ALBERTA INNOVATES

CLEAN ENERGY FINAL PUBLIC REPORT

1. PROJECT INFORMATION:

Project Title:	**Lagoon Utilization Project**
Alberta Innovates Project Number:	AI 2393B
Submission Date:	April 15, 2020
Total Project Cost:	$920,714
Alberta Innovates Funding:	$460,357
AI Project Advisor:	Susan Carlisle

2. APPLICANT INFORMATION:

Applicant (Organization):	**Swirltex Inc.**
Address:	#56, 5335 6th Street NE, Calgary AB, T2K 5Y4
Applicant Representative Name:	Melanie McClare
Title:	Chief Executive Officer
Phone Number:	403-869-6799
Email:	mmcclare@swirltex.com

3. PROJECT PARTNERS

Throughout this project, Swirltex has been very fortunate to have had such supportive and collaborative partners. The town council members and operation staff in Drayton Valley, Ponoka, Crossfield and the Edmonton International Airport, have all been instrumental in the execution and operation of this project. We acknowledge their dedication, hard work and support in this project. In addition, without Alberta Innovates, we would not have been able to build this asset and gain the valuable knowledge and intellectual property advancements that have moved the needle for Swirltex.

A. EXECUTIVE SUMMARY

With the support of this grant, Swirltex designed, constructed and commissioned a wastewater treatment plant consisting of novel Swirltex technology encompassing membranes and aeration devices. The purpose of this pilot was to assess the effect that the Swirltex process has on the long-term health and capacity of rural municipal wastewater lagoons. In addition, the quality of filtered water and logistics involved in the recycling of this water was evaluated. The objective of the project was to demonstrate the immediate and long-term effects of the Swirltex Lagoon Unit (SLU) on contaminant and nutrient concentrations in a wastewater lagoon. With this project, Swirltex was aiming to demonstrate the feasibility and benefits of implementing mobile membrane units on existing lagoon infrastructure in rural Albertan municipalities.

The results that were measured and recorded included key wastewater quality metrics, such as total suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia, nitrates and bacterial counts. With operation and testing on both the Ponoka and Crossfield lagoons, it was demonstrated that the Swirltex treatment was making a positive impact on lagoon through aeration and mixing at the same time as producing high quality permeate (or effluent) through the membranes. This permeate was produced consistently at a high quality and therefore fit for re-use for several applications. There were challenges involved with achieving sustained operation of this pilot. These challenges were both technical and regulatory in nature. Through these challenges, Swirltex was able to learn and grow, to be better prepared for future projects. Swirltex was therefore required to move the unit a couple of times, as well as suspend operations due to regulatory and logistical hurdles. During the suspended times, Swirltex focused on lab scale testing and R&D for intellectual property development. The time spent in the lab has been invaluable to the development and continued improvement of the technology.

Through this process, Swirltex gained many technical insights and learnings that will be carried forward to future unit designs. These learnings are both specific to our membrane process, as well as more general design considerations for modular units in this climate and for this application. Specific to the Swirltex process, we made significant advancements in our understanding of aeration technologies, their benefits and drawbacks with respect to our process. By operating the two different membrane trains side by side, we were able to compare a variety of configurations, two different membrane suppliers, in addition to multiple different aeration mechanisms. In the lab, Swirltex was able to better refine the membrane cleaning process and chemicals through sustained testing and experimentation.

The benefit that we demonstrated and realized most significantly is the ability to produce high quality permeate for discharge or for re-use for agricultural applications. In the Town of Crossfield, Swirltex collaborated with the Collicutt golf course to deliver treated water for irrigation. We delivered over 30,000,000 L of water to the golf course for irrigation in the summer of 2019.

B. INTRODUCTION

Sector Introduction

The Swirltex Lagoon Utilization Project contributes to wastewater treatment in rural Albertan municipalities for the improvement and augmentation of lagoon systems. Rural communities struggle with increasing populations and aging wastewater treatment infrastructure. The cost to upgrade a lagoon with an additional cell, increased aeration or continuous mixing is costly and a financial burden on the community and its members. Alberta Environment reports over 400 lagoons in Alberta that will require upgrading in the next 10 years. With a deficit on infrastructure spending, it is becoming more difficult for rural communities to remain compliant with increasingly stringent environmental regulations. The need for effective and affordable water treatment upgrades is therefore essential.

Swirltex's unique business model, treatment as a service, and mobile unit design reduces capital investment for the community and allows for this municipality to benefit from a new technology with lower risk. Another benefit for the community, with this business model, is that the treated reuse water can be marketed and sold to local industry and used to encourage economic development through cost savings from recycled water.

Knowledge/Technology Gaps

The knowledge gaps that were addressed with this project include the technical feasibility and economic viability of membrane treatment as a solution for municipal wastewater treatment. Additionally, Swirltex investigated the extent to which added aeration, through the Swirltex process, can enhance the performance of a lagoon in terms of biological breakdown. The way by which the SLU is designed allows for clean water (permeate) produced by the membranes to be collected in a tank or piped directly to be re-used. The concentrate stream is recycled back to the lagoon. This concentrate stream contains significantly higher concentrations of oxygen than the original feed water and therefore facilitates biological and chemical breakdown within the lagoon. Refer to Figure 1 below illustrating the process flow of lagoon wastewater through the unit. The extent to which this aeration in the concentrate stream improved lagoon performance was a technology gap being investigated in this project.

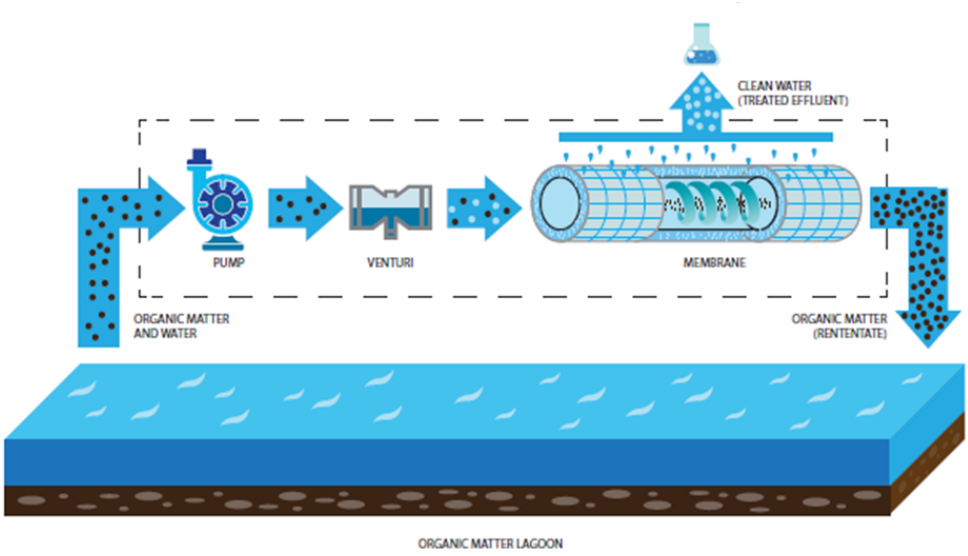

Figure 1: Process flow of the Swirltex Lagoon Unit

The unique technical aspect of the Swirltex system is the centrifugal flow pattern by which the wastewater flows through the tubular membrane. Refer to Figure 2 below for a photo of the PVDF membranes utilized by Swirltex. To date, implementing membrane systems on lagoons has not been effective due to poor configurations and infrastructure requirements. Suspended solids, like algae, can quickly clog a membrane making less ineffective. The SLU overcomes this by manipulating the buoyancy of the wastewater through microbubble air injection, preventing the suspended solids from contacting the surface of the membrane. As the liquid is pumped through the tubular membrane, the dissolved air forms small bubbles which adhere to the suspended solids, allowing the solids to "float" into the center of the membrane. A helical vane generates a vortex directed along the length of the tube. This rotational motion causes the lighter air-solid particles to be concentrated toward the center axis through centrifugal force, thus avoiding fouling and improving flux.

Figure 2: Tubular membranes utilized by Swirltex

The air-infused wastewater is separated from clean water as it passes along the length of the tubular membrane. The clean water permeates through membrane wall while the highly oxygenated concentrate stream is sent back to the lagoon through the center of the tubes. The rapid increase in dissolved oxygen and drastic pressure change diminishes carbonaceous biochemical oxygen demand (CBOD) from the waste stream. In addition, the dissolved oxygen stream returned to the lagoon accelerates the natural biological breakdown of solids within the lagoon.

Figure 3: Demonstration of concentrate from SLU adding aeration to lagoon

Methods by which to inject air into the Swirltex process was tested and studied. There are many different methods used in industry for air addition into water for wastewater treatment purposes. The various methods have benefits and drawbacks in terms of energy requirements, pressure drops, air bubble size, cost, etc. The device or method that is beneficial for some processes may not work for the Swirltex process due to the process flow. This is what was studied over the life of this pilot. Therefore, aeration mechanisms are another technology gap Swirltex aimed to fill with this project.

Additionally, this project focused on addressing the technological gap of vortex and centrifugal flow generation within a tube. This aspect of the project was mostly investigated and tested at the bench scale unit at the Swirltex headquarters during the time that the pilot was not operating.

C. PROJECT DESCRIPTION

Knowledge/Technical Description

This grant supported the design, construction, commissioning and operation of a Swirltex Lagoon Unit (SLU). This unit contained two trains of tubular membranes, as well as pumps, instrumentation, air compressor and air injection mechanisms. The unit was to be situated along a wastewater lagoon, to be fed by lagoon wastewater. Once through the system, the wastewater would be separated into permeate (clean filtered water) and concentrate (containing solids) to be recycled back to the lagoon.

The ultrafiltration membranes used in the plant are polymeric and tubular in configuration. Each membrane module, 8in in diameter, contained hundreds of 8mm tubes where the wastewater is passed through the microscopic pores, to separate the solid contaminants and bacteria. The pilot plant contained two different trains on either side of the unit. One train had membranes from Pentair, and the others were Memos membranes. This allowed Swirltex to compare the qualities from each manufacturer.

In terms of aeration, Swirltex tested different devices and mechanisms on the two trains over the course of this project. These methods included venturi, aeration stones, nozzle injection and air sparging.

Updates to Project Objectives

As the project has evolved significantly since the beginning, there have been updates to the project objectives. Due to economic and regulatory hurdles, the unit had to move from Ponoka to Crossfield and lastly to the Edmonton Airport.

Due to the smaller capacity of the unit, it was difficult to identify significant impacts of BOD and ammonia reduction as a result of the Swirltex unit on the Ponoka lagoon. The objective, therefore, once the unit moved the Crossfield, was to measure energy consumption and operating up-time of the unit. Concentrations of ammonia and BOD were no longer metrics of success measured.

Performance Metrics

The metrics chosen as measures of success included reductions in TSS and fecal coliforms in the wastewater stream. The energy consumption and run time of the unit was also recorded and measured as a performance metric. As previously stated, ammonia levels and BOD were originally listed as performance metrics, however, due to the size of the unit and treatment configuration, these were measured were removed.

D. METHODOLOGY

This project was divided into milestones by which Swirltex set goals to complete. The first milestone was manufacturing of the SLU.

Manufacturing

This process was divided into sub-tasks, including design, modelling, sourcing material, procurement and fabrication. The manufacturing was completed in Calgary with the design support and fabrication of the firm, Aerotech Specialty Welding, that is experienced in building wastewater treatment systems.

Mechanical & Electrical Tie-Ins

The next step in the progress of the project involved moving the unit to site and connecting it electrically and mechanically. The electrical work was conducted by a Global Controls and mechanical tie-ins was done by the Swirltex team.

Operation and Testing

Once the unit was up and running, wastewater samples were to be taken from three different streams. Samples were to be taken from the feed water from the lagoon, membrane permeate as well as concentrate streams. These samples were planned to be taken twice per week at the Ponoka lagoon.

Initially, we used Red Deer Labs for testing, soon after changing to ALS Lab Services due to convenience.

Changes & Troubleshooting (Unplanned)

For various reasons, including logistical, regulatory and technical, the Swirltex team had to delay or postpone continuous testing to address immediate issues. These issues included pump failures (lob pumps), compressor maintenance, and aeration technique changes for each train. We also had trouble getting Alberta Environment approval to run the membrane system at the Crossfield lagoon to irrigate the golf course which caused some project delays and adjustments to operating times.

E. PROJECT RESULTS

Key Results

Milestone #1 – SLU Construction

This task was initially completed in good time. However, the design and equipment within the SLU has been changed, maintained and upgraded throughout the entire life of the project due to learnings and challenges encountered as we went. There have been upgrades to the electrical equipment, heating within the unit, aeration and piping configurations. All of these changes were made at Swirltex cost with no addition to the AI project budget.

Milestone #2 – Operation & Testing

Swirltex was able to gather data over several months demonstrating the benefits of the SLU at each the Ponoka lagoon and the Crossfield lagoon.

From the Ponoka lagoon, the lab testing results demonstrated the expected reduction in TSS levels from feed to permeate. The anticipated reductions in ammonia and cBOD could not be achieved due to the system set-up at the lagoon. The configuration was not optimized for mixing and oxygen transfer for biological breakdown. Continuous testing also proved to be a challenge at the Ponoka site as the unit required a retrofit and regular unforeseen maintenance. Swirltex made significant technical learnings from this experience for future designs.

In July 2019, the unit was moved to the Town of Crossfield, Alberta. The data collected over the summer of 2019 in Crossfield included both water quality data and system run time. The Swirltex unit treated water for golf course irrigation at the Collicutt course in Crossfield. However, Swirltex and the Town of Crossfield did not obtain approval from Alberta Environment to operate the system as per designed. We were unable to recycle concentrate water back to the lagoon. Therefore, the effect of the Swirltex treatment on the lagoon could not be measured.

Through operation, the Swirltex team was able to test out various aeration technologies. Swirltex compared these solutions based on energy requirements, air pressure and bubble size optimization.

- Venturi: Initially, venturi devices were installed as air injection mechanisms. Upon operation, however, these devices proved to be energy inefficient as a large pressure drop was experienced across them. The venturis restricted flow within the unit and caused shaking.

- Moleaer: this system utilized compressed air through a porous medium to produce microbubbles aeration. The benefit to this solution is the ability to control bubble size for more optimum floatation. We learned from operation, however, that the Moleaer system also has a large pressure drop and does not supply sufficient air bubbles for our application.

- Nozzle injection: this system was a custom designed and fabricated unit for air injection using small orifice spray nozzles. These were effective at delivering high volumes of air. It was difficult, however, to control bubble size or assess the degree to which the solids were being manipulated by the air.

- Sparger: Swirltex has just recently purchased a sparging device from Eriez, by which high pressure air is injected at an angle into the stream, creating fine bubble dispersion, allowing for even mixing and promoting solid particle attachment. The team is still learning and experimenting with this technology currently.

Swirltex recently earned a project at the Edmonton International Airport for treating glycol in a lagoon. The SLU was moved to serve this project in March, 2020 and it is currently being set up for continuous operation. The effect of aeration on reduction of chemical oxygen demand (COD) levels is the most important metric for this project. This application to the Swirltex lagoon unit is out of scope of this grant project, however, demonstrates the benefit the adoption potential of this technology in wider markets.

In parallel with testing the SLU in the field, the Swirltex team was working at the bench scale to advance the technology and design. Lab testing involved testing wastewater on scaled down membranes to assess water quality results on various wastewater feeds. Additionally, the team tested various flow configurations and air-water ratios to assess hydraulics for flow optimization. This lab work is not included in this scope of this grant.

From this testing, the team gained a stronger understanding of membrane operation, including frequency of cleaning cycles and best cleaning chemicals for particular contaminants. This supported the development of standard operating procedures (SOPs) used in the pilot.

On the IP side, the team made significant advancements in the design of the membrane caps for vortex generation as a result of the lab testing. The team filed a second patent for this updated configuration in February 2020.

Milestone #3 – Third Party Assessment & Final Reporting

Originally, the plan was to employ Urban Systems to submit a final assessment and report on the SLU. In lieu of that, Swirltex and the Town of Crossfield engaged Fossil Water (Bill Berzins, P.Eng) to work with Alberta Environment and the Town of Crossfield as a third party reviewer for the pilot project. The assessment, outlines and details the benefits of the SLU system for the Town of Crossfield as well as for the Nose Creek Watershed. The technical memorandum analyzes the wastewater treatment upgrade solutions for the Town of Crossfield and compares these to the Swirltex solution. The Swirltex treatment option proposed would draw wastewater feed from the effluent storage cell, treat through the Swirltex unit, then continuously feed permeate to irrigate the neighboring golf course. The memorandum highlights the environmental benefits of the Swirltex model to the town of Crossfield and the surrounding environment. The memorandum analyses the alternative treatment solutions compared to Swirltex. The analysis was based on the objectives set out by the Town of Crossfield and are summarized below:

- Improve downstream water quality in accordance with the Nose Creek Watershed Partnership Water Management Plan
- Reduce the risk of violating its Code of Practice approval
- Reduce the potential for downstream flooding
- Reduce the use of potable water for industrial purposes by increasing re-use

Both the Town of Crossfield and Fossil Water are currently working together to understand the government's stance on treatment of Crossfield's wastewater.

Project Specific Metrics

The metrics for success measured in this project, as previously mentioned, include:

- TSS
- cBOD (unable to obtain result)
- BOD (unable to obtain result)
- Ammonia (unable to obtain result)
- Phosphorus (unable to obtain result)
- Fecal Coliforms
- Membrane Flux
- Power Consumption
- Operability

Expected vs. Actual Performance

The table below summarizes the expected vs actual performance of the SLU based on its operation in Ponoka and Crossfield.

Table 1: Expected vs. Actual Performance Metrics Swirltex Lagoon Unit

Metric	Ideal target	Minimum requirement	Achievements to date (Permeate)	Note
TSS	< 5 mg/L	< 5 mg/L	< 3 TSS mg/L	Consistently achieved.
cBOD	< 10 mg/L	< 10 mg/L	Inconclusive	Further testing required with longer run time on lagoon. Removed as metric of success
BOD	< 5 mg/L	< 5 mg/L	Inconclusive	Further testing required with longer run time on lagoon. Removed as metric of success
Ammonia	< 5 mg/L	< 5 mg/L	Inconclusive	Further testing required with longer run time on lagoon. Removed as metric of success
Phosphorus	< 5 mg/L	< 5 mg/L	Inconclusive	Further testing required with longer run time on lagoon. Removed as metric of success
Fecal Coliform	< 10/100mL	< 10/100mL	3 / 100mL	Achieved
Flux	140 $L/m^2/hr$	100 $L/m^2/hr$	120 $L/m^2/hr$	Intermittent tests done for short durations. Longer run times required. We did these tests in the lab and achieved better results than expected (200+ L/m2/hr)
Power Consumption	< 1Kwhr/m3	<3 Kwhr/m3	2.5 Kwhr/m3	Horizontal configuration requires larger recirculation pumps than new configuration discovered in the lab.
Operability	Up time 30 days, no mechanical or process issues with the plant	30 days	18 days	Undersized permeate pump could not keep up with flowrate of the system (higher than anticipated flux) – higher throughput than originally designed.
Testing Frequency	Feed (F), Permeate (P) & Effluent (E) samples collected 2x per week for 6 months.	N/A	**Ponoka**: 2x F, P, E samples taken in February 2018, 5 samples F, P & E collected in March 2018, 2 x F, P, E taken June 2018 **Crossfield**: 5x F, P samples collected over July – August 2020	Due to the logistical, technical, and regulatory challenges, the initial targets were difficult to meet.

F. KEY LEARNINGS

Key Learnings

<u>Milestone #1 – SLU Construction</u>

In the construction phase of the SLU, there were several significant learnings made by the Swirltex team.

- Environmental condition considerations: we learned that it is integral to properly design for the site and environment that the unit must operate and weather conditions it must endure. The team did not originally design with proper insulation to protect from winter cold. We had to fix this mistake after running into freezing problems.

- Electrical design: improper electrical design proved to be detrimental, and we came into many electric issues due to changes in loading. For future projects, we will require third party engineering review.

Milestone #2 – Operation & Testing

Most of the learnings from this project were made during operation and from analysis of testing results. These include:

- **Pumps**: Swirltex originally installed a positive displacement pump that was sized for 125 m^3/hr on each of the two process trains. During operation, the output of the pump was lower than specified. After three months of operation, the mechanical seal on one pump failed and the other showed signs of damage. In speaking with the pump manufacturer, EC&M, we learned that the piping configuration upstream of the pump, as well as the air addition to the recycle stream could be contributing factors to the pump failure/damage. The pumps were repaired and supplemented with pressure by an additional feed pump placed in the lagoon.

- **Aeration**: through testing the various devices including the Venturi, Moleaer, nozzle injection and sparger, it was determined that the sparger works most optimally for this application.

- **Membranes**: by running two membrane trains side-by-side, with different sized membranes and different manufacturers, Swirltex came to understand its preferences. The Memos membranes proved to be higher quality in terms of consistent products and greater integrity and durability. It also became evident that shorter length membranes are much easier to maneuver in terms of operability.

During this period, Swirltex also carried out testing work in the lab. The learnings gained on the bench-level were instrumental in moving the technology forwards and used to apply design modifications to the pilot plant.

The learnings we made on the bench level, which aligned with our project objectives include:

- Refined a membrane cleaning process for lagoon wastewater. This includes learning what best chemicals to clean membranes with and at what frequency for this particular stream

- Tested the membrane configuration as well as vortex generating devices in the lab as to improve future designs for commercial units

Milestone #3 – Third Party Assessment & Final Reporting

Swirltex engaged Fossil Water (Bill Berzins, P.Eng) to prepare a technical memorandum analyzing the wastewater treatment upgrade solutions for the Town of Crossfield and comparing these to the Swirltex solution. The alternatives considered by the town, and compared in this memorandum, include expanding existing lagoons, investing in a mechanical treatment plant for discharge or irrigation, or tying into a wastewater pipeline diverted to Airdrie. It was determined, based both environmentally and economically that the Swirltex solution benefits the town the most. The concluded benefits outlined include:

- Lower capital expenditure than the alternatives
- Lower operating costs than the alternative upgrade solutions
- Environmentally reduces strain on the Nose Creek watershed through continuous discharge as opposed to seasonal

Additionally, the team became more familiar with the environmental regulatory process for wastewater treatment and re-use in Alberta. From this process, the hurdles associated with applying for approval became evident. The major reason behind the challenge in receiving approval was based on making changes to the existing lagoon system flow. Alberta Environment did not approve any changes made to the existing lagoon systems without a great deal of supporting data, which is difficult to achieve without testing. One of the major hurdles in particular with the Swirltex technology, is the return of more concentrated solids back to the lagoon system. Our defense to this is the added aeration to the lagoon through the microbubble injection which facilitates the further breakdown of these solids. However, additional data is required by Alberta Environment to accept this claim.

G. OUTCOMES AND IMPACTS

Project Outcomes and Impacts

Regarding the technological and knowledge gaps outlined in Section B, the Swirltex team was able to better understand and fill these gaps with this project.

Feasibility of implementing system for water re-use: the team came to recognize the regulatory hurdles involved with wastewater re-use in Alberta. Swirltex became familiar with the regulations and the process by which to obtain regulatory approval for the water re-use for irrigation, environmental discharge as well as for making design and flow changes to a lagoon. For the next project, Swirltex will be better equipped and prepared to line up this approval ahead of time.

Aeration mechanism: in the field, a number of different aeration technologies were tested out, and we learned about each one under operation, as outlined in the Section F: Learnings. The team has developed a much stronger understanding of the technologies available and their strengths and drawbacks for different applications. We will take these learnings into future designs and projects, improving our ability to deliver the quality of treatment

Vortex generation: as a result of the work done on the Swirltex bench-unit, the team moved forward a great deal in the system design in terms of vortex generation. Through physical testing on prototypes in the lab, a variety of designs were tested, including 10 different twisted tape designs. In addition, both horizontally oriented and vertically oriented tubes were tested and it was determined that vertically oriented tubes are better able to create the desired annular flow pattern that achieved phase separation. The next steps for developing vortex generation include making computer models of these designs we have tested in the lab to better understand the flow characteristics and how they are altered with vortical flow.

Technology Readiness Advancement: prior to this project, the technology was at a TRL level of 4, where the certain components of the system had been tested on a smaller lab scale. All components of the technology and design had never been completely integrated in one system. As a result of this funding

and project, the technology is now at a TRL 7, having had the opportunity to test a complete packaged system in an operational environment.

Program Specific Metrics

% Improvement in overall water efficiency

The Town of Crossfield was able to reuse 30,000,000 L of wastewater rather than discharging to Nose Creek, which is stressed each year by the Town's 21-day discharge. The reuse occurred over the summer of 2019 operations, where the water was re-used by the Collicutt golf course. That re-use reduced the discharge to the Nose Creek by ~6%.

Project Outputs

The outcomes of this project include:

- second patent filed
- several abstracts for conference presentations
- vertical configuration design for next generation
- aeration mechanism and sizing
- increased exposure and case study opportunities

H. BENEFITS

This funded project was Swirltex' first full scale commercial unit that allowed for the generation of revenue. This helped in many areas of the Swirltex business, garnering sales and interested customers, demonstrating the environmental benefits and supporting the retention of key highly qualified personnel at Swirltex.

Economic

This project has been of great benefit to Swirltex in terms of stimulating opportunities and facilitating additional projects. It has aided greatly in the sales process, as we have been able to walk interested customers through the pilot, allowing them to understand the process and its benefits. It has been instrumental in Swirltex gaining customers in the oil and gas space as well as for a new market of airport lagoons.

Not only did this project attract new customers for Swirltex, it has also helped to draw new investors, especially strategic water centered investors.

This project has not only been beneficial economically for Swirltex, but it has demonstrated to the town of Ponoka and Crossfield an economic opportunity in terms of revenue from re-use water sales to local industry. The business model for these customers was a treatment service, whereby they would pay either a rental fee, or a cost per volume of water treated. To create incentive for water re-use, the towns could sell wastewater on a cubic meter basis to businesses in need of water.

It was a challenge to find water re-use opportunities in the town of Ponoka, but in the Town of Crossfield, there were many opportunities for water re-use sales. The Town now has a newfound resolve to re-use their wastewater as a result of the Swirltex influence.

Environmental

Environmentally, this project has inspired and encouraged the possibility of water re-use many Alberta municipalities. With operation at the Crossfield lagoon over the summer, and water re-use at the Collicutt golf course, the unit reduced the discharge load on the Nose Creek Watershed by 30 million litres. The capacity of the unit is much greater than this, and the team is excited for it to operate at full capacity and reduce even more the volume of wastewater discharge.

Social

The lagoon utilization project demonstrated the potential community benefit that can be created through implementation of such a small, modular unit. Through operation at each municipality, Swirltex was able to see and experience the way in which the project brought the community members closer through a shared desire to improve wastewater treatment and environmental practices.

Swirltex was able to demonstrate, especially at the Crossfield lagoon, the benefit that treated wastewater can have to improve the greenspace, recreational value of a community through increased volumes and access to water. With the recycling of wastewater, golf courses, farmers, green spaces are able to increase irrigation, improving the quality and aesthetic of the space for community members.

In the Town of Crossfield, for example, great social benefits can be realized with the implementation of a Swirltex lagoon unit. The town requires a wastewater treatment upgrade and the alternatives do not offer the same social benefits as the Swirltex solution. It has been proposed for Crossfield to tie-in to a regional line, where the wastewater would be piped away and treated in a larger facility outside of the town. This solution, however, takes money out of the town. It requires the residents to pay an increased fee for their sewage treatment, where that money does not stay within the town. With the Swirltex solution, the water is treated locally, and the water re-use benefits will be realized directly in the town by the businesses and residents.

Building Innovation Capacity

This project has allowed for Swirltex to build and refine its' team of highly qualified personnel. The team, including two young engineers, has had the opportunity to learn and grow with direct and hands-on experience working at the pilot plant, operating and understanding the process. Through learning in the field, the newer members of the team are now able to design piping systems, pump requirements with supervision and can assist in troubleshooting technical issues. The team was also able to learn and create at the bench scale. In addition, the team was directly involved with the management and development of computer modelling with Coanda Research and Development. Not only did the team learn from the models themselves but learned a great deal about the process of computer modelling. This skill will definitely be useful in future projects. These two jobs will be sustained after this project.

With Swirltex' strong social media presence, there are many professionals interested in joining the team, from both Alberta and outside the province. Swirltex is continuously receiving inquiries from interested HQPs. We believe there will be many opportunities in the future to bring on more HQP to fill the current gaps of the small team. There will likely be 3 more positions to fill within the next two years.

I. KNOWLEDGE TRANSLATION

This project allowed for the first full scale deployment of the Swirltex technology, through which the team made numerous learnings. These learnings were both technical in nature, as well as logistical, marketing and business centered. We feel that many of these learnings should be shared with others in the industry and in government to improve environmental practices and system quality through collaboration. Swirltex values participating in conferences and events at which we share our learnings and updates. The vision for Swirltex is to improve wastewater treatment practices both in industry and municipalities to allow for recycling, as to reduce strain on fresh water sources. The most noteworthy conferences/public events where Swirltex shared this knowledge has been at the Alberta Water & Wastewater Operators Association seminars, WEFTEC, town hall meetings in Ponoka, Crossfield, Thorsby. Swirltex has presented ~30 times throughout the course of this project. There have been about 12 publications on the technology in magazines and news outlets, including in the Edmonton Journal, the Calgary Herald, and Global News on the Ryan Jespersen show.

The learnings that will be shared with industry from this project include the process by which to gain regulatory approval for water re-use. We believe strongly in advancing Alberta in water treatment and re-use practices, ahead of the curve of demand. We therefore find it very important to inform the public and other companies in order to work together for increasing wastewater treatment quality, and greater volumes of recycling. We do this through a strong presence on social media, promoting our vision to others as well as our attendance at relevant events in the industry.

J. RECOMMENDATIONS AND NEXT STEPS

The Swirltex technology has several applications in wastewater treatment. As a result of this project Swirltex was able to explore the municipal wastewater treatment market and were introduced to the airport lagoon space. This project also served as an example that allowed for us to gain projects in produced water.

Swirltex will continue to pursue municipal projects for wastewater re-use. In this endeavor, we will be working closely with the Town of Crossfield, whom we became partners with through this grant. Swirltex still strongly believes in the value of wastewater to towns and the benefit it can serve as a resource.

The next major project for Swirltex involves piloting the technology in produced water, with the construction of a produced water unit being complete at the end of May. The technical learnings made during this pilot were integrated into the design of the produced water unit. Swirltex has been gaining traction particularly in the United States, where water scarcity in oil and gas regions is a more demanding issue. Swirltex is currently partnering with another wastewater treatment company, Terra Water, to fabricate and design these units.

Lastly, as a result of this unit, Swirltex was introduced to the airport lagoon market, where the Betsie unit is currently operating. We look forward to seeing the water quality results from this project and are beginning to explore the greater airport lagoon market for future projects.

The plan for Swirltex in the next two years is obtain full scale commercial deployment in the municipal space as well as in oil and gas. From the learnings in this pilot project, we are aiming to be better

prepared in the design and execution of projects at a full scale, moving away from piloting. Two years from now, Swirltex plans on having 6 full capacity, automated units in the field. The steps that must be taken to achieve this goal is to establish and maintain a strong partnership to subcontract manufacturing of the units, as this is not something Swirltex can do in-house. The team must also continue to learn test different membrane configurations as well as wastewater streams in the lab to better optimize the design and operation in the field. Financially, Swirltex will be raising a series A round of financing to fund this growth.

K. CONCLUSIONS

The lagoon utilization project involved the design, construction and operation of a Swirltex membrane unit for testing at municipal lagoons in Alberta. The objective of the project was to demonstrate the immediate and long-term effect of operation of an SLU on the nutrient concentrations in a lagoon and in the produced permeate (membrane filtrate).

The membrane unit was constructed with two trains side-by-side to allow for the testing of different membranes, as well as different aeration technologies in parallel. During operation of the unit, samples were taken to assess the results. Samples measured total suspended solids (TSS), chemical oxygen demand (COD), biological oxygen demand (BOD), ammonia, phosphorus and fecal coliforms. Later in the project, we also measured energy consumption and unit run-times. We were able to see consistent and positive results in water quality of permeate, achieving targets for TSS and coliforms. However, due to non-ideal system set-up at the lagoons, and challenges with equipment, we were unable to see the long-term benefits of the aeration on the lagoon in terms of ammonia, phosphorus, COD and BOD. We have learned from this how to more properly plan to achieve positive results.

Technically, Swirltex advanced greatly as a result of this project. Aeration technologies were tested, and the team came to understand what the benefits of each are in the field, allowing us to design future systems with greater confidence and knowledge. In addition, the team also concluded the membrane manufacturer and configuration that is preferred. We were able to come to this conclusion through both field testing and testing in the lab.

The outcomes of this project were significant for Swirltex. As a result of this funding, the Swirltex team was formed and was trained and strengthened greatly in the field. Having a unit in the field created many commercial opportunities for Swirltex, including gaining new customers in oil and gas as well as in the airport lagoon sector. In addition, we were able to gain more investment into the company with the strength of having this asset. The team also achieved filing a provisional patent, which will further strengthen our position to gain investment and customers.

The next steps for Swirltex involve the commercialization of membrane units, implementing the learnings made during this process. We plan to build and deploy 6+ units in the next two years. We are currently targeting the oil and gas sector as well as the municipal lagoon sector, leveraging the partners we have made along the way.