The British Dam Society

Lessons Learnt from the First Inspections of Reservoirs (with capacities of 10,000m³ - 25,000m³) in Wales

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SYNOPSIS This paper outlines the process and challenges Dŵr Cymru Welsh Water (DCWW) has faced working with our regulator Natural Resources Wales (NRW) to carry out the first inspections of 52 reservoirs with capacities of between 10,000m³ and 25,000m³. These reservoirs included a small number of impounding and non-impounding assets but the majority are service reservoirs (SRVs) and raw water tanks (RWTs).

BACKGROUND

Following the change of registration threshold for reservoirs in Wales on 1st April 2016, we initially identified 39 reservoirs that fell between the old threshold of 25,000m³ and the new, lower threshold of 10,000m³. Those 39 were made up of 34 service reservoirs, four impounding reservoirs and one non-impounding reservoir. Prior to this threshold change, we had a total of six service reservoirs that came under the Reservoirs Act, 1975 (hereafter, 'the Act').

During initial discussions with NRW that took place in 2020, we set out our own ambition to have all assets with capacities between 10,000m³ and 25,000m³ formally inspected by 31st March 2025. During these discussions it was agreed that we should prioritise the first inspection of the 34 service reservoirs.

We subsequently received the regulatory position statement *'First Inspection of Reservoirs Prior to Designation under the Reservoirs Act 1975.'* (NRW, 2020) that set out:

> *"This Position Statement sets out how NRW will regulate the inspection of reservoirs under the Reservoirs Act 1975 during the period of risk designation 2020-2025. It allows undertakers of reservoirs to carry out reservoir inspections prior to a confirmed risk designation - before an inspection is legally required - and have that inspection carried forward and accepted as valid when the reservoir designated. It also clarifies the use of section 8 to secure a Final Certificate for a large raised reservoir and the timing of inspection under section 10."* (NRW, 2020).

This gave us a regulatory framework within which we needed to carry out the first inspections.

Managing Risks for Dams and Reservoirs

PROGRESS TO DATE

We have made good progress in our first inspection programme, with 28 of the original 34 service reservoirs having fully undergone first inspection under Section 8 of the Act and a further two service reservoirs having undergone partial inspection (where more than one compartment requires inspection, these are usually completed sequentially). Only four of the original 34 service reservoirs identified have not yet been inspected.

However, we have since identified a further 13 assets that meet the criteria for first inspection, making a total of 52 assets requiring first inspection. Of these additional 13 sites, seven have been fully inspected.

To ensure that dam safety is maintained, Welsh Water made the decision to appoint a Supervising Engineer to each site immediately after the change in threshold was announced in 2016, despite this not being a legal requirement whilst these reservoirs are awaiting designation. For small impounding assets that are <10,000m^3 and do not fall under the ambit of the Act in Wales or those designated as not high risk, we assign internal trainee Supervising Engineers to undertake examinations which are reviewed and approved by an internal Supervising Engineer.

CHALLENGES ENCOUNTERED

Although we have made good progress on carrying out first inspections, we have experienced several challenges that were unforeseen, underestimated or not fully understood. These are presented in no particular order:

1. Alignment with existing work.
2. Operational challenges in emptying service reservoirs.
3. Limited supply chain / availability of experts in service reservoirs.
4. The number of Measures in the Interest of Safety (MITIOS) arising from first inspections.
5. The availability and willingness of Panel Engineers to carry out first inspections on service reservoirs.
6. Inconsistency in reports and differing approaches to the issuing of certificates from Inspecting Engineers.

1. Alignment with Existing Work

The first inspection programme was an additional programme of work that sat alongside our existing regime of statutory inspections under Section 10 of the Act, as well as a significant capital investment programme. As is well documented, there is a very limited pool of All Reservoirs Panel Engineers (ARPEs) so this required careful thought and planning on how we would use these. By the end of Asset Management Plan period 7 (AMP7 - that is the31st March 2025) we will have carried out 43 inspections under Section 10 of the Act, in addition to delivering a £147m capital investment programme. Attempting to carry out 52 first inspections under Section 8 of the Act on top of this was ambitious.

2. Operational Challenges with Service Reservoirs

Service reservoirs which supply treated drinking water are subject to the Act in Wales if they are designed or capable of storing >10,000m^3 of water above the natural level of the land surrounding the reservoir. Service reservoirs are also subject to statutory regulation by the Drinking Water Inspectorate (DWI) to maintain hygiene standards.

Emptying of a service reservoir is also needed to enable cleaning and disinfection to take place to meet bacterial standards for drinking water. If not managed appropriately, these actions may interrupt water supply. A service reservoir needs to be emptied to enable a full and proper safety inspection. There may be multiple cells within a reservoir which can be drawn down independently of each other at different times, but the Inspecting Engineer must be satisfied about all cells to complete an inspection.

Service reservoirs are often inter-dependent with each other to allow continual network supply. The timing of drawdown must be achieved in a way which maintains continuity of supply. Removing a service reservoir from operation for inspection and cleaning activities reduces the resilience of the distribution system and continuity of drinking water supply. Additionally, if there are works ongoing at the Water Treatment Works (WTW) which supplies the service reservoir or water network system this can also add a significant constraint by further reducing the resilience or the ability of the system to recover.

In our experience, when tanks have been emptied for inspection, they have often been kept empty whilst water quality defects are repaired. This has had a knock-on effect of when the next cell / nearby service reservoir can be scheduled for drawdown and inspection . In some cases, service reservoirs have remained empty for up to two years for these reasons. This also raised the question of the maximum permitted period of time between the inspection of multiple cells at the same service reservoir.

3. Limited Supply Chain and Expertise

As an undertaker that only had six service reservoirs under the Act up until 1st April 2020, we had a small framework of contractors approved to work on service reservoirs. Many of these contractors were local companies, not geared up to work on a national programme. In addition to this, there was limited understanding of the requirements of the Reservoirs Act by some of our own colleagues in Production and Distribution. Whilst the business has worked hard over the past 8-10 years to raise the profile of reservoir safety through the promotion of sizeable capital projects on our portfolio of impounding reservoirs, there was little to no mention of service reservoirs and other assets (raw water tanks etc.). Although this has definitely improved throughout the delivery of our first inspection programme, there is further work to be done to educate colleagues about the need for external supervision when carrying out work on these assets.

4. MITIOS Arising from First Inspections

To date we have had 85 MITIOS from first inspections carried out under Section 8 of the Act and with limited resources this has placed significant pressure on a small team. The number of MITIOS on service reservoirs has exceeded the number of MITIOS on our portfolio of impounding reservoirs for significant periods of the last three years.

5. Availability and Willingness of Panel Engineers

With the well discussed small pool of ARPEs and members of the SR Panel (Peters et al, 2018) finding panel engineers willing to undertake inspections has at time been a challenge. We have encountered several occurrences with engineers where they have no availability to work on or inspect a service reservoir but when asked about working on an impounding reservoir (sometimes a few days later) they have availability. It is not clear whether this has been a coincidence on a number of occasions, due to a potentially greater financial reward for services on impounding reservoirs or having less of an interest in working on these structures.

6. Inconsistency and Differing Approaches to Issuing Certificates

This is the issue that has had the biggest impact on the delivery of the programme, and one that we did not anticipate. The NRW position statement states: "*All large raised reservoirs must be supplied with a Final Certificate, along with a Certificate of Efficient Execution of Works. For reservoirs already constructed but only registered since 2016, these certificates are provided by a Construction Engineer under section 8 of the Reservoirs Act 1975. For new reservoirs constructed since 2016, or those which are to be altered, section 6 applies"* (NRW, 2020*).* When we received the first reports under Section 8, it was immediately clear that each ARPE had a different approach to this issue. Some included the Final Certificate as an annex to the Section 8 report, whereas some were not willing to issue a Final Certificate until all MITIOS had been certified complete.

This became particularly problematic when we made the decision to appoint a singular Qualified Civil Engineer (QCE) to sign off all MITIOS arising from the first inspection programme. This decision was taken with the best of intentions, to ensure that there was one standard required for overflow assessments, drawdown assessments, condition surveys etc. This would give us one point of contact who would be familiar with our programme of works and the challenges facing us. Whilst this worked well in terms of securing 10(6) certificates, it presented new difficulties when it came to issuing a Final Certificates.

DESIGNATION AND INSPECTION OF OTHER SMALL RESERVOIRS

In addition to traditional service reservoirs that form a large part of this programme of first inspections, there are a number of other assets such as raw water tanks and settlement lagoons that are also included. Some of these were not part of our original programme because it was not immediately obvious that some of these assets - usually located at Water Treatment Works (WTW) or pumping stations - had the potential to hold large volumes above natural ground level and therefore met the criteria of the Act.

An example of this is the settlement lagoon at Bolton Hill WTW near Haverfordwest, where we were aware of the traditional service reservoir and the two on-site raw water tanks but had never considered the lagoon as having the potential to fall under the Act. Whilst on site carrying out the first inspection of one of the raw water tanks, the Inspecting Engineer identified the potential of the lagoon to require inspection. The lagoons consist of three parallel compartments, each around 90m long and 21m wide.

The available drawings show them as built by infilling a valley, with maximum height above the base of the valley of around 7m although the lagoon depth was only 2m. There is some uncertainty over whether what is shown as "original ground" at the downstream toe was an earlier infilling for the inlet main to the WTW. The lagoons allow the WTW to normally operate as a "dry site" with wash and supernatant water recycled back into the raw water supply. They

also provide a means of improving water quality, by passing site drainage from west to east, with the lagoons desilted by excavation every few years.

As the lagoons had not previously been identified as falling under the Act, it is fair to say that they had not been maintained to the same level as the rest of our portfolio. Amongst other things, the vegetation had been allowed to become extensive, the chamber covers were not visible, the washouts were no longer operational, and there was very little understanding of the flows between the three lagoons or the drawdown capacity.

FIRST INSPECTIONS OF ASSETS NO LONGER IN OPERATION

In the process of identifying assets that met the new, reduced threshold of 10,000m^3, a number of assets were recognised as non-operational. Having carried out a series of checks to ensure these assets did not form part of any drought plans or total loss contingency plans, it was decided that abandonment under the Act would be pursued. However, inspecting these assets under Section 8 before completing any required Measures in the Interest of Safety prior to going down the abandonment route did not make practical sense. This was raised during discussions with NRW and a different approach for these assets was agreed: these assets could be inspected under Section 14 of the Act and formally abandoned once all recommendations are completed and the Inspecting Engineer is satisfied that the measures have been efficiently executed.

Llwyn Du

One of the assets that met the above criteria was Llwyn Du service reservoir, located in Abergavenny in Monmouthshire. The service reservoir was taken permanently out of service in 2012 due to leakage and water quality issues. The first inspection of the asset was completed in January 2022, with an excerpt from the Inspection Report stating:

This is a report under Section 14 of the Reservoirs Act 1975 (1975 Act) as amended by the Flood and Water Management Act 2010 (FWMA), and includes the following items in Welsh Statutory Instrument 2016 No.80 (W.37)

- *items specified under Schedule 5, and*
- *a certificate, as prescribed under Schedule 4.*

This inspection was commissioned by the Undertaker, Dŵr Cymru Welsh Water (DCWW), as

- *Although the reservoir was taken out of service and emptied in 2012 due to leakage and water quality issues it was never formally abandoned under reservoir safety legislation.*
- *It was also overlooked in the transfer for regulation from the Environment Agency to NRW in 2016, so this inspection is the first recorded under the Reservoirs Act.*

There has been some debate over which sections of the Act apply, but it is understood that NRW and DCWW have agreed the following pragmatic approach:

a) This report and Inspection certificate under Section 14 to formally abandon the reservoir.

b) A certificate of efficient execution (CEE) of works as if under Section 8, with an annex describing the reservoir, following the principles of Section 7(6) (Appendix A to this report).

c) A Final certificate as if under Section 8 once any MIOS have been completed.

The reservoir is abandoned under Section 14 of the Reservoirs Act, rather than discontinued under Section 13, so the works needed are to secure that the reservoir is "incapable of filling accidentally", rather than "incapable of holding". This report is therefore structured as a Section 14 report, with the process shown in Flow Chart A.9 of the Guide to the Reservoir Act (ICE, 2014).

The capacity at Llwyn Du was assumed to be <25,000m^3 prior to inspection. However, a routine pre-inspection asset investigation was undertaken in order to inform the Inspecting Engineer of the asset's history. The search brought to the attention of the department a discrepancy between the registered capacity and actual escapable volume of the service reservoir that has been operationally isolated for over a decade. The Welsh Office register from 1984 lists the reservoir, as does the BRE dams database, but neither list a capacity so it was unclear if it was over 25,000m^3. When an archive investigation was conducted it was uncovered that the operational capacity and registered capacity was significantly lower than the capacity to the overflow and therefore the full escapable volume would have been sufficient to exceed the threshold under the Reservoir Act 1975 definition (escapable volume calculated at 31,819m^3). As a result, it was decided that an immediate Section 14 inspection should be undertaken.

This presented a number of challenges, not least balancing reservoir safety whilst delivering sensible solutions with options that satisfied the expectations of the ARPE and could be financially justified whilst still reducing risk to as low as reasonably practicable.

The argument can be made that the Abandonment of a Service Reservoir is a misleading notion, as conventional Abandonment would entail isolation on its inlet and outlet from its distribution system, while the structure remains intact. This would remove the potential for intentionally or accidentally filling the reservoir, but there still remains the potential to fill naturally via ingress. Nevertheless, Abandonment was pursued - Discontinuance options were considered too environmentally damaging, costly, and difficult to justify against the small likelihood of a catastrophic failure.

The solutions for Abandonment still present significant engineering challenges. Primarily, the remediation and replacement of a 65m washout and overflow pipe at depths of 7m across terrain that has a history of slippage. The settlement of the surrounding land is known to be the cause of the collapse of the original pipework.

There are few available alternatives and this work must be completed by November 2025, so we are expecting plenty of challenges ahead.

WORK ARISING FROM FIRST INSPECTIONS

We have noted a number of themes that have emerged from the 85 MITIOS that have arisen from first inspections to date, especially on service reservoirs. To give a flavour of these, twenty sites have required overflow capacity assessments, a dozen sites have required drawdown capacity assessments, ten sites have had MITIOS relating to drainage surveys, and half a dozen sites have required topographical surveys.

As with all inspections, there is also a degree of subjectivity from individual Inspecting Engineers. We have seen this more starkly on our first inspection programme, with significant differences on what constitutes a MITIOS on an SRV. Across a small handful of sites, we have received MITIOS for vegetation management plans, vegetation clearance and even bramble

clearance which, whilst all undoubtedly are best practice, can be argued are not critical to the integrity of the reservoir.

Throughout the programme of first inspections, our level of maturity and understanding has grown and this has given us the confidence to challenge the contents of Inspection Reports. In our experience, it is essential that this is done via constructive conversations with the Inspecting Engineer that can only take place once mutual trust has been established. Building good relationships with the small pool of Inspecting Engineers used on this programme has been key to its success.

Whilst most MITIOS timescales would be perfectly fine in isolation, it is important to consider each measure with a Wales-wide view and a consideration of what other assets are out of service, what other measures are deliverable during the same period, other operational challenges, and the availability of our small supply chain. Giving this context has helped us successfully challenge timescales – there are examples of us doubling and even trebling the amount of time given to deliver Measures in the Interest of Safety.

ON SITE EMERGENCY FLOOD PLANS

As none of the 52 assets that form our first inspection programme had ever previously been inspected under the Act, none of them had On Site Emergency Flood Plans (OSEFPs). Whilst this is a not a legal requirement in Wales in the same way it is in England, it is best practice that we adhere to as a responsible undertaker and is also commented upon by the Supervising Engineers in their Annual Statements.

Writing 52 OSEFPs alongside delivering the programme of first inspections and delivering the MITIOS work presented another significant challenge and placed further pressure on the limited resource we have within our team. To manage this, we successfully negotiated with NRW that we would have a satisfactory (as judged by the Supervising Engineer) OSEFP in place for each site within 12 months of receiving a final risk designation. This allowed us to spread the workload over the five years of the AMP and gave us manageable timescales to work within. Alongside this, we have also had success in moving the requirement for an OSEFP out of the MITIOS category and into Directions in Respect of Records Under Section 11 of the Act.

CASE STUDIES

A number of case studies have been included below to highlight some of the challenges we have encountered in the delivery of our first inspection programme.

Radyr Service Reservoir

Radyr Service Reservoir is located in Radyr, approximately 5.5km northwest of Cardiff. Built around 1970, it is a 4.7m deep service reservoir with an escapable volume of around 19,000m^3. The reservoir is retained by a reinforced concrete perimeter wall, with in situ concrete floor and roof. The first inspection under Section 8 (of compartment no.2) took place in June 2020, with the final compartment expected to be emptied and made available for inspection sometime later in 2020. However, compartment no.2 failed its flood test. Ingress was identified along the northwest joint between the roof and wall. In order to remediate this ingress, a 30m trench was excavated to expose the joint (Figure 1). This allowed the existing material to be removed, and a new bandage applied (Figure 2).

Upon the commencement of the internal inspection, it was already a known concern that compartment no.2 had failed the flood test procedure and that investigative trial holes were being dug. The overriding water quality concerns allowed for an extended investigation phase. Following the guidance from the Inspecting Engineer on likely MITIOS following the

internal inspection of compartment no.2, we were able to mobilise the survey team to develop a 3D model of the compartment to retrospectively create construction drawings – we had been unable to locate the original as-built drawings so this needed rectifying. We also used this opportunity to fully map the drainage on site. Water quality concerns dictated that compartment no.2 remained empty for almost 18 months. In the prolonged period between inspections, we were able to progress one potential MITIOS to the point of completion, and have 50% of the internal schematics completed. The subsequent schematics were completed between the completion of the inspection phase and the MITIOS delivery date. Compartment no.1 was inspected in December 2021.

Figure 1. Excavation of the roof / wall joint at Radyr SRV. (Courtesy of DCWW).

Figure 2. Repair of the roof / wall joint at Radyr SRV. (Courtesy of DCWW).

Sluvad No.2 Service Reservoir

Sluvad No.2 Service Reservoir is one of three service reservoirs on site at Sluvad Water Treatment Works, near Pontypool. The three reservoirs were constructed in stages between 1961 and 1992, and although there is no exact known date of construction of Sluvad No.2, it is believed to be around 1964. The reservoir comprises two equally sized compartments of approximately 6800m^3 with a reinforced concrete roof, columns and floor slabs and mass concrete gravity walls.

Prior to the first inspection in January 2022, compartment A failed a flood test along the dividing wall. Water quality concerns determined that the best course of action following the failed flood test and the area of the failure that the adjoining compartment should be isolated from the network and drained to eliminate potential water quality parameter failure.

Investigations determined the membrane installed in the mid 1990s was beyond repair and a membrane reinstallation was required. The excavation of the grass cover and membrane layers (Figure 3) permitted the Inspecting Engineer to undertake a thorough visual inspection of the roof during the subsequent inspection in February 2024, and to see firsthand the ingress repairs prior to the new membrane being installed (Figure 4). With over two years between the inspection of the two compartments, it was agreed that compartment A would be

reinspected at the time of the inspection of compartment B in February 2024. W hilst having such an extended period of time between inspections was not ideal, the Inspecting Engineer was kept up to date throughout and the repairs carried out between inspections meant the inspection report contained no MITIOS.

Figure 3. The exposed roof slab at Sluvad No.2. (Courtesy of DCWW).

Figure 4. The new roof membrane being installed at Sluvad No.2. (Courtesy of DCWW).

Tongwynlais No.2 SRV

Tongwynlais No.2 Service Reservoir is one of two reservoirs located on a hill approximately 7.5km northwest of Cardiff, constructed sometime between 1990 and 1993. Tongwynlais No.2 has a capacity of 21,000m^3 and is approximately 6m high. The structure appears to comprise a reinforced concrete base slab and roof with mass concrete outer walls.

Immediately following the High-Risk designation of Tongwynlais No.1 (the inspection of which was completed in February 2021) it was decided the next stage would be to undertake the inspection of Tongwynlais No.2. Compartment 2B was taken out of service and inspected in July 2021. The inspection coincided with temperatures in South Wales reaching 30°C and an unusually prolonged period of dry weather resulting in the declaration of a drought by the Welsh Government. This brought difficulties mobilising sufficient tankers to facilitate the flood test as the tanker fleet was mobilised supplementing the network, and when the flood test was completed, the tank was shown to be suffering with significant ingress. Standard Welsh Water flood test procedure dictates that the roof is visibly saturated, and that a minimum flood depth of 25mm should be achieved over the top of the roof. The depth of water is confirmed by strategically dug trial holes that consider historic ingress repairs and the fall of the roof. Due to the temperatures and limited tankers, it was recognised that sustaining a 25mm flood was not achievable, and it was agreed that the upstands, hatches and the roof joints would be targeted. The targeted flooding showed that a number of upstands were not watertight and significant ingress was recorded (Figure 5). The secondary access hatch required sealing at the joint of the upstand and the roof. The existing bandage was removed, a layer of Natcem 35 was applied between the upstand and the roof and following a curing time a MasterSeal bandage applied along the joint (Figure 6).

Following the repairs to the tank the compartment was to be brought back in to service in November 2021. To date the inspection is still in progress, and due to the period of time that has elapsed since the inspection of compartment 2B, this will be reinspected at the time compartment 2A is made available for inspection. An ongoing capital programme is improving resilience across the network to facilitate the recommencement of the inspection.

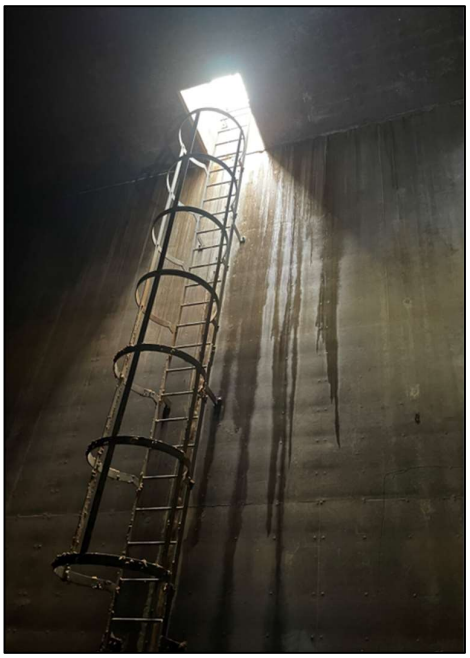

Figure 5. Roof ingress at Tongwynlais No.2. (Courtesy of DCWW).

Figure 6. Repairs around a roof hatch at Tongwynlais No.2. (Courtesy of DCWW).

Stumpy Service Reservoir

Stumpy Service Reservoir is a reinforced concrete reservoir with two compartments situated in the town of Barry in the Vale of Glamorgan. It was constructed in 1955 and has a capacity of 15,552m^3. In total, there are four compartments located within the boundary of the site, two of which are not connected and are regarded as redundant tanks.

At the commencement of our programme of first inspections, there was a known inability to remove Stumpy SRV from service whilst maintaining supply to the 15,000 properties directly fed by the reservoir. Bypassing the SRV increased the peak flow in the inlet main, as well as increasing the peak head loss and peak velocity which presented an unacceptable risk of discolouration in an area that had already experienced supply outages and water quality concerns. To facilitate the emptying of the service reservoir for cleaning and inspection, the inlet main required conditioning to deal with this higher flow, and new pressure relief valves were installed on the main.

The reservoir was subsequently made available for inspection in November 2022. However, the challenges did not end there. We have a MITIOS that is proving difficult to conclude to the satisfaction of the QCE. Initial investigations have proven that the overflow (Figure 7) has insufficient capacity. In addition, it has not been possible to conclusively demonstrate that the overflow discharges to the assumed discharge point (Figure 8). Attempts to prove the discharge location have been inconclusive due to the distance 500m distance through third-party land and the lack of inspection chambers along the assumed route. Conventional next

steps would be to empty the reservoir and undertake physical investigations from the point of overflow. However, this is considered as having high operational risk for the continuity of supply because the refilling of the reservoir during the winter of 2022 required supplementary tankers to maintain customer supply. As we approach the statutory due date of the MITIOS - which coincides with the high demand summer months - we find ourselves at an impasse. The alternative option of filling the tank to the point of overflow is considered a potential threat to water quality for the 15,000 properties and industrial customers.

Figure 7. The overflow at Stumpy SRV. (Courtesy of DCWW).

Figure 8. The assumed discharge point at Stumpy SRV. (Courtesy of DCWW).

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