Post–incident reporting: learning from experience to promote reservoir safety

L J HAMILTON-KING, Environment Agency, Exeter, UK
I M HOPE, Environment Agency, Exeter, UK
A L WARREN, Halcrow Group Ltd, Swindon, UK

SYNOPSIS. This paper explains how the new role of post-incident reporting for UK dams is working and considers the challenges for the future.

The paper will:

- explain how the post-incident reporting system works;
- summarise the type of incidents reported to the Environment Agency;
- highlight findings from post-incident investigations;
- summarise how the industry has been kept informed (bulletins, first annual report etc.) and expand on communications issues (freedom of information requests etc);
- expand on how similar systems are being engaged (e.g. The Standing Committee on Structural Safety (SCOSS) and Confidential Reporting on Structural Safety (CROSS);
- consider the need for mandatory post-incident reporting in the future;
- explain how the system can inform the reservoir research and development programme.

INTRODUCTION

The average age of dams in the UK is more than 110 years. Whilst some new reservoirs are still being built, the expectation is that the existing stock of dams will continue to serve future generations.

As well as planned improvements and repairs, the reservoir industry needs to have more accurate information on the likely lifespan of these critical structures and the likelihood of potential modes of failure. This will be achieved by promoting and adding to the new post-incident reporting database. Having a formal process in place to alert undertakers and panel

Ensuring reservoir safety into the future. Thomas Telford, London, 2008

engineers to critical events and issues will further help to improve reservoir safety.

The new post-incident reporting system for UK reservoirs (Warren and Hope, 2006) began on 1 January 2007. The system is administered by the Environment Agency on behalf of the reservoir industry and is overseen by an independent inspecting engineer. It draws upon previous work carried out by the Building Research Establishment (Charles 2005).

The system is operated on a voluntary basis: there is currently no legislation in place to require a reservoir owner to share details of an incident when dam safety is threatened or even when dams fail. Other industries have long recognised the need to continually improve safety by sharing knowledge when incidents happen. Learned societies such as the British Dam Society play a valuable role in helping to share experiences to benefit everyone.

The system provides a consistent way of capturing, analysing and sharing information about incidents, which is a valuable tool for the industry. The information can also be used to inform research and development priorities.

This paper aims to summarise the incidents and investigations carried out in the first year of administering the system and considers future developments.

A SUMMARY OF THE NEW SYSTEM

Incident reporting procedure

Anyone can report an incident at a reservoir and the procedure for doing so is summarised in Figure 1. The procedure distinguishes between dealing with the initial emergency and reporting the incident to the Reservoir Safety team once the incident has been brought under control. Hence the term ‘post-incident reporting’.

UK-wide reporting

The database allows post-incident data to be entered for any reservoir within the UK, both statutory and non-statutory. This is because lessons can be learned from incidents at any dam, irrespective of its size or location.

The database contains information on all statutory reservoirs in England and Wales. Information on non-statutory reservoirs and reservoirs in Scotland and Northern Ireland is entered as and when information becomes available. The Scottish Government and the Northern Ireland Rivers Authority support this process.

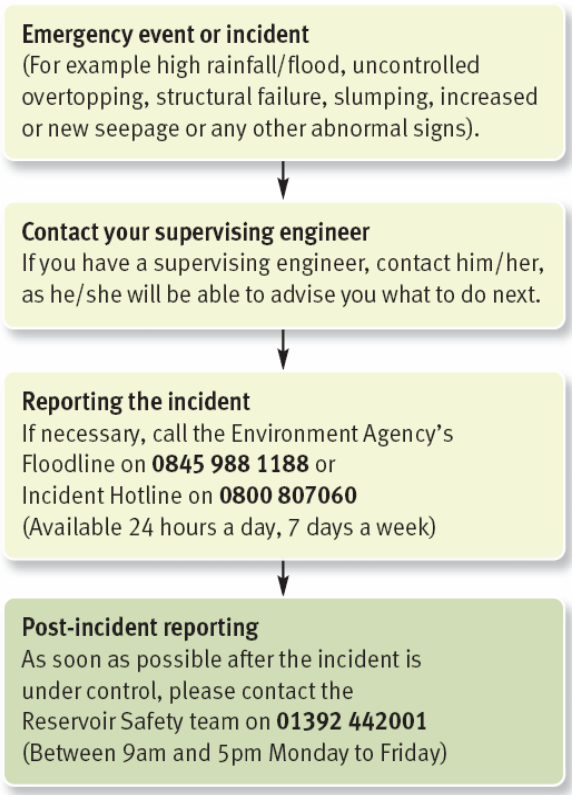

Figure 1. Procedure for reporting an incident

Incident level definitions

Incidents are entered on the new database if we consider that they are reportable. Assigning a level to each incident is important for managing the system and for reporting on incidents according to how severe they are. Table 1 below defines what a reportable incident is.

Table 1. Reportable incidents

Incident level	Definition
One	Failure (uncontrolled sudden large release of retained water)
Two	Serious incident involving any of the following: o emergency drawdown o emergency works o serious operational failure in an emergency
Three	Any incident leading to: o an unscheduled visit by an inspecting engineer o a precautionary drawdown o unplanned physical works o human error leading to a major (adverse) change in operating procedures

ENSURING RESERVOIR SAFETY

How incidents are reported

Incidents are reported using a post-incident report form which can be downloaded from the Environment Agency website or requested by e-mail. When the system administrator receives a completed post-incident report form, the information is added to the database.

Database

A new database was developed from the existing Building Research Establishment (BRE) database of incidents. The database contains information on historical incidents recorded by BRE as well as information on more recent incidents. The database can hold information on dam characteristics as well as incidents.

The database can be used to produce reports on the nature of incidents, the lessons learned and, over time, it will also help to identify trends.

Dam characteristics

A detailed database of the characteristics of UK dams is important, as it will allow the reservoir industry to make best use of the post-incident data and provide a focus for future research.

Information on dam characteristics is gathered via a reservoir data sheet in one of two ways. For each reported incident, the undertaker, supervising engineer or investigating engineer is asked to complete a reservoir data sheet as well as a post-incident report form. The data sheet comprises a simple spreadsheet, which typically takes around 30 minutes to complete. This is the only way data is collected for non-statutory reservoirs and reservoirs in Scotland and Northern Ireland. For statutory reservoirs in England and Wales a reservoir data sheet is sent to the inspecting engineer when he is appointed to do the next statutory inspection of a reservoir. The inspecting engineer is asked to complete and return the data sheet as part of his/her inspection.

System reporting to the reservoir industry

An annual report is prepared for the reservoir industry, which aims to set a structured and consistent approach to reporting that can be referred to in the future. The following information was presented in the 2007 annual report:

- incidents in 2007 and over the past four years by types of lesson learned;

- incidents in 2007 and over the past four years by the main threat posed to the reservoir (internal or external);

- incident severity against:
    - the mechanism of deterioration
    - flood category

- a summary of the main lessons learned from reported incidents.

Apart from high profile incidents, such as Ulley reservoir in 2007, the reservoir names, locations and owners are not disclosed. This is to encourage voluntary reporting.

Bulletins are prepared, when appropriate, to provide information about an incident or group of incidents where there are particular lessons that should be shared with the reservoir industry. The aim of the bulletins is to alert undertakers and panel engineers to the issues that have arisen and the actions they should take.

Anyone wanting further information from the database can contact the Environment Agency's Reservoir Safety team.

RESERVOIR SAFETY INCIDENTS

Before January 2007 there was no formal system for reporting reservoir incidents. In the past, incident data was gathered on an ad-hoc basis from a variety of sources, including technical papers (Warren and Hope, 2006). The new post-incident reporting database currently holds data on 218 reportable incidents dating from 1800 to 2007. To date, 25 level 1, 85 level 2 and 108 level 3 incidents have been recorded. Some additional historical incidents have yet to be processed and added to the database.

Reservoir safety incidents since 2004

There have been 24 reportable incidents recorded since 2004. Figure 2 shows the breakdown of these incidents in each year by severity.

Dams in the UK can be categorised by the hazard they pose to life and property (ICE, 1996). The categories range from category A for reservoirs that pose a significant threat to life, to category D where no risk to life is likely in the event of dam failure. The majority of reported incidents between 2004 and 2007 occurred at category A dams as shown in Figure 3. It is unclear if this truly represents a greater number of incidents at category A dams or merely a greater level of reporting of incidents at category A dams. It might be that incidents at category A dams are more high profile, therefore more likely to be reported. The dam category is not known in some cases and this reflects incidents reported at non-statutory reservoirs or those still under construction.

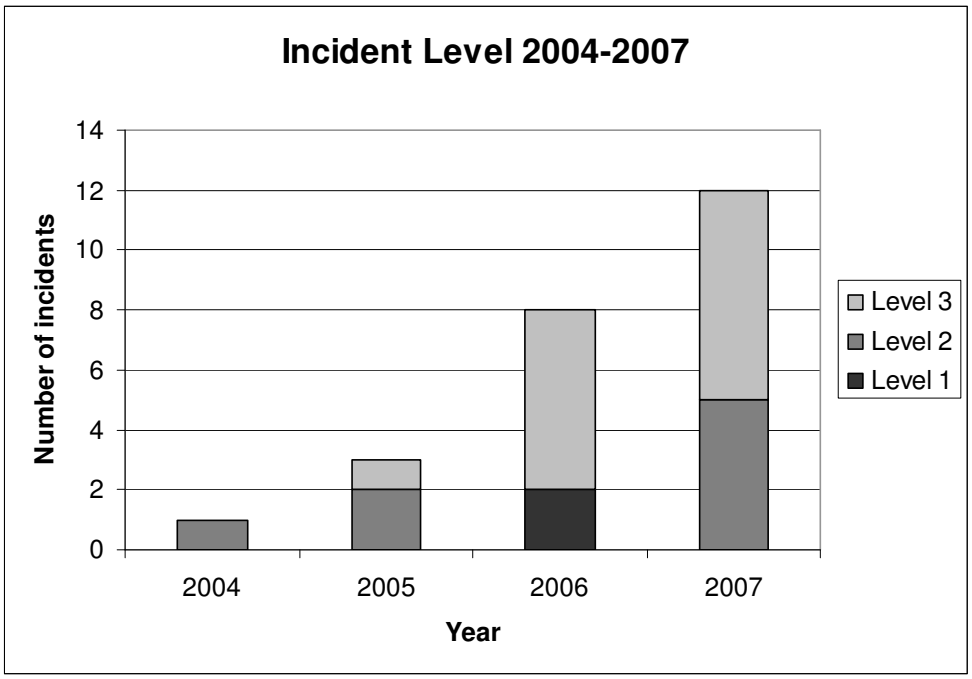

Figure 2. UK reservoir incidents by severity, 2004-2007

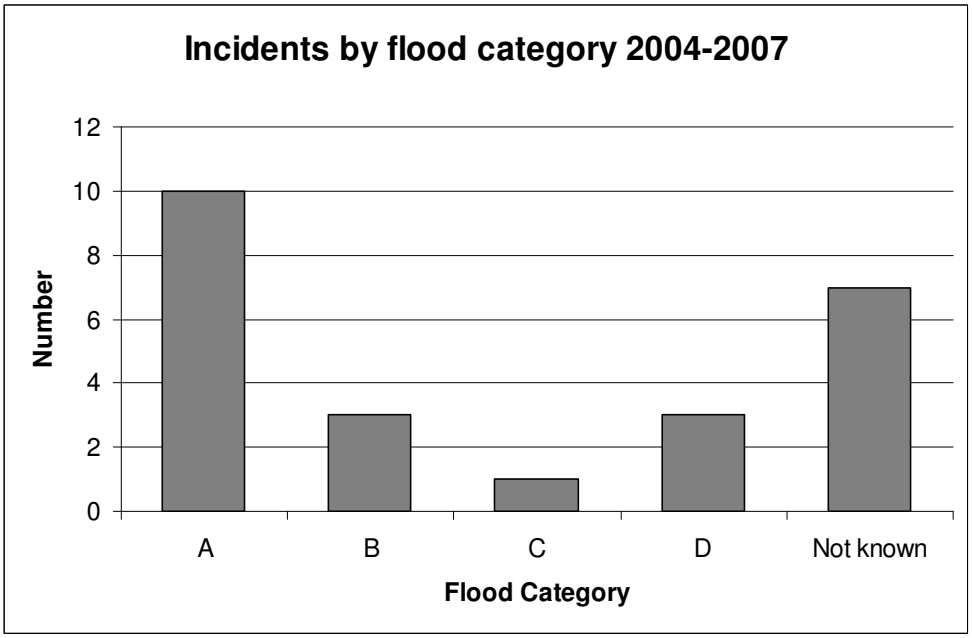

Figure 3. Reported incidents by flood category, 2004-2007

The great majority of incidents occurred at earthfill embankments as shown in Figure 4. This is not surprising given that 85% of dams in England and Wales are of the earthfill type.

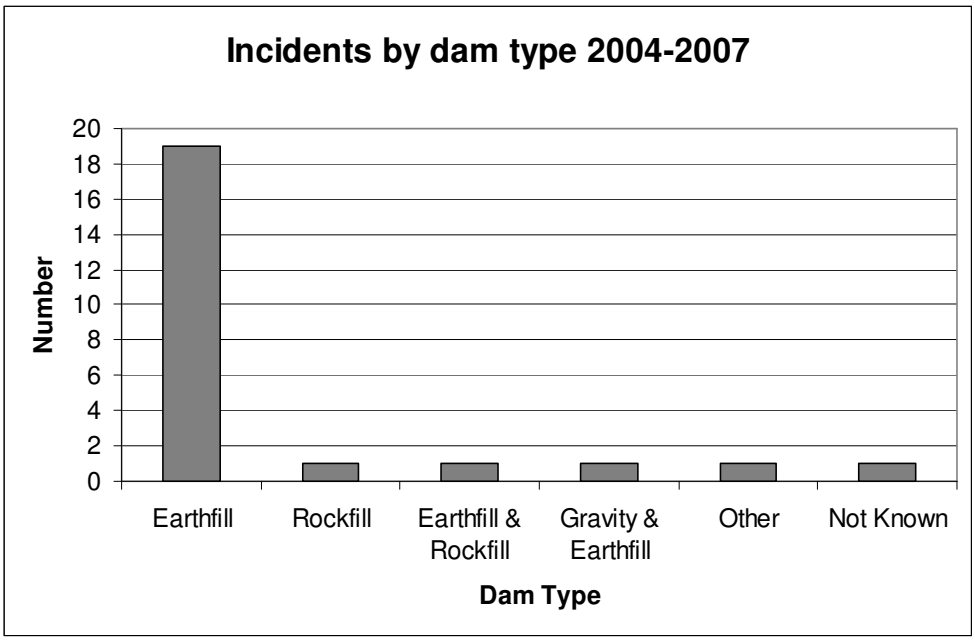

Figure 4. Reported incidents by dam type, 2004-2007

Incidents recorded in the database are classified by the type of lesson learned. The lessons learned are split into eight categories. The five main types are explained in Table 2. The other three are 'none', 'other' and 'not known'. Incidents reported by lesson type are illustrated in Figure 5.

The database allows for more than one of the lesson types to be assigned to any particular incident where appropriate, but only the main lesson type is reported here. Categorising the lessons learned in this way will make it easier to highlight trends in the sort of incident arising.

Table 2. Types of lesson that can be learned from reservoir incidents

Type	Examples	Possible implications
Surveillance	Inadequate surveillance or processing of instrument observations.	Reservoirs require more or better monitoring and surveillance.
Operation	Malfunction or mis-use of reservoir control facilities.	Reservoirs require more or better trained staff or security against mis-use.
Physical (current condition)	Inadequate performance due to deterioration of a design element by erosion, wear, weathering, corrosion, vandalism, poor maintenance, etc.	Reservoir components are inadequately maintained.
Physical features (intrinsic)	Inadequate performance due to the original design and/or construction of a structure, or through changes in the loading (structural or hydraulic) experienced.	Reservoir components are inadequately designed or built to meet current physical conditions.
Emergency planning	Incidents relating to the application of emergency planning provisions (alarms, evacuations, etc).	There is a need for more effective use of emergency planning provisions at reservoirs.

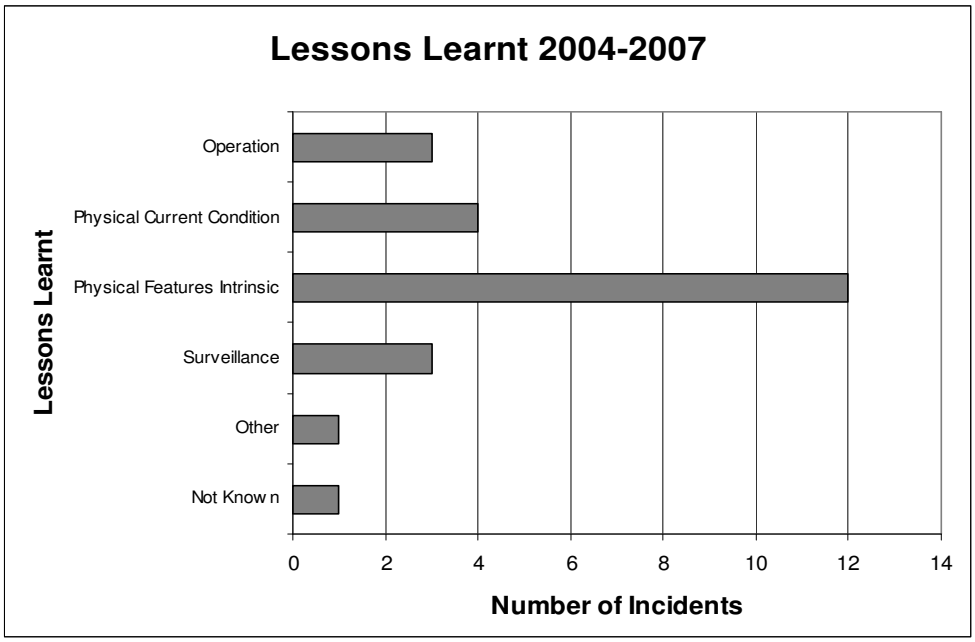

Figure 5. Reported incidents by type of lesson learnt, 2004-2007

INCIDENT INVESTIGATIONS

Following review with a panel engineer, post-incident investigations are carried out for the most serious or complex incidents where permission has been gained from the dam owner. A post-incident investigation has been carried out for four reservoir incidents to date. Each investigation was carried out by a qualified civil engineer to explore the root cause of the incident without apportioning blame. Investigations are also commissioned for significant incidents at non-statutory reservoirs where, generally, there is no supervising engineer or other person with enough technical knowledge about the reservoir to gather information for the database.

Investigations will often be commissioned by the Environment Agency where there may be important lessons to share with the industry through a bulletin or technical paper. A good example is the investigation into the causes of the Ulley reservoir incident in 2007, where the investigation:

- made sure that the information held on the database was well-informed and accurate;
- provided detailed information to the reservoir industry on the key findings of the investigation in a bulletin;
- provided valuable information for future research;
- allowed the reservoir industry to demonstrate that it responded in an effective and responsible way, taking account of the severity of the incident, to try to understand what contributed to the incident.

LIMITATIONS AND CONCERNS FOR VOLUNTARY REPORTING

Completeness of reporting

The main difficulty with a voluntary incident reporting system is that accurate information on how often incidents occur cannot be gathered, due to considerable uncertainty about the completeness of reporting. This limits the value of using the current system for quantitative risk assessments which rely on information relating to incident frequency (probability) by incident type.

Voluntary reporting relies on individuals giving up a small amount of their time to complete incidents forms and reservoir data sheets. Some have had difficulty in making this time available or have simply not reported incidents for personal, corporate or other reasons. When deciding whether to take the time to report an incident it is worth considering that:

- the Environment Agency is administering the system on behalf of the reservoir industry as a whole; it does not use the information for

any secondary purpose in particular prosecution under the Reservoirs Act 1975;

- the effectiveness of voluntary reporting has influenced the call for a mandatory reporting system as part of the proposed changes to the current reservoir legislation.

The completeness of reporting for incidents at statutory reservoirs is low and might be below 50%, but it is impossible to estimate from the information available. However, the new system has been effective in capturing more incident data for non-statutory reservoirs, and raising our awareness of the threats that small reservoirs can pose (Goff and Warren, 2008).

Under reporting – a loss to the industry

There is anecdotal information from the industry that around the time of the Ulley incident there were problems at a number of other masonry spillway channels but these were not reported. In particular, there was a case of high velocity flows removing blockwork on a spillway channel which was only 15 years old.

The Environment Agency's first bulletin to the reservoir industry was based on incidents involving Ashlar block spillways commonly used during the Victorian era. Arguably some engineers and undertakers whose spillway(s) are of the more recent concrete block variety will read that bulletin and consider that it does not apply to them.

Taum Sauk – a case study

The publication of the cause of the failure of the upper reservoir at the Taum Sauk pumped-storage hydroelectric plant provides an excellent example of good practice. Detailed information on the cause of the incident was publicised ahead of any lawsuit.

Immediately following the incident, which occurred in December 2005, the regulator FERC (Federal Energy Regulatory Commission) promptly established a dedicated webpage, provided briefings and updates, and appointed a panel of experts to conduct a detailed forensic investigation. Their report was available for public comment within 5 months, and in addition to an independent detailed analysis of the causes of the incident, the report provides a concise history of plant operation and issues that arose.

We have cited this incident at previous BDS presentations and asked the audience if they were aware of the incident and its causes. Encouragingly, all those involved in the power generating industry knew about the case because it has been so openly reported, and had taken action accordingly.

A number of reports on the incident are available on the FERC website at http://www.ferc.gov/industries/hydropower/safety/projects/taum-sauk.asp

Figure 6. Taum Sauk Dam

Regulatory change – mandatory incident reporting

As the post-incident reporting system relies on voluntary reporting, a strategy for communicating with the reservoir industry was developed (Hope 2007). The aim of the strategy was to encourage undertakers and panel engineers to contribute to the new system. However, as discussed, we believe there has been under-reporting of incidents under the voluntary system.

The ICOLD bulletin 59 highlights the need for regulators to continually review 'safety regulations and procedures'. The Environment Agency has previously highlighted a number of shortfalls in the Reservoirs Act 1975 (Hope 2007) and has alerted the Pitt Review to its concerns about under-reporting of incidents. One of the Environment Agency's proposals to the Pitt Review is to establish a mandatory reporting system.

Confidentiality

Some concern has been expressed that information provided to the Environment Agency about incidents could enter the public domain. This concern arises because, as a public body, the Environment Agency is subject

to the Freedom of Information Act 2004 and the associated Environmental Information Regulations 2004.

Following the incident at Ulley in June 2007, the Environment Agency received requests from the media for post-incident report forms for a number of incidents. However, the information requested was not released, as disclosing it would have adversely affected public safety and national security. This decision was reached after referring to the Ministry of Justice and was upheld following a subsequent appeal.

Fear of prosecution

Concern has been expressed that the Environment Agency's role as the enforcement authority for the Reservoirs Act 1975 conflicts with the post-incident reporting role. However, the aim of post-incident reporting is only to improve reservoir safety. The Environment Agency does not intend to use information acquired through post-incident reporting to retrospectively initiate enforcement action under the Reservoirs Act 1975.

As the enforcement authority, the Environment Agency is well placed to administer the post-incident reporting system as it already holds reservoir details and acts as a single point of contact for dam owners and engineers on a number of issues. In addition, due to its wider flood risk management role, the Environment Agency can pick up reports of incidents at non-statutory reservoirs through its incident hotline (0800 80 70 60) and Floodline (0845 988 1188), as happened during the 2007 summer floods.

OVERVIEW OF SIMILAR SYSTEMS

The Institution of Civil Engineers, the Institution of Structural Engineers and the Health & Safety Executive have established the Standing Committee on Structural Safety (SCOSS). The role of SCOSS is to monitor and investigate trends or practices that might cause structural failure. They have also established Confidential Reporting on Structural Safety (CROSS), which is a voluntary system.

Since the Environment Agency became the enforcement authority for the Reservoirs Act 1975, it has held annual liaison meetings with the Health & Safety Executive to make sure there is a coordinated approach to all reservoir safety matters. A productive working relationship has also been established with SCOSS who publish annual reports and bulletins which can be viewed on their website. (http://www.scoss.org.uk/).

ICOLD are planning to introduce a system of incident reporting 'Dam Failures and Incidents Database' which will draw on the data and

information held by member countries. The University of Stanford in the United States has established a web-based reporting system (http://npdp.stanford.edu/index.html).

Issues for developing a mandatory system

In September 2007 the Environment Agency provided evidence to Sir Michael Pitt as part of his review into the summer 2007 floods. The Environment Agency called for a number of changes to the Reservoirs Act 1975, including the requirement for mandatory incident reporting.

The proposal is in its early stages and many detailed policy decisions will need to be resolved. These include who should be responsible for incident reporting, which reservoirs should it apply to (statutory/non-statutory) and should there be an incentive to encourage reporting or a fine for not reporting? The definition of a reportable incident may also need to be more clearly defined.

INFORMING RESEARCH AND DEVELOPMENT

Historical reservoir safety incidents and the original BRE database have helped to inform many reservoir safety guides commonly used by the UK reservoir industry today. A national strategy for research and development can only be effective if it is informed by good quality information on the many safety issues that arise every year. The system can inform legislative change as well as research and has served to raise the awareness of incidents at small reservoirs. In time, it is anticipated that the system will inform quantitative risk assessments by providing information that can help determine the frequency of incidents. Mandatory incident reporting would be important in this respect to promote completeness of reporting.

CONCLUSION

2007 might be regarded as a pivotal year for reservoir incident reporting in the UK. It was the first year of operating the new post-incident reporting system. The summer floods resulted in a large number of incidents in England. The Ulley incident was a high profile event and the new system was in place to investigate the causes and to share points of learning. Many incidents were reported to the Environment Agency but there were also some that were not reported.

The aim of the post-incident reporting system is to improve reservoir safety by sharing lessons learned with the reservoir industry and informing research and development. The Environment Agency will publish annual reports and special bulletins on incidents that occur each year and

administer the continuing development of the national database. The value of these documents and the database to the UK reservoir industry will depend in part on the level of support provided by reservoir owners and panel engineers.

ACKNOWLEDGEMENTS

The authors wish to thank the Environment Agency for permission to publish this paper.

REFERENCES

Charles, J.A., 2005. *Use of incident reporting and data collection in enhancing reservoir safety*. Dams and Reservoirs Vol.13 No.2 November 2005.

Environment Agency, 2007. *Learning from Experience: Post-incident reporting for UK dams*.

Goff, C.A. and Warren, A.L. (2008) "The safety of small British reservoirs" in *Ensuring reservoir safety*, proceedings of conference of the British Dam Society, Warwick. Thomas Telford, London.

Halcrow Group Ltd, 2007. *Post-incident reporting system for UK dams – Final Report*.

Hope, I.M., 2007. *Reservoir Safety in England and Wales – A Time of Change*. Dams and Reservoirs Vol.17 No.1 April 2007.

ICOLD Bulletin 59, 1987. Dam Safety Guidelines, ICOLD.

ICE 1996. *Floods and Reservoir Safety*. Thomas Telford, London.

Institution of Civil Engineers, 1996, *Floods and Reservoir Safety*, 3rd edition, Thomas Telford.

Warren, A.L. and Hope, I.M., 2006. *A new incident reporting system for UK dams*. Proceedings of the 14th conference of the British Dam Society, Durham. Thomas Telford, London.

www.environment-agency.gov.uk/reservoirsafety

http://www.scoss.org.uk/

http://npdp.stanford.edu/index.html.