DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Restoration Design for Lake Banook

Sophie Boutilier, Joseph Francis, Qike Li, Greg Simms, Tianjian Yu

Department of Environmental Engineering

HALIFAX

Scope of Work

- Lake Banook is a freshwater lake located in Dartmouth, NS. It is a recreational hub for the community and is home to many aquatic and boat clubs.
- In recent years, it has experienced closures during the summer months due to cyanobacterial algae blooms, which is harmful to human health.
- Phosphorus is the limiting nutrient in algae growth, due to this, the design objective for this project is to reduce phosphorus loading into the lake, which will in turn reduce algae in the lake.
- Phosphorus reduction will be achieved through a combination of standard and floating treatment wetlands to absorb phosphorus from lake inflow and uptake phosphorus from the lake.

Lake Bathymetry

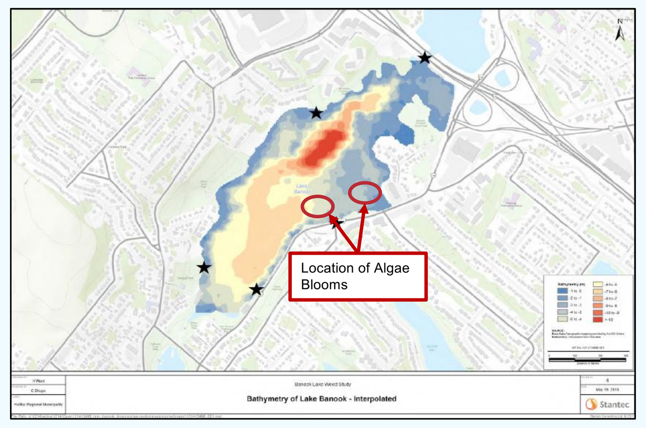

Figure 1. Bathymetry of Lake Banook.[1]

- Mean depth: 2.6 m
- Max depth: 11.3 m
- Locations of past algae blooms circled in red

Surface Water Quality

Criteria	Minimum Conc.	Maximum Conc.	Average Conc.
pH	7.31	7.84	6.61
Chloride (mg/L)	196	243	213
TSS (mg/L)	<5	<5	<5
TN (mg/L)	<0.4	1.4	1.3
TP (ug/L)	7	18	11

Figure 2. Water quality of Lake Banook in 2017.[2]

- Lake Banook contains relatively high concentrations of total phosphorus and total nitrogen
- It generally maintains a mesotrophic state year round

Watershed Analysis

Figure 3. Watershed delineation of Lake Banook.

Watershed Delineation

- ArcGIS was used to delineate watershed and analyze land use
- Total area of the drainage basin is 16.3 km^2; outlined in red
- Sub-drainage basin area for Lake Banook is 4.3 km^2; outlined in yellow
- Lake Charles is also included in the watershed, which is not included in the photo

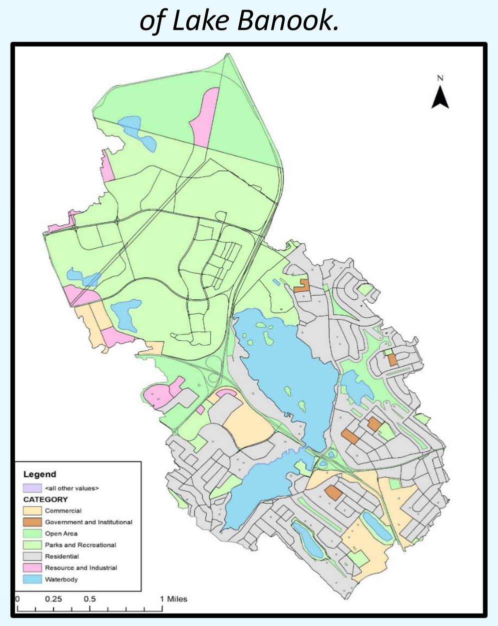

Figure 4. Watershed land use survey.

Land Use Survey

- Residential: 32%
- Park & Recreational: 34.1%
- Industrial: 2.6%
- Commercial: 5.6%
- Other: 25.7%

Source of nutrients

- Likely to be urban non-point source contaminants (domestic fertilizers, highway runoff)

Phosphorus Model:

The NS Phosphorus Model was applied to find where the main sources of phosphorus were originating.

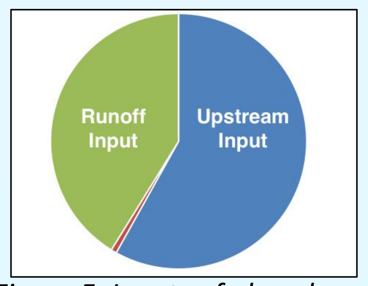

Figure 5. Inputs of phosphorus loading in Lake Banook.

Design Component 1 - First Flush Tank

- Designed as a flow control structure and first flush volume diversion tank for the standard treatment wetland
- First flush principle states, 30-85% of total phosphorus is contained in the first 50% of runoff [3]
- Capable of diverting 50% of a 60 minute storm event at an intensity of 3.7 mm/hr
- Baffles partially isolate first flush volume from mixing with the remaining runoff volume
- Estimated cost: $115,000

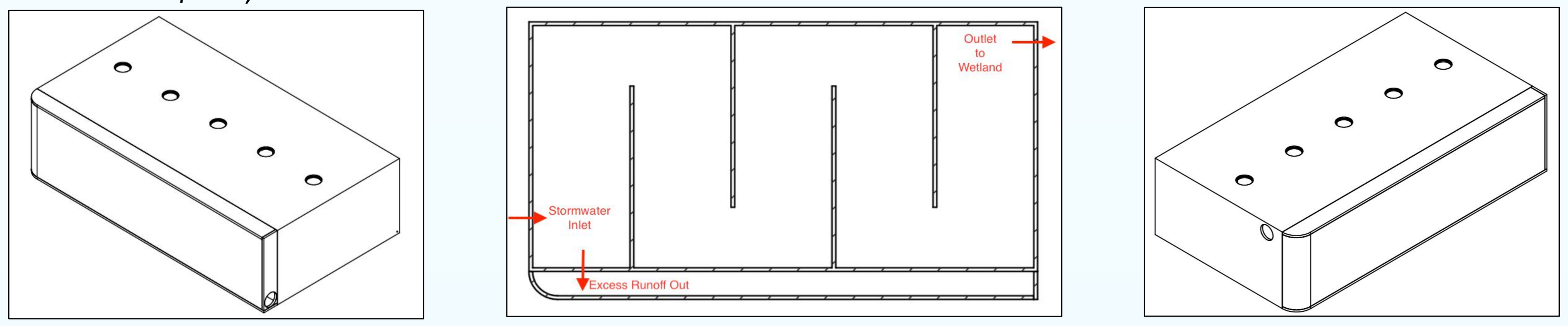

Figure 6. First flush tank downstream face (left), plan view (center), and upstream face (right).

Design Component 2 - Standard Wetland

Design Details

- The wetland will be 60 m x 33.3 m with 1m berms, for a total footprint of 0.22 hectares
- The wetland will have 3 deep zones and 2 shallow zones
- Pickerelweed and softstem bulrush will be planted on the shallow zones
- Berms will be placed around the wetland at a 2:1 slope and 1 m width at the top
- Phosphprus will be absorbed by the wetland vegetation, and then the water will be discharged into Lake Banook

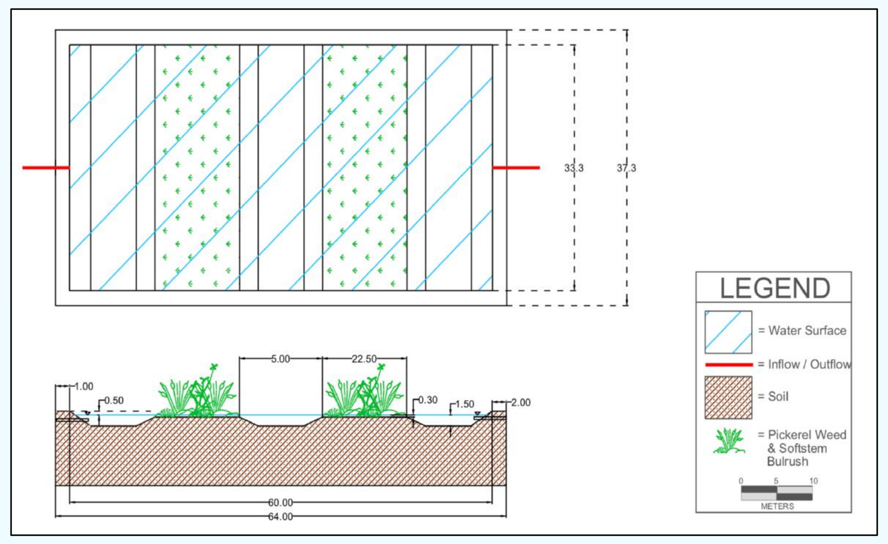

Figure 7. Wetland top view (top), and side view (bottom).

Location

The wetland will be constructed within the Brookdale Crescent Park, which is located on the northern shore of Lake Banook.

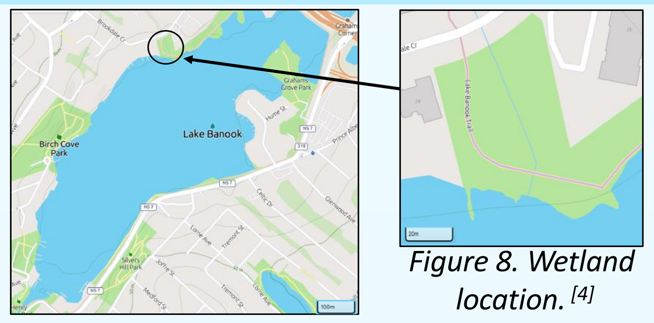

Figure 8. Wetland location. [4]

Predicted Results

50% removal of phosphorus runoff (33 ug/L to 16.4 ug/L)

Estimated Cost

$70,000

Design Component 3 - Floating Wetland

How it works

- Floating platform for plants to grow
- Plant roots underneath the platform filter TSS, promote the growth of biofilm, and absorb critical nutrients for algae (P & N)

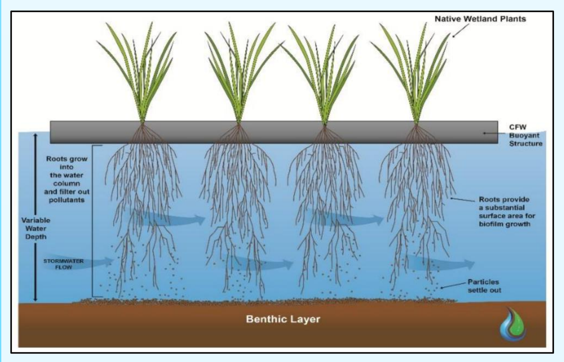

Figure 9. Floating wetland. [5]

Details

- Located in the eastern portion of the lake, where multiple algae blooms were observed last year
- Area: 12000 m^2
- Ideal wetland plant: pickerelweed, a native aquatic plant of Nova Scotia with a high P uptake rate of 7.67 mg per plant
- Module Size: 2 m x 2 m
- Layers and Material Used:
  a) Flora – Pickerelweed
  b) Substrate – Coco coir mat
  c) Inner structure – Geotextile 200
  d) Frame – 5'' PVC pipe
  e) Floatation device – Dock floats

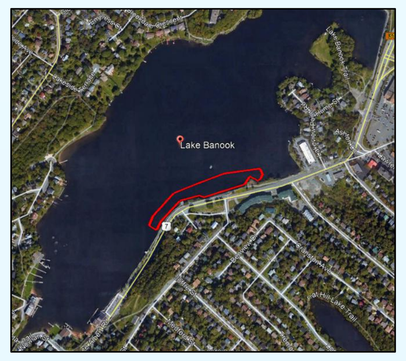

Figure 10. Wetland location.

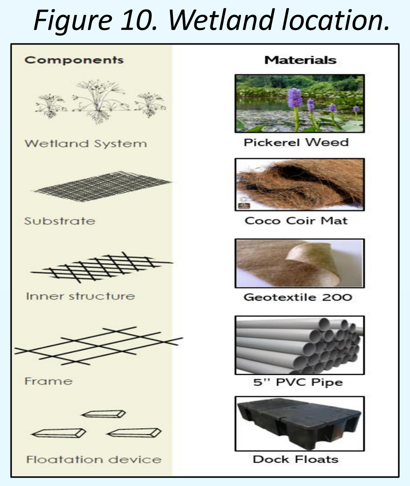

Figure 11. Wetland components.[6]

Estimated Results

With a 12000 m^2 floating wetland; 50% removal rate for a in-lake phosphorus concentration of 30 mg/L could be achieved.

Maintenance & Cost

- For maximum nutrient removal efficiency, FTWs need to be harvested seasonally
- Cost: $360,000 startup

Design Component 4 - Monitoring

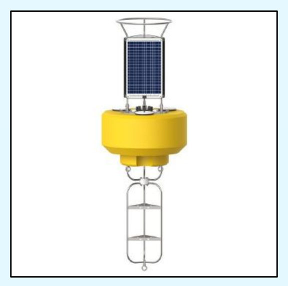

Figure 12. Monitor. [7]

- Model: CB-950 with YSI EXO2 Sonde from Nexsens Technology
- Cost: $15,000
- This model detects nutrient concentrations such as phosphorus, as well as chlorophyll
- The data will be recorded and transmitted to an online database
- Compared to traditional lab water analysis techniques (ion chromatography, segmented flow, automated distillation and titration as well as discrete analyzers), this is cheaper, faster and more accurate

Conclusion

Excess nutrient loading has caused Lake Banook to progressively approach a eutrophic state which increases its risk of hosting cyanobacteria. The sources of nutrient loading are runoff from the Lake Banook watershed, and upstream nutrient input from Lake Micmac. The proposed design solution takes direct action on these mechanisms and ensures Lake Banook remains in a mesotrophic state year round.

Design Elements Include:

- Constructed floating treatment wetlands applied in Lake Banook and Lake Micmac resulting in ~50% phosphorus removal from Lake Banook
- A first flush hydraulic diversion structure designed to capture and reroute the first 50% of runoff from a selected sub-catchment area of Lake Banook
- A constructed terrestrial based treatment wetland to process the runoff volume diverted from the first flush tank and the base flow from the selected sub-catchment area
- A monitoring system and program to obtain continuous water quality data with the objective of tracking progress and act as a warning system for the presence of cyanobacterial blooms
- Future recommendations for a watershed management program and infrastructure improvements to help reduce the runoff volumes Lake Banook experiences

Recommendations

Regarding the in-lake treatment designs, developing a future development plan is essential.

- To prevent runoff
  - Construct green infrastructure and green barriers
- To reduce nutrient loading
  - Use phosphorus-free fertilizer
  - Community involvement
  - By-laws to aid in accomplishing the above tasks
- To reduce chlorine concentration
  - Implement a new product as a substitute to road salt

References

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