Small Raised Reservoirs – the need for regulation

June 2013

The British Dam Society, The Institution of Civil Engineers
1 – 7 Great George Street, London, SW1P 3AA
T: 020 7665 2234 / Email bds@ice.org.uk

Forward by Chairman of the British Dam Society (BDS)

The UK is witnessing a time of change for reservoir regulation with an inconsistent approach to the regulation of reservoirs emerging across the 4 countries.

The current Reservoirs Act 1975 applies to Great Britain only, this excludes Northern Ireland.

In Scotland a completely new Act is being introduced and similar legislation is planned for the first time in Northern Ireland.

Following a government enquiry led by Sir Michael Pitt, which appraised the effects of the devastating floods of 2007, the Flood and Water Management Act 2010 has been passed. This amends the existing Act in England and Wales. It proposes a risk based approach, together with a reduction for the threshold of reservoir capacity changing from 25,000m^3 to 10,000m^3 – these are known as 'small raised reservoirs' (SRRs) as opposed to "large raised reservoirs" (LRRs) that are currently regulated.

In Wales the devolved government has embraced the changes and plans are being developed to regulate the SRRs that pose a risk to life.

For England the government have taken an unusual step in stalling the introduction of these previously planned changes by asking for further evidence. The BDS has responded to this request and asked Dr Andy Hughes, AR Panel Engineer, to assemble evidence of incidents, accidents and the risks posed by these SRRs.

The following response has been passed to defra and the Environment Agency.

As Chairman of BDS, I remain concerned by the government's delay in introducing the planned changes to the Act in England and trust that this further evidence will provide the persuasive argument ministers are looking for.

Ian Hope BSc MA CEng FICE

BDS Chairman

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1. Introduction

Historically the legislation of Great Britain has been based on historic consequence. The failures of dams in 1925, which precipitated the legislation – the Reservoirs (Safety Provision) Act, 1930. One of the dams had a capacity of 5 million gallons and this was adopted at the time for the limit to include or not include a dam in the legislative framework.

The criteria were not changed when the Reservoirs Act 1975 was formulated. The criteria determines whether a dam is subject to the Act was merely 'metricised' and rounded up to 25000m^3. A 'large raised reservoir' (LRR) is one which retains 25000m^3 or more above the natural ground. The legislation does not consider the consequence of failure.

There have been no failures resulting in loss of life since 1925 but I would suggest the UK has been fortunate and lucky. There have been many failures of what can be called 'small raised reservoirs' (SRR) and many incidents. The EA have initiated a post incident reporting system, but not all incidents have been reported.

Flood events, particularly in 2007, showed that many SRR's were not being maintained properly, operated properly and exposed that the risks posed by SRR's were significant. This was recognised by Pitt (2008) who recommended a move to a risk based system and a move to include SRR's.

Pitt said "*SRR's are outside the scope of the legislation, regardless of the potential impact of any breach".*

With very little guidance and no regulatory framework applicable to SRR's few are maintained and operated to modern and acceptable standards. The ownership of many is in doubt or cannot be established and in some cases ownership resides in persons with no skills and often no money to maintain and operate their dams adequately.

Despite a clear recommendation from Pitt there seems to be a reluctance to recognise the risk that these SRR's pose. Many are situated above communities or are even attached to communities in terms of mill buildings; an industrial facility often related to the industrial revolution. Many have fallen into disrepair. The dams vary in size quite dramatically both in terms of embankment height and reservoir capacity.

A survey of incidents, accidents and failures was undertaken by contacting all Supervising Engineers and Inspecting Engineers. A relatively short period of time was given to return the questionnaire. **Forty nine separate Panel Engineers have reported serious incidents at SRR's.**

The questionnaire was kept quite simple to try to ensure a high percentage return and to try to ensure maximum 'coverage' of the country.

The number of questionnaires issued was	500
The number of questionnaires returned was	49
The number of incidents monitored was	53

2. Dams in the UK

The number of SRR's that exist is unknown. What is known is that there are many reservoirs which were built to support the industrial revolution in the UK.

These reservoirs are often arranged in deep, narrow and steep valleys to make use of the 'head' they can generate and are often in cascade.

With the demise of industry in the areas where many of these dams exist (Yorkshire, Lancashire, Wales etc) they have been left unattended, unmanaged, not maintained, not visited etc, etc.

The majority of dams built which are under the 25000m^3 threshold were probably built with no formal engineering design or supervision.

3. Results

From the cases reported the following information was gathered:-

- Maximum height 15 metres – this is about the average height of all dams in the UK
- Minimum height 1.2 metres
- Maximum capacity 24,300m^3
- Minimum capacity 1,400m^3

The maximum height of the dams cited was 26 metres and the minimum length was 220 metres.

A number of cases lack of maintenance has been cited as the cause of failure:-

- blocked overflow - on a number of cases
- collapse of outlet pipes
- internal erosion
- leakage along the outlet pipes
- foundation failure
- spillway break-up

If one looks at the information in Appendix A it is clear that we have been fortunate that many of the failures have occurred in a way which has resulted in a fairly slow breach.

Clearly there is an argument that would say the number of cases is a very small percentage of the number of SRR's that exist but the counter argument would be that like Aberfan which led to legislation for all mine waste tips.

In the history of reservoirs, Skelmorlie which was one of the dams which failed in 1925 and which led to the Reservoirs Act 1975, had a capacity of 23500m^3 – 5 persons lost their lives.

Bold Venture at Darwen had a capacity of 20000m^3. It failed in 1848 and 12 people lost their lives after a heavy rainstorm.

Clydach Vale, which is thought to have a capacity of 15000m^3, failed in 1910 and cost the lives of 5 people.

In one case an incident at a reservoir with a capacity of only 6000m^3 nearly led to a failure and loss of life.

As we seem to be entering a period of weather with heavy, locally intense storms, it is likely we will get more failures and incidents of this type.

We now have the legislation to apply a risk based approach. Reservoirs with a low consequence of failure will not be subject to legislation and so many of those who oppose the introduction of this legislation will not be affected by it. Only high consequence reservoirs, which, if considered as assets by their owners, would benefit from an external audit and review of condition and be subject to the Act.

BDS applauds and supports the reduction in the capacity of reservoirs subject to the Act and suggests that there is legislation available that will save lives. Failure to introduce this legislation supported by engineers and many owners is putting life and property at risk.

Appendix A
Case Histories

Small Raised Reservoirs - Dam Breach

No	Name of Reservoir	Location	Height of Dam (m)	Length of Dam (m)	Capacity (m3)	Date of Incident	Details / Consequence of Failure
1	Sherbrooke	Cannock, Staffs	3	150	15,000	Nov-12	Dam failed via a breach due to an overflow blockage arising from lack of maintenance. A wall of water flowed across an A road causing a local flood then surcharged a culvert below the west coast rail line and surcharged a stream at a large country house. Fortunately it was early in the morning and the surcharge was not at a height to flood property and it affected no workers in the country park.
2	Higgin Chamber	Sowerby Bridge	2	66	2,400	2008	Blockage in the outlet culvert caused internal flooding to 2 properties. *Consequence* : Internal flooding of up to 7 properties plus rural highway
3	Jowler Dam	Wainstalls, Halifax	5	28	6,000	2007	Lower dam breached. Only woodland downstream - no recorded property flooding or significant damage. *Consequence:* If the upper dam failed it would flood one large property between upper and lower. It would probably take out the lower dam which has been reinstated. There may be channel and infrastructure damage but no other property flooding envisaged.
4	Nutclough Dam	Hebden Bridge	unknown, steep hillside, dam almost 100% silted	26	unknown, currently less than 500 - no plan to remove silt	2012	Freak storm blocked sluice culvert and caused overtopping - flooded 2 properties, major road and large area of town centre. There is some indication that wormholes were caused in the upstream face - still to be studied in detail. *Consequence* : Negligible unless coincident with another freak storm.
5	Unknown	Dam Head Road, Sowerby Bridge	12	45	4,300	2007	Minor breach causing erosion to woodland path towards lower dam. *Consequence* : Inundation of lower dam and potential to flood 40-50 properties and several highways.
6	Washer Lane	Halifax	12	120	3,000	2009	Dam breached internally flooding a downstream property. *Consequence* : Dam has not been reinstated. Owner is seeking permission to build on the site.
7	Hollins Lane	Sowerby Bridge	8	71	1,500	2008	Outlet pipes collapsed causing minor flooding in highway. *Consequence* : Internal flooding of up to 12 properties plus a locally significant highway is likely.
8	Ramsden Clough	Sowerby Bridge	15	135	6,000	2009	Submission of details to discharge planning condition on development immediately below raised serious concerns about the dam's integrity. Initial FRA rejected. More appropriate one accepted. *Consequence* : Internal flooding would be caused to up to 22 properties plus significant infrastructure damage.
9	Marshall Hall Mills	Elland	1.2	70	2,000	unknown	Outlet pipes overwhelmed during significant rainfall event causing flooding to industrial units and highway. *Consequence* : More severe flooding to industrial units and highway.
10	Shut Mill Dam	Romsley, Worcester	6	51	6,000	1999 and 2008	Severe storm which resulted in damage to the embankment of the dam and to the cottage and nearly resulted in a fatality at the annex to Shut Mill Cottage and caused injury to another resident. *Consequence* : A small dam of just 6,000m^3 has the potential to cause loss of life, injury and damage.
11	Maich Fishery Dam	Scotland	9	35	24,300	2008	Serious erosion of downstream face of dam by overtopping during local heavy rainstorm. *Consequence* : Erosion and collapse of embankment dam.
12	Pennal	Machynlleth	tba	tba	tba	2012	Village downstream
13	Blakedown 1	Kidderminster	4	70	11,000	2007	
14	Blakedown 2	Kidderminster	5	90	12,000	2007	
15	Blakedown 3	Kidderminster	6	120	20,000	2007	
16	Soudley 1	Forest of Dean	2	120	5,000	2012	
17	Soudley 2	Forest of Dean	2	70	6,000	2012	
18	Soudley 3	Forest of Dean	3	60	5,000	2012	
19	Soudley 4	Forest of Dean	5	90	12,000	2012	
20	Eden Field	Manchester	6	70	12,000	1979	

No	Name of Reservoir	Location	Height of Dam (m)	Length of Dam (m)	Capacity (m3)	Date of Incident	Details / Consequence of Failure
21	Rydings Dam	Rochdale	15	75	12,000	2010	Plant hire yard to toe of embankment (approx 15 employees), housing estate built in valley below the dam.
22	Makins Lake 3	Bedworth, Warwickshire	5	200	12,000	2003	The water would have entered an adjacent fishing lake, probably overtopped the bank, entered the River Anker and been conducted away without adverse consequences.
23	Minster Pool	Lichfield	4	50	2,300	2010	Flooding of roads and cellars
24	Hafodty	Corris Uchaf, North Wales	7.5	40.6	4,000	2012	9 properties, (assuming 3 persons per property), 27 lives at risk, 1 B road.
25	Rural Mill Pond	Worcestershire	4	90	10,000	1972 - 2011	6 houses close to the watercourse immediately downstream of the dam would be at risk if the dam failed.
26	Industrial Reservoir	Manchester	6	150	20,000	1950 - 2012	Occupied industrial buildings immediately downstream would be at risk if the dam failed.
27	Avon Tyrrell Lake	Ringwood, Hants	5.5	124	14,000	2002	Reported as having a significant breach requiring urgent attention by the lake owner in Dec 2002. Water escaped into receiving watercourse and caused minor damage to gardens and land but no flooding occurred to dwelling houses of which there were only a few at immediate risk downstream. Subsequent to being included in an early non-statutory reservoirs survey by Halcrow in 2006 an IE was voluntarily appointed by the owners to investigate improving on residual repairs made after the 2002 breach. The owners, a charitable organisation, UK Youth, run the site as an outdoor activity centre in which the larger of two lakes is used for water sport training etc. The receiving watercourse is an ordinary watercourse regulated by Dorset County Council as the LLFA.
28	Wardour Castle	Tisbury, Wilts	8	220	15,800	2006	Found during a Halcrow/Environment Agency survey of non-statutory reservoirs in Wessex Area (South) and reported as having a significant leak requiring urgent attention by the contracted engineer working for Halcrow Ltd. Lord Talbot the then owner who had an angling club running the lake as tenants has since sold the reservoir on to the owner of Ark Farm immediately downstream and that owner has carried out repairs as recommended in the Halcrow/EA 2006 report. The receiving watercourse is an ordinary watercourse regulated by Wiltshire Council as the LLFA which feeds into the R Nadder at Tisbury a small town that benefits from a small FRS.
29	Camerton Lake	Radstock, Somerset	7-8	71	15,000	2011	Reported as having a significant leak requiring urgent attention by EA staff in June 2011, water escaped into receiving watercourse but no flooding has yet occurred to dwellings of which there are none at immediate risk downstream as a redundant railway embankment protects the valley below. Subsequent to the report an IE was voluntarily contacted by the owners to assess the structure and give guidance on remedial repairs. The progress of such work has not been ascertained. The dam impounds an ordinary watercourse regulated by the LLFA, Bath & North East Somerset Council.
30	Latchbrook FSR	Saltash, Cornwall	5-6	55	21,000	2012	A non-statutory flood storage area in Saltash, Cornwall reported as having a scour erosion problem within a gabion spillway managed as an EA asset on Devon & Cornwall Area. The receiving watercourse is an ordinary watercourse regulated by Devon County Council as the LLFA. The hamlet of Burraton Coombe lies downstream with a nearby STW.

No	Name of Reservoir	Location	Height of Dam (m)	Length of Dam (m)	Capacity (m3)	Date of Incident	Details / Consequence of Failure
31	Cotford St Luke	Taunton, Somerset	1.7	150	3,691	2012	Found during a Halcrow/Environment Agency survey of non-statutory reservoirs in Wessex Area (North) and reported as having a leak requiring urgent attention by the contracted engineer working for Halcrow Ltd. The receiving watercourse is an ordinary watercourse regulated by Somerset County Council as the LLFA. There is a housing downstream forming part of Cotford St Luke.
32	River Farm Agricultural Reservoir	Petworth, West Sussex	4.8	195	22,000	1999	Housing and schools immediately downstream. Offices and public house 300m downstream, A272 road bridge and 5 detached house beyond.
33	Cottage Pool	Brockton, Shropshire	5-8	150 - 200	15-20,000	2008	Inundation of school, 5-10 residential houses, rural business premise and infrastructure. Busy rural intersection washed out by preceding flood from watercourse.
34	Horndoyne	near Aberdeen	5		1,400	1990	The earth dam was breached during the night of 17 November 1990. Water had been seen to trickle along the side of the outlet pipe and this developed into a stream taking earth with it. Eventually a breach was formed and a wall of water, a metre or more deep, swept down the small valley. Four houses were flooded causing considerable damage to the buildings and their contents. A large residential caravan was swept over 100 m from its site, but there were no injuries to people
35	Bold Venture	Darwen	10		20,000	1848	The embankment dam was overtopped an breached during a heavy rainstorm and the released reservoir water caused 12 deaths in Darwen. An inquest was held on the Friday following the incident on the Wednesday. The jury returned a verdict of accidental death in all cases. The verdict of the jury at the inquest was that "*all the deaths inquired into occurred by an accidental cause* ".
36	Maich Water	near Lochwinnoch	9		24,300	2008	In the early hours of 1 August 2008, heavy rain fell in west central Scotland causing local flooding and severe damage to Maich dam by overtopping (Mann and Mackay, 2009). Flow had taken place over the entire length of the 35-m long dam and it is estimated that the peak reservoir level was possibly 350 mm above the crest. The overtopping eroded away a large part of the downstream fill, leaving a vertical face at the downstream edge of the central clay core, Figure 2.31. The edge of the downstream face eroded 150 mm over the next two days, leaving only one metre of crest between the vertical face and the water line. There was concern that complete failure of the dam would take place.

No	Name of Reservoir	Location	Height of Dam (m)	Length of Dam (m)	Capacity (m3)	Date of Incident	Details / Consequence of Failure
37	Cwm Ebol	North Wales	11		1,400	2012	Flooding occurred in the Pennal area over the two days before the incident. Local rainfall records indicate a storm return period of 100-200 years. On the morning of 10 June, the reservoir owner inspected the flood damage to his land and noticed that the reservoir was full and overspilling the crest. Damage had occurred to the downstream edge of the dam crest where an area of rockfill had been scoured by overtopping flows. The emergency services were called and approximately 200 people were evacuated from Pennal. A local contractor excavated an emergency relief spillway channel through the rockfill adjacent to the slate bedrock forming the right abutment. Investigations by a panel engineer on behalf of the Environment Agency identified a landslide scar on the valley side about 1 km upstream from the reservoir. A debris slide of mud and floodwater had passed down the valley, stripping topsoil from the valley sides to a height of seven metres and entering the reservoir area at high speed. It was speculated that the reservoir had not been full at the time the debris slide entered the reservoir as there was no woody debris found
38	Fish Pool Valley	Hereford	3-5	30-50	above 10,000	2012	Yarpole village approx 1km downstream
39	Titmus Lake	Crawley	7	90	20,000	2005	Piping failure alongside existing control structure resulted in a large sink hole appearing on the crest of the dam. *Consequence:* Housing & Primary School immediately (ranging less than 200 - 450m) down-stream. Note Apparently this lake had been subject to a number of similar but smaller incidents during the previous decade. During these incidents 'patch up' & temporary repair works were completed with little thought or understanding given to potential consequences should failure occur
40	Broadfield Lake	Crawley	7	75	22,000	2008	Large wet patch observed on face of dam. *Consequence:* Business Centre, Housing & Sports venue (stadium) immediately (ranging less than 80, 100 & 250m) down-stream. Note Apparently this lake had also subject to a number of leakage reports of wet patches from the public during the previous decade but it was only after vegetation clearance that the full extent of the potential problem was realised.
41	Maich	Lochwinnoch	9	35	24,300	2008	Severe: By-pass channel had failed previously. Overflow weir was partly blocked by screens. Overtopping of dam during flood washed away downstream shoulder, posing risk of imminent collapse. Emergency intervention required. *Consequence:* Risk to about 3 inhabited houses, 1 A-road, trunk gas and water mains, possibly 1 National Grid pylon
42	Polvinister	Oban (Argyll)	8	45	16,000	2010 - 2012	Lack of freeboard, and seepage and slip on downstream face. Precautionary lowering carried out. *Consequence:* Risk to 3 habitations, one secondary road and possibly services
43	Tobermory	Isle of Mull	6	70	10,000	2004 onwards	Leakage, and at least one occurrence of overtopping of dam. Unscheduled work called for and carried out. *Consequence:* Possible risk to campsite and damage to property in Tobermory.
44	Smallburn	Kilbirnie (North Ayrshire)	Not available	Not available	Not available (less than 25,000)	Not available	Not an incident as such. Reported by prospective purchaser as in state of neglect, evident as collapse of tower access bridge deck. Apparent neglect of valves that are likely seized. *Consequence:* Failure would pose risk to life and property in Kilbirnie - not assessed in detail

No	Name of Reservoir	Location	Height of Dam (m)	Length of Dam (m)	Capacity (m3)	Date of Incident	Details / Consequence of Failure
45	Knockamillie	Firth of Clyde coast	6	150	15,000	2008	the reservoir is located on a steep fjordic slope above the Firth of Clyde. Failure would affect housing immediately downstream.
46	Battery Pool	Greenfield, Holywell	7	60	13,000	2012	Ground collapsed about 5m from the downstream masonry wall - see photos attached. Cause is to be determined. Reservoir drawn down and still similar quantity of water flowing. *Consequence:* This is the top reservoir in a cascade of 6. Flour Mill, lower down comes under the RA and it's category is being reassessed A or B. At bottom of cascade are offices, a pub and housing. A few houses on the sides of the valley could be affected also
47	Little Eaton WTW Lagoons	Derby	3	100	,10,000	2000 incident 1 20011 incident 2	Release of lagoon contents onto field and public highway. *Consequence:* Overtopping of lagoon embankment immediately adjacent to mainline railway embankment.
48	Melbourne WTW Lagoons	Derbyshire	3	100	10,000	2012	Overtopping of embankment. Release of sludge into large raw water reservoir with potential for outage of treatment works and loss of public water supply.
49	Blackshaw Moor	Staffs	15	100	20,000	2012	Fish ponds built upstream without check or notification. Possibility that failure of ponds may result in overtopping of downstream impounding reservoirs. Downstream road bridge and cottage could be impacted.

Dr Andy Hughes
Atkins Ltd
Epsom Gateway
Ashley Avenue
Epsom
Surrey
KT18 5AL

Email: andy.hughes@atkinsglobal.com
Direct telephone: 01372 756287