reservoir changes. It is critical to the safety of reservoirs that all reasonable steps are taken to preserve information which can be used to effectively review failure modes, investigate problems, plan improvement works and deal with incidents and emergencies. Under current guidance Undertakers should furnish inspecting engineers a 'data pack' ahead of inspections and we envisage that the History Log would largely serve this purpose. We envisage that the RSMP will provide guidance on the registration and management of reservoir documentation without being too prescriptive on how the Undertaker manages information.

OPERATION AND MAINTENANCE PLAN

Reservoir structures vary greatly in terms of their operational and maintenance requirements. Maintaining design conditions and preserving operability are key factors in keeping reservoirs safe. We envisage that the Operation and Maintenance (O&M) plan should include:

- Details of the equipment and operating processes relating to reservoir safety functions. This would include details of permanently-installed equipment that is likely to be used in managing an emergency.
- Restrictions on reservoir operation (e.g. water level, inflow control etc) imposed during construction or in service by a panel engineer.
- Key maintenance activities and a log of actions taken. These activities could be set out in the RSC.
- Documentation of surveys and planned operations to verify condition. The RSC might require that certain activities are carried out by trained individuals of a certain level of competency, for example in the servicing of spillway gates.

SURVEILLANCE PLAN

Visual inspection of reservoir structures is a vital component of any reservoir safety management system. The current legislation does not ensure that surveillance activities are regular or sufficient. We propose that, at least for the higher hazard class(es), the regulatory controls for reservoir surveillance should be improved. ICOLD Bulletin 154 (2014) states that a lack of financial, management or engineering resources cannot be a justification for inaction in carrying out effective surveillance. Improvements can be brought through training Reservoir Technicians to carry out the surveillance role and for these individuals to be accountable for ensuring that visits are both sufficient and regular. Many of the larger reservoir owners already provide training for site staff which could be assessed against new guidelines to ensure that the burden on the industry is minimised. For many smaller reservoir owners, the need to nominate two or more individuals to complete periodic Reservoir Technician training and certification could represent a significant change. The industry would need to decide how reservoir surveillance training is developed, delivered and maintained. In parallel with this it is proposed that there should be a Reservoir Safety Manager course which would help to raise awareness of reservoir safety management and legal obligations. There are international precedents for requiring formal reservoir safety training of reservoir owners/operators, for example in Norway and Sweden.

The Surveillance Plan would set out the details and certification status of the Reservoir Technicians and provide for a register to record any key findings or events. Guidance on the scope and frequency of surveillance visits to the reservoir could be provided in the RSC.

MONITORING PLAN

Together with surveillance, monitoring is a critical activity for most reservoirs. The current legislation does provide for scoping the minimum requirements for taking instrument readings so we do not envisage that significant changes are needed. There are problems in determining compliance where instruments fail or are damaged or where the minimum frequency of readings is not achieved due to, for example, lack of access during bad weather, staff sickness etc. New guidance will be required in this respect.

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The monitoring plan could include:

- A description of how the monitoring requirements link with failure modes and historical performance
- A description of the instruments required for monitoring performance together with the frequency and manner of recording information
- Any special supplementary short-term provisions required by the Supervising Engineer
- A description of where and how the data are stored.

MANAGEMENT OF SURVEILLANCE AND MONITORING INFORMATION

A decision will be required on whether information/data gained through surveillance and monitoring is held or referenced within the respective surveillance and monitoring plans described above or held in a separate part of the RSMP. Periodic reviews/summary reports of the data produced by the Undertaker and reviewed by the Supervising Engineer could then either remain in this part of the RSMP or be transferred into the History Log. With the advent of big data we recognise that a distinction must be made between provisions for the storage of large datasets and general reservoir records. The RSMP should set out the minimum requirements but should not be prescriptive in how or where data is stored and analysed.

EMERGENCY ACTION PLAN

There should be a requirement to maintain a Flood Plan or Emergency Action Plan (EAP). Currently, the Defra guidance requires that all relevant information be contained within the plan and updated/re-certified as required. Many elements of the plan are common with the requirements of other elements of the RSMP. For example, the reservoir owner's contact details would be in the registered information and details of how to open gates and valves would be in the O&M plan. We therefore propose that the EAP need only contain the information which is relevant to dealing with an emergency, for example the use of temporary pumps and details of how the plan should be tested. We recognise that there is value in being able to print off a document that contains all relevant information for dealing with an emergency. We believe guidance could be provided to achieve this without the need to duplicate information within the RSMP.

PERFORMANCE REVIEWS

It is important that the findings of surveillance visits, monitoring data, surveys, investigations etc are critically reviewed by the Undertaker on a regular basis to assess whether the reservoir structures are performing in an acceptable manner and whether any 'trigger level' criteria set out in the RSC or by panel engineers have been exceeded. The research considered whether performance reviews carried out by the Undertaker should be included as part of the RSMP. We consider that although this is critically important to effective reservoir safety management it is not necessarily a matter that needs to be formally captured within the scope of a RSMP. On a broader scale, larger reservoir owners typically carry out portfolio reviews. The role and responsibility of owners in carrying out performance reviews should however be covered in new guidance.

MONITORING COMPLIANCE

The Review recommended that the Supervising Engineer should review the RSMP annually and approve and certify it as being compliant with the requirements. The Review also places responsibility for the safety management of a reservoir first and foremost with the Undertaker. It could be considered an unfair burden on Supervising Engineers to certify that a RSMP is fully correct and complete. The Supervising Engineer only gains a 'snapshot' of reservoir performance typically once or twice each year through site visits, and the plan is prepared and maintained by the Undertaker. Therefore, we recommend that it should not be a requirement that the Supervising Engineer certifies the RSMP.

New legislation will likely require an Undertaker to prepare a RSMP. The contents of the plan should be steered through guidance according to hazard class. The legislation could provide powers for the Supervising Engineer, an Inspecting Engineer and possibly the enforcement authority to serve improvement notices where safety-critical changes are needed to the RSMP to comply with the guidance or to reflect changes at the site. Examples might include:

- The need to update contact details in the Registered Information
- Updating of the History Log with information on an incident
- Corrections to the information relating to a replacement telemetry system in the O&M plan
- Need for a Reservoir Technician to renew certification and record it in the Surveillance Plan
- Need to replace a water level gauge and update the Monitoring Plan
- Need to change the access provisions in the EAP for the installation of mobile pumps.

SUMMARY

This paper sets out the key findings of recent research to inform the scope of a RSMP. The research was informed by a review of international guidance on reservoir safety management and through discussion with several national and international dam operators on current best practice. Under any new reservoir safety legislation, the preparation and maintenance of the RSMP will be critical in driving good reservoir safety practices and promoting dam safety. The further development of proposals for new legislation and guidance will likely be steered through further research and industry consultations.

REFERENCES

- Balmforth D (2021) Independent Reservoir Safety Review Report – Part B. Available at: <https://www.gov.uk/government/publications/reservoir-review-part-b-2020>
- ICOLD (2009) *Bulletin 138 General approach to dam surveillance*. International Commission on Large Dams, Paris
- ICOLD (2014) *Bulletin 154. Dam safety management: operational phase of the dam life cycle*. International Commission on Large Dams, Paris
- ICOLD (2017) *Bulletin 168. Recommendations for operation, maintenance and rehabilitation*. International Commission on Large Dams, Paris

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ICOLD (2018) *Bulletin 180. Dam surveillance – Lessons learnt from case histories*. International Commission on Large Dams, Paris

ICOLD (2019) *Bulletin 158. Dam surveillance guide*. International Commission on Large Dams, Paris.