SWAN HILL WTP "POOLIFIER"

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ABSTRACT

Lower Murray Water's Swan Hill Water Treatment Plant (SHWTP) was commissioned in 1962 and supplies treated water to a population of approximately 13,000. The plant has a design treated water capacity of 410 L/s and in summer produces an average of 16 ML/d. Raw water is extracted from the Murray River and is treated through a conventional treatment process featuring coagulation using aluminium chlorohydrate (ACH), flocculation, reactivator clarification, dual media pressure filtration, fluoridation, chlorination, and pH correction (caustic soda).

The plant includes one circular reactivator clarifier which features metallic internal mechanical components. In 2011 it was identified that these components required refurbishment, meaning the clarifier would have to be removed from service for up to 3 months and hence an alternative means of clarification was necessary. Fortunately SHWTP is located directly adjacent to the Swan Hill Rural City Council Swimming Complex, which includes a 50 m swimming pool. This was identified as the most suitable pool for operation as a temporary sedimentation tank. The pool in sedimentation tank mode was given the moniker "Poolifier".

This paper details the application of water treatment design and operating principles in the design of temporary structures to enable coagulation, flocculation and settling in the swimming pool; describes the construction and commissioning of the equipment; details the operating performance achieved; and describes the challenges and obstacles faced and resolved in providing a temporary but robust and reliable process for clarification using a structure not intended for water treatment purposes.

INTRODUCTION

The SHWTP clarifier includes key metallic mechanical components, including sludge rakes, flocculator, draft tube and settled water launders. These components require periodic maintenance, primarily painting for corrosion protection. Also the internal concrete surface of the tank had worn to the extent that all surface concrete between the aggregate had eroded and several areas showed rust staining where steel reinforcing was close to the surface. The mechanical components in the SHWTP clarifier had not been painted since 1983 In order for these components to be refurbished, the clarifier must be removed from service, drained and dried to enable the application of the paint. Concrete tank repairs were also schedule to occur after the mechanical repairs were complete.

As there is only one clarifier at SHWTP, an alternative clarification process was required. Previous shutdowns for periods of less than one week for spot patching of the coating and minor mechanical repairs had been programmed for the middle of winter. The clarification area of the clarifier was bypassed, with raw water pumped directly into the clarifier settled water race, where coagulant was added, for gravitation to the pressure filters. The filters were not backwashed during this period as experience had shown that backwashing was not successful. The shut down time was limited to the loading of the filters which were backwashed once the clarifier was returned to service. As the extended maintenance works undertaken in 1983 would see the plant shutdown for greater than one week an advertisement was taken in the local paper stating that the town would be supplied with chlorinated raw water straight from the Murray River for a period of six weeks. Customers were advised to boil water for consumption purposes. Clearly times have changed and this approach would no longer be acceptable today so an alternative supply method had to be found. Since this time, Lower Murray Water's (LMW's) performance targets have tightened along with drinking water quality standards. The poorer filtered water quality that would result from this mode of operation is not acceptable.

In October of 2011, LMW and HWA began investigations into potential options at the Swan Hill Council Swimming Complex for use of one or multiple pools for temporary use as a sedimentation tank. The assessment considered issues such as delivering raw water to the Swimming Complex, the dimensions and configuration of each pool and the likely suitability for providing reliable and effective sedimentation, returning settled water to the SHWTP filters, providing power, sludge removal and process control.

It was decided that the 50 m swimming pool was most suitable given the long detention time provided and the lower velocities achievable. The maintenance of the clarifier would be undertaken in winter when the Swimming Complex would typically be closed, and when typical treated water demand from SHWTP would be in the order of 5.3 ML/d. The poolifier system would be designed for flowrates of between 80 and 110 L/s.

DESIGN

Figure 1 is a process flow diagram for typical SHWTP operation.

Figure 2 is a process flow diagram of the treatment process with the "Poolifier" in operation.

A T-piece was installed on the raw water line. An isolation valve downstream of the first T-piece and one on the branch to the pool enabled raw water pumping to either the pool or the clarifier. This was important during commissioning. Settled water was pumped back from the Poolifier direct to the clarifier race.

Temporary 315 mm PPE piping was installed to and from the Poolifier.

A section of mild steel auger screw flight was installed in the temporary raw water PPE piping for use as a static mixer for aluminium chlorohydrate (ACH) mixing. Various lengths of screw flight were trialled in order to identify the optimum configuration for coagulation. A new section of temporary dosing pipework was installed with injection of ACH just before the static mixer.

A key component of the Poolifier was the flocculation structure. The structure was designed for an overall hydraulic detention time of 15 minutes, and was constructed in the deep end of the pool. Figure 3 is a schematic drawing of the poolifier showing the flocculation structure. The flocculation structure considered two zones. Dosed raw water was delivered into a square 5 m by 5 m central flocculation zone. The velocity gradient in this zone was estimated at 50 to 75 s^{-1}. Water then overflowed from this compartment through a port at the top of each wall into an 10 m by 10 m square compartment. The velocity gradient in this zone was estimated at 25 s^{-1}. Water then flowed out of this compartment through three ports in each side wall of the compartment at the base. The flocculation structure was constructed of readily available building materials mainly consisting of untreated pine framing timber and fibre cement sheeting. Figure 4 shows construction of the flocculation structure in progress. Figure 5 shows the flocculation structure in operation.

From the furthest outer corners of the flocculation structure, walls were installed with adjustable ports at the base to direct water towards the centre of the pool. Directing water to the centre of the pool prevented water travelling up along the sides of the pool only and short-circuiting.

An additional curtain of geo fabric was installed perpendicular to flow along the width of the pool approximately 3 m from the flocculation outlet to again direct water to the bottom of the pool and also to disperse flow over the pool width.

Sand bags were placed above the overflow channel for approximately 45 m from the deep end of the pool to enable the inflow to travel this distance before overflowing to the collection channels along the side of the pool. These channels drain to a collection pit which usually feeds a filtration system at the Swimming Complex. For poolifier operation, a submersible pump was installed in this pit and connected to the temporary PPE piping for return of settled water to the clarifier settled water race.

At the shallow end of the pool a series of 150 mm PVC pipes were installed along the full width of the pool just below the water level. These were perforated at approximately 0.5 m intervals with 20 mm holes for collection of settled water. Each end of the piping discharged to zones either side of the pool where the overflow channels were not covered by sandbags.

A pool cleaner head was coupled to a pump for suction of sludge from the tank. Operational staff moved the head around the pool for sludge removal, with the sludge discharged to sewer.

COMMISSIONING

The "Poolifier" was first operated in June 2012 for a trial run. A number of issues experienced meant that the process took quite sometime before it was considered reliable. The key issues were:

1) It was found that in the Poolifier the coagulation pH had to be maintained at 7.5 for adequate performance. If this varied more than ± 0.2 pH units a deterioration in water quality was observed. Caustic soda was required to increase and maintain pH at this optimum level. This is significantly different from the actual SHWTP clarifier operation where caustic soda is not typical required for coagulation and the settled water pH is typically in the range of 6.8 – 7.2.
2) The coagulation caustic soda dosing pumps were flowpaced to raw water flow. Initially, errors in the control coding for dosing pump flowpacing meant that at times the caustic dose was double the requirement as they were being asked to

dose for the sum of the raw and filtered water flows.

3) Given the importance of coagulation pH and the narrow operating range, a small sample pump was installed in the flocculation structure to send water to the plant laboratory for continuous online monitoring and alarming.

4) A ferrule in the injection point for ACH was found to be causing an issue in that it would sometimes block dosing and hence coagulation would be lost.

5) Flows from the flocculation structure seemed to naturally travel along the sides of the pool, bypassing much of the pool volume. This was solved by constructing solid "wings" from the corners of the flocculation structure to the side of the pool with an adjustable opening to direct water to the pool centre.

6) It was believed that the sand bags over the overflow channels were not completely sealing the channels, leading to floc collection and higher settled water turbidity. In 2013 this system was redesigned utilising concrete expansion joint foam and black builders plasic to provide a water-tight seal.

7) Maintaining sufficient water level in the clarifier settled water race during a backwash was challenging. The filters are pressure filters with the master valve rotating between the cells. There is effectively no flow into a filter while the valve rotates and hence overflows are a potential issue. This clearly was not going to be permissible when the clarifier was drained and undergoing refurbishment. To avoid this, two filters had to be always in operation to enable backwashing, such that the second filter could take excess flow while the other filter backwashed. A temporary overflow and drain line was installed just below race level in case of high level.

8) Most of the flocculated solids settled just outside the flocculation structure. To facilitate easier removal, a PVC grid was installed on the floor of the pool at each side of the structure in 2013. The grids were perforated with holes and were connected to a pump suction which enabled settled sludge to be removed effectively, with the pump discharging to sewer.

While the issues described above were being resolved the Poolifier ran intermiitently for periods of several days. Once the issues were resolved the Poolifier operated continuously for approximately two weeks including automatic starting and stopping and overnight, unmanned operation However once this confidence was gained there was insufficient low demand period remaining to facilitate clarifier refurbishment. Hence clarifier maintenance was deferred until 2013 and the Poolifier was decommissioned, with the pool again used for swimming by the public during the 2012-13 summer.

CONTINUOUS OPERATION

Following the testing undertaken in 2012, the Poolifier was again constructed and commissioned in 2013. The improvements which were identified in 2012 were incorporated into the design. Commissiong and re-testing of the system was undertaken from the 25th April 2013, with continuous operation commencing from 30th April 2013 to 9th September 2013. Table gives a summary of the key raw water quality parameters ove this period. The complete data set for these parameters is presented graphically in Figure 6.

Table 1: Raw water quality during continuous operation (30th April to 9th September 2013).

Parameter	Average	Minimum	Maximum
Turbidity (NTU)	36.2	11.2	94.4
pH	7.3	6.7	7.8
True Colour (HU)	12	44.1	125
Temperature (^{O}C)	12.7	9.1	20.3

RESULTS AND DISCUSSION

The Poolifier was operated in a continuous mode of operation from 30th April to 9th September 2013. During this time the plant was operated in automatic mode, starting and stopping based on the level of treated water in the distribution network. Table 2 gives the settled and transfer (combined filtered) turbidity during the operation period. Figure 7 graphically presents the raw, settled and transfer turbidity during the operational period.

Table 2: Settled and Transfer water turbidity during continuous operation (Daily grab samples - 30th April to 9th September 2013).

Parameter	Average	Minimum	Maximum
Settled Turbidity (NTU)	2.0	0.5	5.7
Transfer Turbidity (NTU)	0.06	0.03	0.21

Filter head loss accumulation remained acceptable during operation of the Poolifier. The SHWTP reactivtor typically achieves a clarified water turbidity of less than 1 NTU. Despite the high turbidity from the Poolifier the filtrate quality was still within the LMW target limit of less than 0.2 NTU and run times were acceptable, exceeding 12 hours.

The majority of the sludge removal proces was undertaken manually throughout operation. It was found that the majority of solids settled quickly and hence accumulated in the first half of the pool, with much of it around the flocculation structure itself. In fact the solids retention in the sections around the 10 m x 10 m flocculation structure almost acted as a sludge blanket, with flocculated water undergoing further solids contact in this zone. Lighter solids that did travel further up the pool that settled to the bottom were removed by an automatic pool cleaning type device. Rather than waste this water to sewer, it was instead returned to the flocculation structure.

CONCLUSION

A public Olympic size swimming pool was successfully configured to serve as a sedimentation tank for the supply of treated water to the community of Swan Hill, while SHWTP's one and only clarifier was removed from service and refurbished. Without the clarifier, treated water quality could not be produced at the plant to meet LMW standards. The use of sound engineering design fundamentals and a commitment by operational staff led to the development of a robust treatment alternative that enabled the refurbishment of a critical WTP component while the supply to the community was maintained over an extended period.

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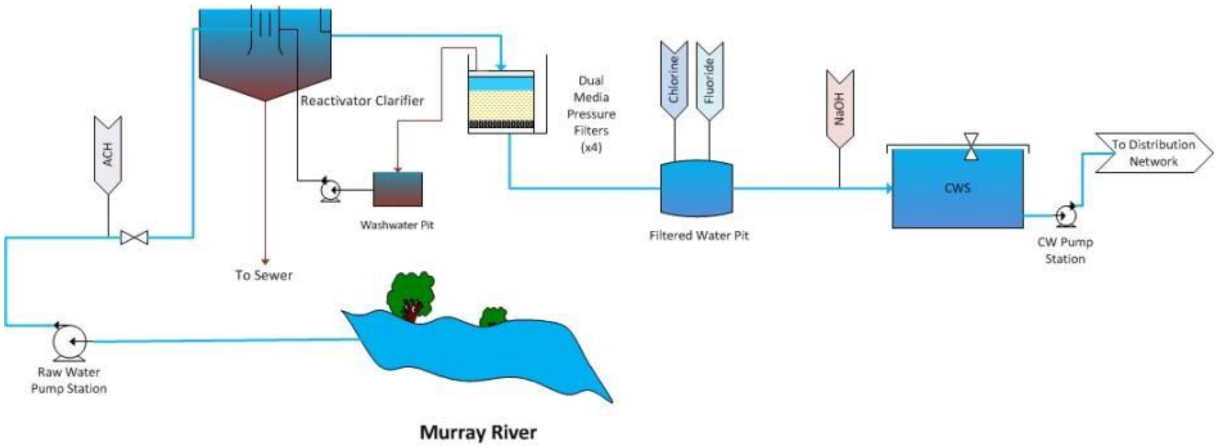

Figure 1: Swan Hill WTP Process Flow Diagram.

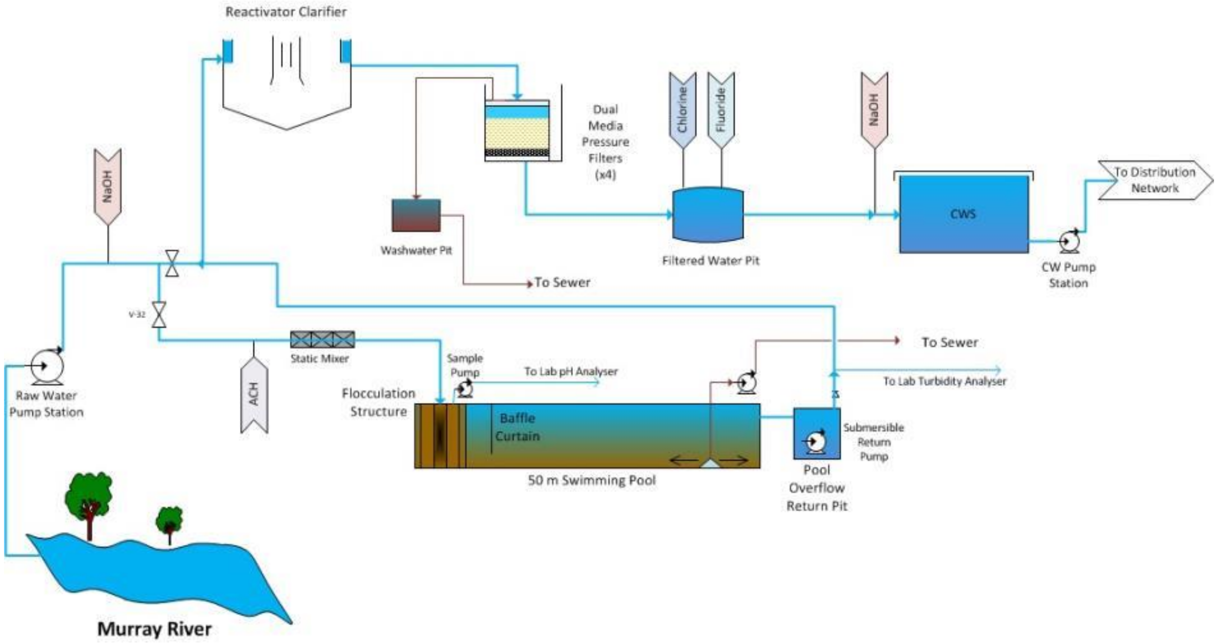

Figure 2: Modified Swan Hill WTP Process Flow Diagram for Poolifier operation.

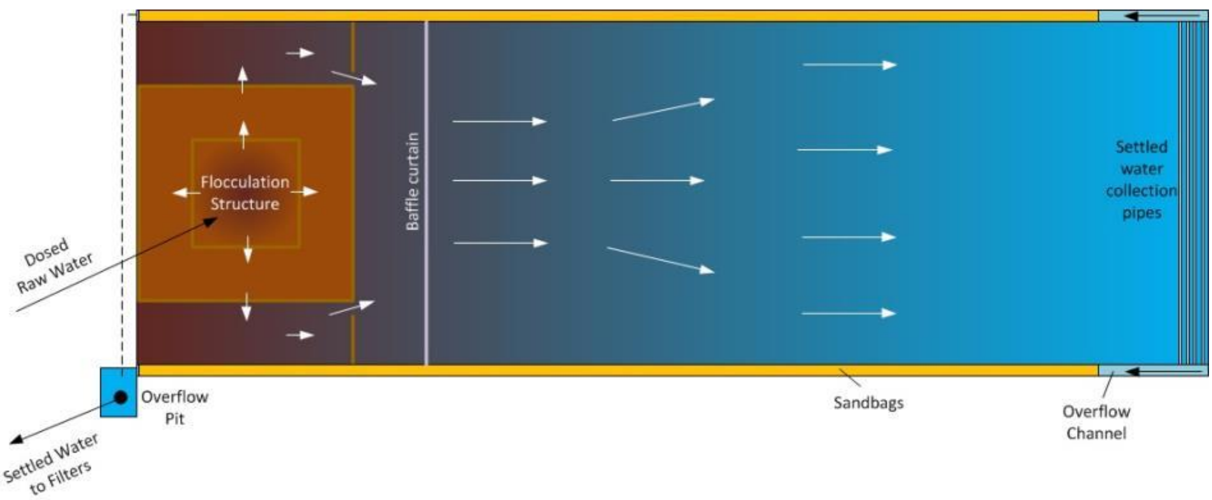

Figure 3: Poolifier schematic showing flocculation structure and flow path.

Figure 4: Construction of flocculation compartments.

Figure 5: Flocculation structure in operation.

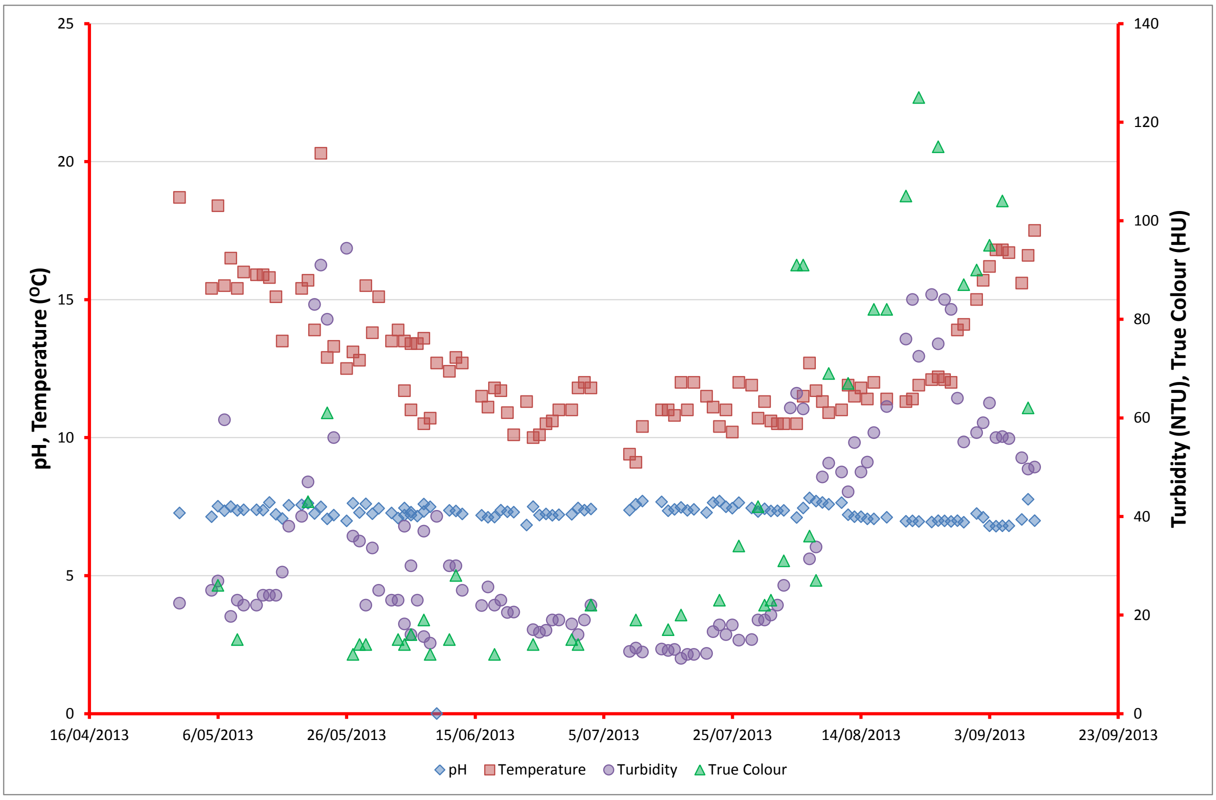

Figure 6: Swan Hill WTP raw water during continuous Poolifier operation (30th April to 9th September 2013).

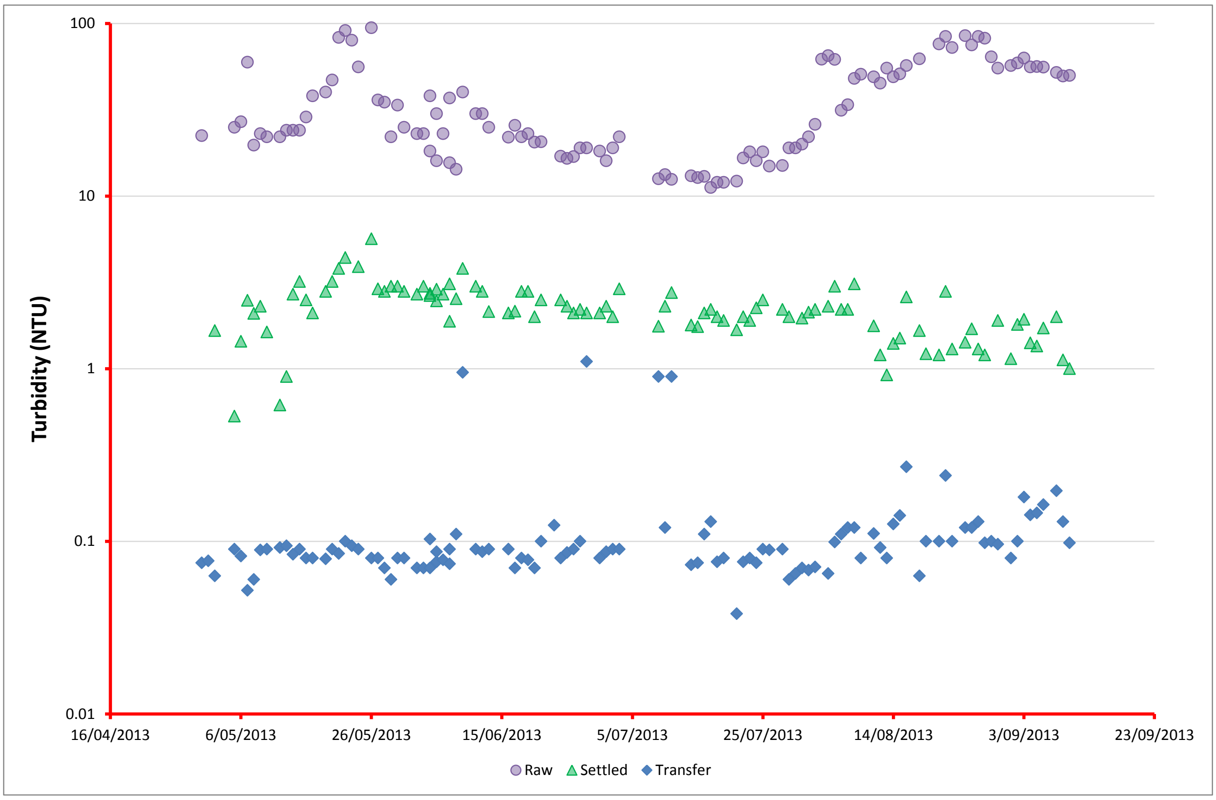

Figure 7: Swan Hill WTP raw, settled and transfer water turbidity during continuous Poolifier operation (30th April to 9th September 2013).

Figure 8. "Poolifer" in operation.

Figure 9. Sludge removal.