TRADE “WASTE OF TIME” – CRAFT BREWERY WWTP SIMPLIFICATION AND IMPROVEMENT

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ABSTRACT

The worlds’ tastes are becoming more refined. With this development of palette, discerning drinkers are turning increasingly towards microbreweries and craft beer. Malt Shovel Brewery (MSB), Sydney, NSW, is one of Lion Co.’s craft breweries where it tests new products and produces small batch beer volumes. With the importance of this Craft Beer stream of sales the focus on treating the wastes produced increases in kind.

The waste water treatment plant (WWTP) at MSB was over-complicated, prone to blockage and failure, incited multiple manual handling risks and consumed large amounts of caustic soda for pH correction while still exceeding license discharge limits on occasion. This paper describes the steps taken to develop, simplify and improve the WWTP. It also discusses the importance of developing simple, robust WWTPs to apply across the wider Craft/Microbrewery industry as more home-brewers graduate into the Microbrewery scene and major breweries look to scale-down their brewing and treatment processes.

The old MSB WWTP consisted of a large mesh bag filter, followed by tri-filtration, gravity settling, ultra-filtration and pH correction. During times of full production, the bag filter would block 20-30 times a day from spent grain, hop trub, yeast, and diatomaceous earth, requiring the operators to lift a large, heavy bag out of the filter and transfer waste into a local bin. Regardless of this upfront filtration step, the ultra-filtration unit would constantly block and require back-flushing, leading to the statement that it was never “fit for purpose”. Caustic soda was dosed into the inlet tank which would be subjected to wide fluctuations of pH, occasionally not meeting the discharge pH specifications.

This project improved and simplified the WWTP process in the following ways:

- Removal of the bag filtration step.
- Removal of the inline self-cleaning filter and ultra-filtration processes.
- Conversion of the previous neutralisation tank and settling tank to inlet buffer tanks.
- Installation of a rotating filter-mesh Salsnes™ unit as one process to remove all solids.
- pH correction in a small tank immediately prior to discharge to sewer.
- Utilisation of as much of the existing equipment as possible.

In completing the above, the project achieved the following benefits/outcomes:

- Removal of the manual handling risk and down time required to remove fouled bag filters.
- Process simplification by replacing three filtration steps for one.

- The additional inlet buffering volume provided by combining existing tanks lead to improved pH buffering and correction with mixed inlet streams.
- Minimising solids waste and manual handling by screw-compressing spent grain and solids prior to discharge.
- Significantly reduced caustic usage, and manual chemical handling.
- Delivery of the project, under budget, that achieved all client requirements and discharged trade waste to council specifications.

Providing this solution to MSB has allowed the brewers to focus on what they do best while being comfortable that they are discharging in-spec wastewater. This filtration process has been implemented at another Lion craft brewery and has the potential of being applied to many other craft and microbreweries throughout Australia and New Zealand, providing confidence and cost-savings for both brewers and local authorities alike.

KEYWORDS

Craft Beer, Microbrewery, Simplification, Robust, Waste Water Treatment, Filtration

1 INTRODUCTION

New Zealanders' and Australians' taste in beer is shifting from mainstream products to craft brews (Thomson, 2017). As a result, the number of breweries and brewing companies in Australia increased from 200 to 350 between 2013 and 2016 (Terrill & Leith, n.d.) and small breweries in New Zealand increased from 59 to 130 between 2011 and 2016 (ANZ New Zealand, 2017). This growth in production in turn results in an increase in the wastes produced from the craft brewing process.

Brewery wastewater typically has high soluble biochemical oxygen demand (BOD) and total suspended solids (TSS), which can cause issues within municipal treatment. Challenges involved in treating craft brewery wastewater include the high variations of wastes from the brewing process and the typical lack of staff and expertise around wastewater treatment.

Located in Sydney, NSW, Malt Shovel Brewery (MSB) is one of Lion Co.'s craft breweries where it tests new products and produces small batch beer volumes. The brewery was first opened in 1988 by Chuck Hahn, and renamed to Malt Shovel Brewery in 1998.

In 2013, the MSB undertook a project to upgrade its wastewater treatment plant (WWTP) however as time progressed, it became apparent that the WWTP was over-complicated and not performing as desired. It incurred significant manual handling requirements, production downtime and occasionally exceeded license discharge limits.

This paper details the drawbacks and over-complications of the old MSB WWTP and the project implemented to address these issues, resulting in a simple, robust WWTP. With the ability to successfully develop and implement a simple WWTP, the possibility of implementation throughout new and existing craft breweries is discussed and how this may positively impact both brewers and local water authorities.

2 DISCUSSION

2.1 ORIGINAL WASTE WATER TREATMENT PLANT

In 2013, the Malt Shovel Brewery upgraded its WWTP. This upgrade consisted of the unit processes described below and shown in Figure 1.

- Trade waste collection sump,
- Sump pump and bag filter,
- Booster pump and inline self-cleaning filter,
- Balance/pH correction tank for filter permeate. Where low turbidity solution is sent directly to sewer, and high turbidity solution further treated via downstream ultra-filtration (UF) unit prior to sewer discharge and
- Flocculation tank for self-cleaning filter retentate and bank of bag filters prior to sewer discharge.

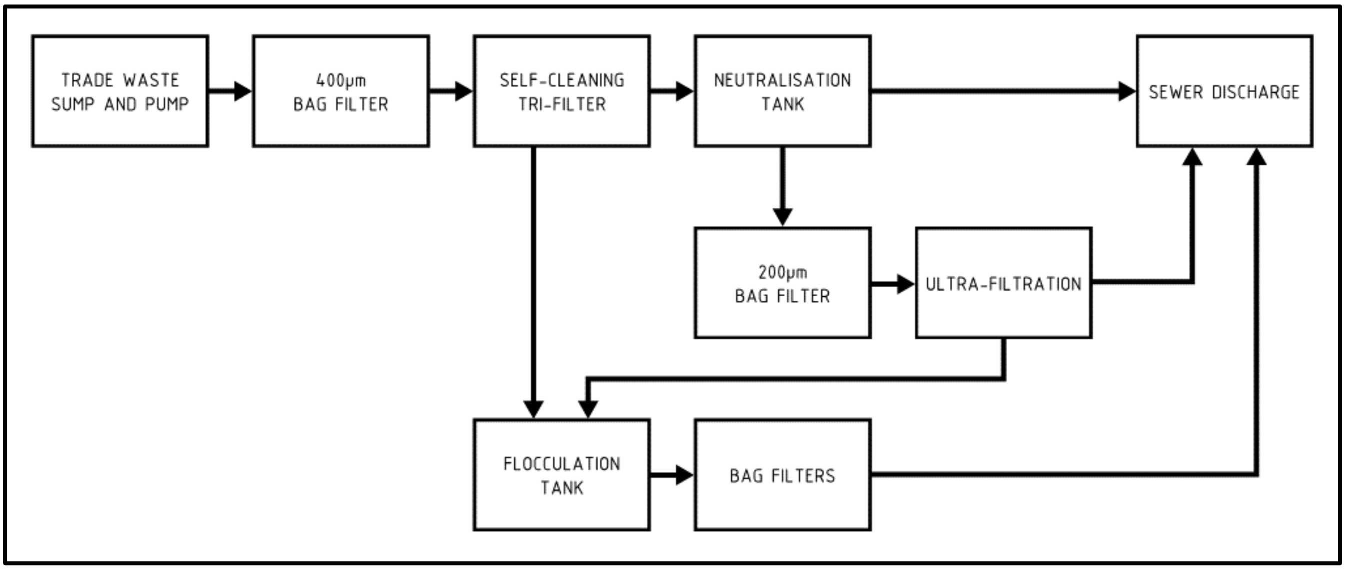

Figure 1: Original MSB WWTP Block Flow Diagram

From the outset, the WWTP displayed issues in its design which affected operations, production and sewer discharge. The major issues were:

- Regular filling and blockage of the first bag filter,
- Large amounts of caustic soda consumed to neutralise pH,
- Irregular reading of the turbidity meter,
- Regular blockage of the UF unit,
- Occasional failure of the PVC pipework, which was not rated to temperatures sent to drain (70°C+)
- Occasional breaches of trade waste license sewer discharge limits.

The filling and blockage of the lead bag filter caused the most issues for site personnel. A bag filter blockage would shut down any feed into the WWTP and require the operator to manually lift the bag filled with water, spent grain, hop trub, yeast, and diatomaceous earth from the filter and empty it into a bin. This could occur up to 20-30 times a day and would affect production and WWTP efficiencies and add physical strain to operators. These disturbances could accumulate to over 2 hours per day, costing the business money and distracting operators from focussing on producing beer.

All unit processes within MSB's factory send trade waste to the WWTP via floor drains to a common sump. The WWTP would then be subjected to the instantaneous fluctuations of pH from the brewing process, filling processes and CIPs. This in turn would result in short periods of (mostly) low pH infeed, consuming large volumes of caustic soda. Caustic soda was dosed into the plant via diaphragm pump and 25L container, refilled by operations on nearly a daily basis.

The turbidity meter would consistently foul and give inaccurate readings and inadequate pre-filtration of UF feed water would tend to block the filters prematurely, requiring regular operation intervention, back-flushing and WWTP inefficiencies.

With the aforementioned fluctuations and plant inefficiencies, breaches of license sewer discharge limits occurred on multiple occassions, incurring extra costs for the Malt Shovel Brewery.

2.2 DESIGN DEVELOPMENT AND INSTALLATION OF NEW WWTP

Beca Pty Ltd was engaged by Lion Co. early-2015 to investigate and review options to upgrade the MSB WWTP. The following sections outline the process undertaken in designing and implementing the new WWTP.

2.2.1 BASIS OF DESIGN

The following influent basis was developed to inform the design and specification of the new WWTP. The data was collected from existing site data, and waste samples collected.

Table 1: Basis of Design for new WWTP

Parameter	Units	Value
Average Flow	L/s	3.5
Peak Flow	L/s	5
Influent TSS		
Average	mg/L	730
Peak	mg/L	4700
Particle Size		
Minimum	μg/L	>3
Median	μg/L	16
Required Effluent TSS	mg/L	500
Required Sludge Concentration	%DS	15
Plant Footprint	m x m	4 x 2
Operator Input	hours per day	1

The required treatment standards for the trade waste discharge are driven by the consent conditions set by the local water authority. The conditions of the consent to discharge are summarised in Table 2 below. From previous assessments of the trade waste at MSB, the acceptance standard of 600mg/L for TSS was the main parameter of concern.

Table 2: MSB Conditions of the Consent to Discharge

Parameter	Units	Limits	LTADM	MDM	Acceptance Standard
BOD_5	mg/L kg/day		 110	 600	
TSS	mg/L kg/day		 20	 70	600
TDS	mg/L kg/day		 50	 90	10,000
Grease	mg/L kg/day		 0.6	 1.0	110
pH	units	7≤ pH ≤ 10			
Temperature	°C	38			
Instantaneous Discharge	L/s	5.0			
Maximum Daily Discharge	kL	70			
Average Daily Discharge	kL	27			

Abbreviations:

BOD_5 – biochemical oxygen demand (5 day)

TSS – total suspended solids

LTADM – Long term average daily mass

TDS – total dissolved solids

MDM – Maximum daily mass

2.2.2 TREATMENT TECHNOLOGY EVALUATION

Several technologies were evaluated at a high level for solids and BOD removal from the wastewater at MSB. This high level review is summarized in Table 3

Table 3: Comparisons of Technologies for MSB WWTP

Technology	Relative Cost	Footprint	Technical Complexity	Ops Input	Sludge Production	Suitability for MSB WWTP
DAF	Moderate	Moderate	Moderate	Low	High volume Low solids	Low
Biological Treatment	High	High	High	High	High volume Low solids	Low
Bag Filter	Low	Low	Low	High	High solids Lower volume	Moderate
Sand Filter	Moderate	Moderate	Moderate	Low	High volume Low solids	Low
Disc or Drum Filter	Moderate	Low	Moderate	Low	High volume Low solids	Low
Baleen™ Filter	Moderate	Low	Low	Low	High solids Lower volume	High
Salsnes™ Filter	Moderate	Low	Moderate	Low	High solids Lower volume	High

The comparison showed that the Baleen™ and Salsnes™ filters were the most suitable solution for treatment. Both types of filters follow a similar philosophy in processing wastewater where the unfiltered waste water is fed over a filter screen and pressurised jets (water or air) dislodge the solids from the screen into a separate catchment. The Baleen™ filter mesh is stationary, while moving water jets 'sweep' the solids off the mesh whereas the Salsnes™ filter mesh is constantly rotating and stationary air jets spray solids into an integrated screw press.

2.2.3 DESIGN DEVELOPMENT

Through further investigation into the two filters identified as suitable for the MSB WWTP, the Salsnes™ filter was chosen as the preferred option due to the

- Smaller footprint,
- Integrated air blower, and
- Integrated screw press for solids dewatering.

A trial Salsnes filter was organised to be installed at the MSB to verify its operation in-situ prior to Lion Co. committing to purchase the unit. The trial unit was installed using flexible hoses and temporary connections and inlet, outlet and centrate (water from dewatered sludge) samples were collected and tested. Results are shown in Table 4

Table 4: Trial Unit TSS removal

Sample	Inlet TSS [mg/L]	Outlet TSS [mg/L]
1	260	185
2	848	150
3	233	142
4	330	164
5	323	221
Centrate		8180

The results showed that the Salsnes™ filter could achieve the required solids removal, removing between 29% and 82% of the TSS. Although the Salsnes™ filter mesh size was larger than the Baleen™, it utilised the build-up of a solids cake on the filter to augment the filtration of smaller sized particles.

Craft breweries are not often funded by a large revenue stream and in this project, the available funds for the upgrade of the plant were limited. With this in mind, the design of the upgraded WWTP attempted to utilise as much of the existing plant equipment as possible while still providing a safe, workable solution.

2.2.4 INSTALLATION

The installation and commissioning stage of the project was set across a single week where production was put on hold to allow the works to take place. Construction was achieved on time, with minor adjustments made to the design to better suit the location. The process as installed is depicted in Figure 2 with Photographs 1-3 showing the installed system. The installation of the plant was on time with no LTI or MTIs and the total project was completed within the original budget.

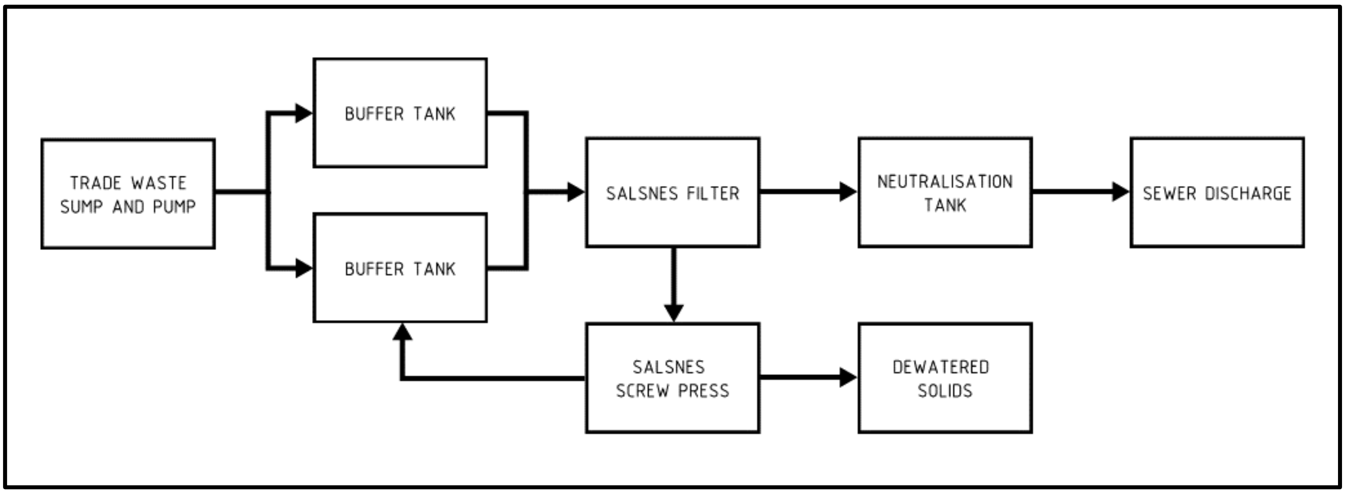

Figure 2: New MSB WWTP Block Flow Diagram

Photograph 1: Trade Waste sump and lead bag filter with steel mesh insert

Photograph 2: Inlet buffer tanks (background) and Salsnes™ filter (foreground)

Photograph 3: Neutralisation tank and chemical dosing

2.3 PERFORMANCE AND BENEFITS OF NEW WWTP

The newly installed plant was able to be started immediately after installation, and commissioned on the full wastewater flow from the brewing process, minimising the downtime incurred from installation of the plant. Benefits from the new plant were evident soon after commissioning.

2.3.1 REDUCED MANUAL HANDLING

As the Salsnes™ filter performs better with a higher solids loading, the 400µm bag filter was able to be removed from the first bag filter and replaced with a steel mesh insert to retain any large items (bottles caps, glass) that may damage the pumps or the Salsnes™ filter. Through this, operations were able to avoid 20-30 daily occurrences of shutting down the WWTP and emptying the bag filter, weighing greater than 20kg when full, from its housing. This alone saved approximately 2hours per day of site personnel time and reduced the likelihood of injury.

2.3.2 REDUCED CHEMICAL HANDLING

An operator initiated daytank refill of caustic was implemented to remove the need to manually transport and refill the daytank from the bulk store. In addition to avoiding manual handling of a container exceeding 30kg, operations were able to remove the risks associated with handling of a corrosive chemical.

2.3.3 REDUCED CHEMICAL USAGE

The previous WWTP did not allow any buffering of wastewater prior to pH neutralisation. The chemical dosing system was then subjected to wide fluctuations of pH and often struggled to dose enough chemical and maintain pH in the correct range (7.0-10).

In the new plant, the flocculation and neutralisation tanks were repurposed to act as buffer tanks upstream to the Salsnes™ filter and neutralisation was transferred to a smaller product tank prior to discharge. This buffering reduced the fluctuations in pH subjected onto the chemical dosing system which was then able to maintain dosing requirements while reducing chemical usage.

2.3.4 REDUCED OPERATOR INTERVENTION AND REQUIRED KNOWLEDGE

The new simplified WWTP is cleaned and maintained under a standard operation procedure which involves set daily, weekly and monthly checks and tasks. Outside of these tasks, operations are rarely required to intervene with the WWTP process which is in stark contrast to the 20-30 daily interventions operators were required to conduct in order to keep the previous WWTP operating. This increased predictability and reliability lead to more confidence in planning and time for maintenance tasks and less personnel frustrations.

Taking unit processes out of the WWTP such as the self-cleaning filter and UF plant reduced the knowledge required to operate and troubleshoot the new plant. If an issue occurs within the new plant, it was more easily identified and addressed.

2.3.5 IMPROVED AREA AESTHETICS AND ODOUR

With many craft breweries performing brewery tours through their plants, dirty and odorous WWTPs are undesirable. The new WWTP has proven to be relatively clean, only requiring a daily hose-down, and not suffering from any foul smells.

2.4 APPLICATION THROUGHOUT THE CRAFT BREWING INDUSTRY

The basis of the brewing process is common throughout all breweries. Wort is produced from ground malt, which is then boiled with the addition of hops. Yeast is added and the beer allowed to ferment prior to filtration and conditioning. Different breweries adjust recipes, quantities, ingredients, and times between stages however the outputs are largely the same – beer as a product, spent grain, hop trub, yeast, filtration/flocculation agents (in MSB case, diatomaceous earth) and cleaning/sanitising chemicals as waste. Typically, brewery wastewater is high in BOD and TSS content, which drives the design of the WWTP. In this case, the MSB wastewater's BOD was less of an issue compared to its high TSS content.

This commonality in processes and outputs lends itself to potential reapplication of this proven simple and robust solution for a craft brewery WWTP to other breweries.

3 CONCLUSIONS

Wastewater treatment plants can be daunting and complicated on sites where there is no specific wastewater expertise. The upgrade to the Malt Shovel Brewery's WWTP demonstrated how a plant design that does not properly consider the applicable parameters can affect production, compliance and operator wellbeing.

Understanding how the brewing process works, and the wastes it produces is critical in designing a practical, robust WWTP. The design should take into account throughput of plant, ease of operation, the possible impact on production, operability, the maintainability and discharge limits for the local authority. By taking a pragmatic approach, the re-designed WWTP at MSB was able to achieve greater production up-time, lower operator intervention, lower chemical usage and reduced the risks of injury from manual handling and the reduced the possibility of exceeding licensed discharge limits.

With the craft brewery industry constantly growing, more brewers are entering the market and along with the production of more craft beer, comes similar wastewater treatment issues. Although having specialised knowledge in brewing from study and experience, the brewer's knowledge around what to do with what goes down the drain may not be as vast. Being able to provide a simple design process, robust solution, and better understanding of wastewater treatment to these brewers benefits both the craft brewing industry and respective local water authorities.

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