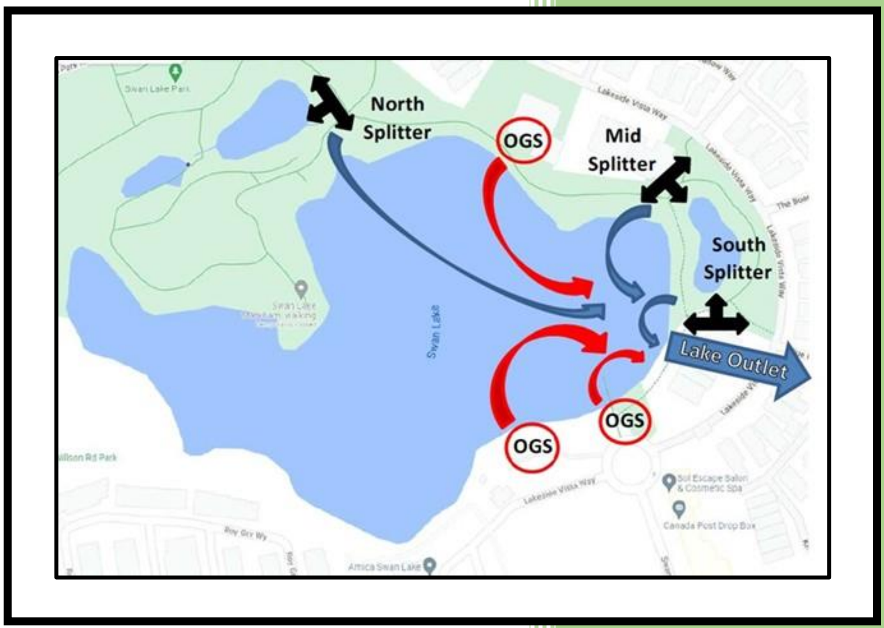
Action Plan to End Swan Lake's Stormwater Management Role



May 2022

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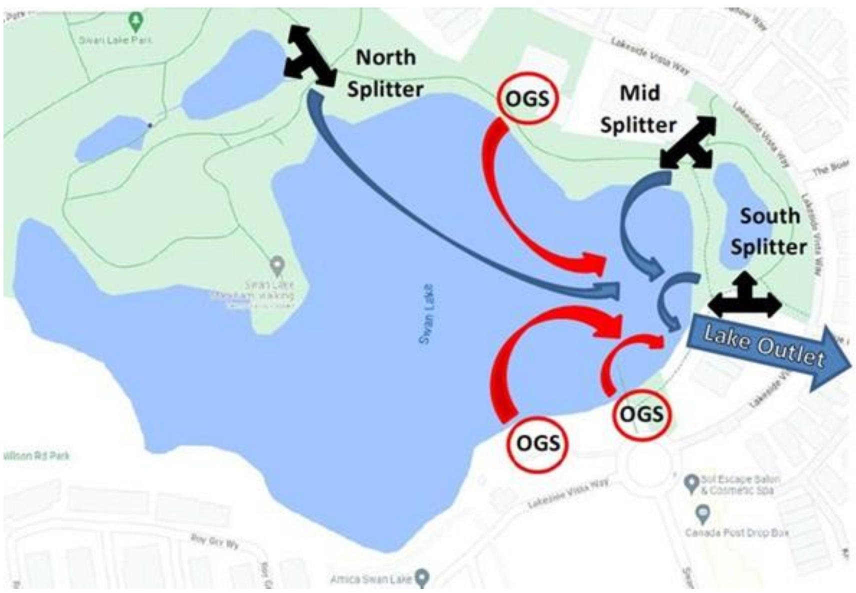
EXECUTIVE SUMMARY: ACTION PLAN TO END SWAN LAKE'S STORMWATER ROLE

Swan Lake Park's role as a "Natural Spaces/Wildlife Places" community park is undermined by several early design decisions that established Swan Lake as an active element in the local stormwater management regime. In essence, Swan Lake is the "third" stormwater pond in Swan Lake Park, and we believe this role is not necessary and should be minimized.

Water quality in Swan Lake is deteriorating each year. Initiatives are underway to minimize and manage phosphorus and nitrogen levels. The focus of this report is to identify ways to reduce the build-up of chloride from road salt that is undermining the aquatic environment.

Swan Lake can no longer be described as a freshwater lake. Due to the chloride, the water is classified as "brackish" and the condition is only going to get worse since there are no obvious ways to remove the chloride and there are no substantive programs in place to reduce the annual build-up of chloride.

Recycling Stormwater Through Swan Lake



Currently, annual stormwater flows, and road salt are unnecessarily being recycled through Swan Lake from six areas.

Enhanced salt management practices must be encouraged but the challenge of addressing excessive chloride levels in Swan Lake lies primarily in minimizing Swan Lake's role in the local stormwater management regime and establishing a rigorous maintenance routine.

Five-Step Action Program

Given that use of road salt can only be minimized, not discontinued, we recommend Markham adopt a five-step program as soon as possible to reduce the continuing inflow of road salt into Swan Lake:

Action #1: Reroute the three oil/grit separator flows into the main stormwater sewer system.

Action #2: Minimize the stormwater flows bypassing the ponds and entering Swan Lake by redesigning the pond infrastructure.

Action #3: Implement an effective pond monitoring and maintenance program to ensure future stormwater flows are not unnecessarily contaminating Swan Lake.

Action #4: Initiate an educational and awareness program in the local community to minimize use of road salt.

Action #5: Expedite research into approaches for removing chloride already in Swan Lake.

Our analysis identifies three core benefits arising from these proposed changes to the local infrastructure:

1) Swan Lake would become a self-contained entity retaining more of the clean local runoff and precipitation. Contaminated stormwater from the local communities would substantially remain in the stormwater system. Simply increasing the blend of fresh water within the lake should help enhance water quality and the aquatic environment.
2) Any additional flows directed downstream would be rerouted through the more tightly controlled pond management system rather than the lake outlet system, further minimizing downstream flooding risk.
3) Annual chloride contributions would be reduced over 80%. Minimizing the increase in chloride levels will provide an improved aquatic environment for zooplankton and small fish that are a natural means of controlling algae growth, reduce the risk of chloride contamination of the downstream aquifer and reduce future costs of expensive chemical treatments.

Ending Stormwater Role and Reducing the Sources of Chloride

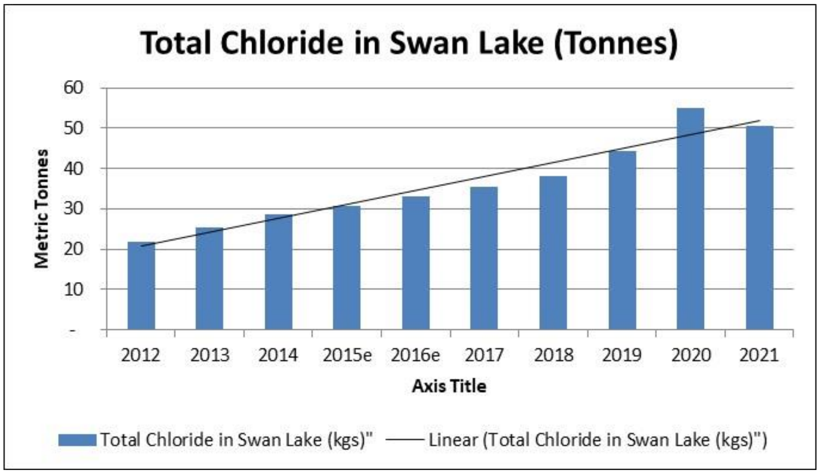
The following sections identify approaches that could end or significantly reduce Swan Lake's role as a stormwater pond.

1. All the OGS flows could be rerouted away from the lake reducing chloride inflows by 53% - 71%. The Amica and traffic circle flows could be redirected to the existing lake outlet system and the Swan Club OGS to the North Pond.
2. A technical assessment is required to quantify the reduction; however, the following analysis concludes that a significant portion of the flows currently bypassing the two ponds could be redirected into the ponds by raising the splitters and by increasing the size of the pipes going into the pond system. A 50% reduction in pond bypass flows would reduce chloride inflows from 11% - 21% while a 66% reduction in bypass flows would reduce chloride inflows by 15% - 28%.

EXCESSIVE CHLORIDE: THE PROBLEM

Swan Lake contains an excessive amount of chloride that Markham[14] and Freshwater Research[6] attribute to winter de-icing operations.

Chloride does not break down and will accumulate within the lake over time, impairing the health of aquatic plants and many forms of aquatic species. The excessive chloride (from road salt) is sufficient to kill small fish and eliminate zooplankton in the water, natural elements that consume algae.

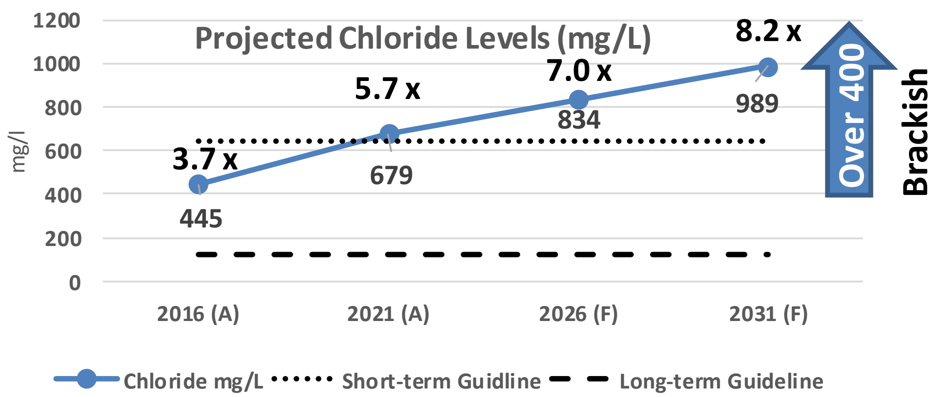


The adjacent chart illustrates the rapid increase in chloride levels in Swan Lake over the past few years. The annual increase prior to 2018 is estimated at 2.3 metric tonnes per year.

Markham concludes that the rapid rise in 2019 is not attributable to changes in normal winter salt management practices in the area but rather due to poor maintenance of the pond infrastructure.

The Mid-Splitter which serves the largest catchment area, was clogged for an estimated 3 years. The excess attributable to poor maintenance is estimated at 11% of the current chloride content in Swan Lake.

In 2021, the seasonal average for chloride in Swan Lake was 5.7 times higher than the Federal long-term guidelines[1] of 640 mg/l and well above the short-term (30 day) guideline of 120 mg/l. Individual recordings have been as high as 793 mg/l.



The Mid-Splitter system was cleared in 2021. If we revert to the traditional increase of 2.3 tonnes per year, the amount of chloride in the lake is projected to increase to 7.0x the long-term guidelines within 5 years and to 8.2x the guidelines in 10 years.

Other factors such as the amount of precipitation and volume of flows leaving the lake may result in diluting the build-up of chloride as projected, but those factors were present prior to 2018 so they may already be reflected in the average build-up of 2.3 tonnes per year.

Reduction in chloride levels, restoration of a healthy zooplankton community and a robust stock of small algae eating fish could provide a meaningful natural contribution to the control of algal growth and cyanobacteria in Swan Lake.

The decline in the fish population in Swan Lake is well documented. The only substantive species identified in the 2021 fish inventory by the TRCA were Fathead Minnows. However, the 10,000 estimated for Swan Lake appears low compared to comparable sized water bodies. In a study of Fathead Minnows in a South Dakoda pond comparable in size to Swan Lake, the study reported a population of over 100,000.

Historical Reports	2021 Fish Inventory
• Fathead Minnows	• Fathead Minnows (>10,000)
• Carp	• Common Carp (7 euthanized)
	• Brown Bullhead (209 relocated)
• Pumpkinseed Sunfish	• nil
• Catfish	• nil
• Goldfish	• nil
• Largemouth Bass	• nil

Fathead Minnows were included in the analysis setting the Federal chloride guidelines. Fathead Minnows were shown to have a high tolerance for short-term peaks in chloride levels but were at risk after 33 days with chloride levels of 598 mg/l. Chloride levels in Swan Lake. Not consistently exceed a safe level for Fathead Minnows.

Markham staff have stated that the existence of the Fatheaded Minnow illustrates the health of Swan Lake. The Federal guidelines would suggest they are in fact a species at risk.

Zooplankton is a beneficial element in freshwater because it consumes phytoplankton (microscopic algae and microbes).

A healthy zooplankton colony would be an important contributor to controlling algal growth in Swan Lake, but the high level of chloride is undermining the existence of zooplankton in Swan Lake.

As a first step in its Fish Management program, Markham should initiate an assessment of zooplankton and invertebrates to determine the current state of health of the lower-level aquatic life that sustain fish and consume algae. This assessment would also serve as a benchmark for determining success of future efforts to restore the aquatic health of the lake.

Research studies suggest that high chloride levels can lead to lower oxygen levels by diminishing aquatic plant life. There is little visible water-based plant life in Swan Lake. Controlling oxygen levels and chloride levels provides more natural biomanipulation options for the management of water quality in Swan Lake.

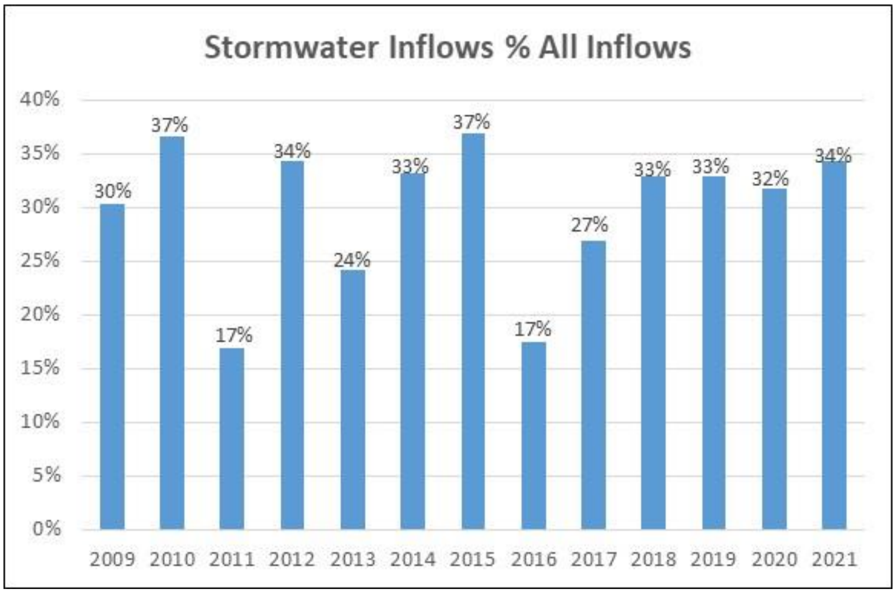
A small amount of chloride may enter Swan Lake via the aquifer but that is not likely a major concern. The greater concern should be that Swan Lake, with its very high concentrations, is likely a source adding chloride to the downstream aquifer. Stormwater ponds are designed to minimize leakage into the aquifer.

Swan Lake has no similar leakage prevention capabilities, so a continued buildup of chloride is endangering water quality in the downstream aquifer.

Sources of Excessive Chloride

In April 2022, Markham staff completed a high-level review of the inflows and outflows in Swan Lake for the 13-year period, 2009 - 2021.

The primary natural sources of water for Swan Lake, accounting for 69% of all inflows were identified as direct precipitation and runoff from the adjacent parklands. The remaining 31% was attributed to stormwater sources.



Stormwater Inflows 2009-2021

	Year	**Dec-Mar**
North Pond	35%	34%
East Pond	30%	23%
OGS Total	36%	43%
Amica OGS	15%	19%
Traffic Circle OGS	11%	13%
Swan Club OGS	9%	11%

Over the 13-year period, 35% of all stormwater flows were attributed to the North Pond, 30% to the East Pond and 36% to the three OGS units. During the winter months when the road salt is applied the OGS units accounted for 43% of all flows with 32% attributed to the Amica and Traffic Circle units.

Markham staff recently completed an analysis to determine the sources of road salt entering Swan Lake. There is very little data available, so they developed estimates using two different methods. One method was based on a few water samples taken in the March/April of 2021 and 2022 that provided data on the amount entering from the OGS units and the amount of salt bypassing the ponds. The second approach was based on annual volumes of salt used by Markham and Swan Lake Village applied to the drainage areas served by the ponds and OGS units.

The estimate based on water samples attributes the three OGS units as being responsible for 71% of the road salt entering the lake with the amounts bypassing the ponds accounting for 23%. The estimates based on total annual usage attributes 53% to the OGS units and 43% to the ponds. In either case, the three OGS units are seen as the primary problem.

	Basis for Estimate	
Stormwater Source	Water Samples	Usage Data
Three OGS Units	71%	53%
Two Stormwater Ponds	23%	43%
Shoreline	7%	4%
Total	100%	100%

	Basis for Estimate	
Community Origin	Water Samples	Usage Data
Markham	38%	31%
Swan Lake Village	30%	42%
Amica	25%	24%
Shoreline	7%	4%
Total	100%	100%

The analysis also attributed Markham being responsible for 31% - 38% of the road salt, Swan Lake Village for 30% - 42% and Amica for 24% - 25% of the chloride.

Markham's analysis concluded that, other than the blockage of the Mid-Splitter, the pond infrastructure was performing to the original design specifications. The primary analysis was based on properly functioning pond infrastructure as designed but also attempted to estimate the impact of the blocked Mid-Splitter.

	Basis for Estimate	
Total Inflows	Water Samples	Usage Data
Regulated Flows	34%	36%
Blockage (100%)	66%	64%
Regulated Flows	51%	53%
Blockage (50%%)	49%	47%

The analysis estimated that the blockage accounted for 64% - 66% of the chloride entering Swan Lake over the 3-year period. If you adjust to assume the blockage was only 50% (not 100% as assumed in the analysis) then the blockage still attributes 47% - 49% of the chloride entering during that period,

Over the period 2018 – 2021 the amount of chloride increased 12.5 tonnes. The expected increase over 3 years would be 6.9 tonnes suggesting that the excess of 5.6 tonnes (45%) is attributable to the blockage or 11% of the current 51 tonnes in the lake.

Reducing the Sources of Chloride

The following sections identify approaches that could end or significantly reduce Swan Lake's role as a stormwater pond.

1. All the OGS flows could be rerouted away from the lake. The Amica and traffic circle flows could be redirected to the existing lake outlet system and the Swan Club OGS unit could be redirected to the North Pond.
2. A technical assessment is required to quantify the reduction; however, the following analysis concludes that a significant portion of the flows currently bypassing the two ponds could be redirected into the ponds by raising the splitters and by increasing the size of the pipes going into the pond system.

The following table illustrates that if 100% of the OGS flows are directed away from the lake and the amounts bypassing the ponds are reduced by 50% then chloride entering Swan Lake can be reduced by 75% - 82%.

	Basis for Estimate					
	Water Samples			Usage Data		
Stormwater Source	**Qty**	**Reduction**	**Qty**	**Qty**	**Reduction**	**Qty**
Three OGS Units	33.7	100%	0.0	25.0	100%	0.0
Two Stormwater Ponds	10.8	50%	5.4	20.2	50%	10.1
Shoreline	3.1	0%	3.1	1.8	0%	1.8
Total	47.6		8.5	47.0		11.9
% of original Flows			18%			25%
Reduction			82%			75%

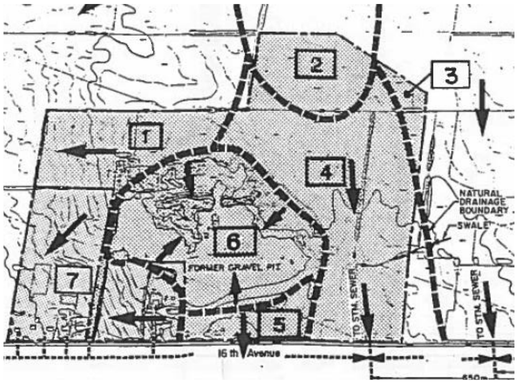
With 66% reduction of pond bypass		
Reduction	86%	82%

If the redesign of the splitters were able to reduce the amounts bypassing the ponds by 66%, overall chloride flows would be reduced 82% - 86%.

ACTION #1: REROUTING SWAN LAKE OGS FLOWS

Original Drainage Design (1995)

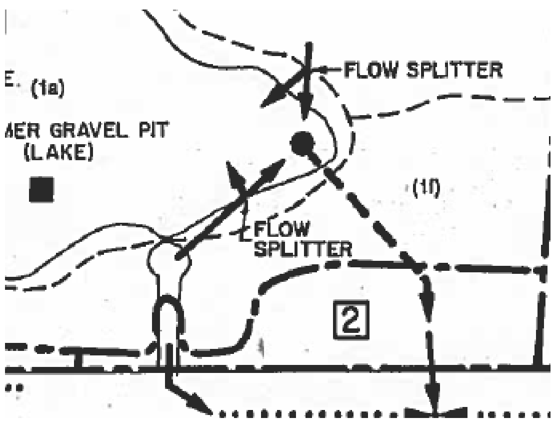
This analysis entails revisiting the original design decisions made regarding the use of OGS units.



Natural Area Drainage: Cosburn Figure 5

The original master drainage design[2] for the area noted that the land immediately north of 16th Avenue (area 5), which included the Amica property and most of the traffic circle, all drained naturally southwards towards 16th Avenue or west towards Mount Joy Creek (Exhibition Creek as it was then known). Consequently, stormwater from the southern end of Swan Lake Village and the new townhomes east of Williamson Road at 16th Avenue were directed to stormwater systems along 16th Avenue.

Outflows from the East Pond and Swan Lake also go the stormwater system on 16th Avenue.



Original Drainage Plan for Traffic Circle
Cosburn Figure 6

As indicted in the adjacent diagram, the report indicated that the traffic circle would be directed to the stormwater pond. However, contrary to these original recommendations, the Amica properties and the traffic circle area on Swan Lake Boulevard were permitted to drain directly into Swan Lake via oil/grit separators. Consequently, these two areas unnecessarily directly contribute chloride and other contaminants not removed from the oil/grit separators into the lake.

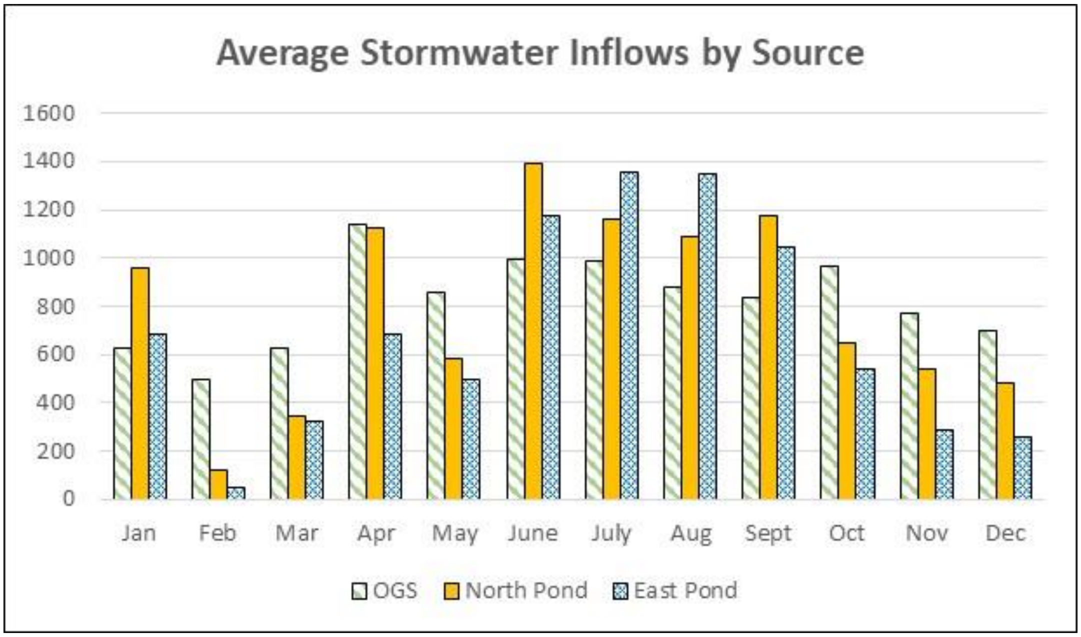
It is not clear why these areas were not routed to the East Stormwater Pond or to the lake outlet. Our analysis in Appendix D concludes that the pond has the capacity to handle these additional volumes. Our analysis involved revisiting the original design decisions, trying to identify any impediments. We concluded that there are feasible route alternatives.

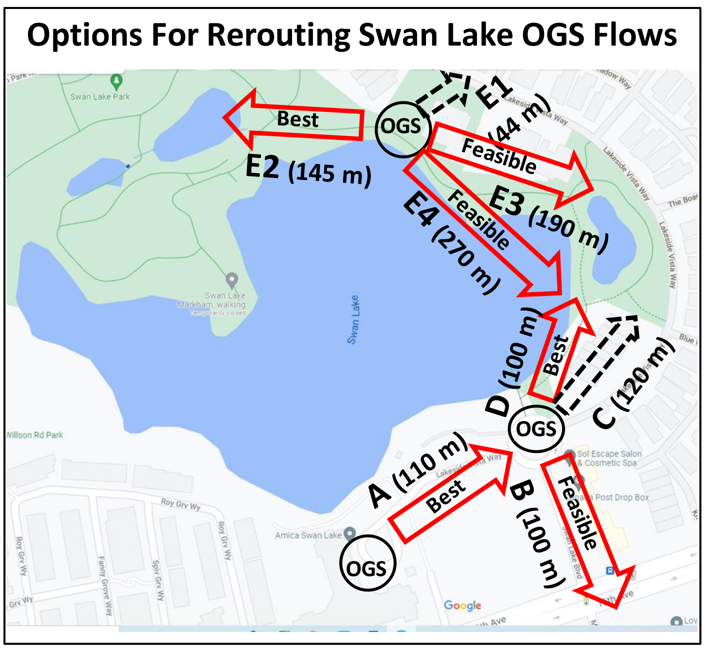
The three OGS units serve approximately 1.75 ha. with the Amica and Traffic Circle Units serving approximately 74% of the area.

Markham's water budget model provided estimates for the total OGS areas. In our analysis, the volumes were attributed to each area based on the relative size of the areas served.

OGS Units		
	Area (ha)	%
Amica	0.75	43%
Traffic Circle	0.54	31%
Swan Club	0.46	26%
Total Area	1.75	100%
Amica & TC	1.29	74%

The following table illustrates that the total OGS flows are of comparable scale to the amounts estimated to be bypassing the East Pond and North Pond. All flows are higher during the summer months.





A) Redirecting flows from the Amica property to the traffic circle
B) Redirecting the combined Amica and current traffic circle volumes south to 16th Avenue
C) Redirecting the combined flows from Amica and the traffic circle to the East Pond
D) Redirecting the combined flows from Amica and the traffic circle to the lake outlet
E) Redirecting the flows from the Swan Club OGS either to the Swan Lake Village Collector System (E1), the North Pond (E2), the East Pond (E3) or to the lake outlet (E4).

Conclusions: Several Feasible Options Identified

Our analysis notes whether the proposed route falls within the scope of the existing flood protection system or whether it would involve bypassing these protective devices. Any route that would bypass existing flood protection devices would require a detailed technical assessment of any potential downstream risks. Such assessment is beyond the scope of this analysis.

Summary of Options for Rerouting OGS Flows					
Rerouting Options	**Distance (m)**	**Feasible**	**Within Flood Protection**	**System Technical Assessment**	**Jurisdiction**
A: Amica to Traffic Circle	**110**	**Yes**	**No**	**Depends on route**	**Amica/Developer/ Markham**
B: Traffic Circle to 16th Avenue	100	Possible	No	Yes	Markham/York Region
C: Traffic Circle to East Pond Outlets					
C3 To SLV Collector	170	Possible	No	Yes	Markham/ SLV
D: Traffic Circle to Lake Outlets					
D1 To Lake Head Outlet	**80**	**Best**	**Yes**	**No**	**Markham/ Developer**
D2 To MH10B	**90**	**Best**	**Yes**	**No**	**Markham/ Developer**
D3 To SLV Collector	130	Possible	No	Yes	Markham/ Developer/SLV
E: Rerouting Swan Club OGS Flows					
E1(b) Swan Club OGS to SLV FDC System	44	Possible	No	Yes	Markham/SLV
E2 Swan Club OGS to North Pond Splitter	**145**	**Best**	**Yes**	**Pond Only**	**Markham/ Developer**
E3 Swan Club OGS to East Pond Mid-Splitter	190	Possible	Yes	No	Markham/Developer/SLV
E4 Swan Club OGS to Lake Outlet	270	Possible	Yes	No	Markham

I) Amica and Traffic Circle OGS Flows

a) It appears feasible to connect the Amica OGS flows to the traffic circle (Route A)

b) The best option for rerouting the combined Amica and traffic circle OGS flows is to direct the flows to the existing lake outlet either at the lake outlet headwall or at MH10B (Routes D1 or D2). These routes have the lowest risk of back flows and remain within the existing flood control mechanism and thus should reduce the need for a full-scale technical analysis of downstream systems.

c) It appears feasible to direct the combined flows directly south along Swan Lake Boulevard to the 16^{th} Avenue system (Route B). This would require a detailed technical assessment of the downstream impact of these additional volumes flowing eastward along 16^{th} Avenue.

d) It may be possible to use Route C2 to reroute the flows to the pond outlet system (MH4B) however backflow risk may be a significant factor, so it is not considered one of the better options.

e) There appear to be two possible routes for connecting the combined flows to the Swan Lake Village collector system as a route to the 16^{th} Avenue system (Routes C3 and D3). These routes would bypass existing flood control mechanisms so the flow may need to be managed by use of additional orifice plates and/or possible reduction of the lake outflow volumes. A detailed technical analysis of the impact of additional flows, if any, on the Swan Lake Village Collector System would be required.

II) Swan Club OGS

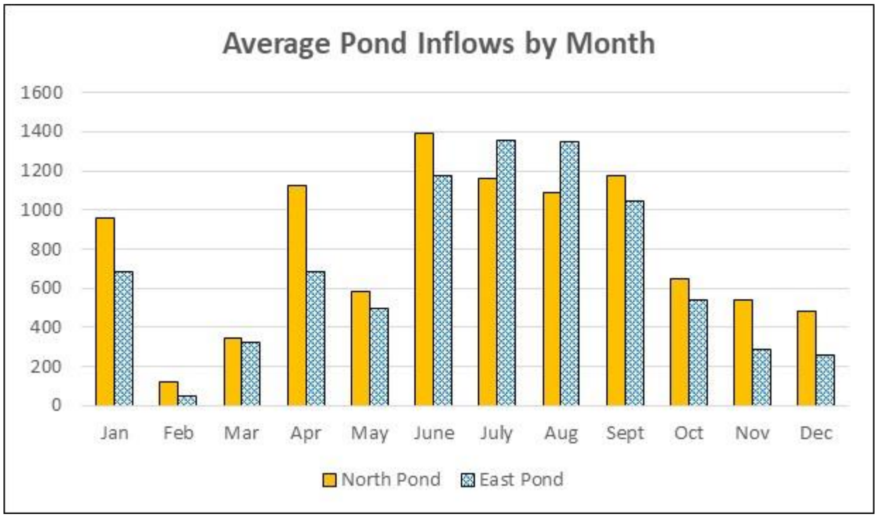
a) The best option is routing the OGS flows from the Swan Club to the North Pond (E2).

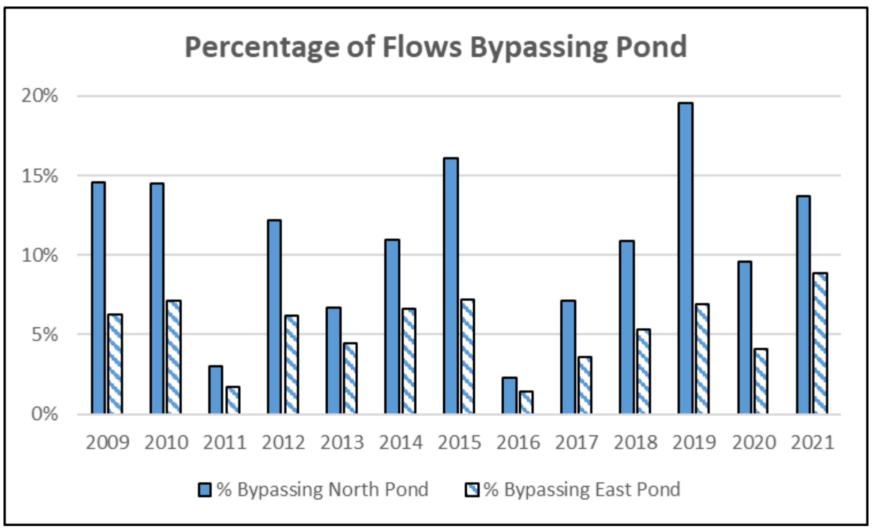
b) Another feasible option for the Swan Club OGS is to route the flows 270 m along the lakeside pathway to the lake outflow system at the lakehead or at MH10B (E4) and join with the flows from the traffic circle (Route D1 or D2).

If flows from the OGS units are redirected to the lake outlet system, there should be less outflow from the lake, therefore consideration should be given to lessening backflow risk by reducing the outflows from the lake by reducing the size of the orifice plate at the lake outlet headwall .

ACTION #2: REDUCING FLOWS BYPASSING THE PONDS

The two stormwater ponds contribute 65% of all stormwater entering Swan Lake and account for approximately 23%-43% of the chloride volumes added to the lake each year.





The North Pond is responsible for 35% of the total stormwater volume over the 13-year period while 30% is attributed to the East Pond. The balance of 35% is attributed to the three OGS units. The peak inflows from the ponds into the lake are in the May though August period.

Over the 13-year period 2009 – 2021, estimates based on the recent water budget analysis indicate that from 2% - 20% of the annual flows entering the North Pond stormwater system are bypassing the pond and going into Swan Lake. The average over the 13-year period is 10.9%.

Similarly, it is estimated that from 1% - 9% of the annual flows entering the East Pond stormwater system are bypassing the pond with the average volume entering the lake estimated at 5.3% of the total flow.

The two stormwater ponds in Swan Lake Park have underutilized capacity. The analysis detailed in Appendix D provides a high-level assessment of the ability to reduce the amount of stormwater that bypasses these ponds by directing more stormwater into the ponds.

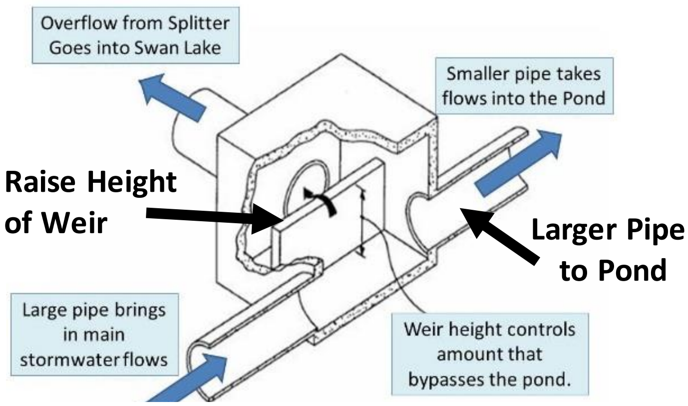
The capacity of the East Pond is 129% of the required capacity to serve its drainage area. Raising the splitters by 0.2 m will increase the pond capacity to 181% of the required capacity.

Raising the splitter in the North Pond by 0.1 m will increase pond capacity to 209% from the current 175% of required capacity.

Pond Capacity as % of Required	As Built	By Raising Splitters
East Pond (#105)	129%	181%
North Pond (#104)	175%	209%

Two approaches were considered to reduce the flows bypassing the ponds:

1) Raising the height of the weir within each flow splitter which has the dual effect of redirecting more water while increasing the pond capacity, and
2) increasing the size of the pipes that carry water from the splitter into the pond



The rate of flow through a pipe depends on the size of the pipe but it is also impacted by the height of the water and the speed of the flow. A hydraulic analysis would incorporate all the factors and would be required to determine the impact of raising the height of the weir and changing the size of the pipe on the increase in flow through the pipe. In this analysis we are only able to comment on the relative size of the pipe area as a benchmark for the potential impact of changing pipe sizes.

Raising the splitter in the South Splitter will have the impact of utilizing an additional 18% of the existing pipe capacity but will have no impact on either the Mid-Splitter or the North Splitter because the existing 450 mm pipe is already below the height of the splitter.
A hydraulic analysis would be required to determine the appropriate size of pipe and the potential impact on flows through the pipe.

Percentage Increase in Pipe Area Under The Weir			
Splitter	**South**	**Mid**	**North**
Existing 450 mm pipes			
Raising Splitter	18%	0%	0%
Enlarged 600 mm pipes			
Existing Splitter	44%	42%	51%
Raised Splitter	103%	78%	76%

To illustrate the potential impact of increasing the size of the pipe from the splitter to the pond, we compared the portion of the current 450 mm pipe below the weir height to the portion of a 600 mm pipe that would be below the weir.

With the existing splitter height, a 600 mm pipe would increase the pipe area below the weir by 44% in the South Splitter, 42% in the Mid-Splitter and 51% in the North Splitter. Raising the splitters increases the utilized pipe area by 103%, 78% and 76% respectively.

There should be little downstream risk associated with the proposed changes. First, all pond outflows are regulated using orifice plates to constrain outflow into the downstream systems. The East Pond outflows are regulated by a 66 mm orifice plate while the North Pond flows are regulated by a 100 mm plate. The operation of the orifice plates will need to be assessed with the higher maximum water levels and adjusted if necessary. The second factor is that these flows currently add to the lake volumes flowing downstream. In essence additional flows into the pond will be substantially offset by a reduction in outflows from the lake into the downstream system where they would pass through a more tightly regulated facility.

A technical analysis is required to quantify the potential reductions to flows bypassing the ponds if the proposed design changes were implements.

If the proposed adjustments to the pond dynamics were to redirect the first 500 m^3 of stormwater into the pond each winter month, then the road salt laden flows bypassing the North Pond would be reduced by 35% and the East Pond flows by 44%.

If the adjustments were able to reduce the initial flows by 1,000 m^3 per month during the winter, then the reduction in road salt laden flows could be reduced by 54% and 61%.

Reduction in Monthly Stormwater Flows	First 500 cu m	First 1000 cu m
North Pond		
Full Year	30%	49%
Winter Months	35%	54%
East Pond		
Full Year	32%	52%
Winter Months	44%	61%

The splitters provide an important local flood protection role and for that reason it will not be possible to stop all the stormwater flows from bypassing the ponds, but it appears that the flows could be significantly reduced and have a correspondingly important impact on reducing one of the primary sources of road salt entering the lake.

A technical assessment of the ponds ability to managed increased flows within Markham's design criteria would be required but this analysis illustrates that with relative minor changes there is the potential to significantly reduce the amount of road salt laden stormwater that is bypassing the ponds and going into Swan Lake.

ACTION #3: RIGOROUS POND MAINTENANCE PROGRAM

Maintenance of the Pond and Lake Inlets

The inlets into the ponds require routine maintenance. The Mid-Splitter was clogged for about three years before being cleared in December 2021. It is estimated that this blockage accounts for approximately 11% of the chloride in Swan Lake.

The following photos show the before and after images of the East Pond inlet pipe from the Mid-Splitter.

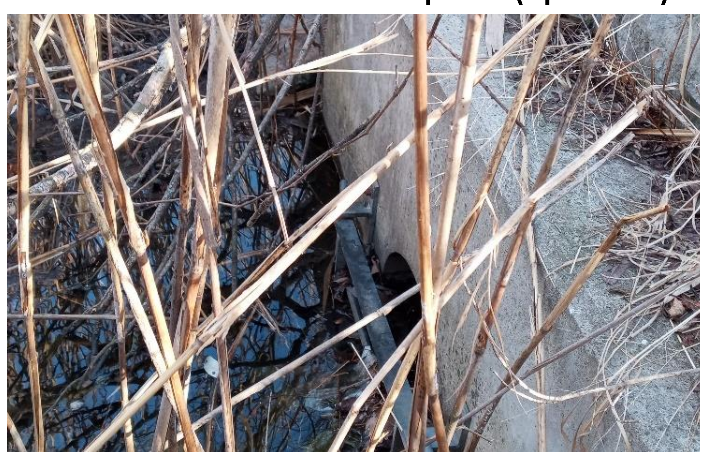
East Pond Mid-Splitter Before Cleaning (Dec 2021)

East Pond Mid-Splitter After Cleaning (April 2022)

The other inlet pipes do not appear to be clogged but the there is a build-up of reeds and mud at the pond entrance.

East Pond –Inlet from South Splitter (April 2022)

North Pond Inlet from North Splitter (April 2022)



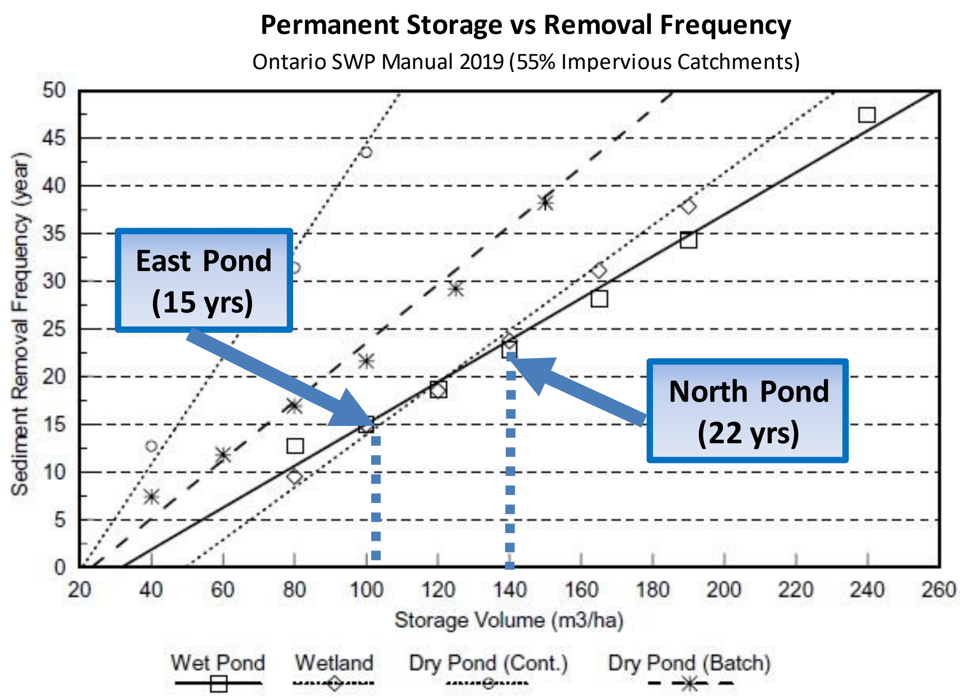
Pond Cleaning

Typically ponds such as these are cleaned for the first time immediately before being turned over to the municipality. This is often 10 years after being built.

These ponds remain under the control of the developer. The East Pond was built in 1996 and has been operational for 26 years. The North Pond was built in 2001 and operational for 21 years. Ontario's guidelines[11] call for regular monitoring and maintenance of all the elements of a stormwater pond system.

The ponds require cleaning periodically based on the relationship between the size of the area served and the pond design capacity. The oil/grit separators are recommended to be cleaned every year and the overall design assumes that all outlets and inlets remain clear and fully functional.

Other than the cleaning of the Mid-Splitter in December 2021, which was cleared only after the Friends of Swan Lake brought the problem to the attention of city staff, there is little evidence of active monitoring and maintenance of the Swan Lake pond infrastructure.



The guidelines suggest that the East Pond should be cleaned approximately every 15 years and the North Pond every 22 years. There may have been some cleaning activity performed at the East Pond around 2010 when the last phase of construction was completed in Swan Lake Village.

The Ministry of the Environment typically imposes requirements to monitor the ponds to ensure they are performing as designed when they issue their Certificate of Approval. In the case of these ponds, we have been unable to determine if any monitoring program for the ponds was required by the MOE or if any has been done.

ACTION # 4: IMPROVEMENTS IN SALT MANAGEMENT PRACTICES

The annual winter use of road salt in the adjacent areas is the primary source of chloride that has accumulated in the lake. A fundamental objective should be to encourage minimal use of road salt in the area. Prudent management of road salt in the local communities must be encouraged however it remains a fact that road salt is the primary tool for winter safety management and its use will continue.

Improvement in management practices needs to be encouraged. Two initiatives should be considered:

a) Review of Salt Management Protocols

Markham is responsible for the management of about 15% of the areas draining into the Swan Lake stormwater systems. The remainder is under the control of private owners.

- We believe Markham manages its salt applications under a 2005 policy guideline[10]. If so, then this should be reviewed to see if there have been material advancements that could be adopted.
- Private owners should be encouraged to adopt environmentally safe protocols.
- Markham and private owners should be encouraged to hire only contractors that have completed the training program and are certified under the "Smart About Salt" program. Information on the program is available at http://smartaboutsalt.com/.

b) Consider Use of Brine

Brine introduces the concept of "anti-icing" by placing a layer of brine on the surface area before the storm to prevent freezing. Traditional road salt practices involve "de-icing" – using salt to remove ice after it has formed.

The benefit of adopting brine as part of the salt management regime was illustrated by a recent pilot project at Ryerson University that resulted in a 25% reduction in the use of salt and a modest reduction in costs.

The November 2021 long-term water quality plan for Swan Lake, did not include any specific programs to address the build-up of chloride in Swan Lake. The report has suggested that local communities be encouraged to reduce the use of road salt to help mitigate the amount entering the lake. The primary neighbouring communities are senior retirement communities that are conscious of the environmental issue but also empathize the need for road salt as a safety measure for their residents. Swan Lake Village has confirmed that its contractor is certified under the Smart About Salt program.

Improvement in salt management practices is important however it alone will not have a material impact on the ongoing build-up of chloride in Swan Lake.

ACTION #5: RESEARCH INTO REMOVING CHLORIDE

The challenges in addressing the restoration challenges in Swan Lake are complex and a diversity of skills and views is required. The following summary outlines a variety of resources that may be able to contribute to key elements of a long-term sustainable plan for Swan Lake.

In the November 2021 Swan Lake Long-Term Management Plan[13] Markham has recognized the need for research into the removal of chloride already in the lake and for means to improve oxygen levels.

York University Research into Removal of Phosphorus, Nitrogen and Chloride

The Swan Lake long-term plan calls for research into means for removal of chloride starting in 5 years. Since the intrinsic chloride problem is known and expected to get progressively worse and research programs take 2-3 years, a more expedient timeframe is required. To that end, the Friends of Swan Lake Park have solicited a proposal by researchers at York University to initiate a study of using charcoal-based products to remove phosphorus, nitrogen, and chloride from Swan Lake. The proposal is provided in Appendix E. We encourage Markham to commit to a timelier research effort and support this and other research efforts to improve and restore water quality in Swan Lake.

Fleming College Research into Improving Oxygen Levels

The Swan Lake long-term plan calls for research into the potential for the use of Calcium Peroxide as a means for improving oxygen levels in Swan Lake during the initial 5 years. This concept arose from a 2020 report by Fleming College sponsored by the Friends of Swan Lake Park. The Friends of Swan Lake Park have solicited a proposal by researchers at the Centre for Water and Wastewater Technologies at Fleming College on the potential for use of calcium peroxide for improving oxygen levels in Swan Lake. The proposal is provided in Appendix F.

Technical Assessment of Rerouting OGS Flows and Reducing Flows Bypassing the Ponds

The engineering issues raised related to rerouting OGS flows and in raising the splitters and potentially resizing the pond inlet pipes could be assessed in several ways:

a) The developer responsible for the two stormwater ponds could include a review of the design of the pond splitters in the context of their technical assessment of whether the ponds require cleaning.
b) City staff could provide a technical review of the proposal to reroute the Amica and Traffic Circle OGS flows to the lake outlet and the Swan Club OGS flows to the North Pond and determine whether further technical downstream assessment is required since these changes fall within the current flood protection mechanisms.
c) Engineering students could be engaged to undertake an assessment of the above issues.

Water Environment Association of Ontario Student Design Competition

In its June 2020 report, the Friends of Swan Lake Park recommended that the challenge of establishing a comprehensive restoration plan for Swan Lake and Swan Lake Park be submitted as a topic for the annual student design competition sponsored by WEAO. This recommendation was endorsed by Freshwater Research in its July 2020 report.

IMPACT OF PROPOSED CHANGES ON DOWNSTREAM SYSTEMS

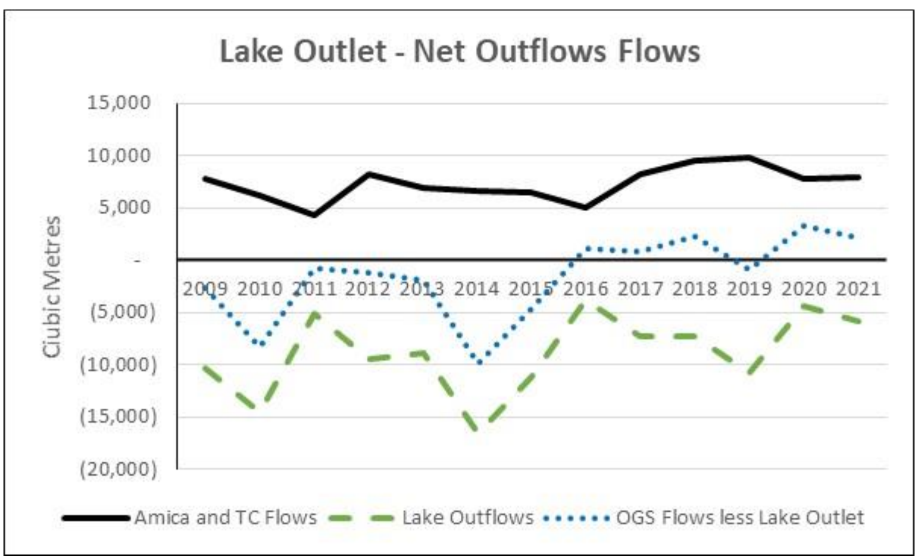
Once fully implemented the program for rerouting stormwater inflows away from Swan Lake will impact the three primary stormwater outlets:

a) The lake outlet would be used primarily to serve the Amica and Traffic Circle flows with minimal flows expected from the lake.
b) The flows from the East Pond into the Swan Lake Village Collector System and ultimately the 16th Avenue southern system will increase up to 3%-5% depending on the success in reducing the flows bypassing the East Pond.
c) The flows from the North Pond going into the Williamson Road system and ultimately the 16th Avenue westward system will increase by the additional volume of the Swan Club OGS unit and up to 5% - 8% depending on the success of reducing amounts bypassing the ponds.

The following section summarizes the estimated impact on total annual flows. For flood control purposes, the rate of flow in litres/sec is a significant factor. By managing these flows through the existing flood protection mechanisms there should be no change in the rate of flow and therefore nominal impact on flood control risk. A technical confirmation would be required.

a) Impact on Lake Outlet Flows

The current outflows from the lake can be largely attributed to the stormwater inflows. If these inflows are eliminated, the lake will level out at a natural balance determined by the amount of precipitation, the amount of evaporation and the forces of the aquifer.



This chart illustrates that over the 11-year period 2009 – 2021, the OGS flows from Amica, and the traffic circle have generally been smaller than the lake outflows.

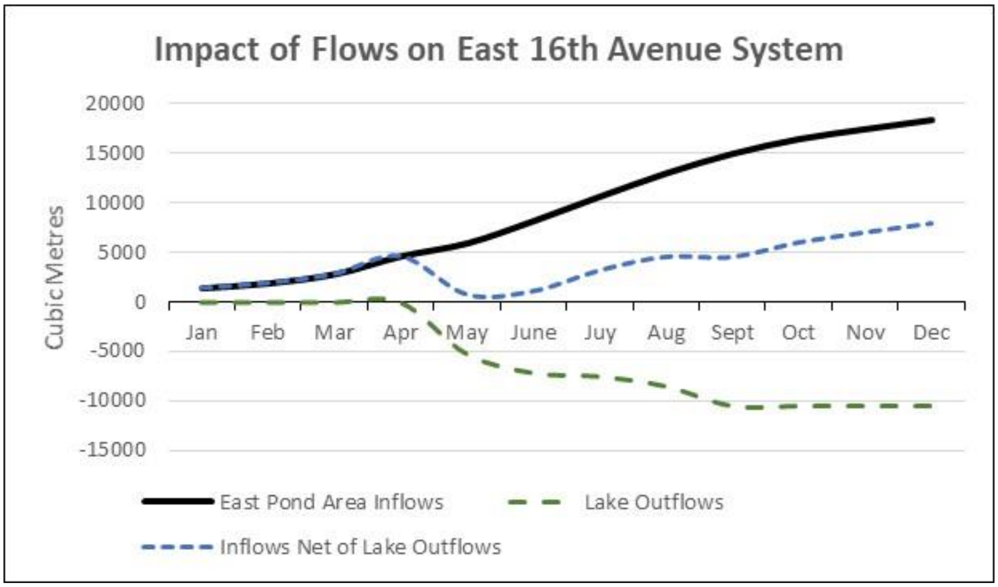
By rerouting the Amica and Traffic Circle OGS flows to the lake outlet there should be a lower volume of water passing through the lake outlet system.

Historical observation, before the construction of the stormwater connections, record the lake level as ranging from 208.2 – 208.5 and averaging 208.35, slightly above the current regulated level of 208.3. It is expected outflows from the lake as a stand-alone entity will be virtually eliminated or infrequent. The amount the lake can absorb before there are direct outflows from the lake will be influenced by natural sources and by the success in reducing the flows bypassing the ponds.

b) Impact on the East Pond Outlet

It is estimated that on average 5.3% of the flows entering the East Pond system bypass the pond and enter Swan Lake. Raising the splitters and increasing the pipe sizes has the potential to reduce flows going into the lake during all but the summer months.

The additional flows retained in the pond will leave through a tightly regulated system that greatly restricts outflows so the downstream risk should be minimal.

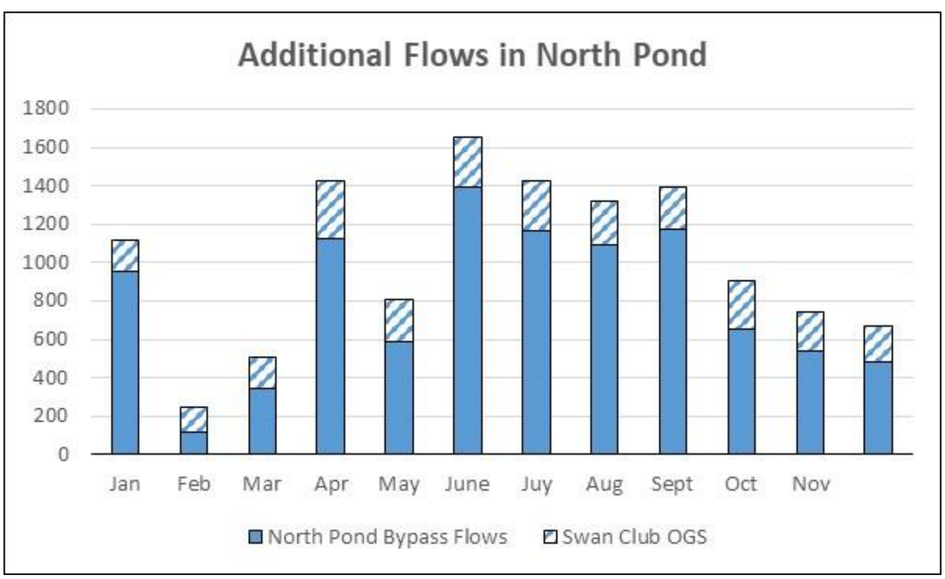


The adjacent chart illustrates the combined impact on the Eastern 16th Avenue system on the combined OGS flows from the Lake Outlet System and the additional flows from the East Pond.

The estimated net inflows indicates that the cumulative impact will build towards the second half of the year.

c) Impact on Williamson Road System

The North Pond and the Williamson Road system will be impacted in two ways: a) relatively small volume flows from the Swan Club OGS system, and 2) retained flows, estimated at potentially up to 5% - 8% of current pond flows.



The adjacent chart illustrates the average additional flows expected to be directed into the North Pond assuming that no flows bypass the pond and go into Swan Lake.

These flows, currently directed into Swan Lake and ultimately the 16th Avenue system, would be rerouted into the Williamson Road system.

References:

1) Canadian Water Quality Guidelines for Protection of Aquatic Life, Canadian Council of Minsters of the Environment, 2011

2) Environmental Master Drainage Plan, Cosburn Patterson Wardman Limited, Revised Sept. 1995

3) Swan Lake Water Budget and Levels, Letter to Town of Markham from Barenco, Sept. 19, 2000

4) Swan Lake – North Pond, Stormwater Management Brief, Earth Tech Canada Inc., Revised July 31, 2000

5) Swan Lake Village Townhouses, Stormwater Management Brief, Earth Tech Canada, Revised September 2005

6) Swan Lake Water Quality Management, Freshwater Research, July 17, 2020

7) Hydrological Modeling (City of Markham), Appendix C, Swan Lake Water Quality Management, Freshwater Research July 17, 2020

8) Swan Lake Monitoring Program 2020 Annual Report, Markham Environmental Services, March 2021

9) Markham Stormwater Management Guidelines, City of Markham, October 2016

10) Salt Management Plan, City of Markham, March 16, 2005

11) Stormwater Management Planning and Design Manual, Ministry of Environment, Ontario, Mar 2003

12) Storm Water Management Facility Sediment Maintenance Guide, Greenland International Consulting Inc. August 1999

13) Swan Lake Long-Term Management Plan, City of Markham, November 2021

14) Swan Lake Water Quality Management – Water Flow and Chloride Analysis, Markham, April 2022

15) Various technical drawings made available by City of Markham and Swan Lake Village
    a) East Pond, Drawing 10, Cosburn Patterson Wardman, Town File 3057, Project 87464, Jan. 1996
    b) East Pond, Drawing 101, Cosburn Patterson Wardman, Project 87464, September 1995
    c) East Pond, Drawing 301, Cosburn Patterson Wardman, Project 87464, As recorded, Aug. 2002
    d) East Pond, Drawing 501, Cosburn Patterson Wardman, Project 87464, August 1995
    e) East Pond, Drawing 502, Cosburn Patterson Wardman, Project 87464, August 1995
    f) Traffic Circle OGS and Lake Outlet, Drawing 504, Cosburn Patterson Wardman, Project 87464, August 1995
    g) North Pond, Drawing A1-99647, Earth Tech, Project 99647, April 2000
    h) Amica 6380, Drawing R-1, Cosburn Patterson Wardman, Project 87464D, August 1999
    i) Swan Lake Village, Drawing S1, Cosburn Patterson Mather, Project 87464, August 1995
    j) Swan Lake Village, Drawing G1, Earth Tech, Project 76814, February 2005
    k) The Swan Club, Drawing A1-00727-G1, Earth Tech, Project 00727, April 2000

Appendix A: Limitations of the Analysis

In assessing the feasibility of the routes, or the dynamics of flow splitters we used some very basic tools that were sufficient to outline reasons why certain options could be dismissed but not technically sufficient to confirm that they would work.

In reviewing the feasibility of rerouting the OGS flows, the initial focus was whether there was sufficient slope for potential pipes within the existing infrastructure to support the proposed route.

Consideration was also given as to whether there were any known physical impediments such as other buried utility services (electrical, water, other sewer systems). In most cases, the engineering drawings used in this analysis did not identify other adjacent utility services so additional work would be required to confirm if there are any physical impediments to be considered.

In our analysis of the impact of raising the height of the weirs within each splitter or on changing pipe sizes within the splitters, our analysis was limited to only comparing the actual change in capacity (area) of the pipe. While we can illustrate the ability to increase the weirs or the percentage increase in the size of the pipe, the rate of flow through a pipe is also impacted by the height of the water column, water pressure and the speed of the flow. A hydraulic analysis would incorporate all the relevant factors and would be required to determine the impact of a change in weir height and pipe capacity on the change in the volume flowing through the pipe. We can estimate the potential impact of only one factor.

One of the challenges that impacts the range of options is the low-lying nature of the area surrounding the lake. For example, most of the adjacent land and existing infrastructure is a matter of centimeters above or below the lake and pond levels. Anytime a connection is below the lake or pond level, the risk of "backflow" was considered i.e.: the risk that at high levels, water could flow from the lake or pond back into the collector system – a reversal of the intended design. Almost all options considered "feasible" will need to be reviewed to consider whether backflow is a potential problem.

Stormwater systems are designed primarily to remove stormwater from the specified drainage areas but to do so in a way that also mitigates local and downstream flooding risk.

Our analysis notes whether the proposed route falls within the scope of the existing flood protection system or whether it would involve bypassing these protective devices. Any route that would bypass existing flood protection devices would require a detailed technical assessment of any potential downstream risks. Such assessment is beyond the scope of this analysis.

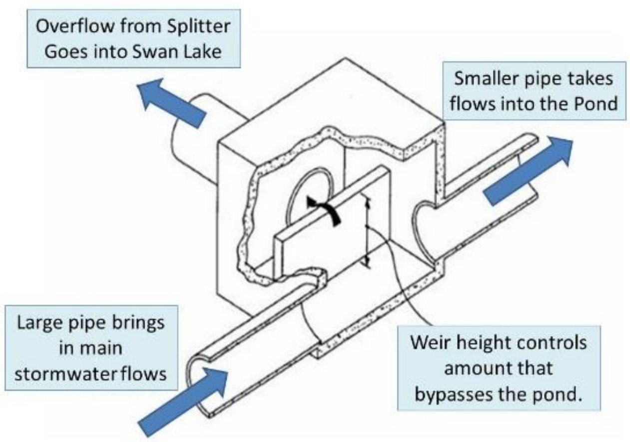
For the purposes of this analysis, we have ignored jurisdictional issues and focused solely on the physical designs of the systems. Different elements in the stormwater system are under the control and responsibility of different organizations. Most solutions would require co-operation between two or more organizations to proceed. In our summary table in Appendix C, we indicate the parties we believe would need to be involved if the option were to proceed.

Appendix B: Flood Protection Measures

Stormwater systems are designed primarily to remove stormwater from a specific drainage area but to do so in a way that also mitigates both local and downstream flooding risk. The primary stormwater system around Swan Lake was designed to direct rainfalls of up to 25 ml to the ponds. In the event of more intense rainfalls, the design of the system employs two techniques to help manage the risk of local and downstream flooding:

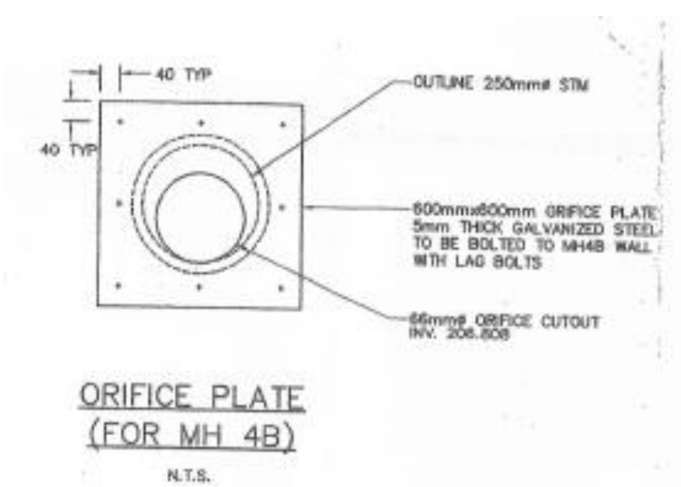
1) the use of "splitters" at the stormwater ponds enables heavy volumes and spring run-offs to bypass the pond system and go into Swan Lake, and
2) the use of "orifice plates" to reduce flows from one part of the system to another. For example, the outflow pipe from the lake is 375 mm in diameter but a 165 mm orifice plate installed over the lakehead outlet reduces the volume of water that can enter this outlet pipe from the lake. A similar arrangement is in place to regulate the outflows from both ponds.

Flood Protection Role of Splitters



The splitters installed at each pond contribute to flood risk management in two ways: 1) Under normal rainfall conditions, the splitters direct stormwater runoff directly to the pond but during large rain events some of the runoff is directed into Swan Lake. 2) As the ponds approach the limit of their storage capacity, the splitters serve to direct overflow from the ponds into the lake.

Flood Protection Role of Orifice Plates



Orifice plates are used to reduce average flows leaving an area and to reduce surges in the outflow.

An orifice plate consists of a large medal plate that is placed over a large pipe. The orifice plate contains a hole cut-out smaller than the pipe. This illustration shows the orifice plate at the East Pond outlet.

The plate covers a 250 mm pipe. The cut-out is 66 mm restricting the amount of water that can leave the East Pond to the capacity that can flow through the 66 mm opening.

The folowing table sumarizes the location and relative size of the orifice plates installed within the Swan Lake stormwater system.

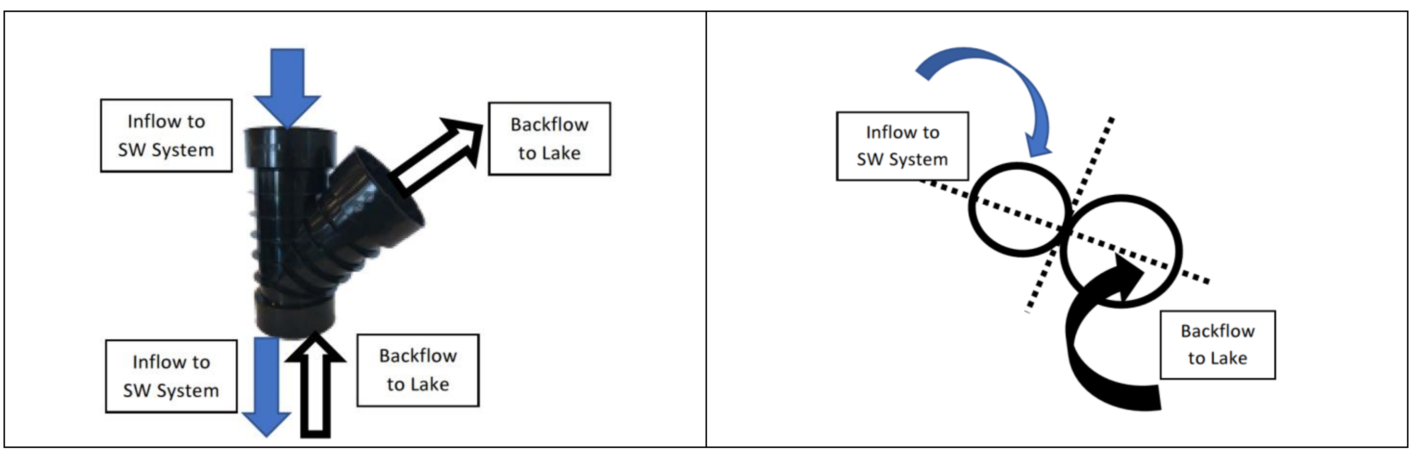
	Size of Pipe			Relative Size of Orifice Plate		
Location	Diameter (mm)		Area (m2)	Diameter (mm)	Area (m2)	% of Pipe
Lakehead wall	Lakehead	375	0.1104	165	0.0214	19%
East Pond Outlet (#105)	MH4B	250	0.0491	66	0.0034	7%
North Pond Outlet (#104)	MHB	200	0.0314	100	0.0079	25%
SLV Connection to 16th	West	450	0.1590	190	0.0284	18%
Avenue	East	375	0.1104	160	0.0201	18%

OGS Units and Backflow Risk

As noted earlier, the OGS units and related infrastructure are just marginally above or below the lake surface. Anytime a connection is below the lake or pond level, the risk of "backflow" was considered i.e.: the risk that at high levels, water could flow from the lake or pond back into the collector system – a reversal of the intended design.

Connected Infrastructure: Distance Above Lake/Ponds					
Pond Splitters		Above	OGS Units		Above
South Splitter (East Pond)	208.391	0.091	Amica	208.21	-0.090
Mid-Splitter (East Pond)	208.340	0.040	Traffic Circle	208.25	-0.050
North Splitter (North Pond)	208.310	0.010	Swan Club	208.94	0.640
Swan Lake and both ponds are regulated at 208.3 m					

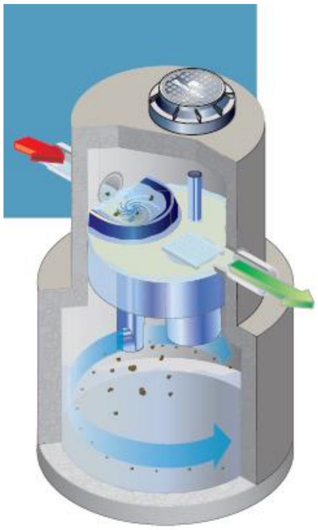
If appropriate, the design of any changes should consider installing an element to control and reduce backflow risk near each OGS unit. One option may be to install "Y" shaped pipes to redirect any backflow to the lake.



In this example, the pipe would be slightly rotated so that the portion carrying backflows to the lake would be lower than the outflows. The outflows would head downstream through the smaller portion on the higher side of the pipe. In the event of any backflow, it would be directed back through the lower portion and into the lake.

Appendix C: Rerouting Oil/Grit Separator Flows from Swan Lake

The following analysis provides a high-level assessment of the feasibility of rerouting the stormwater flows from the three oil/grit separator units away from Swan Lake and into the stormwater system.



Oil/grit separators ("OGS") are designed to remove oils and heavy particles to minimize the pollutants. The polluted water enters the container and falls to the bottom. The heavy material remains in the container and the somewhat cleaner water then rises and flows out and into Swan Lake.

These units have no ability to remove road salt and other pollutants that are soluble and absorbed by stormwater runoff. The units installed at Swan Lake are all manufactured by Imbrium and are units in their Stormceptor product line.

These units are not designed to retain the runoff. As noted in the table below most of the storage capacity is devoted to retaining sediment. The manufacturer notes the importance of monitoring the buildup of sediment each year and removing the sediment once it exceeds 15% of capacity.

Oil/grit separators are installed in the parking lot at Amica, adjacent to the dock area in the traffic circle on Swan Lake Boulevard and in the parking lot of the Swan Club in Swan Lake Village.

					Sediment Capacity	
Location	**Elevation of Outlet to Lake**	**Size of Area Supported**	**Product**	**Total Storage Volume (m^3)**	**Maximum (m^3)**	**% of Storage**
Traffic Circle on Swan Lake Blvd	208.25	0.54 ha	STC 2000	6.2	5.9	82%
Amica property	208.21	0.75 ha	STC 1500	7.3	6.2	85%
Swan Club Parking Lot	208.94	0.46 ha	STC 300	1.8	1.5	95%

In reviewing the feasibility of rerouting the OGS flows, the initial focus was whether there was sufficient slope for potential pipes within the existing infrastructure to support the proposed route. Two slope rates were used – a minimum rate of slope of 0.20% or 0.30% (a decline of 0.20 m or 0.30 m per 100 metres of distance). Steeper slopes (greater than 0.30%) are helpful in moving sediment through the system. Slope rates within the existing pipe infrastructure are generally between 0.14% and 0.51%.

I) Route A - Redirecting Amica Flows to the Traffic Circle

It is approximately 110 metres along the Amica driveway from the current OGS unit at Amica to the centre of the traffic circle.

Amica 6360 - Retirement Block Servicing Plan (Cosburn Patterson, Project 87464D, Drawing R-1)			
OGS (STC1500)		**Lake Headwall**	
Pipe (mm)	**Elevation (M)**		
W 375	Inv = 208.26		
S 450	Inv = 208.24		
N 450	Inv = 208.21 ➡	S 450	Inv = 208.20

Amica to Traffic Circle		
Distance (m)	110	110
Minimum slope	0.30%	0.20%
Slope (m)	0.33	0.22
Elevation Amica OGS	208.21	208.21
Entry Traffic Circle	207.88	207.99
Minimum allowance	0.02	0.02
Exit Elevation	**207.86**	**207.97**

The current 450 mm outflow pipe to the lake in the Amica OGS is at an elevation of 208.21 m above sea level. Allowing for a potential pipe slope of between 0.20% and 0.30% over the 110-metre distance indicates that the entry into the traffic circle would be at an elevation of between 207.88 and 207.99 m.

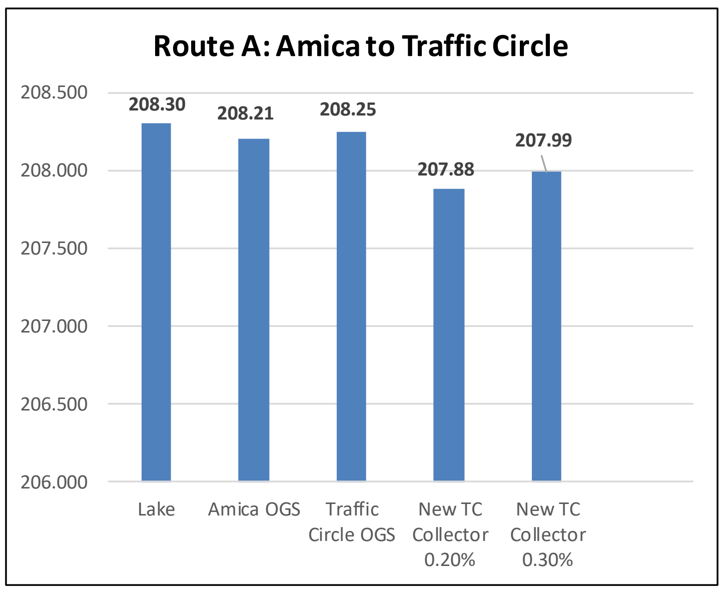
After allowing for a minimum drop of 0.02 m for the outflow pipe, the outflow pipe from the traffic circle would be between an elevation of 207.86 to 207.97 m.

There are no known obstacles along the proposed route along Amica's driveway, but an analysis of other utility features would be required.

Three Traffic Circle Collector Options

Three locations were considered for consolidating the Amica and the traffic circle flows within the traffic circle - using one of two existing manholes at the traffic circle or creation of a new manhole. We conclude that the best solution would be to install a new manhole as the collection point.

As highlighted in the adjacent chart, the new pipes would enter the traffic circle below the existing OGS unit in the traffic circle.



Traffic Circle (Source: Cosborn Patterson Town File 3057 Project 87464 Drawing 10 - Jan 1996)							
STM MH3		**STM MH2**		**STM MH1 (OGS-STC2000)**		**Lake Headwall**	
Pipe (mm)	**Elevation (M)**	**Pipe (mm)**	**Elevation (M)**	**Pipe (mm)**	**Elevation (M)**		
W 375	Inv = 208.44						
E 375	Inv = 208.47	E 375	Inv = 208.33				
		N 450	Inv = 208.28	S 450	Inv = 208.26		
				N 450	Inv = 208.25	S 450	Inv = 208.20
		Connections		**Connections**		**Connections**	
		From MH3 to MH2		**From MH2 to MH1**		**From MH1 to Lake**	
		Size	375 Conc	Size	450 Conc	Size	450 Conc
		Distance	21.5 m	Distance	14.0 m	Distance	10.0 m
		Slope	0.51%	Slope	0.14%	Slope	0.40%

First option: STM MH1 (Drawing 10) contains the current OGS unit. It has a 450 mm inflow pipe from STM MH2 entering at an elevation of 208.26 and a 450 mm outflow pipe to the lake at an elevation of 208.25. The proposed new inflow pipe from Amica (207.88 – 207.99) would be below the existing inflow from STM MH2 inflow so the OGS unit would need to be removed and replaced with a new manhole.

Second option: Alternatively, the new connection from Amica could be directed to STM MH2 in the traffic circle. A 375 mm inflow pipe from STM MH3 enters at an elevation of 208.33. The proposed line from Amica would enter below this connection. Pipe between MH1 and MH2 would need to be removed and replaced. Accordingly, this option is not as good as the first.

Third Option: Rather than rework an existing manhole it appears preferable to use a new manhole unit that would provide for inflow pipes from STM MH2 (at 208.26 m) and from Amica (between 207.88 and 207.99).

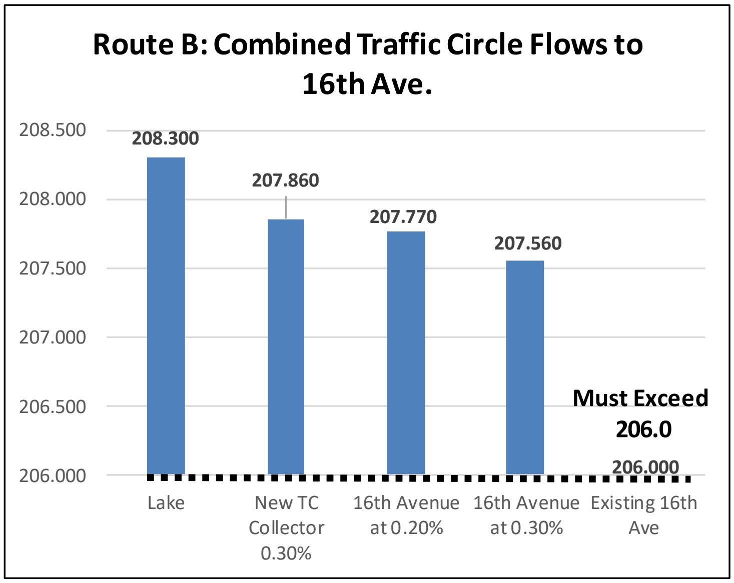
In either case, if we provide for an outflow allowance of 0.02 m below the lowest inflow pipe from Amica, the outflow pipe from the traffic circle collector unit would be at an elevation of between 207.86 and 207.97.

It is beyond the scope of this analysis, but the system design may require different pipe sizes and slopes for carrying the consolidate Amica and traffic circle flows depending on whether it is connecting to either 16th Avenue, the East Pond or to the lake outlet system.

II) Route B - Direct Connection to 16th Avenue and the SLV Collector System

Combined Flows Traffic Circle to 16th Ave.		
Distance (m)	100	100
Minimum slope	0.30%	0.20%
Slope (m)	0.30	0.20
Departure Elevation from Traffic Circle (New Collector))	207.86	207.97
Inflows to 16th Ave	**207.56**	**207.77**

The distance from the traffic circle to 16th Avenue and Swan Lake Boulevard is approximately 100 m. With a minimum pipe slope of between 0.20% - 0.30% it would indicate that the inflow pipe from the traffic circle would enter the 16th Avenue system at an elevation of between 207.56 and 207.77 m.



The outflow from MH6 at 16th Avenue is at 206.0 m which is well below the proposed entry pipe from the traffic circle. Therefore, there is sufficient slope to support the proposed connection.

There are several utility services (electrical, water, sanitary sewers) connections along Swan Lake Boulevard so a clear route for a stormwater pipe would need to be defined along Swan Lake Boulevard.

This route bypasses any existing flood protection infrastructure so surge suppression devices such as an orifice plate may be warranted.

It should be noted that the Route B connection on 16th Avenue flows back into the southern end of Swan Lake Village before connecting to MH14 and then the external system on 16th Avenue. Consideration would have to be given to the ability of the Swan Lake Village Collector system to handle the additional average volumes

Conclusion

The preliminary analysis suggests that Route B is a viable option depending on the ability of the southern portion of the Swan Lake Village Collector system to handle the volumes. A detailed technical analysis of the downstream impact would be required to validate the viability of this route. The addition of surge suppression devices needs to be considered.

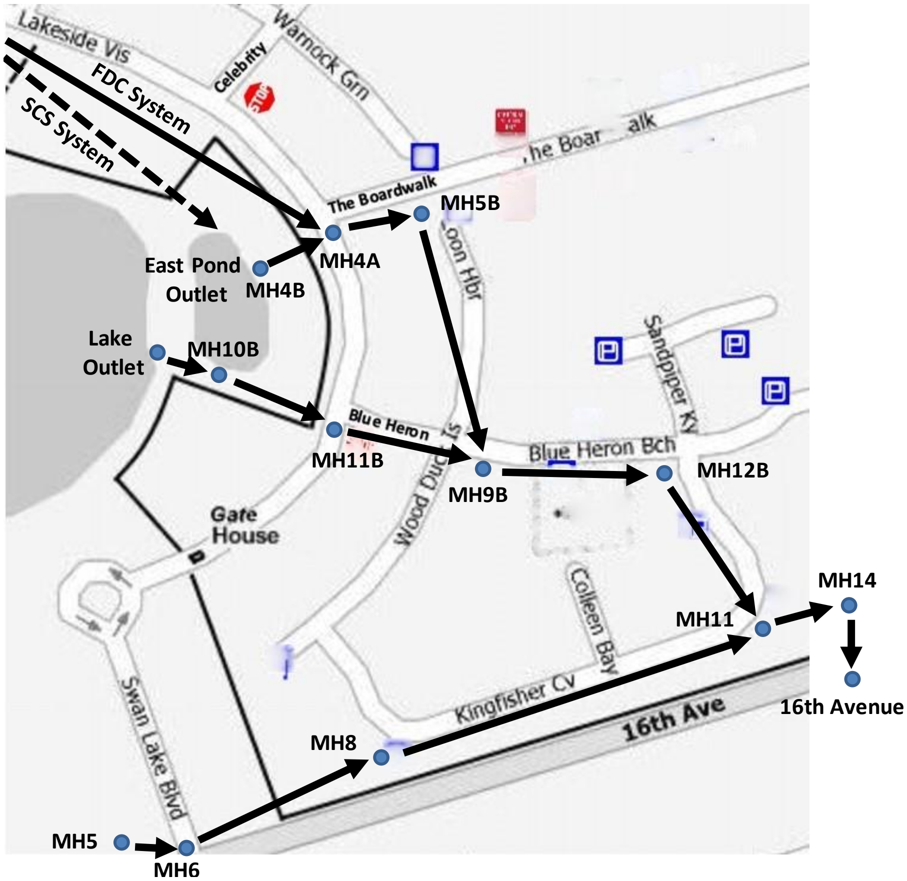
III) Utilizing Existing Pond and Lake Infrastructure

The ideal option would be to direct the OGS flows into the existing infrastructure with the built-in flood protections. At present the OGS flows go into the lake and contribute to the volume of water that leaves the lake, passing through a collector system within Swan Lake Village then into the 16th Avenue system about 150 m east of Swan Lake Boulevard. In essence, the bulk of the OGS flows are already leaving through this collector system so finding a direct route for the OGS flows should minimize any downstream impact. Directing OGS flows directly to either the pond or lake outlets could be offset by reduced lake outflows.

Two routes were considered within the managed system: Route C) directing OGS flows to the pond outlet system, either via the existing service manholes or directly into the pond; Route D) directing OGS flows to the lake outlet system via the existing manholes or into the lake level outlet.

Other options considered were to connect directly with the Swan Lake Village Collector System near the East Pond, bypassing the pond management infrastructure.

Swan Lake Village Collector System



Once the flows leave either the pond or the lake, they flow into a system that is a combination of stormwater and a Foundation Collection System which means there is the risk of basement flooding in this area if the flows are not controlled properly.

So, the first area of local flooding risk is within the southern end of Swan Lake Village. The downstream risk, if any, begins after flows leave Swan Lake Village at MH14 near 16th Avenue.

Flows from the street, Amica and the retail plaza flow eastward from Swan Lake Blvd and 16th Avenue into the southern end of Swan Lake Village before connecting to MH14 and then the external system on 16th Avenue.

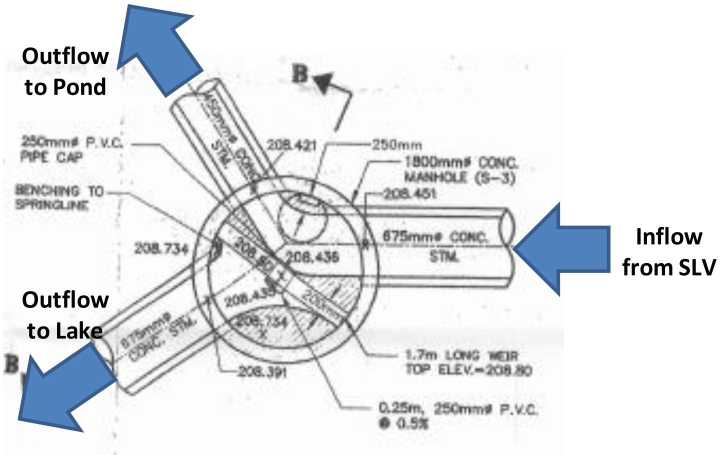
Route C: Directing Traffic Circle Flows to the East Pond

Three possibilities were considered: C1) Connecting to the existing splitter structures or to the pond surface directly, C2) connecting into the regulated portion of the pond outflow system and C3) bypassing the regulated pond outflow by connecting directly to the Swan Lake Village collector system and then on to 16th Avenue.

Combined Flows Traffic Circle to East Pond		
Distance (m)	90	90
Minimum slope	0.30%	0.20%
Slope (m)	0.27	0.18
Traffic Circle (New Collector)	207.86	207.97
Inflow to pond	**207.59**	**207.79**

The distance from the traffic circle to the pond is approximately 90 m. A minimum slope of between 0.20% and 0.30% would indicate that the inflow pipe carrying combined flows from the traffic circle would enter at an elevation of between 207.59 and 207.79 m.

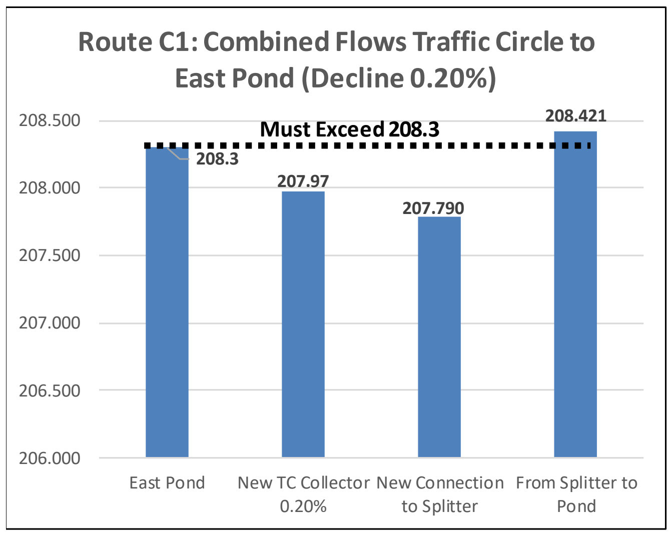
Route C1 - Connecting to the Splitter System or Directly to Pond



MH27 (Drawing 501)[13d] contains the South Splitter unit. The main inflow pipe (675 mm) from Swan Lake Village enters at an elevation of 208.451 and a 450 mm outflow pipe to the pond leaves at an elevation of 208.421.

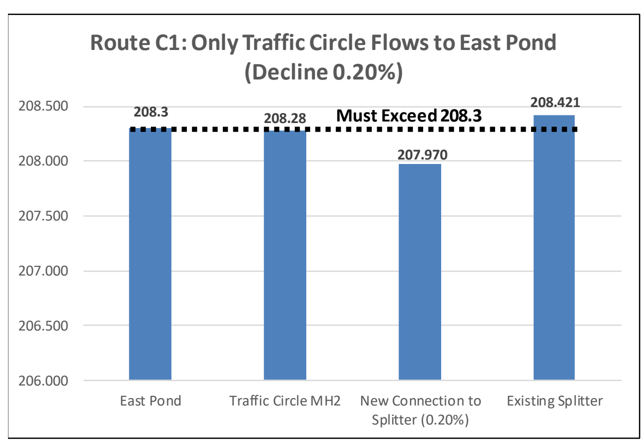
The 675 mm pipe that takes overflow water from the splitter to the lake is at an elevation of 208.391 m.

At the lower slope of 0.20%, the combined flows from the traffic circle would enter at 207.79 m so the proposed new inflow pipe from the traffic circle would be below the existing pond outflow pipe within the splitter manhole (208.421). Using the splitter would not be an option since the new pipe would be lower than the existing. Similarly, bypassing the splitter and going directly to the pond is not an option since the pond level is designed to be maintained at 208.3 m which is above the traffic circle elevation so there is the risk of backflow if connected directly to the pond.



The analysis considered whether the backflow risk would still be a factor even if only the flows from the traffic circle were considered.

The adjacent chart illustrates that the infrastructure in the traffic circle (MH2) is at an elevation of 208.28 m, slightly below the regulated level in the East Pond (208.3 m) and below the main inflow pipe from the splitter to the East Pond (208.421).



So even if only the flows from the traffic circle were included, the connection at 207.97 would still be below the splitter connection and a connection to the splitter or pond would not be feasible due to the risk of backflow.

Conclusion

Any connection to the South Splitter or the pond would not work.

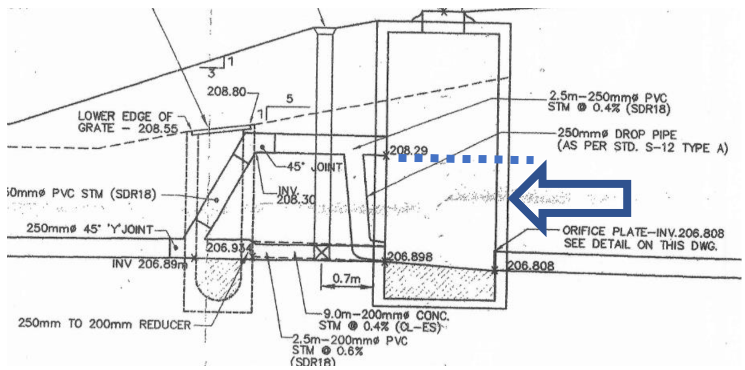
Route C2 - Via Regulated East Pond Outlet

Traffic Circle to East Pond Outlet (MH4B)		
Distance (m)	170	170
Minimum slope	0.30%	0.20%
Slope (m)	0.51	0.34
Traffic Circle (New	207.86	207.97
Inflow to Pond Outlet/SVL	**207.35**	**207.63**

East Pond Outlet - Drawing 501					
	Pond Drain	MH4B		MH4A (SLV Collector)	
Pipe (mm)	Elevation (M)	Pipe (mm)	Elevation (M)	Pipe (mm)	Elevation (M)
250	206.83	250	206.898		
		Outflow 250	206.808		
		Orifice 66	206.808	250	206.688
				Lake Outflow	206.125
				Outflow to SLV	206.038
		Connections		**Connections**	
		Pond Drain to MH4B		**From MH4B to MH4A**	
		Size	250 Conc	Size	250 Conc
		Distance	14 m	Distance	12 m
		Slope	0.40%	Slope	1.00%
				Note: MH4A is SLV Collector	

The pond depth is regulated at a normal depth of 208.3 m through a structure contained within MH4B (Drawing 501) located near Lakeside Vista and The Boardwalk.

While the primary pipes are 250 mm in diameter, the outflow to the Swan Lake Village Collector System (MH4A) is regulated by a 66 mm orifice plate within MH4B.



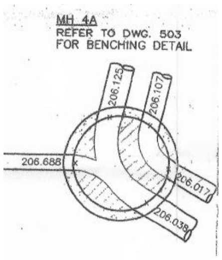
The outflows pass through the orifice plate at an elevation of 206.808 which would be below the intake level from the traffic circle (207.35 - 207.63). However, once the pond exceeds the regulated depth of 208.3 m, due to the outflow restrictions of the orifice plate, the chamber within MH4B could fill above the level of the inlet pipe from the traffic circle and there would be significant risk of backflow making this option not feasible.

Conclusion

Routing the combined flows to the Pond Outlet at MH4B could work if the design included a means to eliminate or reduce the "back flow risk" from MH4B to the traffic circle.

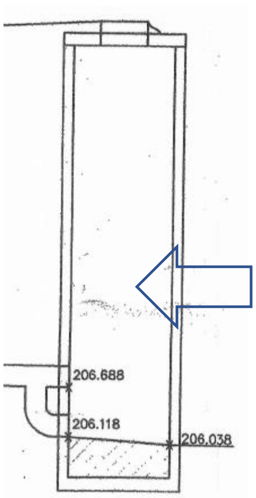
Route C3 – Connecting to Swan Lake Village System - Bypassing East Pond Regulated Flows

The third option considered would be to bypass the regulated pond system and connect directly to the collector system within Swan Lake Village which outflows to 16th Avenue. After passing through the restrictions of the 66 mm orifice plate, pond outflows go from MH4B go into MH4A (Drawing 501) and are combined with other flows from the Foundation Collector System within Swan Lake Village (SLV). (Note: the parallel pipe shown in the diagram below is believed to be the sanitary system pipe.)



It may be feasible to direct OGS flows directly into the SLV collector system (MH4A) which is approximately an additional distance of 12 m (total of 182 m from the traffic circle). Investigation would be required to ensure there are not buried obstacles.

The OGS inflows could be regulated, like the pond outflows, by use of an orifice plate before entering MH4A or before leaving the traffic circle.



There would be little risk of backflows from the 16th Swan Lake Village collector system. Consideration should be given to reducing lake outflows to offset the OGS flows.

If installation of a back flow mechanism at the traffic circle is not feasible but extra storage is required, perhaps oversized pipes could be used from the traffic circle to MH4A to provide additional storage.

Conclusion

This option is comparable to Route D3, the lake outlet connection to the Swan Lake Collector System, but involves an additional distance of approximately 50 m. Both options are comparable to Route B in that they bypass the existing pond infrastructure and provide a connection to the 16th Avenue system via the Swan Lake Village Collector System.

This option would require an in-depth technical review of the impact on the collector system within Swan Lake Village and a review to determine if there are any infrastructure obstacles blocking the route.

Route D: Directing Traffic Circle Flows to the Lake Outlet System

Route D involves using the exiting lake outlet infrastructure. At present all lake flows pass though a system with some basic surge protection. Indirectly the OGS flows use this system since the OGS flows go into the lake. When the lake is at its regulated height, by displacement other water is pushed out of the lake while when the lake is below its regulated height the flows adds to the build up within the lake.

Three options were considered: D1: connecting at the lake level outlet at the headwall, D2: connecting at manhole MH10B or D3: at the connecting point with the Swan Lake Village Collector system (MH11B)

Lake Outlet (Drawings 101 and 502)					
Lake Head		MH10B (near splitter)		MH11B (SLV Collector)	
Pipe (mm)	Elevation (M)	Pipe (mm)	Elevation (M)	Pipe (mm)	Elevation (M)
Lake Level	208.30				
375	207.00				
Orifice 165	207.00	375	206.88 *		
		375	206.808	375	206.125
		Connections		Connections	
		Lakehead to MH10B		From MH10B to MH11B	
		Size	375 Conc	Size	375 Conc
		Distance	21 m	Distance	40 m
		Slope	0.57%	Slope	0.40%

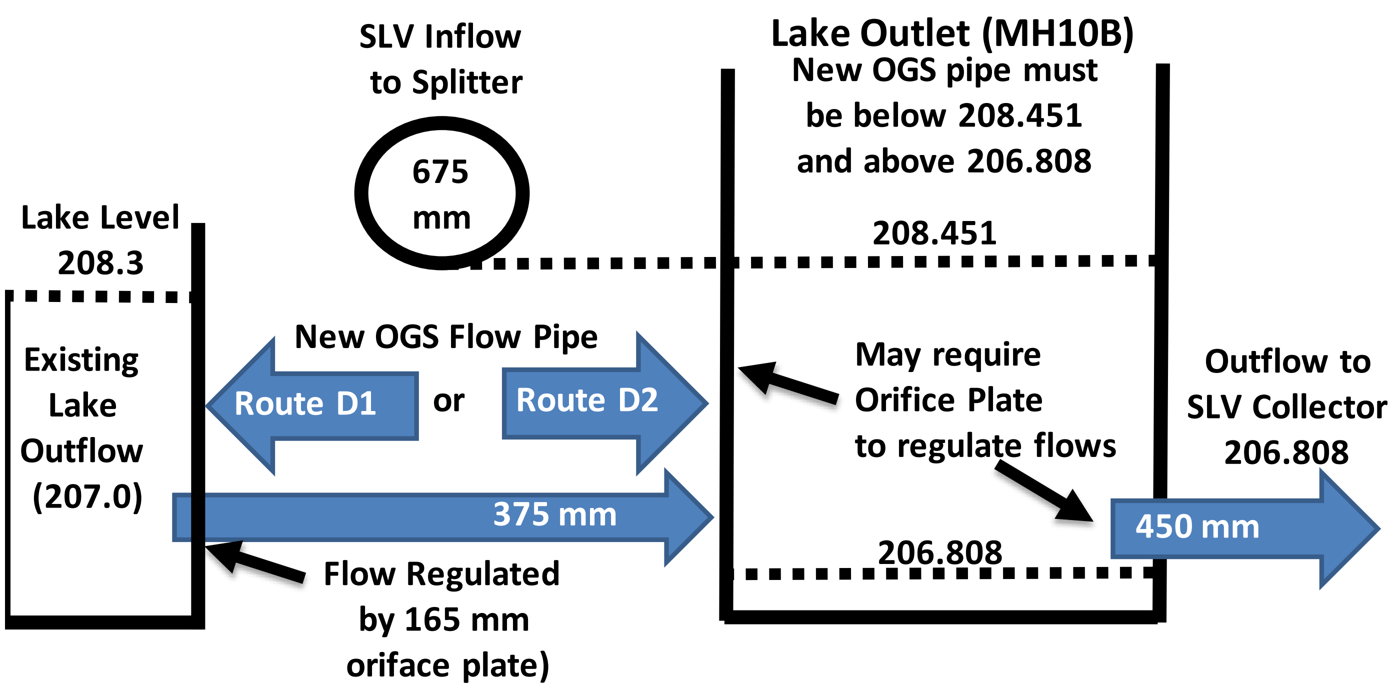
* Estimate. Not all elevation details for MH10B were available

Route D1 – Connecting the Lake Level Headwall

The lake level is currently regulated by the lower end of a service grate at 208.3 m. on the southeast shoreline of the lake. Route D1 considered directing OGS outflows to the lake level outlet.

As the diagram below illustrates, the Lake Outlet System is significantly below the pond infrastructure so pipes can pass beneath the pond infrastructure.

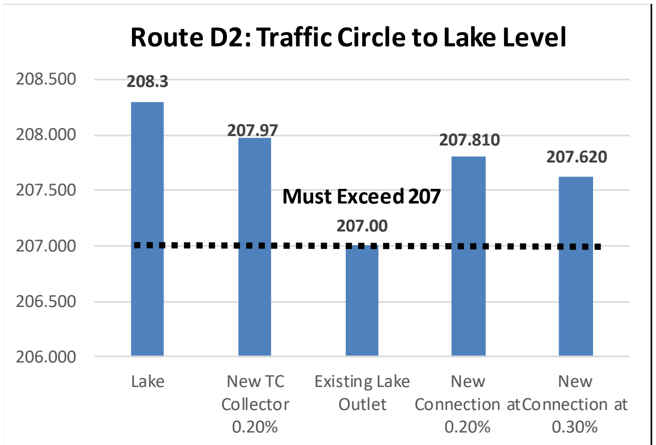
Connecting to the Swan Lake Outlet System



Combined Flows Traffic Circle to Lake Level Outlet (Headwall/Drawing 504)		
Distance (m)	80	80
Minimum slope	0.30%	0.20%
Slope (m)	0.24	0.16
Departure Elevation from	207.86	207.97
Inflow to lake	**207.62**	**207.81**

The distance from the traffic circle directly to the lake level outlet is approximately 80 m. indicating that an inflow pipe from the traffic circle would enter at 207.62 and 207.81 m.

The outflow pipe is near the base of the chamber at an elevation of 207.0 m[13g] indicating that direct inflows from the traffic circle would be feasible.



The outlet pipe is 375 mm however the flows through the outlet are regulated by a 165 mm orifice plate. There could be a risk of back flow when the lake level exceeds 208.3 m. Once the chamber collecting the lake outflow exceeds the entry pipe from the traffic circle there is the risk of back flow.

Conclusion

Directly connecting to the lake outlet headwall may work but there would need to be a design element to control back flow. Any solution would need to pass below the existing inflow and outflow pipes connected to the South Splitter.

Route D2 – Connecting to MH10B

Combined Flows Traffic Circle to Lake Outlet (MH10B/Drawing 301)		
Distance (m)	90	90
Minimum slope	0.30%	0.20%
Slope (m)	0.27	0.18
Traffic Circle (New Collector)	207.86	207.97
Inflow to lake MH10B	**207.59**	**207.79**

The outflows from the lake pass through MH10B (Drawing 301). The distance from the traffic circle to the service manhole MH10B is approximately 90 m. The inflow pipe from the traffic circle would enter at an elevation between 207.59 - 207.79 m.

This is above the inflow pipe from the lake which is estimated to be 206.88 m and above the outflow pipe (206.808) that carries the flow to 16th Avenue.

The outflow from MH10B is through a 375 mm pipe. There does not appear to be an orifice plate within MH10B to regulate the outflow from this unit. If additional flows are directed into this unit, it may be desirable to add an orifice plate to restrict outflows into the 16th Avenue collector system.

Consideration should be given to reducing the outflows from the lake by reducing the size of the orifice plate at the lakehead outlet. If flows from the OGS units are redirected to the outlet system, then there should be less outflow from the lake.

Conclusion

Direct flows to MH10B appears feasible and to offer a low level of backflow risk. A build up of flows in MH10B may back up into the traffic circle system so the back flow risk requires further analysis. This may require consideration of reviewing pipe storage capacity in any line coming from the traffic circle, possibly by oversizing the pipe.

Route D3 – Connecting to the Swan Lake Village Collector System

It may be feasible to connect to the Swan Lake Collector system at MH11B if it was determined to be preferable to D1 or D2. This manhole is closer to the traffic circle compared to the pond outlet connection at MH4A (Route C3) but connects to a different portion of the system leading to 16th Avenue. We were not able to determine whether there was another orifice plate at the connection with the Swan Lake Village System. Both D3 and C3 are not within the existing flood control mechanisms and would likely require a technical analysis of the impact, if any, on the Swan Lake Village Collector System.

Conclusion: Lake Outlet System: Most Viable Options

It appears that the Lake Outlet system provides the most viable options for rerouting the OGS flows from Swan Lake. Both the lakehead outlet (D1) and the MH10B collector (D2) are within the existing flood control mechanisms. Assuming the backflow risk can be managed, a connection to either the lakehead (D1) or the MH10B connector (D2) provide viable options.

IV) Route E - Redirect Swan Club OGS Flows to the Pond or the Lake Outlet

Four routes were considered: E1: Directing OGS flows to the existing stormwater collector systems within Swan Lake Village; E2) directing OGS flows to the North Pond; E3) directing OGS flows to the East Pond; or E4) directing OGS flows to the lake outlet via the existing service manholes or into the lake outlet.

The OGS unit at the Swan Club in Swan Lake Village sits in the lower portion of the parking lot well below the adjacent street, Lakeside Vista.

At 208.94 m, which is 0.64 m above the lake level, the Swan Club OGS unit is at the highest elevation relative to the lake of all three OGS units which provides more flexibility compared to the other OGS units.

Swan Club OGS Drawing A1-00727-01				
OGS (STC300)			**Lake Headwall**	
Pipe (mm)	**Elevation (M)**			
W 250	Inv = 208.94	⇒	E 250	Inv = 208.50
			Connections	
			From OGS to Lake	
			Size	250 PVC
			Distance	14.5 m
			Slope	3.00%

Route E1: Connecting to the Existing Swan Lake Village Collector Systems

Within Swan Lake Village there are two collector systems that run parallel along Lakeside Vista: 1) the Stormwater Collector System (SCS) that takes water to the Mid-Splitter and then the East Pond, and (2) The Swan Lake Village Foundation Drain Collector (FDC) system that takes flows directly to 16th Avenue bypassing the East Pond. The FDC system is a 250 mm pipe that is approximately 2.0 m lower than the SCS system.

A 44 m extension from the OGS unit to Lakeside Vista would enter at an elevation of between 208.81 and 208.85.

The elevation of the SCS along Lakeside Vista was shown as 208.77 m at MH1 while the adjacent FDC at MH1B was given as 206.75 m.

Based on an estimated distance of 80 m from the Swan Club to MH1, we estimated the elevation of the SCS system near the Swan Club to be approximately 209.17 while the FDC system is at an elevation of 207.15 m, 2.02 m lower.

This estimate suggests that the better route of taking the flows to the East Pond is not feasible because the connection from the OGS unit would enter below the SCS system.

Swan Club to Lakeside Vista (Drawing A1-000727-01)		
Distance (m)	44	44
Minimum slope	0.30%	0.20%
Slope (m)	0.132	0.088
Elevation Swan Club OGS	208.94	208.94
Entry Lakeside Vista	**208.81**	**208.85**

SWM/FDC Collector System on Lakeside Vista (Drawing A1-000727-01)		
	SCS(MH1)	**FDC (MH1B)**
Size of pipe	525 mm	250 mm
Swan Club to MH1/MH1B	80	80
Elevation MH1/MH1B	208.77	206.75
Slope	0.50%	0.50%
Slope (m)	0.40	0.40
Elevation at Swan Club	209.17	207.15
OGS extension	**Below SWM Not Feasible**	**Above FDC Feasible**
Extension from OGS between 208.81 - 208.85		

However, a connection to the FDC system may be feasible. The FDC System is not designed for taking hard surface runoff like the parking lot. A technical analysis would be required to determine whether there was any material flooding risk introduced into the FDC System if the Swan Club OGS flows were added. Consideration would have to be given to use of surge protection devices such as orifice plates.

An additional consideration is that the FDC System carries cleaner water that can bypass the stormwater pond. It may be necessary to maintain the OGS unit at the Swan Club to remove some of the sediments before the OGS flows enter the FDC system.

Conclusion

A direct connection of the Swan Club OGS unit to the Swan Lake Village Foundation Drain Collector System may be feasible but a technical assessment would be required. A connection to the Swan Lake Village Stormwater Collector that takes flows to the East Pond is not feasible.

Route E2: Directing Swan Club OGS Flows to the North Pond System

The distance from the Swan Club OGS unit to the splitter at the North Pond is approximately 145 m. A pipe would enter the area between 208.51 and 208.65. This is above the splitter outlet to the pond (208.33) and the regulated pond level of 208.3 m therefore a connection would be feasible from a gravity perspective. An appropriate route and size for such a pipe would need to be determined.

Swan Club to North Pond		
Distance (m)	145	145
Minimum slope	0.30%	0.20%
Slope (m)	0.44	0.29
Elevation Swan Club OGS	208.94	208.94
Entry North Pond	**208.51**	**208.65**

North Pond Splitter	
Source (Earth Tech Project 99647 Drawing A1-99647-D2 Apr 2000)	
Pipe	**Elevation**
Inflow 1050	Inv = 208.391
Pond Outflow 450	Inv = 208.33
Lake Outflow 1050	Inv = 208.31

Conclusion

A connection from the Swan Club OGS unit to the North Pond system is feasible.

Route E3: Directing Swan Club OGS Flows to the East Pond System

The distance along the lakeside pathway from the Swan Club OGS unit to the splitter on the north side of the East Pond (Mid-Splitter) is approximately 190 m. A pipe would enter the area at 207.37 and 207.56. It is estimated that a pipe using a lower slope of 0.20% would enter above the elevation of the connections in the splitter connection to the pond which we estimate to be 208.34 and above the regulated pond level of 208.3 m so it may be a feasible option.

Swan Club to East Pond - Mid-Splitter		
Distance (m)	190	190
Minimum slope	0.30%	0.20%
Slope (m)	0.57	0.38
Elevation Swan Club OGS	208.94	208.94
Entry East Pond/Lake	**208.37**	**208.56**

Detailed drawings were not available for the East Pond Mid-Splitter, so elevation numbers are based on estimates calculated based on the known elevation at the lakehead and the distance.

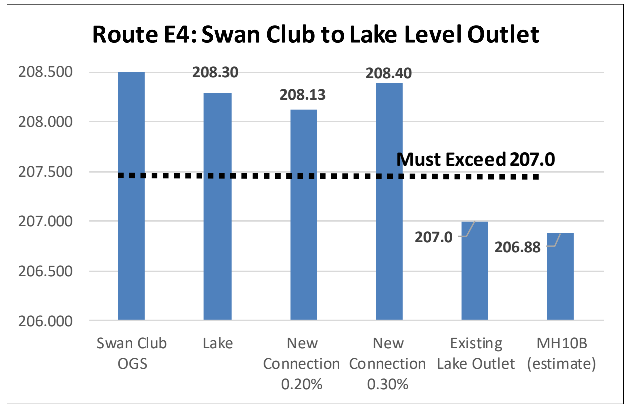
East Pond Mid-Splitter	
(Source: Drawing 87464 - S1)	
Pipe (mm)	**Elevation (M)**
Inflow Box 2.4 x 1.2	Inv = 208.451 (e)
Pond Outflow 450	Inv = 208.34 (e)
Lake Outflow Box 2.4 x 1.2	Inv = 208.391 (e)
Lake Headwall	208.3
Distance splitter to headwall	10.0 m

Conclusion

A connection from the Swan Club OGS unit to the East Pond Mid-Splitter or directly to the pond is feasible using a lower sloped pipe but this is a much longer route than to the North Pond.

Route E4: Directing Swan Club OGS Flows to the Lake Outlet System

Swan Club to Lakeside Outlet		
Distance (m)	270	270
Minimum slope	0.30%	0.20%
Slope (m)	0.81	0.54
Elevation Swan Club OGS	208.94	208.94
Entry East Pond/Lake	**208.13**	**208.40**



A 270 m connection from the Swan Club OGS to the lakeside headwall would be above the current outlets for the lake outflows. may be possible to direct the flows to the lakehead unit or to MH10B as per Route D1 and D2 and blend with combined flows from the traffic circle provided the pipe could pass under the pipe connecting the Mid-Splitter to the lake headwall. It

Conclusion:

Route D4 may be feasible for directing the Swan Club OGS flows to the lake outlet system, but this is a much longer route compared to the alternatives (E2 and E3).

Summary of Options for Rerouting OGS Flows

Rerouting Options	Distance (m)	Feasible	Comments/Conditions	Within Flood Protection	System Technical Assessment	Jurisdiction
A: Amica to Traffic Circle	**110**	**Yes**	**Need to manage backflow risk**	**No**	**Depends on route**	**Amica/Developer/ Markham**
B: Traffic Circle to 16th Avenue	100	Possible	If 16th Ave. system can support volumes	No	Yes	Markham/York Region
C: Traffic Circle to East Pond Outlets						
C1 To South Splitter or East Pond	90	No	Not feasible due to backflow risk	Yes	No	Markham/ Developer
C2 To East Pond Outlet (Regulated)	170	No	Not feasible due to backflow risk	Yes	No	Markham/Developer/SLV
C3 To SLV Collector	170	Possible	If SLV collector system can support volumes	No	Yes	Markham/ SLV
D: Traffic Circle to Lake Outlets						
D1 To Lake Head Outlet	**80**	**Best**	**Need to manage backflow risk**	**Yes**	**No**	**Markham/ Developer**
D2 To MH10B	**90**	**Best**	**Need to manage backflow risk**	**Yes**	**No**	**Markham/ Developer**
D3 To SLV Collector	130	Possible	If SLV collector system can support volumes	No	Yes	Markham/ Developer/SLV
E: Rerouting Swan Club OGS Flows						
E1(a) Swan Club OGS to SLV SCS Collector	44	No	Not feasible due to elevation	No	Yes	Markham/SLV
E1(b) Swan Club OGS to SLV FDC System	44	Possible	Need to manage surge risk	No	Yes	Markham/SLV
E2 Swan Club OGS to North Pond Splitter	**145**	**Best**	**Need to manage backflow risk**	**Yes**	**Pond Only**	**Markham/ Developer**
E3 Swan Club OGS to East Pond Mid-Splitter	190	Possible	Need to manage backflow risk	Yes	No	Markham/Developer/SLV
E4 Swan Club OGS to Lake Outlet	270	Possible	Need to manage backflow risk	Yes	No	Markham

Appendix D: The Case for Reducing Stormwater Flows Bypassing the Ponds

In assessing the ability to reduce the amount of stormwater bypassing the two stormwater ponds three factors were considered: 1) Raising the splitters 2) Increasing the size of pipes flowing from the splitter to the pond and 3) the ability of the ponds to manage additional volumes.

In our analysis of the impact of raising the height of the weirs within each splitter or on changing pipe sizes within the splitters, our analysis was limited to only comparing the actual change in capacity (area) of the pipe. While we can illustrate the ability to increase the weirs or the percentage increase in the size of the pipe, the rate of flow through a pipe is also impacted by the height of the water column, water pressure and the speed of the flow. A hydraulic analysis would incorporate all the relevant factors and would be required to determine the impact of a change in weir height and pipe capacity on the change in volume flowing through the pipe.

A) Storm Management Role of the Splitters

Basic Design requirement

24 hr	20 mm

3-hour Design Storm Measures

5 Year	42 mm
100 Year	80 mm

The ponds have been built to exceed Markham's requirements[9] for the area served by the ponds. The criteria set out in the design of the two stormwater ponds at Swan Lake include that they must be able to clear a 25 mm rain event in 24 hrs, slightly above the minimum requirement of 20 mm over 24 hr. The ponds must also be able to handle extreme weather events. Markham sets out two measures for extreme weather events: i) the ability to handle a 5-year rain event of 42 mm over 3 hours and ii) the ability to handle a 100-year rain event defined as 80 mm over 3 hours.

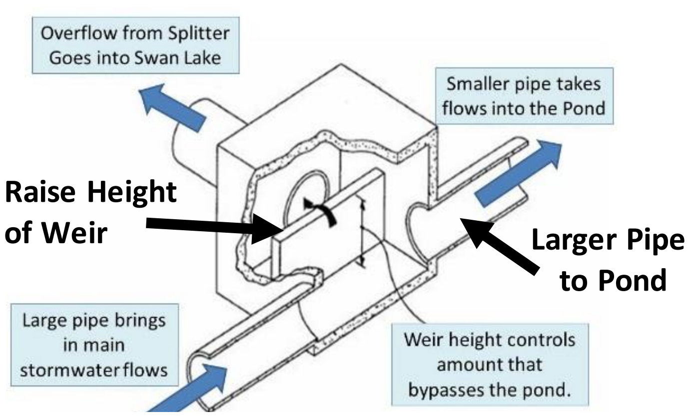
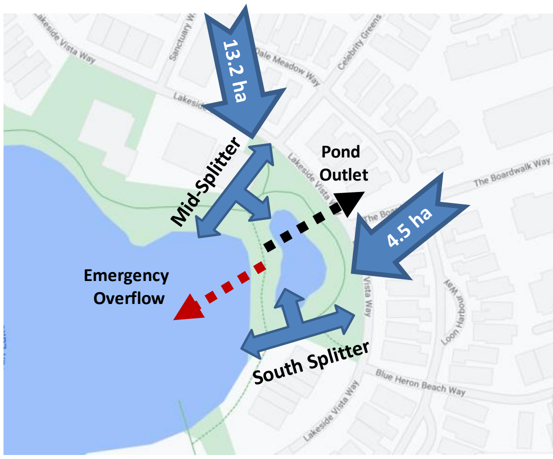


Illustration of a typical Splitter Design

The splitters installed at each pond contribute in two ways: 1) Under normal rainfall conditions, the splitters direct stormwater runoff directly to the pond but during large rain events some of the runoff is directed into Swan Lake. 2) As the ponds approach the limit of their storage capacity, the splitters serve to direct overflow from the ponds into the lake.

Any changes would have to ensure that the local flood protection role is maintained.

B) Reducing Flows from the East Pond (#105) into Swan Lake



The East Stormwater Pond serves 18.4 hectares (ha) of which 13.2 ha is in the central area of Swan Lake Village and flows through the Mid-Splitter and 4.5 ha enters through the South Splitter. The pond and adjacent parkland account for another 0.7 ha.

Once the inlet chamber within the splitter is at capacity, the excess storm water will go over the weir and flow directly into Swan Lake, bypassing the pond.

i) Raising the Splitter

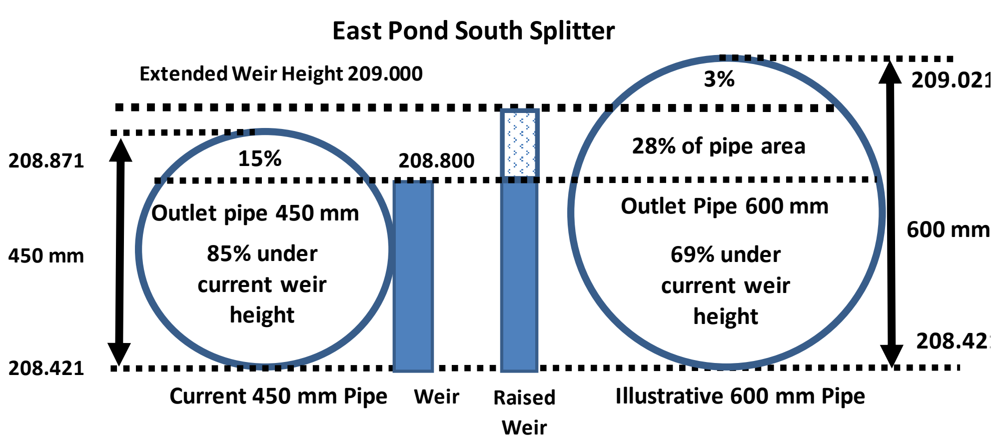
The amount of water bypassing the splitters can be reduced by increasing the height of the weir within each splitter. There is a difference of 0.45 metres between the current height of the weir and the maximum level that the East Pond can support. The weir within the East Pond splitters is at an elevation of 208.8 m. Increasing the weir height by 0.2 metres (7.87 inches) will add 40% to the pond's active storage capability.

ii) Increasing Pipe Capacity

Increasing the size of the pipe taking water from the splitter into the pond may also reduce the flows bypassing the pond. To illustrate the impact of increasing the pipe sizes we compared a 600 mm pipe to the current 450 mm pipe in relationship to the height of the weir. A hydraulic analysis would be required to determine the appropriate size of pipe and the impact, if any, on the flow through the pipe.

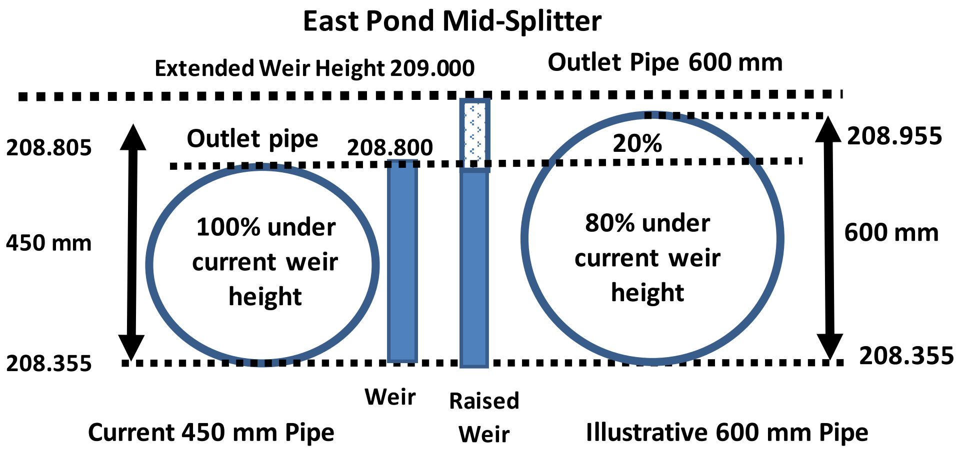
The East Pond is served by two splitters, the South Splitter, and the Mid-Splitter.

In the South Splitter, the main sewers bringing stormwater into the East Pond are 675 mm in diameter while the pipe that carries flows from the splitter into the pond is only 450 mm in diameter and therefore only 85% of the pipe area is below the top of the weir.



If the weir were raised 0.2 m, then the entire pipe would be utilized, and the total flow through the pipe may be increased. If a 600 mm pipe were installed, then 69% of the pipe area would be below the current weir height. If the weir were raised only 3% of the larger pipe would be above the weir.

In the Mid-Splitter, the main sewers bringing stormwater into the East Pond area are box culverts, so the fluid dynamics involved will be different from the those of the South and North Splitters. The main collector structures are 1.8 m x 0.9 m however in the splitter area the culvert is 2.4 m x 0.9 m representing a large chamber area.



The pipe that carries flows from the Mid-Splitter into the pond is only 450 mm. A detailed technical drawing of the Mid-Splitter was not available however we were able to estimate elevations based on the information provided in Drawing S1[15b].

At present, the outlet pipe in the Mid-Splitter is essentially at the same height as the weir. Increasing the weir height may have little impact on the utilization of the existing 450 mm pipe other than some possible increased flow due to increased hydraulic pressure.

Enlarging the outlet to a 600 mm pipe would increase the active pipe capacity without changing the weir height. If the weir height were increased the 600 mm pipe would be fully utilized. A hydraulic analysis would be required to determine the impact on the total flow.

iii) East Pond Capacity

The East Pond was built with an active storage capacity of 1,096 m^3 that is 129% of the required capacity[5]. Increasing the splitter level increases the active capacity by 438 m^3 to 1,534 m^3 or 181% of the required capacity.

	Required	As Built	% Of Required	With Proposed Increase	Percent Of Required
Active Storage	848 m^3	1,096 m^3	129%	1,534 m^3	181%

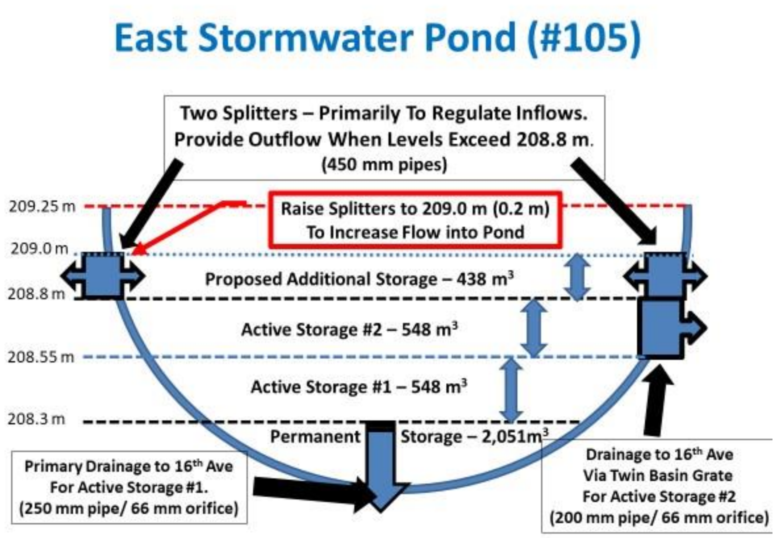
There are two outlets in the East Pond that join up with the Swan Lake Village Collector System that passes through the south end of Swan Lake Village before connecting to the stormwater sewer system on 16th Avenue.

The lower outlet in the middle of the pond controls the normal water level at an elevation of 208.3 metres (m) and regulates the permanent storage volumes in the pond. This lower outlet removes any build up to 208.55 m at which point the second outlet (grates on the east shoreline) direct additional volumes to 16th Avenue through a 200 mm pipe. Pond outflows through either route are restricted by a 66 mm orifice plate at the outlet before entering the Swan Lake Village Collector System.

Under normal rainfall circumstances the two splitters route water into the ponds but they have another role. The splitters also serve as the third tier of outlets when the pond level exceeds 208.8 m, the top of the dividing barrier in the splitters (the "weir"). Under these conditions water can leave the pond and flow into Swan Lake via the splitters. It may be required to also increase the height of the regulating structure for the pond if the height of the weirs is increased.

Under extreme conditions, if the pond were to rise an additional 0.45 metres to 209.25 m, there is an emergency overflow area that will take pond water to the lake over the pathway adjacent to the lake.

It is proposed to use some of this underutilized capacity to increase pond retention volumes by increasing the height of the barriers in the splitters.



The adjacent chart illustrates the active storage elements and the proposed extension of the storage realized by raising the level of the splitters by 0.2 metres.

Calculations for determining the capacity of stormwater ponds are complex. Preliminary estimates suggest that if the weirs were raised by 0.2 metres, the East Pond would support and clear the additional volumes.

The performance of the pond should not be materially impacted by raising the splitters, but less rainfall will bypass the ponds during major rain events and therefore less road salt will be redirected to the lake.

A) Reducing Flows from the North Pond (#104) into Swan Lake

The North Stormwater Pond serves 11.2 hectares (ha) which includes 6.0 ha in the western portion of Swan Lake Village, 4.0 ha consisting of homes north of Swan Park Road, the northern boundary of Swan Lake Park and another 1.2 ha which includes the pond and surrounding parkland.

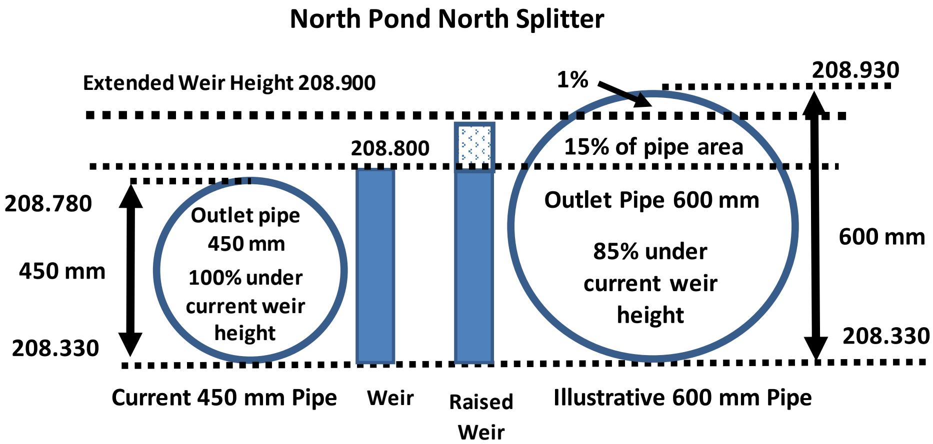
i) Raising the Splitter

The amount of water bypassing the North Splitter can be reduced by increasing the height of the weir within the splitter. There is a difference of 0.2 metres between the current height of the weir and the maximum level that the North Pond can support. The weir within the North Pond splitters is at an elevation of 208.8 m. Increasing the weir height by 0.1 metres will add 20% to the pond's active storage capability.

ii) Increasing Pipe Capacity

The main pipe bringing stormwater into the North Pond is 1050 mm in diameter while the pipe that carries flows from the splitter into the pond is only 450 mm in diameter. The height of the weir within the splitter serving the North Pond is already above the top of the 450 mm outlet pipe.

Other than the possible benefit of increased hydraulic pressure, increasing the weir height is expected to have a nominal impact on the utilization of the existing 450 mm pipe.



If a 600 mm pipe were installed, 85% of the pipe area would be below the current weir height and substantially all the pipe area would be below the increased weir height of 208.9 m.

A hydraulic analysis would be required to determine the impact on the total flow and the appropriate size of pipe.

iii) North Pond Capacity

Unlike the East Pond which has two outlets supporting the active storage capacity, the North Pond has only one outlet in the middle of the pond to clear the active storage volumes. This outlet maintains the pond at an elevation of 208.3 metres (m) and regulates the permanent storage volumes in the pond.

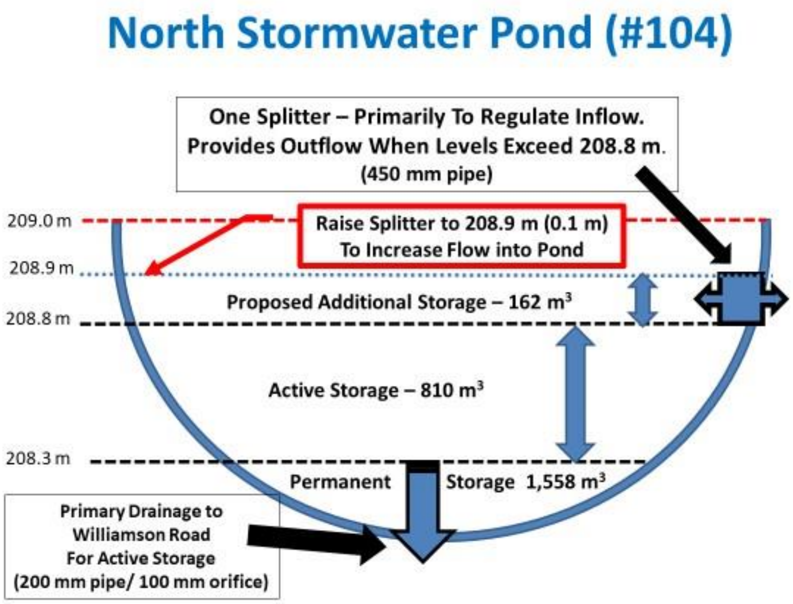
Under normal rainfall circumstances the splitter will route water into the pond but its second role is to serve as the second-tier outlet when the pond level exceeds 208.8 m, the top of the dividing barrier in the splitter (the "weir"). Under these flood level conditions water can leave the pond and flow into Swan Lake via the splitter.

Under extreme conditions, if the pond were to rise an additional 0.2 metres to 209.0 m, there is an emergency overflow area that will take pond water to the lake through the North Channel.

It is proposed to use 50% of this underutilized capacity to increase pond retention volumes by increasing the height of the barrier within the splitter by 0.1 metres.

The North Pond has an active storage capacity of 810 m^3 that is 175% of the required capacity[3]. Increasing the splitter level 0.1 m increases the active capacity by 162 m^3 to 972 m^3 or 209% of the required capacity.

	Required	As Built	% Of Required	With Proposed Increase	Percent of Required
Active Storage	464 m^3	810 m^3	175%	972 m^3	209%



The adjacent chart illustrates the active storage elements and the proposed extension of the storage by raising the level of the splitters by 0.1 metres.

Calculations for determining the capacity of stormwater ponds are complex. Preliminary estimates that suggest that if the weir were raised by 0.1 metres, the North Pond would support and clear the additional volumes.

The performance of the North Pond should not be materially impacted by raising the splitter and increasing the pipe capacity, but less rainfall will bypass the ponds during major rain events and therefore less road salt will be redirected to the lake.

Outbound flows from the North Pond go into a stormwater system on Williamson Road and then ultimately into a westbound system along 16th Avenue.

One unique feature of the North Pond system is that water that bypasses the pond and goes into Swan Lake contributes to the flows that leave Swan Lake and go into the eastbound system on 16th Avenue. Keeping more water in the North Pond system ultimately contributes more water to the westbound 16th Avenue system and less to the eastbound 16th Avenue system.

A detailed technical analysis would be required to determine the balance between the additional volumes that could be redirected into the North Pond and the storage capacity of the pond.

Appendix E: York University Research into Removal of Nutrients and Chlorides

Research Into Removal of Nutrients and Chlorides from Swan Lake

Rama Pulicharla Ph.D.

Post Doctoral Researcher

Dr. Satinder K Brar

Professor

May 2, 2022

Removal of Nutrients (N and P) and Chlorides from Swan Lake Water

1. Introduction:

Nitrogen (N) and phosphorus (P) are essential elements for many important life processes such as protein and DNA synthesis, primary production, cellular growth, and reproduction for both plants and animals that make up the aquatic food web[1,2]. Both elements are critical nutrients for crop productivity and are largely responsible for ensuring adequate food, fiber, and shelter for the growing human population[3]. To meet the demands of the current population excessive use of nutrients are in use to grow food leading to nutrient surpluses and mismanagement of nutrients in developed countries and developing countries, respectively[4,5]. Surface water receives water from municipal sewage treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, and industrial wastewater. Hence, excessive usage of these nutrients has resulted in losses of nutrients from land (urban and agricultural runoff) to water bodies[6]. A modest increase in P and N can cause undesirable events including accelerated plant growth, algae bloom (eutrophication), low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals[7].

Apart from these nutrients, Chlorides are very common water pollutants, especially in Canada[8]. The Canadian industries produced 10 million metric tonnes of salt in 2021 and nearly three-quarters of this total is rock salt used primarily for highway de-icing[9], [10]. Surface runoff of this salt serves as the primary anthropogenic source of chloride to the receiving water bodies apart from industrial chemicals and fertilizer from agriculture such as sodium chloride, and potassium chloride, respectively. Like N and P, Chloride is an essential element for maintaining proper osmotic pressure, water balance, and acid-base balance in aquatic and terrestrial ecosystems[11]. Increased chloride concentrations can induce a variety of environmental effects such as acidification of streams, effect on mortality and reproduction of aquatic plants and animals, inhibit the process of denitrification, the microbial process, that's critical for removing nitrate and maintaining water quality[12].

Over the past decades, significant progress has been made towards our understanding of the dynamics of anthropogenic inputs of N, P, and Cl^- and the development of various removal techniques from the receiving water bodies[13,13–15]. Furthermore, the recognition of enormous amounts of N, P, and Cl^- inputs by humans has driven much research into the scope for better management of these nutrients. In this project, we are proposing the adsorption technology using biochar produced from Char technologies to remove all three nutrients from Swan Lake water. Based on the characteristics of the lake water, biochar adsorption technology will be developed and tested on a lab-scale to understand the critical parameters to achieve optimal efficiency.

2. Objectives:

The global objective of this project is to "Development of biochar adsorption techniques to remove nutrients from Swan Lake and its scale-up. The specific objectives are:

Objective 1. Adsorption removal of nutrients (N, P, and Cl^-) from Swan Lake water

- 1.1 Characterization of Swan Lake water
- 1.2 Biochar utilization for the removal of nitrogen, phosphorus, and chloride nutrients

Objective 2. lab-scale units to test the biochar efficiency on the removal of selected nutrients

3. Methodology:

Objective 1. Removal of nutrients (N, P, and Cl^-) from Swan Lake water

3.1 Characterization of Swan Lake water: Nearly, one-month Swan Lake samples (twice a week) will be collected to monitor the existing concentration of selected nutrients in the surface water. Apart from the N, P, and Cl^-, other physical and chemical characterization of water samples such as total dissolved solids, pH, dissolved oxygen, total suspended solids, chemical oxygen demand, conductivity, and heavy metals will be measured as per standard methods[16].

3.2 Biochar utilization for the removal of nutrients

Biochar is produced by the CHAR Biocarbon Inc. organization from wood residues and will be used in this project. The biochar will be received from CHAR as a complimentary for this project. The received biochar sample will be ground and sieved to obtain uniform biochar microparticles 1-100 µm with an increased surface area. The treated biochar samples will be dried at 60 °C overnight and used for the adsorption removal of nutrients. Further, characterization (size analysis, porosity, pore distribution, ash, and moisture content) of processed biochar will be carried out as per ASTM methods described in the studies of Brar's group[17].

3.2.1 Adsorption capacity of biochar for Nutrients: The processed biochar will be subjected to adsorption studies of selected Nutrients in the collected lake samples. To find the adsorption efficiency, two types of tests will be carried out: (1) The optimization of the biochar weight at a constant concentration of each nutrient (10 mg; this will be determined based on the objective 1) individually and in combination; (2) Optimization of concentrations of nutrients 5-100 mg for a constant weight of biochar obtained from test 1. Once the optimization of biochar weight and its efficiency was determined, collected lake samples will be used to test the removal efficiency of biochar in real samples. All the experiments will be conducted at constant pH (surface water pH) and agitation speed (150 rpm) for 24h in an incubator shaker at 25 ± 1 °C and in triplicates. After incubation, the mixture of biochar and nutrient suspensions will be centrifuged, and the clear supernatant will be used for estimating the concentration of the un-adsorbed nutrient by the methods used in objective 1[18].

Objective 2. Lab-scale unit to test the biochar efficiency

Bench-scale testing will be performed as rapid small-scale column tests (RSSCTs) to validate the performance of biochar. This approach is critically important before going for the pilot- and full-scale surface water treatment, to evaluate how real water conditions (e.g., dissolved organic carbon, pH), and water constituents (e.g., organic matrix, residual chlorine for drinking water) impact the overall nutrients removal[16].
Lab-scale filter: The optimized biochar weight obtained from *objective 2.2* will be further used to develop a lab-scale filter, a rapid small-scale column test (RSSCTs). RSSCT setup: Column experiments will be conducted using a glass column (1 cm inner diameter, 20 cm long) packed with biochar (2 g and 5 g) and sealed with glass pearls/glass wool and glass beads to hold the biochar frameworks in place. This type of packing will give compactness to the adsorbent (i.e. MBEFs). Dr. Brar's group has already conducted biochar-packed column tests to study the removal of trace contaminants[19]. The collected lake samples spiked with selected nutrients, 10 mg (each N, P, and Cl^-) will be pumped through the column using a peristaltic pump. Various nutrient concentrations (1 – 10 mg/g) at a different flow rate (1- 5-mL/min) for all nutrients will be tested for 24 h and the collected samples will be analyzed for residual nutrients as per *Objective 1*.
Performance indicators: For the lab-scale filter, indicators such as the loading behavior of biochar will be expressed in terms of the normalized concentration C_0/C_t (where C_0 and C_t are the inlet and outlet (at time t) of nutrient concentrations, respectively) for a given mass of biochar (bed height). Other performance indicators such as equilibrium uptake of the column, the total amount of nutrient adsorbed, and removal percent of nutrients will be determined as per our previous studies. Column regeneration: Chemical

regeneration methods will be adopted from the literature. Briefly, the used biochar will be equilibrated in a mechanical shaker for 1 h with sodium chloride and HCl for biochar recovery.

4. Project budget:

Timeline: We suggest using a Gantt chart to provide a timeline showing which task will be done when to achieve each objective

Research goals	**July – August 2022**	**September-October 2022**	**November-December 2022**
Project initial meeting at York University	York University		
1. Removal of nutrients (N, P, and Cl-)			
1.1 Characterization of Swan Lake water			
1.2 Biochar utilization for the removal of nutrients			
2. Lab-scale units to test the biochar efficiency			

Expenditure:

Expenditure type	**July-August 2022**	**September-October 2022**	**November - December 2022**	**Total**
Salaries and Wages				
Research Associate	2,500	3,000	4,000	**9,500**
Student	500	1,500	1,500	**3,500**
Project Management and corodination	250	500	500	**1,250**
Professional service expenditure (Lab analysis)	2,500	3,500	3,500	**9,500**
Field service (sampling and travel)	750	1,000	1,000	**2,750**
Subtotal of Salaries and benefits	6,500	9,500	10,500	**26,500**
Material and supplies expenditure				
Lab consumables and supply	3,000	3,000	3,500	**9,500**
Subtotal of Material and supplies expenditure	3,000	3,000	3,500	**9,500**
University overhead (20% of total)				
Overhead (20%)	1,900	2,500	2,800	**7,200**
Total Budjget	11,400	15,000	16,800	**43,200**

Deliverables:

Objective 1: Optimization of biochar weight as per Swan Lake characteristics to remove the selected nutrients
Objective 2: Verifying the efficiency of the lab-scale biochar-based filter for the removal of the nutrients

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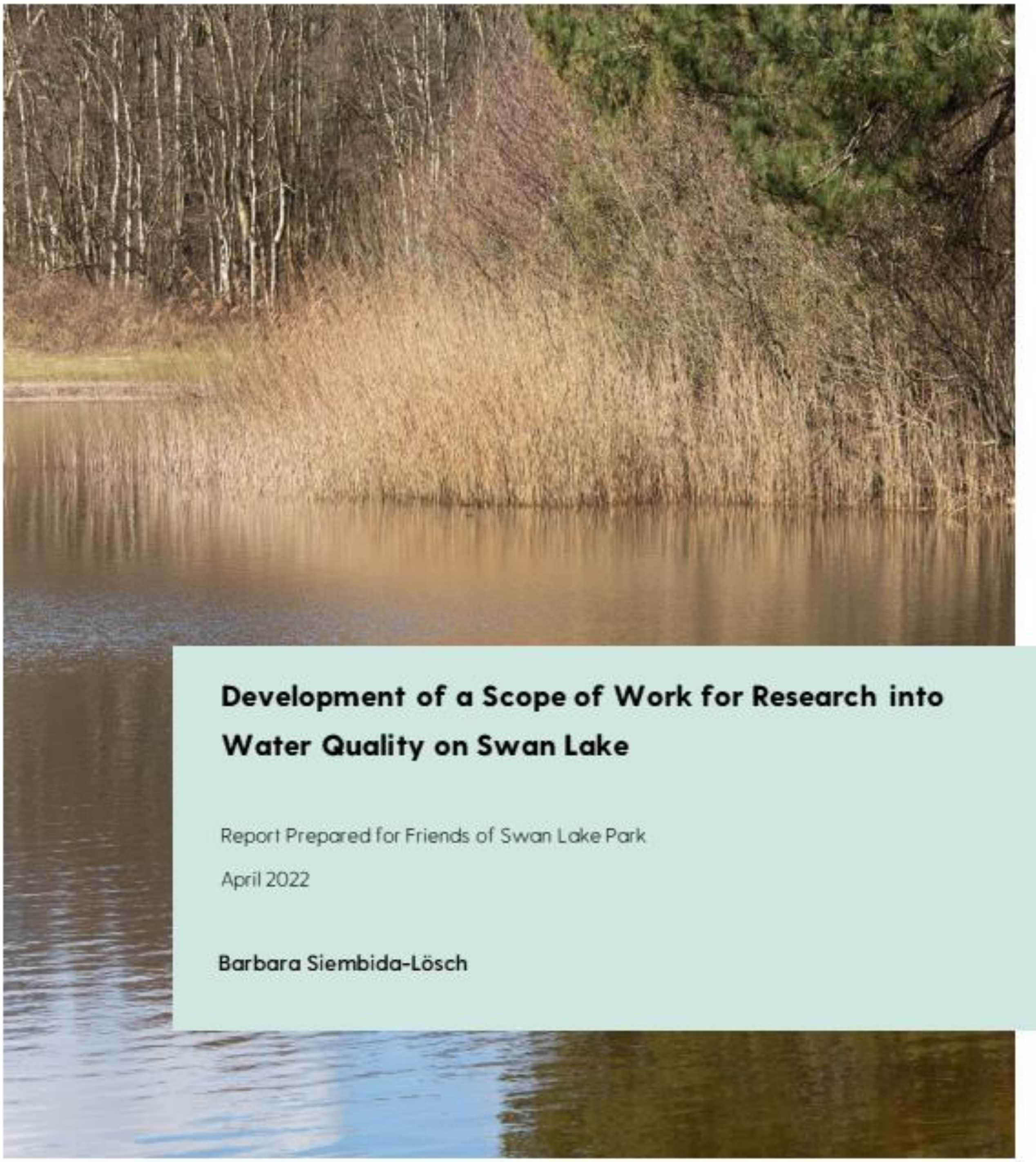
Prof. Satinder K Brar

Dr. Brar has an H-index of 65 and is a nationally and internationally recognized researcher with exceptional expertise in the two converging fields of value-addition of wastes and removal of emerging contaminants. Her research has transcended frontiers and is now adapted all around the world. For example, her research on biopesticides and biofertilizers using wastewaters is now applied in Vietnam, Morocco, Ivory Coast, Thailand, Mexico, and India. In fact, she is frequently invited to give talks in different international forums and conferences, about the wide-ranging subject of applied biotechnology. For example, she was invited by German, Mexican, Indian and Chinese Academy of Sciences to share her experiences on solid waste value-addition and the fate of emerging contaminants. She has been counted amongst the most outstanding and innovative world-class researchers whose accomplishments have made a major impact in her field. She has been invited by different grant agencies worldwide (including France, Switzerland, Spain, Germany, Poland, Austria, Malaysia, Australia, US, Taiwan, Hong Kong, India, among others) as a reviewer and expert in panels that talk volumes about her exceptional research prowess and expertise.

Rama Pulicharla, Dr.

Experienced analytical chemist with a demonstrated history of working in analytical laboratories and developing validated methods for pharmaceuticals and other organic compounds. Water treatment scientist with a strong background in water treatment methods, contaminant fate and transport, site remediation, data collection and management. Skilled in chemistry, Good Laboratory Practice (GLP), chromatographic techniques, mass spectrometry, elemental analysis, development & validation of analytical methods. Strong Pharmacy and Chemistry professional background.

Appendix F: Fleming College Research into use of Calcium Peroxide to Improve Oxygen Levels



Development of a Scope of Work for Research into Water Quality on Swan Lake

Report Prepared for Friends of Swan Lake Park

April 2022

Barbara Siembida-Lösch

centre for advancement of water and wastewater technologies

FLEMING

Development of a Scope of Work for Research into Water Quality on Swan Lake

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Barbara Siembida-Lösch, Ph.D., P.Eng.

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Contents

1.0 Introduction

1.1 Background

Swan Lake, a man-made lake located in Markham, Ontario, has long suffered the effects of eutrophication, an over enrichment of minerals and nutrients. A surplus of external nutrient inputs has resulted in the continued accumulation of nutrients stored within the lake from year to year. The overall nutrient load, accompanied with warm weather conditions, has allowed for continued oxygen depletion (anoxia) and prolonged cyanobacteria blooms throughout Swan Lake, perpetuating the eutrophication issue even further.

Currently, phosphorus levels in Swan Lake are managed in two ways: using Phoslock®, a patented phosphorus locking technology, and/or using Polyaluminium Chloride (PAC), an inorganic coagulant. While these chemicals address the phosphorus concerns, they do not necessarily address the anoxia issues within Swan Lake. Anoxic conditions remain a concern for the health of Swan Lake and in the long-term care and sustainability of the flora and fauna in the area.

1.2 Purpose

The Friends of Swan Lake Park (FSLP) is a not-for-profit organization located in Markham, Ontario. Working with the City of Markham, the FSLP have spent several years providing input and feedback into important environmental concerns related to the quality and treatment of Swan Lake and its surrounding environment. Of particular interest is addressing oxygen levels within Swan Lake through possible treatment options. The focus of this report is to address this challenge, and to detail a scope of work outlining the use of calcium peroxide as a treatment option to improve oxygen levels within Swan Lake.

2.0 Research on Use of Oxygen Release Compounds

2.1 Calcium/Magnesium Peroxide

The biological mineralization of organic matter in lake sediments consumes large quantities of oxygen. This consumption can lead to more serious issues, including anoxic conditions. A lack of oxygen in the lake environment can result in the release of excess nitrogen and phosphorus from sediment into the overlying water. These excess nutrients, in turn, allow for excessive plant and algae growth, inevitably leading to deterioration of water quality (Lu et al., 2017; Li et al., 2020). Therefore, the improvement of dissolved oxygen (DO) levels is significant in the restoration and sustainability of surface water bodies.

The common approaches to controlling eutrophic water include:

1) physical methods (e.g., environmental water diversion/hydraulic control, artificial aeration, sediment dredging);

2) chemical methods (e.g., flocculation/precipitation, chemical alga-killing, adding Fe/Al salt or Phoslock®); and

3) biological methods (e.g., ecological floating islands, constructed wetlands).

Although these approaches can occasionally alleviate eutrophication, they are often characterized by high costs and low efficiency. In addition, some (e.g. biological methods) are susceptible to environmental factors while others (e.g. aluminium salts) can be toxic to aquatic organisms (Wang et al., 2019).

An alternative technique for the oxygenation of the water column and sediments is chemical oxidation. This technique can be performed using oxygen release compounds (ORCs) such as calcium peroxide (CaO_2) and/or magnesium peroxide (MgO_2). This alternative method avoids the limitation of mechanical aeration in the affected area and inefficient oxygen diffusion (Lu et al., 2017; Xu et al., 2018; Wang et al., 2019, Li et al., 2020). CaO_2 is an oxygen release compound, comprising a high-energy peroxide covalent bond, which can easily liberate oxygen when it is in contact with hydrous media (Song et al., 2020).

Various studies have proven that the addition of CaO_2 to surface water and sediments, slowly releases oxygen in water, leading to an increase in the DO levels, suppression of anaerobic conditions, control of water blooming, and aerobic biodegradation of accumulated organic contaminants in the sediments (Lu et al., 2017).

In a study by Huang et al. (2017) the addition of 20 g CaO_2 to 37.5 L water containing municipal river sediments increased the DO (1 mg/L) of surface water for eight weeks (Huang et al., 2017). Nykänen et al. (2012) observed more prominent effects of increasing the DO levels of sediments for 14 weeks in laboratory tests (75 g CaO_2/m^2 sediment surface) and 40 weeks in field tests (50 g CaO_2/m^2

sediment surface) when using granulated CaO_2. In addition to the increased DO levels of sediments, Nykänen's study also showed accelerated aerobic microbial activity following CaO_2 amendment. The organic matter contents in the pond sediment decreased from 18% to 4% while the control test showed no changes.

Other studies have shown that adding CaO_2 into sediment could restrain phosphorus release from sediment for over 10 weeks, controlling water blooming (Huang et al., 2011). In the aerobic conditions, phosphorus concentrated in the sediment creates insoluble metal-phosphate complexes and can't be released to the water column. Cho and Lee (2002) investigated the effect of CaO_2 on the growth and proliferation of a water-blooming cyanobacterium and observed that the phosphate concentration quickly decreased when CaO_2 was added. Most of the soluble phosphate was removed within 1 hour, and an accumulation of precipitated residue was observed as a result of the reaction with CaO_2. Therefore, it could be concluded that the addition of CaO_2 promotes phosphorus transfer into the sediment from the total water system (Lu et al., 2017).

In practical applications, it is crucial to modify CaO_2, permitting the slow, continuous release of oxygen. Application of CaO_2 in compressed forms such as granules, briquettes, or as composites with other materials for surface water and sediments restoration can meet that requirement. These coarser CaO_2 products sink more easily to the sediment, where oxygen is required. Mixing of water is avoided to prevent the movement of nutrients to the surface and the growth of algae and aquatic plants (Lu et al., 2017).

In addition, using other materials to embed CaO_2 powder to achieve more controllable release rates have been studied. The composite of CaO_2 and stearic acid was found to have a longer oxygen-releasing period, a milder effect on pH, and reduced 79.6% total phosphorus (TP) in 35 days compared to CaO_2 powder during experiments with urban river sediments (Li et al., 2014). Zhou et al. (2019) mixed calcium peroxide material with water purification sludge and cement, suggesting that modified calcium material can release oxygen continuously and slowly, effectively reducing the dissolved inorganic phosphorus concentration of the overlying water and pore water.

The aforementioned research demonstrates that use of CaO_2 may have promising treatment effects on the increase of DO and should be considered for use in Swan Lake. The following scope of work outlines how to introduce and assess its treatment capability.

3.0 Proposed Scope of Work

The following scope is all encompassing, meaning it contains the full suite of recommended parameters and analytes to be tested for maximum results. This scope is a draft and open to feedback and input from stakeholders and researchers working on Swan Lake. In an attempt to keep costs low, two treatment totes have been included, however it may be beneficial to include a third treatment tote to evaluate a range of CaO_2 concentrations and their effect (high vs low).

3.1 Laboratory Scale Testing

Sample collection and characterization

Sediment samples from Swan Lake would be collected with a columnar sampler from the top 40 cm layer. Overlying water would be collected in plastic buckets at the same time, at a depth of approximately 3.5 - 4 m (depending on sampling site). Sampling would occur during summer months (July – August) when anoxia conditions are the most severe within the lake. The collected samples would then be transported to the CAWT laboratory immediately after sampling. To maintain sample integrity all samples would be kept cool during transportation, avoiding light exposure and disturbance.

Temperature, pH, conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP) in the overlying water would be analyzed immediately following sample collection and while on site. Prior to commencing experiments, sediment and water samples would first need to be characterized. The following parameters are recommended, and would be analyzed in the CAWT's ISO 17025:2017 accredited laboratory:

- Sediment: ammonia, nitrate, nitrite, total Kjeldahl nitrogen (TKN-N), total phosphorus (TP), total solids (TS), volatile solids (VS), total organic carbon (TOC), moisture, total and dissolved iron (Fe), Aluminum (Al), Magnesium (Mg), and Calcium (Ca), dissolved Chloride (Cl), ORP, pH, alkalinity, adenosine triphosphate (ATP), DO
- Overlying water: ammonia, nitrate, nitrite, TKN-N, TP, soluble reactive phosphorus (SRP, also called orthophosphate), total suspended solids (TSS), TOC, total and dissolved iron (Fe), Aluminum (Al), Magnesium (Mg), and Calcium (Ca), dissolved Chloride (Cl), ORP, pH, alkalinity, DO, colour, turbidity, and conductivity

Experimental set-up

Following the collection and characterization of sediment and overlying water samples, experiments would be carried out under the following operating conditions:

- Equipment: 2 totes (1 treatment tote and 1 control)

- Sampling location and timelines: sediment and overlying water samples would be collected from Swan Lake during summer (July-August)
- Sample volume: 1000 L of lake sediment and 1000 L of the sediment overlying water
- Oxidant: granulated CaO_2
- Doses: suggest either 100 g CaO_2/m^2 or 1000 g CaO_2/m^2 (estimated amount of CaO_2 is 1.5 kg)
- Sample analysis of the overlying water: ammonia, nitrate, nitrite, total Kjeldahl nitrogen (TKN-N), total phosphorus (TP), SRP, total suspended solids (TSS), TOC, total and dissolved Fe, Al, Mg, Ca, dissolved Cl, ORP, pH, alkalinity, DO, turbidity, temperature and conductivity
- Sample analysis of the sediment: TKN-N, TP, total solids (TS), volatile solids (VS), total organic carbon (TOC), Fe, Al, Mg, Ca, Cl, ORP, pH, adenosine triphosphate (ATP), DO, temperature

The analytical methods to be used are outlined in Table 1 (over).

Table 1. A summary of the analytical methods used at the CAWT for the analysis of the sediment and overlying water parameters.

Analyte	Test Method	Accredited*	Reference Method	Unit	CAWT Reporting Limit
pH	M531	Yes	SM 4500-H+B	n/a	n/a
conductivity	M531	Yes	SM 2510B,	µs/cm	4
turbidity	M562	Yes	SM 2130B,	NTU	0.2
alkalinity	M531	Yes	SM 2320 B	mg/L	5.0
ORP	M555	No	SM 2850	mV	n/a
DO	M554	No	SM 4500-O H	mg/L	n/a
Ammonia	M546	Yes	In-house	mg/L	0.020
Nitrate	M532	Yes	EPA 353.2	mg/L	0.020
Nitrite	M532	Yes	EPA 353.2	mg/L	0.006
TKN	M533	Yes	EPA 351.2	mg/L	0.29
TP	M534	Yes	SM 4500-P E	mg/L	0.01
SRP	M534	Yes	SM 4500-P-E	mg/L	0.003
TS	M561	No	EPA 180.1	mg/L	3
TVS	M561	No	EPA 180.1	mg/L	3
TSS	M545	Yes	SM 2540D	mg/L	3
ATP	M575	No	LUMINULTRA MICROBIAL; MONITORING (QGA-25/QGA-100)	pg ATP/mL	n/a
TOC	M547	Yes	SM 5310 B	m/L	1.0
Cations/anions	M549	Yes	ASTM D6919-09, SM 4110 B	mg/L	

* *ISO/IEC 17025:2017*

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Test plan

The following experiments would be carried out to identify the effect the addition of calcium peroxide will have on DO and phosphorus levels in sediment and overlying water.

<u>Step 1:</u> Two reactors (totes) named A and B would be operated as follows: Reactor A would act as a blank (control) test and would be filled with sediment and water collected from Swan Lake without any oxidizing agent. Reactor B would be filled with the Swan Lake sediment and overlying water and a granular grade of calcium peroxide (CaO_2) spread evenly over the sediment surface (concentration to be determined).

<u>Step 2:</u> All reactors would be sealed and kept in an environmental chamber in the dark at 20 °C for 4-6 weeks.

<u>Step 3:</u> Sediment samples would be collected from the reactors twice a week using a sample corer. The overlying water samples would twice a week be collected half way between the sediment and water surface. Samples would be analyzed for parameters outlined in *Experimental set-up*.

Statistical analysis and data interpretation

The experimental data would be statistically analyzed, calculated, and plotted using Excel software. The average value, standard deviation, and variance of the data would be analyzed. The mean would be tested using t-test methods with a significance level of $p < 0.05$.

3.2 Bench-Scale Testing - Bioavailable Phosphorus Assay (Optional)

Phosphorus bioavailability in lake sediment is an important factor to consider with regards to Swan Lake's potentially worsening trophic status. Internal phosphorus release from sediment could become a predominant long-term source of phosphorus to the water once the external phosphorus load is controlled. The total and/or dissolved phosphorus concentration may not be adequate to assess the phosphorus release risk associated with its presence in natural waters. Before an environmentally-sound and long-term phosphorus management strategy for Swan Lake can be developed, it is important to understand what forms of phosphorus occur in sediments, the dynamics of cycling between forms of differing bioavailability (i.e., available for uptake by plants and aquatic biota), and the processes controlling sediment phosphorus removal. Sediment samples collected from various locations along the lake would be subjected to varying anoxic conditions, changes in pH, and perhaps temperature, to identify the factors that influence the release of phosphorus, which is either particulate-bound or dissolved in the overlying water.

Using this information, we can assess how to best manage phosphorus to minimize environmental impacts.

Therefore, it is important to investigate the potential release of bioavailable phosphorus from the lake's sediment. This can be done in a bench-scale study (anaerobic chamber/glove box) by simulating anoxic conditions in the collected sediment samples. The study would determine and assess the environmental factors influencing phosphorus mobilization from sediments (e.g. pH, temperature, redox). Additionally, while analyzing the sediment composition the levels of bioavailable phosphorus fractions that are released from sediments under various environmental conditions could be determined. The CAWT has an algal bioassay in place to determine and monitor the bioavailable fractions of phosphorus in water and sediments. It would be of great value to monitor this parameter over several seasons to evaluate changes.

The CAWT has the capability to perform this testing should there be interest in pursuing this work in future.

4.0 Proposed Timeline and Budget

Anticipated Start Date: June 13, 2022

Anticipated End Date: September 16, 2022

Duration: 14 weeks

Phase	Project Start-up	Sample characterization	Calcium Peroxide Experiments	Decommission & Summary	Total
Duration (weeks)	2	2	6	4	14
Anticipated Start Date	13-Jun-22	27-Jun-22	11-Jul-22	22-Aug-22	13-Jun-22
Anticipated End Date	24-Jun-22	08-Jul-22	19-Aug-22	16-Sep-22	16-Sep-22
Salary & Benefits					
Project Management & Coordination	$ 415	$ 83	$ 332	$ 415	$ 1,245
Research Scientist	$ 663	$ 332	$ 1,326	$ 1,326	$ 3,647
Lab Analysis & Quality Assurance		$ 732	$ 9,407		$ 10,139
Operations & Field	$ 787	$ 525	$ 2,098	$ 263	$ 3,673
Student	$ 255	$ 255	$ 1,020	$ 255	$ 1,785
SUBTOTAL Salaries & Benefits	**$ 2,120**	**$ 1,927**	**$ 14,183**	**$ 2,259**	**$ 20,489**
Non Capital					
Lab Consumables & supplies		$ 237	$ 3,983		$ 4,220
Operational Supplies		$ 15	$ 660		$ 675
Travel & Shipping		$ 1,130	$ 3,323		$ 4,453
SUBTOTAL Non Capital	**$ -**	**$ 1,382**	**$ 7,966**	**$ -**	**$ 9,348**
Overhead, Admin & Contingency					
Overhead (20%)	$ 424	$ 662	$ 4,430	$ 452	$ 5,968
Contingency (5%)	$ 106	$ 166	$ 1,108	$ 113	$ 1,493
SUBTOTAL Non Capital	**$ 530**	**$ 828**	**$ 5,538**	**$ 565**	**$ 7,461**
Total Budget	**$ 2,650**	**$ 4,137**	**$ 27,687**	**$ 2,824**	**$ 37,298**

**Budget is an estimate based on maximum number of parameters analyzed; it can be reduced and optimized at request.*

5.0 References

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About the CAWT

Fleming College's Centre for Advancement of Water and Wastewater Technologies (formerly the Centre for Alternative Wastewater Treatment) is a research centre located at the college's Lindsay, Ontario, Canada campus. When its doors opened in 2004, the CAWT was primarily focused on researching treatment wetland systems and phytoremediation technologies for cold climates.

No longer focusing on just alternative technologies, in the last decade the CAWT has gained an international reputation for engaging in innovative water and wastewater applied research and offering technology development services to the private sector, governments, non-governmental agencies, and to universities.

Designed for customizable operations and project implementation, the CAWT is a unique centre with advanced infrastructure and on-site facilities.

The CAWT is ISO/IEC 17025 certified by the Canadian Association for Laboratory Accreditation (CALA), participates in the CALA Proficiency Testing Program, and has passed the VerifiGlobal Peer Assessment (ISO/IEC 17020:2012 Conformity Assessment in the scope of ISO 14034:2016 Environmental Management – ETV).

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