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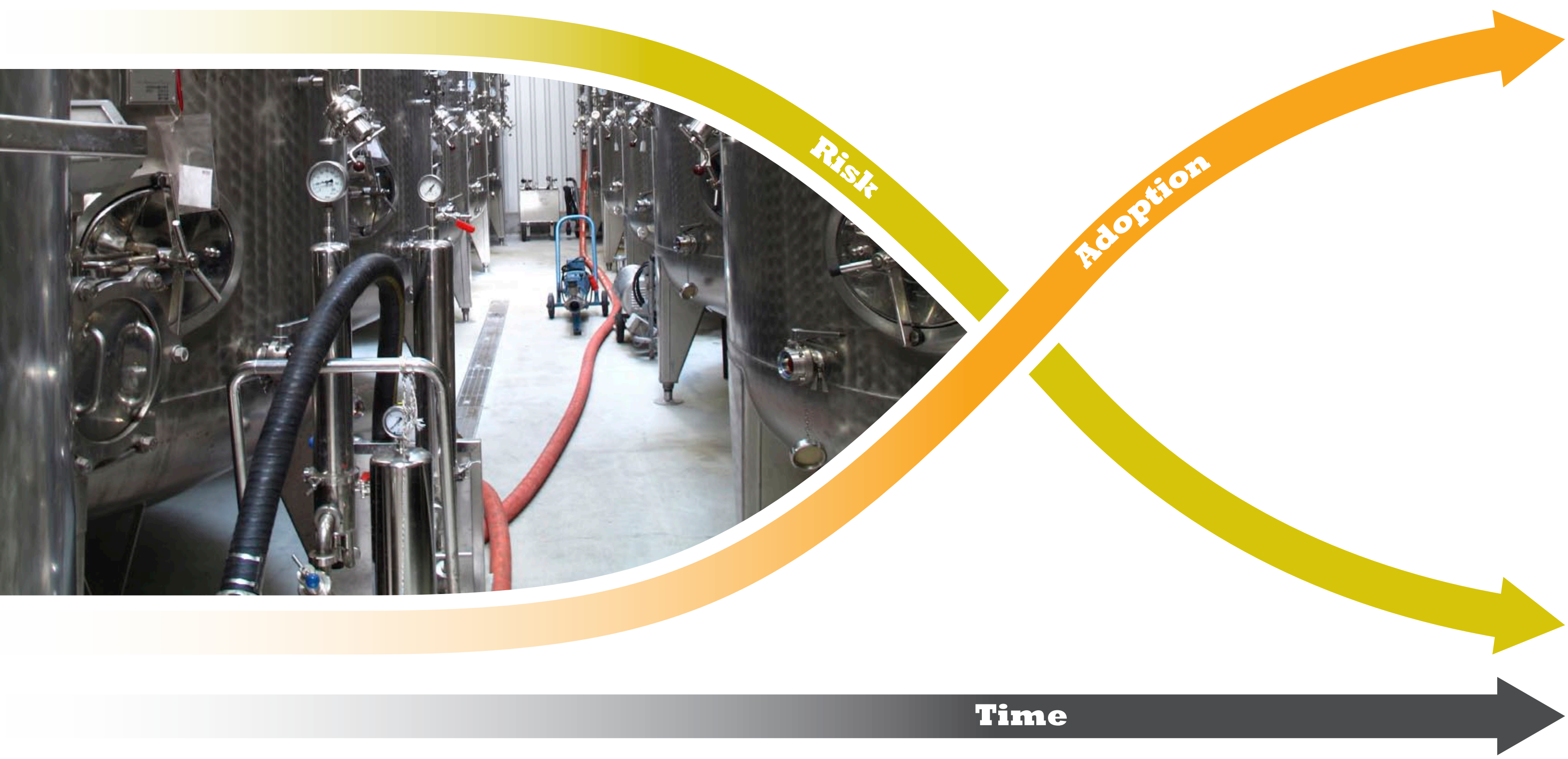
DEMONSTRATING THE CHALLENGES AND BENEFITS OF ON-SITE WASTEWATER MANAGEMENT IN ONTARIO'S FOOD AND BEVERAGE PROCESSING INDUSTRY



Investment in this project has been provided by Agriculture and Agri-Food Canada, the Ontario Ministry of Agriculture and Food, and the Ministry of Rural Affairs, through Growing Forward, a federal-provincial-territorial initiative.

Canada

Ontario

Growing Forward
A federal-provincial-territorial initiative

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Project Background

Water is an integral and strategic resource for the Ontario Food Processing Sector. It is emerging as one of the most pressing business risks facing the food sector. New and innovative solutions to manage water related risks and to address emerging water supply and wastewater issues are critical to the future economic success of the food sector and its ability to compete in both domestic and global markets.

The Bloom Centre for Sustainability (BLOOM) has been developing and delivering initiatives to increase the business acceptance and adoption of innovative water solutions by the Ontario Food Processing Sector. These activities have received support from Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs (OMAF and MRA), through Growing Forward.

The activities focused on addressing sector barriers to change and overcoming the risk averse nature of Ontario food processing businesses to innovative water solutions. This has been achieved, in part, by undertaking activities to understand water and water-related risks, to quantify the business benefits of water innovation, and to communicate innovation successes through case study examples and Water Innovation Forums.

Based on engagements with individual food processing companies and industry experts, one dominant issue emerged that was common to all of them, regardless of facility size, sub-sector or geographic location – the regulatory risks and increasing compliance costs related to wastewater management. The opportunity therefore, was to demonstrate the potential of on-site practices and solutions to cost-effectively manage and treat wastewater effluent from small and medium-sized food processing operations.

Pilot demonstrations of an innovative on-site wastewater treatment technology were undertaken in three different food processing sub-sectors – a cheese processor, a craft brewer and a winery.

The overall objectives of these pilot demonstration projects were to:

- Show how innovative solutions can be applied;
- Identify what changes are required at the operational and facility level to install and integrate these solutions – particularly by small-to-medium sized food processors;
- Determine how to capture and disseminate knowledge necessary to increase the capacity of the Ontario Food Processing Sector to adopt sustainable water solutions that can improve productivity, profitability and competitiveness.

Project Highlights

- Water is an integral and strategic resource
- New and innovative solutions to manage water risks
- Address sector barriers to change and overcome risk adverse nature
- Dominant issue – regulatory risks and increasing wastewater management compliance costs

The solution provider that supplied the technology for the pilots was EcoEthic, an Ontario-based firm that has the Canadian licensing rights to a wastewater treatment technology called BioGill. The project outcomes have added to the learnings from a bakery sub-sector demonstration of the BioGill technology with Weston Foods Canada, funded as part of a different project. The Weston Foods case study is available for download at:
www.bloomcentre.com/docs/BLOOM_CaseStudy_Weston_CI.pdf

The balance of this document is organized as follows:

- Sector Overview
- Pilot Demonstration Project – Overview and Objectives
- The BioGill Wastewater Treatment Technology
- Case Study – Portuguese Cheese
- Case Study – Flying Monkeys Craft Brewery
- Case Study – Cave Spring Cellars
- Key Findings
- Learnings
- Next Steps
- References

Sector Overview

With almost 3,000 individual processors, the Ontario Food and Beverage processing sector has an annual economic impact of over $35 billion. In 2010, food and beverage processors comprised the second largest manufacturing sector in terms of value of shipments and employment in Ontario. The sector is fiercely competitive, with company profit margins generally in the range of 3 percent to 6 percent[1]. With a wide range in operation scale, there is extensive variation in the capability and capacity to look beyond production objectives and pursue the business benefits associated with water innovation.

Inextricably linked within a food processing operation, water, waste and energy are key financial risk points for a processor, accounting for 15 percent of cost. According to the Ontario Ministry of Agriculture and Food (OMAF), the sector's annual combined expenditure on water, energy and waste is greater than the sector's overall profitability.

OMAF staff suggests that without efficiency measures, food processors can double their water use in eight years. Published municipal water supply and wastewater treatment costs are currently doubling every six years. As municipalities raise prices to full-cost recovery to finance water infrastructure renewal, this doubling rate is projected to shorten. Combined with rising energy and waste management costs, ever increasing water costs could push the sector to a position of reduced competitiveness.

In terms of water, about 70 percent of food processors rely on municipal water infrastructure for potable water supply and wastewater management, creating a strong degree of connectivity with municipalities. This makes the municipal water utility a key impacted stakeholder for food processors.

Yet, like food processors, municipalities have their own set of unique pressures and challenges. These include financing future water infrastructure renewal, increased regulatory compliance and rising utility costs, all of which they must continually balance with a mandate to provide affordable water services for their residential, commercial and industrial customer base.

Sector Highlights

- Over $35 billion sector
- Water, waste and energy are key financial risks accounting for 15 percent of costs
- About 70 percent of food processors rely on municipal water and wastewater infrastructure

Pilot Demonstration Project – Overview and Objectives

For the Ontario Food Processing Sector to successfully transform itself and implement more innovative water solutions, the various barriers to adoption must be addressed. Because food safety is of primary importance to food processors, individual facilities that make similar products are similarly configured. It is unrealistic to look to each processor to individually identify sustainable water solutions, obtain the necessary decision support information, and determine the adoption path. Not only is it duplication of effort, but given the limited capacity of the sector, an "individual" approach is not likely to achieve success for the majority of sector food processors.

Therefore, demonstrations must not only assess the technical capabilities of the proposed solution, but equally importantly, address collective issues, decision criteria, and success expectations of the relevant sector stakeholders who will be impacted by broad adoption – from the food processor through to the municipality and solution provider.

Success in these objectives is critical since the adoption of disruptive sustainable water solutions within a sector is often inhibited by a combination of barriers. These include: habits, behaviours and practices (an organizational culture of "we have always done it this way"), myths, misinformation, lack of awareness, and opinions not founded on facts.

The outcome goals of this pilot demonstration project were to:

- Define, collect and present key performance metrics and benchmarks;
    - Prove that the technology can treat wastewater that is representative of the food processing sector, to biological oxygen demand (BOD) and fat, oil and grease (FOG) levels that are below municipal discharge standards.
- Generate performance data to allow the solution provider, EcoEthic Inc., to design a commercial scale system, wherein lifecycle direct and indirect costs can be projected and return on investment (ROI) calculated.
- Highlight key learnings and insights that would facilitate broader adoption of on-site wastewater management solutions; and
- Use the demonstrations to showcase "what can be done".

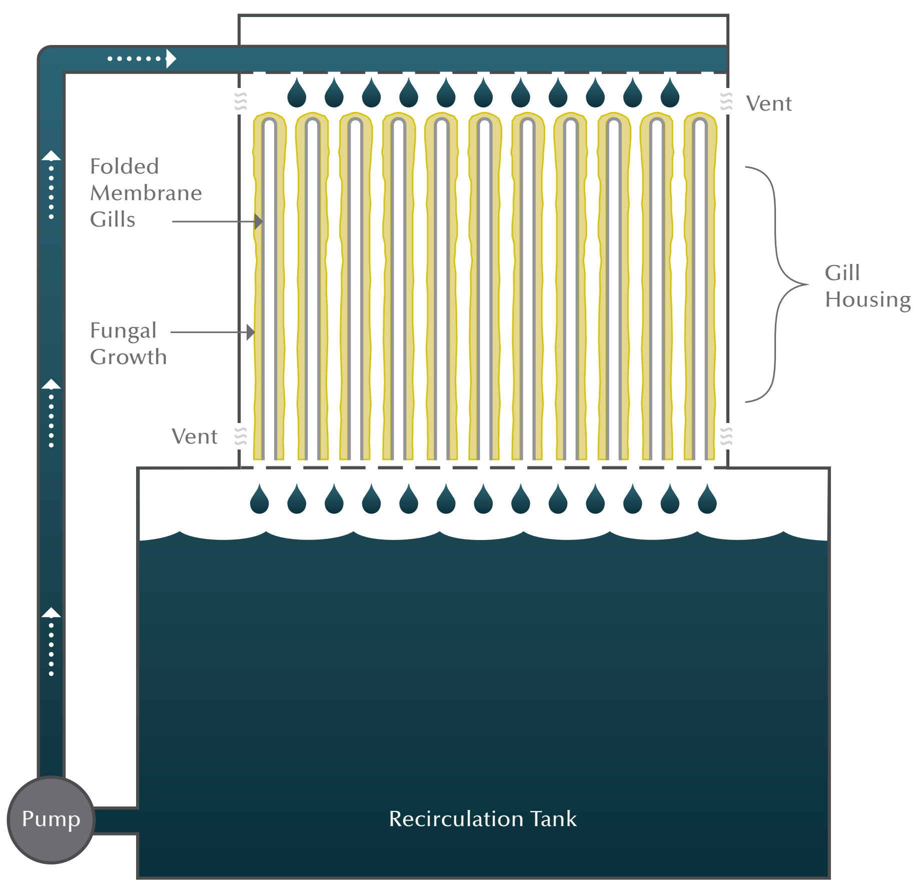
The BioGill Wastewater Treatment Technology

The wastewater treatment system used for the three pilot demonstration projects was provided by EcoEthic, a Canadian company that has licensed an innovative wastewater treatment technology developed in Australia. This new technology, called BioGill, is a low-energy, low-cost modular system that has the potential to treat high BOD and high FOG wastewater.

Most existing bio-reactor wastewater treatment technologies use large tanks, where the bacteria are submerged in water and aerated like the bubbles in a fish tank. Aeration is energy intensive and can create a "sludge cake" on top of the water which is difficult to treat. Additionally, water can only maintain a finite concentration of oxygen, creating a limiting barrier to bacterial metabolism.

The BioGill system is a unique bioreactor that provides optimized growth conditions for microbes (both bacterial and fungal). By providing the ideal habitat, above the wastewater recirculation tank and surrounded by oxygen, the microorganisms grow and flourish (see Figure 1).

Figure 1: BioGill System



BioGills are manufactured using a Nano-Ceramic Membrane™ (see Figure 2) incorporated into a bioreactor design to effectively operate as both a "stomach" and a "lung". The microorganisms develop on membranes that are folded to form a series of "gills", with the gills suspended above the wastewater tank. The folding allows wastewater to flow down one side of the membrane with ambient air on the other side.

Figure 2: BioGill Membranes prior to application

In operation, wastewater is pumped to the top of the gills, where it then travels down between the gills. With oxygen freely available, this provides the ideal environment for the microbes, allowing for the growth of fungal biomass which is not possible in submerged cultures. The resulting fungal biomass is much more effective than bacterial biomass in removing nutrients from the liquid stream.

As with many technology solutions that are commercially available in other parts of the world, the BioGill system has not yet been proven in Canada. It is important to note that, for many food processors, "not proven" can really be interpreted to mean "not demonstrated" under the commercial conditions that food processors require as part of their adoption decision process.

The concept of a solution not being "proven" also applies to technologies that are being effectively used in other sectors under similar conditions as the sector in question. Both of these definitions of "proven" apply to the BioGill system as it has been successfully demonstrated to treat high BOD/FOG wastewater in a variety of applications, including a travel resort and various food processors in Australia.

Case Study: Portuguese Cheese

Artisan Cheese Industry Overview

Cheese-making in Ontario pre-dates confederation, initially taking place on farmsteads in what is now Essex County as long ago as the 1780's. Ontario's first cheese "factory" opened in Norwich in 1864. By 1867 more than 200 cheese plants were operating in the province[2].

Industrialization of the sector through the early part of the 20th century led to consolidation of production, and the subsequent decline and closure of many of the smaller processors after World War II. However the smaller artisan cheese makers did not disappear completely. Today, the industry is revitalized with significant opportunity for growth.

Like any small food processor, the artisan cheese producer is focused on production, quality and food safety. However, there are emerging business challenges related to water and wastewater that can impact future growth and profitability of the artisan cheese industry.

Ontario Cheese Industry Facts

Canada	National production is close to 400,000 tonnes a year[3]
	A little over half of annual production is specialty cheeses[3]
Ontario	Ontario accounts for about 30 % of Canada's total cheese production[3]
	30 % of provincial production is attributed to Ontario's small scale and artisan cheese sales at approximately $300 million a year[3]
	Sales of small-scale and artisan cheeses are set to grow by $100 million in Ontario over the next decade[4]
	To support this growth, there is an opportunity for a further 25 to 50 new artisan cheese makers within the province[4]

Drivers for Change – Cheese Production

Whey is a liquid by-product of cheese production that is also a significant contributor to wastewater issues for small cheese producers.

Unfortunately, for many small cheese processors the only viable option is to view the whey as a "waste" to be disposed of as part of their wastewater. This approach presents a significant wastewater challenge as the biological oxygen demand (BOD) of whey is very high at 40,000 mg per kg, in addition to its high fat content. Consequently, even small amounts of whey in the wastewater loading can easily result in the facility being out of compliance with regulatory standards.

The whey can become a value added product for the cheese producer, but not in the form that it is in when removed from the cheese vat. To extract the value, the whey must be further processed, which means handling in a manner conducive to the intended end use. Common value-added whey usage alternatives, as a liquid and/or powder, include:

- Food ingredient through further refinement
- Feed source for farm livestock
- Feedstock in biodigesters producing energy

Cheese Whey

- Approximately nine kg of whey are produced for every one kg of cheese
- Whey is approximately 93 percent water
- Whey solids equate to ½ kg for every one kg of cheese produced

The handling and processing for the first two options is similar to any other food product, requiring pre-processing, including sanitary handling, cooling and prevention of contamination. It requires the processed whey to be collected and transported to secondary processors. Unfortunately, taking advantage of this opportunity is where economies of scale come into play.

For the small cheese processor, who focuses most of their attention on production, their ability to invest in whey handling equipment and processing systems is minimal or non-existent. Furthermore, small cheese companies do not generate sufficient daily whey volumes to justify the investment to process whey for sale as a value-add product.

A small facility could consider combining whey volume from several production days in order to reduce transportation cost, but this would still require significant investment in whey handling and storage equipment not to mention the space required for the various tanks and handling equipment.

Demonstration Host

Portuguese Cheese Company is a family-owned business. The current owners purchased the business from the founder in 1999. Portuguese Cheese brings together the best of the old and new worlds, by integrating Ontario ingredients with heritage know-how.

With more than 40 years in business, the company is dedicated to the art of crafting traditional Portuguese cheeses based upon family recipes from Portugal. Portuguese Cheese is known for their fresh and semi soft cheeses and has in the recent years expanded into serving new markets in the Latin American and Middle Eastern communities.

In their federally licensed cheese plant, they use 100 percent fresh cow and goat milk under exact quality specifications, and utilize modern packaging equipment.

Facility Details

Portuguese Cheese is located in an older industrial area in the City of Toronto. The cinder block constructed building has two stories, with total area of approximately 10,000 square feet.

Expanding production is limited by the small footprint of the facility. Space is at a premium both internally (Figure 3) and externally, as the facility has a very small lot and shares a driveway with a neighboring business. Expansion is also challenged with the area becoming increasingly residential, with little public support for a continued industrial presence.

Figure 3: Portuguese Cheese Company Production Area

As with many smaller processors, Portuguese Cheese does not have identical daily operations throughout the week. The facility has one shift per week, with cheese production normally occurring Monday to Thursday, and Fridays used for cutting, packaging and plant sanitization. The operation is closed over the weekend.

Current Situation

Portuguese Cheese has a total of ten staff, with five in production including: Production Manager; Assistant Cheesemaker; and factory staff.

To produce their cheese, Portuguese Cheese buys an annual volume of almost 1.9 million litres of cow and goat milk. This generates approximately 28,000 to 36,000 litres per week of whey production. Currently, all of the resulting whey and process wash/rinse water goes down the drain with no pre-treatment. As a result, Portuguese Cheese is out of compliance with the City of Toronto sewer use by-law and paying high wastewater surcharges.

Management has been evaluating options to address this issue. For example, fine mesh screens were placed over floor drains in late 2012 to reduce solids entering the wastewater flow. Also, the facility recently installed a clean-out-of-place (COP) wash tank which allows for wash water (including soapy water) to be recycled 3 to 4 times prior to it being sent down the drain. It is expected that this will save chemical costs, while hopefully reducing wastewater pH and phosphorus levels.

Like other small food processors, Portuguese Cheese has to constantly balance the requirements of different regulations. Portuguese Cheese is a real world example of this balancing act as they work with their sanitation chemical supplier to ensure that the new COP system will maintain the acceptable levels of sanitation for the cheese molds and containers as required by CFIA, while endeavoring to reduce chemical use and the resulting residual concentration of the chemicals in the wastewater.

Specific to the issue of whey, Portuguese Cheese has been pursuing options to capture and remove the majority of the whey from the wastewater. This will require a silo to hold the diverted whey stream. Space constraints have forced Portuguese Cheese to site the silo at the front of their building.

Project Details

For the demonstration project at Portuguese Cheese, EcoEthic installed a temporary pilot-scale BioGill system. As noted earlier, Portuguese Cheese is representative of many small processors in its extremely restricted available space and access to water, energy and wastewater infrastructure. This made the installation of the demonstration unit a challenge as the equipment could not be located near the wastewater access.

Figure 4: Wastewater Access Challenges – Deep, Narrow Diameter External Access

Within the Portuguese Cheese facility, all wastewater sources consolidate into a common drain under the concrete floor. Unfortunately, there is no internal access to the consolidated wastewater, so the EcoEthic team had to draw their influent water from a deep, narrow external access well in the front parking lot (Figure 4).

To make the demonstration set-up work, EcoEthic placed an insulated holding tank in the parking lot beside the access well. The wastewater was drawn up into the storage tank, which also acted as a "balancing tank" to smooth out any periodic high and low concentrations of wastewater contaminants in an effort to maintain a consistent composite wastewater profile (Figure 5).

While the ideal set-up for a pilot would have been to locate the BioGill equipment near the wastewater access and the drain, this was not feasible for Portuguese Cheese. The layout of the Portuguese Cheese building has cheese production positioned at the front of the facility, so there was no feasible way to locate the BioGill equipment nearby. The only available location was at the back of the building on the second floor (Figure 6). The wastewater was therefore pumped from the external tank at the front of the building to a second holding tank situated on the second floor beside the BioGill equipment. This second tank was used to fill the BioGill equipment during its batch runs.

Figure 5: External insulated wastewater holding tank

Figure 6: Internal equipment location – BioGill and second wastewater holding tank

Results

The characteristics of the wastewater turned out to be different than expected, which in turn negatively affected the demonstration performance.

The demonstration operating parameters and membrane surface area were based upon wastewater analyses. Experience during the demonstration highlighted that this data did properly represent the fluctuations in wastewater composition associated with production variability over the work week. While this disconnect between design expectations and actual wastewater composition impacted the performance of the BioGill technology, the bigger technical challenge was due to the unexpected behaviour and impact of residual fine curd solids and fats in the wastewater.

When the wastewater is drawn from the combined drain, the issue is not readily apparent when visually assessing a sample. However, when the wastewater was collected and stored in the holding tanks, the undisturbed conditions permitted a large percentage of suspended fats and fine solids to separate out. Despite this beneficial separation, residual suspended fine solids entered the BioGill unit. In doing so, they eventually partially blocked the lower parts of the gill structure, effectively reducing the useful gill surface area.

Technology Performance

BOD Removal	Up to 60% of the high BOD influent
TSS Removal	Up to 62% reduction
TKN Removal	Up to 60 % reduction
Total FOG Removal	Up to 72% reduction

The wastewater variability, combined with the restricted gill area, pushed the system to an operating condition well outside of design. Despite this, the BioGill system still delivered very promising removal performance as noted in the sidebar. Progressive buildup of solids within the gill structure ultimately limited the performance of the demonstration.

However, based on the results, it would be expected that with diversion of the whey from the wastewater, followed by pre-filtration to reduce fine solids to design levels, the BioGill technology would be capable of treating effluent wastewater concentrations to below City of Toronto discharge requirement levels.

Case Study: Flying Monkeys Craft Brewery

Craft Brewing Industry Overview

The modern craft brewing sector in Ontario emerged in 1984 with the opening of the Brick Brewing Company in Waterloo. This successful business proved the market potential and demand for craft beer.

The sector became more organized in 2005 when several craft brewers formed the Ontario Craft Brewers (OCB) Association.

"Craft brewery" is a marketing term to reflect micro-brewery scale organizations. According to the OCB, a craft brewery is defined by its production volume. For the OCB, their cut-off is 400,000 hectolitres per year, a value that is currently well beyond the production of any OCB members.

The craft brewing sector is a vibrant industry in Ontario, recognized by the provincial government as a growth area. Government interest and support is reflected in a recently closed government program, the Ontario Microbrewery Strategy, where they revised the tax structure to support growth, development and competitiveness of the industry. A key focus of the strategy was to increase awareness and marketing to drive consumption.

The program was successful, expanding consumer awareness of Ontario craft brewers from 20 to 80 percent over four years. Awareness is obviously linked with consumption as Ontario consumption of craft beers is growing despite the fact that alcohol consumption on the whole is largely flat[8].

Ontario Craft Brewers Association Facts[5]

- 30 members
- Estimated economic impact on Ontario of approximately $300 million annually
- 600 direct jobs – 20 per cent of the total employment of the Ontario brewing industry

Other Craft Brewery Industry Facts

- Sales of Ontario craft beer reached 6 % of the total beer market, or roughly $190 million in 2010[6]
- Ontario craft beer sales rose 45 percent in 2011[6]
- The female beer drinker market is relatively untapped and is an increasingly growing target[7]
- $4.7 billion worth of beer, wine and spirits were purchased through the LCBO in 2011[7]

The OCB does not represent the full breadth of independent brewing in the province. In fact, there are many other "craft breweries", as defined by either their size and/or business structure. The *Ontario Brewers Directory*[9] contains a listing of all craft brewers. These include nanobreweries, microbreweries, contract brewers, and brewpubs that are currently operating commercially, or have applied or intend to operate commercially in Ontario.

Sector Water Use Breakdown (L Water/L Beer Produced)[14]

- Packaging – 38 %
- Cellars – 17 %
- Utilities – 20 %
- Brew house – 25 %

Source Contribution Examples[14]

Spent Grain Wash	Cellulose, Nitrogenous material
	Very high in suspended solids (approx. 30,000 ppm)
Yeast Rinse (Fermenter)	Suspended solids of approx. 6,000 ppm
	BOD up to 100,000 ppm
Beer Spillage	11,000 ppm BOD

Drivers for Change – Craft Brewing

Water is a critical component of the craft brewing business, both in the product itself and as part of the production and bottling processes. Water use varies significantly among breweries, and is influenced by the size of the brewery and the processes used within the operation. The U.S. average is seven litres of water used per litre of beer produced. The amount of water used is closely linked with wastewater generation, as most brewers discharge 70 percent of the input water as wastewater[10].

The wastewater challenge for breweries goes beyond volume to what is in it. There are a variety of process steps associated with beer production, each with significant differences in contributions to both wastewater volume and composition. For example, bottling can generate a large volume, but have low BOD levels. In comparison, fermentation and filtering can account for 97 percent of the BOD and significant suspended solids (SS), but only three percent of the volume.

Wastewater will continue to grow as a business hurdle that directly affects breweries and their growth. A key contributor to its continued existence is the fact that craft brewers, given their size and capacity limits, must ensure that production and quality objectives take top priority.

Yet given the expected future risks of increasing wastewater treatment costs and competition for treatment capacity, brewers need to be mindful of the need to change their practices. The long-term sustainability and growth of the craft brewing sector will be impacted by its ability to cost-effectively manage its wastewater.

Demonstration Host

Flying Monkeys Craft Brewery is located in downtown Barrie, Ontario in a renovated and expanded heritage building dating back to the 1800's. Founded by Peter Chiodo in 2004, the brewery initially operated as Robert Simpson Brewing Company, in honour of Barrie's first Mayor and brewmaster, Robert Simpson.

The original brews that they were producing did not represent Peter's interest to deliver beers that were truly unique in taste. As a result, the name was changed in 2009 to its current moniker, Flying Monkeys Craft Brewery. Along with their tagline "Normal is Weird", the change was felt to better reflect the personality of both the business and its brewing philosophy.

Flying Monkey's goal is to excite and engage their customers by producing high quality, uniquely flavoured beer that heightens the craft beer drinking experience. To do so, the brewery produces five year-round beers, along with a variety of specialty beers throughout the year.

Facility Details

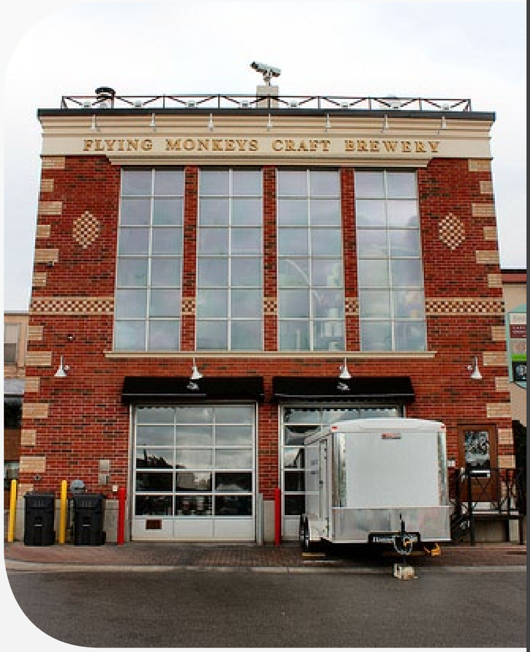
The brewery operations (Figure 7) are located in a 3600 ft^2 modern extension built off the back of a storefront in the old part of downtown Barrie. The extension (Figure 8) was part of the 2004 start-up activities. The original storefront is being utilized as offices, a main floor retail facility and a second floor event room. Production takes place in a two story main floor brewhouse, with packaging taking place on the lower level, directly beneath the brewhouse.

Production occurs daily Monday to Friday, which includes several days of brewing and filtering. Three days of the week are also usually committed to bottling.

Flying Monkeys doubled their production capacity in 2012 through the addition of five new 90 hectolitre fermenters and one 120 hectolitre bright beer tank for finished beer. They currently produce 8,500 hectolitres of beer (2.4 million bottles) annually. Along with this growth in production, the work force has doubled over the past two years to 30 full-time and several part-time positions. Their current water to finished beer volume ratio is 5:1, which is better than the US average.

Credit: Katy Watts (www.sgmw.ca)

Figure 7: Brewery Operations



Credit: Katy Watts (www.sgmw.ca)

Figure 8: Rear View of Brewery Extension

Flying Monkeys has currently reached maximum capacity for the space available in the expansion. There is no room left in the brewhouse for additional tanks, with a potential expansion to their bottling line eliminating the balance of space in the packaging area. External expansion is constrained by their location in downtown Barrie.

Current Situation

As Flying Monkeys focused on growing their business, they were unaware of the high BOD wastewater that they were generating and discharging to the municipal sewer. With support from the City of Barrie, they started addressing their brewery effluent, beginning with their processes. A key component of the change is efforts to manually remove the majority of their spent grains from the process, as well as yeast, hops, and filter powders. These solids are collected in a large trailer in the lower level which, when full, is picked up by a local farmer for use as a feed supplement.

Figure 9: Installation in Corner

As part of a treatment strategy prior to wastewater discharge, there is a two stage interceptor in the floor of the lower level. The interceptor captures the majority of the suspended solids, resulting in a reasonably clear wastewater effluent going to discharge. In addition to improved solids management, a chemical reclamation and reuse practice has also been implemented, to save costs and to reduce the chemicals that were going to the drain.

Through these changes, Flying Monkeys believed that they significantly reduced their BOD to a level that was just slightly over the 300 mg/L limit set by the City of Barrie. Their interest in this demonstration was to explore if the BioGill technology could treat their relatively low BOD wastewater to a level below discharge limits, which would bring them into compliance and reinforce their commitment to be a sustainable brewer.

"We are very limited by our available space. This poses a challenge when it comes to adding new equipment or systems."

Paul Buttery, Head Brewer and Hop Warlock, Flying Monkeys Craft Brewery

Project Details

Similar to Portuguese Cheese, space was at a premium in this facility. The equipment had to be located in a corner away from the wastewater source (Figure 9).

Despite this, the location was still very close to high usage filling and packaging areas. To ensure that the piping was not interfering with fork lift traffic, nor contributing to any health and safety concerns, all of the piping was suspended through the ceiling joists (Figure 10). To further ensure that there were no issues with food safety, the lines were assembled without any overhead joints to prevent any overhead leakage.

Figure 10: Piping Through Ceiling

The system was initially designed to operate within the wastewater parameters that Flying Monkeys believed that they were achieving at the exit of their interceptor – approximately 1,000 mg/L BOD and marginal total suspended solids (TSS). The resulting set-up had a pump pulling wastewater from the second stage of the interceptor, and transferring that water into a holding tank to be used to fill the BioGill as part of its batch runs. The system was to run for two to four weeks to develop the microbial and fungal cultures to a steady state level prior to undertaking the full performance trials.

This long ramp-up was not actually required as brewery wastewater rapidly cultured on the gill membrane fabric. In fact, culturing was even taking place on the distribution manifold that distributed wastewater over the gill membrane.

Figure 11: Solids Blockage

Unfortunately, at the start of the demonstration it was found that wastewater contaminants were considerably in excess of the levels that Flying Monkeys believed that they were achieving, with BOD, TSS, and TKN levels much higher than expected. The significant variances in wastewater influent were attributed to the different strengths and flow volumes created by variations in filtering, brewing and bottling from day to day. These operational realities were further exacerbated by issues with interceptor performance.

Despite the removal of a large percentage of solids as part of their solids management strategy, residual solids built up very quickly in both stages of the interceptor. Compounding the issue was the fact that the residual solids from the brewing operation tended to be fairly fine. As such, they were easily disturbed by periodic hydraulic flows passing through the interceptor system, which "re-suspended" the settled solids.

These suspended solids were picked up by the transfer pump and distributed throughout the entire BioGill equipment (Figure 11), causing blockages in the manifold apertures and loading the membranes with solids. The severely restricted flow within the BioGill unit, combined with solids "blinding" of the membrane microbial and fungal mass to oxygen and nutrients, led to a partial die-off of the biomass with a resultant odor.

Figure 12: Pump Vault in Interceptor

To address this, EcoEthic had to re-design and re-install the system after the first week of operation. To mitigate the rapid build-up of solids in the interceptor, they installed a pump vault (Figure 12) within the second stage of the interceptor to protect the pump.

To further reduce exposure to suspended solids, they also added a 200 litre pump vault within the 1,000 litre black plastic holding tank, as well as inline filters between the holding tank and the BioGill system. Valves were also added to the plastic tank and the BioGill process tank to facilitate solids sludge removal. This revised system was used to complete the balance of the demonstration.

Results

As noted above, there was considerable variance in the wastewater influent composition, which in turn impacted the performance of the BioGill technology.

The system was configured to address the target incoming effluent of approximately 1,000 mg/L BOD with marginal TSS. Unfortunately, the system was exposed to BOD levels that varied by a factor of 10 times design levels, often within the span of a week. Experience over the course of the demonstration indicated a need to pump out the interceptor weekly, if BOD levels and TSS levels were to be maintained at the low levels that Flying Monkeys expected.

Technology Performance

Influent BODs	688 mg/L right after servicing interceptor to 9,727 mg/L in one week
BOD Removal	49 to 76 % of the high BOD influent
TSS Removal	80 to 86 % reduction
TKN Removal	41 to 77 % reduction
Total P Removal	7 to 41% reduction

The BioGill technology was able to remove substantial amounts of BOD, TSS and TKN with a small trial system. Positive trending occurred in the latter parts of the pilot after sustainable cultures had been established within the system, with BOD and TSS reduction levels hitting 72 and 88 percent respectively. Constant buildup of solids within the components was a constant limiting factor to achieving a consistent performance benchmark.

Assuming appropriate pre-treatment to reduce suspended solids and maintain a consistent influent composition as per design expectations, the BioGill technology should easily be capable of treating effluent wastewater concentrations to below City of Barrie discharge limits.

The City of Barrie currently does not apply a wastewater surcharge to Flying Monkeys, which directly impacts the business case and ROI for any wastewater treatment system. Further complicating the development of a business case for wastewater treatment solutions in the current operation is the fact that Flying Monkeys will probably move to a new production facility within five years.

Case Study: Cave Spring Cellars

Wine Industry Overview

The Ontario wine industry has grown rapidly over the past 20 years. In 1993 there were only 17 wineries in Ontario, yet today there are 140 wineries located across the province in five major regions – Lake Erie North Shore & Pelee Island, Niagara Escarpment & Twenty Valley, Niagara-on-the-Lake, Prince Edward County, and emerging regions[11].

Ontario wineries have 40 per cent of the total market of all wine sold in the Province[12]. Beyond the value from sales directly adding to Ontario's economy, every bottle of Ontario VQA wine sold in the province generates $12.29 in added value (above sales and direct markups) to the Ontario economy for a total economic impact of approximately $215 million[13].

Ontario VQA Wine Industry Key Facts and Statistics[11]

- Total retail sales of Ontario VQA wines in 2013 were $346 million
- 17.4 million litres of VQA wine was sold in 2013
- 21.9 million litres of VQA wine was produced in 2013
- 750,000 litres of Icewine was produced in 2013
- 150,000 litres of late harvest wine was produced in 2013

Tourism is a large contributor to the "added value", driven by an estimated 1.8 million people visiting VQA wineries annually[11]. When considering the broader wine regions, the Ontario wine industry attracts over 1,900,000 visitors annually, generating $644 million in tourism and tourism employment related wine industry economic impact[14].

Drivers for Change – Wine Making

The majority of winery wastewater is generated during the cleaning of winemaking equipment and facilities. The quantity and quality of wastewater is subject to large seasonal variations, with peak generation of wastewater occurring during crushing, when the grapes are processed into juice for fermentation.

Wastewater issues within the Ontario wine sector are largely related to specific issues including high BOD, acidic pH (around 3.5), and in some instances phosphorus (K). Wastewater issues can also limit business expansion. For wineries that discharge to municipal sewers, plans to expand production under the present treatment arrangements can be an issue for the municipality. For the many Ontario wineries that use septic systems, the availability of land, as well as the associated engineering costs, present difficulties when seeking to expand their septic beds to meet planned production growth.

Beyond compliance objectives, wastewater management is also linked to efficient winery operations and profitability, therefore being as much a business issue as an environmental or technical issue. For example, given the tourism impact of the sector, sustainable wastewater management is a visible indication of sound winery management and reinforces the image of wine as a product that is made with a focus on quality at all levels. The proactive management of winery wastewater can also position wineries to mitigate the risks associated with rising water/wastewater costs and regulatory reporting requirements, while supporting their public relations and brand reputation.

Demonstration Host

Cave Spring Cellars is a family owned winery located in Jordan, Ontario that has been producing VQA wines since 1986.

More than three decades ago, the cultivation of European grape varietals on the Niagara Peninsula was pioneered by the family with the planting of their first Riesling and Chardonnay vines at the Cave Spring Vineyard in 1978. Five years later, Cave Spring Cellars was established in Jordan, Ontario.

The company has expanded over the years to include the On The Twenty Restaurant and the Inn on the Twenty. In 2003, a new spa facility was added to the Inn and in 2005 the growing hospitality business expanded with the renovation of a local landmark, the Jordan House Tavern and Hotel.

Since its establishment over 25 years ago, Cave Spring Cellars has established itself as one of Canada's most acclaimed wineries and is earning a reputation for crafting elegant and distinctive cool-climate wines in the heart of Ontario's wine country.

Facility Details

Figure 13: Cave Spring Cellars Basement with Tanks and Barrels

With the growth of the business over the years, the facility now combines a restaurant, shops and an Inn, in addition to the winery operation. The primary facility is an older building circa 1920's with a main level and basement (Figure 13). The winery is situated on the main floor and runs under the length of the building. At the back of the winery, there is a drop off to a ravine, which prevents any opportunity to expand in that direction.

Cave Spring Cellars produces 60,000 to 70,000 cases of wine per year. The number of production staff ranges from five to ten people, working 8 am to 5 pm, Monday through Friday. However, during the September and October harvest season the operation shifts to 20 hours per day, seven days per week.

Current Situation

With the growth of production over the years, the existing wastewater treatment system is under-sized and cannot meet the current needs of the winery. In addition, this system is located in the wine cellar, close to production and there are issues with operational disruptions and odours.

The existing wastewater treatment is unsophisticated, with two tanks of approximately 2,500 litre volume each connected in series. The first tank is a primary settling tank with a coarse bag filter on the tank inlet, with manual pH adjustment. The secondary tank has a limited degree of aeration intended to lower BOD to required discharge levels. The system is not automated, with manual operation creating risks around inaccurate pH adjustment in addition to wastewater overflows.

“...what are we to do and who do we believe.”

Dave Hooper, Winery Operations Manager, Cave Spring Cellars

Unlike many food and beverage processors, the desire to change at Cave Spring Cellars is not being driven by wastewater surcharge costs, which are approximately $4,000 per year. Rather, the driver for change is the close proximity of the current system to production and its potential negative impact, both actual and perceived, on quality. In addition, there are public tours of the winery operation and ideally the wastewater treatment system should be located in a separate enclosed area.

Faced with a desire to improve their treatment approach, Cave Spring Cellars approached several vendors for potential solutions. There was considerable variation in the recommendations at a range in costs from $70,000 to $1.25 million. The lack of consistency across the proposed solutions, combined with this wide cost variation, left the winery confused on how to move forward effectively.

Project Details

Unlike the other two demonstration sites (Portuguese Cheese and Flying Monkeys), Cave Spring Cellars was able to provide a near ideal installation location for the demonstration. EcoEthic installed the BioGill pilot equipment (Figure 14) adjacent to the current wastewater treatment equipment.

Figure 14: BioGill Pilot Unit and Balancing Tank in Basement at Cave Spring Cellars

The BioGill drew the wastewater from the first tank of the existing wastewater treatment equipment. The wastewater was held in a large 5,000 litre balancing tank, which was used to fill the BioGill for the various batch runs. The BioGill pilot equipment was able to be automated in the Cave Spring Cellars demonstration due to the reliable influent composition that aligned with expected wastewater design parameters. The treated BioGill effluent was discharged back into the existing wastewater system for disposal to drain.

The winery wastewater took longer to culture on the BioGill membranes than wastewater from brewing or cheese processing due to several factors, including the impact of alcohol and other naturally occurring grape and wine components that act to inhibit microbial growth. Also, the winery BOD was much lower than the other two pilot demonstration facilities thereby providing less "nutrients" for microbial growth.

Results

The first indication of positive performance was related to odor. The wastewater influent is normally quite odorous, but after recirculation through the BioGill equipment, it quickly became odour free. As this was a key performance objective of the winery, facility staff were quite happy with the noticeable improvement, noting that it "smells better down there now than ever before".

By the end of the trial, the water effluent from the BioGill unit was achieving levels far below discharge limits – BOD 42 mg/L (300 limit), TSS 91 (350 limit), pH and total phosphorus were both within range.

Based upon the successful pilot results, Cave Spring Cellars is proceeding with the purchase and installation of a full-scale commercial BioGill system.

Technology Performance

Influent BODs	4100 mg/L
BOD Removal	Greater than 97%
TSS Removal	90% reduction
Total P Removal	83% reduction

> **"...the system is a raging success. I am excited to ramp up to the full size and see what we can accomplish."**

Dave Hooper, Winery Operations Manager, Cave Spring Cellars

Key Findings

Despite differences between food sub-sectors in these three demonstration projects, the lessons learned are relevant across the broader food and beverage sector.

Wastewater Characterization

In two of the three demonstration facilities, there was a disconnect between the actual wastewater composition and what was expected based upon pre-installation discussions with the host processors. There appear to be three primary reasons for this:

- **Internal operational variability** – All three of the facilities were "batch" operations, with a different balance of production, packaging and other processes taking place over different days within any given week. As a result, the volumes, flow rates and composition of wastewater effluent varied significantly from day to day, and even hour to hour.

  For small processors to be successfully positioned to address their wastewater challenges, they need to be able to cost-effectively develop accurate, representative profiles of their wastewater relative to operations. This critical data is the foundation for internal process and practice changes such as source reduction.

  In addition, a detailed understanding of this operational variability is equally important to potential solution vendors, as they cannot design and implement new approaches that are based upon assumptions and/or incomplete information.

- **Wastewater testing** – There was no capacity for or capability within the three facilities to characterize their own wastewater. Instead, like many SME's, they rely upon periodic municipal tests. As a result the company's wastewater profiles lacked the granularity to relate to real-time production or sanitation.

- **Pre-treatment requirement** – One aspect of the demonstration activities included "pushing" the performance of a promising technology solution. All three hosts provided "expected wastewater composition profiles based on municipally-measured parameters. The actual wastewater composition of both Portuguese Cheese and Flying Monkeys differed so much that the end-of-pipe system was overwhelmed. The demonstration "failures" provide proof that source reduction and pre-treatment technologies prior to primary treatment are imperative. This is a cost that smaller processors cannot avoid and will reduce the cost of any primary treatment solution.

- **Portuguese Cheese** – In this instance, diversion of the whey from the drain system would significantly reduce both the total volume of wastewater going to sewer and also the BOD loading of the wastewater. With a proper whey management system in place, the resulting wastewater could then be collected in a large holding tank with a capacity of several days' wastewater volume. This would address daily operational variances, balancing concentration spikes to a more homogeneous level.

  This balanced wastewater would then require additional fine solids removal, followed by secondary treatment (i.e., BioGill) to below discharge levels.

- **Flying Monkeys** – The solids, both course and fine, were the unexpected issue that contributed to the operational challenges experienced by the BioGill pilot equipment. The nature and quantity of the solids exceeded the ability of the current interceptor to prevent their migration downstream.

  To facilitate successful treatment of their wastewater by a technology such as the BioGill, a craft brewer such as Flying Monkeys will likely require a multiple stage solids management approach, prior to any further treatment.

A craft brewer such as Flying Monkeys will likely require a multiple stage solids management approach, prior to any further treatment.

To address daily variances, the wastewater should go into a large holding tank to balance concentration spikes and also to reduce the impact of flow surges disturbing settled solids in the interceptor due to the tanks being drained. This holding tank would also act as a primary solids settling vessel, with settled solids removal through the bottom. The settled solids can be pumped out and disposed of either with the spent grains (if compatible with end use) or as a waste. The settled wastewater will then require fine filtration through filter bags and/or a similar screening approach.

Given the low BOD levels noted in the wastewater influent to the BioGill when the interceptor was recently cleaned out, this suggested solids management approach should position the craft brewery for successful treatment by a technology solution such as BioGill.

Operational Upsets

Unfortunately, the unexpected wastewater challenges at both Portuguese Cheese and Flying Monkeys, led to the demonstrations not achieving the wastewater BOD discharge goal of less than 300 mg/L. However, by greatly exceeding the BOD/m^2 design envelope of the BioGill demonstration unit, the demonstration was able to explore system behaviour and performance that could be expected under conditions representative of operational upset.

- **Performance Envelope** – EcoEthic was able to better understand how the system operates under very high BOD and TSS conditions, which helped to define the "upset indicators" such as odor, microbial overgrowth, and biomass die-off. Additionally, there is now a more complete understanding of severe flow restriction and its impact on channeling of both air and/or water flow over the membrane gills. This type of practical operational knowledge is key to addressing future installation issues as well as contributing to operator and service training.

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- **Odor** – When considering any microbial-based wastewater system, there is always concern about odor. In the case of the three demonstrations, when the system was operating within design parameters, there was no odor from the BioGill unit. For example, at Cave Spring Cellars where the actual wastewater composition aligned with design information provided at the start of the demonstration, even though the influent initially had a strong odor, it became largely undetectable within an hour of beginning treatment by the BioGill unit.

  Where there were odor issues at Portuguese Cheese and Flying Monkeys, this was largely due to:

  - Influent well above expected levels of BOD and TSS, contributing to equipment operation issues, or,
  - Operational interruptions due to locating the BioGill pilot system in busy work areas.

Space Constraints and Scale of Operations

Space and scale are a challenge for small food processors.

- **Space** – For small processors, all available space is prioritized to production, packaging and inventory management. Furthermore, using the three demonstration host facilities as examples, small processors do not usually have access to large areas of available outside property. Consequently, they have very limited space to install solutions.
- **Scale** – The challenge of installing solutions that tend to be designed for larger facilities is further impacted by the comparatively lower water and/or wastewater quantities. In many instances, conventional industry solutions are not effective at the reduced operating scale of the smaller food processor.

Modularity and easy mobility will be key design requirements.

The opportunity for technology and solution providers is to design and make available equipment that can be flexibly configured and easily scaled to work within the facility and process needs of the small food and beverage processor. Solution providers must also recognize that there is potential for growth by small processors, hence the solutions must be easily expanded to match changing needs. Modularity and easy mobility will be key design requirements to successfully address many food and beverage processor's business growth, water and wastewater challenges.

Learnings

The three pilot demonstration projects were successful in several ways, providing learnings that can support both the development and greater adoption of innovative water solutions. These include:

- Confirmation that the pilot on-site wastewater treatment solution is technically and economically feasible within defined influent and effluent performance boundaries.
- Development of insights into what other solution components are required to ensure a full-scale commercial system can be integrated into an operation and achieve regulatory compliance requirements.
- Identification of the need to implement upstream source reduction practices and other operational improvements to improve water and wastewater management practices.
- A better understanding, by both the processors and the solution providers, of how food facility operational procedures and processes can have unanticipated impacts on the effectiveness of new treatment technologies and systems.
- Obtaining equipment operational insights and performance data to allow the solution provider to design and install a full-scale commercial system that is compatible with the capacity and size of the smaller food and beverage processor.

When considered in hindsight, many of the learnings presented above might seem obvious. Yet it is a reflection of the capacity challenges of small food processors that apparently obvious issues must be given lesser priority, with production and food safety always at the top of the priority list.

Solution vendors interested in serving this market must also re-think their role in supporting their clients. Commercial solutions targeted to small food processors must accommodate their operational realities and perform in such a way that there is minimal risk associated with their adoption.

Practical, commercially relevant demonstrations, where outcomes and key performance metrics can be quantified and communicated, are key to reducing uncertainties associated with adopting something new.

The data and insights from the demonstrations have been used by BioGill in the design of their next generation of demonstration and commercial-scale systems. EcoEthic is also aware that pre-treatment of the influent is critical to the successful adoption of the BioGill system, and are exploring application specific options to "de-risk" operational integration by specific sub-sectors of the food and beverage processing industry.

For the sector at large, a key method to continue to reduce the uncertainties associated with adopting something new is through practical, commercially relevant demonstrations where the outcomes and key performance metrics can be quantified and communicated.

Next Steps

This demonstration project can be viewed as a first step in what is a progression of continued activities to pilot and demonstrate innovative water technologies, approaches and solutions under "real world" conditions within the Ontario Food Processing Sector. This is a critical requirement as it is this key performance data, learnings and other findings that facilitates adoption and mitigates risk – not only for the processor but all other stakeholders who could be either barriers or advocates of adoption.

BLOOM is now collaborating with the Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs to plan and conduct additional pilots and demonstrations.

Some of the opportunities that will be investigated and demonstrated include the following:

- **Integrated Water Reuse** including characterization of water usage opportunities and water quality "requirements" to allow for reuse within the facility and/or in other aspects of the business operations.
- **Disruptive Wastewater Prevention and Treatment Solutions** that support optimized resource management and food safety expectations.
- **Water Management Utility Information Systems** that support the understanding of how and where water is used, and allow food processors to capture and measure the hidden or "invisible" costs of water beyond the purchased water costs or the wastewater discharge costs, and also include the costs related to lost energy, lost product and lost ingredients.
- **Full-Scale Commercial Integrated Wastewater Treatment System Solutions** Including other technology components such as solids management, monitoring and control systems.

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