Cite this article

Neeve D, Fletcher J, Williams R, Davies R and Fisher S (2018)
Wentwood tower and valve refurbishment.
Dams and Reservoirs **28**(3): 123–129,
<https://doi.org/10.1680/jdare.18.00034>

Research Article

Paper 1800034
Published online 09/07/2018

ICE Publishing: All rights reserved

Keywords: dams, barrages & reservoirs/
maintenance and inspection/pipes &
pipelines

ice publishing

Dams and Reservoirs

Wentwood tower and valve refurbishment

David Neeve BEng, CEng, MICE

Associate, Arup, Leeds, UK

Jeremy Fletcher MEng

Dam Engineer, Arup, Leeds, UK

Richard Williams MEng

Dam Safety Engineering Manager, DCWW, Newport, UK

Rachel Davies PGC, BEng

Dam Safety Capital Client Manager, DCWW, Newport, UK (corresponding author: david.neeve@arup.com)

Simon Fisher BSc

Project Manager, MorganSindall, Newport, UK

The valve and operating system had reached the end of its asset life and the tower was showing signs of structural distress. The wet tower arrangement required a full drawdown of the reservoir basin to allow surveys of the valve, pipework and tower condition. A pro-active silt management system was required to discharge into the downstream watercourse that flows into sinkholes. The paper covers the development of the scheme through to selection of the preferred solution.

1. Background

The reservoir on Llanvaches Brook was created in 1904 to provide drinking water for the town of Newport that is situated a few miles to the south (Figures 1 and 2). Prior to distribution by way of the clean water network a waterworks provided raw water treatment a short distance beyond the downstream toe of the dam. The waterworks was abandoned several decades ago but is still connected to the reservoir basin by way of draw-off valves at multiple levels within a nine-storey high circular masonry wet tower located in the reservoir. A separate scour inlet was provided upstream of the tower with valves and separate pipework running through the bottom of the tower (Figure 3).

The wet tower created a difficult operating environment and maintenance challenges for the hydraulically operated valve system installed in the early 1970s. In recent years, the system was reaching the end of its usable design life. Concern was raised that should all the valves become inoperable an emergency draw down by way of gravity would not be possible. The dam has a credible threat of internal erosion as sinkholes have been known to appear on the left abutment. In addition, the tower was showing signs of distress and structural cracking (Figures 4–6).

2. Investigations

The scour valve developed operational issues during a routine operation and prompted an internal inspection of the tower using a submersible remotely operated vehicle (ROV). This was inconclusive to the cause of the issues, so a detailed investigation was launched to determine the cause and scope of works.

Dwr Cymru/Welsh Water (DCWW) appointed MorganSindall & Arup as Alliance Partners to investigate and propose a viable solution. The aim of project was to refurbish the tower and replace the valves. However, the time and effort required

to undertake the investigations became substantial in their own right. As is often commonplace with assets of this age, records of the original construction and subsequent improvement works were incomplete and sometimes conflicting, which required substantial surveys to scope the design. To give an understanding of the access challenges, the design scope was finalised 15 months into project.

3. Draining the reservoir

The wet tower arrangement required the reservoir to be drained to allow surveys of the entire tower. Consideration was given to emptying the tower whilst the reservoir was full or partially full. However, the limited records, the unknown condition of the tower fabric and valves precluded a dry tower as the risk to an operative working in the base of the tower was too great. Further to the safety concerns, the risk of floatation through buoyancy of a dry tower that had been wet for possibly its entire life was considered unwise.

The draw down was complicated part way through, due to the lower draw off valves in the tower being closed. This required a safe system of work to be established to isolate the upper valves, in order to provide safe working access to the base of the tower and allow refurbishment of the hydraulic system to open the lowest valve. Parts of the uppermost draw off valve were removed and reconditioned, and then installed at the base of the tower on the butterfly valve. New hydraulic lines were installed separating the lowest valve from the malfunctioning system and this allowed the remaining water in the reservoir to be drained in a controlled manner.

The reservoir contained an active on-site fishing club who maintain the fringes of the reservoir to a good standard and a well-stocked reservoir. Five thousand fish were rescued and relocated over a number of weeks. The rescue could not be undertaken until the water level had been reduced and required substantial scaffolding for access staircases and a ‘fish elevator’

Figure 1. Historic drawing of the valve tower and access bridge

Figure 2. Site layout

Figure 3. Scour pipe inlet

Figure 4. Corbel damage

to transport the fish approximately 35 vertical metres out of the partially drained reservoir basin.

Approximately two-thirds of the reservoir volume was discharged with no risk of silt transportation into the downstream watercourse. However, the final $c. 500\,000\text{ m}^3$ required monitoring and treatment for suspended solids. The consenting authority placed a strict discharge turbidity limit, not dissimilar to a major wastewater treatment plant that has substantial settlement tanks, to achieve compliance. The project team achieved the consent and provided a safeguard by re-energising the former waterworks and utilising a tapping on the supply pipeline to install a turbidity monitor. The monitor was connected

Figure 5. Pipe encrustation within the tower

Figure 6. Tower crack

to a control panel that would close the incoming valve if the flow from the reservoir could not be successfully treated by the 24 h temporary silt management system, see Figure 7. The water treatment system comprised of three primary dosing

Figure 7. Temporary silt mitigation

Figure 8. Emptied reservoir basin

Figure 9. Settlement lagoons

tanks adding coagulant to flocculate the fine silt particles, the flow then passed through eight clarifying tanks with the overall system having a capacity of 10 Mlitre/d. Once the reservoir was emptied, a series of settlement lagoons were created within the basin to allow removal of the temporary silt management system and keep the reservoir empty (Figures 8 and 9).

The remote location and reservoir basin orientation limited plant access. Careful planning and communication with local

Figure 10. Sinkhole downstream of waterworks

Figure 11. Rope access structural survey

stakeholders was necessary by way of correspondence and meetings to allow stone deliveries along narrow lanes for access roads, the crane pad, the settlement lagoon and removal of fish.

4. Downstream sinkholes

Wentwood Reservoir is unusual as there is no downstream watercourse. The stream ‘disappears’ into several limestone sinkholes a few 100 m downstream of the dam (Figure 10). Only when the sinkholes become blocked by sedimentation or

Figure 12. Summary of tower and valve issues

in higher flow events does the watercourse downstream of the sinkholes operate. As such, the local village residents and farmers have become used to no flow within the watercourse. To minimise pass forward flows beyond the sinkholes they were cleaned to accept the full discharge capacity of the temporary silt mitigation system. A new grill was installed to improve safety.

The prestart ecological survey identified a badger sett near the sinkholes. To mitigate the period required to obtain a license, camera monitoring was installed and submitted with the application. Prior to cleaning, access improvements and vegetation clearance were required. This identified that one of the

sinkholes had increased and was dangerously close to undermining the public road. Works were undertaken with the agreement of the relevant authority to shore up the public highway.

5. Tower surveys

Once the reservoir was empty, the tower was internally cleaned and the investigation surveys could start. Internal and external point cloud surveys were used to generate a building information modelling three-dimensional (BIM 3D) model for wall thickness, beam and spindle clash detection and ensuring sufficient space for safe operation. The flexibility of the model allowed rapid accommodation of design suggestions and changes. The tower structural condition was surveyed

Figure 13. Proposed summary of tower and valve works

externally by way of rope access and internally along with pipework and access surveys (Figure 11).

6. Scour pipe

Locating the scour pipe inlet within the reservoir basin proved problematic and time consuming. It was deemed necessary to locate the pipe so that the original 120 year old abandoned guard valve could be removed during the refurbishment. Utilising the scour pipe is instrumental in contributing to the drawdown rate at the reservoir so it could not be abandoned. Several factors hindered locating the pipe including scattered ferrous debris from previous metalwork and pipework replacements, which had been discarded into the water during previous

schemes, an unknown bend approximately 10 m from the tower, the distance of the inlet from the tower and accumulation of approximately 2 m of silt over the pipe soffit. The final location, around 15 m from the tower and arrangement can be seen in Figure 12, which required the relocation of around 3000 t of silt.

7. Investigation summary

The extract from the BIM 3D model summarised the findings of the investigation phase.

8. Proposed works

The proposed works are summarised in Figure 13 – proposed summary of tower and valve works. They include total

platform removal, replacement platforms with new valves and rising spindles, an extension to the scour pipe along with structural repairs including a new roof.

Construction challenges will revolve around access. The tower is restricted to a single-entry point by way of a pedestrian footbridge and the existing multiple off-set landings create a complicated confined space rescue scenario, which requires a six-man mines rescue standby safety cover. Lifting items using a crane is restricted to less than 1.5 t due to the size of

crane that can physically access site and the lifting radius. Any lifts are further complicated by a 1 m diameter central opening down through the tower.

To facilitate the external repairs to the tower, corbels and to replace the roof, a 34 m high access scaffold will be required, that will take around a month to erect. Although the tower has multiple landings and therefore multiple potential workfaces, a linear programme is required due to safety, access and crane restrictions limiting activities within the tower to a single workface.

How can you contribute?

To discuss this paper, please email up to 500 words to the editor at editor@britishdams.org. Your contribution will be forwarded to the author(s) for a reply and, if considered appropriate by the editorial board, it will be published as discussion in a future issue of the journal.