Department of Biosystems
and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

BE 487 - Spring 2025
Biosystems Design Projects

Treatment of Harmful Algal Blooms in Soldan Dog Park

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Client: Ingham County Parks Faculty Advisor: Dawn Dechand Ph.D.

Background

Blooms appeared in Scott Woods Pond in October 2022 and reoccurs every Fall. The blooms were suspected to be cyanobacteria due to the spilled paint appearance (Figure 1A) and thick mats formed (Figure 1B).

Some cyanobacteria produce cyanotoxins. Cyanobacteria are often referred to as blue-green algae, but they're actually a prokaryotic phototrophic bacteria. Blooms are caused by eutrophication, the addition of excess nutrients to the pond water (TN > 1 mg/L, TP > 0.1 mg/L).

Figure 1. Cyanobacteria on pond surface

Figure 2. Bloom by stormwater inlet

Symptoms of cyanotoxin poisoning include vomiting, drooling, damage to liver, brain, kidneys, and reproductive organs, muscle paralysis, and death.

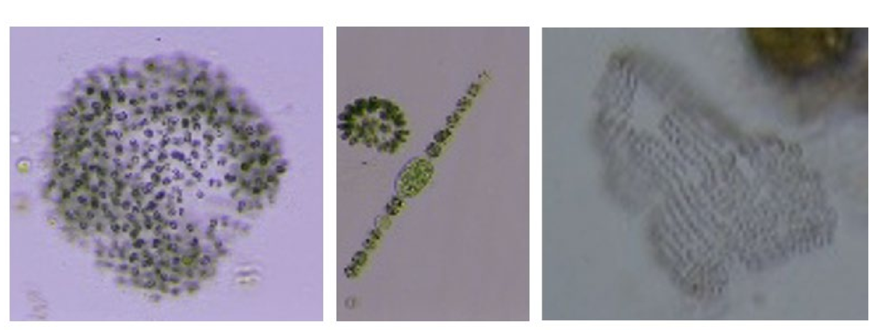


Figure 3. Toxin-producing cyanobacteria found in pond water

Objectives

- Decrease cyanobacteria below 20,000 cells/mL (USEPA, 2017)
- Reduce total phosphorus below 0.1 mg/L (Boyd, 2019)
- Requires maintenance less than 3 times per year
- Identify cyanobacteria, cyanotoxins, and impact on park patrons
- Determine limiting factors for cyanobacteria growth

Constraints

- Spend < $1,000 to develop the initial design
- Cyanobacteria samples must be collected above 32°F
- Comply with EPA and EGLE regulations

Figure 4. Dog at fenced section

Design Alternatives

- Algal Turf Scrubber (ATS)
- Biological Control (BC)
- Floating Treatment Wetland (FTW)
- Iron Chloride and Bentonite Clay (ICBC)
- Water Lifting Aerators (WLA)

Criteria

- Toxin removal efficiency
- Cost
- Environmental impact
- Nutrient removal efficiency
- Maintenance required
- Ease of implementation

Decision Matrix

Table 1. Decision Matrix

Category	Weights	ATS	BC	FTW	ICBC	WLA
Toxin Removal Efficiency	30%	1	4	4	1	3
Cost	20%	5	5	4	2	1
Environmental Impact	15%	5	2	5	5	5
Nutrient Removal Efficiency	15%	3	5	4	5	1
Maintenance Required	10%	1	3	3	5	4
Ease of Implementation	10%	3	4	5	5	2
Total	100%	2.9	4.0	4.2	3.2	2.6

The Floating Treatment Wetland was determined to be the best alternative for this project.

Selected Design

Floating Treatment Wetland Prototype

- EVA foam rubber mat
- Hydroponic cups
- Light expanded clay pebbles
- Poly-Flo ©
- American Sweet Flag
- Soft stem Bulrush

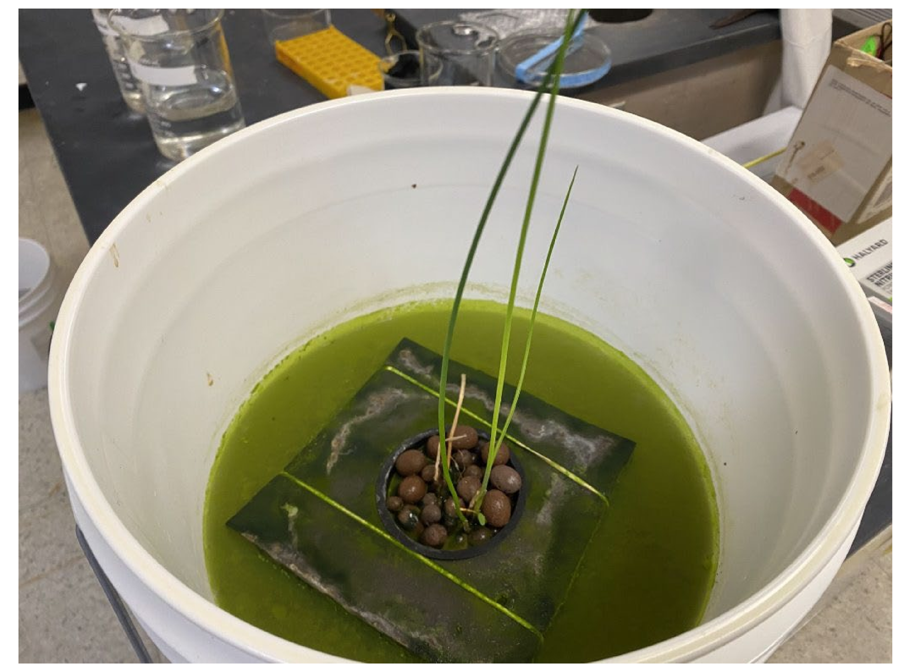


Figure 5. Floating treatment wetland prototype

Relevant Equations

Flotation capacity:

$$W_{max} = (\rho_f - \rho_m) * V_m * g$$

EVA foam flotation capacity = 2.36 lb/ft^2

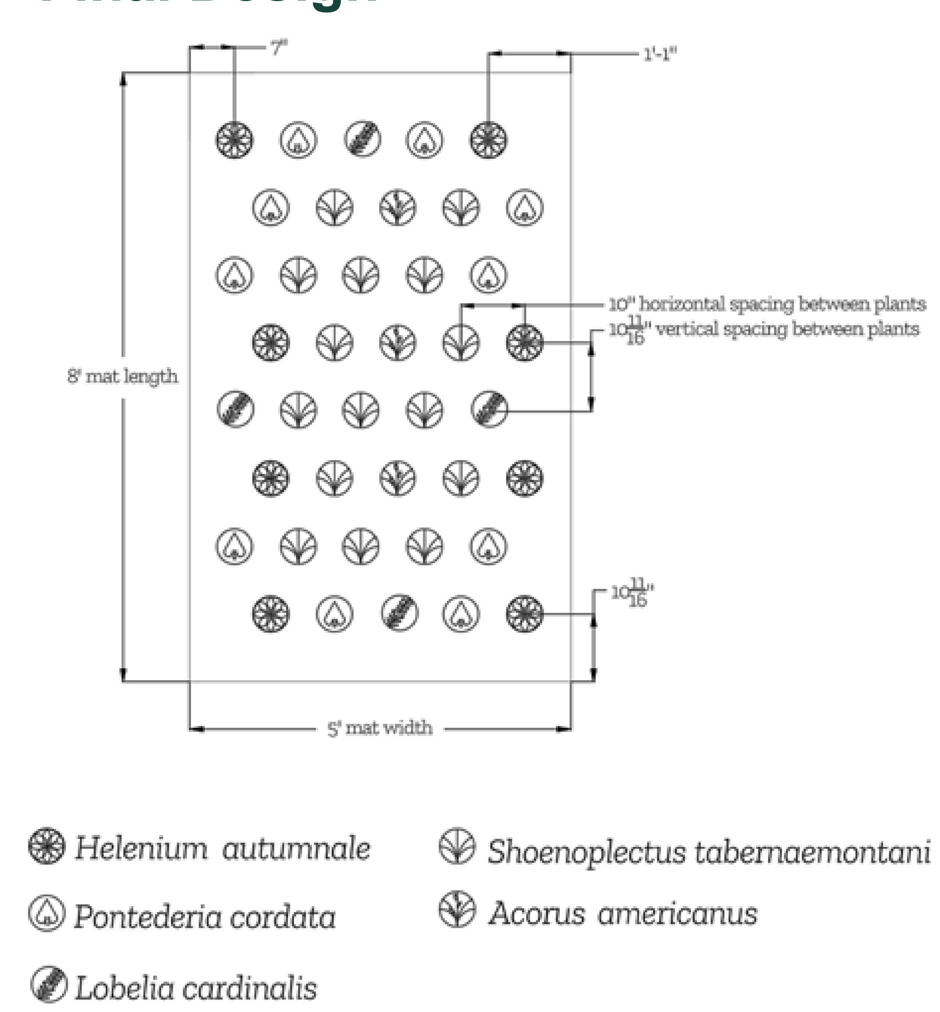
Nutrient Dilution:

$$C_f V_f = C_i V_i + C_a V_a$$

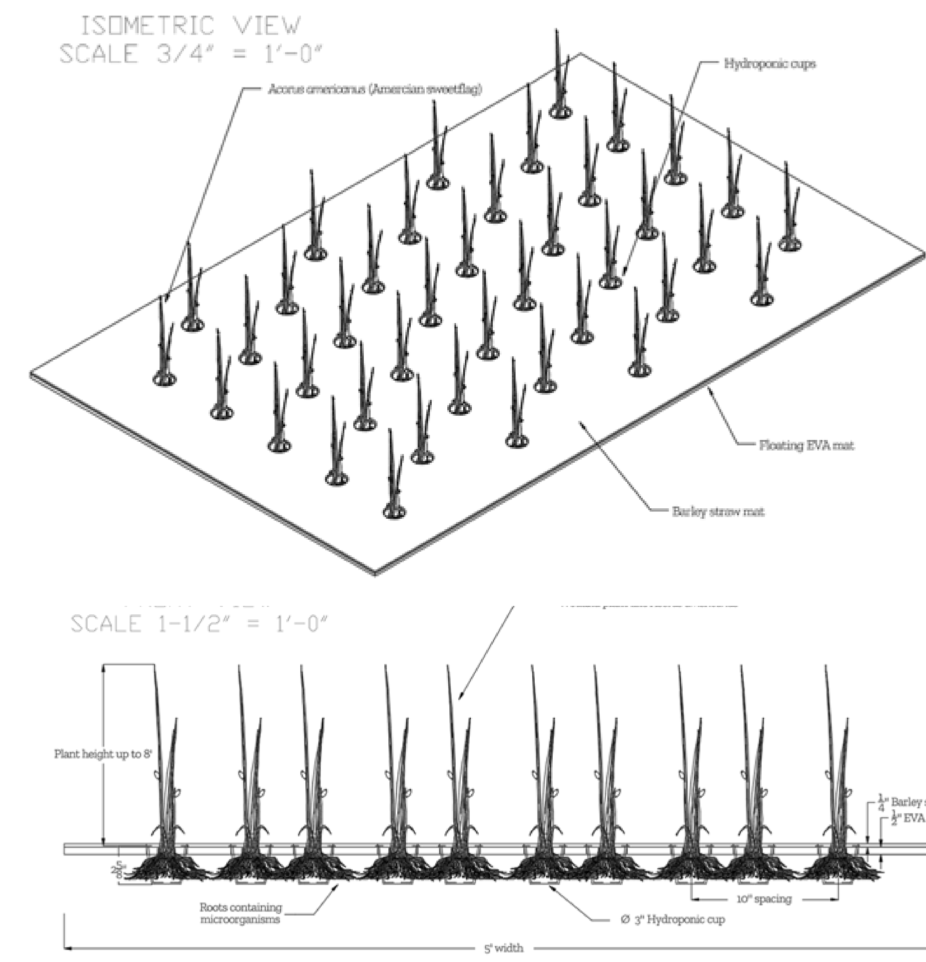
Phosphorus Sorption:

$$K_d = \frac{V * (C_0 - C_{eq})}{m_{clay}} = 1.76\, mg \frac{P}{kg\ clay}$$

Final Design



Selected Design Cont.



Design Parameters

- Parameters determined experimentally:
  - Phosphorus uptake for each plant
  - Effect on cyanobacterial growth
  - Phosphorus sorption with the clay

Figure 6. Sorption experiment

- Small scale experimental setup:
  - 2 control beakers (clay)
  - 2 Sweet Flag beakers
  - 2 Soft Stem Bulrush beakers

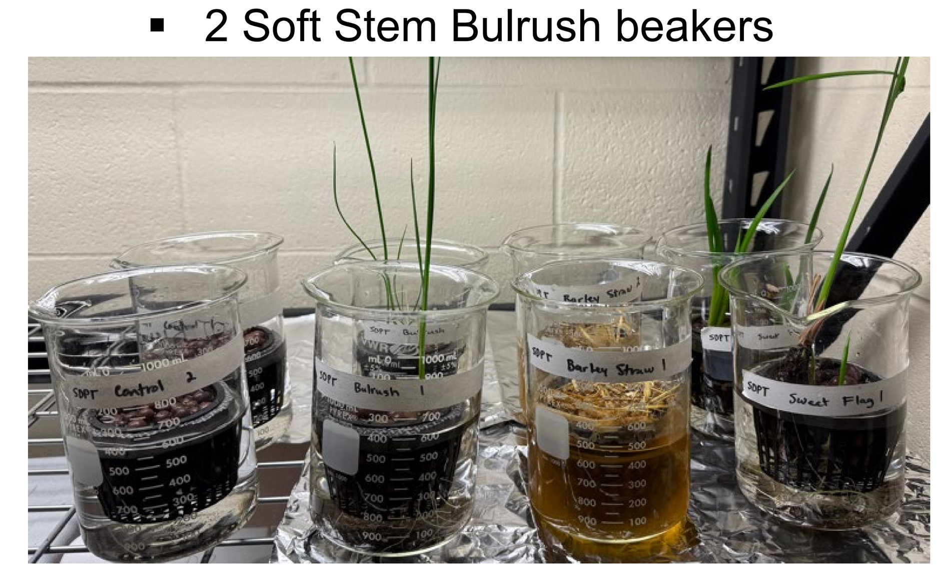


Figure 7. Bench-scale experiment

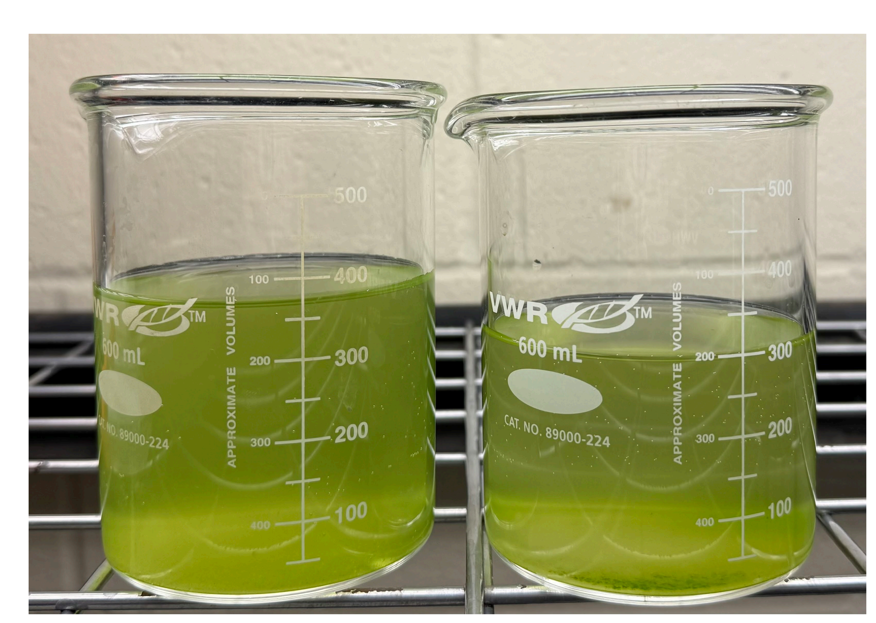


Figure 8. Cyanobacteria culture

Economic Analysis

- Difficult to quantify- no direct profit
- Could improve park activity
  - 12-month membership: $30
  - Day pass: $5
- Will save the park money from liability

Table 2. Final Design Cost

Item	Cost	Unit
Hydroponic Mat	$0.92	per ft^2
Hydroponic Cup	$3.57	per 50 cups
Zip ties	$20.00	per 1000 zip ties
Plants (Aesthetic mix)	$36.50	per 20 plants
Plants (Functional mix)	$30.00	per 20 plants
Anchor	$24.00	per 2 anchors
Rope	$24.00	per 120 ft
Maintenance	$381.92	8 hrs, x2/year
Labor	$1553.28	4 ppl,16 hrs
Total	**Aesthetic & Functional**	**Functional**
1 mat	$144.87	$138.37
100 mats	$7,560.80	$6,910.80
250 mats	$18,830.00	$17,205.00

Total removal of the 250-mat floating treatment wetland is approximately 418 g of P/year.

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- Ingham County Parks

Selected References

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