ALMS Position Paper on In-Lake Treatment

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Intent

With this document, ALMS aims to provide guidance on evaluating in-lake treatments for the control of Harmful Algae Blooms (HABs) on a case-by-case basis, including environmental, social and economic considerations. **This position paper promotes a holistic approach to lake management, which may or may not include in-lake treatment as part of the suite of management tools, but does not endorse any specific in-lake treatment method or project.** This provides a starting point for assessing potential in-lake treatments and is limited to the management of harmful algal blooms. It does not, however, supersede any guidance or requirements put forth by regulatory authorities.

Key Messages

- A long-term, holistic and collaborative approach that considers all aspects of watershed management, potentially including in-lake treatment, is needed for successful lake management.
- In-lake treatment can play a part in lake water quality management in some situations but typically requires repeat or continuous intervention.
- Beware of the "Silver Bullet": solutions sold by providers can either be prohibitively costly, ineffective under certain conditions, legislatively prohibited, of short-lived effect, may be controversial, and may have unacceptable side effects to aquatic life.
- Each lake is different and complex - scientific analysis is needed to identify potential reasons for algal blooms (e.g., nutrient sources, climate, water temperature), and to select the proper management techniques.
- In-lake treatment requires regulatory approval by the Government of Alberta and the Government of Canada, which requires an accountable organization, time and resources.

Definitions

- **Abiotic –** physical rather than biological, not derived from living organisms, such as water chemistry
- **Biotic –** relating to or resulting from organisms
- **Harmful Algal Blooms –** colonies of blue-green algae (cyanobacteria) that grow out of control and produce toxins that may affect people, pets and birds.
- **In-lake treatments -** physical, chemical or biological interventions directly applied to a lake with the intent to reduce the frequency and intensity of harmful algal blooms.

- **Non-point source pollutants –** pollutants that enter a waterbody from diffuse or undefined sources through runoff or atmospheric deposition.
- **Point source pollutants –** pollutants that come from a single identifiable location, such as a pipe.

Introduction

The Alberta Lake Management Society (ALMS), established in November 1991, is a charitable non-profit organization. Its vision is "Healthy Lakes for Alberta's Future" and its mission statement is "ALMS builds awareness and understanding of lakes by engaging individuals and communities in monitoring, management, and education." ALMS connects individuals, local communities, educational institutions, governments, and industries across Alberta who are interested in lake and watershed management.[1]

In recent years, discussion around in-lake treatment has increased and ALMS, recognized as a credible leader in lake monitoring and management, has received requests for support or evaluation of in-lake treatments. However, every lake system is unique, and ALMS is not a regulatory body nor consultant, and therefore does not provide recommendations on specific in-lake treatments, rank their effectiveness, or indicate when to use them.

Instead, ALMS offers this position paper as a roadmap to help other lake stewardship groups, First Nations, municipalities, not-for-profits, the Government of Alberta, and others involved in lake stewardship evaluate the appropriateness and efficacy of a given treatment at a particular lake. ALMS may assist in data collection, provide information, and participate in multi-stakeholder consultation processes. However, any decision-making process about in-lake treatments should be led by a well-supported local organization and qualified professionals, once all other watershed level options for water quality improvement have been explored.

In-Lake Treatment in the Context of the Lake Watershed System

Watersheds are the geographical, geological, biological, ecological, and climatological matrix in which lakes exist. Each lake is a unique ecosystem hosting a collection of biotic and abiotic components and is affected by the interactions between these components. The nature of these components is dependent upon the surrounding watershed.

Water flows across the surrounding landscape before arriving at the lake; accordingly, the watershed influences lake levels, chemical makeup and nutrient loading into the lake. Understanding that lakes are largely products of their watersheds allows us to evaluate the applicability and longevity of in-lake treatments and assess whether their effects will be overwhelmed by larger watershed processes (e.g., external nutrient loading).[3]

A comprehensive understanding of the watershed and its relationship with the lake, including but not limited to nutrient and water budgets, are necessary to begin evaluating management approaches and assessing suitability of in-lake treatments.

Main Components of the Lake Watershed System:

- **Water Budget**: Determining source of water to the lake, generally broken down into surface water, precipitation, and groundwater inputs; and where water from the lake goes to, mostly evaporation, recharging groundwater and surface outflows.

- **Climate**: Long-term and broad geographical weather and precipitation patterns are critical in determining the amount of water available for any given lake and influence the quality of the lake water. Seasonality and evaporation rates are important factors for lake levels. Climate change is impacting lakes through drought, increased water temperature and extreme variations in weather.

- **Water Volume**: The volume of water in a lake greatly affects lake processes (e.g., nutrient cycling, the structure and function of plant and animal communities, evaporation rates). Understanding the volume of water to be treated is important in assessing the viability of any in-lake treatment option.

- **Water Quality**: Water quality is influenced by many factors, including nutrients from external sources (e.g., watershed) and internal sources (e.g., sediments), contaminants, energy, and biota, and is controlled by complex processes.[2]

- **Watershed and Lake Area**: The area of the watershed and the lake are important variables to consider when evaluating a watershed or lake management plan. Large lake areas are expensive and difficult to treat while smaller areas are more easily managed in both nutrient control and treatment volumes. Large watersheds make it difficult to identify and control external non-point nutrient sources.

- **Land Use**: Human footprint and its effects on the lake need to be understood. Common land uses in Alberta include agriculture, forestry, oil and gas, recreational, and residential, all of which can affect water quality. Identifying sources of nutrients from within the watershed is critical in any management plan.

- **Lake Biota**: Consideration must be given to lake biota, such as bacteria, algae, plankton and fish communities and their food web dynamics, which are an integral part of the ecosystem.[3]

Lake Dynamics

Lake dynamics refer to the movement of energy, substances, and biota within the lake itself. There is great variability in these dynamics among Alberta lakes.[4] Water and

sediment chemistry, including the substances present and the reactions they are involved in, will affect the outcome of any in-lake treatment. Understanding both external loading and internal cycling of lake nutrients is necessary to assess treatments and how long their effects will last.

Common Issues that may Partially be Addressed by In-Lake Treatment

The most common water quality concern that raises the topic of in-lake treatment is cyanobacteria (more commonly known as blue-green algae), which can form harmful algal blooms. Harmful algal blooms, commonly referred to as HABs, impair the aesthetic enjoyment of the lake, may harm human and animal health due to toxin production, and may result in fish kills. They thereby impact drinking water users, lake residents, visitors, and the economy of lakeside communities. Most in-lake management techniques aim to curb blue-green algae blooms by interrupting factors that promote the growth of blooms, or by destroying the blue-green algae directly.

Algal Blooms and In-Lake Treatment

Nutrients are crucial for the growth of blue-green algae; thus, reducing available nutrients in a lake is the most common strategy to curtail nuisance blooms. There are two main sources of nutrients: inputs from the watershed (external loading) and release from sediments (internal loading). Sediment release of nutrients, particularly phosphorus, can represent a significant portion of nutrient budgets in Alberta lakes. Studies have shown that sediment is the main contributor to annual phosphorus budgets in many Canadian lakes, especially in the prairies[5], and sediment release is highest during the open-water season when lakes are most prone to blooms.

Determining the sources of nutrients and amount contributed by each source is critical for deciding what approaches are needed to reduce concentrations.

Several chemical and physical in-lake treatment techniques may temporarily help suppress harmful algal blooms:

- **Sediment Inactivation**: Adding a substance to the lake to settle on the sediment surface, creating a chemical barrier between the sediment and water, reducing nutrient flux to the water column (e.g., Alum, Phoslock, iron, and calcium amendments[6]). These chemical treatments may have undesirable side effects to the aquatic environment and are costly at a large scale.

- **Hypolimnetic Aeration/Oxygenation**: Adding oxygen to the lower layer of stratified lakes to prevent anoxia, as phosphorus release rates are higher under low oxygen conditions.[7] It may have the added benefit of improving fish habitat. This is less controversial, but still very costly due to the power and infrastructure requirements, and may cause ice thinning and circulation of nutrients.

- **Hypolimnetic Withdrawal**: Extracting nutrient-rich bottom waters of stratified lakes to reduce the total amount of nutrients in the lake. This water must be released to a suitable downstream receiving watercourse or waterbody, without causing detrimental environmental impact.

- **Mixing Techniques**: Blue-green algae thrive under calm, stable conditions. Mixing techniques, such as aeration, may disrupt this stability and prevent surface blooms but may increase nutrient cycling.

There are also options to kill blue-green algae once they have grown, such as sonication, sediment dredging or removal of biomass (harvesting). However, currently there is no conclusive evidence on the impacts of sonication to other aquatic life, and harvesting has been found impractical for typical lake situations. Algaecides are not approved in natural lakes due to their effects on the entire ecosystem. An extensive review of in-lake treatment options and their potential applicability to an Alberta lake (Pigeon Lake) can be found in Teichreb[8].

Given the large number of in-lake treatments on the market and the unique nature of each lake, ALMS recommends following the roadmap described in this guidance paper. While individual in-lake treatments may appear to be strong, immediate candidates for lake improvement, they should not be considered until first exploring watershed management techniques. Stewardship groups must consider the biophysical, regulatory, economic and community context for each lake.

Alberta Experiences in In-Lake Management

Alberta has a long history of innovation in lake science and in-lake treatment, including calcium amendment (e.g., Halfmoon Lake[9,10]), experimental iron amendment on Nakamun Lake[11], aeration for fish habitat improvement[12], hypolimnetic withdrawal at Pine Lake[13], and Phoslock treatment at the urban, man-made Henderson Lake[14]. More recent applications include Alum and peroxide at Summerside Lake, and Alum and aeration at Westlock Pond[15], which are both man-made as well. ALMS does not intend to comment on the success of any these interventions.

Outside of Alberta, there is a vast body of literature about the science and practical experience of in-lake treatment, such as in the United States, Europe and Australia. A review of in-lake treatment literature is recommended as part of any project to understand key learnings from both successes and failures. All aspects need to be considered including regulatory approval, community support and economic considerations.

Federal and Alberta Regulatory Environment

In-lake treatment methods require approval under several pieces of legislation, for example:

- ***Environmental Protection and Enhancement Act***: Supports the protection, enhancement, and wise use of the environment. Any addition of a substance to a lake environment requires approval under this *Act*.

- ***Water Act***: Promotes the conservation and management of water through its use and allocation. Any lake treatment methods involving the addition, removal or diversion of water require approval under this *Act*.

- ***Federal Fisheries Act***: Provides a framework for the conservation and protection of fish and fish habitat, including pollution prevention.

- ***Federal Pest Control Products Act and Fertilizers Act* and Regulations**. Chemical amendments that are not routinely produced and applied in Canada, may require a registration under this legislation.

It is the responsibility of the proponent (i.e., the lead organization of the in-lake treatment) to understand potential liability concerns and meet all applicable regulations at the time of treatment implementation and throughout the duration of any approvals obtained. When planning to apply for these approvals, consultation with the regulatory authority upfront is required. Lakes are under jurisdiction of the Province, which therefore has the ultimate authority about any lake intervention and related processes for consultation, studies and monitoring.

There is currently no standard process in Alberta for approving in-lake treatments and therefore, information requirements for an application will likely vary by lake and treatment. Consultation with affected stakeholders, including Indigenous communities, is part of the application process.

Best Practices to Consider When Contemplating In-Lake Management

1. **Develop a Lake Watershed Management Plan**: Includes a lake management target, considers all main nutrient sources (watershed and in-lake nutrient budget; water budget), and engages, stakeholders, including Indigenous communities, regulators, and lake experts early in the process. Establish clear goals and expectations to ensure the project supports ecological and human values without negatively impacting the aquatic ecosystem or impairing drinking water supplies. For more on Lake Watershed Management Planning in Alberta see the ALMS guide.[16]

2. **Characterize the Problem**: Understand the lake by analyzing available monitoring data, such as current and past water quality, long-term trends, algal community composition, toxins, phosphorus budget, sediment conditions, processes promoting blooms, zooplankton, fish community, economics, lake carrying capacity, temperature regime, and depth profiles. Additional information may be needed depending on the situation.

3. **Evaluate and Select Watershed Management and In-Lake Treatment Options**: Consider long-term plans and cost estimates for controlling nutrient inputs. If in-lake treatment is chosen as a tool, select based on anticipated effectiveness, environmental risk, cost, and duration of effect. In-lake treatments can be considered an expensive "band-aid" approach if the long-term effects of watershed nutrient inputs are not addressed.

The following are some important questions to ask when considering in-lake treatment:

- Is the proposed product approved for use in Canada?
- Is the treatment safe and effective given the lake's specific chemical, biological and physical characteristics?
- Are there peer-reviewed studies supporting its use in lakes with similar size, depth, and climate?
- If such studies exist, what do they show about the long-term efficacy of the treatment?
- Will a single application be sufficient, or will repeated treatments be necessary?
- What is the cost of the product?
- What training/certification is required for application?
- What government approvals are required for this product?
- What is the total cost when scaled to the size of the lake?
- Who will be responsible and accountable for the project including current and ongoing costs, implementation, monitoring and liabilities?
- Are there ongoing or hidden expenses, such as energy, monitoring, or maintenance costs?
- What is the plan for monitoring the treatment's effectiveness before, during, and after application?
- Have all relevant stakeholders and rights holders been meaningfully consulted?

Concluding Statement

In-lake treatments have supported lake management efforts with varying degrees of success in the past and therefore may be a tool for maintaining the benefits of lakes for Albertans. When considering the use of these tools, it is essential for lake managers to apply the highest standards of scientific rigor, stakeholder engagement, regulatory compliance, and professional due diligence. In-lake treatments should be viewed as one component of a comprehensive lake and watershed management strategy and should not be considered in isolation or as a substitute for other effective watershed-scale management actions. Any in-lake treatment must be thoroughly evaluated for its applicability and implemented with the involvement of qualified aquatic professionals, sufficient economic resources and community support.

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