

Pebley Reservoir

improvements to a 238 year old Derbyshire reservoir in the interest of safety, including an improved draw off system

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The Canal and River Trust (CRT) is the undertaker for 72 'large raised reservoirs' (as per the Reservoirs Act 1975 definition) in England. They have an average age of 195 years, ranging from Pebley Reservoir at 238 years old, to the 123 year old Winterburn Reservoir. Pebley Reservoir is situated between Sheffield and Worksop to the east of the M1 motorway in North Derbyshire. The reservoir was built in 1776 to supply water to the Chesterfield Canal via a feed into Harthill Reservoir. It is classified as a Category A (where a breach could endanger lives in a community) reservoir as defined in the 3rd edition of Floods and Reservoir Safety. The reservoir embankment dam reaches a maximum height of 8.5m and has an average crest width of 4m along its 160m length. The reservoir impounds 280,000m³ of water which was confirmed by a hydrographic survey in 2008. Water control is via a spillway channel at the eastern end of the dam and via a low level timber and stone box culvert from a Neptune Shaft near the centre of the dam, as indicated in Figure 1.

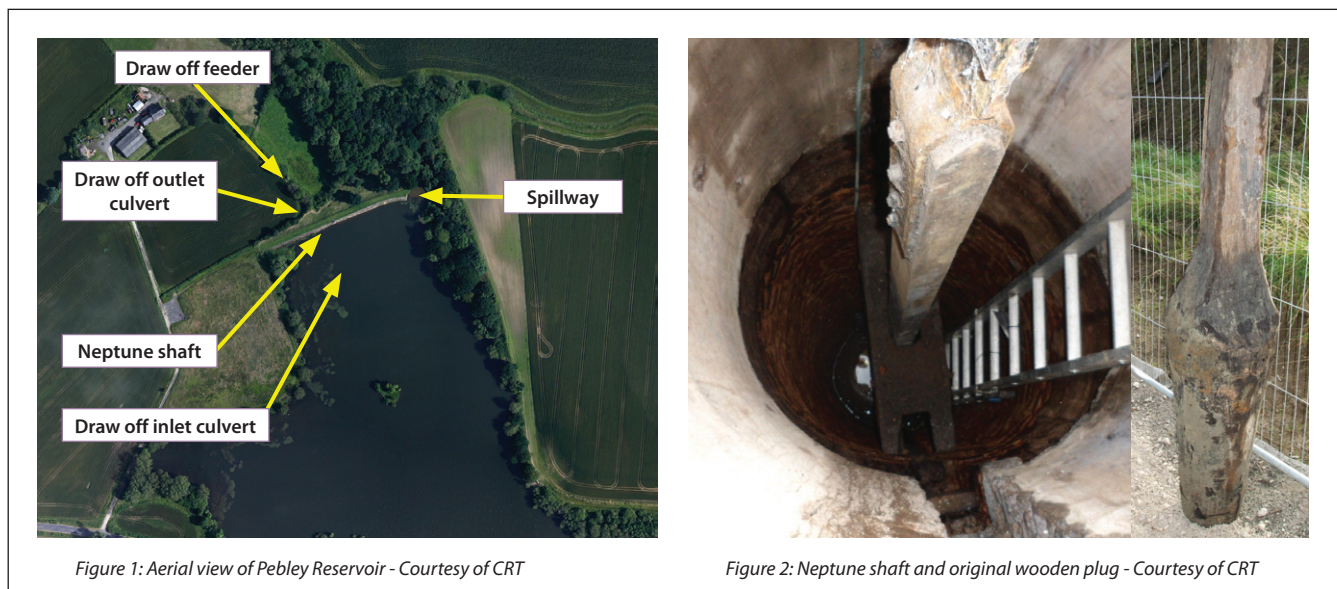


Figure 1: Aerial view of Pebley Reservoir - Courtesy of CRT



Figure 2: Neptune shaft and original wooden plug - Courtesy of CRT

Scheme drivers - Section 10 report

The Reservoirs Act 1975 requires an inspection of the reservoir every 10 years (a Section 10 inspection) and the 2010 inspection contained some recommendations in the interests of safety, the most pertinent being the requirement to repair or replace a timber and stone box culvert within 4 years.

Following the Section 10 inspection the Canal and River Trust framework consultant (Hyder) and contractor (Kier Services) were contracted under the NEC3 Engineering and Construction Contract to develop an appropriate design solution and subsequent implementation on site.

Existing draw off structures

The inlet structure of the outlet consists of a circular 840mm diameter brick barrel inlet culvert upstream of the 'Neptune' shaft with a submerged protective grille and approach channel inside the reservoir at low level.

The Neptune shaft is located within the crest of the embankment and consists of a 1.04m diameter round brickwork/masonry shaft, approximately 5m deep. Within the shaft, flow had been controlled historically with an oak plug valve with a worm and wheel gear, driving the rack and pinion gearing located in a kiosk at the top of the shaft.

Downstream of the Neptune shaft there is a timber and stone box draw off culvert (300mm x 460mm) that runs to the base of the downstream embankment and discharges via a brick headwall into a feeder channel.

Investigations

The reservoir had been drawn down in 2009 to repair the timber plug and mechanism associated with the Neptune shaft, and again in November 2011 when a CCTV survey of the outlet was undertaken. The condition of the culvert was significant as its primary importance, apart from acting as a feeder to the canal, was as an emergency drawdown facility.

Emergency drawdown plan

The reservoir has a specific On-Site Emergency Drawdown Plan (EDP) and within this there is a requirement to drawdown water levels by 50% within 5 days. The importance of this can be demonstrated by a full exercise of the on-site emergency drawdown plan, undertaken by CRT in 2011. Full details of the exercise are outlined within the British Dam Society (BDS) paper published in the proceedings of the 17th Conference of the BDS in 2012.

Design

In order to make safety and operational improvements to the draw off system the following works were outlined for completion:



Figure 3: Commencement of coffer dam construction at inlet channel
Courtesy of CRT



Figure 4: New inlet grille - Courtesy of CRT

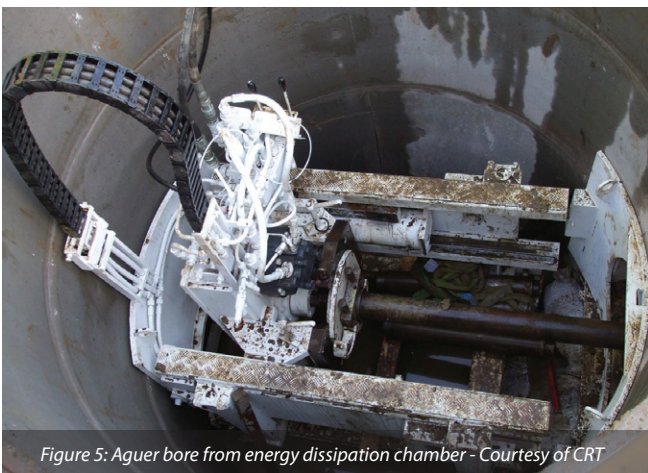


Figure 5: Auger bore from energy dissipation chamber - Courtesy of CRT



Figure 6: Outlet channel - Courtesy of CRT

- Installation of a new grille at the draw off inlet.
- Removal of the timber plug from the Neptune shaft, and subsequent replacement with a penstock operable from the dam crest.
- A new outlet pipe (from the Neptune shaft), installed using an auger.
- A new energy dissipation chamber.
- A new outlet headwall and channel.
- Clearance of the downstream channel.
- Grouting of the existing timber and stone culvert.
- A full topographical survey of the site to aid design of the above.

Access

Access to the site was from the adjacent main road with the contractors compound (40m x 40m) located alongside the reservoir. This served a dual purpose acting as both the temporary compound area, and subsequent use as a car park for the reservoir fishing club after completion of the works.

In order to access the main inlet and brick culvert the reservoir level was drawn down to 10%. If the reservoir had been drawn down lower than 10% aeration would have been required to ensure existing fish stocks were not affected, or a fish rescue undertaken.

The contractor entered the reservoir from the compound area via the reservoir bank (not part of the dam structure) and a coffer dam was installed around the existing headwall and brick culvert to allow inspection.

Inlet headwall and grille

The inlet culvert was inspected and a decision was made to provide a more robust solution by insertion of a 610mm ID pipe within the culvert and grouting of the annulus.

The existing grille was replaced with a new Fibre Reinforced Polymer (FRP) grille, installed at in front of the culvert, with doors to allow access for divers in the future. The grille bars had a clear opening of 75mm, designed to allow a maximum flow rate of 400l/s. FRP was used due to the benefits of being a lightweight and easy to install structure compared to conventional steel. The grille would be submerged, so UV degradation would be minimal.

Neptune shaft

The diameter of the Neptune shaft makes man entry to the shaft and culvert for any work, or future maintenance, very restricted. To reduce the frequency of maintenance visits, the existing timber system was replaced with a new wall mounted cast iron penstock with a clear opening of 300mm.

The penstock is located within, and just above, the floor slab of the Neptune shaft with a vertical rising spindle within the shaft (approximately 5m) and a bevel gearing system within the existing kiosk operated by a hand wheel.

Auger bore

An auger was proposed as the most effective way to install a new outlet pipe with minimal disruption to the embankment. The auger pipe consisted of 355mm diameter steel pipe sections, with a total length of 18m. A launch pit was required to accommodate the installation equipment. In order to minimise temporary works, the new energy dissipation chamber was designed to be used as the auger launch pit.

The auger level was set to minimise the potential for a clash with the existing timber and stone culvert, whilst maintaining a suitable invert level. The auger pipe was extended sufficiently into the Neptune shaft to allow installation of the new penstock, and a structural liner installed to give a continuous smooth lined pipe surface.

In order to connect with the Neptune Shaft the auger would have to go through the clay core within the embankment. The contractor monitored arisings from installation of the steel pipe to verify the presence and location of the core to improve existing records of the dam's construction.

Energy dissipation chamber (discharge chamber)

The discharge chamber was constructed of pre cast manhole rings, incorporating the inlet pipe (auger pipe) from the Neptune shaft, an energy dissipation wall (cross wall), and a larger discharge pipe at approximately 90° to the inlet pipe, at a lower level. The chamber was designed in accordance with the impact stilling basins methodology of the United States Bureau of Reclamation "Design of Small Dams".

The manhole chamber is relatively deep considering its location at the base of the embankment and care was therefore taken to provide sufficient support for all the temporary works.

Outlet channel

From the discharge chamber an outlet pipe transfers flow a short distance, including a change in the direction of flow, and discharges into a lined outlet channel. This arrangement accommodates the maximum discharge flow (400l/s) at a velocity of <1.5ms, to minimise erosion to the existing bank.

Grouting of existing timber and stone culvert draw-off

Historic records indicated that the existing box culvert was of timber and stone construction 0.3m by 0.46m, and approximately 18m long. Some voids had been identified along the line of the culvert. These voids and the body of the culvert were filled by pressure grouting with a non shrink grout. Regular holes were drilled from the surface into the culvert to allow grout to be pumped into the structure and voids, and to enable grout to be released to the surface to indicate each section was complete.

Conclusion

The reservoir was drawn down to 10% between June and September in 2012 and construction of the scheme commenced in earnest in September 2012. The scheme was completed at a capital cost of £350,000, for the elements outlined above, and commissioned in January 2013. The reservoir was subsequently refilled and is now fully operational.

The project has successfully replaced the existing timber plug and timber and stone culvert outlet structure, with a new inlet grille, penstock, 355mm diameter auger outlet pipe, energy dissipation chamber and outlet channel.

The design of the structural liner and installation of the draw-off pipe was undertaken to facilitate the Canal and River Trusts requirement for emergency draw down of the reservoir storage by 50% over 5 days. The maximum flow to be accommodated through the auger pipe/liner was therefore 400l/s.

The project has replaced the original deteriorating wooden components, allowing the reservoir to continue to operate successfully into its 3rd century of use.

Key participants

- **Client:** Canal & River Trust (CRT).
- **Contractor:** Kier Services Ltd.
- **Consultant:** Hyder Consulting (UK) Ltd.
- **Acknowledgements:** Paul Howlett (CRT Supervising Engineer).

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