Two-step hybrid wetlands as the low-maintenance solution for communities in cold climates – approvals and implementation

A. Skorobogatov* and J. Massig*

* MAGNA Engineering Services, 109 East Chestermere Road, Chestermere, Alberta, T1X 1A1, Canada
(E-mail: askorobogatov@magnaengineering.ca; jmassig@magnaengineering.ca)

Abstract
In Canada, there are many small and medium-sized communities, which are unable to meet current effluent quality targets or require major upgrades to meet community growth needs. Engineered wetlands provide communities with a cost-effective wastewater treatment upgrade that meets regulatory requirements. MAGNA has worked with several communities in Alberta, Canada to design and secure approval for wetland treatment systems. The wetlands are being utilized to amend and upgrade existing lagoons. Design elements were implemented to promote cold weather operations include conservative sizing for wetland cells; soil and mulch cover; combination of both vertical flow and horizontal flow wetland cells for complete treatment of nitrogen; utilizing existing lagoon for storage in the winter as treatment redundancy to secure attainable discharge targets on the operating permit; and a recirculation line connecting the lagoon to the wetland cells allowing constant flow through and additional polishing to occur if discharge limits are not met.

Keywords
Cold climate; constructed wetlands; domestic sewage; effluent treatment; green infrastructure; wastewater treatment

INTRODUCTION

Constructed wetlands have been utilized across the globe for wastewater treatment, but their implementation in cold climates has been challenging (Wang et al, 2017). Biological processes are slowed in low temperatures, resulting in decreased treatment potential in the winter months (Kadlec and Wallace, 2009). As a result, constructed wetlands are frequently met with scepticism by wastewater experts and regulatory agencies. Despite the challenges, constructed wetlands offer unique benefits to smaller communities that cannot afford the financial and operational burden of conventional mechanical treatment facilities. MAGNA Engineering Inc. has responded to the need of smaller municipalities by offering a unique naturalized engineered wastewater system called the MAGNA Omni-Processor, or the MOP. This system combines constructed wetland treatment units with solids removal while offering ancillary opportunities for gasification of the organic waste by-products.

This work highlights the implementation barriers for constructed wetlands and showcases a unique design solution that was adopted as a result of regulatory engagement and an innovative engineering approach to a wastewater lagoon upgrade in a municipal district in west central Alberta. MAGNA was engaged to design an upgraded wastewater treatment facility (WWTF) in the municipal district of Clearwater County to support long-term growth and sustainability for a cluster of hamlets. Prior to construction, MAGNA conducted engagement sessions with regulators on the benefits of engineered wetland systems and went through an extensive design review to create a system that is optimized for cold climate operations to the satisfaction of all parties involved. In addition to education with the regulator's forward-facing representative, MAGNA also engaged in policy discussions on the role of innovative wastewater management systems in the province in order to promote acceptance and funding of alternative systems for rural communities.

To address the challenges of cold climate and minimize the risks associated with innovative wastewater technologies, unique design adaptations were adopted in the case study presented herein. The facility in question is set to be operational in late 2022/early 2023. The Clearwater County system will provide further evidence to the year-round effectiveness of treatment wetlands.

MATERIALS AND METHODS

A survey of small and medium-sized municipalities was conducted to identify key challenges for municipal wastewater infrastructure management, followed by the creation of a task force to address these key challenges and to advocate for changes to the provincial regulatory and funding pathways that would allow for innovative wastewater solutions for communities. Task force members included municipalities and governmental agencies responsible for wastewater approvals and funding. The outcomes included recommendations, an overview of innovation opportunities for the province, and a list of shovel-ready projects that could be used to test out the recommendations.

One of these projects was the highlighted Clearwater County MAGNA Omni-Processor, which is eligible to test out the recommendations of the task force engagement. The service population of this project is currently about 300, and the facility will additionally treat septage hauling from the surrounding rural county residences. Because of the external hauling, the wastewater will be highly concentrated and variable, average influent values are presented in Table 1.

Table 1. Design Flow Characteristics.

Characteristic	Flow (m^3/d)	BOD (mg/L)	TSS (mg/L)	TKN (mg/L)	TP (mg/L)
Sewage	44	220	220	40	6.5
External hauling	48	720	450	220	22
Combined	**92**	**481**	**340**	**134**	**14.6**

The site layout and process diagram are summarized in Figure 1.

Figure 1. Site Layout.

Sediment filtering and solids handling will be managed in the receiving building before the wastewater flows to the wetlands. Primary treatment is provided through a rotating mesh filter, which minimizes the risk of clogging the wetland treatment cells. After passing the filter, effluent is directed to the vertical subsurface flow biofilter for simultaneous removal of organics and nitrification. The vertical flow biofilter incorporates 300-500 mm of insulating wood mulch to minimize seasonal treatment fluctuations. Following the vertical flow biofilter, treated effluent is discharged to a horizontal subsurface flow wetland designed to promote denitrification and additional wastewater effluent polishing.

RESULTS AND DISCUSSION

The survey of municipalities identified the following challenges: increasingly stringent environmental regulations; increasing capital costs for wastewater infrastructure; and the financial burden of operating these facilities. In response to identified challenges, recommendations were made, many of which applied to the innovative facility in Clearwater County. Key recommendations included: differentiating between communities over and under 20,000 people to create a set of standard effluent targets that are applied to smaller communities, developing a process for piloting innovative technologies that utilize existing policy to approve innovative technologies, and updating the wastewater grant funding model so that smaller communities can receive grant funding to account for the alternative methods of wastewater servicing those low-density rural municipalities need to provide.

Parallel to that, regulatory authorizations were secured for the Clearwater project with technology verification and validation objectives set through treatment expectations and regulatory engagement. The system is designed to meet the following effluent targets: 25 mg/L BOD, 25 mg/L TSS, 16 mg/L Total Ammonia, and 1.25 mg/L Unionized Ammonia. Monitoring will occur in three stages. Weekly testing and reporting will begin immediately after the system is put online and continue for one year. After twelve months of weekly testing, the county will apply for final approval for the treatment system, which would effectively position it as a viable wastewater treatment option. Following approval, monthly testing will occur for two more years to monitor long-term performance. After three years of closely monitoring the system, the frequency of sampling will be reduced to standard compliance standards.

A unique aspect of this design is having both the wetland system and the lagoon, which enables contingency that was necessary for technology adoption in the local regulatory context. A similar approach of contingency-based design solutions may enable the implementation of treatment wetlands in other challenging regulatory or technical contexts.

CONCLUSION

This project demonstrates that constructed wetlands provide a much-needed low-maintenance wastewater treatment option for smaller communities and that cold climate challenges do not pose a technical barrier to implementation. Design challenges presented by this environment can be resolved by innovative engineering solutions and complex regulatory hurdles can be overcome with open engagement and adequate risk mitigation strategies. This project sets a precedent where constructed wetlands present a viable alternative to building a costly mechanical treatment facility with high long-term operating costs. Engineered wetland systems have been designed, constructed, and studied in Europe and North America, yet have not been widely adopted in Canada. These systems can provide naturalized passive treatment at lower long-term costs and do not require chemical inputs. This project is a milestone in the design and approval of engineered wetlands and nature-based solutions in Alberta, Canada and the lessons learned are applicable to a variety of other settings.

REFERENCES

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