

## **Reservoir safety – what do we mean?**

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**SYNOPSIS.** In 1984 the then Institution of Water Engineers and Scientists held a two-day Symposium entitled Water Management – A Review of Current Issues. One of the topics covered was the imminent implementation of the Reservoirs Act 1975. That legislation has governed reservoir safety since 1985 - the change of Enforcement Authority from local authorities to the Environment Agency on 1 October 2004 did not change the fundamental tenets of the Act. When fully implemented, the provisions of the Floods and Water Act 2011 will introduce further changes. Again these changes do not change the fundamental principles and approach to reservoir safety that underlies the 1975 Act.

This paper will seek to restate and review the fundamental principles that have underlain reservoir safety legislation since the 1930 Act and explore the question of whether they remain “fit for purpose” in the 21<sup>st</sup> Century.

### **BACKGROUND**

The dam failures at Skelmorlie in south west Scotland and Dalgarrig in North Wales in 1925 ultimately led to the enactment of the Reservoirs (Safety Provisions) Act 1930. The principles and practices introduced by this Act, which remained in force until the full implementation of the Reservoirs Act 1975 on 1 April 1986, continue to provide the foundation for reservoir safety in the United Kingdom.

It is generally presumed that the Reservoirs (Safety Provisions) Act 1930 represented the first statutory requirements for reservoir safety. As noted by Agnew (1984), the Waterworks Clauses Act 1863 included provisions on the “security of reservoirs”. These provisions allowed “any Person interested” to complain to two Justices (or a Sheriff in Scotland) that a reservoir was in a “dangerous state”. The Justices could, if satisfied that the complaint was well founded, order that the water in the reservoir be lowered and the execution of “all such Works and Things as the Justices think requisite and proper for removing the Cause of Complaint”. These provisions continued in subsequent consolidations of legislation until repealed in 1945 (1946 in Scotland).

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### RESERVOIR (SAFETY PROVISIONS) ACT 1930

The Act laid a duty on the owners of all reservoirs capable of holding more than 5 million gallons above ground level (defined as a “large raised reservoir”) to have them inspected at intervals not exceeding 10 years by a “qualified” civil engineer and to carry out all works necessary in the interests of safety. In addition the design and construction of all new large reservoirs and alterations to existing large reservoirs must be done by a “qualified” civil engineer. For the purposes of the Act “qualified” meant being a member of a panel constituted for the purposes of the Act and appropriate to the particular class of reservoir concerned.

### REVIEW OF ICE COMMITTEE

An ad-hoc committee of the Institution of Civil Engineers reviewed the operation of the 1930 Act in 1966 and made a number of specific recommendations to improve and strengthen the Act. These included:

- Effective powers of enforcement
- Some tightening of the requirements for inspection
- Independence of the Inspecting Engineer.

This report ultimately led to the Reservoirs Act 1975.

### RESERVOIRS ACT 1975

The legislative response to the recommended changes was the enactment of new legislation replacing the 1930 Act. The 1975 retained the essential provisions of the earlier Act. The main changes were:

- Enforcement Authority with a duty and more explicit powers to enforce the Act (Local Authorities were identified as the Enforcement Authority);
- Reservoir owners to appoint a named supervising engineer to keep each reservoir under continuous supervision between inspections;
- Non-compliance with the safety provisions of the Act became a criminal offence;
- Panel appointments limited to a five-year term, subject to reappointment;
- Precautions required if a reservoir is to be abandoned.

Implementation of the 1975 Act was both delayed and somewhat protracted; beginning on 8 November 1983 and with the full Act in force from 1 April 1986.

#### LEGISLATIVE CHANGES SINCE 1986

The Water Act 2003 transferred the responsibility for enforcement in England and Wales from local authorities to the Environment Agency.

The Floods and Water Management Act 2010 modifies the Reservoirs Act 1975. It seeks “to reflect a more risk based approach to reservoir safety” but makes no change to the essential provisions of the 1930 Act. The changes empowered by the 2010 Act are:

- Reducing the capacity at which a reservoir will be regulated from 25,000m<sup>3</sup> to 10,000m<sup>3</sup>;
- Ensuring that only those reservoirs assessed as a higher risk are subject to regulation;
- All undertakers with reservoirs over 10,000m<sup>3</sup> must register their reservoirs;
- Inspecting engineers must provide a report on their inspection within six months;
- All undertakers must prepare a reservoir flood plan;
- All incidents at reservoirs must be reported.

The reservoir sections of the Flood and Water Management Act are dependent upon on the development of secondary legislation (regulations and orders) before the law can be fully implemented, so it is likely that many of the provisions in the Act will not come into force for some time yet.

#### PURPOSE OF LEGISLATION

The fundamental purpose of legislative intervention in reservoir management is to impose precautions in the interests of public safety. This was the driver for the 1930 Act and all subsequent legislation has been largely focussed on improving and strengthening the operation of the safety regime set up by the 1930 Act. None of the post 1930 legislation has changed the fundamental safety intervention introduced by the 1930 Act: the involvement of a “qualified engineer” in the construction, alteration and periodic inspection of large reservoirs.

Michael Kennard noted that the 1975 Act introduced “many aspects of enforcement and bureaucracy with little or no change to the technical requirements” (Kennard, 1984). The same can be said for the Floods and Water Management Act 2010: the changes introduced by the 2010 Act primarily affect the selection of reservoirs to which the safety regime applies (first three bullets above) rather than amending the safety regime itself. Put another way, the 2010 Act introduces a more “risk” based assessment of the reservoirs to which the full safety regime applies. The

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safety regime itself is unchanged although the written evidence of the safety intervention (the report and certificate) is now required to be produced in a specified period.

### STATUTORY SAFETY REGIME

The statutory safety regime for reservoirs that are covered by legislation in the UK requires a qualified civil engineer:

- to have oversight of design and construction of new reservoirs and alterations to existing reservoirs
- to undertake periodic inspections of reservoirs at an interval of not more than 10 years

In the capacity of Construction Engineer the qualified civil engineer is required to issue certificates allowing a new or modified reservoir to be filled (and indicating the level to which it can be filled). The Construction Engineer is ultimately asked to certify that the reservoir is “sound and satisfactory and may be used to store water up to a level of  $h$  subject to the following conditions ...” The exception to this is if the Construction Engineer has been appointed under Sections 8 or 9 of the Act, the details of which are described in the Guide to the Reservoirs Act (ICE, 2000).

In the capacity of Inspecting Engineer the qualified civil engineer is required to certify that an inspection has taken place and whether measures in the interests of safety are required.

Thus, the task of the qualified civil engineer is to assess whether or not a reservoir covered by the Act is “safe”; explicitly in the Final Certificate and implicitly in a Section 10 certificate if no works in the interests of safety are required. This is a binary assessment: safe or not. Put another way: this is a deterministic assessment rather than a probabilistic one. None of the legislation that amends and modifies the 1975 Act has changed this fundamental fact.

### SAFETY AND JUDGEMENT

In essence the safety or otherwise of a reservoir is a matter of the judgement of the qualified civil engineer who is acting in one of the capacities defined within the Reservoirs Act 1975. Charles (2002) states “The legislation provides a framework within which independent qualified civil engineers make technical decisions relating to reservoir safety and great reliance is placed on the competence of those engineers.” To expand this point, there are two factors that need to be considered:

- what constitutes safety in this context, and
- the judgement of the qualified engineer in applying their technical competence.

No definitions of what constitutes safety are given in the Act. The Guide to the Reservoirs Act (ICE, 2000) suggests that “safety is not defined in relation to the integrity of the structure forming the reservoir but in relation to its effects on the public, both persons and property.”

Judgement in this context is taken to refer to the critical faculty; the ability to discern safe from unsafe. It refers to the ability to apply good sense (interestingly a further meaning of “judgement” according to the OED).

The potential for inconsistency that arises from the subjective nature of an individual engineer’s judgment can give rise to concerns (Hay, 1996). However, the wide variety of reservoirs covered by legislation and the widely varying contexts within which these reservoirs are owned and operated make the imposition of a more rigid approach extremely problematic.

Milne noted that the inherently subjective nature of an Inspection “makes the choice of Inspecting Engineer all the more important – common sense and realism are as important as technical ability” (Milne, 1996). Common sense and realism can be considered as integral to judgement in this context.

This discussion highlights the importance of the role played by the Reservoirs Committee of the Institution of Civil Engineers in recommending the appointment of engineers to panels constituted under the 1975 Act is clear. It is vital that the criteria for appointment and reappointment focus on the key areas of technical competence, realism and common sense identified by Milne.

#### JUDGEMENT AND GUIDANCE

As the number of reservoirs constructed has reduced there has been an increase in quantity of Guidance (and the claims made for that Guidance).

Guidance documents can be helpful in providing a consistent methodology for undertaking certain aspects of a safety assessment, thus Floods and Reservoir Safety is a widely respected and used document. Some other guidance documents are perhaps less well used.

An ever increasing quantity of Guidance is not automatically a benefit. Loss prevention considerations within the employers of qualified civil engineers can have the effect of making guidance mandatory. In the opinion of the author, such an outcome is not automatically in the interests of public safety.

Part of the success of the reservoir safety regime introduced by the 1930 Act has been its ability to flex to accommodate the wide variety of reservoirs to which it applies, the wide variety of situations and circumstances that can apply to those reservoirs and the development of the body of knowledge on the behaviour of reservoirs. This is achieved through the qualified

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engineer's ability (and obligation) to apply technical competence and judgement in assessing the safety of reservoirs covered by the statutory regime. Guidance has a valuable role in providing snapshots of the "state-of-the-art" in particular areas of practice. Of its very nature guidance is of the time that it is written and cannot be amended or updated in direct alignment with the development of the body of knowledge.

In this context it is interesting to note that the working party that published the 1978 edition of *Floods and Reservoir Safety* decided it was not appropriate to produce an Engineering Design Manual as their brief required. Instead they decided to produce a guide "to benefit engineers operating within the requirements of the Reservoirs Act" (ICE, 1978). Subsequently updated editions have followed that precedent.

Charles notes "future safety depends on maintaining the professional and technical standards of qualified civil engineers" (Charles, 2002). All the Guidance in the world will not make an engineer competent in the exercise of professional and technical judgement if they are not competent in the first place.

### RISK ASSESSMENT AND RESERVOIR SAFETY

There seems to have been some sort of formal investigation or preparation of guidance on the application of risk assessment methodologies to reservoirs for at least three decades: Kennard (1984) references a feasibility study into risk assessment for reservoirs being undertaken by the Water Research Centre. Recent work has taken the form of a number of guides and research reports focussing on quantitative risk assessment (Hughes *et al*, 2000; Brown & Gosden, 2004).

None of the work that has been done seems to the author to reconcile the deterministic approach of the statutory reservoir safety regime that was initiated by the Reservoirs (Safety Provisions) Act 1930 with a quantitative risk based safety assessment.

The value of relative risk rankings in managing a portfolio of reservoirs is apparent but that is not the task of the qualified civil engineer. The Inspecting Engineer's task is to determine whether the particular reservoir under inspection is safe and to make such recommendations for safety, maintenance and the proper management of the reservoir as he deems necessary. Risk assessment methodologies can provide a structured approach to consider the hazards that could jeopardise a reservoir but they cannot and should not take the place of the engineering judgement of the qualified engineer.

### CONCLUSIONS

The purpose of this paper has been to redirect attention to the fundamental statutory safety interaction affecting UK reservoirs: the involvement of a

“qualified civil engineer” in the construction, alteration and periodic inspection of large reservoirs and the application by that qualified civil engineer of their professional judgment as to the safety or otherwise of the particular reservoir in question.

Notwithstanding the observations that the statutory safety regime set up by the 1930 Act “could be improved and ... does not compare well with the management of other high hazard installations” made in the research report “Reservoir Safety – Floods and Reservoir Safety Integration” (KBR, 2002), no legislation has been introduced and none is understood to be in the offing that would significantly change this fundamental interaction. Therefore there is no legislative mandate to introduce documents or requirements that seek to “alter the obligations of Inspecting Engineers and Construction Engineers in the exercise of their personal judgement in all technical matters” (ICE, 1996).

The Floods and Reservoir Safety Guide made this statement in respect to the selection of design floods for reservoirs but the same could be said for all technical matters pertaining to the safety of reservoirs.

This is not a call to complacency. No one involved with reservoir safety should be complacent about the risk posed by reservoirs. Public tolerance of the risk of accidental death from any cause is reducing. Expectations about transparency and accountability are also increasing. These public expectations need to be met and addressed within the context of the existing statutory regime until such time as that regime is amended by Parliament.

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