

Testing Wastewater Technology Designed for Rural Areas Under Canadian Cold Climate

Public Final Report

Submitted on: July 30, 2026

Prepared for

Alberta Innovates

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Executive Summary

This project installed and tested the Jokaso municipal wastewater treatment technology in cold Canadian winters to test its reliability and effectiveness to treat BOD, COD, total nitrogen and partial phosphorous. The technology was piloted at ACWA's upgraded wastewater research facility, where primary influent from the Pine Creek wastewater treatment plant will be diverted to the piloting site.

Key results and learnings

The gathered data indicates a clear relationship between water temperature and ammonia nitrogen (NH₃-N) removal performance. During the warm months (August to November), when water temperatures ranged from approximately 18–20°C, the system achieved relatively high NH₃-N removal rates of approximately 35%–95%.

As water temperatures decreased during the winter months (December to February), reaching approximately 12–13°C, NH₃-N removal performance declined, falling to around 10%–15%. This suggests that the biological nitrification processes responsible for ammonia removal were adversely affected by lower temperatures.

With the gradual increase in water temperature during spring (March to May), NH₃-N removal efficiency began to recover, increasing from approximately 15% in March to over 50% by May. Overall, the results demonstrate that NH₃-N removal is temperature-dependent, with higher treatment efficiency observed under warmer operating conditions and reduced performance during colder periods. These findings highlight the importance of considering seasonal temperature variations when evaluating wastewater treatment performance in colder climates such as Alberta.

Outcome and Benefits

The project demonstrates that the Jokaso system can provide an efficient, sustainable, and scalable wastewater treatment solution for communities. Its energy-efficient design and potential integration with renewable energy sources can reduce operating costs and greenhouse gas emissions, while effective nutrient removal improves water quality and environmental protection.

The system's compact footprint minimizes land use and environmental disturbance compared to conventional centralized treatment systems. In addition, its low maintenance requirements and ease of operation reduce the need for highly specialized operators, making it particularly suitable for small and rural communities.

The modular design allows communities to expand treatment capacity incrementally as demand grows, avoiding costly infrastructure expansions and providing a flexible schedule, cost-effective approach to wastewater management. The project also supports economic development through the creation of high-skilled jobs and the introduction of innovative wastewater treatment technology to the region.

1. Introduction

LM is a wastewater and water technology provider based in Calgary. LM installed the Jokaso system at the Pine Creek WWTP (Wastewater Treatment Plant) and demonstrated its performance from August 2025 to May 2026.

The Jokaso system is a wastewater treatment system with a biological treatment function for small and rural communities. The foundational technology has numerous installations all over the world. However, these have primarily been in warm and hot climates, and effective functionality of the system in a cold climate, like Canada, were previously untested. Therefore, LM conducted the pilot test to demonstrate that the Jokaso system's capability under the harsh conditions of a Canadian winter, while also identifying opportunities for adjustments and improvements based on the results.



Figure 1 - Jokaso System at Pine Creek WWTP

The project is supported by the Clean Resources Continuous Intake Program from Alberta Innovates, as well as by its contributing partners:

- University of Calgary (U of C)
- FujiClean Co., Ltd. (FC)
- Japan Sewage Works Agency (JS)
- Phil-Japan Worldwide Management Services Inc. (PJW)

The U of C took the water sample through their water specialized research division, Advancing Canadian Water Asset (ACWA). FC provided the pilot Jokaso unit to LM, and JS analyzed the pilot data. Additional project support was sourced from local a consulting firm and construction

contractors.

1.1 Sector Introduction

Many rural and small communities in Alberta and across Canada continue to rely on traditional lagoons and conventional septic systems, which can face challenges related to land requirements, environmental compliance, and operational efficiency.

This project focuses on evaluating Jokaso technology under Alberta cold climate. Through collaboration between LM and ACWA, the project aimed to demonstrate the feasibility of decentralized wastewater treatment as a sustainable and cost-effective solution for all Canadian communities.

1.2 Technology Gaps

Small and rural communities lack compact wastewater treatment systems that meet nutrient limits, enable continuous discharge, and perform reliably in cold climates. Alberta has limited operational experience with Jokaso under winter conditions.

Furthermore, the operation and maintenance (O&M) of the traditional centralized treatment is complicated and usually needs highly trained skilled O&M staff. Due to the limited budget and workforce resources in rural communities, it forced these communities to rely on traditional lagoon systems. The cold climate in Canada has results in lagoon bacteria die-off during the winter freeze, which creates smelly, rotting conditions come spring.. Spring melt and increased surface water run-off into these lagoons can sometimes result in overflows, which increases the risk of cross-contamination into the community's sanitation and water bodies.

Because the Jokaso system is prefabricated, it can eliminate this issue through its design with an easy and worry-free installation, operations and maintenance.

1.3 Technology Description

The Jokaso system is prefabricated wastewater treatment system with a FRP material casing of and is durable, lasting more than 30 years. The inside of the system is mainly composed of ①Primary Clarification Tank, ②Anaerobic tank, ③Aerobic tank, ④Secondary Clarification tank and ⑤Disinfection/Sampling Tank. A recirculation system ensures denitrification of the wastewater material.

The aeration is conducted with diaphragm blowers, with air also used as an airlift pump inside the Jokaso to transfer sludge from the anaerobic and aerobic tanks to the primary clarifier. The aeration process also enables water circulation for denitrification.



Figure 2 - Jokaso System Composition

(From left: Primary Clarifier; anaerobic tank, aerobic tank, Secondary clarification tank, and blower)

1.4 Performance Metrics

Designed for small community treatment systems, the Jokaso system targets communities with a population under 20,000. Project and commercial performance metrics were established for the project during pilot operations (Table 1). Commercialization targets align with either applicable provincial or federal guidelines for wastewater treatment where they exist. In most cases, the pilot targets were more conservatives than the applicable regulatory guidelines.

Table 1 - Target Treatment Criteria

Metric	Project Target	Commercialization Target	Applicable Guideline References
Carbonaceous biochemical oxygen demand (C-BOD)	≤ 15 mg/L	≤ 25 mg/L	GoA, 2012
Total Suspended Solids (TSS)	≤ 15 mg/L	≤ 25 mg/L	
Un-ionized Ammonia	≤ 1.25 mg/L (15 ± 1 °C)		GoC, 2015
Total Nitrogen	≤ 14.7 mg/L(Summer) ≤ 18.8 mg/L (Winter)	N/A	No Guideline
Total Ammonia	≤ 5.1 mg/L(Summer) ≤ 10.2 mg/L(Winter)	N/A	No Guideline

2. Methodology

2.1 Pilot Facility

Figure 3 indicates the flow of the pilot facility with the process description steps provided in the point below.

- This project takes raw wastewater after the grid chamber. The raw wastewater comes to the pump tank and is pumped up to the Jokaso system.
- Treated water is transferred to ACWA's primary settling tank with the discharge pump through the flow rate meter.
- The inflow pump works with a 24-hour timer system, and with the combination of the flow rate meter. It can control the inflow water volume to the Jokaso system.

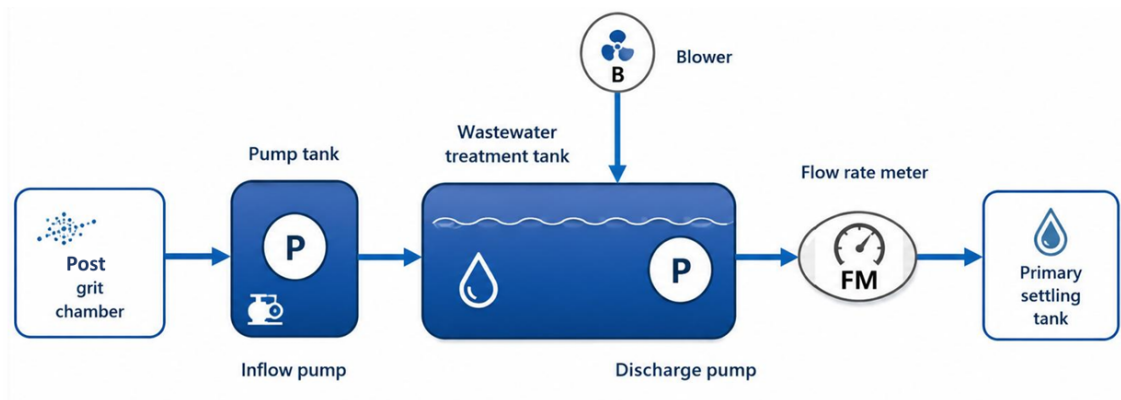


Figure 3 - Pilot Facility Flow

2.2 Operation and Maintenance

The pilot system works fully automatically, and the stationed operator is not needed. To ensure the operation, ACWA's staff check the Jokaso system to verify that its blower is functioning properly and measure the daily flow volume every weekday. The primary maintenance was conducted once a month with Table 2 listing the monthly maintenance items to be checked.

Table 2 - Monthly Maintenance Checklist

1. Check the operating status of the water treatment tank	- Check for abnormalities in wastewater characteristics, power outages, foreign object contamination, foul odors, manhole damage, and other noise or vibration issues
2. Inflow	- Check the condition of connections between pipes and tanks, etc. - Check for the adhesion of foreign objects, and water flow conditions
3. General Inspection	Inspection parameters include: - Water flow conditions (e.g., foreign matter buildup) - Tank leveling, etc.: Subsidence, floating, damage, and other issues - Blower status - Presence of mosquitoes, flies, etc.: Implementation of extermination measures
4. Circulation System	- Pumping status, measurement of circulating water volume, and circulation valve settings - Adhesion of foreign matter, biofilm adhesion
5. Sludge Transfer System	- Pumping status, measurement of sludge transfer flow rate, transfer valve settings - Adhesion of foreign matter, biofilm formation
6. Water Quality Measurement	- Appearance and turbidity of treated water - Water temperature, dissolved oxygen (DO), and pH in the contact filter bed tank
7. Impurity Removal Tank	- Abnormal rise in water level, formation of scum and accumulated sludge
8. Anaerobic Filter Tank	- Abnormal rise in water level, formation of scum and accumulated sludge - Water level difference; confirmation of gas accumulation within the filter bed
9. Contact Filter Tank	- Aeration status, foaming status
10. Treatment tank	- Conditions regarding scum and sludge accumulation
11. Backwashing of the contact filter bed and transfer of backwash water	- Backwashing operations - Transfer of backwash water via circulating airlift
12. Circulation System	- Adjustment of circulating water flow
13. Scum Transfer from the Treatment Tank	- Return of scum via the scum skimmer
14. Backwashing of the anaerobic filter bed and transfer of backwash water	- Backwashing operation - Transfer of backwash water via sludge transfer equipment
15. Sludge Transfer System	- Adjustment of sludge transfer flow rate
16. Blower	- Checking operating status, cleaning the air filter

The Jokaso system is also necessary for the periodical desludging with sludge vacuum services required twice during the test period.

2.3 Water Sampling and Analysis

The water sampling and analyses were conducted by ACWA's staff. A grab sample was taken every Tuesday and Thursday and analyzed in ACWA's lab facility during pilot operation. Sample analysis and methodology is listed in the table below (Table 3).

Table 3 - Analytical Methods

Item	Method	Notes
BOD/CBOD	5-day test	APHA 5210 B
TSS	Gravimetric analysis	APHA 2540 D
Alkalinity	Methyl orange	EPA 310.2
Ammonia (NH ₃)	Modified indophenol	APHA 4500-NH ₃ F/DIN 38406
Un-ionized ammonia	$\text{Ammonia} \times 1 \div (1 + 10^{0.0901821 + (2729.92 / (\text{Temp} + 273.15 - \text{pH}))})$	
Nitrite/nitrate	Cadmium reduction, sulfanilamide	APHA 4500-NO ₃ F
Total nitrogen	oxidative digestion followed by cadmium/sulfanilamide	APHA 4500-P J
Total phosphorus	oxidative digestion followed by ascorbic acid reduction	APHA 4500-P J

3. Project Results

3.1 Project Schedule

The project started in March 2025 and continued until May 2026 as per the project schedule (Table 4).

The piping construction between the existing raw wastewater chamber and the pump tank for Jokaso was conducted from May to June pf 2025, with the installed the Jokaso system installed in July and commissioned the system in August. Testing commenced after commissioning with on-going testing conducted until May 2026.

During winter, the influent volume was adjusted with a heater installed to monitor how water volume and temperature influenced the nitrification reaction. ACWA's staff conducted monthly checks and maintenance work once the heater was installed to ensure that an optimum temperature range was maintained for the rest of the pilot duration.

Desludging was conducted on October 30th prior to winter and again May 4th. Sludge accumulation measurements were taken during desludging activities.

Due to the dissolved oxygen (DO) measurements being lower than expected, the total blower setting increased from 7 units to 9 units at the end of October, in order to increase overall oxygen levels going into the system to support necessary microbial processes.

Table 4 - Schedule

	2025								2026				
	5	6	7	8	9	10※	11	12	1	2	3	4	5
Piping construction													
Jokaso installation													
Commissioning													
Test conditions				Configuration 1						2	3	2	
Maintenance													
Desludging													

※ Configuration 1 :32 m³/day inflow without heater

※ Configuration 2: 24 m³/day inflow without heater

※ Configuration 3: 24 m³/day inflow with heater

※ Adding the blower from 7 units to 9units

3.2 Performance Summary

A summary of lab testing results obtained during the pilot project are presented below, with discussions about the results in the following sections.

Table 5 - Summary of Lab Results

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Ave
Influent volume	23.1	31.3	30.9	31.2	29.7	31.3	24.5	25.6	28.1	23.0	27.9
Water temperature	20.4	19.1	17.7	15.5	13.5	12.2	12.0	12.9	12.7	14.8	15.1
T-BOD inf	142.0	181.6	200.7	191.0	188.0	203.9	217.6	242.6	199.9	206.3	197.3
C-BOD eff	7.2	7.1	12.3	11.7	10.6	19.1	16.1	16.1	18.8	10.3	12.9
BOD removal rate	95.0%	96.1%	93.9%	93.9%	94.4%	90.6%	92.6%	93.4%	90.6%	95.0%	93.5%
TSS inf	30.7	86.4	116.9	92.3	82.2	93.7	108.4	184.7	148.9	157.1	110.1
TSS eff	5.7	7.3	17.8	13.0	11.8	14.2	11.7	16.1	15.3	11.3	12.4
TSS removal rate	81.5%	91.6%	84.8%	85.9%	85.7%	84.8%	89.2%	91.3%	89.7%	92.8%	87.7%
Ave inf un-ionized ammonia	0.14	0.17	0.17	0.17	0.12	0.14	0.12	0.16	0.26	0.25	0.17
Ave eff un-ionized ammonia	0.33	0.23	0.38	0.22	0.24	0.43	0.41	0.37	0.49	0.31	0.34
Ave inf NH3-N	27.9	32.3	35.5	37.4	36.8	38.4	39.1	39.7	43.5	42.7	37.3
Ave eff NH3-N	9.8	13.7	23.8	18.8	24.0	34.3	34.8	31.4	35.7	19.9	24.6
NH3 removal rate	65.0%	57.7%	32.9%	49.7%	34.7%	10.9%	10.9%	20.8%	17.9%	53.4%	35.4%
Ave inf T-N	34.9	41.6	42.2	42.2	49.5	52.1	50.7	52.5	52.4	53.1	47.1
Ave eff T-N	21.0	21.7	26.4	27.7	30.1	40.2	39.5	35.1	38.3	27.0	30.7
T-N removal rate	40.0%	47.9%	37.4%	34.4%	39.3%	22.8%	22.1%	33.3%	27.0%	49.2%	35.3%

3.3 Inflow Volume and Temperature

The first influent volume was recorded on August 25, 2025. The installed effluent pump malfunctioned and was replaced from August 25 to September 5. After the replacement, flow meter was recalibrated. As a result, the inflow volume data could not be obtained from August 29 to September 3. Settings were updated to increase the inflow rate to correct for the issue on September 4 and 5, allowing for more water into the system. Once the designed volume had recovered and stabilized on September 6, it was observed that the unit recovered, and inflow volumes were reset

to the original design volume of 32 m³/day..

To test the nitrification reaction under cold temperatures, the influent volume was reduced from 32m³/day to 24m³/day on February 3 and continued to the end of the pilot testing period for the project.

The figure below (Figure 4) showcases instances where the inflow was reduced during the desludging period and FC's technical investigation into the pump and flowmeter issue. The high spike of inflow on April 24 is due to maintenance staff forgetting to return the switch from the manual inflow mode to auto mode after the water sampling, and the water went into the Jokaso system for 24 hours.

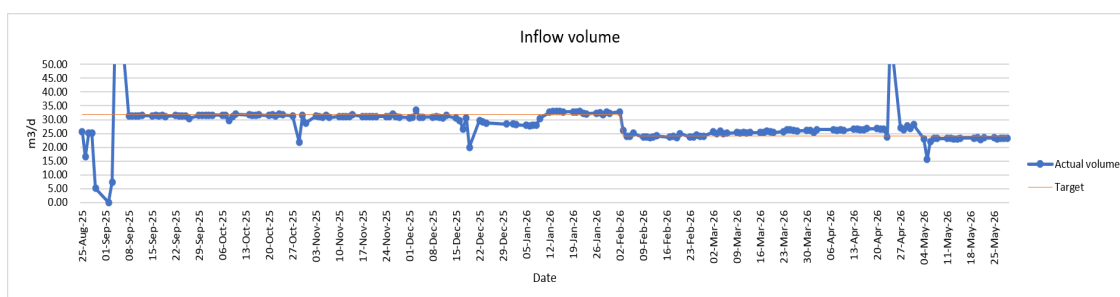


Figure 4 - Inflow Volume Graph

The ambient water temperature (water outside the effluent chamber) and water temperature (water inside the effluent chamber) were measured. The ambient temperature fluctuated during the test period, whereas the water temperature has been stable in the range between about 12°C and 20 °C. The coldest water temperature was 11.3°C from February 20 to 24.

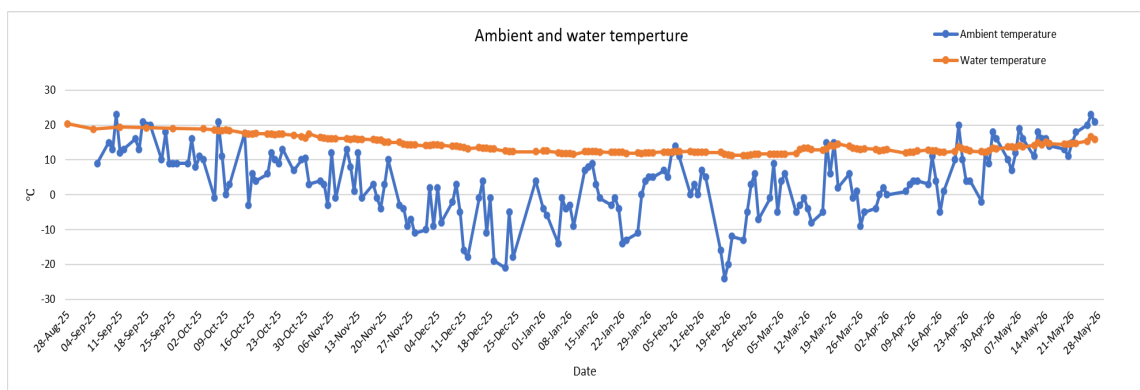


Figure 5 - Ambient vs Water Temperature

Two immersion heaters installed from May 9 to April 23 increased the water temperature post installation; the heaters weren't fully implemented due to the issues with the relay section waterproofing.

3.4 BOD, TSS, and Un-ionized Ammonia Results

The effluent C-BOD and TSS have maintained relative stable rates between 10 and 20 mg/L during the test period. The influent spike occasionally occurred, but the effluent was impacted for only a day or two post-spike, where rates then returned to normal.

On average, the effluent C-BOD and TSS are 12.9 mg/L and 12.4 mg/L, respectively. These values are below applicable regulatory guidelines and with target ranges set for the project.

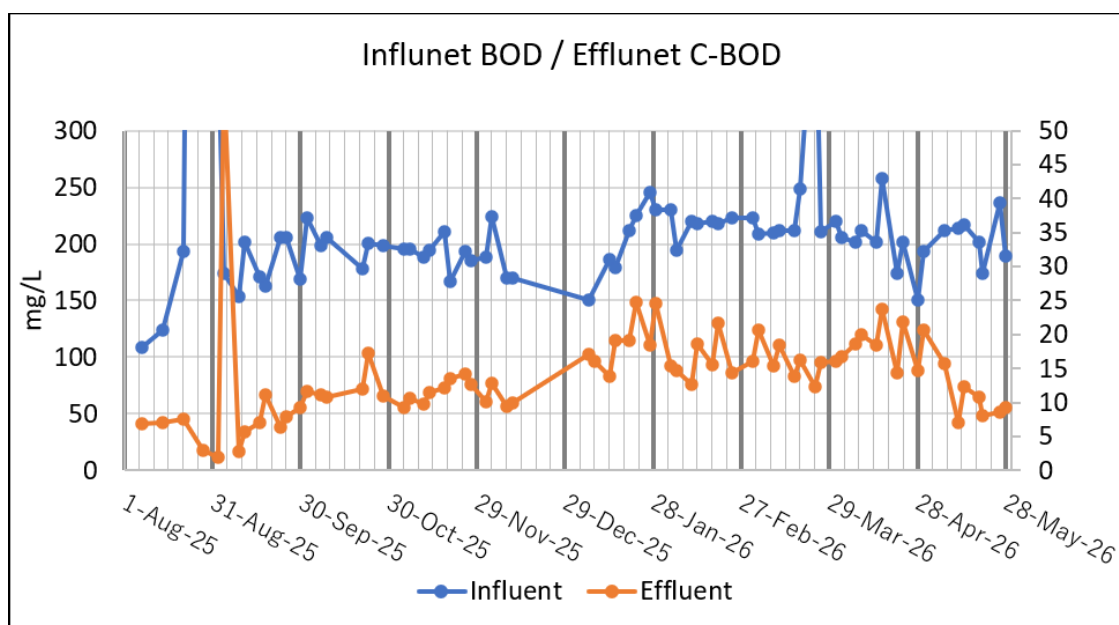


Figure 6 - Influent vs Effluent BOD

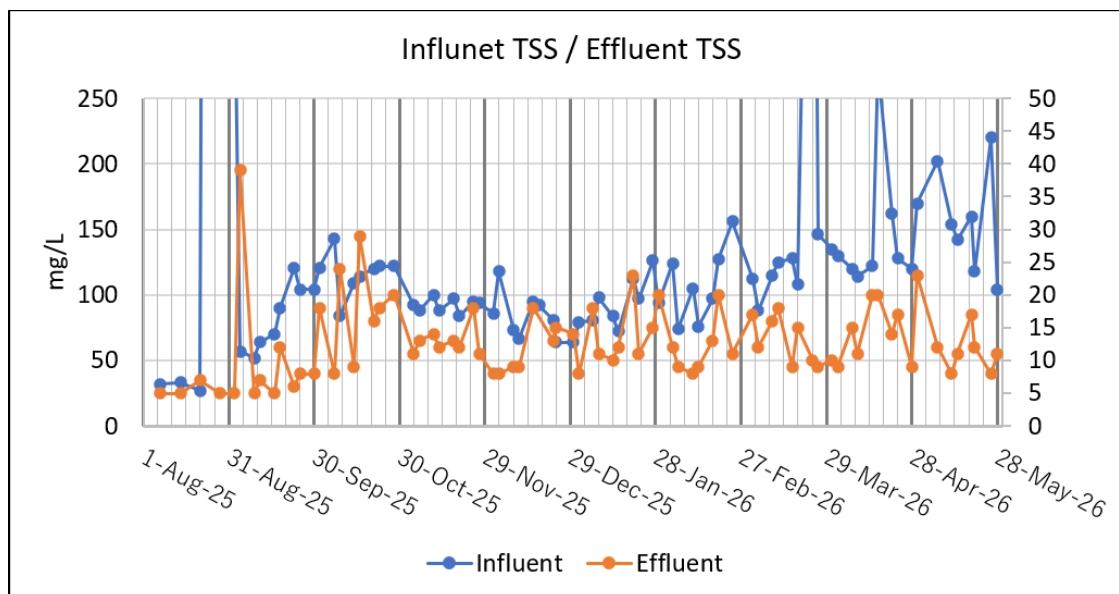


Figure 7 - Influent vs Effluent TSS

The influent and effluent un-ionized ammonia have consistently been lower than the federal guidelines.

Most of the test period, the effluent un-ionized ammonia was higher than the influent due to introduction of CO₂ by the blower. This additional CO₂ caused stripping of raw sewage thereby impacting the carbonic acid equilibrium in water is represented in the following mass-balance equation.



When CO₂ is released into the atmosphere through aeration, the equilibrium shifts to the left generating carbon dioxide and water, reducing hydrogen ion concentrations, and increasing hydronium ion concentrations (alkalinization or an increase in pH). Additionally, volatile fatty acids (VFAs) such as acetic acid, propionic acid, and butyric acid contained in raw sewage were broken down during biological treatment, which would contribute to additional hydronium ions as part of the acid metabolism, resulting in a more alkaline solution.

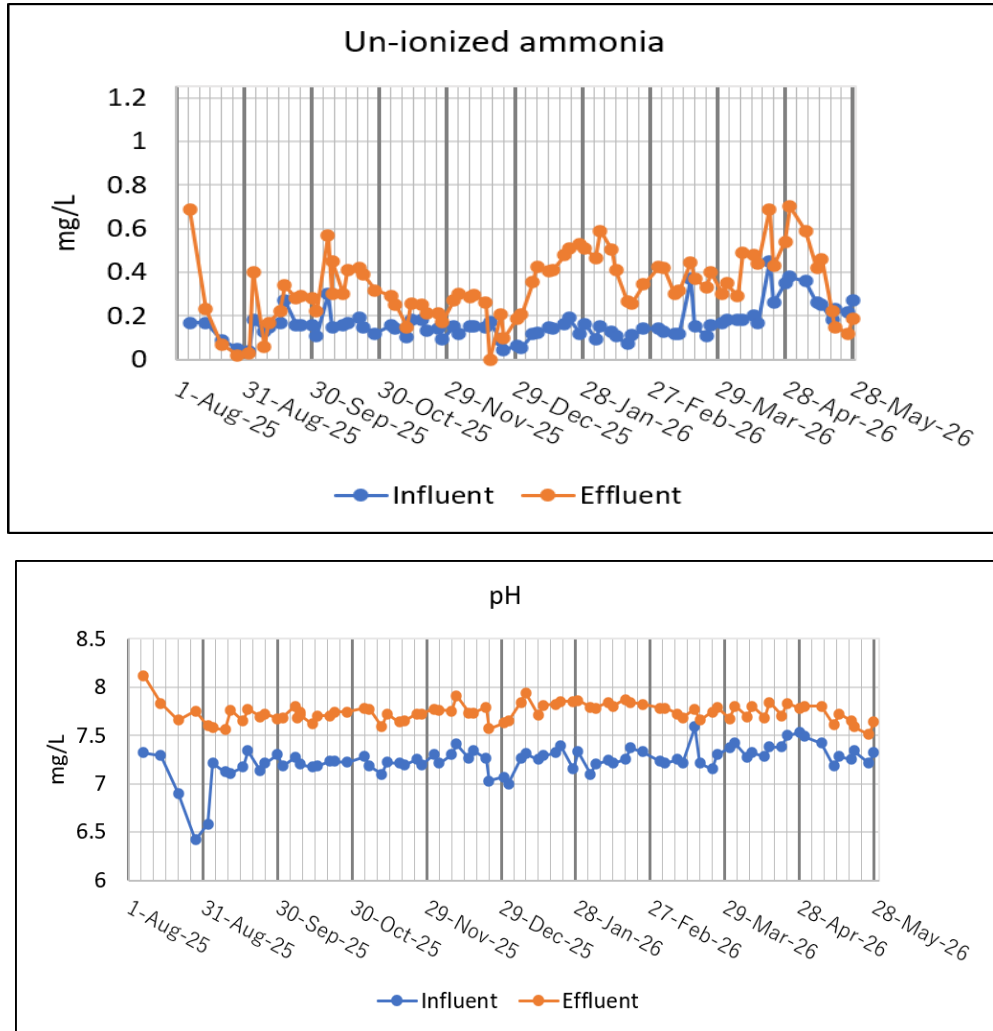


Figure 8 - Unionized Ammonia and pH Graphs

The pH of the effluent water is mainly lower than that of the influent due to nitrification during the biological process. Since the alkalinity of the inflow water is high, it prevents a significant decreases in overall effluent pH.

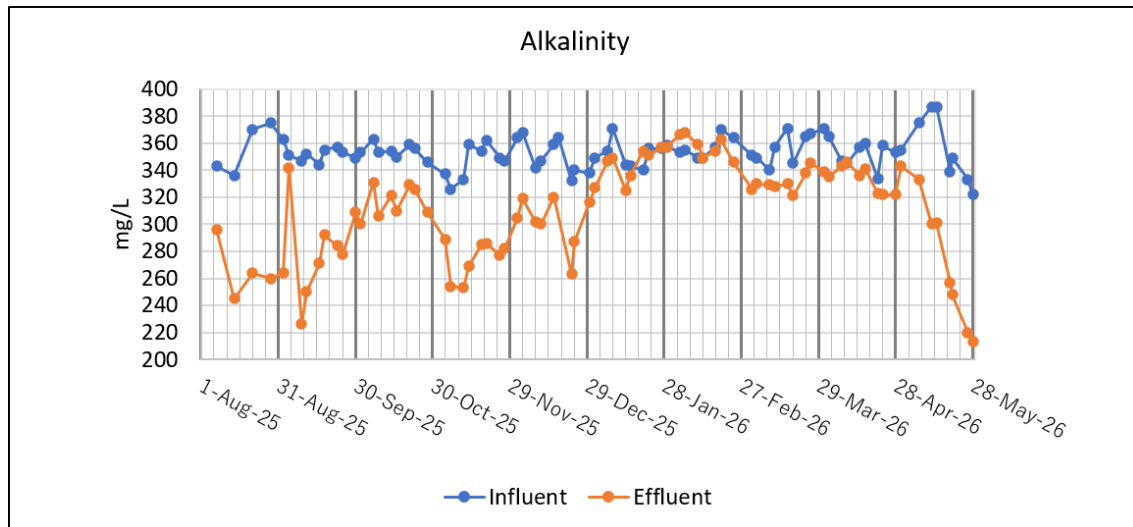


Figure 9 - Alkalinity

3.5 Total Ammonia and Total Nitrogen Result

The total ammonia effluent has fluctuated during the test period. Preliminary results met testing targets. High carbon levels experienced over a few days in August 28 created an optimal environment for heterotrophic bacterium, which inhibited the growth of nitrifying bacteria. Ammonia levels continued to be elevated in the aerobic tank until the first desludging at the end of October; after which it started recovering. However, decreased temperature due to seasonal conditions continued to contribute to suboptimum conditions for nitrifying bacterial activity, with ammonia removal rapidly deteriorating at the end of December.

To confirm how HRT affects the nitrification action, the influent water volume was changed from 32m³/day to 24m³/day on February 2, with moderate improvements observed thereafter.

A second round of desludging activities on May 5, and an increase in ambient air temperature, saw dramatic improvement in ammonia removal. These positively affected the nitrification, and the final effluent water sample recorded 9.63mg/L, which is less than the target value for the winter period.

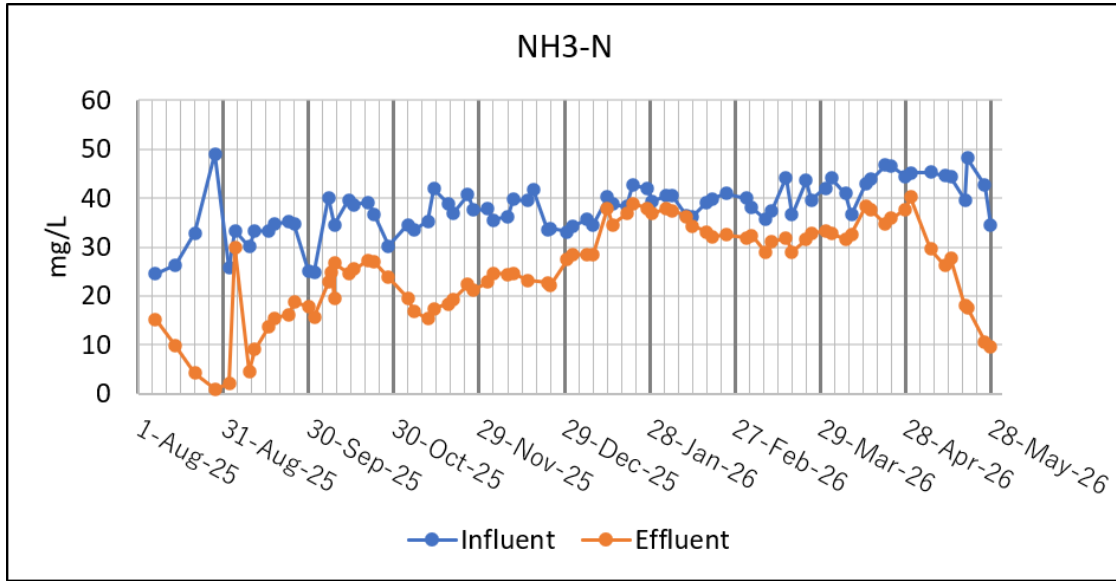


Figure 10 - Influent vs Effluent Ammonia

Total nitrogen (T-N) followed a similar trend in alignment with ammonia level changes. The T-N decreased during the test period, which indicated that a series of nitrogen removal processes, decomposition of organic nitrogen, nitrification of ammonia, and denitrification were carried out throughout the entire pilot period. Alkalinity consumption ceased from the end of December to the beginning of February, demonstrating that the decrease in T-N was solely due to the conversion of organic nitrogen into sludge during this time period.

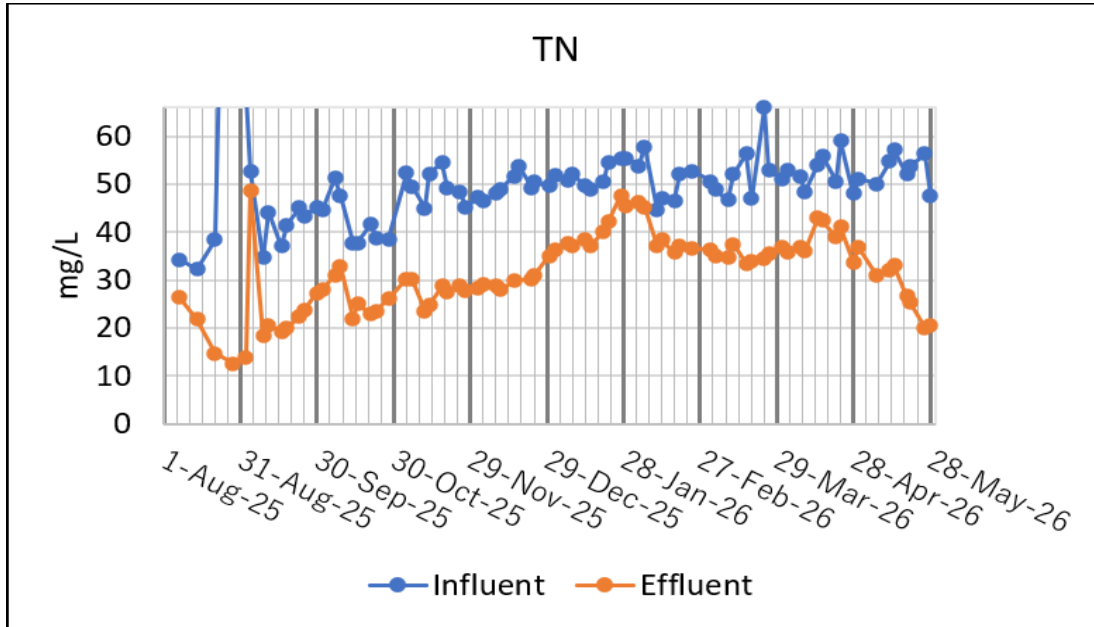


Figure 11 - Influent vs Effluent Total Nitrogen

Data regarding nitrite ($\text{NO}_2\text{-N}$) and nitrate ($\text{NO}_3\text{-N}$) concentration show the effluent levels were nearly 0 except when nitrification was active. Even during active periods, the level of $\text{NO}_3\text{-N}$ was around 6mg /L, demonstrating that Jokaso's denitrification consistently worked during the pilot period, and the critical factor for T-N removal is the active nitrification process.

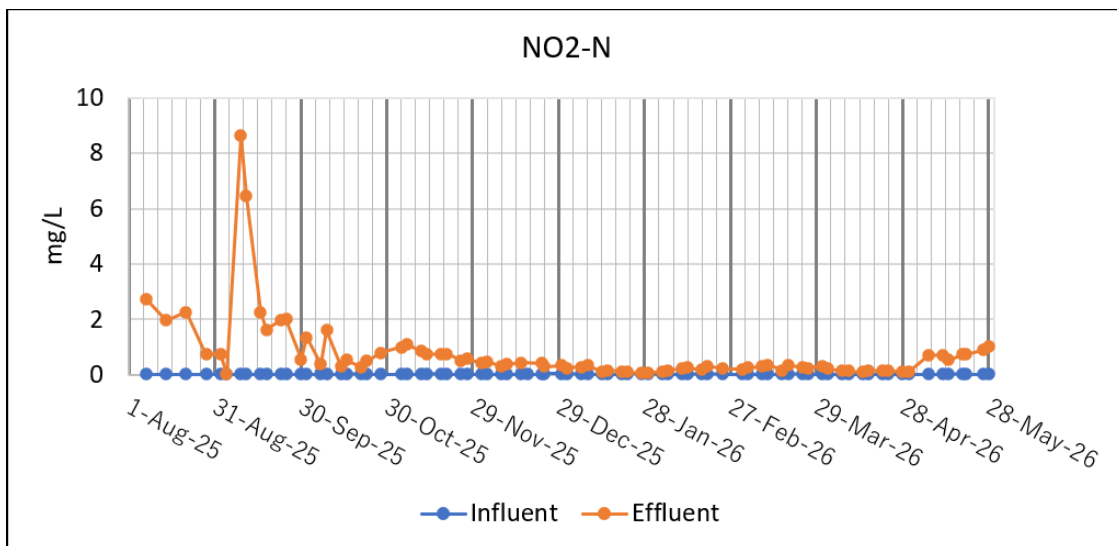


Figure 12 - Influent vs Effluent of Nitrite

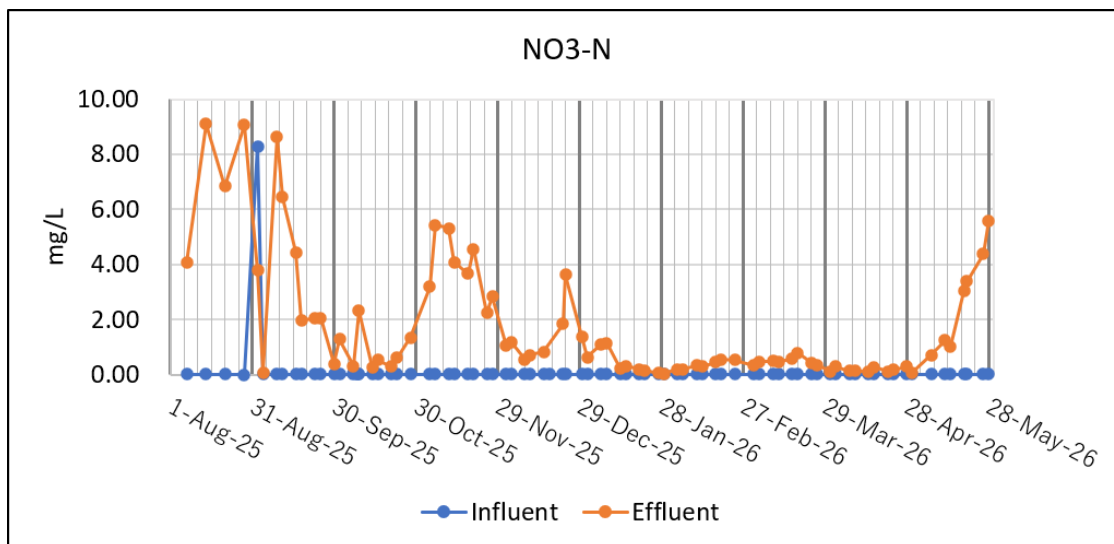


Figure 13 - Influent vs Effluent of Nitrate

3.6 Total Phosphorus

The amount of total phosphorus (T-P) removed in the Jokaso was recorded and monitored during the pilot period. Regardless of the season, the margin between inflow and effluent been consistently stable at a concentration of about 1 mg/L, showing that T-P is converted to sludge as part of the process.

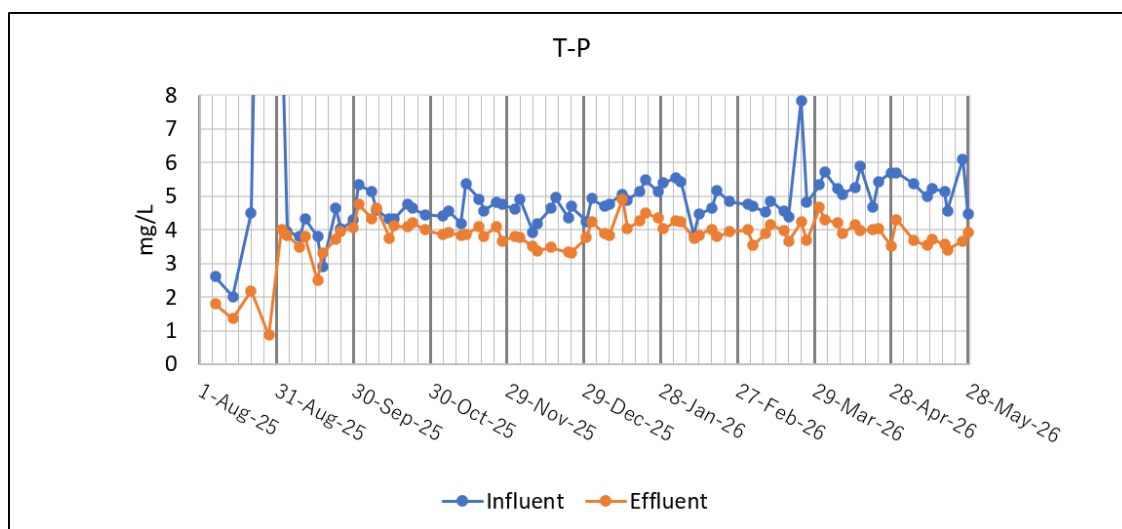


Figure 14 - Influent vs Effluent of Phosphorous

3.7 Electrical Consumption

The electricity consumption intensity was originally around 1.0 kWh/m³ while tested at 32m³/day inflow, but it changed to 1.4 kWh/m³ due to reducing the inflow capacity.

The table below shows the electricity consumption of the Jokaso system under pilot conditions during this project.

Table 6 - Electrical Cost Comparison for Different Configurations

Number of blowers	Electricity consumption Per unit(kw)	Number of Heaters	Electricity consumption Per unit(kw)	Treated water volume (m³/day)	Electricity consumption intensity (kWh/m³)
9	0.155	0	2	32	1.05
9	0.155	0	2	24	1.40
9	0.155	2	2	24	5.4

Though the Canadian Standards Association has established benchmark energy factors for wastewater treatment facilities (CSA, 2024), these benchmarks have been established for municipal scaled facilities which support much waste volumes and are not representative of the small volume operations.

Rather, the Jokaso system's energy consumption data collected for this project was compared to results presented in an energy and reliability study of wastewater treatment plants in small communities in Ontario (Hamza et al., 2022) from a high-leveled analysis standpoint. Though limited, the Hamza et al. study is one of the few performance-based comparative studies completed in Canada regarding small community scaled wastewater treatment.

This study collected data on energy consumption from eight different treatment plants using one of five different treatment technologies including: rotating biological contractors, activated sludge sequential batch reactors, membrane bio reactors, one extended aeration activated sludge process, and a standard wastewater treatment lagoon. The different technologies cited average energy consumption rates of the different technologies between 0.03 to 11.3 kWh/m³ respectively, with lagoon treatment being the least energy intensive and activated sludge sequential batch reactors being the most energy intensive.

In comparison, under ideal operating conditions, the Jokason system consumed more energy the passive lagoon treatment method (0.03 kWh/m^3), was comparable to rotating biological contractor performance averages (0.8 to 1.6 kWh/m^3), and outperformed the other reported treatment methods, with energy intensities recorded from 1.05 to 1.40 kWh/m^3 of water treatment,

When heaters are needed to maintain optimal operating conditions, based on pilot data collected and limited study information, the Jokason system appears to be more efficient than average reported referenced results for bio membrane systems (6.6 kWh/m^3) and sequential batch reactors (8.6 - 11.3 kWh/m^3).

Data collected during this pilot indicate that the Jokason system appears to be competitive from an energy consumption standpoint, relative to existing documented active community wastewater treatment methods currently used in Canada at small community scales.

3.8 Maintainability

The maintenance procedures were explained to the ACWA staff and performed monthly. The primary work involves transferring scum from the secondary clarifier to the primary, manual backwashing for the aerobic tank, and cleaning for the blowers. These tasks do not require any special skills and can be conducted with the appropriate orientation and the O&M manual.

As the indicator for desludging, the accumulation limit of sludge is set in the sedimentation and anaerobic tanks. After the first desludging, the thickness of the sludge was recorded, and after six (6) months from the desludging, it did not reach the limit in reverse. The accumulation of sludge tended to decrease which demonstrated the effectiveness of the biological degradation process or sludge to scum to gas and water.

Based on data collected during this pilot demonstration, the Jokaso system monthly to quarterly maintenance is recommended to minimize sludge accumulation, with desludging activities needed every six months, under optimal operating conditions in Canada's climate.

Table 7 - Sludge and Scum Accumulation

		Accumulation limit	Nov 21	Dec 19	Jan 19	Feb 24	Mar 23	May 4
Sludge	Primary Clarifier (cm)	120	35	10 ~ 20	50	20	15	15
	Anaerobic (cm)	60	0	0	25	20	35	25
	Secondary Clarifier (cm)	No Limit	60	20 ~ 30	25	35	35	30
Scum	Primary Clarifier (cm)	No Limit	30	40 ~ 60	20	20	20	50
	Anaerobic (cm)	No Limit	32	30 ~ 50	20	20	15	0
	Secondary Clarifier (cm)	No Limit	32	30 ~ 50	20	20	15	15

4. Key Learnings and Conclusions

4.1 Key Findings

According to the NH₃-N removal and water temperature data, it is proportional, and it's concluded that chipping point for nitrification is about 13°C. Therefore, the key finding of this project is that ensuring stable NH₃-N removal requires maintaining the water temperature above 13°C. When the heaters were active, consumption increased to 5.4 kWh/m³. Unless a site requires strict ammonia removal, heater use may not be necessary or limited.

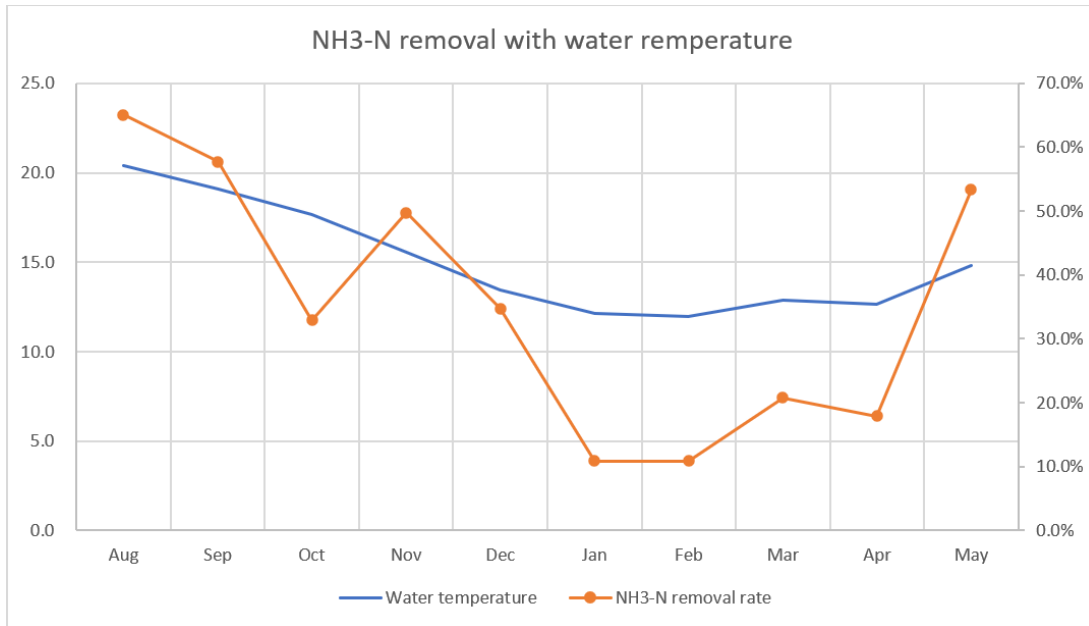


Figure 15 - Ammonia Removal Relative to Temperature

The influent water temperature was measured from March 19, after installing the heater. The heater experienced repeated trips and automatic restarts immediately following installation, preventing accurate evaluation of its heating performance and the resulting increase in water temperature. However, the data from immediately after installation suggests that it is useful.

One benefit to the process observed was that the blower also helped to raise the influent temperature using warmer ambient air relative to winter influent temperatures. This reduced the amount of additional heating required to optimize necessary microbial activity of the treatment system.

Based on the findings, it is suggested that for a small treatment system, such as Jokaso, the water temperature can be maintained and nitrification sustained by supplying heat from an external source.

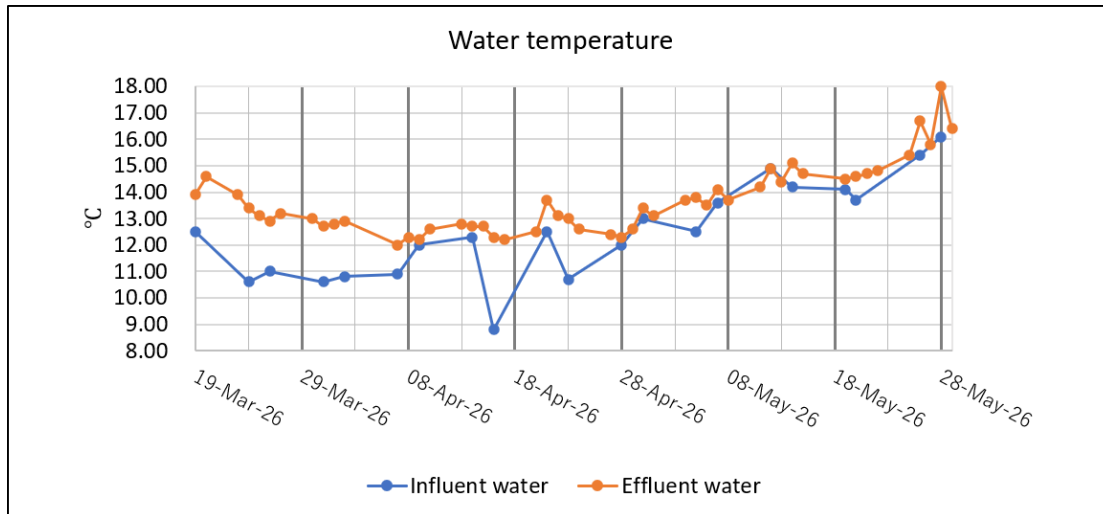


Figure 16 - Influent vs Effluent of Water Temperature

4.2 Conclusions

Based on the data collected from this pilot demonstration, the following observations have been made:

- ① The Jokaso system demonstrated that effluent streams for C-BOD and TSS were averaged at 12.9 mg/L and 12.4 mg/L. The average removal rate is 93.5% for C-BOD and 87.7% for TSS. It is below the project C-BOD and TSS upper limit target (15 mg/L) and the provincial regulation (25 mg/L) concentrations.
- ② The un-ionized ammonia levels was averaged at 0.34 mg/L and did not exceed the wastewater standard (1.25 mg/L).
- ③ The ammonia and T-N removal were averaged at 35.4% and 35.3%. It could reach the target (50% removal) with countermeasure implementation to stable the water temperature at 13°C.
- ④ The installation for Jokaso was completed within two to three (2-3) weeks, which could see reduced the initial establishment costs compared to the traditional lagoon system.
- ⑤ The electricity consumption of Jokaso is about 1~1.5 kWh/m³ under optimal operating conditions, and 5.4 kWh/m³ when heaters were employed. These results were comparable or an improvement based on referenced data for other active treatment wastewater plants at this scale in Canada (Hamza et al, 2022).
- ⑥ The Jokaso system was effective and cost competitive under cold conditions at or above 13°C. When water temperatures dropped below this temperature, the treatment performance effectiveness for ammonia removal was impacted. Supplemental heating was implemented to achieve the design treatment targets. Future development efforts will focus on optimizing the

technology to maintain performance under lower influent temperatures typical of Alberta's climate.

- ⑦ Jokaso can be operated with any operator with orientation and receiving Jokaso O&M manual.
- ⑧ Jokaso only needs monthly to quarterly maintenance and desludging every half year.

5. Outcomes and Impacts

Through this demonstration, it is confirmed that the Jokaso can operate smoothly in Canadian winters, and that they can treat C-BOD and TSS, which are required to be removed by provincial standards, to levels lower than applicable guidelines without any special measures.

To achieve full system optimization, temperatures above 13°C need to be maintained to support nitrification reactions and to enable complete sludge degradation to meet applicable wastewater discharge guidelines. Continued optimization of the Jokaso system is essential to address the observed nitrification issues in the winter.

The power consumption in winter with heaters is 5.4 kWh/m³, which is needed to support optimal nitrification reactions. This power consumption rate is comparable or better than most standard small community water treatment options for small communities based on available comparable data, particularly since heaters are likely only needed for part of the year. If clients have access to renewable or cost competitive power rates, this could make the Jokaso system more competitive.

This technology could increase the feasibility for small communities to access alternative sewage treatment systems to replace lagoons. These communities can have an alternative solution to the problems associated with lagoons, such as odor, low treatment efficiency in winter, and high construction and maintenance costs.

6. Potential Benefits

6.1 Economics

The successful demonstration of Jokaso system in Alberta supports the introduction of advanced decentralized wastewater treatment technology to the Canadian market, creating opportunities for future equipment sales, engineering services, especially local installation/construction work, and long-term maintenance activities to many rural and remote areas in Alberta.

Upgrading an existing lagoon not constructing a new one for Winfield Lagoon in Alberta budget costs at \$1.54 million for approximately population of 193 (Max, 2023). The actual project cost was at \$2,195,432.97 awarded to Alpha Construction Inc (*Bids and Tenders - MPE*, 2024).

For a Jokaso system designed to serve an equivalent population of approximately 193 people like Winfield, the estimated capital cost is approximately CAD 1.0 million, including system design, fabrication, delivery, installation, commissioning, and start-up with price break down listed in Appendix A.

For Winfield Lagoon, the service fee for it is \$38,480 in 2021 and requires a liner repair capital cost at \$350,650 (Dextraze, 2021).

The estimated annual preventive maintenance cost for Jokaso system is approximately CAD 30,000, which includes quarterly operator inspections, replenishment of chlorine and dechlorination chemicals, air blower maintenance and replacement of wear components, and sludge removal twice per year. Annual electricity consumption is estimated to cost CAD 3,000 with current electricity rate in Alberta.

In addition, the Jokaso system is fabricated with fiber-reinforced plastic (FRP), eliminating the need for lagoon liner repairs. The FRP tanks have an expected service life of approximately 30 years. After successful installation, it presents a very low risk of leakage into the surrounding environment.

Because the Jokaso system treats wastewater at or near its source, the need for lift stations is significantly reduced compared with conventional lagoon systems. This decentralized approach lowers the capital investment required for lift station construction while also reducing long-term operation, maintenance, and rehabilitation costs. For example, the City of Airdrie allocated CAD

158,903 for upgrades to the Sunridge Lift Station (Project ID 707274), demonstrating the substantial costs associated with maintaining lift station infrastructure in conventional wastewater systems (AIRDRIE, n.d.).

By providing an effective and decentralized wastewater treatment solution, this technology has the potential to reduce infrastructure costs for municipalities and developers while improving environmental performance, providing affordable power options are available, or expansion of the operational temperatures by way of additional innovation to elements of the system.

Successful commercialization could support job creation across engineering, construction, operations, and technical service sectors, while positioning Alberta as a leader in adopting innovative water treatment technologies for rural and underserved communities.

6.2 Environmental

The energy consumption estimates at 1.4 kWh/m³ for operations from May to October, and at 5.4 kWh/m³ from November to April to keep the ammonia removal performance. It gives the energy consumption averages at 3.4 kWh/m³ for the whole year. Based on the project results, Jokaso system electrical consumption is lower than bio membrane systems (average at 6.6 kWh/m³) and sequential batch reactors (average at 8.6-11.3 kWh/m³) with better treatment performance than conventional lagoon system. Therefore, environmental impact is reduced compared to bio memberane systems, sequential batch reactors, and lagoon system.

The project demonstrates a decentralized wastewater treatment technology that can improve wastewater effluent quality while reducing the environmental impacts associated with conventional lagoon and septic systems. The Jokaso system utilizes an efficient biological treatment process with a compact footprint, enabling effective removal of organic matter and nutrients before discharge. The system may contribute to reduced algae bloom risk through its biological treatment process and associated nutrient removal capabilities. Additional data collection and analysis are required to validate this potential benefit.

Compared with conventional wastewater treatment systems commonly used in small and rural communities, the Jokaso technology has the potential to reduce land requirements, lower the risk of environmental impacts associated with untreated or partially treated wastewater, and provide more consistent treatment performance throughout the year with appropriate system optimization and operation.

The compact design and energy-efficient operation of the Jokaso system have the potential to contribute to indirect greenhouse gas (GHG) emission reductions by reducing infrastructure requirements compared with conventional wastewater treatment approaches. The reduced construction footprint and shorter installation timeline result in lower excavation requirements, fewer labour hours, reduced material transportation needs, and decreased construction waste generation. These factors could contribute to lower embodied emissions associated with wastewater infrastructure development, particularly when compared with traditional lagoon-based systems that typically require extensive earthworks and longer construction periods. Winfield Sewage Lagoon Upgrade project took 2.5 to 3 years from project funding announcement to completion (Max, 2023).

6.3 Social

The project could support rural and small communities by providing access to reliable and sustainable wastewater treatment solutions that can improve public health, environmental protection, and quality of life.

This pilot project demonstrated that this technology has the potential, either under low-cost power supply, or through further technology development for lower operating temperatures, to enable communities address wastewater management challenges as it relates to the need for additional infrastructure while supporting long-term population growth and economic development.

This project fostered collaboration among municipalities, regulators, industry partners, and academic stakeholders, promoting knowledge sharing and capacity building within Alberta's water sector. LM Wastewater is under discussions with other interested indigenous community pilot partners for expanded testing of the Jakaso system.

Successful implementation may encourage further innovation and entrepreneurship opportunities related to water infrastructure, environmental services, and clean technology deployment, generating long-term value for communities across the province.

6.4 Building Innovation Capacity

The project will contribute to Alberta's innovation capacity by introducing advanced decentralized wastewater treatment technology. Through the planning, installation, operation, and evaluation of the Jokaso system, highly qualified and skilled personnel (HQSP), including one person from

ACWA and one technical engineer from local engineering firm, have gained hands-on experience with new decentralized wastewater treatment technologies and best practices.

The project has the possibility to attract HQSP from outside Alberta, including specialists from manufacturing and engineering industry with extensive experience in water and wastewater treatment systems. Their interest and future involvement may strengthen local technical capabilities, foster international collaboration, and support the development of specialized expertise within Alberta's water sector.

Through ACWA and the project, the performance data and operational experience generated through this project helped to build local expertise, support future research and development activities, and strengthen Alberta's capacity to deploy innovative water and wastewater solutions across the province.

7. Recommendations and Next Steps

The Jokaso system demonstrates stable treatment performance at water temperatures above 13°C. When temperatures fall below 13°C, a reduction in ammonia removal efficiency has been observed, indicating that further optimization is required for reliable winter operation under Alberta winter conditions. Ammonia removal performance can be restored through the addition of a heating system to maintain optimal biological treatment temperatures. Alternatively, partnering with an Alberta-based membrane technology company to enhance the membrane system may improve cold-weather performance while minimizing additional energy consumption.

Building on the pilot demonstration and the knowledge generated through the project, LM's next step is to further advance the commercialization of the Jokaso technology across Alberta and Canada. The project has showcased Jokaso technology's technical performance for operating conditions (above and under 13 °C). The operational data, engineering experience, and environmental performance results obtained through the pilot will be used to support future technology optimization for cold environment operations, potential project development, and strengthen business cases for municipalities, Indigenous communities, industrial facilities, and remote developments seeking sustainable wastewater treatment solutions.

Over the coming years, LM intends to implement a phased commercialization strategy focused initially on Indigenous communities through strategic partnerships and utility-based delivery models, through its partners, followed by municipal, industrial, work camp, and remote community markets.

Future activities aim to include additional demonstration and commercial projects, expansion into other provinces, development of long-term operations and maintenance services, and continued collaboration with regulators, engineering firms, academic institutions, and technology partners. LM will also continue to work to attract highly qualified personnel, investment, and strategic partnerships from outside Alberta to strengthen local expertise and support the province's position as a hub for innovative water and environmental technologies. Through these efforts, the knowledge generated by the pilot project is aimed to be translated into long-term economic, environmental, and social benefits while supporting the widespread adoption of advanced decentralized wastewater treatment solutions across Canada.

8. Knowledge Dissemination

The knowledge generated through this project will be disseminated through a combination of technical reports, presentations, stakeholder workshops, and industry engagement activities. During the opening ceremony on August 13, 2025, Embassy and Consulate of Japan, Urban Systems, University of Calgary, City of Calgary have sent representatives to attend and got introduced to the Jokaso technology. Facility tours, project findings, operational performance data, and lessons learned has been shared with one indigenous service company, an investment firm, two engineering consulting firms, and two construction contractors (Everest Construction and Hawkrige Creations Inc.). On March 12, 2026, LM attended and did a technology presentation for 51st Alberta Water & Wastewater Operators Association (AWWOA) annual operators seminar. Knowledge and lessons learned from this project were shared with AWWOA during the seminar. The presentation received positive feedback and generated strong interest in the technology and its applications. The engagement also proposes promising opportunities for future collaboration with AWWOA and its members.

The project team will also prepare technical documentation to support future project development and technology adoption across Alberta and Canada.

In addition to standard dissemination methods, LM and its partners such as JS and FujiClean have started utilized its existing industry networks and collaborative platforms such as JS's website, future publications, events and marketing to maximize outreach and knowledge transfer since the data in winter conditions is out.

The project has promoted and will further promote knowledge exchange through ongoing collaboration with organizations such as ACWA, municipalities, Indigenous communities, government agencies, and technology providers. These partnerships will help ensure that the experience and insights gained from the pilot project contribute to future innovation, policy development, and broader adoption of advanced wastewater treatment technologies throughout the province and beyond.

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*Project ID Local Government Project Title Project Description Investment Category Total Project
Cost Funds (GTF) Spent Completed 707274 AIRDRIE. (n.d.).*

10. Appendix A.

Jokaso system Installation Capital Cost Sample

- Supply and delivery of Jokaso system (40 m³ /day flow rate load): CAD 250,000
- Engineering Design, Permit Works: CAD 100,000
- Construction, Installation: CAD 500,000
- Testing and Commissioning: CAD 50,000
- GST (5%): CAD 45,000

Grand Total: 945,000.00