INCIDENT AT YERING GORGE PUMPING STATION. HOW WHAT YOU DON'T KNOW CAN HURT YOU

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ABSTRACT

On the 12th of May, 2015, a sequence events began that, 10 days later, would culminate in a major hydraulic incident leaving the Yering Gorge pumping station critically damaged and exposing the operator on site to significant risk. This event would result in the station being out of operation for two months before partial pumping could be reinstated and a total of eight months before the station would again operate at its full capacity. The ultimate cost of this incident included approximately 10 Gigalitres of lost water harvest and a significant restoration operation costing over $1.2 million. This paper describes the events leading up to the incident, the investigation process and the key learnings identified.

1.0 INTRODUCTION

The Sugarloaf Reservoir is a 96 Gigalitre storage located 35 Km North East of Melbourne in Christmas Hills and supplies potable water to the Northern suburbs via the Winneke Water Treatment Plant. The Yering Gorge pumping station delivers water from the Maroondah Aqueduct and the Yarra River into the Sugarloaf Reservoir and is the primary source of inflow to Sugarloaf.

The total pump station capacity is approximately 1100 ML/day and comprises of 4 main pumps each with a capacity of 250ML/day and two additional supplementary pumps each with a capacity of 40 ML/day. The station is operated to harvest approximately 200 ML/day from the aqueduct together with the maximum available river flow excluding the minimum required environmental passing flow of 350 ML/day.

2.0 DISCUSSION

2.1 Pump Station Configuration

The Yering Gorge pump station can deliver water from either the Yarra River or the Maroondah aqueduct which is supplied from the Maroondah Reservoir in Healesville. The pump well is situated approximately three meters below the river bed and 55 meters below the Maroondah Aqueduct, with the station delivering water into Sugarloaf Reservoir which is approximately 120 meters above the pumping station. The aqueduct suction main is an 1100mm diameter pipeline which drops almost vertically from the aqueduct into the station below (see Figure 1). There is a manually operated diversion valve at the aqueduct, an actuated isolation valve on ground level 17 meters above the pump well, and an 1100mm actuated suction valve at each of the two aqueduct duty pumps.

The station draws water from the aqueduct suction main to supply critical station services such as motor cooling, bearing cooling and seal ring flushing systems. Whenever the aqueduct is taken out of service, the station services supply is re-valved to be supplied from the pump delivery main via a pressure reducing, service water control valve (see Figure 1).

2.2 Station Emergency Shutdown System.

In order to protect the station against critical flooding events, the control system includes a ***"Station Shutdown"*** function. When this occurs all pumps are stopped and the Station Isolation Valve, River Suction Gate and the Aqueduct Isolation Valve immediately close to protect the station from external sources of stored energy. Critical faults that initiate a station shutdown include:

- Delivery main reverse flow
- Pump well flooded alarm
- 110 Volt DC system failure
- Pressing the manual "Station Shutdown" E-stop button

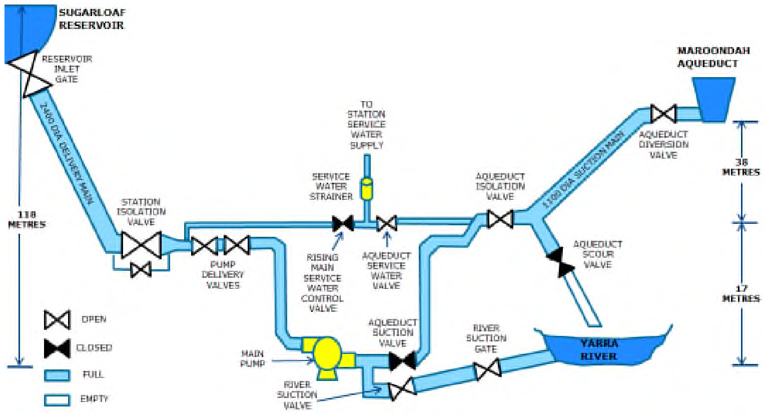


Figure 1: ***Pump Station normal configuration (River Duty)***

2.3 Event 1: May 12 -13

On May 12th the Maroondah aqueduct was dewatered to the Yarra River to enable structural repairs to take place upstream of the pump station. The aqueduct scour valve was opened to dewater the aqueduct and the suction main down to the same level as the aqueduct isolation valve. During this time the station was offline as the river flow was too low to allow pumping and the aqueduct supply was now unavailable. The following day river levels had risen sufficiently to allow river harvesting to resume. To facilitate this, the station services supply was transferred to the rising main and one of the main pumps was started on river duty.

2.4 Event 2: May 19

During the 6 days between May 13 to May 19 the remaining section of the aqueduct suction main gradually dewatered a further 17 meters to river level through, what was later discovered to be, a passing suction valve on one of the main pumps. With the aqueduct service water valve now closed, there was no means to ensure the suction main remained fully charged and there was no online pressure monitoring available to alert the operator that the main was now empty.

In the afternoon of May 19, operators shutdown the pump station as river flows had once again declined to below minimum environmental levels. During the pump stopping sequence a minor "*reverse flow*" was detected in the rising main. This alarm initiated a ***"Station Shutdown"*** sequence which automatically closed the Station Isolation Valve, River Suction Gate and Aqueduct Isolation Valve. The reverse flow alarm during a pump stop sequence was not uncommon and was known to occur periodically.

As the pumping station was no longer required to operate it was left offline in "Shutdown" mode with the major isolation valves remaining closed (see Figure 2).

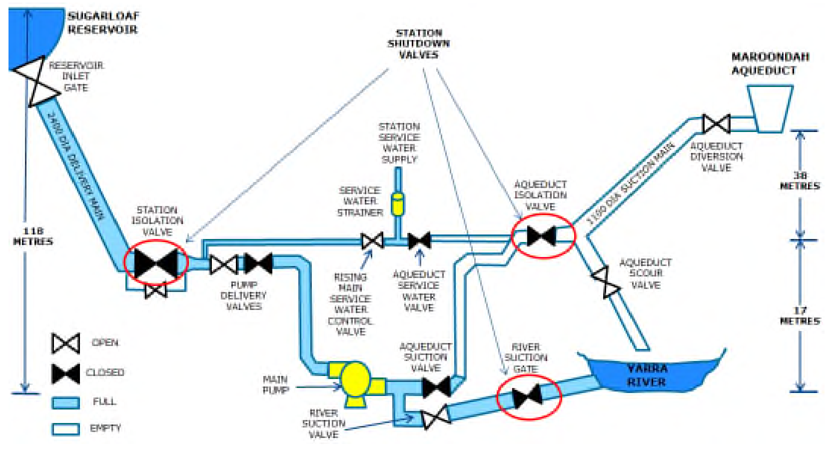


Figure 2: ***Station in "Emergency Shutdown" Mode with Aqueduct suction main dewatered***

2.5 Event 3: May 21

With the Aqueduct maintenance works now complete, the aqueduct is slowly recharged but only filled as far as the, now closed, aqueduct isolation valve leaving approximately 17 meters of empty 1100mm diameter suction main beneath it (see Figure 3).

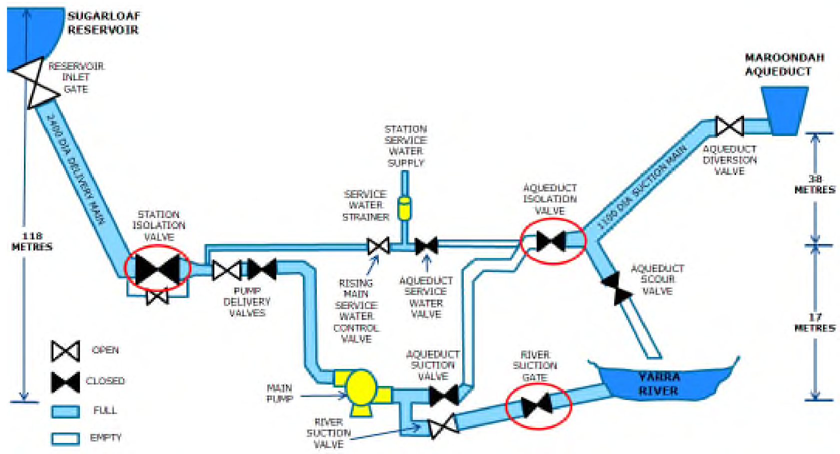
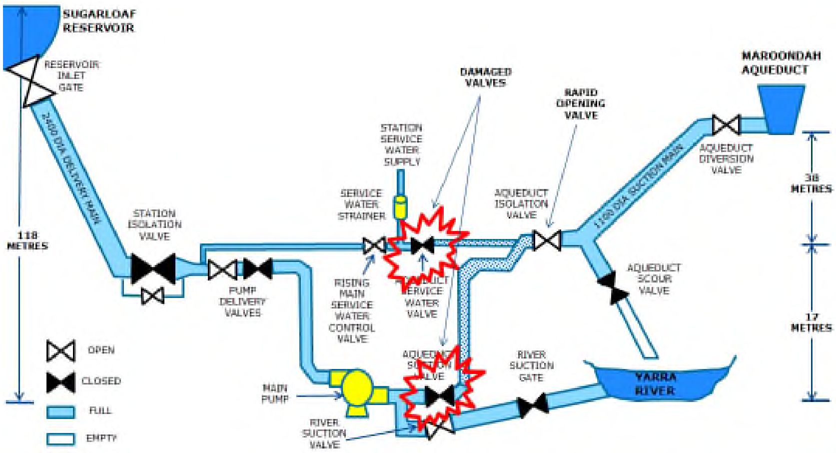


Figure 3: ***Aqueduct main recharged***

2.6 Event 4: May 22

The Operator attends site to prepare the station to resume pumping from the, now recharged, aqueduct supply. He initiates a ***"Station Reset"*** command. This control function returns the Aqueduct Isolation Valve to its pre-shutdown condition, immediately opening the valve. The opening travel time of the 1100mm diameter butterfly valve is less than three seconds and the rapid opening of this valve allowed the 40 tonnes of stored water above the valve to drop rapidly into the empty void below. The resulting pressure shock split the housing of the 250mm service water valve causing water to flood from the ground floor into the station below showering the high voltage pump drives with water and causing an electrical fault which turned off all the station lighting.

The shock also hits the two closed, 1100mm diameter, aqueduct pump suction valves tearing the butterfly's from their cast housings and punching a 300mm hole in the side of one of the valves (Figure 4 & 5). Water flowing from these valves knocked down a blockwork wall and flooded into the pump well at a much greater rate than the sump pumps could manage.



<u>Figure 4:</u> ***Location of damaged valves***

<u>Figure 5:</u> ***Damaged butterfly valves***

2.7 In the Line of Fire

The Operator Interface Unit used for station control is situated on "C" floor at the bottom of the pump well, one level above the main pumps. With water flooding over high voltage equipment from above, the pump well flooding from below and the station in total darkness, the operator was trapped in a precarious position. To add to the operator's predicament, an emergency escape ladder adjacent to the operator interface had been recently deemed non-compliant and was barricaded pending further investigation. This left the operator with no choice but to remain in this location (Figure 6) until help arrived to safely isolate the electrical supply.

2.8 Saved from Flooding

One of the alarm conditions that initiate the ***"Station Shutdown"*** sequence is a 110V DC supply failure. The water flooding in from the failed service water valve above faulted the 110V system initiating a Station Shutdown which closed the Aqueduct Isolation Valve preventing any further flooding. With the station power supply now faulted leaving the sump pumps no longer operational, the safety measure that initially led to this incident was the same measure that ultimately protected the station from being totally flooded.

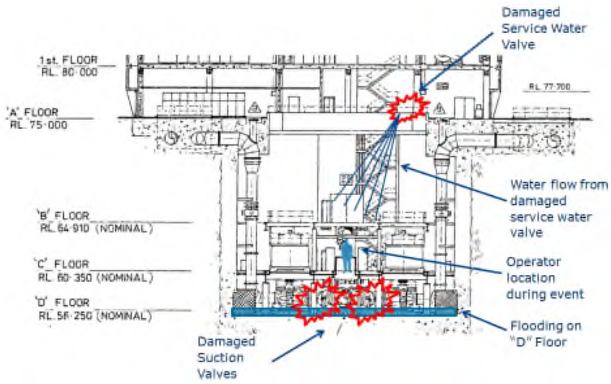


Figure 6: ***Operator location during the incident***

2.9 Recovery Works

With all personnel now safe and the station safely isolated, work began immediately to repair the station to an operational state. Transfer of water from the Maroondah Aqueduct was ceased and 10 Gigalitres of river water flowed past the station, unable to be pumped into Sugarloaf Reservoir. The Winneke Treatment Plant continued to supply water to Melbourne but, with no inflow, the level in Sugarloaf reservoir began to steadily decline.

A team of operations, asset management and project engineering representatives worked tirelessly together to implement the recovery project in as short a time as possible.

Orders were immediately placed for replacement valves. Meanwhile detailed isolation risk assessments and implementation plans were developed to allow the safe removal of the damaged valves and installation of blank flanges to enable the station to harvest from the Yarra River until the new valves arrived. A second shutdown was then conducted to remove the blank flanges and install the new valves returning the station to its full operating capacity. These restoration works were conducted over a period of eight months at a cost in excess of $1.2 million.

2.10 The Investigation

Following this incident a lengthy investigation was conducted using the “ICAM” investigation methodology. This investigation examined several key focus areas including:

- Organisational Factors
- Task / Environmental Factors
- Individual Actions
- Absent or Failed Defences

Whilst there were many key factors associated with this incident the root cause was ultimately determined as to be: ***“The hazard of the aqueduct suction pipe becoming dewatered was not identified in the design and subsequent operation of the pump station.”***

2.11 Key Learnings

This incident involved hazards affecting the asset/technical integrity of the facility. The installed engineering controls did not effectively mitigate the process safety risks to asset integrity, which had the potential to affect personal safety.

In the facts and documentation considered during the investigation there was no evidence that the hazard of dewatering the lower section of the aqueduct suction pipe had been identified in the pump station design. The hazard was not identified in the relevant manuals, training or procedures, nor had it been observed in the operating experience of the pump station, and no mitigation measures were installed or implemented at the pump station. (Gall 2015)

The key learnings from this investigation include the importance of:

- Risk assessment processes during the design stage (HAZOP, CHAZOP & Safety in Design) to identify this type of hazard;
- Understanding hydraulic gradients and potential stored energy in pipes and pump stations;
- Monitoring and managing the differential pressure across control or reducing valves when de-isolating, recharging or resetting plant;
- Understanding how the loss of the control of stored energy can create process safety hazards, arising from the failure of asset/technical integrity, which have the potential to affect personal safety;
- Selecting the correct engineering controls to prevent the plant from operating in an unsafe condition e.g. bypass valves, control interlocks and permissive alarms;
- Ensuring asset risk assessment processes include consideration of process safety risks in evaluating the effectiveness of engineering controls and safe guards;
- Ensuring that risk assessments of operational or asset changes include a holistic (whole-of-system) review of the potential impact of the relevant change, and ensuring that those risk assessments are appropriately documented;
- Proactively reviewing local operations that may expose people to "line of fire" hazards in the event of an asset/technical integrity failure, including evaluating egress from these locations in the event of an emergency; and
- Ensuring core risks are identified for each operational site, and effective controls are in place and appropriately documented in procedures. (Gall 2015)

3.0 CONCLUSION

This incident was significant in identifying the need for renewed focus on process safety at Melbourne Water's key high risk assets with potential to house large volumes of stored energy and high pressures. It also highlighted the potential for Operations and Maintenance staff to be in danger should a similar incident occur during routine plant operations. The ripple effect from this incident spread to all corners of Melbourne Water's Service Delivery arm, as teams from both the water and sewer sides of the business took a fresh look at process safety at their keys assets and asked themselves the question, ***"Could something we don't know be waiting to harm us on our site?"***

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

Gall P, *Yering Gorge Asset Failure, ICAM Investigation Report*, (June 2015)