PROJECT OVERVIEW: WAGGA WAGGA WTP SLUDGE TANK MIXER UPGRADE

Renier van Zyl, *Operations Engineer,* Riverina Water County Council

ABSTRACT

Riverina Water's Wagga Wagga Water Treatment Plant thickens and dewaters sedimentation sludge on site. The thickened sludge holding tank was built in 2003 as a balance tank and repurposed when the new plant was commissioned in 2021. Sixteen metres across, with negligible floor gradient and a single wall-mounted submersible mixer, the tank could not keep solids fluidised. Material accumulated in a mound at the centre or packed against the wall depending on how the mixer was aimed. Feed concentration to the centrifuges varied, usable storage fell through the year, and the tank required annual cleaning involving confined space entry, work at height and crane operations.

Preliminary sizing indicated that a single central agitator would require between 150 and 300 kW, against 60 kW available at the site. Dividing the duty between four smaller agitators brought the requirement within that limit. Four top-entry agitators with twin hydrofoil impellers were installed on a purpose-built cruciform bridge, surveyed, modelled, designed and fabricated in house and installed in a single lift.

This paper describes the project from problem definition through to installation, and the verification still to be completed. It highlights the risk of repurposing an asset without reassessing its duty, and the value of retained internal capability.

1.0 INTRODUCTION

Riverina Water County Council (Riverina Water) is a New South Wales local water utility supplying drinking water to approximately 77,000 people across multiple local government areas through some 33,000 connections. It employs approximately 150 staff and delivers most of its operations, maintenance and minor capital works using internal resources. That operating model shaped how this project was conceived, resourced and delivered.

The Wagga Wagga Water Treatment Plant, commissioned in 2021, treats Murrumbidgee River water at up to 55 ML/d. Sludge from the sedimentation process is thickened, held in a 1 ML tank, and dewatered on site by centrifuge. Dewatering performance depends on the sludge arriving at a consistent concentration.

The holding tank was constructed in 2003 as a balance tank for the previous treatment plant and was repurposed in 2021. The repurposing offered significant savings given the asset's remaining life, but the mixing requirements were not fully considered. The tank is 16 metres in diameter, with a floor that is close to flat and no hopper to draw solids toward the outlet.

For several years, the resulting sediment accumulation was accepted as an unavoidable consequence of operating the tank. This project sought to address that limitation by replacing the existing mixing system with an arrangement capable of fluidising the full tank floor. The upgrade was intended to improve operator safety by reducing the need for tank cleaning, restore usable storage capacity, provide a more consistent sludge feed to the centrifuges, and optimise chemical usage.

Figure 1: Plant operations for cleaning

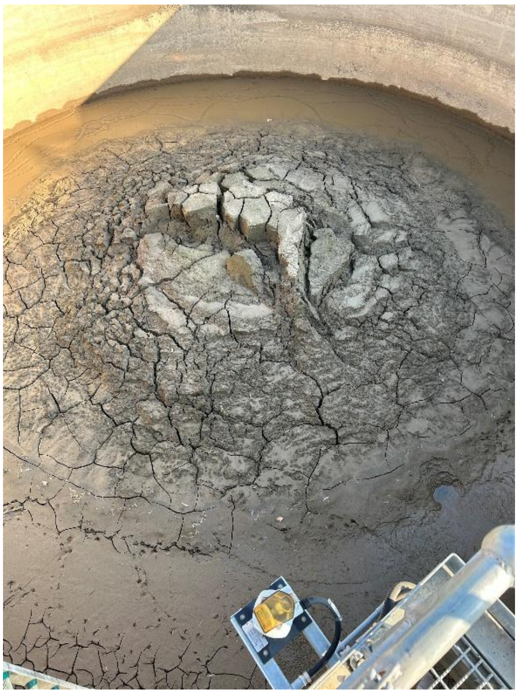

Figure 2: Accumulated Sludge

2.0 DISCUSSION

The tank itself could not be changed. Its diameter, floor profile and absence of a hopper were fixed, and replacing the structure was not justifiable while the asset retained useful life. Mixing was the only part of the system available to work with.

2.1 The Mixing Problem

A single submersible mixer was mounted on the outer wall. It worked by driving a fast, narrow jet across the tank, which suits blending liquids but does little to move settled material across a floor of roughly 200 square metres. Testing of deposit recovered from the tank found it to be mostly sand (Standards Australia, 2009). The high fluid velocity generated by the small, fast-turning impeller, combined with the sand content, caused excessive wear, so maintenance became more frequent and mixing efficiency declined over time.

The mixer was tried in various orientations, and none resolved the problem. Aimed to one side, the tank contents rotated slowly, and solids gathered in a mound at the centre, the same mechanism that gathers tea leaves at the centre of a stirred cup. The tank floor, which falls slightly toward the middle, worked in the same direction. Aimed at the centre, the jet pushed solids outward until they packed against the wall. Repositioning the mixer therefore moved the deposit rather than fluidising it. The limitation was coverage, not orientation.

Once a year, the tank was emptied and dug out. Mobile plant was craned in, and the work required confined space entry, working at height and crane operations, drawing multiple internal teams and contractors over several days. Feed concentration to the centrifuges varied, making the 5 to 6 per cent target difficult to hold, and usable storage fell through the year as the deposit grew.

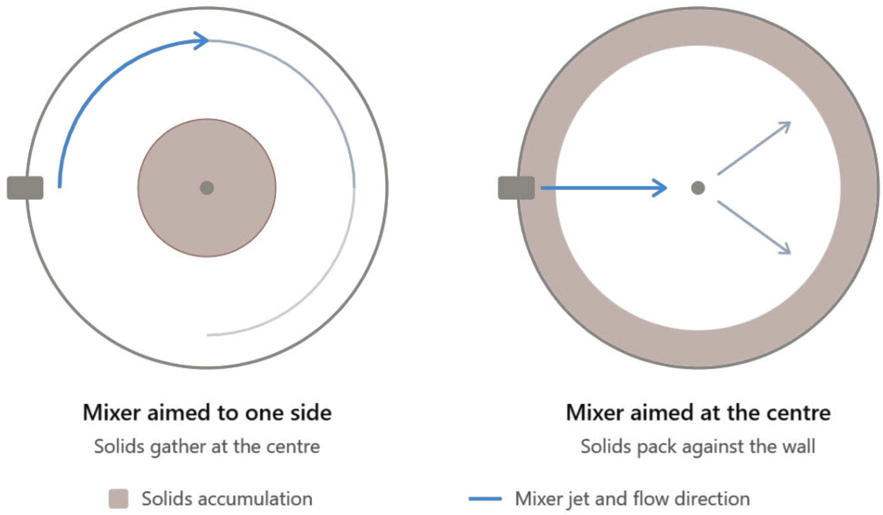

Figure 3: Mixer Orientation vs Solids Deposit

2.2 Power and Geometry

Mixing performance depends heavily on the relationship between a tank's depth and its diameter. Where depth is roughly equal to diameter, a single impeller can drive flow down through the centre, out across the floor, up the walls and back to the surface. The sludge holding tank holds about 4.5 metres of liquid across 16 metres, a ratio of roughly 0.28. In this shallow geometry, flow from a central impeller must travel across as much as 8 metres of tank floor and may lose much of its geometry before reaching the perimeter.

Agitator power rises with the cube of rotational speed and with the fifth power of impeller diameter (Paul et al, 2004). Impeller diameter cannot be chosen freely, because it has to be sized in proportion to the area the impeller is required to sweep. A single impeller serving 200 square metres of floor therefore drives the fifth-power term hard. Preliminary sizing from first principles returned an indicative motor rating between 150 and 300 kW. An option using one agitator with wall baffles was also assessed and remained above the power available.

An assessment of spare capacity at the site switchboard established a maximum available nameplate rating of 60 kW. A single-agitator solution could not have been supplied without upgrading the electrical infrastructure, at a cost that would have been difficult to justify against the value of the asset it served. The design question became how much mixing could be extracted from the power available.

2.3 Modelling and Agitator Selection

The same relationship works in the opposite direction. Four agitators sharing the floor each serve about a quarter of its area, which corresponds to half the diameter. At equal speed, halving the impeller diameter reduces the power each unit requires by a factor of 32, so four units together need in the order of one eighth of the power of a single large machine. Preliminary sizing on that basis came in under 60 kW combined.

Two contributions from Riverina Water shaped the outcome. The first was the proposal to divide the duty between several smaller agitators rather than continue pursuing a single machine. The second was a change to the process requirement. Full suspension of the coarsest particles was not necessary for the tank to do its job; what mattered operationally was that the heavier material kept moving along the floor rather than settling and consolidating. An adjacent 10 metre tank was also assessed and set aside, because the loss of storage volume would have cost the operational flexibility the project was intended to restore.

Modelling then identified a further problem. A single impeller on each shaft performed acceptably with the tank full, but as the liquid level fell below the impeller, the circulation pattern deteriorated. Options examined included adding a small secondary impeller and lowering the main impeller closer to the floor, the latter rejected because it would produce a more radial discharge pattern, increasing power demand and the risk of vortex formation. Twin 2920 mm impellers were therefore selected. They generate more flow in combination than a single larger impeller, and the arrangement allows speed to be increased when the level falls below the upper impeller while remaining within the 15 kW motor rating.

Computational fluid dynamics modelling, undertaken by the agitator supplier, confirmed performance at full and partially filled conditions and settled the impeller elevations. Because speed varies with level, a level control philosophy was written in house and issued with the electrical package. Every setpoint and both zone frequencies are adjustable from SCADA, so speed can be refined against observed performance.

2.4 Bridge Design and Installation

The four agitators are top entry and required support above an open tank with no roof or internal structure. Each unit weighs approximately 1.9 tonnes and applies axial and radial loads, torque and bending moments that may act in any direction. Stiffness rather than strength controlled the design, with deflection at each mounting held below 0.4 degrees from vertical.

A cruciform bridge was adopted, spanning 16.5 metres equidistant in every direction, formed from four primary and four secondary girders meeting at a central node and bearing on the wall crest. Each girder consists of twin 610UB125 sections braced to act together as a single member, the pairing providing the couple needed to resist the torque each agitator applies at its mounting. Agitators are mounted partway along each arm, placing each individual agitator in the centre of the quadrant's area.

No as-built information existed to the accuracy needed to fabricate a structure that had to land on a tank built in 2003. A Riverina Water engineer carried out a point cloud survey and modelled the bridge within the survey data. The survey found that the tank was not perfectly circular, so each bridge arm was fabricated to an individually varied length. The survey, modelling and structural design were completed in house and the bridge was fabricated in Riverina Water's own workshop. Certification and assessment of the existing concrete were outsourced.

The bridge was designed from the outset to be assembled at ground level and installed in a single lift, a safety-driven decision taken to keep steel erection and cable installation off an open tank at height. Fabrication in eight segments allowed the galvanised sections to be assembled and checked on the ground over a few weeks, with cable tray installed and cables pre-wired during the same period.

The 14.5 tonne platform was installed in a single lift of 17 tonnes including rigging, using a 300-tonne crane, and completed in one day. Restricted space around the tank forced a set-up position well back from it, increasing the lift radius and the crane size required. The work was scheduled while the plant was offline for seasonal maintenance and capital works. The tank had to be emptied and cleaned to provide access, so the project required one final confined space entry in order to remove the need for all future ones. The agitators were installed several weeks later using a 60-tonne crane, bringing the completed installation to approximately 24 tonnes.

The bridge also carries railed walkways and grating across the full diameter, giving operators permanent safe access to a tank that previously had none.

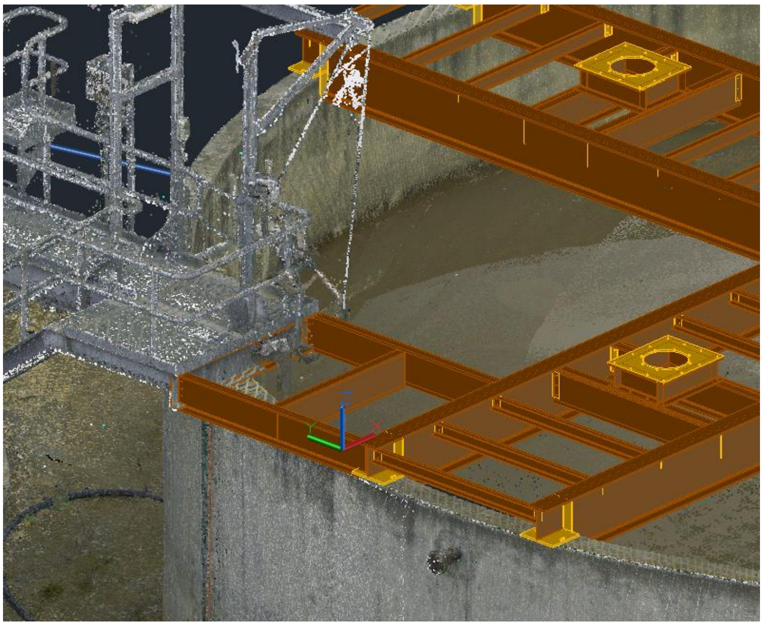

Figure 4: Bridge model within the point cloud survey

Figure 5: Bridge installation as a single lift

2.5 Commissioning and Verification

The installation is complete and the agitators being commissioned. Early indications are positive, and the issues encountered during commissioning have been minor and well within the capability of the internal team to resolve.

Verification of the four objectives requires observation across a full operating cycle. The interval achieved between tank clean-outs will be the primary measure and can only be established with time in service. Feed concentration will be monitored over time to determine whether it holds within the 5 to 6 per cent target, and polymer consumption per tonne of dry solids will be assessed once the feed has been shown to be stable.

Agitator power draw will be recorded in both operating zones to establish the actual duty against design assumptions, and speed setpoints will be tuned accordingly. Modelling indicated lower velocities at the tank centre and between adjacent agitators, and those areas will be inspected to confirm that material is not accumulating.

3.0 CONCLUSION

The mixing system has been replaced and the installation is complete. Verification of the operational objectives is ongoing, and the results will determine how closely the outcome matches the intent.

Three points may be useful to others in the industry.

Repurposing an asset can deliver real savings, but the new duty has to be assessed against the asset's geometry rather than assumed to be equivalent. The proportions of this tank were entirely suitable for balancing flow and poorly suited to agitation, and that was not recognised at the time.

Stating what the process needs, rather than the strictest reading of a specification, can open options that would otherwise stay closed. Relaxing the requirement from full suspension to sustained movement along the floor was the judgement that brought the project within reach of the available power.

Retaining internal capability in survey, design and fabrication allowed a structure to be built in house to retain skills and allowed the assembly sequence to be arranged around eliminating high-risk work rather than around contract boundaries. For a utility of this size, that capability is worth deliberate investment.

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

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