Improving Hydraulic Performance of a 15km Recycled Water Rising Main using Ice Pigging Technology

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Abstract

A 15km recycled water rising main transferring recycled water from The Brinkley Wastewater Treatment Plant (WWTP) to lagoons where it is used for agriculture and irrigation experienced reduced hydraulic performance due to internal fouling from sludge and polymer accumulation. The 15 km recycled water rising main—comprising DN250 to DN400 pipelines of varying materials, including critical crossings beneath the Princes Highway and the Murray River—operated at a reduced flow, limiting the WWTP's ability to transfer treated effluent to storage lagoons, resulting in operational inefficiencies and local discharge.

Ice Pigging technology was selected as a low-risk, non-invasive remediation technique to restore hydraulic capacity. The rising main was divided into 13 sections and cleaning was undertaken over a three-week period using 10,000L of ice slurry per day. Ice was inserted and discharged via existing air and scour valves, with no excavations required. All the ice and materials removed from the pipe were captured and removed via waste tankers.

Post-cleaning SCADA data confirmed progressive and sustained improvements in hydraulic performance each day. Overall flow increased from 26.0 L/s to 34.6 L/s (33% increase), while pump discharge pressure reduced by approximately 35 kPa (from 775 kPa to 740 kPa), indicating a significant reduction in head loss. After a subsequent UV clean at the WWTP, the rising main was restored to its full design capacity of 35 L/s.

Introduction

The 4.5 ML/d Brinkley WWTP in Murray Bridge was commissioned in late 2019, and is a state-of-the-art facility that recycles 100% of its treated wastewater for productive reuse. It is the first plant in the world to integrate and use a Meteor[T] Moving Bed Biofilm Reactor and the Densadeg® compact high-rate lamella clarification system, both SUEZ technologies. This innovative combination was formally recognised by Infrastructure Sustainability Council of Australia awarding the WWTP an 'excellent' design rating - the highest sustainability rating awarded to date for an Australian water or wastewater project, and demonstrates SA Water and SUEZ's commitment to delivering infrastructure that not only meets operational requirements but also sets new benchmarks for environmental sustainability and operational efficiency.

Recycled water from the WWTP is distributed for agricultural and irrigation purposes, involving transfer through a 15km rising main to the customer lagoons where it is stored and used. The rising main consists of 7km of new DN250 PVC-O pressure main, and the rest of older DN300 pressure main (majority uPVC but also DICL and GRP). It also includes a new section of DN400 HDPE section under Princes Hwy (the main highway between Adelaide and the East Coast), and an older section of DN400 HDPE travelling under the Murray River.

However, the rising main was partially constricted with sludge and polymer that reduced the hydraulic performance of the pipeline, reducing flow to 26L/s, down from the design capacity of 35L/s. This resulted in the WWTP producing water quicker than it could discharge it to the lagoons, resulting in some recycled water having to be discharged near to the WWTP.

A smaller 500m section of pipe had been jetted, resulting in small flow increases, however Ice Pigging technology was chosen as the preferred method due to its non-invasive nature (utilising existing pipe fittings to insert and discharge the ice), speed, effectiveness, and low risk application.

The Ice Pigging Technology

Ice Pigging technology is an innovative, non-invasive, and water-efficient method of cleaning pressurized pipelines using an ice slurry, a semi-solid, two-phase material. The ice behaves like a liquid whilst being pumped into the pipe and flowing through the pipe (navigating bends and changes in diameter), however with the abrasiveness of a solid, collecting loose materials and biofilms from within the pipe.

FIGURE 1: THE ICE SLURRY

It has been delivered by SUEZ across Australia since 2013, primarily used by Utilities to improve drinking water quality. However, the Ice Pigging process is also an extremely effective and low risk way of cleaning rising mains, with approx. 50% of water industry Ice Pigging in the UK, where the technique originated, now used this way.

Ice Pigging technology can significantly improve hydraulic performance of rising mains, with typical flow improvements often between 20-50%, with the greatest flow improvement seen in Australia of 157% (3.5L/s to 9L/s). The subsequent benefits include reduced electricity costs and pump runtime, reduced pressure in the mains and reduced environmental spills from wet wells during wet weather events.

Ice Pigging technology is a genuine no-dig technique, utilising existing pipe fittings such as air valves or scour valves. It also has minimal impact on the network, with rising mains only out of service briefly, and is extremely low risk, with the ice melting if it were to ever become stuck. This is very useful for mains travelling under water bodies or critical infrastructure such as highways and trainlines and pipelines with changing inside diameters

Methodology

The rising main was broken down into 13 sections. Three sections were Ice Pigged twice; one section where the pipe was believed to the be most blocked, and two due to access issues and length, including the pipeline section crossing underneath the Murray River. Each section was cleaned using 10,000L of ice over a 3 week period.

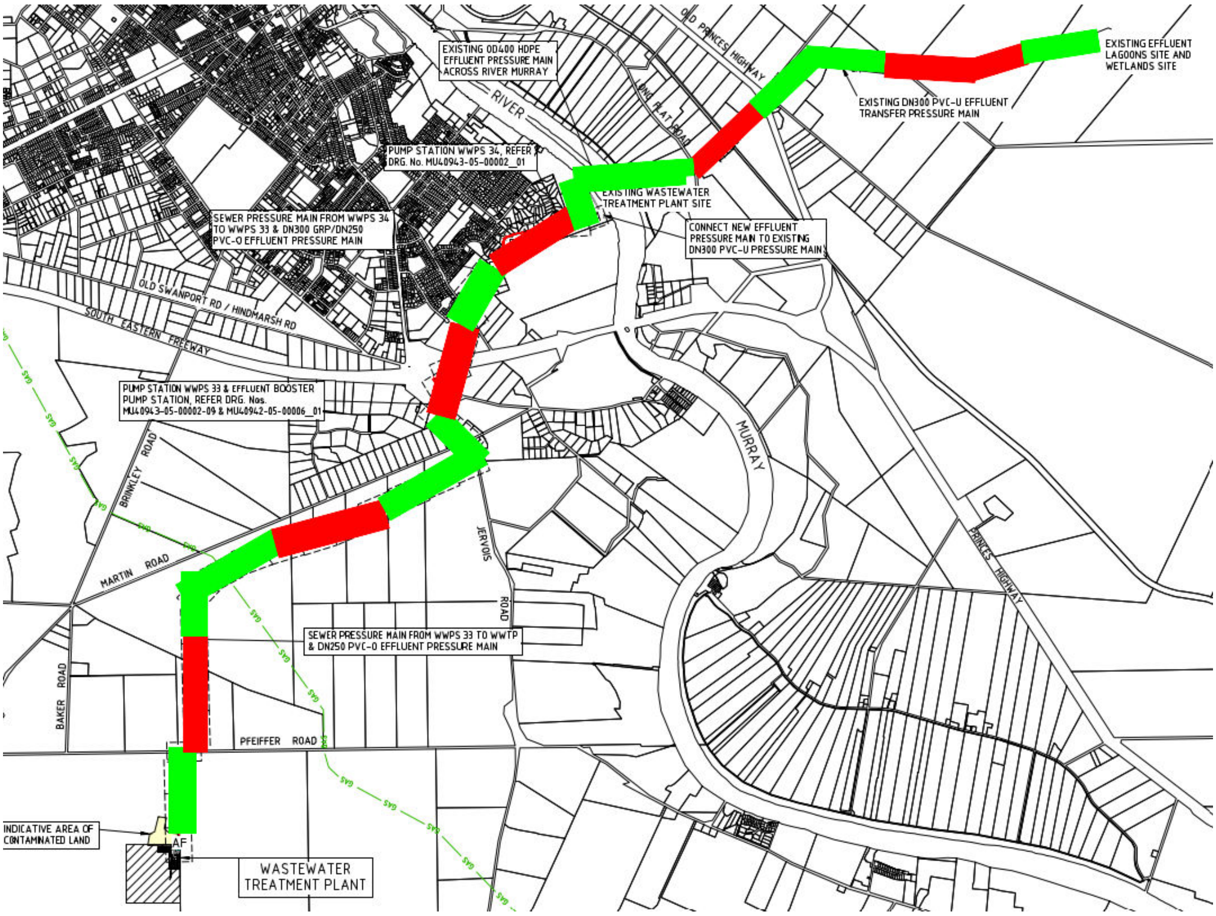

FIGURE 2: THE RISING MAIN BROKEN INTO SECTIONS TO ICE PIG

Existing Air Valves and Scour Valves were used for ice insertion and discharge with no excavations required.

FIGURE 3: INSERTION OF ICE INTO THE MAIN

The entire process is described below and the Figure 4 shows a representation on Day 3. The red line showing the flowrate at the WWTP and the yellow line showing the flowrate into the lagoons.

1. Recycled water pumps isolated at the WWTP
2. 10,000L of ice then injected into the insertion fitting (adapted air valve)
3. Recycled water pumps turned back on, with pipeline in normal operation discharging into the lagoons
4. A small amount of recycled water was allowed out from discharge fitting (< 0.5L/s) and collected in a waste tanker. To monitor and indicate when the ice was near, by a reduction in temperature and increase in turbidity.
5. When ice was imminent the recycled water pumps were reduced to 10L/s, the discharge fitting opened to collect the ice into the waste tanker, and a downstream valve on the pipeline closed to ensure all of the ice was collected into the tanker. The pumps were then increased to 18L/s. Once all of the ice was collected the downstream valve was opened again and the pipeline returned to normal operation.
6. The entire operation took less than 2 hours, with less than 30 minutes where the recycled water pumps were not transferring recycled water through the rising main

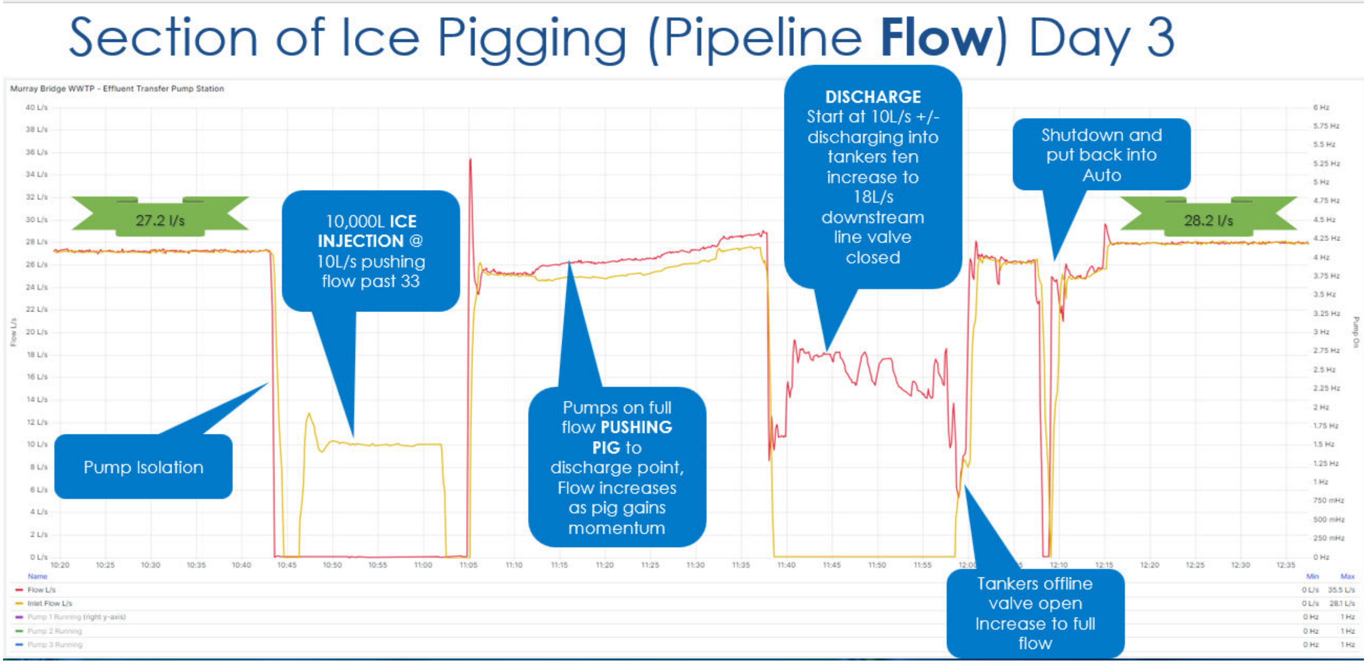

FIGURE 4: SCADA DEMONSTRATING THE ICE PIGGING DAILY OPERATION

FIGURE 5: DISCHARGE AND COLLECTION OF THE DIRTY ICE

All of the ice was collected each day into a waste tanker for safe disposal, preventing any sludge or salt from entering the lagoons.

Results

An increase in flowrate was observed after each Ice Pigging operation, as clearly demonstrated by the SCADA in Figure 6. Each dip indicates an Ice Pigging operation as the pumps were temporarily stopped for ice insertion. Hydraulic head loss was also reduced through the pipe. With the recycled water pumps (at the WWTP) running at 35kPa lower pressure (reduced from 775kPa to 740kPa), whilst the flow rate increased from 26.0L/s to 34.6L/s (33% increase). After a UV clean, **the flow rate was back up to 35L/s, and returned the rising main to its design capacity.**

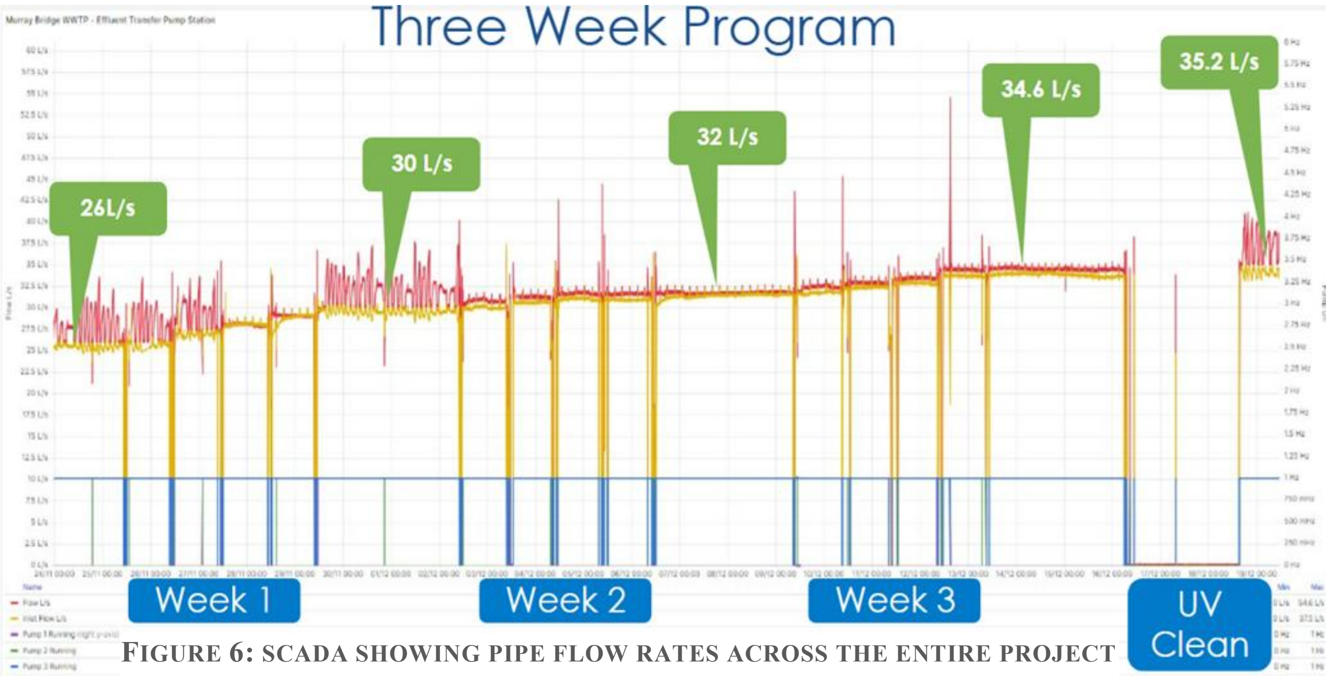

FIGURE 6: SCADA SHOWING PIPE FLOW RATES ACROSS THE ENTIRE PROJECT

Hydraulic head loss is shown in the SCADA in Figure 7. The red line shows the pressure at the pumps at the WWTP, the green line shows the pressure at Sewer Pump Station (SPS) 33 (Note: no pumps are currently operating at this SPS) which is a third of the way along the pipe. The first 4 days of cleaning between the WWTP and SPS 33, show a reduction in pressure at the pumps, and increase at SPS 33, this indicates this section of the pipe was most constricted and demostrates a significant reduction the headloss. This is also equates to the biggest increase in flow observed after cleaning this section.

After day 4, sections downstream of SPS 33 were cleaned, from this point we observe a reduction in pressure at both the pumps at the WWTP and SPS 33, which demonstrates a reduction headloss in these sections downstream of SPS 33 (to the outlet of the pipe).

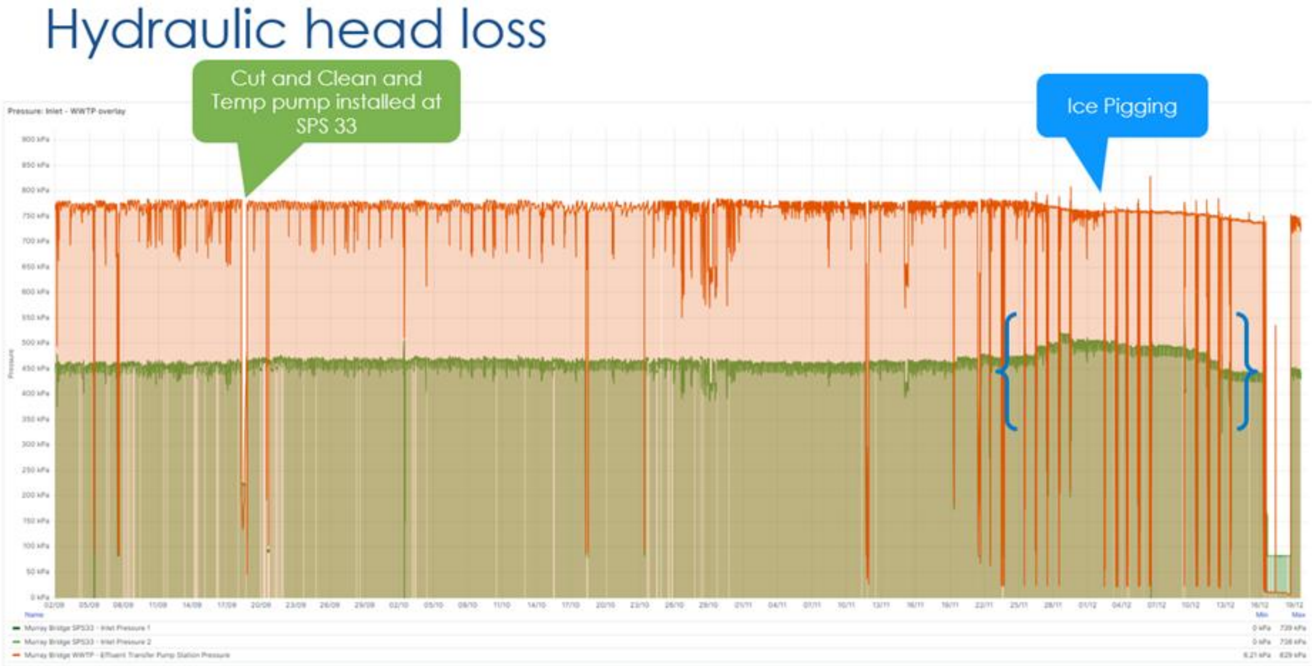

FIGURE 7: SCADA SHOWING PIPE PRESSURES

Pump calculations estimate an increased consumption of 21% more electricity (per m3 of recycled water) prior to cleaning. Over a year of delivering 3MLD this reduces electricity consumption by approximately 46,000kWh, with an annual cost saving in the region of $10,000 (based on an average electricity rate of $0.21/kWh).