Report

MUNICIPALITY OF NORTH Cowichan

Date	September 21, 2022	File:
Subject	Mitigating blue-green algae blooms in Quamichan Lake	

PURPOSE

To determine which steps the Municipality of North Cowichan should take to mitigate the blue-green algae in Quamichan Lake. A staff presentation will be provided.

BACKGROUND

Assessment and research work completed in 2018 for the Municipality was used to develop a monitoring plan that would inform the assessment of management options to improve water quality on Quamichan Lake with the specific goal of mitigating blue-green algae blooms and/or the phosphorus that fuels those blooms. One of the primary tasks of the Senior Environmental Specialist upon commencing work for the Municipality was to establish a water quality monitoring program for Quamichan Lake and to use the data collected from this work to develop a management plan to improve water quality and mitigate blue-green algae blooms in the lake. Regular monitoring of lake water quality commenced in 2020 and is ongoing.

It is also known that an important factor in the biochemical processes that govern blue-green algae blooms is the makeup of Quamichan Lake's sediment. The 2018 research suggested that 85-90% of the phosphorus causing blue-green algae blooms was derived from sediment in the lake. In order to get a precise assessment of the lake sediment and the effect it has on phosphorus and blue-green algae, a consultant was hired in 2022 to take sediment core samples, analyze their chemistry and report back to the Municipality on the implications of this information on management options to mitigate blue-green algae blooms in the lake.

DISCUSSION

A regular monitoring program began in 2020 which features the following work:

- installation of a sampling platform to record hourly changes in temperature and oxygen;
- monthly (winter) and bimonthly (summer) sampling in the lake and tributary streams to track nutrients, i.e., nitrogen and phosphorus with phosphate (PO_4) being the form of phosphorus that fuels blue-green algae blooms; and,
- monthly (winter) and bimonthly (summer) sampling in the lake to track changes in the lake's phytoplankton community.

This monitoring program has helped staff develop a solid understanding of the biogeochemical processes in the lake that are associated with blue-green algae blooms (Attachment 1). Specifically, monitoring has shown how changes in temperature and oxygen concentration in different parts of the lake govern phosphorus cycling between the sediment and lake water to drive blue-green algae blooms. Data also shows that the timing and duration of these physical changes can drastically alter the blue-green algae blooms' timing, duration and size (Attachment 1- slides 7, 8, and 9).

Monitoring the phytoplankton community also has shown that most plankton blooms are not blue-green algae. The analysis also demonstrates that, even when blue-green algae is dominant in the phytoplankton community, toxic species of blue-green algae, *i.e., Microcystis spp.*, are not usually the dominant portion of the blue-green algae species (Attachment 1 - slides 5 and 6). Although this may be of some reassurance, the lake retains the capacity to generate lengthy blue-green algae blooms that can be very unpleasant due to the odour and appearance often associated with these rapidly growing and decaying organisms, regardless of their toxicity.

The timing and duration of these blue-green algae blooms are associated with the onset of peak summer temperatures at the surface of the lake and the onset of anoxia (zero oxygen) at the bottom of the lake. As phytoplankton species die, they are consumed by bacteria as they sink through the water column. The high temperature at the surface slows down mixing as it has a lower density than the cooler water below. The small amount of oxygen that makes its way to the lake's depths is rapidly consumed by bacteria that are digesting the decaying phytoplankton. In the absence of oxygen at depth, phosphate is liberated from the lake sediment. The vast store of phosphate in the lake sediment is then slowly cycled to the shallower portions of the lake. Because blue-green algae are more suited to habitats with relatively high phosphate concentrations, it begins to dominate the phytoplankton community. The predominance of blue-green algae continues until the lake turns over in the winter and oxygen levels are restored at depth in the lake (Attachment 1 - slide 6).

The initial research and assessment conducted in 2018 suggested that several options existed to mitigate blue-green algae by removing phosphorus, and therefore the phosphate, from the lake or severing the link between phosphate and blue-green algae:

- dredging: collecting sediment from the lake and moving it and the embedded phosphorus elsewhere;
- artificial mixing: using forced air or mechanical means to mix surface water to the depths thus supressing anoxia and keeping phosphate in the sediment;
- Aeration: forcing air into the lake depths or cycling super-oxygenated lake water to deep parts of the lake to supress anoxia and keeping phosphate in the sediment;
- Flushing; pumping the phosphate-rich water out of the lake, or augmenting discharge to move phosphate-rich water out of the lake; and,
- phosphorus capture: using different treatments, e.g., iron, alum, and Phoslock ®to capture phosphate and sequester it on the lake sediment.

In addition to the monitoring work conducted by staff, it was recognized that an assessment of the lake sediment would provide significant insight into which potential management options may be most suited to the situation. A contract for this research and assessment was awarded to Dr. Maira Mucci and Limno Solutions in late 2021. Sediment sampling was conducted in February 2022 with North Cowichan Environment staff providing a boat as a sampling platform and assisting in the collection of sediment core samples (Attachment 1 - slide 10).

Quamichan Lake sediment samples were sent to Limno Solutions and research partners for analysis (Attachment 2). Dr. Mucci’s analysis led to the following conclusions:

- sediment phosphorus is a key driver of the lake's water quality;
- there is about 32 tonnes of releasable phosphorus in lake sediment;
- sediments of Quamichan Lake may not have enough iron to bind the releasable phosphorus; and,

- high sulphur concentrations in the sediment might reduce the natural binding capacity of the sediment for phosphorus.

Dr. Mucci's conclusion that a large pool of phosphorus in the lake sediment is the primary driver of phosphorus and, therefore, blue-green algae blooms in the lake supports the conclusion of the 2018 analysis and subsequent monitoring work by municipal staff that has been based on sampling water quality in the lake. The precision of the sediment analysis, however, provides a quantifiable target for managing phosphorus dynamics in the lake. In combination with data collected by staff on temperature, oxygen and nutrients in the water column we can work with potential contractors and partners in federal and provincial agencies on a tractable management approach.

The report by Dr. Mucci (Attachment 2) also provides an assessment of the efficacy of management options to control phosphorus in the lake. The assessment of the efficacy of the potential approaches is similar to those provided in the 2018 report but has a higher precision in its estimate of potential costs, particularly in the case of phosphorus capture.

A summary of the assessment of the potential management options is that:

- dredging is not suitable for Quamichan Lake; large quantity of sediment to be removed, high costs, and uncertain efficiency;
- artificial mixing may cause sediment resuspension and stimulate cyanobacteria;
- aeration may attenuate fish kills, but its effect on phosphorus depends on iron available in sediment;
- flushing/deep water withdrawal will likely require a few years to take effect and would involve moving phosphorus-rich effluent out of the lake, which may face regulatory challenges, and,
- phosphorus capture, e.g., Phoslock® has a very high cost and may need reapplication.

Staff is of the opinion that both dredging and artificial mixing have enough risk and cost that they are not viable candidates as management approaches for controlling phosphorus dynamics in Quamichan Lake. In order to go forward with a program that is inviting to partners in other levels of government, staff recommends that Council engage a consultant to assess the potential of using aeration as a management option for the lake.

After preparation of an aeration analysis, staff will return to Council with an analysis of the costs and benefits associated with aeration, flushing and phosphorus capture. Council will be asked to provide guidance to staff on proceeding with a management approach which:

- selects a management option;
- outlines a management goal;
- has a monitoring program;
- determines budget and staffing required;
- determines support required from provincial and federal agencies;
- identifies partners in local and First nations Governments; and,
- identifies partners in stewardship groups and stakeholders.

OPTIONS

1. **(Recommended Option)** THAT Council direct staff to:
   (1) Engage a consultant to assess the costs and benefits of aeration in Quamichan Lake to manage phosphorus dynamics and mitigate blue-green algae blooms; and,
   (2) Prepare a report for Council, which includes a recommendation on the most beneficial management option for mitigating blue-green algae blooms in Quamichan Lake.

   - This option builds on the existing monitoring work and research conducted over the last five years. It provides clarity on the potential benefits of aeration in the lake and provides more certainty on the potential costs of setting up and operating an aeration management approach in Quamichan Lake. If approved, the consultant cost will be added as an expenditure in 2023 from Quamichan Lake Water Quality Reserve Fund.

2. THAT Council direct staff to prepare a report for Council recommending a management option for mitigating blue-green algae blooms in Quamichan Lake.

   - This option speeds up the process of selecting a management option for mitigating blue-green algae blooms in Quamichan Lake. But, will not allow for a precise analysis on the potential costs and benefits of aeration, which could lower the opportunity to attract provincial and federal funding.

IMPLICATIONS

Selection of a management option for mitigating blue-green algae blooms will be a big step for the Municipality, and choosing between the potential options will require a thoughtful assessment of the cost, risks and potential benefits of each choice

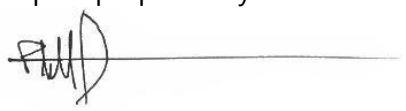
Option 1 provides North Cowichan with a path to developing a management plan that leverages the Municipality's existing research and monitoring within a realistic framework of financing, resources, and staffing. Successful introduction of any management policy will involve other levels of government as financial and working partners. Establishing these partnerships will require a sound knowledge of lake dynamics and a realistic assessment of the costs, risks, and benefits associated with all viable management options.

Option 2 may lack the detail on all available management options and thus detract from the ability of North Cowichan to attract partners to the program.

RECOMMENDATION

THAT Council direct staff to:
(1) Engage a consultant to assess the costs and benefits of aeration in Quamichan Lake to manage phosphorus dynamics and mitigate blue-green algae blooms; and,
(2) Prepare a report for Council, which includes a recommendation on the most beneficial management option for mitigating blue-green algae blooms in Quamichan Lake.

Report prepared by:



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Attachments:
(1) Quamichan Lake Monitoring Presentation (September 21, 2022)
(2) Limno Solutions International's Report on Lake Quamichan (June 2022)