Friends of Swan Lake Park

# Swan Lake Water Quality Plan: Summary of Phase 1 Discussions

Swan Lake Park is a municipal park located at 25 Swan Park Road in the City of Markham, Ontario. Swan Lake, within Swan Lake Park, has a history of poor water quality. A bird's eye view of Swan Lake Park is available on YouTube courtesy of Thomas Yee Swan Lake Park by Drone - DJI Mavic Mini - YouTube.

Founded in 2019, the Friends of Swan Lake Park ("FOSLP") are residents of Markham committed to saving Swan Lake and Swan Lake Park through environmentally best practices that will rehabilitate aquatic and terrestrial habitat and provide safe lake water for sustainable human and wildlife activity.

The following report outlines the history of lake management at Swan Lake and discussions during Phase 1 (2021-2025) of Markham's current plan for addressing water quality issues in Swan Lake and summarizes the additional lake management options recommended by FOSLP.

## Contents



July 15, 2025

# 1) History of Lake Management at Swan Lake

**a) Creation of Swan Lake Park (1993 – 2000)**

Swan Lake was an active gravel quarry in the 1960s and 1970s until it filled with water. During the 1970s the pit was used as a local landfill site and there was some illegal dumping of household waste which has resulted in some environmentally sensitive areas within the park and lake. The lake was stocked with Largemouth Bass around 1992 and an application of Copper Sulfate was applied in 1995 presumably to address algae issues.

During the 1990s, the area was slated for conversion from active farmland to urban development. The December 1993 Swan Lake Community Environmental Management Study[1] set out the developer's objectives and plan for the conversion of the gravel pit into a community feature with multiple trails including "a diverse natural habitat for aquatic and terrestrial wildlife … that incorporates passive use opportunities surrounding the lake". The plan was accepted by Markham and substantially completed by 2000 and serves as an important benchmark for ongoing rehabilitation discussions.

There are no natural surface level streams flowing into or out of Swan Lake. However, the original development included the integration of Swan Lake with the local stormwater systems. Six stormwater sources direct stormwater flows into the lake. The lake depth is regulated by an outflow pipe to the area's stormwater system which effectively maintains the average depth at 1.65 m. (see Appendix C).

**b) Treatment with Phoslock (2013)**

By 2012, Swan Lake was described by the city's consultant, Freshwater Research[2] , as a "highly eutrophic lake with a history of cyanobacterial blooms". Freshwater Research noted that of 17 man-made urban lakes in Ontario, Swan Lake exhibited the third-highest total phosphorus concentration and the highest chlorophyll concentration in a subset of six lakes. Freshwater recommended abatement efforts be taken to address external phosphorus load but noted that most of the water quality problems originated from internal phosphorus sources including the bottom sediments, and recommended a Phoslock treatment.

In 2013, a 25.2 tonne Phoslock treatment was administered. The treatment improved water quality from hyper-eutrophic to eutrophic conditions for two years but by 2016 the water quality was as low or lower than in the pre-treatment year.

**c) Swan Lake Water Quality Improvement Program (June 2020)**

In June 2020, FOSLP submitted a report to Markham Council outlining a variety of lake management options for consideration[10] . Markham staff submitted for Council's approval a "Swan Lake Quality Improvement Program"[3] that outlined reasons for rejecting a number of the lake management proposals submitted by FOSLP. To address the increasing recurrence of algal blooms and the concerns about cyanobacteria, Markham staff recommended another treatment of Phoslock in 2021. To contain algal blooms, future treatments would be triggered following two consecutive summers of a hypereutrophic state (phosphorus levels exceeding 150 ug/L) implying treatments every 5 – 7 years.

In December 2020, FOSLP submitted a report "A Pathway to Sustainable Water Quality for Swan Lake"[11] to Markham Council focusing in greater detail on additional lake management options that should be considered in addressing the issues in Swan Lake. In addition, in February 2021, FOSLP submitted a report titled Literature Review of Potential Engineering Solutions for the Restoration of Swan Lake[16] by the Centre for Advancement of Water and Wastewater Technologies at Fleming College which provided commentary on some of the concepts raised by FOSLP. Markham Council directed staff to consider the submission from FOSLP and Fleming College and to prepare a long-term plan for Swan Lake. Most of the FOSLP and Fleming College recommendations were rejected [16(a), 16(b)] in the long-term plan.

**d) Swan Lake Long-Term Plan (2021)**

In December 2021, Markham Council approved the Swan Lake Long-term Water Quality Plan[5] which describes a phased adaptive approach with the initial five year phase from 2021-2025 and with a planned review in 2026 of the initial phase. Highlights of the long-term plan are provided in the following section followed by concerns expressed by FOSLP.

The long-term plan included provisions during Phase 1 (2021-2025) for chemical treatments initially every three years starting in 2021 and 2024 with additional treatments to be considered during Phase 2. Phoslock was not available for use in Canada in August 2021 and it is believed that AECOM, Markham's new consultant, preferred PAC for use in Swan Lake rather than Phoslock. Under the guidance of AECOM, 13 tonnes of Poly Aluminum Chloride (PAC) were applied to the lake in 2021 and an additional 9.4 tonnes in 2024.

**e) Independent Workshop**

In May 2023, FOSLP submitted a report[15] outlining additional lake management options for Markham's consideration. At the request of FOSLP, Markham Council asked staff to consider incorporating a "workshop" of independent consultants into the planned 2026 review of the Long-term Plan for Swan Lake.

Markham has hired AECOM to undertake the Phase 1 review and to advise on actions for the next phase and have adopted a process that supports input from community groups such as FOSLP and from environmental experts. Markham staff have agreed to host a workshop or some other interactive forum to discuss submissions from various parties. AECOM's draft recommendations will be shared with the workshop participants for commentary prior to the revised plan being submitted to Markham Council for consideration.

A specific timetable has not been outlined by Markham staff but FOSLP is assuming and working to the following timetable:

| | | |
|---|---|---|
| a) | October 31, 2025 | Submissions to Markham by interested participants |
| b) | Nov./Dec. 2025 | Workshop discussions or feedback on submissions |
| c) | February 2026 | Participants review of the draft Phase 2 plan |
| d) | April 2026 | Presentation of Phase 2 plan for approval by the Markham Subcommittee of Markham Council. |

## 2) Markham's Long-term Plan for Swan Lake (December 2021)

a) Goal and Interim Targets

The long-term plan[5] includes the following goal statement.

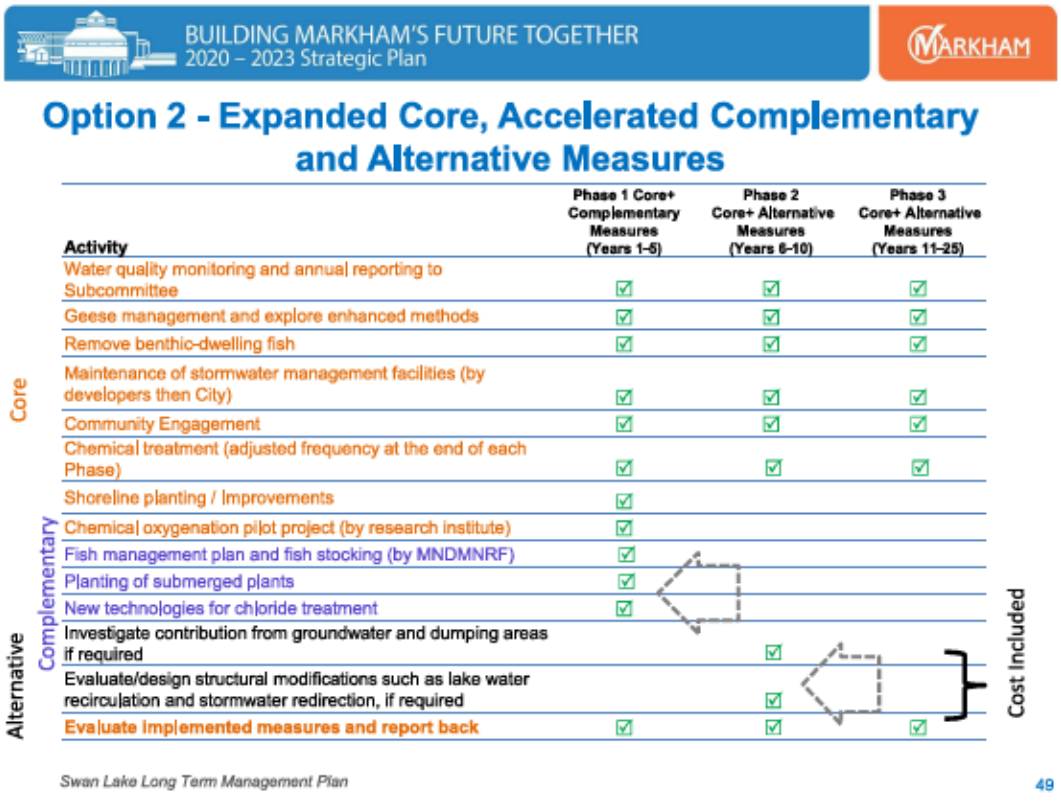
> ***GOAL:*** *To improve the overall health of Swan Lake, which will provide opportunities for no-contact activities for the enjoyment of the community.*

The table below sets out the "Interim" water quality targets for the initial five year period (2021 – 2025).

| Parameter | Current Values | Interim Target | Objective and Rationale |
|---|---|---|---|
| Total Phosphorus (µg/L) | >200 | 50 - 100 | Current value: the average of growing season TP values in the period since 2016 has been 200. Interim target: will provide a low eutrophic condition in the first year after treatment increasing to eutrophic in year 3. |
| Secchi Transparency (m) | < 0.5 | 0.6 – 0.8 | Based on correlation with the phosphorus target. Secchi is also a substitute for Chlorophyll a. |
| Frequency of algae blooms | Annual | Every 3 years | Trigger for treatment every three years |
| Internal phosphorus load (kg/yr.) | 53 | 0 - 25 | Both internal and external loads should be controlled to achieve the lake concentration target (see above) |
| External phosphorus load (kg/yr.) | 30 | 15 | |

**b) Scheduled Activities**

Based on subsequent discussions and undertakings, Markham's current activities closely mirror the "Option 2" activities outlined in the original plan.



**c) Actions Undertaken by Markham Staff Since December 2021**

A listing of Key Measures considered under the plan and their perceived technical feasibility and effectiveness is provided in Appendix B. Actions undertaken by Markham during Phase 1 include:

**i) Measure IL1:** A Poly Aluminum Chloride (PAC) treatment was applied in July 2021 and a second treatment during the summer of 2024.

**ii) Measure OL1**: In 2023, Markham installed an oxygen monitor at the dock to track oxygen levels over a 24-hour cycle.

**iii) Measure NF2:** In 2023, the Toronto Region Conservation Authority ("TRCA") initiated a pilot aquatic plant project with the planting of wild celery (Vallisneria americana) in five areas. The TRCA preliminary comments on the program note that:

a) In 2023, the 1500 stems were planted at 0.3 – 1.0 m deep, the mid-point for optimal growing depths for Wild Celery. Approximately 90% beyond the 30 cm. mark were absent in 2024 with a few persisting in deeper nodes. Only about 30% of the plantings were found at 30 cm depth.
b) Another 1500 stems were planted in 2024 between 20 – 40 cm.
c) Recommendation is to observe the success of the 2024 plantings through 2025 and if successful follow up with more plantings in 2026 in adjacent areas and other shallow areas.

The TRCA reports attribute the lack of success of the 2023 plantings to turbidity which prevented light from penetrating to the greater depths and to the fluctuating lake levels. The report makes no reference to whether high chloride levels in the lake were a possible factor.

**iv) Measure EL3:** The TRCA recommended redesigning the shoreline[6] around the lake to restrict Canada geese and to improve recreational access to the lake. Removal of phragmites was undertaken in 2022 and 2023 by the TRCA. Installation of shoreline fencing is expected in 2025 but Markham staff are not recommending improved recreational nodes due to cost. FOSLP has appealed to Council for additional shoreline enhancements.

**v) Measure IL2:** Early reports cite Swan Lake as supporting Black Crappie, Carp, Goldfish, Catfish, Pumpkinseed Sunfish, Fathead Minnows and Largemouth Bass. The bass is believed to have been stocked before 1992 by the TRCA.

Markham engaged the TRCA to undertake a fish inventory and removal of bottom feeding fish such as Carp and Goldfish from Swan Lake. The fish species identified through 2024 by the TRCA include Brown Bullhead, Common Carp and Goldfish which are euthanized while Fathead Minnows recovered are returned to the lake. Local residents have reported sighting Catfish in the lake.

The long-term plan has provisions for restocking the lake with a variety of fish species when the water quality is amendable. In spring of 2025, 500 small Largemouth Bass were added. Staff have indicated that Bluegill may be considered if available.

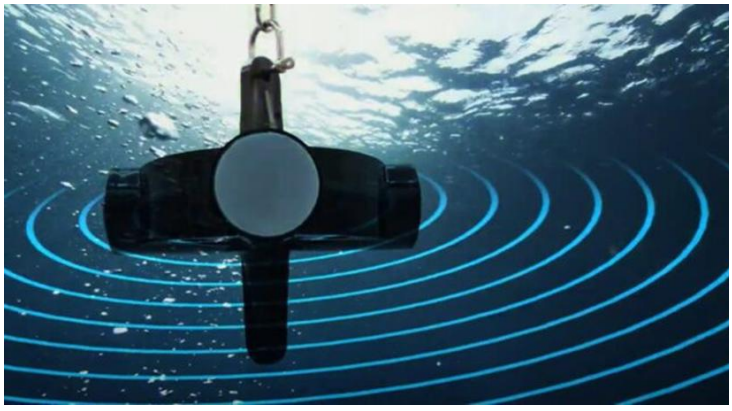
The following table summarizes the fish species identified by the TRCA through 2024.

**Table 6: Fish Species Collected from Swan Lake**

| Date | Fish Species | Number of Fish |
|---|---|---|
| April 2021 (3 days electrofishing + 2 days nets) | Brown Bullhead | 210 |
| | Common Carp | 7 |
| | Fathead Minnow | >10,000 |
| August 2022 (1 day electrofishing, 1 day nets) | Brown Bullhead | 80 |
| | Common Carp | 20 |
| | Fathead Minnow | 875 |
| August 2023 (1 day electrofishing) | Brown Bullhead | 84 |
| | Common Carp | 103 |
| | Fathead Minnow | 14 |
| | Goldfish | 2 |
| April 2024 (1 day electrofishing, 1 day net) | Brown Bullhead | 193 |
| | Common Carp | 1 |
| | Fathead Minnow | 1521 |
| | Goldfish | 13 |
| | Common Carp x Goldfish | 59 |
| | Emerald Shiner | 1 |

**New Ultrasonic Device To Kill Algae**

In 2024, Markham initiated a pilot project for controlling algae in a stormwater pond in another area in Markham using an ultrasonic device that uses sound waves to control algae growth. After a successful trial, a Water IQ Pulsar 4400+ unit was installed along the southern shoreline of Swan Lake in April 2025.



The manufacturer states that the sound waves quickly immobilize the algae causing it to sink to the bottom where it decomposes and is consumed by aquatic life and bacteria.

The device is connected to a solar panel. The city notes that the ultrasound devices are low-powered and do not affect animals, birds or humans. The device does not impact other aquatic plants nor work on species of algae that resemble aquatic plants.

**d) Additional Actions Proposed by FOSLP**

Friends of Swan Lake Park proposed four actions following the adoption of the long-term plan.

**i) Measure CL2:** In 2022, FOSLP recommended research by a York University research team[18] into the use of BioChar (a type of charcoal filter) into the removal of nutrients and chloride from the lake system. This application may be feasible in stormwater inflow areas or in concert with flows directed through the North Channel. Markham staff, based on the recommendations of their consultant AECOM[7], requested budget funding to support continuing research into this possible application.

**ii) Measure CL3:** FOSLP submitted two reports [13,14] detailing the source of the stormwater flows into the lake with recommendations on rerouting the flows. Subsequently, Markham staff undertook an analysis of the inflows confirming that the stormwater sources were contributing on average 3.2 metric tonnes of chloride each year. These reports triggered two actions: a) removal of the blockage in one of the stormwater pipes that was triggering excess flows into the lake, and 2) Council approval of $150,000 for a "Flow Diversion Study" into the feasibility of rerouting stormwater flows as proposed by FOSLP. The report by AECOM[9] was released in May 2025 and reviewed nine different options. The following table, compiled by FOSLP, highlights that 94% of the chloride inflow could be redirected away from the lake at a cost of $2.1 million.

| | | | Annual Chloride | Chloride Reduction | | Estimated Cost | Cost per Tonne |
|---|---|---|---|---|---|---|---|
| | **Summary of Best Options** | | **(t/yr)** | **(t/yr)** | **% Total** | | |
| S3 | Amica & TC OGS | Reroute to lake outlet | 2.33 | 2.33 | 73% | 1,757,025 | 754,088 |
| S4 | Swan Club OGS | Reroute to North Pond | 0.33 | 0.33 | 10% | 275,072 | 833,552 |
| S5(b) | East Pond (2 Inlets) | Raise Weir/Enlarge Pipe | 0.38 | 0.25 | 8% | 84,315 | 337,260 |
| S5(a) | North Pond (1 Inlet) | Raise Weir | 0.17 | 0.10 | 3% | 10,139 | 101,390 |
| | | | **3.21** | **3.01** | **94%** | **$2,126,551** | **$706,495** |

The three Oil Grit Separators ("OGS") units account for 83% of chloride entering the lake. It would require a $2.0 million investment to eliminate these inflows. The remaining 17% of the chloride inflows is attributed to the two stormwater ponds. These inflows could be reduced by 64% or 0.35 tonnes per year for an investment of $95,000.

There has been a significant reduction in chloride levels in the lake over the past few years. The Markham Subcommittee accepted the staff recommendation that consideration of any changes to the stormwater system be deferred until after Phase 2 (2030). FOSLP will be requesting that the alterations to the stormwater ponds be undertaken during Phase 2.

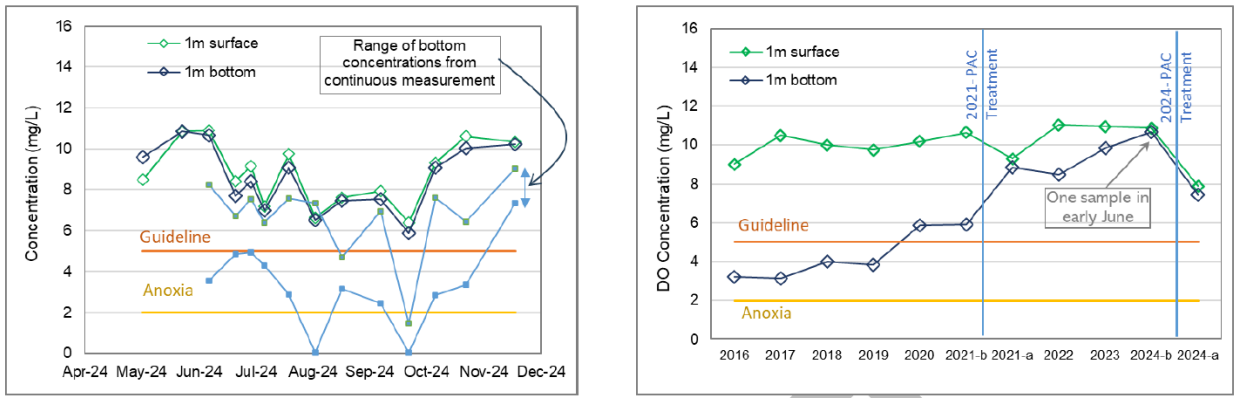
**iii) Measure OL1:** In May 2022, FOLSP recommended research by Fleming College[17] into the use of calcium peroxide as a source for improving oxygen levels. Based on AECOM's analysis[7], Markham has declined to proceed with this "early stage" research.

**iv) Measure OL1:** In May 2023, FOSLP requested approval for a University of Toronto research team[19] to install an oxygenation device for three months on Swan Lake during the summer of 2023 at no cost to the city. It was expected that the research would help gauge the sensitivity of the sediments to mechanical aeration. Staff denied the request on the basis that previous recommendations by Freshwater Research had indicated that mechanical oxygenation would be detrimental to the rehabilitation efforts.

## 3) Discussions on the Role of Oxygenation

The recent 2024 results show improvement in oxygen levels in Swan Lake. The report does not outline any reasons for the improved conditions. The original theory was that oxygen levels would improve with lower levels of algae but algae levels have not declined significantly. The primary improvements in oxygen levels are in the lower level suggesting the possibility that other factors such as the mixing of the upper and lower layers or possibly the inflow of freshwater from the aquifer (see Section 7).

**Figure ES-2: 2024 Monitoring Results and 2016-2024 Annual Results- Dissolved Oxygen**




Several approaches to oxygenation processes have been suggested by FOSLP and rejected by Markham's adviser, Freshwater Research[4] ("FWR)" through a series of reports. The discussion of oxygenation has focused primarily on issues related to the rehabilitation of water quality.

There has been little discussion on whether ongoing oxygenation is beneficial following the rehabilitation phase. Given that Swan Lake is a closed system, lacking any natural surface levels inflows, FOSLP believes that an ongoing oxygenation program should be considered as an important component for sustaining the aquatic environment and controlling contaminants in the post-rehabilitation phase. FOSLP has promoted the concept of recycling water through the North Channel as an option warranting further review.

In 2021, Friends of Swan Lake Park engaged Fleming College[16] ("FC") researchers to provide commentary on various lake management solutions.

**A Summary of Discussions on Oxygenation**

The rationale put forward for rejecting oxygenation processes fall into two categories:

1) The process is ineffective as the sole process for addressing excessive nutrient load.
2) The process will result in increased mixing in the lake and consequently lead to an increased release of nutrients from the sediments.

The following section summarizes various exchanges regarding oxygenation during Phase 1.

### A) Oxygenation Techniques Considered

FC[16] (pg. 10-13) outlines a variety of mechanical oxygenation techniques that would add oxygen and result in mixing. FWR[4] (Pg. 60 – 62.) outlines reasons for rejecting the proposals citing mixing as a key concern.

FC (pg. 12) outlines the potential of calcium peroxide (CaO2) as a slow oxygen releasing compound. FWR sees potential in this approach but notes the concept is still in the research stage. In May 2022, Fleming College submitted a proposal to Markham staff to initiate a lab-based investigation on the use of Calcium Peroxide in Swan Lake. The proposal was reviewed by Markham's advisor AECOM and rejected since the concept it at an early research stage.

### B) Mixing and Nutrient Release

FWR[4] (pg. 18-20) summaries the anoxic conditions in Swan Lake and notes that "Profiles of temperature and dissolved oxygen (DO) indicate that Swan Lake thermally stratifies during the summer despite its shallow depth". FWR notes (pg. 60) that "Swan Lake is shallow and mixes occasionally throughout the summer".

In an August 24, 2021 memo, FWR notes that it has rejected several oxygenation techniques outlined in its 2020 report because they "would only increase the movement of P from the sediment to the illuminated water layer."

Experienced environmental observers have commented that since the lake already mixes naturally for some portion of the year, additional mixing may not be a serious concern. Fleming College (pg. 11) referenced a study by Gachter and Wehrli that suggest that artificial mixing may not be a material factor in the release of nutrients in a shallow lake.

### C) Mixing and Chemical Treatments

FWR[4] (pg. 62) states that a combination of "hypolimnetic aeration or oxygenation coupled with a chemical to absorb P, such as iron or aluminum, have consistently decreased internal load and delivered positive effects on trophic states" buts notes significant technical and financial challenges.

Given that a repeated chemical treatment program, with Phoslock or PAC, has been adopted as the primary tool for managing internal nutrient load, are there oxygenation approaches that could enhance the chemical treatment program or at least not be detrimental to the rehabilitation process?

An analysis by FWR stated that the chemical program for 2021 would attempt to neutralize 146.1 kg of phosphorus, 19.3 kg active in the water column and 126.8 kg in the sediments. The objective of the proposed 3-year cycle of chemical treatments is to treat the build up of phosphorus in the sediments.

Presumably there is a finite amount of nutrients that will be naturally released from the sediments and that repeated chemical treatments will dimmish the significance of the internal load after multiple treatments.

If the chemical treatments are more effective in neutralizing phosphorus in the water column, perhaps stimulating the release of phosphorus from the sediments through mixing will increase the effectiveness of the chemical program. The more phosphorus in the water column, the greater certainty it can be neutralized.

If, as other researchers suggest, mixing has a nominal impact on the release of nutrients then the risks of introducing mixing to the chemical management program would appear low.

**D) Lake Turnover – Counter Productive or an Important Long-Term Objective?**

The Fleming College report (pg. 6) notes that the adjustment of hydraulic detention time (HDT) through circulation becomes a feasible tool in the control and prevention of algal growth. In Swan Lake the process could be enhanced by the addition of oxygen and the removal of contaminants.

A HDT of less than 30 days is suggested as a benchmark which would require circulating 2,700 $m^3$ /day to recycle the 80,000 $m^3$ of lake water over the growing season. Friends of Swan Lake Park have outlined techniques that would support circulation through the North Channel with a small 1.5 hp cottage style pump at rates of up to 4,800 $m^3$/day.

FWR has not commented on whether circulation would be beneficial or detrimental as a long-term tool in the post-restoration phase but concludes that circulation is detrimental during the rehabilitation phase due to risk of stirring the sediments.

**Project to Measure Impact of Oxygenation and Sensitivity of Sediments Rejected.**

In 2023, FOSLP sponsored a proposal by a group of researchers from the University of Toronto[19] to test a new wind-powered oxygenation unit on Swan Lake.

The unit was designed to support fish farming in underdeveloped areas in the world. The unit had been tested on the effectiveness of adding oxygen to the water. The Swan Lake project would have tested both the oxygenation effect and helped determine whether the turbulence would be a factor in releasing nutrients from the sediments.

It was expected the project would shed some light into the complex interaction of the low oxygen levels in Swan Lake, the release of nutrients in the sediments and the sensitivity of the sediments to disturbance.

Unfortunately, Markham denied permission for the project, citing concerns about disturbing the sediments.

## 4) Additional Measures Recommended By FOSLP (May 2023)

The Friends of Swan Lake Park's stated goal is the sustainable rehabilitation of Swan Lake – in terms of water quality and in terms of the aquatic environment, both of which have deteriorated significantly. Sustainable rehabilitation involves restoring the water quality to a stable improved level in ways that can be sustained by natural elements with minimal human intervention in the future.

FOSLP's view is that sustainable water quality can be accomplished only by addressing all three of the primary issues within Swan Lake: (1) excessive nutrients (2) high chloride levels, and (3) that it is a stagnant body of water with chronically low oxygen levels.

FOSLP's view is that the primary shortcoming of Phase 1 of Markham's current long-term plan is that it focuses only on addressing nutrients by reducing external load through an aggressive geese management program and by reducing internal phosphorus load through a periodic chemical program. These efforts have produced only marginal improvements in water quality and are neither environmentally nor financially sustainable over time.

Markham's current plan incorporates virtually no direct actions to address the two chronic structural issues facing the lake:

1) First structural challenge is Swan Lake's role within the area's stormwater system. The Flow Diversion Study has identify ways of redirecting 93% of the stormwater away from the lake at an estimated cost of $2.1 million. Reduction of future inflows of road salt is an important part of the solution; however, there are no plans to address the build-up of 17 tonnes of chloride already within the lake.

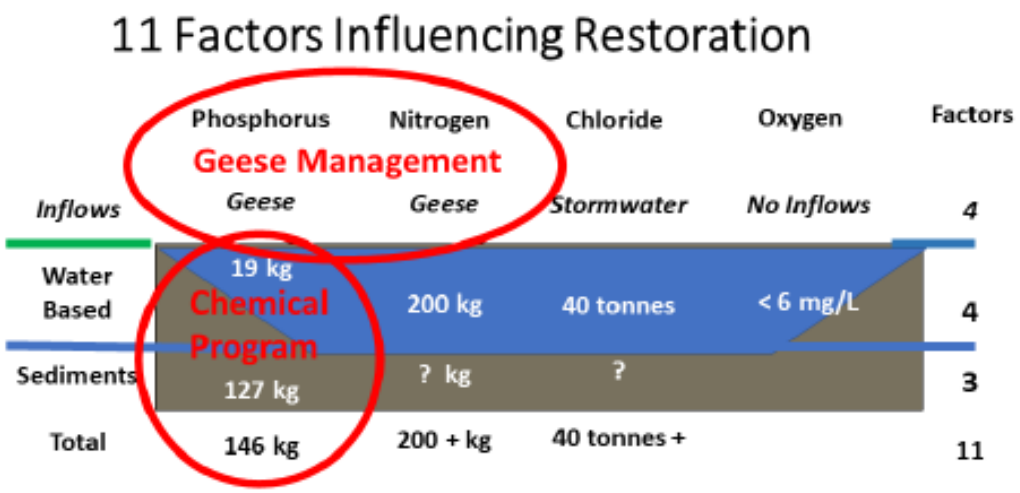
   A drawdown of the lake as proposed by FOSLP could reduce over 50% of the existing chloride content. The 2024 water quality results indicate that another factor may be of benefit. The levels of chloride in the lake have declined significantly over the past 2-3 years without any external actions suggesting that the aquifer may be having a material impact.

2) The second structural issue is that the lake is a stagnant body of water. The current plan suggests oxygen levels will improve with the reduction in algae levels. While helpful, as a stagnant body of water, the lake will face perpetual low oxygen challenges even with lower levels of algae. Swan Lake is a man-made structure – it will require a man-made solution to provide a sustainable source of oxygen.

**b) Other Possible Actions**

In its May 2023 report, "Towards a Comprehensive Restoration Plan for Swan Lake"[15] , FOSLP reviewed a range of lake management options to address inflows of external nutrients and contaminants and options for removing water-based and sediment-based nutrients and contaminants.

Research on water quality in Swan Lake suggests there are eleven (11) factors to be considered in a comprehensive program for restoring water quality.




The current long-term plan addresses only four of the factors directly. By reducing the algae levels, there is expected to be an indirect improvement in oxygen levels since less oxygen will be consumed as the algae dies in the fall.

**Current Plan Addresses Only 4 Factors**

| Current Long-term Plan | Nutrients P | Nutrients N | Cl | O | Factors Addressed | Restoration Timeframe | Costs | Concerns |
|---|---|---|---|---|---|---|---|---|
| Geese, Fish Management & Monitoring | 1 | 1 | | | 2/11 | 25 year | $3.3 m | Perpetual program |
| Chemical (Phoslock/PAC) | 2 | | | 0.5 | 2.5/11 | 25 year | $1.4 m | Addresses only Phosphorus |
| 2021 Long-term Plan | 3 | 1 | 0 | 0.5 | 4.5/11 | 25 year | $4.7 m + | Uncertainty of success, timeline |
| * Costs exclude Shoreline Restoration | | | | | | | | |

A plan including a drawdown to reduce chloride already in the lake, the removal of some of the sediments, and a sustainable oxygenation program such as recycling via the North Channel can potentially address all 11 elements and provide an opportunity to discontinue the chemical treatment program.

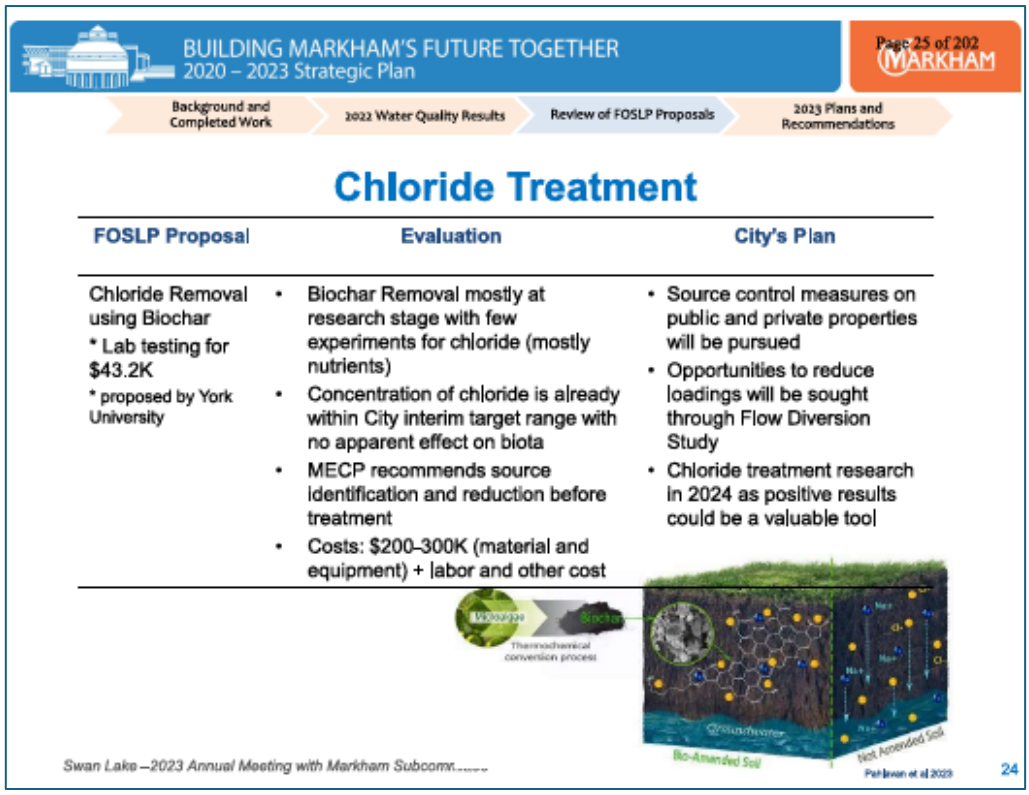
The core question to be answered is whether the potential additional costs of addressing the sediments materially increases the environmental outcomes and reduces other costs.

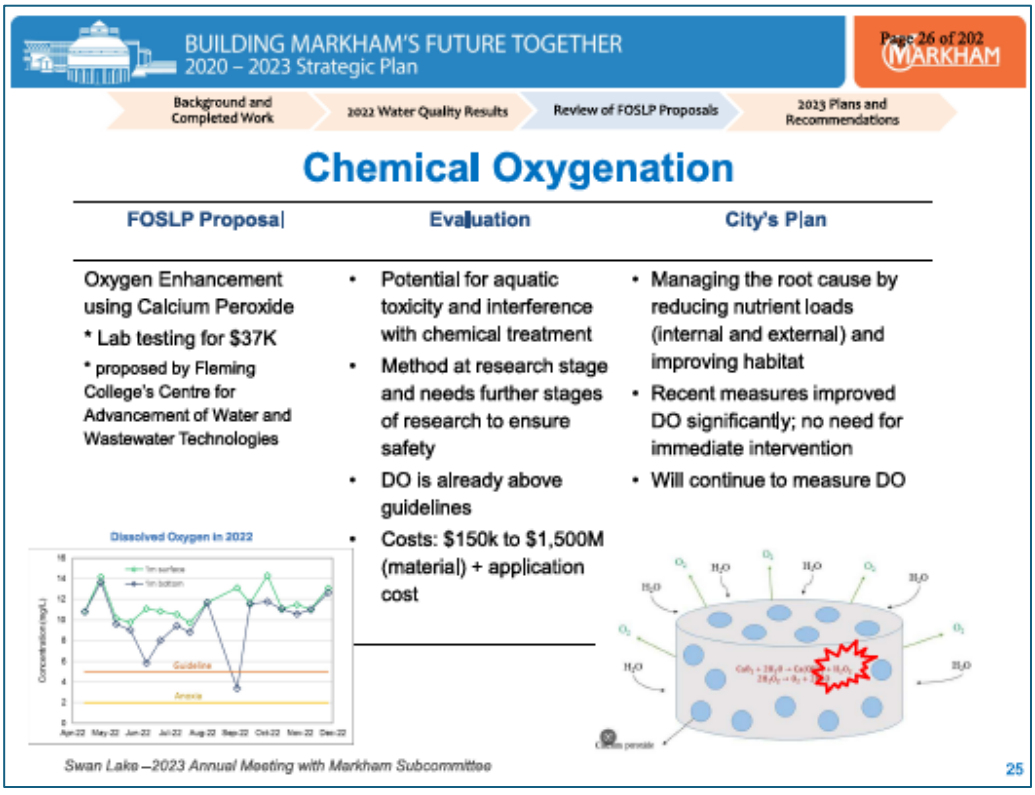
**A Comprehensive Plan Required to Adress 11 factors**

| Path #2: Water & Sediment | Factors Addressed | Restoration Timeframe | Costs | Benefits/Concerns |
|---|---|---|---|---|
| Geese, Fish Management & Monitoring | 2/11 | 10 + years | $3.2 m | Potential to reduce water monitoring costs |
| Rerouting stormwater | 1/11 | 3 - 5 years | $0.7 m + | Essential. Excludes rerouting costs |
| Drawdown | 4/11 | 1 - 3 years | $ | Addresses chloride, Downstream, Refill |
| Recycling Via North Channel | 1 /11 | 10 + years | $ | Reduces need for additonal filtration |
| Sediment Removal & Storage (SW) | 7/11 | 1 year | $1.5 - $3.7 m | Shoreline Restoration Impact, Capacity |
| Comprehensive Water & Sediment Plan | 11/11 | 10 + years | $5.4 - 7.6 m + | Faster aquatic recovery, greater assurance of success, potentially better results, potential to reduce monitoring costs |
| * Costs exclude Shoreline Restoration & Rerouting Stormwater | | | | |

## 5) Markham's Staff Response to FOSLP's 2023 Proposals

Portion of Staff presentation, Markham Subcommittee May 11, 2023



## Survey of Lower Level Aquatic Life

| FOSLP Proposal | Evaluation | City's Plan |
|---|---|---|
| Survey of Lower Level Aquatic Life (Phytoplankton, Zooplankton, Protozoa) | • Phytoplankton identification already done<br>• No benefit in identification of others for the overall health of Swan Lake<br>• Targets not available and results will not be actionable<br>• Ongoing habitat improvement will increase diversity and abundance | • Monitoring parameters already targeted for improvement in Phase 1, including nutrients, oxygen, chloride and phytoplankton<br>• Future opportunity through a research project by Trent U looking at bio-accumulation of rare earth elements (REE's) in biota |



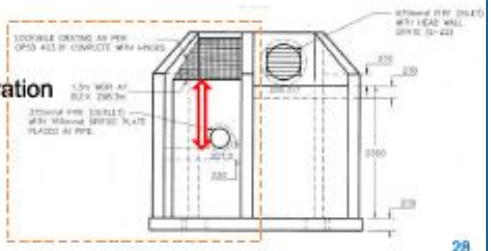



## Drawdown and Sediment Removal

- FOSLP's report Towards a Comprehensive Restoration Plan (Draft Apr. 14, 2023)
- Assumes sediment removal is necessary for water quality improvement
- Draw the Lake down to 207.0 MASL to remove water
- Assumes lake will be refilled with rainfall and groundwater in 1-3 seasons
- Remove exposed sediment
- Storage on site or disposal off-site

## Lake Dewatering Implications

- Drawdown feasibility:
  - Excavate a trench 1.3m deep in the Lake
  - Pump water from lower areas
- Refilling calculation:
  - Evaporation not considered (> rainfall)
  - No basis for groundwater flow estimate
- Ecological impacts:
  - On the lake during dewatering
  - On receiving water- regulatory issues (PWQO exceedance, sediment impacts on fisheries if filtration is not applied)





## Regulatory Context for Discharging Downstream

- Ontario water management: policies, guidelines, provincial water quality objectives (PWQO):
  - Policy 1: In areas which have water quality better than the PWQO, water quality shall be maintained at or above the Objectives.
  - Policy 2: Water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the Objectives.

| Parameter | PWQO/ CCME | Mt. Joy Creek* | Swan Lake |
|---|---|---|---|
| Total phosphorus | 30 µg/L | 70 µg/L (policy 2) | >100 µg/L (pre treatment) 50 µg/L (post treatment) |
| Dissolved chloride | 120 mg/L | 350 mg/L (policy 2) | ~ 500 mg/L in 2022 |

* Rouge River in Box Grove; average of values for 2014–2018 (latest 5-year of available data)

## Sediment Storage or Disposal Issues

- Several scientific studies and experts have recommended against disturbing sediment in Swan Lake (Gartner Lee Limited, 2006; Freshwater Research 2019; AECOM 2022)
- Extensive long-duration disruption to the park (multiple years)
- Substantive damage to the park on staging and drying areas
- Former dump sites contamination
- Sediment needed in lake to grow aquatic plants
- Other Storage issues:
  - Space for on-site storage not available (5000-8000 $m^3$)
  - Contaminated leachate from stored sediment
  - Containment (concrete walls) unsightly and not-environmental friendly and costly
- Transport and disposal costly



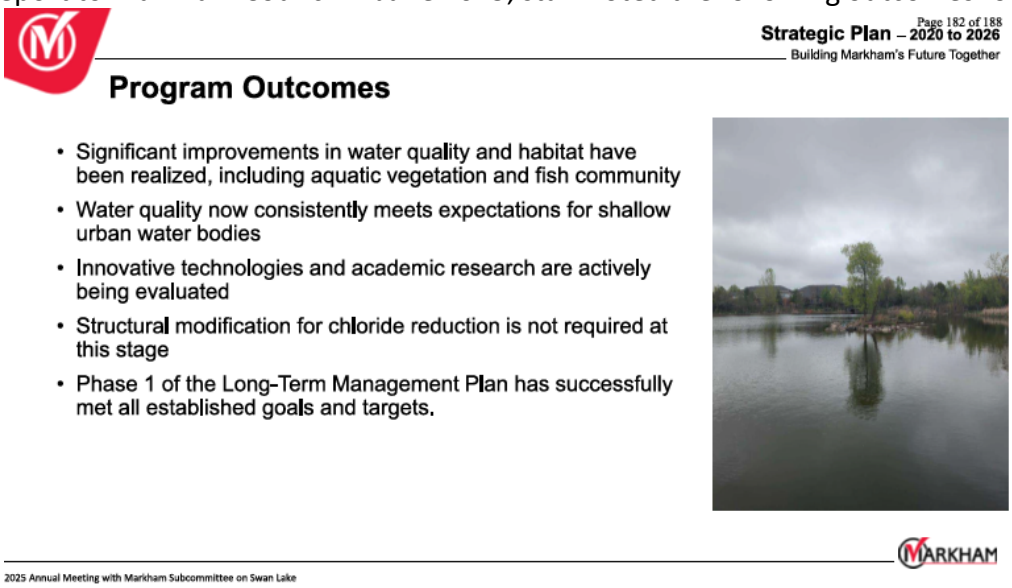



## Other FOSLP Proposals/Statements (April 2023)

| FOSLP Proposal/ Statement | Evaluation |
|---|---|
| • Current programs do not improve nitrogen and Dissolved Oxygen | • Lake processes are interconnected and need to be managed as such<br>• Geese management and chemical treatment using PAC has improved phosphorus, nitrogen and oxygen concentrations as evident in actual measurements in 2021 and 2022 |
| • Further oxygen enhancement is required as the Lake has no surface-level inflow<br>• Proposals include recirculation through the north channel and chemical oxygenation | • Oxygen levels have improved by lowering nutrient levels, and will be further improved through habitat modification (e.g. submerged aquatic vegetation (SAV) planting)<br>• Recirculation with be very disruptive and could increase water temperature (as per FR report); Chemical oxygenation too costly; potential impact on aquatic community<br>• As per the approved Plan, recirculation could be considered in Phase 3 if necessary |
| • New research on impact of oxygenation on P release<br>• New research on impact of Cl on P/N release<br>• Water quality workshop | • Research could be done independently by others as long as it is not interfering with the City's approved program<br>• The current team (City and consultants) already includes all the skills listed; however, a workshop could be considered after Phase 1 completion (2026) |

## 6) Markham Staff Perspective on Phase 1

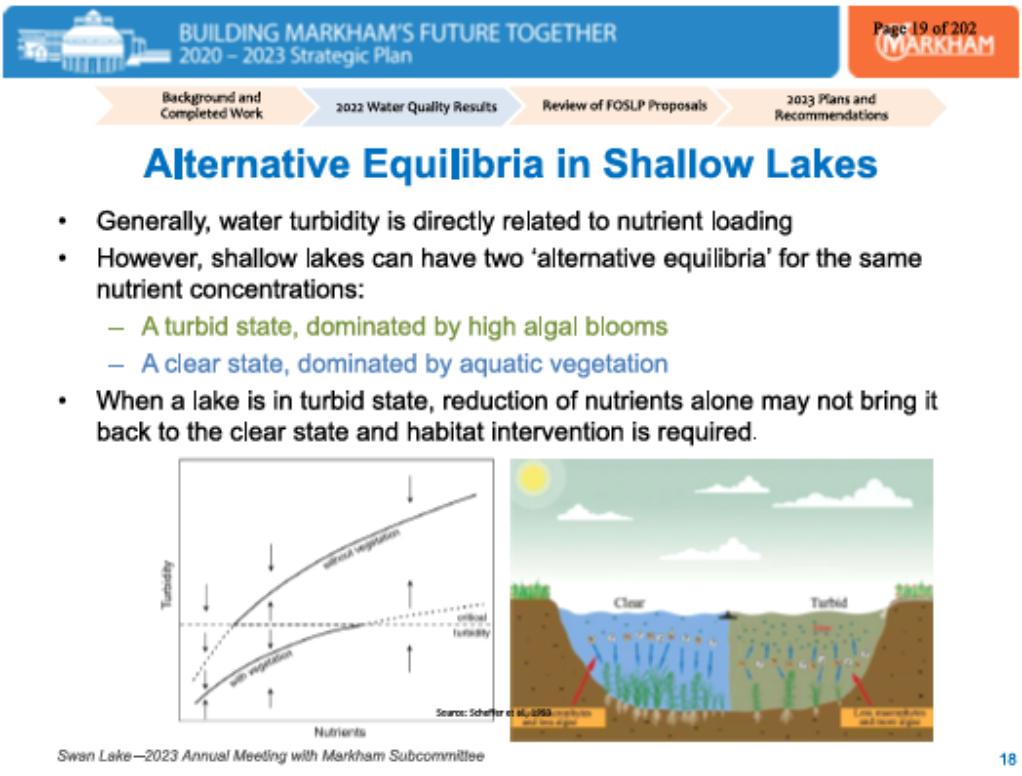
In their report to Markham Council in June 2025, staff noted the following outcomes for Phase 1:

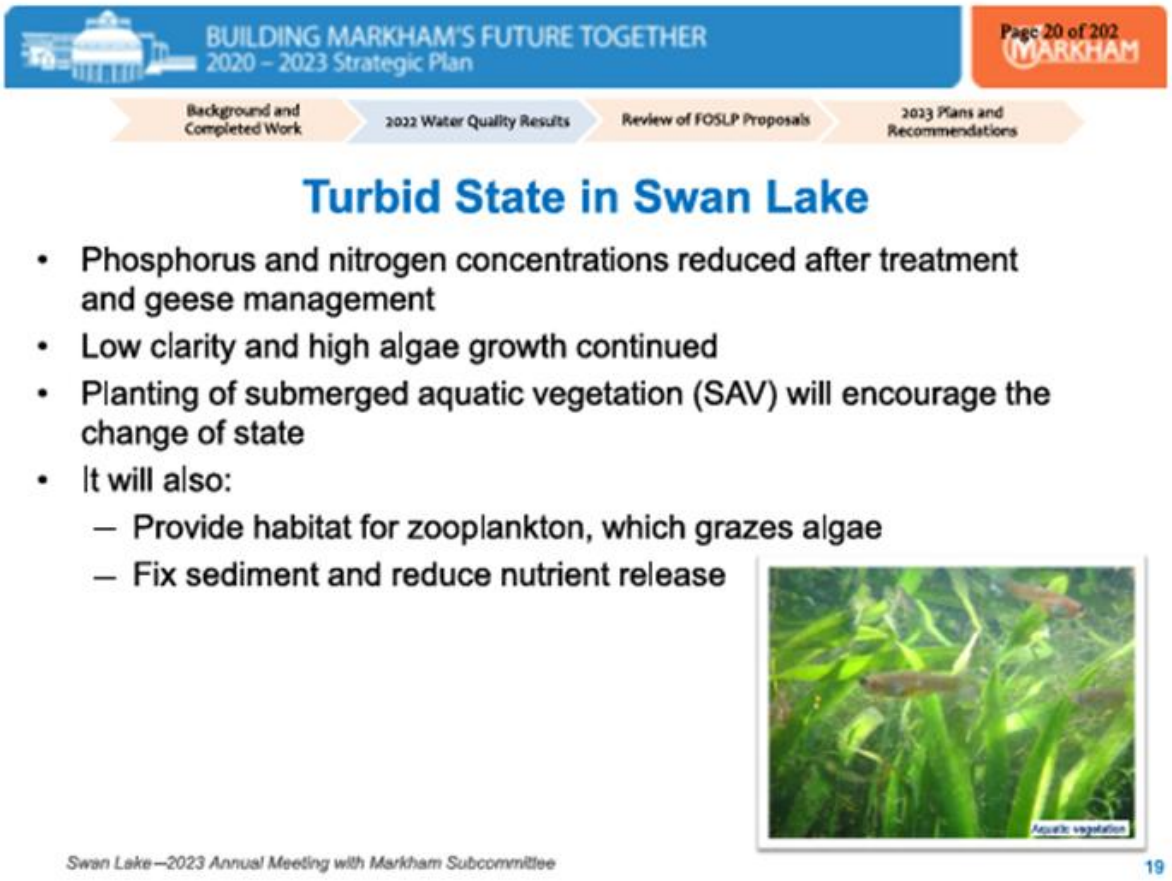



The report also notes that the "presence of minnows in large numbers indicate chloride concentrations are not negatively impacting aquatic life."

**Additional Measures May Be Required**

In their May 11, 2023, report to the Markham Subcommittee, staff concluded that "reduction in nutrients alone may not bring it back to the clear state and habitat intervention is required".






In 2023, Markham introduced submerged aquatic vegetation (macrophytes) to improve algae levels. The TRCA was engaged to initiate a pilot program of planting Wild Celery (Vallisneria americana" in four restricted areas. The report notes that Wild Celery has proven to be effective in absorbing nutrients for algae control and for stabilizing sediments to reduce turbidity.

The TRCA preliminary comments on the program note that:

1) In 2023 the 1500 stems were planted at 0.3 – 1.0 m deep, the mid-point for optimal growing depths for Wild Celery. Approximately 90% beyond the 30 cm. mark were absent in 2024 with a few persisting in deeper nodes. Only about 30% of the plantings were found at 30 cm depth.
2) Another 1500 stems were planted in 2024 between 20 – 40 cm.
3) Recommendation is to observe the success of the 2024 plantings through 2025 and if successful follow up with more plantings in 2026 in adjacent areas and other shallow areas.

The TRCA reports attribute the lack of success of the 2023 plantings to turbidity which prevented light from penetrating to the greater depths and to the fluctuating lake levels. The reports makes no reference to whether chloride levels in the lake were a possible factor.

## 7) FOSLP's Perspective on Phase 1

The Friends of Swan Lake Park acknowledge the significant improvements from the Phase 1 activities, particularly the reduced levels of phosphorus, nitrogen and chloride. While the goals established by Markham for Phase 1 have been met, the water quality and aquatic habitat remain below long-terms goal of sustainable rehabilitation.

FOSLP has suggested that to be successful the long-term rehabilitation plan should recognize two dimensions to the challenge:

1) the undertakings required **to improve** both the water quality and aquatic habitat, and
2) the undertakings required **to sustain** both the water quality and aquatic habitat over time with minimal human intervention.

Phase 1 experience has illustrated:

**a)** The need to clarify water quality goals in the context of aquatic habitat
**b)** The limitations of a phosphorus-centric program
**c)** That the aquifer and groundwater may be a more significant and beneficial factor than previously thought

### a) Water Quality Goals and Aquatic Habitat

Markham staff have made three concerning comments that highlight the need for the 5-year review to address setting goals related to the aquatic habitat in Swan Lake.

Staff have concluded that:

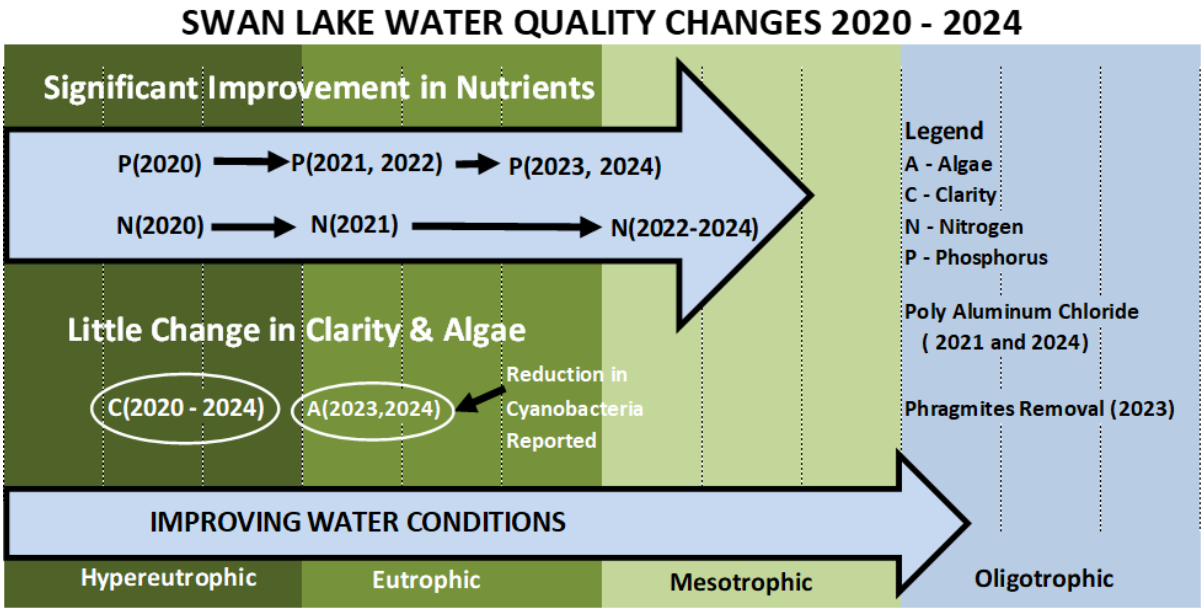
1) Significant improvements in water quality and habitat have been realized, including aquatic vegetation and fish communities.
2) The presence of minnows in large numbers indicate chloride concentrations are not negatively impacting aquatic life.
3) Water quality now consistently meets expectations for shallow urban water bodies.

There have been significant improvements in nutrient and chloride levels but it is not clear on what basis staff can claim an improvement in aquatic vegetation when only 30% of the initial plantings in four small locations have survived and Largemouth Bass were just added in the spring of 2025. Is the survival of a hardy species of minnows an adequate measure of aquatic health? Are the Federal guidelines for chloride level a relevant goal for Swan Lake?

The improved water conditions set the stage for a more focused discussion during the review on defining the ultimate long-term water quality goals and other elements of aquatic habitat.

### b) Drop in Phosphorus but Limited Reduction in Algae Levels

Phosphorus and nitrogen levels have dropped significantly since 2020 to mesotrophic levels, however, only a modest reduction in algae, based on Secchi measures, is observed. The limited direct testing of algae concentration in 2023 and 2024 shows levels at the Eutrophic level. Staff report a 40% drop in microsystins measures.




Four factors are possible contributors to the reduction in phosphorus and nitrogen levels:

i. Success of the annual geese hazing program (migratory geese are considered the primary source of external nutrients)
ii. Periodic chemical treatments – polyaluminum chloride treatments in 2021 and 2024.
iii. The one-time impact of the removal of phragmites in 2023 that removed both phosphorus and nitrogen stored in the mature plants.
iv. The flushing action of the aquifer could have also removed phosphorus and nitrogen active in the water column along with the chloride.

During the 5-year review the discussion about nutrients can now focus on what actions are required to **sustain** the nutrients at a mesotrophic level over the long term.

**d) Significant Reduction in Chloride Levels May Indicate Important Role of Aquifer**

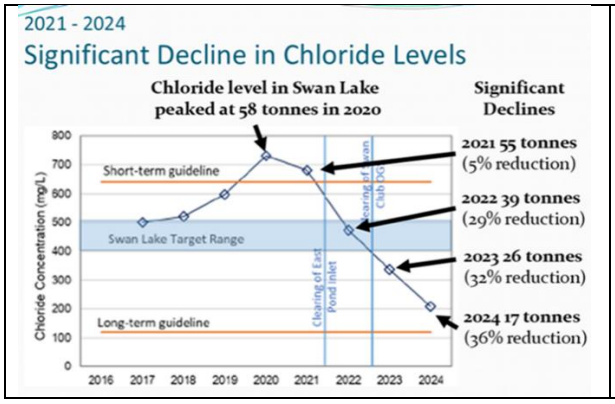
There was a significant drop in chloride levels from 2020 -through 2024. Overall, it was a very good but surprising development. The decline in chloride levels may be evidence of the positive influence that groundwater and the aquifer have on the health of Swan Lake.

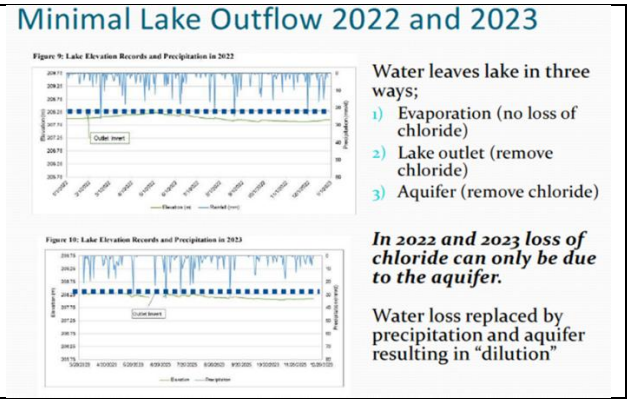
Once quarry operations ceased, Swan Lake filled naturally in the 1970's. An engineering report by Peto MacCallum Ltd. reporting on the geology of the area concluded that:

- The Regional Groundwater table is in hydraulic continuity with the static water level in the former gravel pit.
- The Regional Groundwater flow is directed southwards or southwestwards with an average hydraulic gradient of approximately 1%.
- Hydrogeological records of water wells on the site indicate static groundwater elevations ranging from 207 and 209 m. above sea level. The elevation of the water level in the lake is approximately 208 m, confirming that the lake probably originated from groundwater within the kame aquifer.

Where did the chloride go? The water monitoring report attributes the decline to a reduction of inflows of road salt due to unclogging of two input sources plus "dilution by cleaner water". The capacity of Swan Lake did not increase so in a closed system like Swan Lake, dilution requires a two-step process:

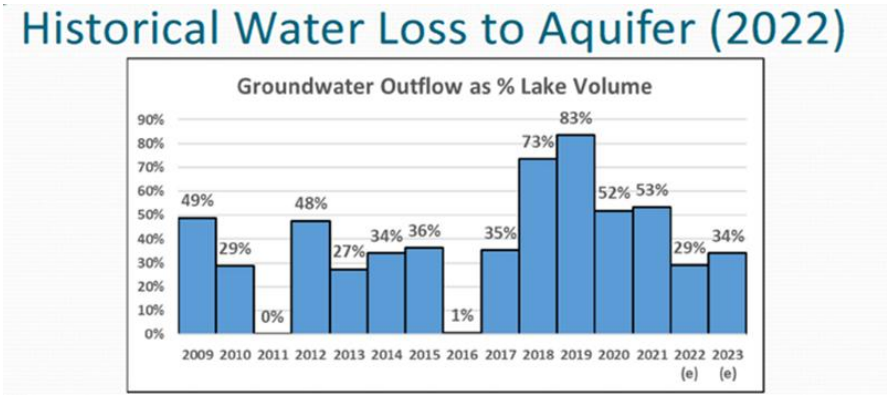
(1) The chloride laden water had to go somewhere. However, the lake levels during the summers of 2022 and 2023 were very low and there was very little outflow through the stormwater outlet, so the aquifer is the only outflow option remaining.




(2) The outflow is replaced by freshwater. In 2022, Markham staff released a "water Budget" model for Swan Lake that indicates that water loss to evaporation from the lake typically exceeds the volume of precipitation particularly during hot summers like 2022 and 2023 so precipitation less the loss due to evaporation is an unlikely source of the freshwater.

The water budget indicated large outflows from the lake. A loss of 29% - 34% in 2022 and 2023 would not be out of line with the earlier estimates.




The summer of 2024 was cooler with greater levels of precipitation and higher lake levels than in 2022 and 2023, but chloride levels continued to decline.

Possibly good news on two fronts:

1) There was no obvious treatment process identified to reduce the buildup of chloride in the lake. Perhaps the flushing action of the aquifer will continue to substantially reduce the buildup of chloride levels, but the rerouting of stormwater inflows is still required.
2) Lower chloride levels may permit acceleration of aquatic planting.

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2) Water Quality and Remediation Options for Swan Lake, Freshwater Research, August 27, 2012*
3) Swan Lake Water Quality Improvement Program, City of Markham, June 15, 2020
4) Swan Lake Water Quality Management, Freshwater Research, July 17, 2020
5) Swan Lake Long-term Water Quality Plan, City of Markham, November 16, 2021
6) Shoreline Restoration Proposal, Toronto and Region Conservation Authority, May 2022
7) Calcium Peroxide and Biochar Proposals – Review, Tammy Karst-Riddock, AECOM, 2023*
8) 2024 Swan Lake Monitoring Report, City of Markham, May 2025
9) Swan Lake Flow Diversion Report, AECOM, May 2025

## Friends of Swan Lake Park Reports

10) Pathway to Sustainability, June 1, 2020
11) A Pathway to Sustainable Water Quality for Swan Lake, December 15, 2020
12) Park Improvement Survey, March 2021
13) Pathway to Sustainable Water Quality: Ending Swan Lake's Stormwater Management Role, June 4, 2021
14) Action Plan to End Swan Lake's Stormwater Management Role, May 2022
15) Towards a Comprehensive Restoration Plan for Swan Lake, May 2023

## Research Submitted by FOSLP*

16) Literature Review of Potential Engineering Solutions for the Restoration of Swan Lake, Barbara Siembida-Lösch, Fleming College, February 2021.
    a. Evaluation of Recommendations by FOSLP, Freshwater Research April 8, 2021
    b. Review of Measures Proposed by FOSLP, Markham staff, April 12, 2021
17) Research Proposal on Use of Oxygen Releasing Compounds, Dr. Barbara Siembida-Lösch, Centre for Water and Wastewater Technologies, Fleming College, April 2022
18) Research into Removal of Nutrients and Chloride from Swan Lake, Dr. Rama Pulicharla, Dr. Satindar K. Brar, York University, May 2, 2022
19) Research Proposal into Nutrient Release from Sediments, Dr. Amy Bilton, University of Toronto


* Reports available on request. All other reports are available at https://friendsofswanlakepark.ca/resources/archives/

# APPENDIX A: Markham's 2024 Water Quality Report

**Swan Lake Monitoring Program**
**2024 Annual Report**

## Executive Summary

### Background

Swan Lake is situated in the City of Markham at the intersection of Sixteenth Avenue and Williamson Road. Swan Lake has an approximate area of 5.5 ha and a maximum water depth of 4.5 m (from the edge of the Lake at 210 meter above sea level). A gravel pit in the 1960s and 1970s, Swan Lake is currently a community feature with multiple trails and urban development surrounding it.

Several issues were discovered with Swan Lake in 2010, including high phosphorus levels and significant algal blooms during the summer months, which led to low oxygen levels and degraded fish habitats. A Phoslock treatment was administered in 2013 to reduce the phosphorus levels and algal blooms in Swan Lake.

In 2019, the City of Markham conducted a study to define a Water Quality Management Strategy for Swan Lake. The Strategy, finalized in July 2020, recommended a chemical treatment in 2021. In August 2021, 13 tonnes of Poly Aluminum Chloride (PAC) were applied to the Lake in a controlled manner over several days.

The Swan Lake Long-Term Management Plan, which was developed based on the 2019 Strategy and extensive consultation with stakeholders, was received by the Markham Sub Committee in November 2021 and approved by the Council in December 2021. It describes a phased adaptive approach, including Core, Complementary and Alternative measures, and periodic reviews to adapt the Plan to the Lake conditions.

In 2024, all Core measures were implemented as planned, including a second application of PAC based on the treatment plan developed by our consultant, AECOM. About nine tonnes of PAC was applied over two application events in late June, with each application event separated by one or two days of downtime to allow for floc formation and environmental testing.

Additional submerged aquatic vegetation was planted in the Lake following PAC application. It is expected that the relative water clarity would help establish the plants, which in turn will improve water clarity further. A geese management program, and a fish inventory and the removal of bottom-dwelling fish were completed in 2024 similar to previous years.

A Flow Diversion feasibility study and a chloride treatment pilot project continued in 2024.

Water quality monitoring of Swan Lake has been conducted almost annually since the first treatment in 2013 to track water quality and the continued effectiveness of the treatment. The collected data presented in this report is part of the ongoing monitoring program that will allow for continuous assessment of the water quality in Swan Lake and will be used to implement and adapt the Long-Term Management Plan for Swan Lake.

This report discusses observations at the monitored stations in the Lake throughout 2024.

### Results– Lake Water Quality

Water quality is regularly monitored at two shoreline sites: the Dock and the Bridge, on a bi-weekly basis (from April to November). Samples and measurements are taken at 0.5 m or 1 m increments for the depth of the lake. A level logger is used to record the water level in the Lake. A Dissolved Oxygen (DO) logger was also installed 1 m from the Lake bottom to record the diurnal changes in DO.

**Swan Lake Monitoring Program**
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Trent University collected samples and launched loggers in Swan Lake in the summer of 2024 to support a study on the environmental fates of lanthanum from La-modified bentonite in the ecosystem of Swan Lake. Data provided by Trent researchers have been incorporated in this report.

The following paragraphs provide the monitoring results for the 2024 monitoring period, as well as annual summaries of available data from 2016 to 2024. The figures include plots of measured DO, water clarity, phosphorus concentration, chloride concentration, and geese count.

**Targets**

Phosphorus concentration and clarity were compared to the eutrophication thresholds and/or the interim targets developed for Swan Lake through the 2019 Water Quality Management Strategy. For DO and chloride, Federal and/or Provincial water quality Guidelines or Objectives are shown for perspective. It should be noted that Swan Lake is not a natural waterbody, and there is no requirement for it to comply with these guidelines and objectives. Where technically and economically feasible, the City will aim to meet these guidelines and objectives to protect and enhance the aquatic environment.

**Dissolved Oxygen (DO), Temperature, and pH**

The minimum dissolved oxygen concentration required for the protection of warm water fish is 5 mg/L for water temperatures up to 20 °C, and 4 mg/L for temperatures above 20 °C. DO concentrations for the 1m from the surface and 1m from the bottom layers are shown below.

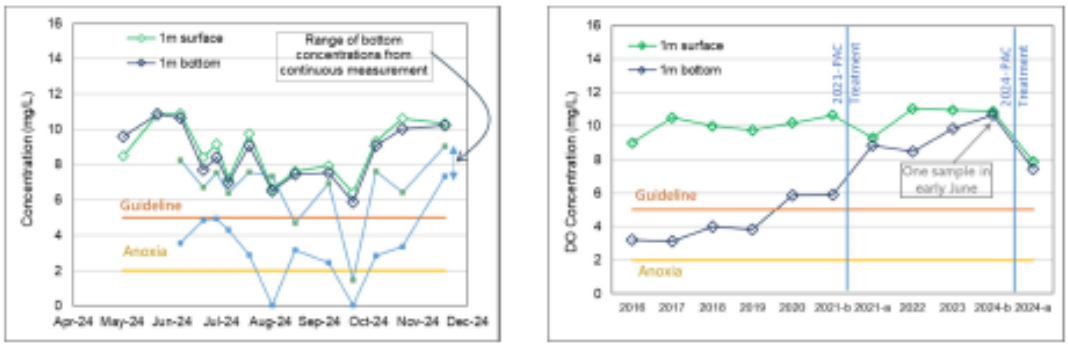
Day-time concentrations measured during biweekly visits were above the DO guideline (above 6.4 mg/L at the surface and above 5.9 mg/L at 1 m from the bottom).

While measured daytime DO levels did not indicate anoxia during the sampling events, continuous measurements at the Dock as well as at the deepest point in the lake (i.e., monitored at a logger commissioned by Trent University) showed a decline in bottom water DO about 50% of the time during August and September, when a dry and warm period followed a wet summer. These declines could have led to periodic anoxic episodes, increasing the potential for nutrient release from the sediments. However, the PAC treatments effectively bind phosphorus in the sediments, preventing its release even under anoxic conditions. Monitoring data support this effect, as surface and bottom phosphorus concentrations do not indicate anoxia-driven phosphorus enrichment, and overall bottom water DO has improved since the PAC treatments.

Lower DO concentrations could have lethal or sub-lethal (physiological and behavioral) effects on fish; however, some fish can acclimate to lower oxygen levels and survive concentrations between 1 and 3 mg/L. During anoxic episodes, which are temporary and restricted to the bottom of the water column, they can also avoid low oxygen conditions.

**Swan Lake Monitoring Program**
**2024 Annual Report**

**Figure ES-2: 2024 Monitoring Results and 2016-2024 Annual Results- Dissolved Oxygen**



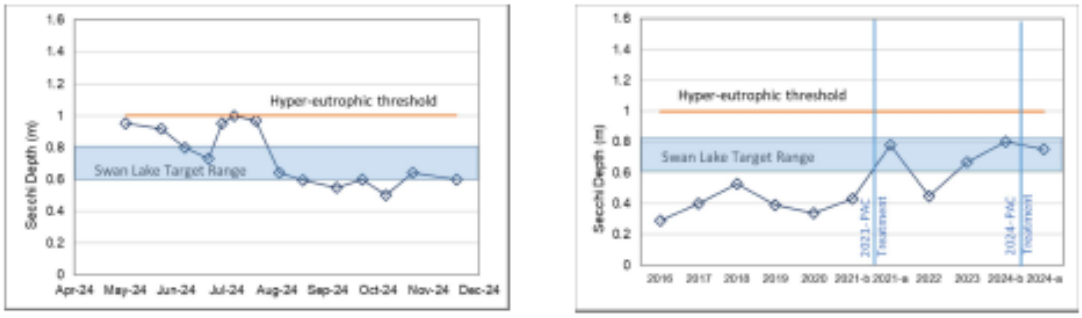

Note 1: DO concentrations are shown at 1 m from the surface (average of 0.5 and 1 m) and 1 m from the bottom (average of two bottom depths). The range shown (light blue lines) is minimum and maximum daily concentrations from the two loggers at the Dock and the deepest point for the sample collection days. DO trends logged in days between sampling days are not reflected in the plot.
Note 2: Historical data are shown for the average growing period (June-Sep) unless otherwise indicated. Data before 2016 are not shown for legibility.

The pH measured at the lab was about 8 throughout the year. High pH is consistent with high levels of algae. Algae take up carbon dioxide, a weak acid, from the water for photosynthesis, causing the water to become more basic (higher pH).

**Water Transparency (Secchi Depth)**

Secchi depth represents water transparency, which declines when the algae level increases. In the trophic state classification scheme, growing period average water clarity of under 1 m is the threshold for a hyper-eutrophic condition. The proposed interim target for Swan Lake is 0.6-0.8 m based on correlation with the phosphorus target. In 2024, the average water clarity during the growing season was within the target, with occasional declines to 0.5 m later in the fall.

**Figure ES-3: 2024 Monitoring Results and 2016-2024 Annual Results- Secchi Depth**



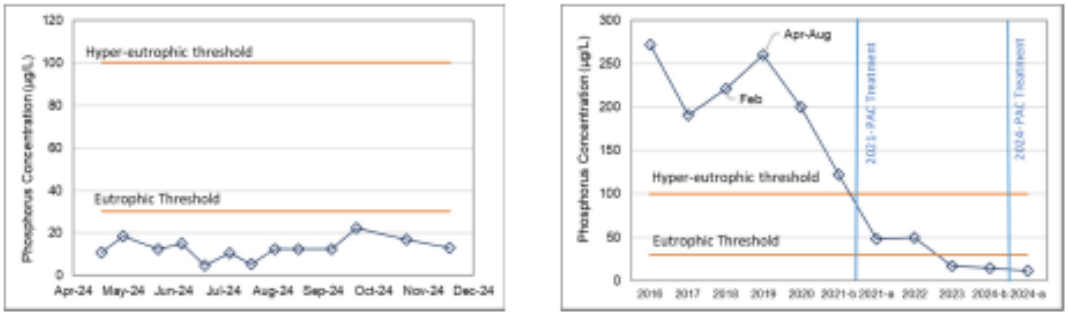

**Phosphorus and Nitrogen Concentrations**

Phosphorus concentration is the most important indicator of the trophic state in Swan Lake. It is an indication of how prone the Lake is to algae growth.

Phosphorus concentrations above 100 µg/L represent a hyper-eutrophic condition, which lead to high algae concentrations. In 2024, total phosphorus concentration in the top 0.5 and 1.5 m depths averaged under 12 µg/L during the growing season (under the 30 µg/L threshold for eutrophic condition, and well below the interim target of 50-100 µg/L). There was significant improvement in phosphorus concentrations after treatment by PAC.

**Swan Lake Monitoring Program**
**2024 Annual Report**

**Figure ES-1: 2024 Monitoring Results and 2016-2024 Annual Results- Total Phosphorus**




Note 1: The 2024 values are averages of samples collected at 0.5 and 1.5 m from the surface.
Note 2: Annual concentrations are summaries of the growing period (June-Sep) unless otherwise indicated.

In 2024, total nitrogen concentrations over the growing season averaged about 0.52 mg/L (below the 0.65 mg/L threshold for a eutrophic condition). In 2024, ammonia and nitrate concentrations (the forms available for uptake by biota) were generally very low (except in September and November), and nitrogen was mainly present in its organic form.

**Chloride Concentration**

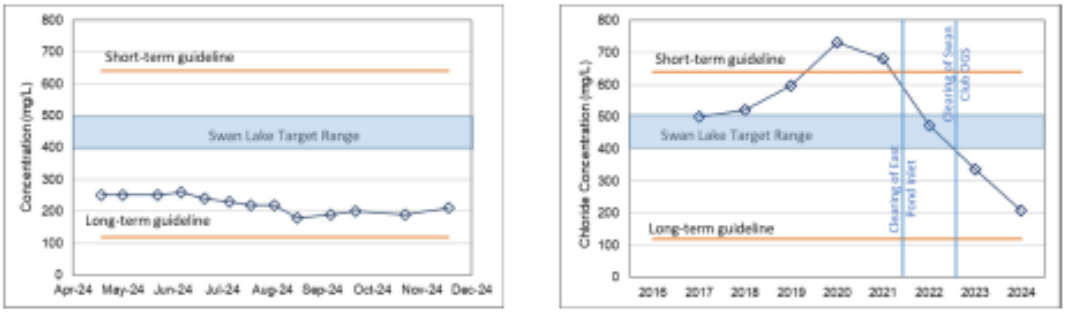
Chloride concentration has been increasing in urban lakes as a result of de-icer application for winter maintenance of roads and walkways. Chloride does not biodegrade, readily precipitate, volatilize, or bioaccumulate. It does not adsorb readily onto mineral surfaces and therefore when introduced, concentrations remain high in surface water.

Chloride guidelines developed for generic environmental data include a long-term guideline (120 mg/L) and a short-term guideline (640 mg/L). The long-term guideline has been developed to protect all organisms (present in Canadian aquatic systems) against negative effects during chronic indefinite exposure. The short-term guideline aims to protect most species against lethality during a sudden hike in chloride concentration for an acute short period (24-96 hrs). These guidelines may be over-protective for areas with an elevated concentration of chloride and associated adapted ecological community. For such circumstances, it has been suggested that site-specific (higher) targets be derived considering local conditions such as water chemistry, background concentrations, and aquatic community structure. The site-specific interim target for chloride for Swan Lake is 400-500 mg/L consistent with 2013-2014 values.

In 2024, chloride levels were below the target and declined considerably compared to previous years, continuing previous declines observed since 2020.

**Swan Lake Monitoring Program**
**2024 Annual Report**

**Figure ES-4: 2024 Monitoring Results and 2016-2024 Annual Results– Chloride**

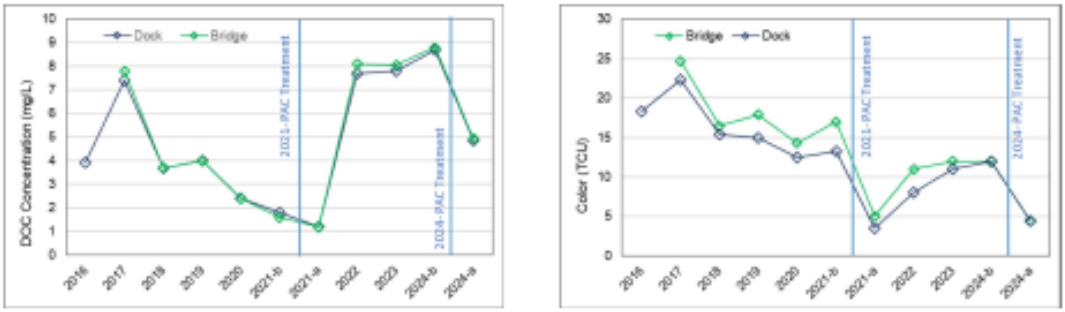



In 2024, water samples were collected from various inlets to the Lake and analyzed for chloride. These data will be used to update the chloride mass balance following the completion of the Flow Diversion Feasibility Study currently underway.

**Dissolved Organic Carbon and Color**

Dissolved organic carbon (DOC) and colour indicate the organic content of lake water. In 2024, DOC ranged between 4 and 9 mg/L, with color change from 3 to 12 TCU at both stations. DOC in 2022 and 2023 was considerably higher than in previous years, even before treatment. The increase may potentially be associated with the remnants of Phragmites in the Lake, as the roots were not removed. Both color and DOC declined sharply in 2024 following the PAC treatment, which precipitates organic matter.

**Figure ES-5: 2016-2024 Annual Results– DOC and Color**




**Geese Count**

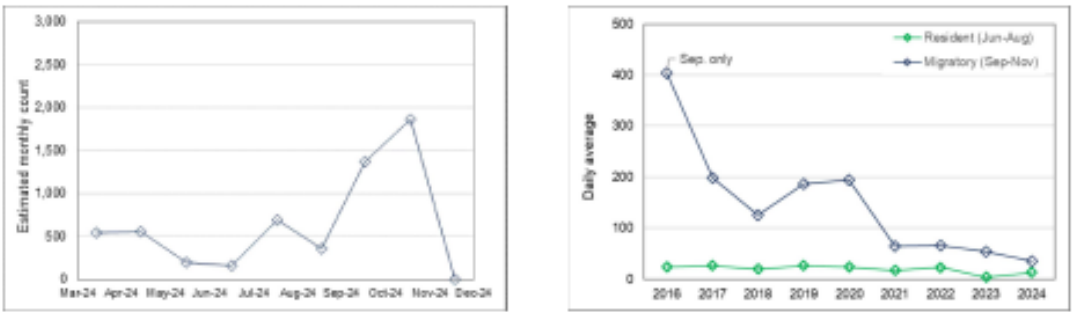
Geese are the primary external source of nutrients in the Lake. Therefore, active geese management is completed annually. The geese control program started in 2014, focusing on resident geese. The program extended to the management of migratory geese in 2016.

The 2024 program focus of control was laser light, avian distress call and limited strategic zinc crackler pyro, as well as geese relocation. A laser emitter was installed on the south island emitting at 1 ft above water surface to prevent overnight goose populations from accumulating in Swan Lake.

The 2024 efforts were very effective in reducing the number of migratory geese visiting the Lake, further lowering the counts. The geese count data helped provide more certainty in the results, and were used to more effectively schedule hazing efforts.

**Swan Lake Monitoring Program**
**2024 Annual Report**

**Figure ES-6: 2024 Monitoring Results and 2016-2024 Annual Results- Geese Count**




Note 1: 2024 data are the sum of counts in each month, compensated for days with no count.
Note 2: Annual trends are shown as daily averages of counts over June-August and September to November, representing resident and migratory geese, respectively.

**Fish Inventory**

A fish inventory and removal campaign were completed to remove bottom-dwelling fish, which could interfere with the chemical treatment efficacy. A limited number of fish species were caught in the Lake through this intensive effort: Common Carp (non-native), Brown Bullhead, and Fathead Minnow, as well as Goldfish and a hybrid of Carp/Goldfish.

**Algal Growth**

In 2024, very limited surface scums were observed along the shoreline around the Dock, as well as in the northern bay at the Bridge site. While the Lake was dominated by phytoplankton from late June, surface scums were not widespread.

Samples were collected and sent to the laboratory for phytoplankton analysis. Test results showed higher diversity and 37 to 44 percent lower cyanobacteria count compared to 2023 at the Dock and the Bridge stations, respectively.

Five samples were analyzed for phytoplankton between May and November. The total cyanobacteria cell count was below or close to Health Canada's indicator value for the potential production of cyanotoxins of 50,000 cells/mL, except in August (three and two times higher at the Dock and the Bridge, respectively).

Several algal blooms with potentially toxic cyanobacteria were observed in years before 2011; however, testing completed before 2011 and following treatment (2013-2016) did not detect any Microcystin in the water. In 2016, a bloom was tested and resulted in a Microcystin concentration of 73 µg/L. Extended blooms were observed at several sites in 2018; however, cell density was at half of World Health Organization (WHO)'s threshold for significantly increased human health risk due to toxins. Since the 2021 PAC treatment, very limited surface scum has been observed at Swan Lake.

## Summary and Recommendations

Overall, the management activities in recent years that focused on the significant nutrient loadings identified in the water quality improvement study (i.e., chemical treatment and fish management to reduce internal loads and geese management to reduce external loads), were effective at improving water quality in the Lake as shown in reduced phosphorus concentrations and improved dissolved oxygen levels. These improvements represent a positive step towards improving the aquatic habitat in the Lake and meeting the long-term water quality goals.

**Swan Lake Monitoring Program**
**2024 Annual Report**

In 2024, chloride levels decreased considerably likely due to clearing the blockage at the East Pond inlet and the Swan Lake Club Oil and Grit Separator (OGS), which resulted in reduced untreated flows to the Lake. Dilution by cleaner water could have contributed to lower chloride concentrations in the Lake.

While internal and external source controls successfully reduced nutrient concentrations, the Lake was dominated by phytoplankton, and water clarity did not improve. In addition to a prolonged dry and warm period in late summer and throughout the fall of 2024, this could be partly due to the absence of Submerged Aquatic Vegetation (SAV), which has been replaced by phytoplankton (algae) due to low water clarity. To ameliorate this condition, an SAV planting initiative was implemented in 2023 and 2024 at fenced areas along the north shore of the Lake.

The 2025 monitoring program will follow the recommendation of the Long-Term Management Plan. As per the Long-Term Management Plan, in 2025 at the end of Phase 1, a 5-year review will be completed to evaluate the effectiveness of Core measures and identify the need for additional Complementary measures in Phase 2.

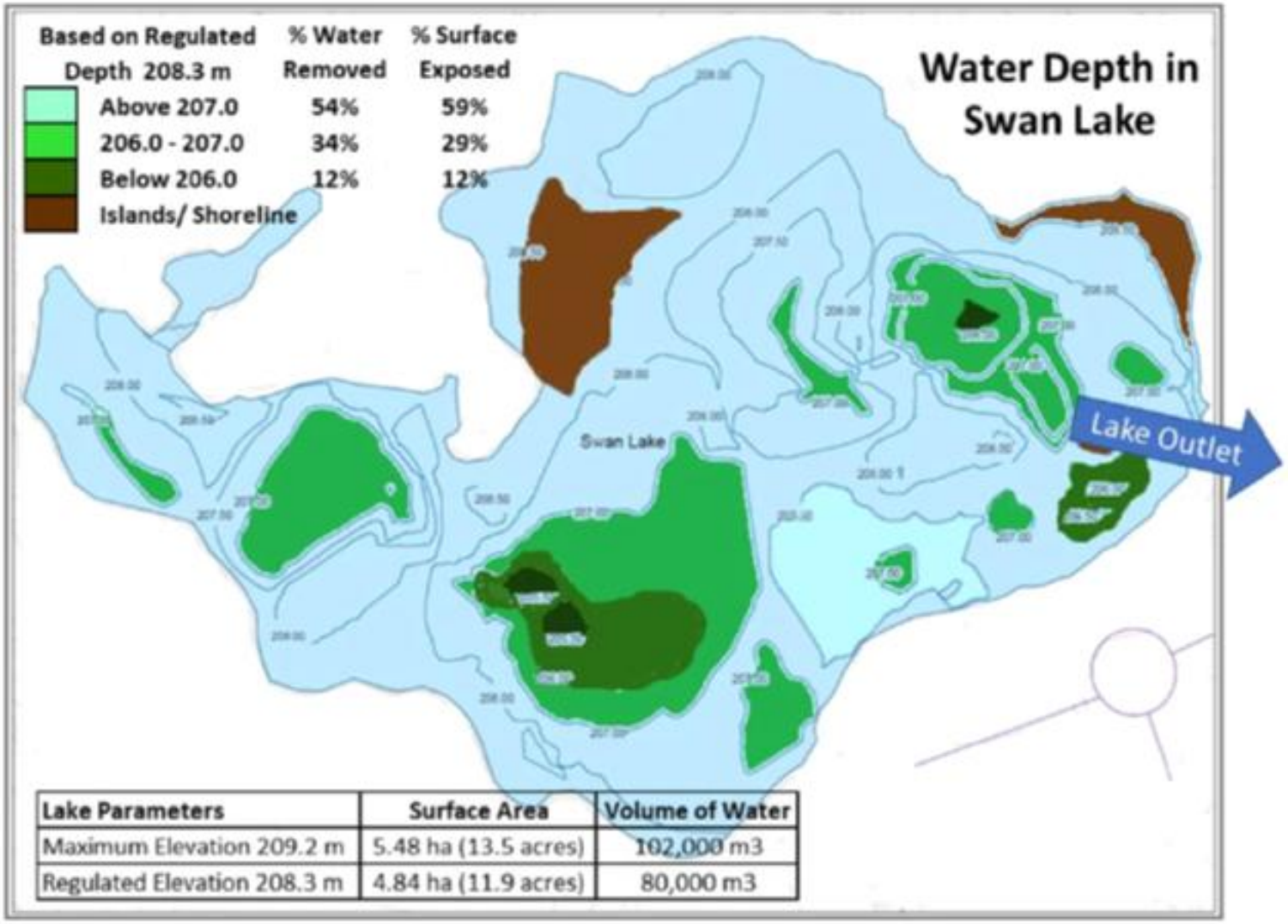
An evaluation of SAVs planting and fish stocking will be pursued, and studies and research on strategies to further reduce chloride concentration in the Lake by diverting runoff will continue. A new pilot project is being considered to apply ultrasound technology for algae control.

# APPENDIX B: Markham's 2021 Long Term Water Quality Plan

**Table 9: Evaluation of Optional Measures**

| Issue | Measure No. | Description | Technical Feasibility and Effectiveness | Unit Cost |
|---|---|---|---|---|
| **Internal Load** | IL1 | Chemical Treatment for Phosphorus Control | Feasible; lowers nutrient input from the most significant and bioavailable source and hence the most immediate and effective solution. | $150,000 per full application (three-year intervals) |
| | IL2 | Bottom-Dwelling Fish Management | Feasible; lowers internal load release. | $18,000 initial<br>$5000 annually |
| | IL3 | Nitrogen Control (by pumping & treatment or artificial wetlands) | Water pumping and treatment will result in increased water temperature, and significant disturbance of the area. Artificial wetlands provide geese habitat and promote settling of solids beneath the mats.<br>Nitrogen will be controlled by lowering productivity through other management measures, and does not need targeted treatment. | Significant |
| **External Load** | EL1 | Geese Management (including Toogood Pond) | Feasible; lowers nutrient input from the most significant external source. | Existing measures: $27,000 annually<br>New measures: $40,000 annually |
| | EL2 | Stormwater Management Ponds Maintenance (2 wet ponds) | Feasible; lowers nutrient input; currently maintained by the developers and, once ponds are assumed, by the City. | $1500 annually<br>$500,000 cleanout ($33,000 annualized) |
| | EL3 | Shoreline Planting/ Improvements | Feasible; lowers nutrient input by blocking geese access to the Lake, intercepts nutrient runoff | $35,000 design<br>$125,000 implementation |
| | EL4 | Groundwater and historic dumping areas | Groundwater requires extensive investigation.<br>A study of the dumping areas will involve the developers and private owners; low priority | Significant |
| **Oxygen Level** | OL1 | Mechanical or chemical oxygenation | Mechanical circulation will have negative impacts because of sediment disturbance and nutrient release. Calcium peroxide may be used in a pilot project. | Pilot project TBD through a research institute |
| **Chloride Level** | CL1 | Winter Maintenance on Private Land | Stakeholder engagement for snow and salt management will help reduce chloride concentration. | Privately funded |
| | CL2 | Physical or Biological Treatment | Existing methods are not very effective; New technologies may be considered when proven effective. | TBD |
| | CL3 | Redirecting Stormwater | Involves private landowners and York Region and detailed study to assess impacts/feasibility, and chloride levels may not impact desired aquatic biota; low priority. | Significant |
| **Natural Features** | NF1 | Shoreline Planting/ Improvements | Feasible; will provide fish habitat | See EL3 |
| | NF2 | Planting of Submerged Water Plants | Feasible; will help solidify sediment and provide fish habitat | TBD |
| | NF3 | Fish Management Plan and Fish Stocking | Feasible; once water quality improves. | TBD for the Plan<br>MNDMNRF for Fish Culture program |

## APPENDIX C: Water Depth in Swan Lake




| Lake Parameters | Surface Area | Volume of Water |
|---|---|---|
| Maximum Elevation 209.2 m | 5.48 ha (13.5 acres) | 102,000 m3 |
| Regulated Elevation 208.3 m | 4.84 ha (11.9 acres) | 80,000 m3 |