

BUILDING RESILIENCE INTO SEWAGE TREATMENT: ADAPTIVE OPERATIONAL STRATEGIES AT PORT FAIRY

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Abstract

Industrial trade waste inflows can introduce significant variability in hydraulic and organic loading at sewage treatment plants (STP), particularly during prolonged periods of low or no flows associated with industrial shutdowns. Anticipated industrial trade waste changes prompted a detailed assessment of processes, operational and biological constraints at Port Fairy Industrial STP.

Using site trial data collected across four representative industrial influent operating modes, the study assessed hydraulic limitations, treatment capacity, carbon availability for denitrification, and options for adjusting plant operation to reduce energy use while maintaining biological activity. Results showed that short-term low-flow conditions of up to two weeks could be managed within existing configurations, however, prolonged low-strength influent increased the risk of hydraulic instability, reduced denitrification and loss of process resilience.

This paper outlines how these risks were identified, assessed and managed, including treatment and operational constraints, effluent quality, regulatory compliance and customer requirements. An adaptable operational strategy was developed that retained operation of all major treatment units, supported by targeted domestic wastewater top-up, aeration control adjustments, and conditional carbon dosing where required. Implementation of this approach has enabled stable plant performance and ongoing compliance with EPA licence conditions at the ocean outfall. This approach reduced operational risk without requiring major process or infrastructure modifications. The strategy has since been applied to other industrially influenced treatment plants within the Wannon Water region, demonstrating its broader applicability.

1. Introduction

A study at the Port Fairy Industrial Sewage Treatment Plant (STP), examined the effectiveness of an adaptable operational strategy intended to sustain plant performance across a range of projected flow conditions. The strategy aims to mitigate operational risks and improve the overall efficiency of wastewater treatment processes, particularly during low flow periods.

Wannon Water identified potential variations in trade waste influent loads expected between April 2024 and March 2025 due to changes in trade waste customer demand. To address this, Wannon Water engaged SMEC to undertake a process and risk investigation and to develop an adaptable operational strategy to identify and mitigate potential risks and impacts on the Port Fairy STP.

1.1 Port Fairy STP Process Description:

The Port Fairy STP consists of three process reactors: the Aerated Lagoon, the Demand Aeration Tank (DAT), and the Intermittent Aeration Tank (IAT), which can be operated in various configurations depending on the influent loads to achieve optimal treatment performance (Figure 1).

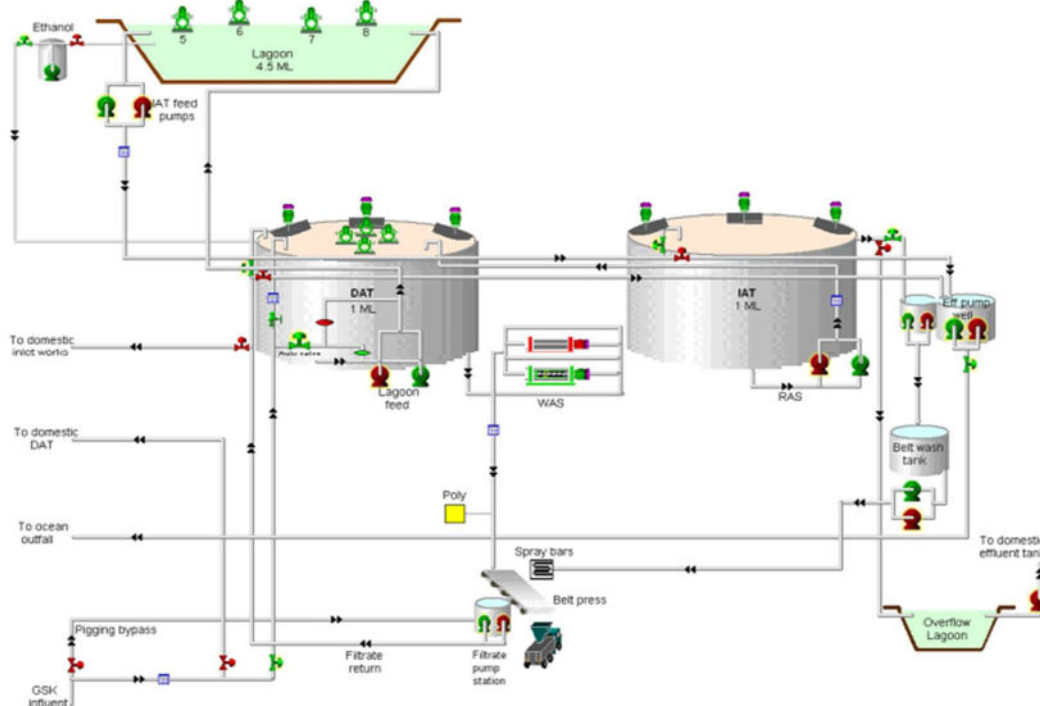


Figure 1- Port Fairy Industrial Sewage Treatment Plant (STP) Flow Diagram

The influent can be directed entirely to the Aerated Lagoon, to the DAT, or split between the two. The IAT receives its feed either from the DAT or the lagoon, depending on the operational configuration. The operator manually adjusts these settings based on the dissolved oxygen levels within the tanks. The IAT operates in a cyclic mode comprising aeration, settling, and decanting phases, with return activated sludge (RAS) directed back to the DAT.

Waste activated sludge (WAS) extracted from the DAT is pumped to a belt filter press for dewatering. The dewatered sludge is transferred to a collection bin, which is periodically removed by truck and transported to a Wannan Water biosolids facility. The filtrate from the belt filter press is collected in a sump and returned to the DAT for further treatment.

During periods of low oxygen demand, the Aerated Lagoon can be bypassed entirely. Under high influent loading conditions, the plant is configured to receive influent with an approximately 50/50 split between the Aerated Lagoon and the DAT. Industrial influent is blended with about 5% domestic sewage to enhance biological activity and accelerate the activated sludge process.

The treated effluent from the Port Fairy STP is discharged through an EPA-licensed ocean outfall located south of Griffiths Island.

1.2 Process Investigation

A trial was conducted between January and February 2024, where the plant experienced four operating modes indicative of what Wannan Water could expect after the impending trade waste demand changes in 2024-2025. However, the timing and duration were expected to be more extensive compared to the trial period, which needed to be considered.

An analysis of historical influent and effluent quality data demonstrated that the Port Fairy Industrial Sewage Treatment Plant (STP) successfully maintained compliance with licence conditions during periods of short-term low flow, provided that the entire treatment process was in operation. However, several key risks were identified associated with the projected long-term low-flow conditions. These included the minimum hydraulic loading required for each process unit, the maximum treatment capacity of the Aerated Lagoon and Demand Aeration Tank (DAT), the potential need for carbon dosing in response to influent characteristics, and the risk of non-compliance with licence conditions due to variations in influent composition. These aspects required further detailed assessment.

1.3 Results

To optimise energy consumption and minimise the plant’s carbon footprint, the feasibility of operating only essential equipment during low-flow periods was investigated. The ultimate treatment capacity of the main process tanks in Figure 1 (Aerated Lagoon, DAT, and IAT) was assessed to ensure that sufficient process units remained operational to sustain microorganism health under low organic loading conditions, thereby preventing cell death and biological activity decay.

Using site trial data (Table 1), the anticipated daily flow and chemical oxygen demand (COD) were projected for the expected low trade waste demand period between April 2024 and March 2025, as summarised in Table 1. Deviations from expected load values indicated a highly variable and unpredictable inflow pattern, with significant fluctuations in wastewater strength. This variability was identified as a major risk when considering the temporary shutdown of treatment process units.

Table 1- Summary of plant operating modes, anticipated and measured influent loads- Jan 2024 to Feb 2024

Mode	Mode Description	Parameter Flow (m ³ /d) COD (kg/d)	Measured Value (50th percentile)	Anticipated Value	Variance (against measured value)
1st	Normal factory operating mode: <i>Full flow, High COD</i>	Daily flow rate	363	385	-6%
		Total COD	3049.2	4500	-32%
2nd	Clean in Place (CIP): <i>Medium flow, Low COD</i>	Daily flow rate	152.5	105	45%
		Total COD	110.6	300	-63%
3rd	Weekend shutdowns from Friday (Low CIP): <i>Medium flow, Medium COD</i>	Daily flow rate	280	105	167%
		Total COD	N/A**	750	N/A**
4th	Maintenance activities: <i>Low flow, Very low COD level</i>	Daily flow rate	50	35	43%
		Total COD	27.6	50	-45%

** No sampling or laboratory analysis was undertaken during weekend periods due to the absence of onsite operational staff; therefore, no data was available for these intervals.

Additionally, the plant's operational constraints associated with the lagoon and DAT, as outlined in Table 2, had to be considered during low-flow modes.

Table 2- Operational constraints (Lagoon and DAT)

Parameter	Unit	Lagoon	DAT
Tank volume	m ³	4600	1000
Operating water level	m	3.3 - 3.9	2.2-2.85
Operating flow	m ³ /d	168-200	160-205
Operating capacity	Kg COD/d	Facultative cap.: 334, surface aerator cap.(each); 497, total: 2323	2300 (include 5L/s domestic influent for dilution purposes) 1600 (exclude domestic share)

2. Discussion

2.1. Hydraulic Levels

Based on Table 2, the plant was expected to struggle with maintaining the required water levels when operating with a 50/50 split between the lagoon and DAT during low-flow conditions (Mode 4). To keep the DAT and lagoon within the required operational level margins, domestic wastewater was recommended to be added to the industrial influent as a top-up. The domestic influent specification, optimum top-up volume and its availability and duration without causing a detrimental impact to the domestic system, as well as any required infrastructure upgrades needed to facilitate this were investigated.

2.2. Treatment Capacity

Although the individual treatment capacities of the lagoon and DAT are sufficient to handle the incoming loads, bypassing either unit during low-flow conditions was not recommended due to challenges associated with future start-up. This is also due to the unstable nature of the influent, significant fluctuations, and the unpredictable duration of low-flow operating modes.

Additionally, in some operating modes, the available treatment capacity including both aeration and hydraulic buffer capacity may exceed demand. To prevent over-aeration and sludge settling in the tank, operators would need to adjust the aeration system accordingly.

2.3. Carbon Supplement

In biological reactors, the availability of organic carbon can be a limiting factor for effective denitrification. If naturally occurring organic matter is insufficient, adding an external carbon source can help facilitate the process.

During the trial at the Port Fairy STP, D.Nitro™, a non-hazardous liquid sugar, was used as a carbon supplement. However, due to the high COD levels in the influent during normal

operation (Mode 1), carbon supplementation was not required. It is only recommended when the incoming influent has low COD levels, particularly during Mode 4. The maximum required dosage of the D.Nitro™ carbon source is shown in Table 3.

Table 3- Required dosage of D. Nitro™ during Mode 4

Mode 4 – low flow operating mode		
Influent COD -Average	mg/l	553
Influent NOx	mg/l	85
Available C/N ratio		6.5
Required C/N for denitrification	20-35	35 (max)
Required Carbon supplement dosage	mg/l	2423
Required D-Nitro	L/d	403

2.4. Treatment Process/Type

Differences in the biological reactors (Lagoon and DAT/IAT) and their unique operations impose limitations on efficiency and ease of operation.

The DAT bioreactor operates as a Completely Mixed Activated Sludge (CMAS) system, where the tank contents are thoroughly mixed to ensure uniform distribution of organic load, oxygen demand, and substrate concentration throughout the aeration tank. Proper mixing is essential to prevent short-circuiting of untreated or partially treated wastewater. To maintain optimal conditions, aerators/aspirators would be carefully adjusted based on their location and supplied power. This is particularly critical under different operating modes to ensure sufficient air supply to the DAT reactor according to influent loads. Maintaining a fully mixed condition is necessary while avoiding over-aeration ($DO > 2 \text{ mg/L}$), which can contribute to poor sludge settling and foaming in the IAT sedimentation process. Therefore, several parameters, including Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) required careful adjustment in the DAT system, whereas lagoon operation remained relatively simple.

3. Conclusion

The outcome of this investigation was a strategy for managing low flow periods. Table 4 summarises the strategy adopted during low/no influent flow periods at Port Fairy Industrial STP.

As a result of this study, Wannon Water staff operating the STP can confidently adapt the treatment process at short notice, using a procedure for extended industrial customer shutdowns lasting more than two weeks. Risks to the biological treatment process, and therefore potential breaches of EPA-licensed effluent quality at the ocean outfall mixing zone, are mitigated by relatively easy adjustments to the treatment process.

Wannon Water was able to apply the same approach at other treatment plants that experience variation in industrial trade waste inflows, including Warrnambool and Portland, both of which handle industrial trade waste components and are subject to licensed ocean outfalls.

Table 4- Adapted operational strategy summary for changing extended low flow periods (mode 4) in 2024/2025

Dominant Mode	Plant configuration (high level)
Mode 1 & short periods (2-3 days) of Modes 2&3	Same as normal operation
Mode 4	Same as normal operation plus: Carbon supplement ~400 L/d Domestic influent top-up (minimum 1.7 l/s to the lagoon, up to 7 l/s to the DAT)
Mode 1 & 2	Same as normal operation During mode 2, the operator should adjust the required carbon supplement and domestic top-up based on the incoming loads

4. Acknowledgements

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5. References

Golkhou, T., De Silva, C., and Singh/Thakur, H. (2024). *Port Fairy IWRP Shutdown Strategy – Rev 02 Final*. Prepared for Wannon Water by SMEC. Reference: FC2025/17924. Dated 11 September 2024.