<u>Improving the Arboretum Water Quality</u>

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Abstract

The Arboretum site has long been affected by poor water quality. This, stemming from the stagnant hydrology of the waterway, and high nutrient concentrations has resulted in low levels of dissolved oxygen. Low dissolved oxygen is problematic in that it can create a positive habitat for algal blooms that further diminish the quality of the water. It also may threaten the life of fish and animal species that are dependent on certain levels of oxygen. Furthermore, the Arboretum, is a landmark at the University of California Davis, and needs upkeep to enhance its aesthetic value.

In this study, a cost-benefit procedure was implemented to decide whether dredging, flushing, a combination of the two, or no implementation, would be the best method to ensure the improved quality of the waterway. These implementations were chosen per their effectiveness against sediment build up (stagnation), and algal blooms (low dissolved oxygen).

Dredging refers to the process of gathering up accumulated sediments from the bottom of a water-source. This method can be done a number of ways, whether it be manual, with a backhoe, or hydraulic with a fleet and pump. For our purposes, and for the lasting quality of the Arboretum we determined that hydraulic dredging would be the most effective.

Hydraulic dredging is a method by which a fleet and suction pump are placed into a water source that then pumps up the sediment. This sediment and accumulated material can be pumped just off site, further downstream, or can be used as fertilizer. Due to the fragile nature of the UC Davis Arboretum, the dredged material would have to be put off-site or in the best scenario used as fertilizer. The overall benefit of Hydraulic Dredging is that it would be the most rapid way of cleaning up the Arboretum.

Flushing refers to the use of outside water being introduced to a water source, in order to 'flush' contaminants and sediments. Flushing is particularly helpful in breaking up algal blooms, and causing circulation in stagnant water bodies. In the case of the UC Davis Arboretum, a monitored of systems flushing of the water retention basin could alleviate the lack of flow, and help prevent against the build-up of nutrients, chemicals, and algae that threaten the vitality of the waterway.

Flushing can aid in the reduction of a number of concerns such as: bacterial accumulation, chemical contaminants, turbidity, and can lessen water discoloration, poor odor, and sediment build-up. There is however a variety of concerns stemming from this method, chiefly being that flushing only move the problem further downstream. In the case of the UC Davis Arboretum costs, we also had to factor in where exactly the water would be pumped to, and what mitigations would be necessary to protect these other water sources.

Additionally, each and every water-body is a sensitive ecosystem, so the introduction of water via flushing has to be done in a way that closely mimics the

natural flow of the waterway. As the UC Davis Arboretum currently has no in-flow, other than storm-water, it does not have the composition of a river, or a creek. However, fish and other species rely on the Arboretum and must be taken into account when the flushing system is put in place.

For this project, a monitored flushing system seemed to be the most beneficial in that it only allows water to flow at certain periods. Coupled with an initial dredging, flushing would help break up any periodic build-up of nutrients and algal blooms.

Introduction

The Arboretum consists solely of stagnant stormwater and high eutrophication. Circulating it and restoring flow will enhance the water quality, levels of algae, and environmental aesthetics. In order to do this, we chose two methods using data such as Arboretum nutrient levels, and the cost per square acre of implementing these methods. We then estimated the costs and damages into monetary value. With that we were able to calculate the benefit and compare each method using a full incremental cost-benefit analysis.

Objective

The objective of our research was to find the most beneficial method for improving the water quality of the Arboretum. A cost-benefit analysis encompasses much more than just what is better for the waterway; it also factors in the expense of the project, how it will affect stakeholders, as well as the affects to the Arboretum.

Data Sources

<u>Dredging</u>:

We spoke with UC Davis Prof. Randy Dahlgren about his experience with the dredging process. He provided us with the following link as an example and his own experiences with successful dredging: <u>http://ecolinfo.ees.adelaide.edu.au/SALMO-OO/docs/Hongping.pdf</u>

We contacted Metropolitan Environmental Services, Inc. in Ohio to gain a sense of what things are considered when dredging a site. A representative (Jim) listed important aspects of such projects and gave us an idea of what we needed to calculate in.

<u>Flushing:</u>

The flushing information that we collected encompassed different resources, including some data from Randy Dahlgren. More supporting data was collected by extensive online research.

Methods and Assumption

Dredging:

methods: hydraulic dredging (expensive equipment) and manual dredging (expensive time-length)

costs:

- man hours and number of workers
- average pay (union wages versus private)
- access points
- pumping site and distance
- area of waterway to be dredged
- predicted nutrient accumulation rate
- size of dredge

assumptions: We have assumed an average rate of dredging per square foot and that the funding and politics of the campus are for dredging of the waterway.

Flushing:

methods: using a monitor (more accurate/efficient) versus scheduled flushing (no cost of monitor)

costs:

- *monitor-flushing*: monitor equipment (most likely $13k), pipeway, water source or recycling, water destination, acre feet of waterway and turn-over time
- *scheduled flushing*: months susceptible to eutrophication (summer/hot)

assumptions: we have assumed the pipeway constructed will cost $10,000 and that flushing coupled with dredging will eventually replace dredging.

Calculation/Results

Project	Life Year	Capital Cost (Million)	O & M (Million)	Damages (Million)
Do Nothing	0	0	0	2
A (Hydraulic Dredging)	5	0.189	0	1
B (Manual Dredging)	5	0.35	0	1
C (Monitory Flushing)	3	0.073	0.15	1
D (Monthy/5 Month Flushing)	5	0.06	0.25	1
AC	8	0.262	0.15	0.5

AD	10	0.249	0	0.5
BC	8	0.423	0.15	0.5
BD	10	0.41	0.25	0.5

COST:

Project		Annual Capial Cost (Million)	O & M (Million)	Cost (Million)
Do Nothing		0	0	0
A (Hydraulic Dredging)		0.189	0	0.189
B (Manual Dredging)		0.35	0	0.35
C (Monitory Flushing)		0.073	0.15	0.223
D (Monthy/5 Month Flushing)		0.06	0.25	0.31
AC		0.262	0.15	0.412
AD		0.249	0.25	0.499
BC		0.423	0.15	0.573
BD		0.41	0.25	0.66

BENEFIT:

Project	Do Nothing Damages (Million	Damages (Million)	Benefits (Million)
Do Nothing	2	2	0
A (Hydraulic Dredging)	2	1	1

B (Manual Dredging)	2	1	1
C (Monitory Flushing)	2	1	1
D (Monthy/5 Month Flushing)	2	1	1
AC	2	0.5	1.5
AD	2	0.5	1.5
BC	2	0.5	1.5
BD	2	0.5	1.5

ANALYSIS:

Project	Benefits (Million)	Costs (Million)	Rank		Net Benefit
Do Nothing	0	0	1		0
A (Hydraulic Dredging)	1	0.189	2		0.811
B (Manual Dredging)	1	0.35	5		0.65
C (Monitory Flushing)	1	0.223	3		0.777
D (Monthy/5 Month Flushing)	1	0.31	4		0.69
AC	1.5	0.412	6		1.088
AD	1.5	0.499	7		1.001
BC	1.5	0.573	8		0.927
BD	1.5	0.66	9		0.84

COMPARE:

compare	Project	B	C	B/C	ΔB	ΔC	ΔB/ΔC	Decision
	Do Nothing							
0-A					1	0.189	5.291005	A>0
	A	1	0.189	5.291005				
A-C					0	0.034	0	A>C
	C	1	0.223	4.484305				
C-D					0	0.087	0	A>D
	D	1	0.31	3.225806				
D-B					0	0.04	0	A>B
	B	1	0.35	2.857143				
B-AC					0.5	0.062	8.064516	AC>A
	AC	1.5	0.412	3.640777				
AC-AD					0	0.087	0	AC>AD
	AD	1.5	0.499	3.006012				
AD-BC					0	-0.38821	0	AC>BC
	BC	1.5	0.573	2.617801				
BC-BD					0	0.087	0	AC>BD

	BD	1.5	0.66	2.272727				

Conclusions

After doing a full Cost-Benefit Analysis, we concluded that option AC is best contender for this project. The alternative is A. We calculated a plethora of numbers that showed us many real-world scales of how both dredging and flushing, along with its combinations were portrayed. We began brainstorming this research with many questions and uncertainties, but now can see how our findings have supported our hypothesis. By creating the most long-term project, which yields a less expensive price tag, the most feasible cost-benefit option has been selected.

Recommendation/Limitations

Based on our research, combining hydraulic dredging with monitored flushing is the most long-term beneficial. For one, when dredging is supplemented with flushing, it does not have to occur regularly, like it would if implemented on its own. With the continuation of flushing, nutrient build-up can't accumulate and create dredge material. This is economical because the act of dredging would be a one-time cost. Additionally, hydraulic dredging has less of an environmental impact than manual dredging and the purpose of our project is primarily for the improvement of the habitat. It's also time efficient and more practical for the dimensions of the narrow Arboretum. Flushing is necessary for preventing eutrophication by not allowing nutrients to accumulate. Using a monitor will allow us to accurately track chlorophyll and oxygen levels and automatically activate a flushing cycle when, for instance, oxygen is at a baseline. If the fish population requires 5 ppm of oxygen, it can guarantee this. The alternative of flushing monthly during the summer could be just as helpful, but potentially unnecessary or not frequent enough. It would pump regardless of nutrient levels, using water and energy inefficiently. Limitations generally include an undefined budget and how much funding is necessary, as there are many routes that can be taken regarding which companies are hired and their prices. For dredging, as mentioned previously, we must consider where the access points for the dredging equipment would be (easy or difficult?), where the dredged material would be dumped, and costs of its transportation. For flushing, we'd have to decide whether to purchase water to flush through the waterway or to recycle the present water. The installation and use of a pipeway would need to be indicated and the destination of the water. Also, a decision would be necessary for what monitor to purchase and what functions it should include.

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