Identification and Mitigation of Harmful Algal Blooms in Mantua Reservoir

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I. Proposal Summary

Cyanobacteria, also known as blue-green algae, are capable of emitting cyanotoxins which are harmful to humans and animals. Harmful Algal Blooms (HABs) occur when cyanobacteria multiply to great densities. Mantua Reservoir in Box Elder County, UT, experiences seasonal HABs, which has resulted in seasonal reservoir closures.

The EnVision team investigated the cause of HABs at Mantua Reservoir by collecting samples from the reservoir's known point sources and frequently visited recreation areas. The samples were analyzed to determine total phosphorus, nitrate, and cyanotoxin concentrations. The team concluded that excessive phosphorus loading in the reservoir is most culpable for the annual HABs the reservoir experiences. Consequently, the EnVision team recommends a dual faceted approach: implementation of a watershed management plan with the objective of reducing phosphorus loading and a targeted approach to eliminate cyanobacteria that are currently present in the reservoir.

II. Alternatives

The team considered several different alternatives to eliminate cyanobacteria in the reservoir. The following is a list of ideas that the team analyzed: algaecides, flocculation, artificial mixing, ultrasound, barley straw deposits, drain and/or dredge, hydroponics/aquaponics, and planting algae-consuming fish.

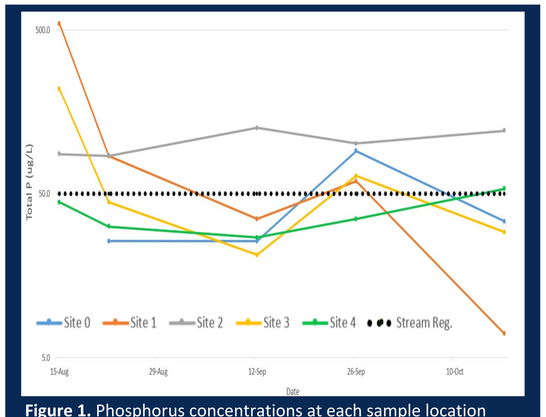


Figure 1. Phosphorus concentrations at each sample location

III. Criteria and Decision Matrix

EnVision developed a list of design criteria to analyze which alternative most closely satisfies the objective of the project. The design criteria included the following: annualized cost, designated use impacts, environmental impacts, treatment efficacy, and frequency of treatment. Annualized cost is an estimated cost for the alternative on a yearly basis. Designated use impacts refer to how the alternative is going to affect Mantua Reservoir's ability to satisfy the beneficial use classifications for a Class 2B, 3A, and 4 water body. Environmental impacts refer to the way in which an alternative will influence the environment, whether for good or bad. Treatment efficacy was judged based on experimental data for projects similar in nature to Mantua Reservoir. Frequency of treatment refers to the regularity of treatment the alternative would require.

To eliminate bias in the evaluation of each alternative, the team developed a pugh matrix. The objective of the pugh matrix is to assign values to each design criteria based on their ability to satisfy the design criteria. For this project, the team rated cost, designated use impacts, environmental impacts, and efficacy of treatment on a 0-5 scale; 0 represents an alternative that does not satisfy the design criteria while a 5 means an alternative does satisfy the design criteria. Frequency of treatment was completed using a 0-1 scale; 1 represents an alternative that required infrequent or single implementation, while a 0 represents frequent treatment.

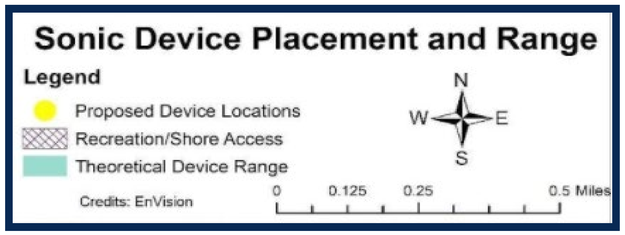
Figure 2. The team collected samples from the locations shown above and performed subsequent lab analysis to determine nutrient loading conditions in Mantua Reservoir

Alternative	Cost (annualized)	Designated Use Impacts	Environmental Impacts	Efficacy	Frequency	Total
Flocculation	3	5	3	3	0	14
Artificial Mixing via Aeration	2	4	4	2	1	12
Ultrasound	4	4	5	4	1	17
Barley Straw	1	2	3	2	0	8
Do Nothing	5	1	0	0	1	6

IV. Selected Alternative

After completing the analysis, it was determined that ultrasound treatment would most closely satisfy all of the design criteria. Ultrasound devices produce sonic waves in the lake which trigger acoustic cavitation to disrupt and rupture the vacuoles used by cyanobacteria to control buoyancy. Without these vacuoles, the cyanobacteria sink to the bottom of the lake, where they are unable to adequately photosynthesize.

This option presents the fewest hazards to lake users as well as non-target biology. Ultrasound devices are capable of being tuned and targeted to specific organisms. Current uses suggest impacts are highly frequency specific. *Microcystis*, a genus of cyanobacteria that is present in Mantua Reservoir, can experience removal rates of 65% (NEIWPCC 2015). Additionally, due to the device's ability to be fine-tuned, sonic waves can be released at a frequency that does not impact the viability of other aquatic biota in the reservoir.



V. Design

For this project, two design layouts are being presented to Brigham City. The first layout optimizes coverage of common recreational areas. This layout would require six devices. Each device is placed near the shoreline for ease of installation and maintenance. The second layout optimizes the surface area per device. This layout would require five devices and covers approximately two times as much surface area as the first layout.

VI. Gratitude

The EnVision team thanks Dr. David Stevens and Professor Austin Ball from the USU College of Engineering, Angela Pritchett from JBS USA and Jen Mickelsen in Brigham City Public Works for their assistance and mentorship during this project. Additionally, the team thanks the Utah Water Research Laboratory, Dr. Joan McLean and Joshua Hortin for their involvement in lab analysis procedures. Funding for this project was provided by the USU College of Engineering.