FLOATING TREATMENT WETLANDS FOR WASTEWATER TREATMENT

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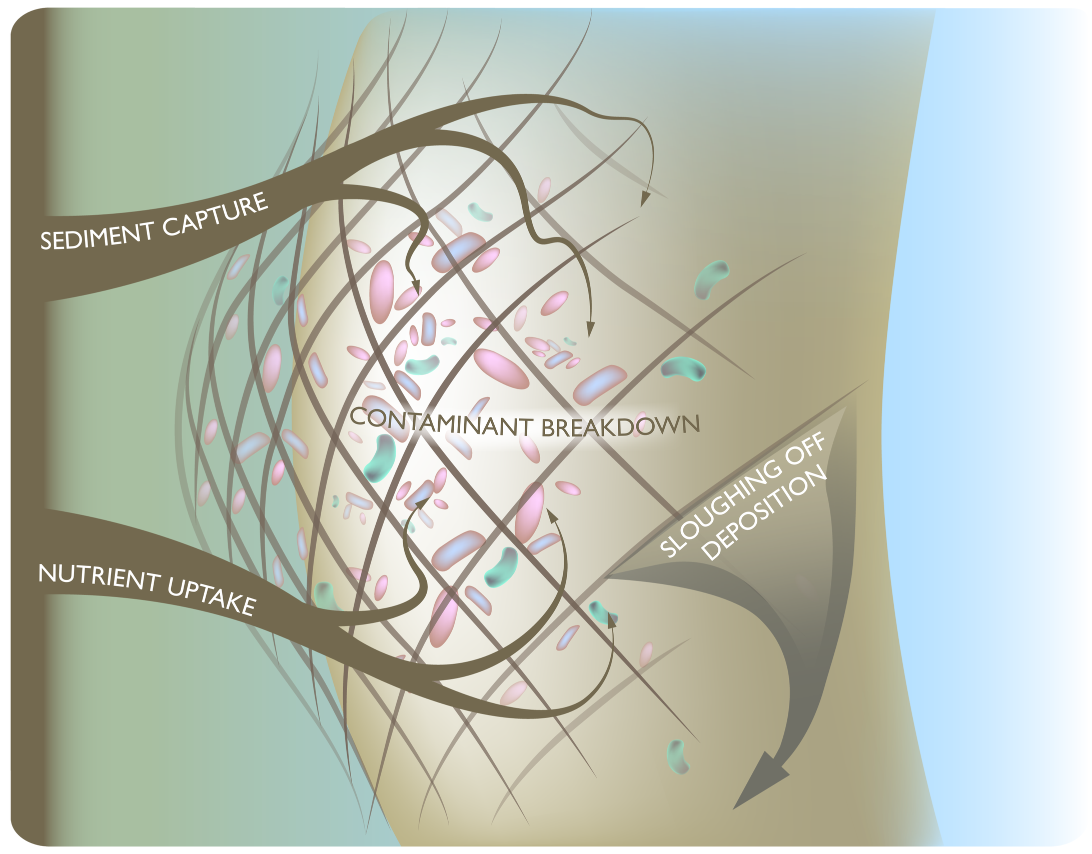
Background

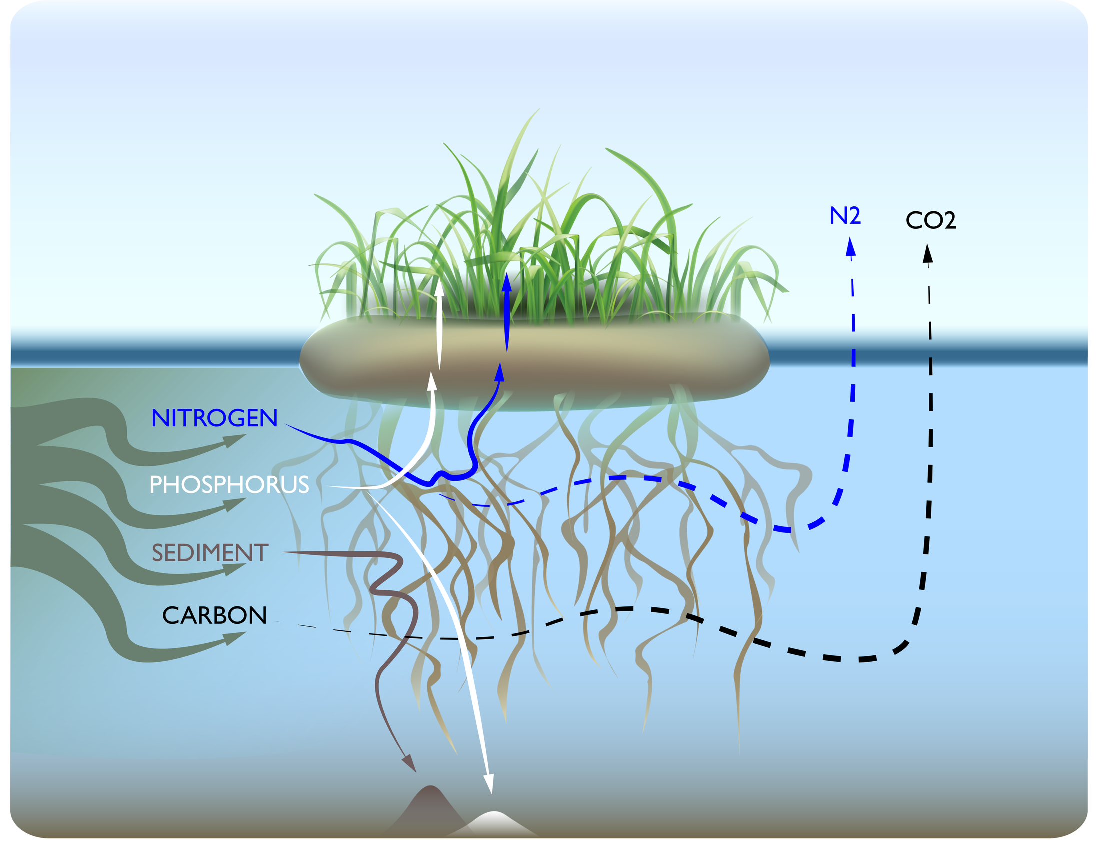
Naturally occurring wetlands are host to a wide array of complex chemical cycles, which remove contaminants from the water. In this study we focus on the fate of phosphorus, nitrogen, organic carbon, and suspended solids, as well as investigating change in water temperature, pH, electrical conductivity and dissolved oxygen. All of these parameters can have a negative impact on water quality, if not managed properly.

Plant roots and their associated microorganisms are responsible for the high treatment potential of an FTW. The community of microorganisms on the plant roots form a biofilm, which filters solid particles and removes dissolved nutrients from the water. The biofilm creates a sticky matrix of proteins and polysaccharides, which is effective at trapping and removing suspended solids. The biofilm community will extract and digest organic compounds, while incorporating nutrients like nitrogen and phosphorus into the biomass.

Although the plants remove dissolved nutrients from the water, their primary purpose is to provide a large surface area for biofilm growth. The plant roots can also act as a carbon and oxygen source for the bacterial community. This combination of roots and microorganisms creates a membrane that can be used to treat wastewater as it flows through a FTW.

As the biofilm grows and forms new layers, previous layers are covered and deprived of oxygen and nutrients. This causes the lower layers to degrade and the upper layers to slough off and sink to the bottom of the water column. Contaminants that had been removed from the water by the biofilm are either broken down, or sequestered on the bottom of the water body.





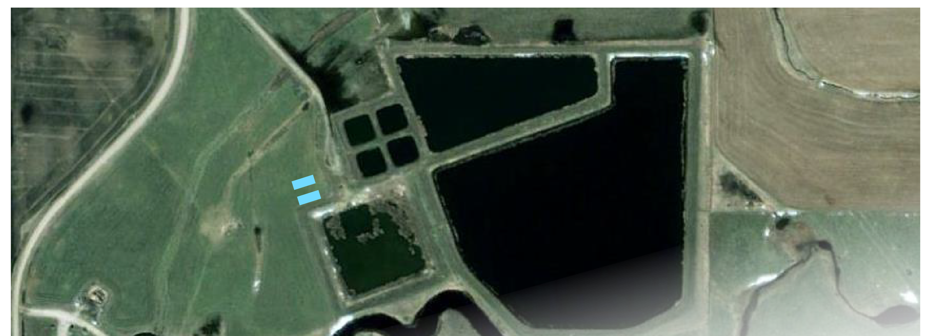
Floating Treatment Wetlands (FTW)

- FTW are an alternative means of wastewater and stormwater treatment
- An FTW platform floats on the surface which allows movement with changing water levels, and allows plants to remain at an optimum position
- The entirety of the root mass is exposed to the water column for treatment
- An FTW can be added to an existing facultative or storage lagoon and positioned to intercept contaminated water

FTW
At Carseland Site

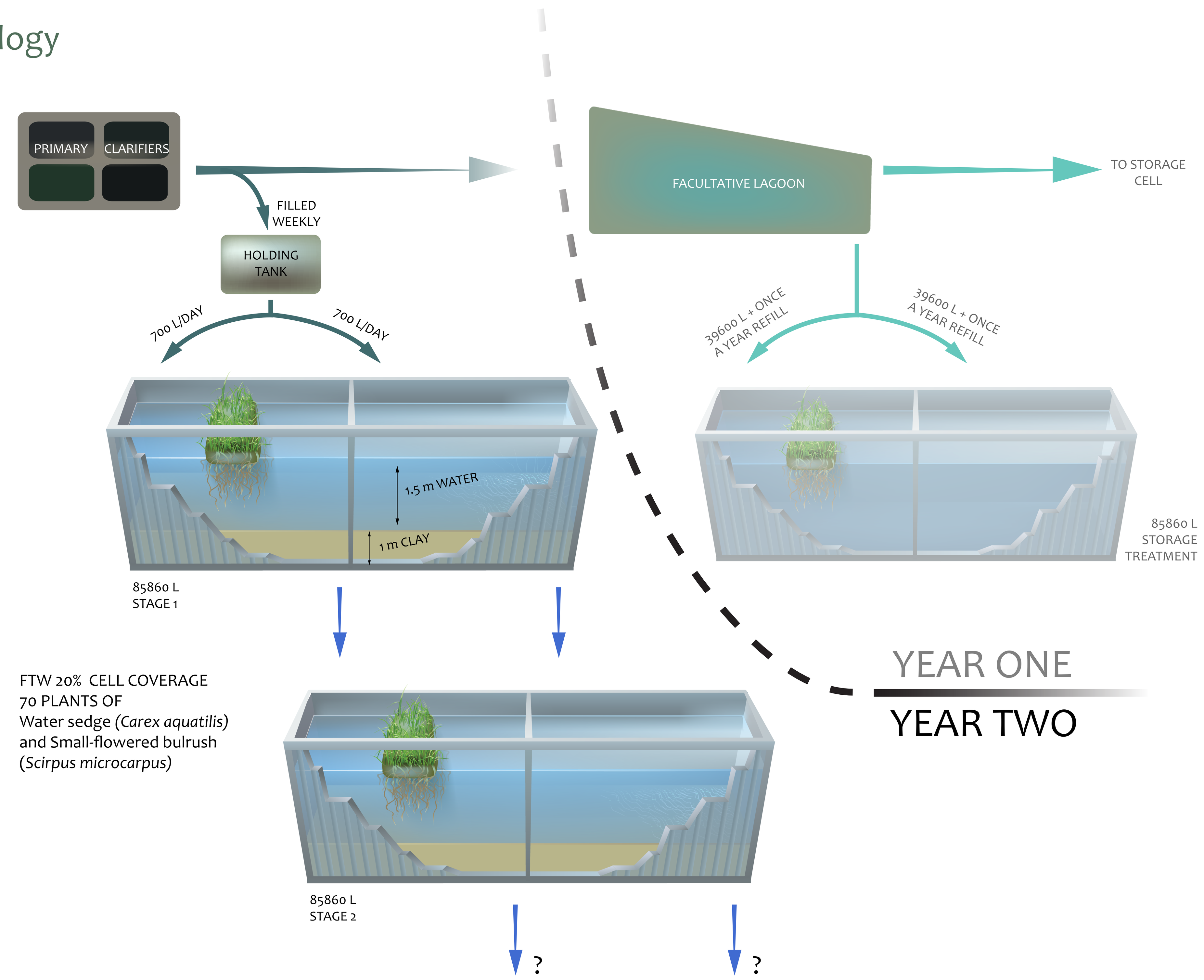
Objectives

- Does the installation of an FTW assist treatment of wastewater effluent in Alberta?
- What is the change in treatment over time as the plants establish? What is the difference in treatment when using high-nutrient vs. low-nutrient wastewater?
- Is it feasible to install an FTW in a lagoon, particularly in a continental Canadian climate? What kind of nutrient removal rates could future applications expect?



Test Site
Carseland Treatment Lagoons

Methodology



Methodology- Year 1
Two separate treatments: A static storage treatment containing low-strength wastewater from the storage lagoon. And a facultative treatment regularly fed effluent from the facultative lagoon, with a 50-day retention time.

Methodology-Year 2
One single two-stage treatment, containing high-strength wastewater from the primary clarifiers. Each stage has a 25-day retention time, creating a 50-day retention for the entire system.

Analysis
Water samples were collected twice a week from June to September for both 2015 and 2016. Contaminants measured included ammonia (NH_3), nitrate (NO_3^-), total nitrogen (TN), orthophosphate (PO_4^{3-}), total phosphorus (TP), total suspended solids (TSS), and biochemical oxygen demand (BOD). Water temperature, dissolved oxygen, electrical conductivity and pH were measured twice a week from June to September, and continuously from August 25 to September 5.

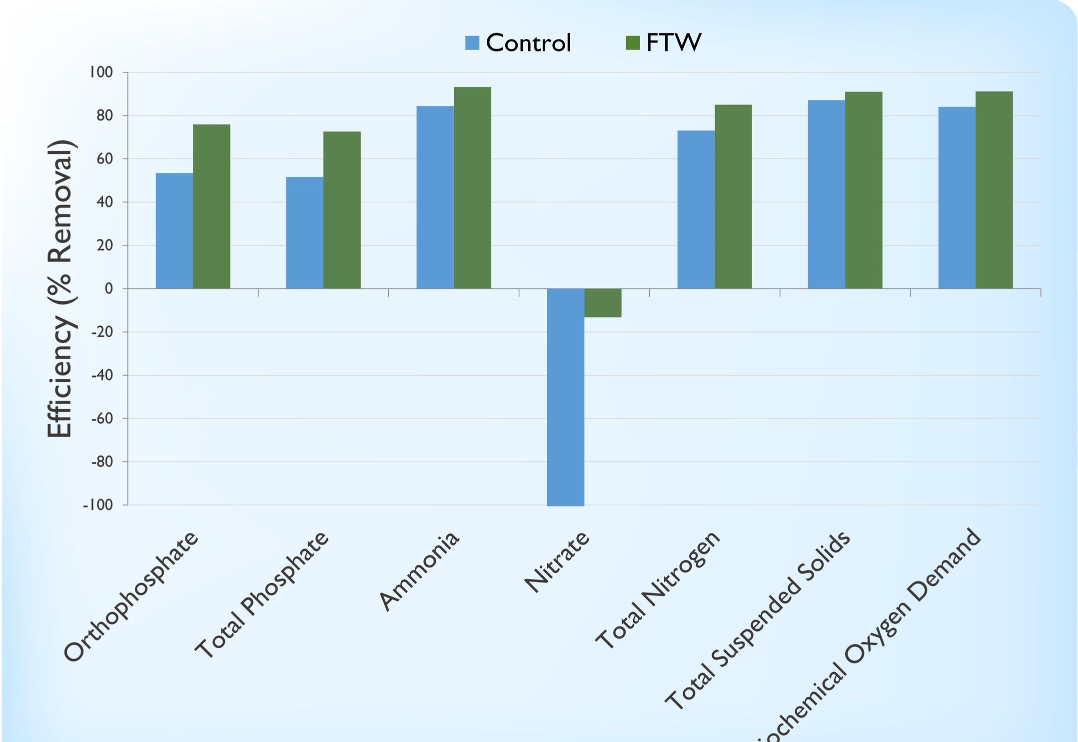
Results

Results from the 2015 field season indicated that the FTW reduced contaminant concentrations, particularly nitrate and ammonia. Ammonia was reduced significantly within the storage treatment ($p<0.05$), and was effectively removed by the FTW cell 45 days before the control. Nitrate production was higher in the FTW cell early in the season (June to Mid-July), but concentration quickly decreased below the control by mid-summer. Phosphorus was reduced by 80% in both cells, but there was no significant difference between the FTW and control. The plants overwintered successfully, as only 1 of 140 plants failed to return in spring 2016.

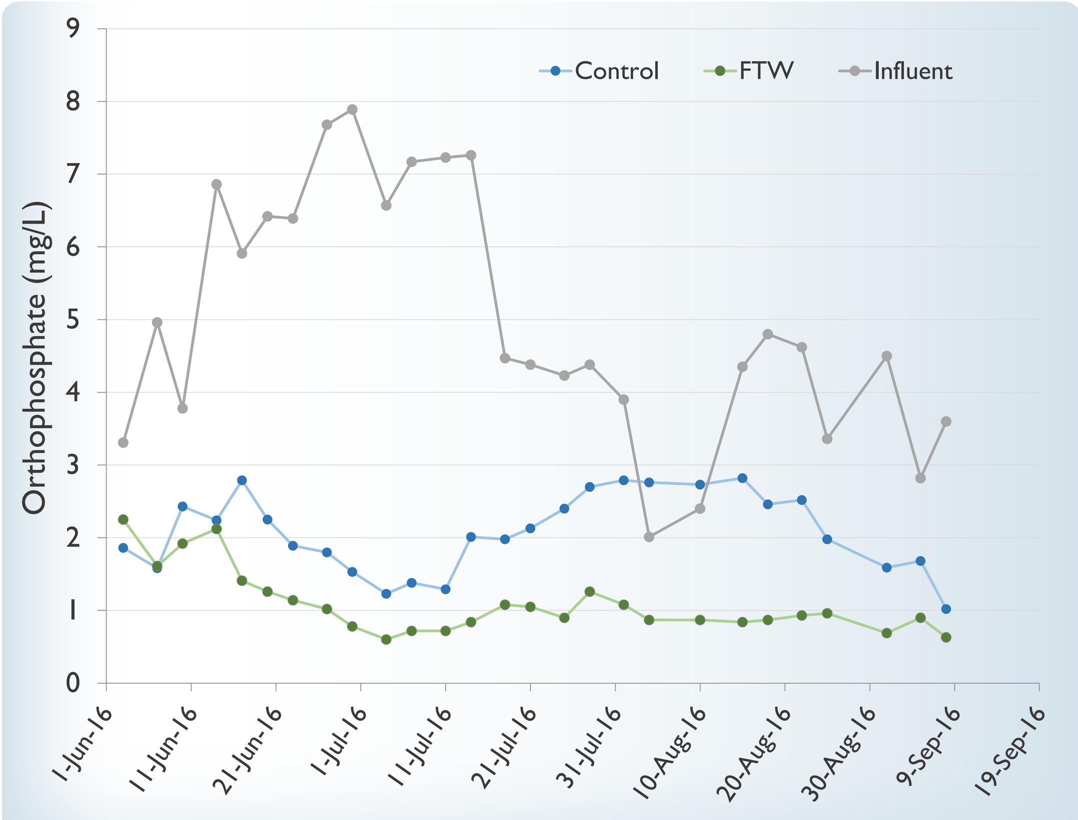
Results from the 2016 field season have shown a much larger difference between the FTW and control, with the FTW cell removing significantly higher levels of orthophosphate, total phosphate, ammonia, and biochemical oxygen demand (BOD), relative to the control ($p<0.05$). Both cells increased nitrate concentration, though the FTW produced significantly less (+13% FTW, +104% Control). Continuous data collection (15 minute intervals) from August 25th to September 5th revealed the FTW cell had lower average temperature (-0.3°C), pH (-0.4), electrical conductivity (-54 µS/cm), and dissolved oxygen concentration (-3.3mg/L).

Conclusions

FTW are an ideal method to increase the treatment efficiency of sewage lagoons, without increasing the total volume of the system. The results of our two-year study indicate that FTW are best suited to treating high nutrient concentrations, such as those found in primary effluent. The growth and overwintering success of the plants reveal that FTW are suitable for cold continental climates, and could be applied to overburdened sewage lagoons throughout Canada.



Removal Efficiency for Stage 2 Treatment



Orthophosphate Concentration for the 2016 Season