Adaptive Strategies to improve the Condition of Ford Lake

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Presentation to the Ford Lake Water Conservation Advisory Committee, Township Trustees, and Guests
14 November 2005
Ford Lake Vital Statistics

- Surface Area = 4,039,000 m²
- Lake Volume = 17,370,000 m³
- Mean Depth = 4.3 m
- Volume below 5 m = 3,019,000 m³
- Mud area below 5 m = 1,639,000 m²
- Average Flushing Time June 2003 to August 2005 (Lake Volume/River Inflow) = 23.3 days
Simple measure of water transparency: use a flat white disk 8 inches (20 cm) in diameter known as a Secchi disk.

Record the distance below the surface where the disk can no longer be seen.
Seasonal Changes in Water Transparency

Seasonal variations in water transparency are evident in the graph. The data shows a clear water phase during May and June, with a significant drop in Secchi depth below 1 meter. The graph indicates that FL1, FL2, and FL3 experience similar trends, with FL1 generally showing the lowest Secchi depth values. The data suggests a decrease in water transparency during the summer months (July to August) and a recovery towards the end of the season (September).
There is a general relationship in Ford Lake between the abundance of microscopic algae, measured in terms of their chlorophyll content, and the water transparency.

The relationship is not strong, however, because transparency is affected by whether or not the algae is organized in large clumps.

It is fair to say that floating surface blooms of the algae are considered a serious problem.
The nuisance problems in Ford Lake are caused by the particular species of algae that come to dominate during warm summer months.

They are called bluegreen algae, or more properly cyanobacteria.

During the rest of the year, Ford Lake is dominated by different species of algae that can be very numerous, but do not form surface mats.
Factors that favor cyanobacteria

- High temperatures and low wind
- Large supply of phosphate
- Low ratio of nitrogen to phosphorus
- Ammonium as a nitrogen source

Usual assumption-- algae nuisance in Ford Lake is caused by phosphate in the Huron River, particularly by phosphate discharged from the Ann Arbor wastewater treatment facility.

This is not so.

The specific triggers for nuisance algal blooms in Ford Lake have an internal cause, and they can potentially be managed.
Anoxic deep waters cause trouble at dams

- Excess sulfides and acids corrode dam structures, pipes, and machinery
- High levels of sulfides and methane pose threats of poisoning to operating staff and of explosion
- Anoxia promotes accumulation of phosphate and ammonium, with risk of large nuisance blooms when mixing occurs
- Reduced fish habitat and risk of fish kills when mixing occurs
Not only are blooms of cyanobacteria a nuisance, they can be toxic, as well

- Some of the cyanobacteria in Ford Lake during late summer 2005 were from a genus called *Microcystis*
- Some strains of *Microcystis* make a potent liver poison called microcystin

The algal toxin microcystin in Ford Lake. The World Health Organization has suggested 1 nM as the maximum level safe for prolonged consumption.
Management options differ depending on lake or reservoir **water depth**

- The ratio of transparency depth to mixing depth has been called the “optical depth”
- Lakes are said to be optically deep if the mixing depth is much greater than the transparency depth
- In optically deep lakes, planktonic algae can be limited by light rather than nutrient

Management options differ depending on lake or reservoir **nutrient sources**

- If **point sources** dominate:
  1. Nutrient diversion
  2. Dilution
  3. Chemical treatment before input
  4. Removal by macrophytes or wetlands
Management options differ depending on lake/reservoir nutrient sources

- If non-point sources dominate:
  1. Sediment oxidation
  2. Sediment removal
  3. Sediment capping
  4. Chemical additives (algaecides)
  5. Artificial circulation
  6. Selective depth withdrawal
  7. Biomanipulation

Is Ford Lake dominated by point source or non-point source nutrients during the nuisance season?

Phosphorus is the nutrient element that most limits the growth of algae in Ford Lake.
June to August, 2003 to 2005, each day:

Huron River delivered 533 moles of phosphate
914 moles of phosphorus in all dissolved and colloidal forms

Ford Lake mud released 1228 moles of phosphate each day on average.

• In Ford Lake, non-point sources dominate.
Evaluate Management Options

1. Sediment oxidation

Ford Lake mud consumes 0.72 grams of oxygen per square meter per day. In order to meet this demand of the mud below 6 meters depth (the region that goes anoxic) it would take 830 kilograms (1800 pounds, or roughly one ton) of oxygen each day.

At the current price of liquid oxygen, this would cost $240 per day ($16,800 for 10 weeks), plus delivery charges, container rental, and delivery system.
Evaluate Management Options

2. Sediment removal
Ford Lake has four square kilometers of mud bottom. Even when the lake was created it was not done by excavation on that scale.

Does not seem economically or logistically feasible.

Evaluate Management Options

3. Sediment capping
Let’s see...build township roads or pave Ford Lake?

Probably not realistic.
Evaluate Management Options

4. Chemical additives (algaecides)

Each treatment could cost tens of thousands of dollars and would be temporary (weeks) because the poisons would be washed downstream. Moreover, existing algaecides have been implicated in killing the small invertebrates that eat algae.

Not economically feasible nor environmentally sound.

Evaluate Management Options

5. Artificial circulation

By installing solar powered mixing machines or pumping underwater jets of water, the small thermocline can be eroded and the lake will mix deeper. This would plunge algae into darkness more often and cause them to be limited by light. Nutrients thus become irrelevant.

This could probably work, but what about: Navigation hazards? Removal and maintenance during winter? Energy costs if water jets are used? Fouling by zebra mussels?
6. Selective Depth Withdrawal

Modify the turbine intake structure, or install a curtain in front of it, ideally something that can be positioned tactically to withdraw surface water (the hottest) and deep water (the coolest, also that which stagnates now). The lake will mix more deeply, achieving the benefits of option 5 but letting gravity do all the work.

This will probably work, but... The dam is regulated by federal bureaucracy. Who will design the intake structure? Fouling by zebra mussels? At least power generation would not have to suffer.

This could advance scientific understanding of bloom dynamics if the structure could be used in an adaptive way based on predictions from theory and measurements.
Evaluate Management Options

6. Selective Depth Withdrawal, Plan B

The dam already has gates at the bottom. Reduce power generation during the vulnerable months and let enough water drain from the bottom to prevent anoxia.

Again this can work, but there is a clear economic tradeoff. Who will offset the lost revenue from lost power generation? On the other hand, no new structures, permits, or annual maintenance is required.

Maybe a careful experiment is in order.

Evaluate Management Options

7. Biomanipulation

Ford Lake presents the features of a shallow lake in the west and a deeper lake in the east. Shallow lakes do not respond to increased mixing because they mix already.

Shallow lakes have two alternative stable states:

(1) low transparency, small fish, lots of algae, or

(2) lots of weeds but more transparency, predatory fish, and few algae.
Evaluate Management Options

7. Biomanipulation, continued

Ford Lake had a long clear water phase this year, but it eventually ended. One way to extend the clear water phase is to stock predators (e.g. pike or walleye) that eat small minnows. Otherwise, the minnows eat the small invertebrates that eat the algae.

Biomanipulation is tried a lot and often it works for at least a few years. Its advantage is low cost and public support.

Evaluate Management Options

7. Biomanipulation, continued: Drawbacks

In order to (over)stock Ford Lake to the desired extent, it would take more fish than the DNR can produce for all lakes in southeastern lower MI. Any attempt to import fish from outside the region runs the risk of introducing pathogens, as well.

Biomanipulation has the potential to cause unexpected outcomes that could be negative, and there is no assurance that it would work all by itself.
Role of Science

- Science is about the creation and testing of theory
- Science can not tell us what is the right or best thing to do.
- Citizens must apply their own value judgments within the framework of participatory democracy.
Hydropower Revenue

- During June, July and August 2005 enough water was passed through the turbines at Ford Lake dam to generate 936,000 KW-h of power
- At $0.045 per KW-h, this could generate gross revenue of $42,000
- If the generators were operating in an adaptive manner to maintain oxygen at the bottom outlet, $32,000 would have been produced.

Best Guess Oxygen Costs

- $240 per day for oxygen x 10 weeks = $16,800
- Tank rental: 12 tanks @$30/mo each x 3 mo = $1080
- Tank delivery/replacement: $15 per delivery x 35 deliveries = $525
- Hose, phase separator, and diffuser-TBD
Simple Model
Steep sided linear basin
West end- 10 compartments, 5 m deep at maximum
East end- 10 compartments 5 m deep, 10 compartments deeper than 5 m
Simulate actual oxygen
Use actual discharge data from dam, courtesy of Ypsilanti Charter Township
Simulate alternative scenario
Same water discharge total
For 10 weeks starting June 1:
Send enough through bottom gates to maintain oxygen in the lake bottom at the dam
Discharge the rest through the turbines.