Logue Brook Dam Outlet Works Upgrade
Sofia Vargas, Dams Engineer, GHD, Perth WA
Robert Wark, Technical Director Dams, GHD, Perth WA

Logue Brook Dam, 130 km south east of Perth, was completed in 1963 and comprises a 49 m high main embankment with a crest length of approximately 335 m and the reservoir impounds 24.59 GL of storage. The outlet works comprise an inlet tower, an outlet pipe (DN 1100 mm) and a valve house. Water from the dam is released through a clam shell valve and there is a sluice valve upstream of the clam shell which acts as a scour isolation valve.

Previously Logue Brook Dam supplied water into the Harvey irrigation system by releasing water down the river which was then drawn off downstream and pumped into the piped network. The scheme planning had identified that constructing a pipeline from the dam outlet to connect directly into the piped irrigation system would eliminate the need for pumping as the system could then be gravity fed directly from the dam.

The outlet works upgrade comprised the refurbishment of the Inlet Tower, refurbishment of the Valve House, installation of new valves, environmental release and magnetic flow meters, electrical, communications, SCADA, instrumentation and security upgrades.

This paper describes the diving inspection and above water inspections of the inlet tower, refurbishment of the existing installation, challenges of the design, adopted solutions, connection to the Harvey Water pipeline and construction issues. The project represents an interesting case history of improving dam safety standards to current ANCOLD guidelines to provide a modern and safe facility.

Keywords: Outlet works, diving, OH &S Issues, safety, deterioration

Introduction

The construction of Logue Brook Dam commenced in December 1961 and was completed in 1963. The dam provides water for irrigation to the Northern Section of Harvey Irrigation District near Cookernup and Yarloop in Western Australia. Logue Brook Dam consists of a main embankment and a saddle embankment. The main embankment is a 49 m high zoned earthfill embankment with a crest length of 335 m. The saddle embankment is a 9 m high earthenfill dam, with a crest length of 640 m. The original reservoir storage capacity was 24.59 GL at RL 235.47 m AHD (spillway crest level). In 2010 a section of the crest was removed from the spillway and the top water level (TWL) was lowered to RL 234.00 m AHD. The current storage capacity at this elevation is 21.7 GL. Logue Brook Dam has been assessed as a High A hazard dam in accordance with the ANCOLD Guidelines on Consequence Assessment (ANCOLD, 2000).

The spillway is a concrete lined open channel chute excavated into the previous valley channel on the right abutment. Entry to the chute is via a side channel spillway with an ogee shaped concrete crest which is 46 m long.

The outlet works consist of a 3.05 m internal diameter circular reinforced concrete inlet tower (wet well topped with 4.88 m diameter reinforced concrete hoist house); a single 1065 mm diameter outlet pipe for irrigation releases connects from the storage to the downstream valve house; and a concrete lined V-shaped offtake channel runs from the valve house to a point on the natural stream approximately 40 m downstream.

The inlet tower is founded on solid rock approximately 8 m below the level of the original ground surface and the tower rises a height of approximately 42 m to RL 236.99 m AHD at the floor level of the hoist house. The tower is fitted with a single intake at RL 202.31 m AHD close to the original stream bed level and is also equipped with a bulkhead gate, associated hoisting equipment and trash screens.

A safety review in 2001 identified a number of operational deficiencies and remedial works were recommended to upgrade the dam to comply with current ANCOLD guidelines and best practice for engineering of large dams. The bulkhead gate in the inlet tower was not capable of closure into flow and access to the inlet tower was difficult as there is no bridge providing access to the inlet tower. This would compromise any response to an emergency. Additionally in the event of failure of the clam shell valve, it would be difficult to close the sluice valve into the flow. No regular maintenance had been carried out since the original construction of the dam in 1963 due to access restrictions and this gave rise to concerns about the integrity of these works.

In 2009 Harvey Water commenced a project to connect Logue Brook Dam to the Harvey Water irrigation system. The project scope had two main components;

- Modification of the outlet works at Logue Brook Dam to provide a connection to the Harvey Water Pipeline
- Construction of the pipeline from the connection at Logue Brook Dam to the Harvey Water Piped Irrigation Network.

The outlet works project included all works required to connect the Harvey Water main to Logue Brook Dam together with flow monitoring, control and SCADA works. The outlet works project included the following phases

- A detailed inspection of the outlet works including diving and mechanical inspections of the inlet tower

ANCOLD Proceedings of Technical Groups 1
• Refurbishment of the inlet tower both above and below water
• Construction of irrigation diversion works to operate for the duration that the dam was offline
• Reconstruction of the downstream outlet works and connection to the piped irrigation system
• Design and construction of the local control system
• Design and implementation of remote operation of the outlet works

Under the original configuration the irrigation water was released from storage through the single DN1065 diameter outlet and regulated by a DN610 diameter clam shell regulating valve located in the valve house downstream of the embankment. A DN610 sluice valve was also fitted to the outlet on the upstream side of the regulating valve. The modified arrangement of the outlet works is presented on Figure 1.

The main function of the inlet tower is to operate the bulkhead gate to shut off the pipework upstream of the valves thereby allowing planned maintenance of these valves and pipework. However the bulkhead gate was only designed to be installed under no flow conditions.

**Key considerations for the inspections**

Access to the tower was only by means of a boat and then climbing up the tower through a hatch in the floor of the hoist house. As the old ladders on the side of the tower were severely corroded and were unserviceable, rope access was needed to gain safe access into the tower. A specialist contractor, Safety and Rescue Equipment (S&RE) had to arrange rope access up the tower to check the security of the equipment in the hoist house and install a temporary rope ladder so that the divers and the mechanical contractors could access the Inlet Tower platform.

**Diving inspection**

The diving inspection was performed to check the condition of the vent pipe, bypass valve, trash screen, sealing of the bulkhead gate and outlet pipe prior to undertaking the works downstream. The diving depth was about 30 m and the divers, Underwater Contracts, required a decompression chamber (Figure 2) to be available at the site.

**Figure 1: General arrangement of Valve House**

**Inspection of Inlet Tower**

The tower is not normally accessed due to the OH&S issues associated with gaining entry and as a result, the bulkhead gate in the tower has not been used for some time. To progress the valve project downstream, it was required to place the existing gate in position from the tower or to arrange for alternate means of closure.

During the 2010 upgrade works GHD organized a detailed inspection of the Inlet Tower including a mechanical and diving inspection. The purpose of the inspections was to assess the condition of components inside the tower to determine the required remedial works to assure a safe closure of the outlet pipe during the downstream refurbishment works.

**Figure 2: Decompression Chamber**

**Figure 3: Divers approaching Inlet Tower**

The Importance of Dams in Our Developing Economy
**Access to the inlet**

SR&E provided a boat and skipper for access to the tower (Figure 3) as well as rope access to the tower (Figure 4). An inspection was made at the top of the tower to ensure that the gate, winch and other plant in this location was secured before the divers entered the water inside the tower.

**Figure 4: Rope access to Inlet Tower**

**Safety issues**

The safety issues for the diving inspection inside the tower required detailed evaluation based on previous experience. Apart from the risks associated with rope access to the tower, a key requirement for the divers was that there was to be no flow through the outlet works when they entered the water.

The downstream guard valve (DN600 sluice valve) and the irrigation regulating valve (DN 600 clam shell valve) were completely closed during the diving inspection as shown in Figures 5 and 6.

**Figure 5: Guard valve (sluice valve) in closed position and tagged**

The divers accessed the Inlet Tower platform and checked that in addition to being supported by the winch rope, the bulkhead gate was safely supported on chocks (Figure 7).

**Planning the diving inspection**

When the diving inspections were being planned, Underwater Contracts considered whether access from inside or outside the tower would be preferable. If they worked from outside the tower they would have had to enter through the bottom intake, swim up inside the tower to undertake work within the tower and then exit from the bottom of the tower. This procedure restricts diving operations as it requires repetitive dives to maximum depth.

**Figure 6: Regulating valve in closed position**

**Figure 7: Bulkhead gate supported on blocks**

The alternate procedure of diving from within the tower required rope access to the top of the tower to get the divers into the tower and then to lower them down to the water and retrieve them afterwards. The existing hatch in the floor of the inlet tower would have to be enlarged for the divers to climb through with their diving helmets on. However, later this option was discarded as the restricted access available in an emergency would have meant that a diver rescue could not be achieved within the required time frame.

The selected approach was to conduct the diving operations from outside the tower, using additional standby divers in the water for the duration of the dive. This was confirmed with a trial dive when two divers were sent down to collect video footage of the dive path to ensure that there were no entanglements or other unforeseen risks.

**Summary of the diving inspection**
The condition of the ventilation pipe, bypass valve and the bulkhead gate face were evaluated. The original trash screen had been replaced by a stainless steel construction and was in good condition, although it did not fit correctly as it was sitting approximately 200 mm from the bottom. The screen is symmetrical on both sides and it appears the concrete guides are smaller towards the bottom of the structure causing the gate to jam before it hits the bottom. The concrete guides were in good condition with no signs of cracking.

The bypass valve was not in place and the pipe work had a blank flange fitted. The bolts on the flange were corroded away, however the flange looked to be intact and capable of accepting a new valve.

**Figure 8: Vent pipe and brackets from bulkhead gate floor**

The vent pipe had a large build-up of corrosion products. The divers removed some of this build up in sections and found that the vent pipe was full of holes. The divers could easily push a knife through the wall of the pipe, and were reluctant to disturb the vent pipe too much because there was a possibility of it collapsing. The vent pipe was corroded right into the point where it connects to the concrete outlet and as a result there was nothing left to attach a new pipe to from the outside. When viewed from inside the outlet pipe, the concrete around the vent hole appeared to be intact. The brackets above the water line and the pipework appeared to be in relatively good condition (Figure 8).

**Figure 9: Bulkhead gate seal**

The bulkhead gate seals against a flat concrete face with the outlet pipe in the middle. The gate slides down two concrete guides and has wheels that drop into four recesses on the sealing face. It was observed that the size of the wheels did not fit the recesses. The divers found that the concrete sealing face has exposed aggregate with a very rough finish with crevices that vary from 5 mm deep to 10 mm deep. The concrete structure was intact with no visible signs of cracking. The wooden bearer that the gate sits on at the base of the structure was intact.

**Mechanical inspection**

As part of construction works involving the downstream valve outlet house and pipework, the bulkhead gate was needed to isolate the dam outlet as the outlet pipework and guard valves are to be removed during the works, thus the gate will be the only point of isolation. The gate and its associated lifting equipment had not been operational for some time, and therefore an inspection of the equipment was undertaken to determine its condition, and to determine the scope of any repairs and modifications that may be required.

As a result of the inspection it was found that much of the equipment and pipework in the tower was unserviceable and had to be replaced or refurbished before the upgrade of the valve house could commence.

**Refurbishment of the inlet tower**

The works carried out in the Inlet Tower are described as follows:

- Provide safe access and a safe working environment in the gate house: The difference in height between the reservoir water level and the floor of the gate house was slightly over 6 m, although this was expected to increase as water was drawn from the reservoir. For the construction phase a rigid ladder fitted with a ladder safe system was suspended from the floor of the gate house. This was removed when construction was completed. The ladder safe components have to be tested every 12 months and although the ladder is to be retained in the Harvey Yard, the ladder safe system will have to be reinstalled by S&RE when the next entry is made to the tower. The ladder was attached to the wall of the gate tower with stainless steel fasteners so that it can be reinstalled at a later date. A permanent stainless steel rope will remain down the side of the tower for future specialist access;

- Refurbishment works on the winch: A new hydraulic powered winch was installed to replace the old winch (Figure 10). The old winch had been converted from a manual winch and did not have an effective load brake. The new winch has a capacity of 3.2 tons and can accommodate 66 m length of 14 mm diameter steel rope. However with a gate weight of 1.4 tons and a double rope drop the required drum capacity was approximately 70 m and allowing for additional rope as dead windings on the drum, a drum capacity
of about 75 m would have been required. The existing 10 mm steel rope was in good condition and would fit on the drum, so the existing steel rope was reused and successfully fitted on the drum. A new winch base was fabricated to suit the winch;

Figure 10: New hydraulic winch and rope

- Refurbishment work on the gate: In the normal storage position, the bulkhead gate is supported at the top of the tower on two steel blocks within the area of the gate frame. The gate had some superficial corrosion but was otherwise in good condition. After wire brushing, a wax based paint treatment was applied to the gate to provide some measure of corrosion protection. The bulkhead gate had previously been leaking when in use. On inspection the seal was found to be in satisfactory condition and did not require any treatment. The face against which the gate seals was grouted with an underwater grout. Several grouts were tested and the final selection was made on the basis of the divers being able to get a satisfactory finish. The hydraulic system for the winch was upgraded; handles for the hydraulic power pack, pressure gauges were installed and load indicator was added. The existing rope and fittings were in good condition. In future the key issues will be serviceability of the new winch and existing steel rope and the need to reapply the paint coating to the gate every five years;

Figure 11: Cross section of Inlet Tower

- Removal and replacement of vent pipe and bypass pipework, valves and fittings in the inlet tower as presented in Figure 11. The existing vent pipe was found to have effectively disintegrated. The remainder of the vent pipe and valve actuator spindle within the gate tower and pipe fittings were removed. The concrete surfaces where the vent/bypass pipework was to be fitted were grouted with an underwater grout. A new DN110 ABS vent pipe/bypass and pipe fittings were installed together with a new valve extension spindle which terminates on the hoist house floor (Figure 12).

Figure 12: Vent pipe and bypass valve actuator spindle

- The trash screen was in good condition, the side guides were trimmed to allow the screen to travel down to the base of the slot; and

- One of the remaining risks identified was the potential for an air bubble released from the outlet pipe during refilling operations to lift the column of water in the tower into the hoist house. Anyone working inside the hoist house would be in danger of being drowned if they were unable to escape through the small manhole and onto the ladder. An incident such as this which occurred at the nearby Waroona Dam inlet tower when an air bubble lifted the water in the tower, flooded the hoist house and seriously injured the four workers in the hoist house at the time (refer to Wark, ANCOLD 2011). Opening the double doors at the front of the hoist house would allow the water to drain out and alleviate this risk. These doors were seized shut on initial inspection. They were made serviceable and a safety barrier put in place (Figure 13). The doors are to be left open to allow any water that may enter the hoist house to drain out. Internal ladders that were previously used for access inside the tower have been decommissioned.
The problem appears to be caused by the gate sitting down on the bottom gate rest slightly clear of the face of the sealing surface, with the weight of the gate being taken directly by the bed log. When the water load is applied, the top of the gate tilts forward, but the bottom of the gate is jammed open. A proposed solution consists of fitting rubber bearing pads on the base of the gate. These can be no more than 20 mm thick and can be designed to displace in shear under the water load on the gate. The modification has been successfully trialled on another gate.

**Connection to the water pipeline**

The strategy for the valve house upgrade was to replace the original sluice valve (DN 610 mm) with a high performance DN 900 mm Butterfly Valve (BV) capable of closing into the flow in the event of a downstream pipeline failure. This is now the primary shutoff valve for emergency use and is capable of remote actuation. In the future most of the water released from the dam will flow down the Harvey Water Pipeline that connects Logue Brook Dam to the Harvey Piped Irrigation System.

The existing DN 610 mm clam shell has been retained for the occasional larger environmental releases and to scour the reservoir if the need arises. This valve has a DN 800 guard/service valve upstream. The normal riparian outlet is a DN 250 plug valve and meter, both capable of remote actuation. Access is provided to the meter for calibration checking purposes. The downstream valve works are shown in Figure 16, 17 and 18.
The Harvey Water offtake also has a DN 800 guard/service valve and is metered with a DN 600 magnetic flow meter located in a pit downstream in the car park. The pit was required as the Water Corporation is required to make regular inspections and tests of the meter for calibration to satisfy the quality standards of the metering.

**Construction Issues**

During the installation of the pipe work at the Valve House, there was be a period of about 6 weeks in which it was not possible to release water from the clam shell valve for irrigation purposes. Alternative arrangements had to be in place to meet the requirements for irrigation and for environmental flows for this period.

Initially three DN200 PN10 PE pipes were installed to act as a siphon as presented in Figure 20. Valves were installed at the end of the siphon pipe to control flow and environmental releases were then possible.

Some problems were experienced in maintaining the suction in the siphons and one additional back up siphon was constructed (Figure 21 and 22).

Leakage from the bulkhead gate had to be controlled so that welding of the pipework downstream could be completed. A temporary plug plate incorporating a DN 100 bypass pipe was manufactured and sealed into the pipework upstream of where the main flange welds were to be made.

**Conclusions**

Many factors need to be considered when an upgrade of an existing outlet structure is planned as an error in
identifying or evaluating potential hazards can have serious consequences. The detailed assessment of the condition of the components of the Inlet Tower was necessary to establish the remedial works to be undertaken. The refurbishment of the Inlet Tower provided a safe closure of the outlet pipe during the upgrade works downstream of Logue Brook Dam.

References


