Fairy Lake Water Quality Update Report, 2021-2022

for:

TOWN OF HALTON HILLS

by:

LGL Limited
environmental research associates

May 2023
LGL File TA9122

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Executive Summary

Fairy Lake was created in the early 1800s when a dam was built on Black Creek to create a mill pond and was deeded to the Town of Halton Hills (Town) in 1989. A dam remains in place today to maintain water levels in the lake which is used by residents for a variety of recreational purposes. The lake is bordered by parkland, rural properties, two trailer parks, and natural open spaces, and is approximately 26 hectares in size.

In June 2021, LGL Limited (LGL) was retained by the Town to provide an update to the baseline water quality study completed by AECOM (2009) to include field studies for lake bathymetry, surface water quality, sediment quality, vegetation and waterfowl. The Fairy Lake Water Quality Study 2021-2022 Report contains data, analyses, results and conclusions from the information collected during the field programs completed between June 2021 and April 2022. To allow for comparison of current conditions to the baseline information reported in AECOM (2009), the monitoring stations were kept consistent in the 2021-2022 study, with some added sampling events. Additionally, a nutrient modelling study was conducted and reported on under separate cover (Water’s Edge, 2023).

Study Area

The study area was generally focused to Fairy Lake and its shoreline; however, for site context, secondary source information was reviewed for the broader geographic area as displayed in **Figure 1**.

Mill operations in 1830 resulted in the damming of Black Creek to create a mill pond which resulted in Fairy Lake. Fairy Lake as it exists today includes a portion of the Eramosa River-Blue Springs Creek Wetland Complex, which is a provincially significant wetland (PSW). There are a couple of deeper areas (> 6.0 m) in the central and northwest basins of the lake, but most of the lake is shallow (<2.0 m). The lake supports a warmwater fish community, and provides habitat for amphibians, reptiles, birds and other wildlife, including species at risk that are protected through various types of provincial and federal regulations (Endangered Species Act, Migratory Birds Convention Act, Fish and Wildlife Conservation Act, and the Fisheries Act).

Water Quality

Lake depths were recorded through a full bathymetric survey. Surface water samples and field measurements were collected once during the ice-cover season (February) and three times during the open-water season (April, July, and September) from a total of 11 locations to capture conditions at a number of lake inputs, the outlet to Black Creek, and within the lake itself (Figure 2). Chemical analysis of the samples included testing for general chemistry, nutrients, metals and bacteria. Surface water and lake bathymetry data were used to calibrate the nutrient modelling reported under separate cover (Water’s Edge, 2023). Supporting environmental data provided by others was

used to describe conditions that might affect water quality in the lake. In some cases, the data was accessed prior to collecting samples for chemical analysis to ensure the target criteria for sampling events was met (e.g., precipitation data to check wet weather flow criteria). Data collected by others is acknowledged throughout the report and includes streamflow data collection by the Halton Region to align with the collection of surface water samples for chemical analysis.

Geese appear to be driving some of the *E. coli* (bacteria) counts that are resulting in localized beach closures (and potentially contributing to blue-green algae (BGA) formation through nutrient inputs). Geese are one source of bacteria and nutrients to the lake but data collection part of the current scope of work does not quantify that contribution. Of note is that very high bacteria counts were observed in stormwater flows from the creek and storm sewer outfalls (3,900 - 9,700 counts/100 mL). It is LGL's understanding that the University of Guelph led study includes microbial source tracking to confirm the source of the bacteria counts in the lake. Where geese are confirmed as the source that is driving the beach closures, management practices at that particular location (e.g., goose deterrents) could be prioritized.

Sediment Quality

Sediment samples were collected in the fall of 2021 at three stations to determine the concentrations of nutrients and metals found in lakebed substrates. TAN, TOC, TKN and phosphorus in SQ3 sediments from the deep central basin were found in similar concentrations to the AECOM (2009) study. At station SQ2 (shallow area in south part of the lake) increases in TAN and TKN were observed and at SQ1 (northwest arm) increases in TOC and TKN were found. TKN concentrations in sediments collected at SQ1 and SQ2 exceeded the PSQG SEL. This summary of results is based on single sampling events, one in 2008 and one in 2021. Additional sediment sampling in the lake would help identify how much of the apparent difference between stations and between years is attributable to the natural variation inherent in sediments in wetland and depositional habitats and clarify where trends are significant. Metal concentrations were analysed as part of the 2022 study and all of the samples collected from the lake met the provincial sediment quality guidelines for metals.

Vegetation Surveys

Mapping of aquatic and terrestrial vegetation communities was completed using data provided by CVC and confirmed in the field for the adjacent shoreline and the lake using a combination of canoe and pedestrian surveys in 2021. The locations of locally rare, species at risk and invasive plants were recorded as they were encountered.

A total of 163 vascular plant species were recorded within and surrounding Fairy Lake. A number of locally rare plants were found in the study area. Approximately 37% of the total flora observed are considered introduced and non-native to Ontario. Invasive plants, such as those observed along the shoreline of the lake, if left unchecked tend to reduce biodiversity and quickly create monocultures. Many Conservation Authorities and municipalities have programs in place to manage invasive species like Common Reed (phragmites), particularly in wetlands where they can take over quickly. It is recommended that the Town discuss with CVC to determine the next steps for invasive species and/or whether a phragmites removal program is already in place for the watershed.

Goose Surveys

Wildlife in the study area were documented as they were encountered (i.e., incidental observations) and focused field studies were completed to document habitat conditions likely to influence geese presence and use of the lake and the surrounding shoreline.

Geese numbers during the moulting period are in excess of the nesting that occurs along the lake shoreline. The Town's egg oiling program is effective in reducing nesting along the lake shoreline. It is not uncommon that geese will move after they nest and remain close to a body of water during the moult period when they are unable to fly. It's recommended that the Town engage other nearby landowners (e.g., golf course) to see what controls they are implementing on site (if any) and gather information on the degree to which nesting might be occurring off-site. The objectives of goose deterrents at Fairy Lake are two-fold, to address local loading of nutrients and bacteria at the public beach and to improve conditions of recreational areas in Prospect Park where geese are fouling playing fields and park lands.

Fairy Lake Management Recommendations

Human activities can negatively impact surface water quality, even when the activity is far removed from the waterbody. The many types of pollution generated by human activities may seem insignificant when viewed separately, but when taken as a whole they can result in significant cumulative impacts on an aquatic ecosystem. Water quality stressors are identified when impacts have been noted to biological communities or when water quality standards/guidelines have been violated. Sources of stressors are most often associated with land use in a watershed, as is the case in Fairy Lake.

Based on the results of the field investigations, stressors to Fairy Lake water quality and recreational use of the lake were identified to include nutrients (phosphorus, and nitrogen containing compounds in some locations), and bacteria (*E.coli.*). Data provided by others (Halton Region Public Health) identify BGA as another stressor. Data collection for the Fairy Lake Water Quality Study points to non-point sources (i.e., contaminants originating from a broad range of land use activity and carried to the lake by rainfall, runoff, and snowmelt) as stressors. Specifically, the non-point stressors identified through data analysis and modelling are urban or impervious surface runoff via storm sewers, and agricultural runoff through Black Creek/Bovis Creek and other stormwater flows. Data suggests that failing septic systems and wildlife waste may also be a source of nutrient and *E.coli*. stressors; however, confirmation of this would require additional study.

Recommendations for management have been identified at the request of the Town with the goal to improve water quality by reducing the impact/source of these stressors to support the recreational uses of the lake while maintaining its ecological function. The following table provides a summary of the key management recommendations for Fairy Lake.

Recommendation	**Goal/Targeted Stressor**	**Example**
Review existing agricultural best management practices part of the watershed rural incentives program and introduce new or enhanced BMPs	Reduce nutrient loading to nearby waterbodies as a result of soil disturbance and erosion	No-till or conservation tillage practices, cover crops, vegetative buffers to creeks, nutrient management plans
Storm sewer retrofits	Reduce contaminants in stormwater flows before they reach the lake	Oil grit separators, filters, adaptive management solutions being investigated for the Region's phosphorus offsetting plan
Low impact development design and retrofits	Reduce contaminants in stormwater flows before they reach the lake	Incorporate LID features in new development – inclusion of green roof, permeable pavement, bioretention/rain gardens, rainwater harvesting, soakaway pits, and infiltration chambers Retrofit existing neighbourhoods, hosting LID features in road right of ways, within residential, industrial or commercial, or public land (Town owned parks and facilities, schools, etc.)

Recommendation	Goal/Targeted Stressor	Example
Natural Channel Design	Attenuate stormwater flow rate and quality, moderate water temperature, reduce nitrogen loading	Restore concrete channel upstream of Fairy Lake Restore the hyporheic zone of rivers
Wetland Design	Attenuate stormwater flow rate and quality, reduce contaminant loading	Tyler Avenue stormwater outfall and mouth of Black Creek/Bovis Creek at Fairy Lake
Vegetation Management	Attenuate stormwater flow rate and quality Reduce erosion, increase infiltration, reduce nutrient loading, improve habitat Limit access to the lake shoreline (reducing goose activity and human disturbance)	Use of planted riparian buffers with, native seed mixes along the lake shoreline and adjacent to Black Creek/Bovis Creek upstream of the lake
Waterfowl Management	Reduce bacteria source Improve conditions at recreational facilities	Daily beach grooming Habitat modification along lake shoreline Changing maintenance practices in grassed areas Using natural applications to open grassed areas to deter geese (e.g., garlic based) Use barriers (retractable fencing) to keep geese from loafing and fouling the beach Use of hazing techniques (dogs or raptors)

Recommendation	Goal/Targeted Stressor	Example
Engage local property owners and businesses adjacent to, or with a surface water connection to the lake	Reduce water quality stressors from private properties adjacent to the lake	Promote stewardship initiatives through education and incentives (e.g., use of LID design and retrofits, vegetative and waterfowl management techniques)
Monitor the effectiveness of management activities at meeting targeted goals	Identifying adaptive management to align with changing conditions over time	Long-term monitoring program
Coordinate efforts of various stakeholders to align goals and share available resources	Allow for adaptive management to align with changing conditions over time and shifting priorities/goals for the Fairy Lake catchment.	Establish a cross agency and disciplinary technical group that meets regularly to review the results of emerging studies, plan future studies, and develop and prioritize management approaches to align with the collective goals of the group and make the best use of available resources.

Closing

The main objective of the 2021-2022 Fairy Lake Water Quality Study was to update existing information from AECOM (2009) to identify water quality stressors and their sources so that recommendations could be made for targeted management practices.

Relatively high loading of nutrients and bacteria was observed through stormwater flows during spring melt and storm events. A number of recommendations have been provided with the goal to improve water quality and maintain recreational uses of the lake and Prospect Park. Key to the long-term management of the lake is a monitoring program to measure the effectiveness of the management tools and allow for adaptive management to be employed over the longer term.

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1.0 Introduction

Fairy Lake was created in the early 1800s when a dam was built on Black Creek to create a mill pond and was deeded to the Town of Halton Hills (Town) in 1989. A dam remains in place today to maintain water levels in the lake which is used by residents for a variety of recreational purposes. The lake is bordered by parkland, rural properties, two trailer parks, and natural open spaces, and is approximately 26 hectares in size. The Credit Valley Conservation (CVC), Halton Region (Region) and the Town are among the list of stakeholders and interested parties where Fairy Lake water quality is concerned, and the Technical Advisory Committee (TAC) participating in the project is comprised of individuals from those groups.

In June 2021, LGL Limited (LGL) was retained by the Town to provide an update to the Fairy Lake Water Quality Study completed previously (AECOM, 2009) to include field studies for lake bathymetry, surface water quality, sediment quality, vegetation and waterfowl. To allow for comparison of current conditions to the previous study (AECOM, 2009) much of the study design was kept consistent in the 2021 study. Additions to the study were focused to expanding upon the seasonal data collection and modelling phosphorus in the lake (summarized here and reported on in full under separate cover).

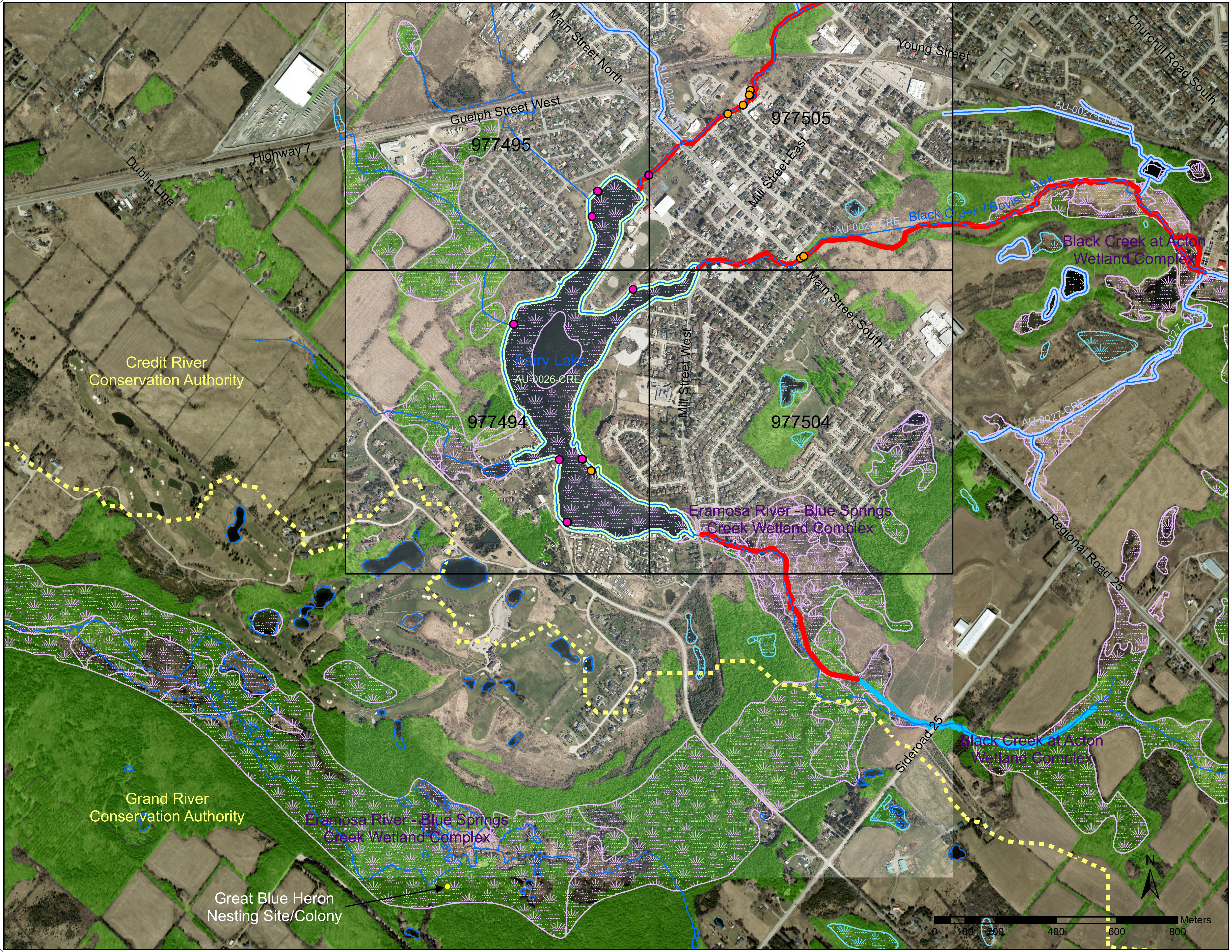
Given the timing of the field work for the study (June 2021 – April 2022) it is noted that some influence of the Covid-19 pandemic may be inherent in the data. Although the study was not completed during the height of public restrictions, some recreational uses of the lake were restricted over this timeframe (e.g., no canoe rental vendor operating) and anecdotal information from local citizens also suggests that Prospect Park attracted more visitors from a wider geographical area than was typical pre-pandemic.

2.0 Study Area

The study area is generally focused to Fairy Lake and its shoreline; however, to provide site context, GIS data layers available for the broader geographic area as displayed in **Figure 1** were reviewed. Mill operations beginning in 1830 resulted in the damming of Black Creek to create a mill pond which resulted in Fairy Lake. The area now occupied by Fairy Lake was historically a wetland. Most of the lake is still quite shallow (less than 2 metres) and part of the Eramosa River-Blue Springs Creek Wetland Complex, which is a provincially significant wetland (PSW). There are a couple of deeper areas (> 6.0 m) in the central basin and within the northwest arm of the lake.

Fairy Lake receives flow from Black Creek/Bovis Creek, from the wetland communities east of Mill Street and west of Dublin Line that are part of the PSW, and from several stormwater inlets. The outlet to Black Creek is dammed and the creek flows in an easterly direction from the lake. The lake is within the jurisdiction of the CVC and the Conservation Authority has been engaged in the current study as well as in other ongoing water quality studies relating to the potential for blue-green algae (BGA) in the lake. The Acton WWTP is located approximately 1.8 km downstream of Fairy Lake and treated flows from the plant outlet to Black Creek. Downstream of the Acton WWTP (in the area of 3rd Line) Black Creek supports a coldwater fishery (CVC et al., 2009). Fairy Lake and local wetlands are known to support Species at Risk (SAR) and provide habitat for a variety of native species.

The Black Creek Subwatershed Study Background Report (CVC et al., 2009) identifies two environmentally significant areas downstream of the lake, the Fairy Lake Marshes which encompass areas of the PSW east of Mill Street and adjacent wooded areas, and the Black Creek at Acton environmentally significant area which includes areas adjacent to the creek east of Acton extending to 5th Line.



LEGEND

- CVC Fisheries Survey Point (1999-2021)
- ARA Survey Point (LIO)
- Provincially Tracked Species 1x1 km Square
- Wildlife Activity Area (LIO)
- Provincially Significant Wetland (LIO)
- Unevaluated Wetland (LIO)
- Wooded Area (LIO)
- Conservation Authority Administrative Area Boundary
- Watercourse (LIO)
- Waterbody (LIO)

CVC Fish Community Summary
- Warmwater Community
- Coolwater Community

Aquatic Resource Area Summary (LIO) Thermal Regime
- Cold
- Cool

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Fairy Lake Water Quality Study

Background Data Review

LGL LIMITED Est. 1971
environmental research associates

Project	TA9122	Figure	1
Date	February 2023	Prepared By:	KC
Scale	1:12,000	Verified By:	LKR

3.0 Study Methodology

3.1 Background Information Review

A review of secondary source information was used to provide context for the Fairy Lake Water Quality Study. The following resources were used to characterize the study area in the context of natural heritage:

- Aerial imagery;
- Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDMNRF) Natural Heritage Information Centre (NHIC) database;
- MNDMNRF Land Information Ontario data (fisheries, woodlands, wetlands, wildlife habitat, significant natural areas); and,
- Department of Fisheries and Oceans (DFO) mapping for aquatic species at risk (SAR).

At project start-up, the project team also met with the Technical Advisory Committee (TAC) as part of the effort to assemble and review background information. The TAC includes representatives from the following groups:

- Credit Valley Conservation (CVC), Engineer (Water and Climate Change Science)
- Halton Region (Region), Hydrogeologist (Infrastructure Planning and Policy)
- Town of Halton Hills (Town)
    - Recreation and Parks
    - Transportation and Public Works
    - Climate Change and Asset Management
    - Corporate Communications

Information sharing was coordinated among others supporting on the study and/or conducting additional studies on the lake to include groups from the University of Guelph, the Town Council (through a site meeting in September 2021), Halton Region Public Health, and various Town departments. The following resources were provided by local municipalities and agencies and were reviewed in the context of Fairy Lake water quality:

- Survey of the Recreational Water Quality of Fairy Lake, Acton Ontario (Fedorowick, 1989)
- Town of Halton Hills Fairy Lake Water Quality Study (AECOM, 2009)
- Weed Inventory Map of Fairy Lake, Acton, Ontario (Town of Halton Hills, 2004)
- Weed Control in Fairy Lake A Presentation and Discussion of Alternatives (Mirek Sharp & Associates Inc., 2003)
- Fairy Lake Southeast Shore Natural Area Inventory (CVC, 2021)
- Black Creek Subwatershed Study Background Report (CVC, 2009)
- Black Creek Subwatershed Study Phase 2 Impact Assessment and Evaluation of Alternative Management Strategies (CVC, 2016)

- Black Creek Subwatershed Study: Management, Implementation, and Monitoring Plan Phase 3 Study (CVC, 2019)
- Ecological Land Classification of vegetation communities (CVC 2020)
- Fish and benthos data (CVC 1999-2019)
- Fairy Lake Bacterial Monitoring Data (Region 2010-2018)
- Acton WWTP Total Phosphorus Offsetting Program (various resources dating from 2009-2017 and the 2021 and 2022 monitoring and verification reports (Halton Region)
- Fairy Lake Community Survey Results (Town of Halton Hills 2020)
- Prospect Park Water Well Field and Extension Fairy Lake Mitigation Strategy: Natural Environment Features and Functions (Dance Environmental, 2016)
- Case study: Monitoring and risk management practices of blue–green algae blooms within the regional municipality of Halton (R. Sereshk and N. Kuchmak, 2017)
- Town of Halton Hills. (2020) Phosphorus Removal Program flyer

A literature review was conducted to identify additional information relevant to waterfowl management. The following resources were reviewed for that purpose:

- Canada and Cackling Geese: management and population control in Southern Canada. Environment Canada (Canadian Wildlife Service, 2010)
- Best practices for destroying eggs or preventing hatching (Canadian Wildlife Service, 2011a)
- Frequently asked questions – Canada Geese (Canadian Wildlife Service, 2011b)
- Population status of migratory game birds in Canada (Canadian Wildlife Service, 2017)
- Goose management (City of St. Catharines, 2014)
- A source book: habitat modification and Canada Geese- techniques for mitigating human/goose conflicts in urban and suburban environments (Doncaster D. and Keller J., 2009)
- Canada Geese and shorelines – seasonal techniques to deter geese (Environment Canada, 2006)
- Geese control program (Toronto City Council, 2002)
- Goose Management Program (Town of Oakville, 2021)

3.2 Fisheries

Available fisheries data (MNRF and CVC) include a mix of warm, cool and coldwater fish species (**Table 1**). The Black Creek Subwatershed Study (CVC et al. 2009) and available GIS open data layers from CVC, identify Fairy Lake and the portions of Black Creek immediately upstream and downstream of the lake as far as 3rd Line, as supporting a warmwater fish community (**Figure 1**). The reaches downstream (east) of the Acton WWTP (and beyond 3rd Line) support a coldwater fishery (CVC et al., 2009). No fish species at risk were found in available records for the lake.

Table 1. Fisheries Records, Fairy Lake and Black Creek (see Figure 1 for survey locations)

Common Name	Scientific Name	Thermal Regime	Tolerance	G Rank	S Rank	SARA	ESA	Black Creek upstream of Fairy Lake (AU-0024-CRE)	Fairy Lake (AU-0026-CRE)	Fairy Lake (CVC 1999-2021)	Black Creek downstream of Fairy Lake (AU-0027-CRE)
Banded Killifish	*Fundulus diaphanus*	coolwater	tolerant	G5	S5		NAR		x	x	
Black Crappie	*Pomoxis nigromaculatus*	coolwater	moderately tolerant of turbidity	G5	S4			x	x	x	x
Blacknose Dace	*Rhinichthys obtusus*	coolwater	intermediate	G5	S5			x			x
Brook Stickleback	*Culaea inconstans*	coolwater	intermediate	G5	S5			x			x
Brook Trout	*Salvenlinus fontinalis*	coldwater	intolerant	G5	S5			x			x
Brown Bullhead	*Ameiurus nebulosus*	warmwater	intermediate	G5	S5				x	x	x
Brown Trout	*Salmo trutta*	coldwater	intolerant of turbidity, siltation, pollution	G5	SNA						x
Central Mudminnow	*Umbra limi*	coolwater	tolerant	G5	S5			x			x
Central Stoneroller	*Campostoma anomalum*	coolwater	intermediate	G5	S4		NAR	x			
Common Carp	*Cyprinus carpio*	warmwater	tolerant of turbidity	G5	SNA				x		
Common Shiner	*Luxilus cornutus*	coolwater	moderately tolerant	G5	S5			x			x

Common Name	Scientific Name	Thermal Regime	Tolerance	G Rank	S Rank	SARA	ESA	Black Creek upstream of Fairy Lake (AU-0024-CRE)	Fairy Lake (AU-0026-CRE)	Fairy Lake (CVC 1999-2021)	Black Creek downstream of Fairy Lake (AU-0027-CRE)
Creek Chub	*Semotilus atromaculatus*	coolwater	intermediate	G5	S5			x	x	x	x
Fantail Darter	*Etheostoma flabellare*	coolwater	intolerant	G5	S4						x
Fathead Minnow	*Pimephales promelas*	warmwater	tolerant	G5	S5			x			x
Johnny Darter	*Etheostoma nigrum*	coolwater	moderately tolerant	G5	S5						x
Golden Shiner	*Notemigonus crysoleucas*	coolwater	moderately tolerant of turbidity	G5	S5				x	x	
Largemouth Bass	*Micropterus salmoides*	warmwater	moderately tolerant of turbidity	G5	S5				x	x	x
Longnose Dace	*Rhinichthys cataractae*	coolwater	moderately tolerant	G5	S5						x
Mottled Sculpin	*Cottus baridii*	coldwater	intermediate	G5	S5						x
Northern Hog Sucker	*Hypentelium nigricans*	warmwater	intolerant	G5	S4						x
Northern Pike	*Esox lucius*	coolwater	intermediate	G5	S5			x	x	x	x
Northern Redbelly Dace	*Chrosomus eos*	coolwater	intermediate	G5	S5			x			x
Pumpkinseed	*Lepomis gibbosus*	warmwater	intermediate	G5	S5			x	x	x	x

Common Name	Scientific Name	Thermal Regime	Tolerance	G Rank	S Rank	SARA	ESA	Black Creek upstream of Fairy Lake (AU-0024-CRE)	Fairy Lake (AU-0026-CRE)	Fairy Lake (CVC 1999-2021)	Black Creek downstream of Fairy Lake (AU-0027-CRE)
Rainbow Darter	*Etheostoma caeruleum*	coolwater	intolerant	G5	S4						x
Rainbow Trout	*Oncorhynchus mykiss*	*coldwater*	intolerant	G5	S5						x
Rock Bass	*Ambloplites rupestris*	coolwater	intolerant of siltation	G5	S5			x	x	x	x
Smallmouth Bass	*Micropterus dolomieu*	coolwater	moderately tolerant	G5	S5				x		
White Sucker	*Catostomus commersonii*	coolwater	generally tolerant,	G5	S5			x	x	x	x

Species Information Source: Eakins, R. J. 2018. Ontario Freshwater Fishes Life History Database. Version 4.82. On-line database. (http://www.ontariofishes.ca)
ESA: Ontario Endangered Species Act, 2007 **SARA:** Species at Risk Act Schedule 1 species list
G-Rank (Global Rank): assigned by consensus of Conservation Data Centres (CDCs), scientific experts and The Nature Conservancy to designate a rarity rank based on the range-wide status of species, subspecies or variety. G1- extremely rare; G2-very rare; G3- rare to uncommon; G4-common; G5-very common; demonstrably secure under present conditions
S-Rank (Provincial or Subnational ranks): used by the Natural Heritage Information Centre to set protection priorities for rare species and natural communities. Provincial ranks are assigned in a manner similar to that described for global ranks but consider only those factors within the political boundaries of Ontario.
SX-presumed extirpated; SH-historical; S1-critically imperiled; S2-imperiled; S3-vulnerable; S4-apparently secure; S5-secure

3.3 Rare Species and Species at Risk

The NHIC database was used to identify records for provincially tracked species found within an area of 4 km^2 including and surrounding the lake. Provincially tracked species include those ranked provincially as S1 to S3 and those identified as Species at Risk in Ontario (SARO). Rare species documented in the Natural Areas Inventory; Volume 9 (CVC, 2021) are also included in **Table 2**. The aquatic SAR mapping available from DFO was also reviewed for the study area. No critical habitat or occurrence records for aquatic SAR were found in the lake or in Black Creek within 5 km downstream of the lake.

Table 2. Provincially tracked records for rare species and species at risk (see Figure 1 for Grid ID)

Common Name	Scientific Name	S-Rank	SARA	SARO	Grid ID 977495	Grid ID 977505	Grid ID 977494	Grid ID 977504
Bobolink	*Dolichonyx oryzivorus*	S4B		THR	X	X	X	X
Chimney Swift	*Chaetura pelagica*	S4B,S4N	THR	THR		X		
Eastern Meadowlark	*Sturnella magna*	S4B		THR	X	X	X	X
Least Bittern	*Ixobrychus exilis*	S4B	THR	THR			X	X
Wood Thrush	*Hylocichla mustelina*	S4B		SC	X	X	X	X
Gypsy Cuckoo Bumble Bee	*Bombus bohemicus*					X		
Rusty-patched Bumble Bee	*Bombus affinis*	S1	END	END		X		
Yellow-banded Bumble Bee	*Bombus terricola*	S5	SC	SC		X		
Blanding's Turtle	*Emydoidea blandingii*		END	THR				X
Midland Painted Turtle	*Chrysemys picta marginata*	S5	SC				X	X
Snapping Turtle	*Chelydra serpentina*	S3	SC	SC	X	X	X	
Finely-nerved Sedge	*Carex leptonervia*	S5					X	
Spotted St. John's-wort	*Hypericum punctatum*	S5					X	

Common Name	Scientific Name	S-Rank	SARA	SARO	Grid ID 977495	Grid ID 977505	Grid ID 977494	Grid ID 977504
Tufted Yellow Loosestrife	*Lysimachia thyrsiflora*	S5					X	
Fragrant Water-lily	*Nymphaea odorata*	S5					X	
Peach-leaved Willow	*Salix amygdaloides*	S5					X	
Sandbar Willow	*Salix interior*	S5					X	

See Table 1 Notes

3.4 Field Investigations

Field investigations for lake bathymetry, surface water quality, lakebed sediment quality, vegetation, and waterfowl were conducted from June 2021 to April 2022 using the methods summarized in the sections that follow on the dates provided in **Table 3**. **Figure 2** displays the locations where LGL field data collection occurred. It should be noted that no site location data (UTM, latitude/longitude) was available from the AECOM (2009) baseline study, however best efforts were made to replicate those station locations in 2021 through digitization of available PDF mapping.

Table 3. Field Investigations Summary

	Secondary Sources Used	LGL Field Investigation		
		Activity/Protocol	**Dates Completed**	**LGL Staff**
Lake Bathymetry	Fairy Lake Water Quality Study (AECOM, 2009)	Spot checks during reconnaissance of water quality stations and lake profiles of in-situ water quality conditions	June 25, 2021 August 3, 2021 September 22, 2021 November 12, 2021 January 24, 2022	L. Renzetti M. O'Halloran A. Bruce B. Pilon
		Full lake survey using a Garmin Echomap 75sv sonar unit equipped with GPS and an ultra high-definition scanning transducer	April 20, 2022	M. O'Halloran
Water Quality	Fairy Lake Water Quality Study (AECOM, 2009) Streamflow data collection by Halton Region staff (A. O'Rourke 2021, 2022)	Field assessment to confirm water and sediment quality stations	June 24 and 25, 2021	M. O'Halloran L. Renzetti T. Kanagasabesan
		Summer dry weather sample collection – all stations Lake profiles of in-situ water quality conditions	August 3, 2021	L. Renzetti B. Pilon
		Fall wet weather monitoring – all stations Lake depth profiles of in-situ water quality conditions	September 22, 2021	L. Renzetti B. Pilon M. O'Halloran
		Winter/under ice sample collection – lake stations Lake depth profiles of in-situ water quality conditions	January 24, 2022	M. O'Halloran A. Bruce
		Spring wet weather monitoring of inlets/outlets	February 17, 2022	L. Renzetti B. Pilon
		Spring sample collection – lake stations Lake depth profiles of in-situ water quality conditions	April 20, 2022	M. O'Halloran B. Pilon
Sediment Quality		Fall sample collection Lake depth profiles of in-situ water quality conditions	November 12, 2021	M. O'Halloran A. Bruce
Vegetation	Fairy Lake Water Quality Study (AECOM, 2009) Ecological Land Classification (ELC) layers provided by CVC	Canoe survey of aquatic vegetation, pedestrian survey of shoreline vegetation Mapping of invasive species and plant species at risk Ecological Land Classification for Southern Ontario (2008)	June 25, 2021 September 15, 2021	J. Noël
Waterfowl	Fairy Lake Water Quality Study (AECOM, 2009) Town of Halton Hills Public Works (M. Gordon, R. Vanderham - egg oiling program) Community data collection through Let's Talk Halton Hills (July 2021 to March 2022)	Goose Habitat Assessment and Inventory Nesting Survey in Spring 2022	June 16 and 23, 2021 July 22, 2021 August 11, 2021 September 22, 2021 April 20, 2022	L. Renzetti T. Kanagasabesan J. Shonfield J. Noël B. Pilon
Species at Risk	Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Information Centre (NHIC) database Department of Fisheries and Oceans	SAR observations recorded during all field investigations described above	All surveys	All staff

Staff Qualifications:
M. O'Halloran, Dipl. – Senior Fish & Wildlife Technician
T. Kanagasabesan, M.Sc. – Aquatic Scientist
J. Shonfield, Ph.D. – Terrestrial Ecologist
J. Noël, M.Sc. – Senior Botanist
A. Bruce, B.A.; Dipl. – Fish & Wildlife Technician
L. Renzetti, B.Sc. – Senior Ecologist
B. Pilon, B.Sc.; Dipl. – Ecologist

3.4.1 Streamflow and Rainfall Data

Halton Region staff collected flow data at each of the stations they monitor upstream and downstream of Fairy Lake. Data from the flow stations shown on **Figure 2** were used as a measure of low flow/dry weather and high flow/wet weather conditions. Data provided are summarized in **Table 4** (A. O'Rourke, pers. comm.).

Table 4. Streamflow Data for Regional Flow Stations in proximity to Fairy Lake (see Figure 2 for locations)**.**

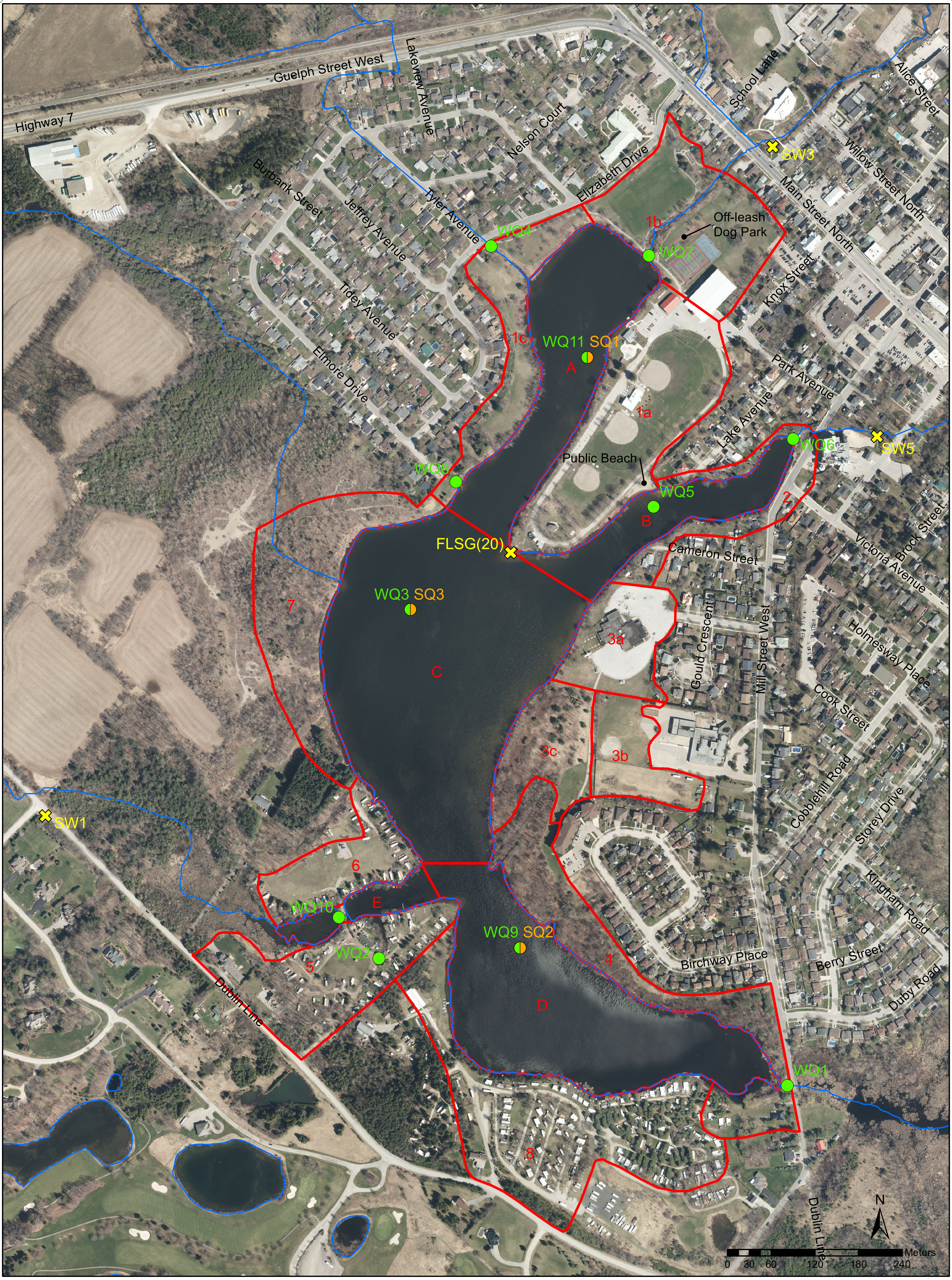
Location	Date	Time	Staff Gauge (m)	Discharge (Q) m^3/s	Event Type
SW1: Dublin Line	August 3, 2021	10:35	Dry	Dry	Summer dry weather low flow
SW3: Library	August 3, 2021	10:07	0.19	0.013	
SW5: Mill St. Dam	August 3, 2021	8:46	0.06	0.013	
FLSG(20)	August 3, 2021	8:26	0.67	-	
SW1: Dublin Line	Sept. 22, 2021	10:21	0.14	0.004	Fall wet weather high flow
SW3: Library	Sept. 22, 2021	11:00	0.55	0.305	
SW5: Mill St. Dam	Sept. 22, 2021	9:07	0.2	0.215	
FLSG(20)	Sept. 22, 2021	8:45	0.75	-	
SW1: Dublin Line	Feb. 17, 2022	10:48	0.6	0.078	Spring melt/freshet high flow
SW3: Library	Feb. 17, 2022	12:20	0.78	0.4475	
SW5: Mill St. Dam	Feb. 17, 2022	10:00	0.28	0.6035	
FLSG(20)	Feb. 17, 2022	9:40	0.81 (to ice)	-	

Table 4 Notes:
FLSG(20): new Fairy Lake staff gauge

Rainfall data from the Acton Reservoir weather station located near 32nd Side Road and 3rd Line was also provided by the Region. These data were used to confirm dry and wet weather flow events. Wet weather is defined for this study as >20 mm of precipitation over a 24-hour period. Sample collection targeted these events to ensure stormwater outfalls were flowing; however, the timing of sampling does not necessarily capture peak flow condition. This is typical of this type of monitoring in that 'peak' flow can't typically be identified until after the event is over. Where a measure of peak flow is required, continuous flow loggers are needed. The rainfall data obtained from the Acton Reservoir is summarized in **Table 5**.

Table 5. Rainfall Data for Wet Weather Events sampled at Fairy Lake.

Date of Sampling	Total Daily Rain (mm)	Event Type
September 22, 2021	52.8	Fall - wet weather, high flow
February 17, 2022	30.0	Spring - wet weather, spring melt, high flow



Fairy Lake Water Quality Study

Station Locations

- Sediment Quality (SQ) Station (LGL)
- Water Quality (WQ) Station (LGL)
- Flow Station (Region of Halton)
- Goose Monitoring Area
- Watercourse (LIO)
- Waterbody (LIO)

Water / Sediment Quality Station (LGL)

WQ1:	south basin - inlet at Mill St
WQ2:	stormwater inlet at trailer park
WQ3 SQ3:	central basin
WQ4:	stormwater outlet - Tyler Avenue
WQ5:	old beach
WQ6:	Fairy Lake dam
WQ7:	Black Creek inlet
WQ8:	stormwater outlet - Elmore Drive
WQ9 SQ2:	south basin
WQ10:	west inlet
WQ11 SQ1:	northwest basin

Flow Station (Region)

SW1:	Dublin Line
SW3:	library
SW5:	Mill St dam
FLSG(20):	staff gauge

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Project	TA9122	Figure	2
Date	February 2023	Prepared By	KC
Scale	1:5,000	Verified By	LKR

3.4.2 Lake Bathymetry

Lake depths were recorded as part of the 2009 Town of Halton Hills Fairy Lake Water Quality Study. LGL reviewed the 2009 mapping and completed some spot checks of depth in the lake in the early stages of the 2021 water quality data collection. In early 2022, a full bathymetric survey of the lake was conducted to provide the level of detail required to support the nutrient modelling component of the current study and the research efforts of others. The focus of the Fairy Lake bathymetric survey was to describe the physical characteristics of the lake bottom and determine depth contours.

The survey was conducted on April 20, 2022 using a Garmin Echomap 75sv sonar unit paired with a National Marine Electronics Association (NMEA) global positioning system (GPS) and a Garmin GT54 ultra-high definition scanning transducer using single channel CHIRP 50/77/83/200 kHz. This unit instantly creates maps with contours and depth labels by scanning both directly under the vessel and directionally port and starboard. The transducer was affixed to a pedal-drive kayak which enabled access to shallow (approximately 50 centimetres depth) areas along the perimeter of the lake. Data was then collected across transects in each of the basins of the lake. Elevation at the time of survey was 345.741 (based on an average of hourly readings from the Prospect Park staff gauge location, as provided by the Region).

Prior to bathymetric data collection, weather data sources (windfinder.com, theweathernetwork.com) were monitored to ensure that lake conditions would be conducive (e.g., negligible wave action). Early morning was selected for data collection as wind/wave action is often lowest at that time of day. A plan was derived to first acquire lake perimeter data (spatial and bathymetric), then to conduct transects across each of the lake basins to include the north and east arms, the south bay, and the main basin. Since the sonar unit builds bathymetric maps in-situ, transects in an east-west or north-south style were not considered necessary, rather, the vessel was directed to address and fill data gaps. Data collection was conducted on April 20, 2022, beginning at 9:00 am following water sample collection. Local weather station data recorded temperatures ranging from 0.5°C to 12°C on the day of the survey. Wind, while not recorded by the station, was calm and estimated to be less than 7 km/h.

Sonar log files were then uploaded from the Garmin Echomap to a desktop computer. Log files were converted to comma-delimited files for sounding position-depth in SonarTRX Pro version 22.1 in the local UTM coordinate system (WGS84 Z17). ESRI ArcGIS Pro's Topo to Raster tool from the 3D Analyst extension was used to generate a raster surface of water depths within the Fairy Lake boundary from the survey data. Soundings without recorded depth values were excluded from the interpolation. An additional set of points, representing the shoreline of Fairy Lake, was included in the interpolation. These points were generated from the vertices of the Land Information Ontario (LIO) shoreline dataset and were assigned a depth value of 0 metres. As the true shoreline on the day of the survey could not be recorded from the sonar survey, an assumption was made for the interpolation that the LIO shoreline represents the shoreline of Fairy Lake. Contour lines (0.1 m interval) were created from the raster surface using the Contour tool from the 3D Analyst extension. Bathymetry and contour mapping was prepared in ArcGIS Desktop.

3.4.3 Water Quality

Surface water samples were collected across all seasons and from a variety of locations to capture conditions at a number of lake inputs, the outlet to Black Creek, and the seasonal variation of water chemistry within the lake. Accordingly, sample collection included winter, spring (high flow/freshet), summer and fall events to capture wet weather and low flow/dry weather conditions, and all seasonal conditions of lake productivity and oxygen demand. Winter (under ice) sampling focused on the three deepest locations in the lake. Other sampling events included a maximum of ten monitoring sites depending on where adequate flows were found for sample collection (e.g., some stormwater outfalls not flowing in dry conditions). The collection of surface water samples during the open water season was done from a footbridge, road crossing, or by boat. In winter, samples were collected from under the ice using an ice auger where a safe ice platform was available. In-situ ambient conditions (water temperature, specific conductivity, dissolved oxygen (DO), and pH) were recorded during each sampling event using a YSI Pro DSS multi-meter and datalogger. Depth profiles of these parameters were also collected under summer/high productivity, fall/high decomposition, and winter/ice covered conditions in the three deepest basins when water depths were observed to be greater than two metres. Information related to weather, and field conditions was recorded at the time of sampling.

The goal of sample collection was to target two wet weather, one dry weather, and one winter event. The analytes of interest chosen for the study are summarized in **Table 6** to include indicators of industrial and residential sources that align with the CVC's Integrated Watershed Monitoring Program for the Black Creek Watershed, and parameters linked to the stressors identified for Fairy Lake water quality in particular. **Table 7** provides a list of the sampling stations, a brief description of each location and the timing and frequency of sample collection. The location and naming of water quality stations has largely been kept consistent with the baseline study (AECOM, 2009) to allow for comparisons to be made between the current and historical conditions. After collection, samples were kept cool and dark while in transport to Bureau Veritas for chemical analysis. Chain of custody was tracked from time of sample collection, through to sample submission and the receipt of final data from the analytical lab.

Table 6. Analytes of Interest, Fairly Lake Water Quality

Analyte Grouping	Analytes Included	Symbol	Units	Matrix	Data Source
General Chemistry	Water temperature		°C	SW	Field
	Dissolved oxygen	DO	mg/L	SW	Field
	Specific conductivity		µS/cm	SW	Field
	pH		-	SW	Field
	Alkalinity (as CaCO3)		mg/L	SW	BV
	Dissolved Calcium	Ca	µg/L	SW	BV
	Dissolved Chloride	Cl-	mg/L	SW	BV
	Dissolved Magnesium	Mg	µg/L	SW	BV
	Dissolved Organic Carbon	DOC	mg/L	SW	BV
	Total Carbonaceous BOD	BOD	mg/L	SW	BV
	Total Dissolved Solids	TDS	mg/L	SW	BV
	Total Suspended Solids	TSS	mg/L	SW	BV
Nutrients	Unionized Ammonia-N	UIA	µg/L	SW	calculated
	Total Ammonia-N	TAN	mg/L	SW	BV
	Total Nitrogen	N	mg/L	SW	BV
	Orthophosphate-P	Ortho-P	mg/L	SW	BV
	Dissolved Phosphorus		mg/L	SW	BV
	Total Phosphorus	TP	mg/L	SW	BV
	Total Kjeldahl Nitrogen	TKN	mg/L	SW	BV
	Nitrite-N	NO_2-N	mg/L	SW	BV
	Nitrate-N	NO_3-N	mg/L	SW	BV
	Nitrite+Nitrate	NO_2-N+NO_3-N	mg/L	SW	BV
Microbiology	*Escherichia coli*	E.coli	CFU/100 ml	SW	BV
Cyanotoxins	Microcystin		µg/L	SW	BV
Metals	Total Aluminum	Al	µg/L, ug/g	SW, SED	BV
	Total Antimony	Sb	µg/L, ug/g	SW, SED	BV
	Total Arsenic	As	µg/L, ug/g	SW, SED	BV
	Total Barium	Ba	µg/L, ug/g	SW, SED	BV
	Total Beryllium	Be	µg/L, ug/g	SW, SED	BV
	Total Bismuth	Bi	µg/L, ug/g	SW, SED	BV
	Total Boron	B	µg/L, ug/g	SW, SED	BV
	Total Cadmium	Cd	µg/L, ug/g	SW, SED	BV
	Total Chromium	Cr	µg/L, ug/g	SW, SED	BV
	Total Cobalt	Co	µg/L, ug/g	SW, SED	BV
	Total Copper	Cu	µg/L, ug/g	SW, SED	BV
	Total Iron	Fe	µg/L, ug/g	SW, SED	BV
	Total Lead	Pb	µg/L, ug/g	SW, SED	BV

Analyte Grouping	Analytes Included	Symbol	Units	Matrix	Data Source
	Total Lithium	Li	µg/L, ug/g	SW, SED	BV
	Total Magnesium	Mg	ug/g	SED	
	Total Manganese	Mn	µg/L, ug/g	SW, SED	BV
	Mercury	Hg	µg/L, ug/g	SW, SED	BV
	Total Molybdenum	Mo	µg/L, ug/g	SW, SED	BV
	Total Nickel	Ni	µg/L, ug/g	SW, SED	BV
	Total Phosphorus	P	µg/L, ug/g	SW, SED	BV
	Total Potassium	K	ug/g	SED	
	Total Selenium	Se	µg/L, ug/g	SW, SED	BV
	Total Silicon	Si	µg/L	SW	BV
	Total Silver	Ag	µg/L, ug/g	SW, SED	BV
	Total Sodium	Na	ug/g	SED	
	Total Strontium	Sr	µg/L, ug/g	SW, SED	BV
	Total Thallium	Tl	µg/L, ug/g	SW, SED	BV
	Total Tin	Sn	µg/L, ug/g	SW, SED	BV
	Total Titanium	Ti	µg/L, ug/g	SW, SED	BV
	Total Uranium	U	µg/L, ug/g	SW, SED	BV
	Total Vanadium	V	µg/L, ug/g	SW, SED	BV
	Total Zinc	Zn	µg/L, ug/g	SW, SED	BV
	Total Zirconium	Zr	µg/L	SW	BV
	Total Sulphur	S	µg/L	SW	BV

Table 6 Notes

SW – surface water

SED – lake sediments

BV – Bureau Veritas laboratory

Calc. – calculated

Metals - ICPMS low level analysis for surface water, Acid extractable for sediments

Table 7. Surface Water and Sediment Quality Sampling Locations (see Figure 2 for station locations)

Station ID	Station Description	Type of Station	Timing of Sampling Events	# WQ Events	# SQ Events	Analysis Type
WQ1	south basin - inlet at Mill Street	inlet from wetland	WQ - Su, Fa, Sp	3	0	1
WQ2	flows from west of Dublin Line through culvert and along the gravel driveway of The Breezes Trailer Park through an open ditch to the lake	stormwater	WQ - Su, Fa, Sp	3	0	1
WQ3 SQ3	central basin	lake	WQ - Su[(b)], Fa, Wi, Sp SQ – Fa Depth profile – all seasons[(a)]	4	1	2, 4
WQ4	stormwater inlet - Tyler Avenue	stormwater	WQ - Fa, Sp	2	0	3
WQ5	Old Beach – Prospect Park	lake	WQ - Su[(b)], Fa, Sp	3	0	2
WQ6	Fairy Lake dam	outlet	WQ - Su, Fa, Sp	3	0	2
WQ7	Black Creek inlet	creek	WQ - Su, Fa, Sp	3	0	3
WQ8	stormwater inlet - Elmore Drive	stormwater	WQ - Fa, Sp	2	0	3
WQ9 SQ2	south basin	lake	WQ - Su[(b)], Fa, Wi, Sp SQ – Fa	4	1	2, 4
WQ10	west inlet	inlet from wetland	WQ - Su[(b)], Fa, Sp	3	0	1
WQ11 SQ1	northwest basin	lake	WQ- Wi SQ – Fa Depth profile – Fa, Wi[(a)]	1	1	2, 4

Table 7 Notes:
WQ = surface water quality; SQ = sediment quality Wi – winter, under ice sample collection
Sp – spring, wet weather sample collection Su – summer, dry weather sample collection Fa – fall, wet weather sample collection
[(a)]DO, temperature, conductivity, and pH depth profiles taken where water depth > 1.5m
[(b)]Surface water sample for microcystin taken at WQ3, WQ5 and WQ9 during summer dry weather sample collection at lake stations
1 = general, nutrients, *E.coli*, chloride; 2 = general, nutrients, *E.coli*; 3 = general, nutrients, *E.coli*, metals, chloride
4 = sediments - total organic carbon, total ammonia, total Kjeldahl nitrogen, nitrate, nitrite, total phosphorus

3.4.4 Nutrient Modelling

Water's Edge developed a hydrologic and water quality model of the Fairy Lake Watershed following current design standards. Through classic hydrology and hydraulics modelling, Fairy Lake water quality was analyzed to assess the hydrologic factors affecting the water quality of the lake and its watershed. Water's Edge used EPA SWMM to develop the hydrologic model. Phosphorus was used as a key indicator of lake health. The model was run using rainfall data from Georgetown and Acton from 2009-2022 and climate data from Guelph for the same time period. Additionally, phosphorus loads were estimated based on land use types from the literature and other pre-existing models for similar watersheds. Model calibration was based on the 2021-2022 water quality results obtained from Fairy Lake.

The modelling report is available under separate cover (Water's Edge, 2023) to include a review of background information for the watershed, a detailed methodology for developing the model, a summary of the results, and the hydraulic analysis. The modelling results were also used to inform the management recommendations provided in Section 6.0 of this report.

3.4.5 Sediment Quality

To characterize the sediment chemistry in the lakebed, grab samples of bottom sediments (top 15 cm) were collected at three stations (SQ1, SQ2 and SQ3) and submitted to Bureau Veritas for chemical analysis. Laboratory analysis included total organic carbon, total ammonia, total Kjeldahl nitrogen, nitrate, nitrite, total phosphorus, and total metals (by ICPMS). Sample collection was completed in the fall season to capture time of high decomposition and oxygen demand in sediments. A YSI Pro DSS logger was used to record water temperature, specific conductivity, pH, dissolved oxygen and pH at 0.5 m depth intervals. Chain of custody of the samples was tracked from time of sample collection, through to sample submission and the receipt of final data from the lab. Sediment quality data was compared to available Provincial Sediment Quality Guidelines (PSQGs) set by the Ontario Ministry of Environment (OMOE, 1994). The PSQGs are intended to provide guidance for sediment quality management decisions using numerical guidelines developed for the protection of aquatic ecosystems by setting safe levels for metals, nutrients, and organic compounds. Canadian Sediment Quality Guidelines (CSQG) are also referenced and used where a PSQG is not available for a particular analyte. Data was also compared to the 2009 data collected for Fairy Lake to identify any apparent changes in sediment chemistry.

3.4.6 Vegetation

Mapping of aquatic and terrestrial vegetation communities was completed initially using data provided by CVC and subsequently confirmed in the field using the *Ecological Land Classification for Southern Ontario: First Approximation and Its Application* (Lee et al., 1998). Field verification of vegetation characteristics was conducted for the adjacent shoreline and the lake using a combination of canoe and pedestrian surveys in 2021 (see **Table 1** for specific dates). Location of locally rare, SAR and invasive plants were recorded. Vascular plant nomenclature follows FOIBIS. Plant species status was reviewed for Peel Region (CVC, 2002) and Ontario (NHIC, 2021).

3.4.7 Waterfowl

Canada geese (*Branta canadensis*) were identified as the predominant waterfowl species on the lake in the 2009 study and were the focus of the waterfowl survey conducted as part of the current study given their tendency to gather in large numbers along the shoreline and produce large quantities of feces potentially affecting water quality in the lake. Data collection for the current study included a goose habitat assessment, and a goose survey to document numbers of geese, their behaviour and nesting locations. The habitat assessment and goose survey utilized the polygons developed for the 2009 study with some refinement (**Figure 2**). Polygons 1 and 3 were divided into three subunits based on habitat type and land use and Polygon 8 was added. All other units remained as presented in AECOM (2009) in order to allow for comparisons to be made.

3.4.7.1 Habitat Assessment

A pedestrian survey of the Fairy Lake shoreline was completed in June 2021 to assess conditions relevant to waterfowl use. This involved documenting habitat conditions that could potentially affect geese use and/or access to areas surrounding the lake during the moult period, particularly the type and height of vegetation, the site's proximity to the lake, and its accessibility (e.g., sloped manicured lawn or hardened retaining wall, presence of islands/sandbars in water).

3.4.7.2 Goose Survey

Data collection for geese was completed during each of the site visits for the collection of water quality samples and during dedicated goose survey dates in the spring and summer of 2021 as summarized in **Table 1**. Using Survey123, the date and time of survey, weather conditions, observer's name, location of the sighting, numbers of adults and juveniles and types of behaviour were noted. A similar version of the survey was made available to the public to collect data through citizen science using the Town of Halton Hills Let's Talk platform.

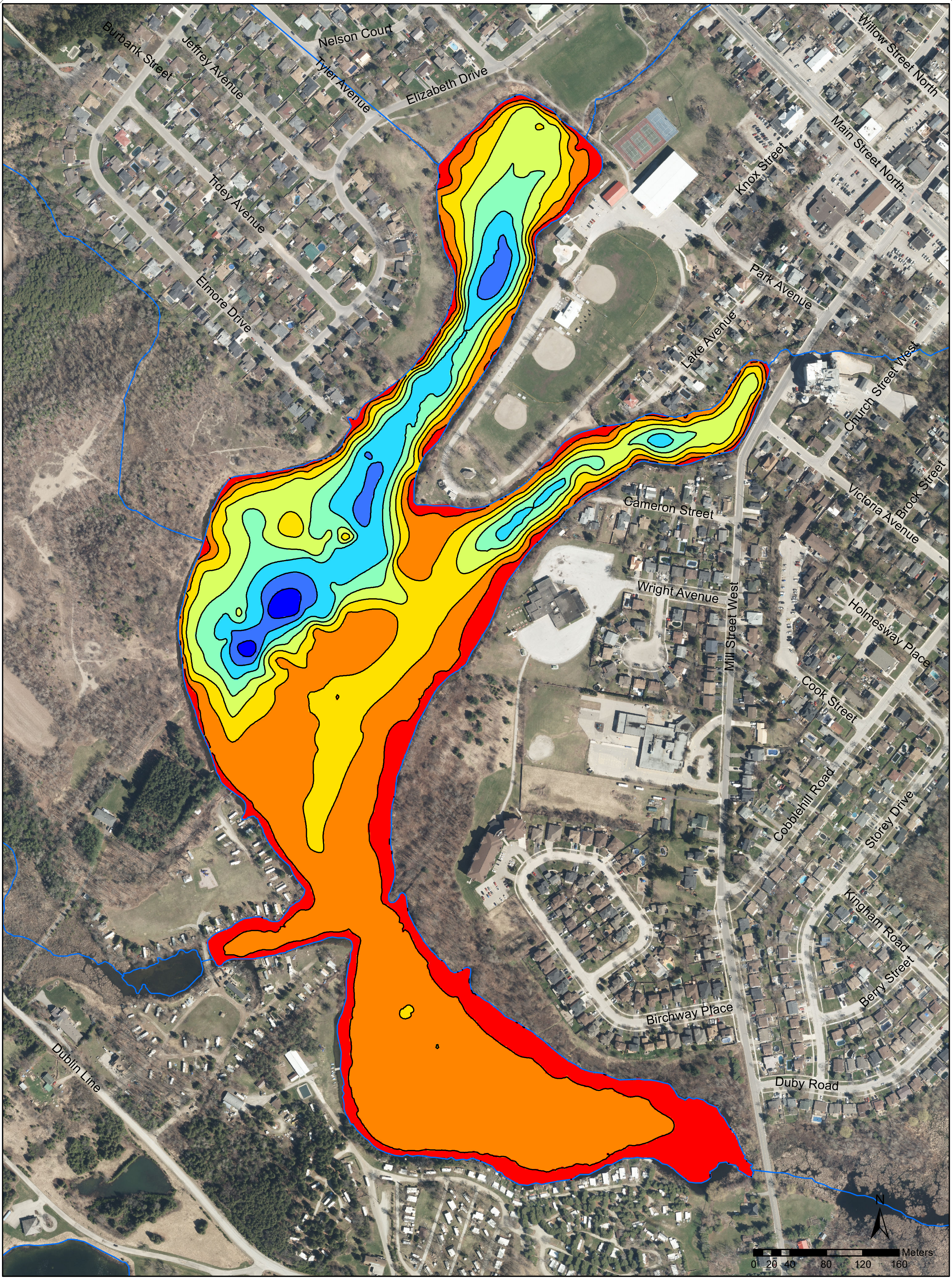
Further data collection was completed throughout the 2022 nesting season. The Town of Halton Hills has been conducting an egg oiling program under a permit issued by the MNRF in an effort to control a nuisance goose population at Fairy Lake for over a decade. An LGL wildlife biologist participated in the egg oiling program conducted on April 20, 2022 and collected data on geese nest locations. The egg oiling program typically runs for several weeks in the spring each year and nests are revisited each week to ensure all eggs laid are oiled, and all nests on the lake are located. Additional data on nest locations and numbers of eggs from subsequent visits was provided by the Town for the remainder of the 2022 nesting season (R. Vanderham, pers. comm.). Through these efforts, the date of the surveys, nest locations, and numbers of eggs were documented. Nests were monitored along the shoreline of the lake and in neighbouring areas where nesting had been observed in the past and where property access was available (Fairview Cemetery and the PSW east of Mill Street).

4.0 Results and Discussion

4.1 Lake Bathymetry

The depth contours developed through the bathymetry survey of Fairy Lake are presented in **Figure 3**. The maximum depth recorded during the survey was 7.73 m, the surface water area as defined using LIO limits for the lake totals 25.4 ha and the lake perimeter measures 4,572 m. Part of the central basin and all of the southern portion of the lake are shallow (less than 2 m in depth) with deeper areas found in the central basin, and within the northwest inlet and the northeast outlet of the lake. The volume of Fairy Lake was calculated at a range of stages from 344.85 m to 345.75 m to derive an average volume of 660,000 m^3 (Water's Edge, 2023).

Efforts were made to compare the 2022 bathymetry to the AECOM (2009) baseline study. Although the results across the two surveys were generally similar in that the central basin and arms of the lake are the deepest and the southern portion the shallowest, there were some limitations to the comparisons that could be made. No digital files or detailed description of the methods for the baseline survey were available to the project team; however, it appears that the data collected by AECOM (2009) may have been at a coarser level than what was collected in 2022. There have been substantial changes in the technology of the equipment used to collect data pertaining to water depth, the two surveys were done in different seasons (previous work completed in summer, while 2022 study done in spring before the growing season to reduce plant interference in depth readings) and, in 2022 a kayak was used to allow for access to the shallowest of areas. Work on the dam was also completed in the intervening years which may have impacted Fairy Lake water levels. The 2022 survey recorded a larger lake volume (660,000 m^3 during the spring of 2022 compared to 400,656 m^3 in the summer of 2008), a deeper maximum depth (7.73 m compared to 7 m in the AECOM (2009) study) and deeper depths through the central part of the lake (2 - 3 metres compared to approximately 1 metre in the AECOM (2009) survey).



Fairy Lake Water Quality Study

Lake Bathymetry

Depth (m)

- 0-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8

- Bathymetric Contour
- Watercourse (LIO)
- Waterbody (LIO)

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Project	TA9122	Figure	3
Date	September 2022	Prepared By	KC
Scale	1:4,000	Verified By	LKR

4.2 Water Quality

Water quality in the lake, the creek, wetland and stormwater inlets, and at the dam outlet was monitored across four seasons to characterize conditions under the summer dry period, wet weather flows in fall, the spring melt/freshet, and under ice cover in winter. A total of 11 surface water quality stations were monitored as summarized in **Table 5**. Representative photos of each station are included in **Appendix A**. The results of the surface water chemistry analysis are summarized in **Appendix B Table 1** and as time series plots in **Appendix C**. Data were compared to provincial water quality objectives or national guidelines where available, and also benchmarked against the baseline data reported in AECOM (2009) to discern trends over time, where possible.

4.2.1 Field Measured Parameters

The in-situ conditions of dissolved oxygen, pH, specific conductivity and water temperature were recorded at each station monitored, as described in Section 3.4. These data are provided in **Appendix B Table 1** and were used to determine the concentration of unionized ammonia (UIA) at the monitored stations, as indicators of water quality in the inlets and outlets monitored, and to characterize water quality conditions at depth in the lake over various seasons. PWQOs have been determined for dissolved oxygen and pH and the data is compared to those standards to characterize aquatic habitat and surface water inputs to the lake.

Water temperature and pH data were used to calculate the theoretical concentration of unionized ammonia (UIA) from the total ammonia concentration determined through laboratory analysis, using the following equations (Ontario Ministry of the Environment, 1994; Canadian Council of Ministers of the Environment, 2010):

<u>Equation 1:</u>

$$pKa=0.0901821+(2729.92)/T$$

Where, T = water temperature in Kelvin (K)
$T(K)=T(°C)+273.15$

<u>Equation 2:</u>

$$f=1/(〖10〗^{(pKa-pH)}+1)$$

Where, f = fraction of total ammonia that is unionized; and,
pKa = dissociation constant from Equation 1

4.2.1.1 Dissolved Oxygen & Water Temperature

There is an inverse relationship that exists between dissolved oxygen and temperature. As the temperature of the water increases, the solubility of oxygen in water decreases, which often results in lower dissolved oxygen levels recorded in warmer conditions. For that reason, the PWQO for DO also changes with changing temperatures to range from

4 mg/L to 7 mg/L at temperatures ranging from 25°C to 0°C, respectively. The decomposition of organic matter in surface water also affects DO levels as the process consumes oxygen. In highly aerated systems, such as turbulent streams, oxygen is replenished from the atmosphere; however, if large quantities of organic matter are present, the demand can deplete dissolved oxygen in a waterbody, particularly if aeration is reduced due to ice cover or lack of turbulence (e.g., small lakes). As decomposition and respiration often occur in the lower layers of the water column, they can become too hypoxic (low dissolved oxygen levels) for organisms to survive. Decomposition tends to increase in fall after the growing season ends. In particular, wetland habitats typically experience relatively high decomposition due to reduced water flow/limited gradient and abundance of vegetation which settles and decomposes in place. The high demand on oxygen coupled with its slow replacement and the lack of turbulence in these features, results in low DO in wetlands during times of high decomposition.

Overall, the stations within wetland habitats (WQ1, WQ10) or wetland like environs (WQ9), demonstrated the lowest overall DO in the study, particularly in fall or under ice conditions when decomposition typically peaks. In particular, DO at WQ1 (PSW inlet) was extremely low in both summer (0.59 mg/L) and fall (1.40 mg/L) demonstrating anoxic levels and well below the PWQO. While conditions at the WQ10 wetland area demonstrated high daytime DO in summer (12.11 mg/L) as a result of high plant productivity, there were subsequent declines in fall and the following spring of 4.44 and 2.77 mg/L, respectively. Although WQ9 is within Fairy Lake, the site is shallow and experiences the prolific plant growth characteristic of the other adjoining wetlands. As such, WQ9 demonstrated similarly low DO in fall (2.91 mg/L) and during ice cover in winter (0.60 mg/L). Biota that remains in the water column in fall and winter typically move into better oxygenated areas during these periods.

DO and water temperature were also recorded during water and sediment sampling at 0.5 m depth increments for lake stations where water depths were in excess of 2 metres (WQ3 and WQ11). These results are displayed seasonally in **Figures 4 and 5**.

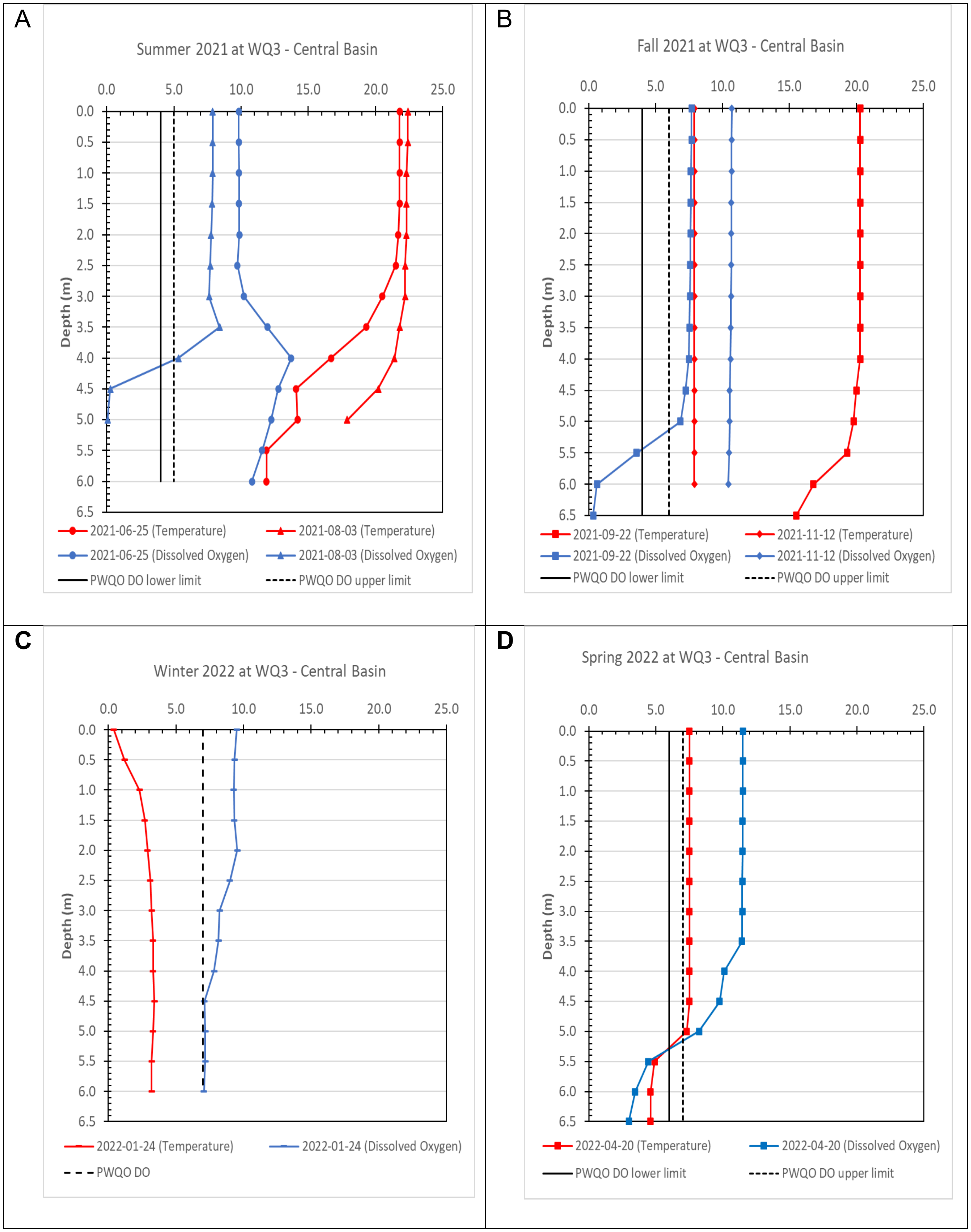


Figure 4. Temperature and dissolved oxygen profiles for Fairy Lake Station WQ3.

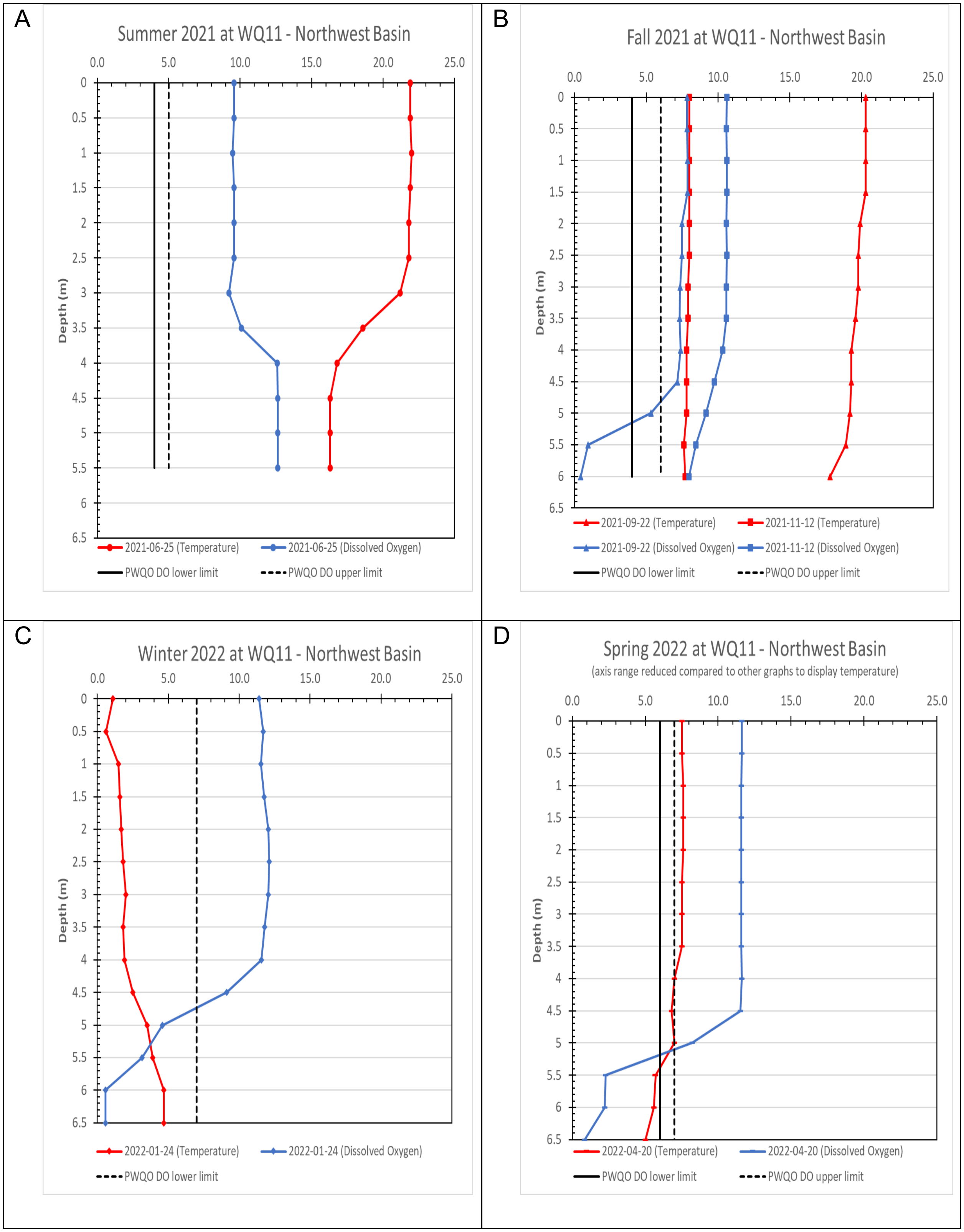


Figure 5. Temperature and dissolved oxygen profiles for Fairy Lake Station WQ11.

Water density is inversely proportional to water temperature up to 4°C when water is at its densest. In deeper lakes, wind and wave action cause the upper water column to mix with deeper waters as the surface warms and density in the upper layer is reduced. The water column then becomes stratified as the differences in temperature (and water density) between the upper and lower water column increase. In shallow lakes, the water column tends to reach a more uniform temperature from the surface down to the lakebed and the water column is generally well mixed with little thermal stratification. Although much of Fairy Lake is shallow, some seasonal stratification was evident in the deeper basins in 2021-2022 (**Figure 4** and **Figure 5**). In June for example, surface water temperatures increased while temperatures at lower depths remained cooler and denser at WQ3 and WQ11 (**Figure 4A** and **Figure 5A**). As the summer progressed, the deeper water column continued to warm and demands on oxygen increased in response to increased decomposition (**Figure A4**; August 3, 2021). This resulted in DO depletion within the deepest areas in September 2021 where DO was recorded at levels below the PWQO established for warmwater species. As temperatures cooled, the rate of decomposition slowed down at WQ3 and water temperatures and DO remain consistent throughout the water column. While at WQ11, DO levels in the deeper areas remained low throughout the winter and early spring (**Figure 5C** and **Figure 5D**).

Overall, DO levels at WQ3 remained above the PWQO for warmwater species in the upper 4 to 5 metres of the water column but demands on DO reduced concentrations in the deepest areas in late summer/early fall and again during the spring melt period. At WQ11 areas deeper than 5 metres experienced DO levels below the PWQO in early fall of 2021, and again during the winter and early spring of 2022. The winter and spring results are an indication of high sediment oxygen demand at this location.

Overall, DO varied with lake morphology (shallow wetland areas vs. deeper lake basins) and the seasonality of plant productivity and decomposition.

4.2.1.2 pH & Alkalinity

At all stations, surface water pH remained within the PWQO range of 6.5-8.5 throughout the monitoring period (**Appendix C, Figure 1-D**). Alkalinity of surface waters was also determined by the analytical lab for use in the calculation of guidelines and objectives for metals which are dependant on water hardness.

4.2.1.3 Conductivity & Dissolved Solids

Conductivity is useful as a general measure of surface water quality. Significant changes in conductivity can be indicators that a deleterious discharge or other source of pollution has entered a waterbody. Conductivity at the monitored stations ranged from 0.131 to 1.242 mS/cm with the highest values recorded in winter under ice cover and during the spring melt (e.g., WQ2 and WQ10; see **Appendix C, Figure 1-C**). Colder air temperatures, snowfall and ice formation can result in elevated conductivity. Surface ice is formed from pure water, therefore where ice formation is prevalent, higher dissolved solids can result as the dissolved solids (salts) remain in solution. Elevated conductivity in fall and early spring is often related to contributions of salt during periods of de-icing.

4.2.2 General Chemistry and Nutrients

4.2.2.1 Total Suspended Solids

Total suspended solids (TSS) ranged from 2 - 45 mg/L in the monitored stations and were highest in stormwater (Tyler (WQ4) and Elmore (WQ8) storm sewers, stormflows at WQ2) and at WQ7 in Black Creek during the spring melt and wet weather events (**Appendix C, Figure 4-B**). Three of the 30 samples collected demonstrated TSS concentrations above the guideline of 25 mg/L (CVC et al., 2009). The exceedances were observed within stormwater flows at WQ2, WQ4 and WQ8 during the melt event in February 2022. Suspended solids (e.g., sediments) can carry nutrients and metals, so elevated concentrations of TSS can result in increased concentrations of other constituents.

4.2.2.2 Dissolved Organic Carbon

In general, organic carbon compounds are the result of decomposition processes from dead organic matter including plants and animals. Relatively high dissolved organic carbon (DOC) is indicative of wetlands. DOC levels at stations monitored as part of the Fairy Lake study ranged from 1.3 to 22.0 mg/L (**Appendix C, Figure 3-B**). The highest concentration recorded overall was in the stormflow at WQ2 in the fall of 2021. The next highest concentrations were recorded at the WQ1 inlet from the wetland units east of Fairy Lake and those west of the lake at WQ10 in summer and fall. This is consistent with the AECOM (2009) monitoring results for WQ10 (data collected by AECOM did not include DOC at WQ1 and WQ2).

4.2.2.3 Carbonaceous Biochemical Oxygen Demand

Carbonaceous Biochemical Oxygen Demand (cBOD) represents oxygen demand associated with biodegradation of organic constituents. cBOD was often found at non-detect levels (<2 mg/L). The exceptions to this were during the early spring melt at the stormwater and creek inlets, however concentrations still remained low at 3-4 mg/L (**Appendix C, Figure 2-C**).

4.2.2.4 Total Ammonia

Concentrations of total ammonia-N (TAN) ranged from 0.065 to 0.4 mg/L and were generally lowest during the dry weather event in August 2021 and highest during the spring melt and wet weather events (**Appendix C, Figure 2-A**). In particular, the highest recorded concentrations were in samples collected from WQ7 at Black Creek, the WQ2 stormwater drainage, WQ10 wetland inlet, and the WQ8 Elmore Drive storm sewer during the February 2022 melt event. The WQ2 stormflow was also observed to have relatively high concentrations of other nitrogenous compounds compared to other monitoring stations in the study, as is noted and described further in the sections that follow.

4.2.2.5 Unionized Ammonia

Ammonia exists in two aqueous forms: ionized (NH4+); and, unionized (NH3). The unionized form is toxic to freshwater fish. A PWQO of 20 µg NH_3/L (equivalent to 16.5 µgN/L) has been established for unionized ammonia (UIA) to protect aquatic biota (MOE 1994). All UIA values calculated for the monitored stations according to the methods described in Section 4.2.1 were below the established PWQO (**Appendix C, Figure 2-B**).

4.2.2.6 Nitrogen, Nitrate and Nitrite

Nitrogen is a critical nutrient that cycles through many different chemical forms to be used and reused by plants. Although nitrogen is naturally abundant it is also introduced into surface water through anthropogenic point sources including municipal and industrial wastewater, and non-point sources such as agricultural runoff (animal waste, fertilizer), septic beds, urban runoff, and storm sewer overflow. Nitrate (NO_3-N) is the most oxidized and stable form of nitrogen in surface water; it is also the main form of nitrogen used by plants. Similar to phosphorus, high nitrate concentrations can result in excessive macrophyte and plankton growth, depriving fish and other aquatic biota of oxygen during periods of plant respiration and decomposition. To protect aquatic life, surface water concentrations of NO_3-N should remain below 3.0 mg/L (CCME, 2012).

Total Nitrogen ranged from 0.5 to 4.3 mg/L with the highest value recorded at WQ2 during the spring melt (**Appendix C, Figure 3-A**). The next highest TAN recorded in the study was less than half of the max value at WQ2.

The majority of nitrate samples collected for the Fairy Lake study ranged from 0.002 to 1.00 mg NO_3-N/L and were well below the Canadian Water Quality Guideline (CWQG) of 3.0 mg/L (**Appendix C, Figure 5-C**). The exception to that was the WQ2 result of 3.0 mg/L found during the spring melt.

Nitrite (NO_2-N) is an intermediate in the oxidation of ammonia to nitrate and can also be used as a nutrient source resulting in plant proliferation and oxygen depletion in aquatic habitats. Nitrite is directly toxic to aquatic life at relatively low concentrations. A federal water quality guideline of 0.06 mg/L has been established for NO_2-N to protect aquatic life (CCME, 2012). All NO_2-N results were well below that guideline, with the highest values recorded at WQ2 (0.018 mg/L) and at WQ7 (0.017 mg/L) during the spring melt in February 2022 (**Appendix C, Figure 5-B**).

4.2.2.7 Total Kjeldahl Nitrogen

TKN is a measure of the combined concentrations of organic nitrogen and ammonia. TKN is a common measurement used as an indicator of nutrient loading from urban runoff and wastewater sources, including lawn and garden fertilizers, pet waste, and leaking septic tanks (Strassler et al., 1999). Nitrogen from aerial and terrestrial sources also accumulates on roads and parking lots and runoff from precipitation events carries it to stormwater drains and on to local waterbodies. Among different land uses, the highest concentrations of TKN from these sources originate from impervious surfaces such as highways, parking lots, and high density residential development (Ip et al. 2001). No Ontario guideline for TKN is currently available; however, surface waters not influenced by excessive organic inputs typically range from 0.100 to 0.500 mg/L according to Environment Canada (1979).

Data collected for the Fairy Lake study was generally in excess of 0.500 mg/L and ranged from 0.20 to 1.28 mg/L, with the highest overall value recorded at the WQ1 PSW inlet in the fall (**Appendix C, Figure 4-C**). The elevated TKN concentration at WQ1 is likely indicative of the organic matter typically held by wetland areas, resulting in naturally high concentrations of organic nitrogen. Concentrations of TKN in the lake were highest in winter (0.699 to 0.886 mg/L). Outside of wetland stations, the highest TKN levels were recorded at the stormwater outfalls and the creek inlet during spring melt, while those same stations recorded the lowest concentrations during the fall wet weather event. Of particular note, TKN at WQ2 was the highest recorded overall during the spring melt and fall wet weather events. This station is at the outlet of a drainage feature crossing a trailer park property which appears to have a connection to a pond upstream, on the north side of Dublin Line. Runoff from neighbouring land uses or contributions from faulty septic systems may be contributing to these results.

4.2.2.8 Ortho-Phosphate

Ortho-P forms are produced by natural processes in rivers, streams, and lakes that recharge aquifers, as well as in the aquifer materials from the erosion of rocks, and the recycling of animal waste and plant and animal tissue. Ortho-P is also contributed through anthropogenic sources including partially treated and untreated sewage, and runoff from agricultural sites. Ortho-P, often referred to as reactive phosphorus, is the form of phosphorus that is available to chemically or biologically react. Yang and Toor (2017) identified sources of orthophosphate in urban stormwater runoff to originate from the erosion of soils and the mineralization of organic materials (leaves, grass clippings). Overall, Ortho-P in surface water samples was found to range from below detection (<0.0010 mg/L) to 0.1200 mg/L (**Appendix C, Figure 3-C**). Overall, the lowest Ortho P levels were observed at the lake stations, with many results reported at non-detect levels. The highest concentrations recorded were found at the Elmore (0.120 mg/L) and Tyler (0.057 mg/L) stormwater outfalls during the spring melt event. Ortho-P during this time was also high (0.062 mg/L) at the WQ2 site. As noted in relation to other nutrients, additional investigation is recommended at WQ2 to determine the source of these nutrient inputs.

4.2.2.9 Total Phosphorus

A similar trend in total phosphorus (TP) to what was observed for Ortho-P was observed in surface water samples collected for the study. Overall, TP ranged from 0.010 to 0.190 mg/L (**Appendix C, Figure 4-A**). TP concentrations were generally below the PWQO at the lake stations (0.020 mg/L). The exceptions to this were observed in winter at WQ9 in the south basin (0.023 mg/L) and at the WQ6 lake outlet (0.021 mg/L) in fall sampling. The highest recorded concentrations in the study were at the Elmore (0.190 mg/L) and Tyler (0.150 mg/L) stormwater outfalls during the spring melt. The PWQO of 0.03 mg/L for rivers was applied to Black Creek and the other inlets to the lake. The results for the creek station (WQ7) were found to exceed the objective during both wet weather events. Concentrations of 0.086 mg/L were recorded during the fall wet weather event and 0.093 mg/L during the spring melt. The wetland stations (WQ1 and WQ10) were also above the PWQO for TP during wet weather events. Similar to the trends noted for Ortho-P and nitrogen containing compounds, WQ2 was also observed to be high in TP. The drainage area and source of the stormflow at WQ2 should be further investigated to determine the source of nutrients in surface water collected from this location. Available topographic data indicates that overland flow from the Blue Springs Golf Course south of Dublin Line does not drain toward Fairy Lake. A culvert directs flow during wet weather and spring melt events from the private property on the west side of Dublin Line, across the road to the Breezes Trailer Park which then flows through a grassed channel into Fairy Lake at WQ2. It is recommended that the chemical composition and source of the flows from the private property on the west side of Dublin Line be further investigated to provide additional information regarding the source of TP and nitrogen containing compounds found in WQ2 samples. This effort should also consider the extent to which septic system inputs in the trailer park or elsewhere may be contributing to these results.

In August 2021, two water samples were collected from the deepest area of the lake at WQ3, one from approximately 1m off the lake bottom and the other 1m from the lake surface. A higher phosphorus concentration was observed in the water collected near the lake bottom (0.037mg/L), compared to that near the lake surface (0.014 mg/L) on the same date. A similar finding was observed in the AECOM (2009) data set. At that time the elevated phosphorus concentration near the lake bottom was attributed to either internal phosphorus loading due to lack of oxygen near the sediment-water interface or, settling and remineralization of organic matter from the upper waters (AECOM, 2009). The DO concentrations on the lake bottom were low in AECOM (2009) but anoxic conditions (0 mg/L) were not present. In summer 2021, DO levels dropped significantly at water depths greater than 4.5 metres and approached anoxia with a recorded DO of <0.10 mg/L (Figure 4A). Some of the other instances of TP exceeding the PWQO (e.g., WQ10 during spring melt, WQ9 under ice on Jan 24, and WQ1 in summer and fall) were coincident with relatively low/hypoxic DO conditions ranging from 0.60 – 2.77 mg/L.

4.2.2.10 Chloride

The chloride ion (Cl^-) is naturally occurring in surface water; however, anthropogenic sources such as the application of salt for road de-icing contributes to the levels observed, particularly in urbanized areas. Other sources of chlorides include industrial and wastewater treatment effluents. In some watersheds, the use of salt-based water softening systems contributes to the chloride levels observed in treated wastewater that is discharged to receiving waters. In the case of the Black Creek Watershed, CVC et al. (2009) attribute elevated chloride in surface water to the application of road salt. The CVC has adopted a guideline of 250 mg/L for evaluating their surface water quality data, however the CCME (2011) guideline of 120 mg/L for the protection of aquatic life has been applied to the Fairy Lake Water Quality Study. Cl^- is toxic to freshwater aquatic organisms and the CWQG of 120 mg/L has been established for long term, or chronic, exposure. Given that the data collected here represent point measurements (not continuous data collection to determine chronic conditions) use of this guideline is considered to be a conservative approach to benchmarking the data.

Overall, Cl^- concentrations ranged from 0.5 to 130 mg/L (**Appendix C, Figure 5-A**). All of the results but one (130 mg/L at WQ7 Black Creek during the spring melt) were below the CWQG of 120 mg/L. Concentrations of Cl^- were elevated at both stormwater outfalls (100 mg/L at WQ4 and 110 mg/L at WQ8) during the melt in February 2022 and at a similar concentration (100 mg/L) at WQ2 during the wet weather event in the fall of 2021. In contrast, the largest concentration reported in AECOM (2009) was the mean of 223 mg/L at the Tyler Avenue storm outfall. Overall, Cl^- was found in reduced concentrations compared to the AECOM (2009) study at sites that had comparative data available.

4.2.3 Metals

Metals analysis was limited to the stormwater inlets at Tyler Avenue (WQ4) and Elmore Drive (WQ8) and the Black Creek inlet at WQ7 during wet weather events. Most metals concentrations were within applicable PWQOs where available (**Appendix B, Table 1**) and were found in similar concentrations between sites (**Appendix C, Figures 7 to 14**). The following metals were observed to be above their respective PWQOs:

- total aluminum at stormwater outfalls (WQ4 and WQ8) and Black Creek (WQ7) during both wet weather events;
- total copper at one of the two wet weather events at each of WQ4, WQ7 and WQ8;

- total iron during five of the seven sampling events;
- total zinc during both wet weather events at WQ4, and the February 2022 spring melt events at WQ7 and WQ8.

The time-series plots provided in **Appendix C, Figures 7 to 14** demonstrate that concentrations of metals were generally highest during the spring melt period in February 2022 and many of the highest values in the study were recorded at the Tyler stormwater outfall (WQ4). Although the Tyler outfall demonstrated the highest values associated with the spring melt, the highest concentrations recorded during the fall wet weather event in September 2021 were often observed in the creek at WQ7 (aluminum, antimony, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, selenium, silicon, strontium, thallium, titanium and vanadium) reflecting the influence of urban runoff on water quality.

4.2.4 Bacteria

Using the Guidelines for Canadian Recreational Water Quality – Third Edition (Health Canada 2012) the following values were applied to the data obtained for the study:

- Geometric mean concentration (minimum of five samples): ≤ 200 *E. coli* /100 mL
- Single-sample maximum concentration: ≤ *400 E. coli* /100 mL

Given that single grab samples were collected for the *E. coli* analysis of Fairy Lake, the single sample maximum of ≤ 400 *E. coli* /100 mL was applied to the data collected by LGL in 2021-2022. However, Halton Region Public Health provided data for their weekly summer sampling conducted at the Fairy Lake beach (WQ5) in 2021 to include five grab samples; for those results the Region applied the geometric mean approach of ≤ 200 *E. coli* /100 mL to determine safe recreational use as shown in **Figure 6**.

In data collected by LGL Limited, *E. coli* counts were highest during the fall wet weather event at WQ4 Tyler stormwater inlet (9700/100 mL) as shown in **Appendix C, Figure 6-C**. That sample, along with all other inlet samples (WQ1, WQ2, WQ7, WQ8 and WQ10) from the same event, were above the guideline for recreational use. *E. coli* counts at the WQ8 Elmore stormwater inlet were very high (8600/100mL) during the spring melt; however, all remaining samples collected during the spring melt events (February 17, 2022 for inlet/outlets and April 20, 2022 for lake stations) were observed at concentrations below the Public Health guideline for recreational use of ≤ *400 E. coli* /100 mL.

Of the three samples collected by LGL at the beach station (WQ5), the highest count was observed to be 110 *E. coli* /100 mL during the wet weather event on September 22, 2021. However, water quality at the beach was found to be unsafe for swimming over 60% of the summer season based on weekly *E.coli* counts sampled from the end of May to September 1, 2021 (Halton Region, see **Figure 6**). The periods of beach closure in 2021 were primarily throughout June and July. The frequency of beach closures since 2019 have exceeded the 12-year average.

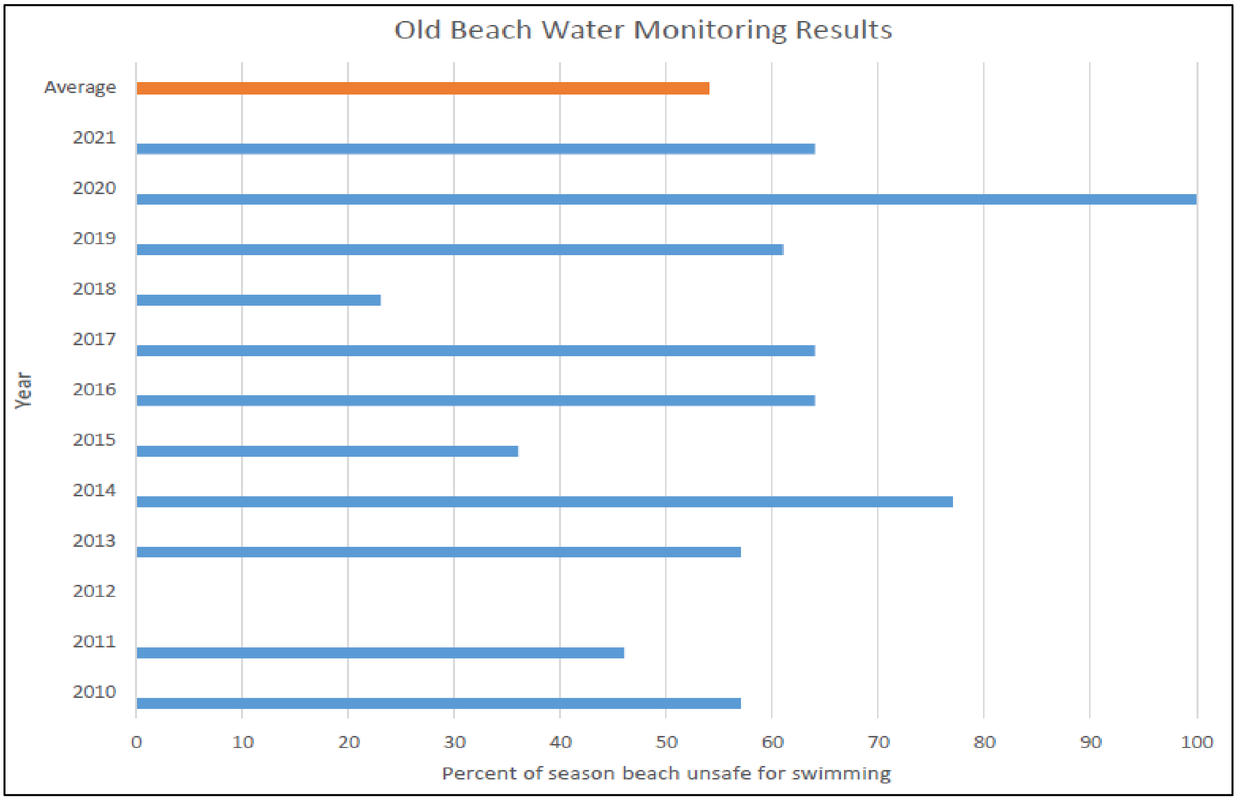


Figure 6. Percentage of Season Old Beach is Closed (Source: Halton Region)

4.2.5 Microcystin

Blue-green algae (BGA) can live in freshwater, salt water, or in mixed “brackish” water. Contrary to what the naming implies, species of blue green algae exist in many colors. They have also been found to share many characteristics of bacteria, which has led to them being known as “cyanobacteria”. Blue-green algae, or cyanobacteria, can multiply quickly in lakes with high nutrient levels, particularly when the water is warm, and the weather is calm (IDPH, 2012). The population explosion of these species when it occurs is referred to as a ‘bloom’. Visually, the waters turn green and often include floating layers of scum. A bloom can also occur beneath the water surface, spontaneously disappear, or move to different areas in the waterbody over short periods of time (Graham et al., 2008). Most BGA species do not produce toxins that are harmful to people or animals; however, some types do produce toxins within their cells that are released when the cells die off or are ruptured (IDPH, 2012). Microcystin are a class of toxins produced by certain freshwater BGA. Human contact with microcystin is typically through exposure to microcystin contaminated drinking or recreational waters. When toxins are present, the bloom is often referred to as a harmful algal bloom (HAB). The federal guideline value for total microcystin in recreational waters used for primary contact recreation (activities where the ingestion of small amounts of water is likely; e.g., swimming) is a maximum concentration of 10 µg/L (Health Canada, 2022). This is based on exposure of children since they are considered the group most likely to ingest water when using surface water for recreational purposes. Some BGA can produce toxins which accumulate in fish. Research suggests that the consumption of fish and fish organs from areas where a major BGA bloom occurs should be avoided during and at least two weeks after the bloom (www.ontario.ca).

Halton Region Public Health visually monitors for BGA at the public beach beginning in late June/early July of any given year and throughout the summer as part of their routine beach monitoring. If BGA is visually observed, staff do not enter the water (for safety reasons), therefore no measure of microcystin is collected. Daily visual monitoring is conducted until BGA is no longer observed, at which point a water sample is collected and analyzed for microcystin. Since 2019, HABs have been observed in the area of the boathouse and public beach. Warning signs are posted to communicate the presence of BGA to the public when it's observed. LGL included microcystin in the sample analysis at five of the Fairy Lake stations during the summer of 2021 (August 3). No visual algal bloom was evident at the time of sample collection and all results were reported at non-detect (<RDL) levels, as summarized in **Table 8.** All of the lake samples collected in August 2021 were below the federal guideline of 10 µg/L for recreational use. These results are consistent with Halton Region Public Health data for the public beach in August 2021; however, BGA was observed in the area of the boathouse in late August of that year.

Table 8. Summary of Microcystin results, August 3, 2021

Station	Microcystin (all below RDL)
WQ3 Central Basin	below 0.10 µg/L
WQ5 Old Beach	below 10 µg/L
WQ9 South Basin	below 2 µg/L
WQ10 West Inlet	below 0.10 µg/L

RDL – reportable detection limit

Note, detection limits change with dilution of the sample for lab analysis.

A detailed multi-year study of HABs in Fairy Lake led by researchers from the University of Guelph began in the spring of 2022. The study includes water quality sampling, microbial source tracking, and eDNA monitoring of Fairy Lake. Results of the study will be reported in 2024. Using the data collected, a Fairy Lake model will be developed to inform the mechanisms and potential for BGA resurgence in the lake. The results of that study, when available, will help agencies, stakeholders and the Town to better understand the extent of the problem and provide some predictive tools or recommendations for the management of the lake to support its recreational uses and improve overall lake health as it pertains to *E.coli* and HABs.

4.2.6 Results of Blind Replicate (QA/QC) Sampling

A blind replicate (duplicate) sample was collected during each of the dry weather and wet weather events. These samples are collected to ascertain the precision of the sampling method and local heterogeneity of samples. To this end, the relative percent difference (RPD) between each replicate sample (R) and the corresponding original sample (O) is calculated as a measure of precision using the following equation:

$$Relative\ Percent\ Difference\ (RPD) = \frac{ABS(R-O)}{(R+O)/2}\ x\ 100$$

Precision is influenced by how close an analytical value is to the laboratory detection limit for a given parameter. As a measured, analytical value approaches the detection limit, variability increases (precision decreases); thus, it is recommended that the use of the RPD be limited to analytical values that are at least five times the detection limit of the analytical method (British Columbia Ministry of the Environment, 2003). For this reason, RPDs are only calculated for those samples where analytical values are detected at five times the detection limit for a given analyte.

For the Fairy Lake Water Quality Study (i.e., surface water) differences between concentrations in duplicate surface water samples were considered notable if the RPD was greater than 20%. Within station variability and field sampling precision in duplicate surface water samples were rated as:

- low variability and high precision if less than 10% of the parameters included in the duplicate sample analysis were notably different from one another;
- medium variability and precision if 10% - 30% of the parameters included in the duplicate sample analysis were notably different from one another; or,
- high variability and low precision if greater than 30% of the parameters included in the duplicate sample analysis were notably different from one another.

Water chemistry results obtained for the replicate samples collected throughout the 2021-2022 sampling are displayed in **Appendix B Table 3**. The analysis showed that 13.0% (2 of 23 results) of the RPDs calculated for replicate samples were outside of the 20% range which represents low-medium variability and high-medium precision within stations. The wet weather event at WQ1 demonstrated the greatest variability of the stations where replicate samples were collected.

4.3 Nutrient Modelling

The results of the Fairy Lake Water Quality Modelling Study are presented under separate cover (Water's Edge 2023) and summarized herein. Fairy Lake generally acts as a storage unit in the watershed and outflow of the dam over long periods is considered to equal Inflow. Therefore, Fairy Lake is a storage facility that temporarily holds water rather than overflowing or completely draining. Evaporation is assumed to equal precipitation. In the model, phosphorus is added to the lake through runoff. The majority comes through the inlets into the lake. Phosphorus then either remains in the lake or flows out through the dam. Using these assumptions, retention time and phosphorus loadings were estimated for the lake. An average volume of 660,000 m^3 was calculated for the lake. The inflow of Fairy Lake was modelled through EPA SWMM with precipitation inputs between 2009 and 2022. The annual inflow was estimated to be about 3,000,000 m^3. From this, a retention time of 0.22 years was calculated for the lake. The average loading of phosphorus through runoff was modelled over 13 years at an average of 0.012 mg/L, obtained by dividing annual mass buildup by annual outflow volume.

The relative loading of phosphorus to the lake was determined for the inlets monitored as part of the Fairy Lake Water Quality Study (**Figure 7**). Most of the TP load to the lake is through the Black Creek/Bovis Creek inlet (60% of the total) and 23% of the annual load comes from the storm sewers at Elmore Drive and Tyler Avenue. The average concentration of phosphorus for the lake was modelled to be 0.038 mg/L which is above the PWQOs of 0.020 mg/L for lakes and 0.030 mg/L for rivers. The results of the model were used to identify recommendations to reduce phosphorus inputs to the lake and evaluate those options using a number of criteria (effectiveness, distribution, level of maintenance, cost/availability of funds and timeline for implementation). Weighting of the criteria was also applied so that 'effectiveness' was treated as the most important factor. The results of that analyses along with the detailed methodology and model outputs are presented in the Fairy Lake Water Quality Study WQ Modelling Report (Water's Edge, 2023). The recommendations that resulted from the modelling report are included herein as part of the Section 6.0 Management Recommendations.

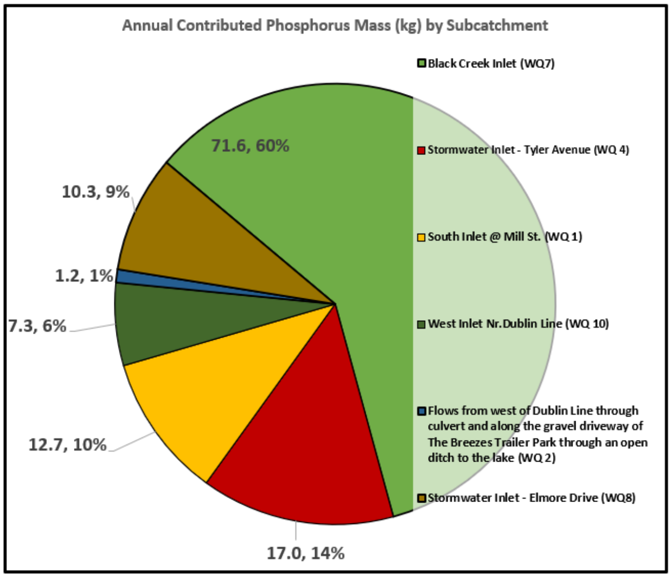


Figure 7. Annual Contributed Phosphorus Load (kg) by Subcatchment (Source: Water's Edge, 2023)

4.4 Sediment Quality

Sediment samples were collected in the fall to characterize the sediment quality in the lakebed during the period of greatest decomposition and oxygen demand. Sediment quality stations are summarized in **Table 5**. Representative photos of each station are included in **Appendix A**. The results of the sediment chemistry analysis are provided in **Appendix B Table 2.**

The PSQGs (see Section 3.4.5) establish three levels of effect based on the long-term effects on benthos (invertebrates living in sediments) that result from exposure to various contaminants. The lowest effect level (LEL) and the severe effect level (SEL) are based on long term effects the sediments can have on these bottom dwelling organisms. The no effect level (NEL) is based on levels of contaminants that are so low, that no contaminants are passed through the food chain. Fairy Lake data were compared to PSQGs or national guidelines, where available. Data were also benchmarked against the baseline data reported in AECOM (2009); however, that data was limited to the four nutrient parameters displayed in **Figure 8**.

4.4.1 General Chemistry and Nutrients

4.4.1.1 Moisture

Physical properties of sediment such as moisture content can be related to other properties like grain size, porosity, and organic matter content. Where higher moisture content occurs there is greater porosity and greater diffusion between the water and underlying soil, which results in greater absorption capacity of the sediment towards chemical parameters. Higher organic matter content corresponds to greater moisture content (Avnimelech, 2001).

Sediment moisture content in the sample sites ranged from 52 to 90%. The highest moisture content was found at SQ2 in the south basin of Fairy Lake. This is likely due to the wetland-like condition of the lake in that area where water depth is shallow, there is abundant aquatic macrophyte growth, and a larger layer of organic matter in the soil.

4.4.1.2 Total Organic Carbon

Carbon is present in sediment in both organic and inorganic forms. Organic forms include chemical, plant, and animal matter which use available oxygen, thereby reducing dissolved oxygen in water. Total organic carbon (TOC) results ranged from 42000 mg/kg at SQ3 in the central basin to 94000 mg/kg at SQ2 in the south basin. All results were above the PWQG for the LEL of 10000 mg/kg but below the SEL of 100,000 mg/kg. TOC was one of the four parameters measured in the AECOM 2009 study. Results from 2022 were similar to those reported in 2009 (**Figure 7B**).

4.4.1.3 Total Ammonia

Concentrations of total ammonia (TAN) in 2022 sampling were below the detection limit of 20 ug/g at both SQ1 and SQ3 and were 57 ug/g at SQ2. Total ammonia was one of the four parameters measured in the AECOM 2009 study. Results at SQ1 and SQ3 were similar between 2009 and 2022, but an increase in TAN was observed at SQ2 in 2022 (**Figure 7A**).

4.4.1.4 Nitrogen, Nitrate and Nitrite

As noted previously, nitrogen is a critical nutrient in aquatic ecosystems and is naturally abundant, however it is also introduced into surface water through anthropogenic point sources including municipal and industrial wastewater, and non-point sources such as agricultural runoff (animal waste, fertilizer), septic beds, urban runoff, and storm sewer overflow. Nitrogen levels ranged from 0.3% at SQ3 in the central basin to 1.3% at SQ2 in the south basin. At stations SQ1 and SQ3, NO_2-N concentrations were below the detection limit of 0.5 ug/g. SQ2 had the highest nitrite concentration at 0.8 ug/g. NO_3-N concentrations at all sediment sampling stations were below the detection limit of 2 ug/g (**Appendix B Table 2**).

4.4.1.5 Total Kjeldahl Nitrogen

TKN is a measure of the combined concentrations of organic nitrogen and ammonia (i.e., TKN is calculated by the lab based on other analyses). Concentrations of TKN ranged from 2970 ug/g at SW3 to 13500 ug/g at SQ2 and followed a similar trend to other parameters. The results at SQ1 and SQ2 were both above the PSQG for the severe effects level of 4800 ug/g and results at SQ3 were above the PSQG for the lowest effects level of 550 ug/g but below the severe effects level. Compared to the

AECOM (2009) baseline study, TKN was found in similar concentrations at SQ3, somewhat elevated at SQ1, and was found at concentrations 1.5 times greater at SQ2 (**Figure 7C**). Given the limitations of comparing a single sediment TKN result from 2008 to a single result from 2021 (i.e., inherent variation in sediment quality data, lack of information available to confirm consistency in sampling location, lab methodology and detection limits from the previous study), the difference between years at SQ2 is identified along with a recommendation for further study as part of a longer term water quality monitoring program for Fairy Lake to confirm potential trends in sediment TKN at this location.

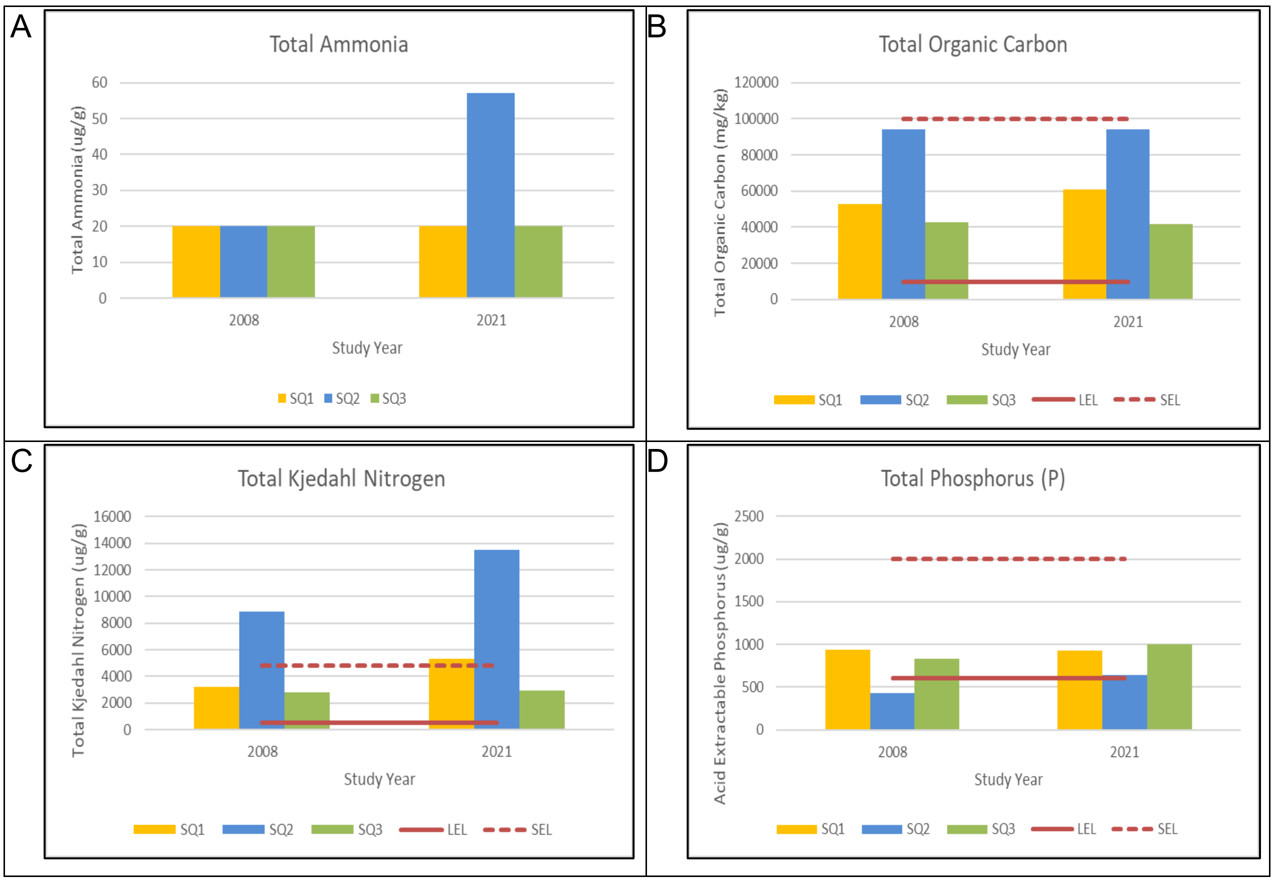


Figure 8. Total ammonia-N (A), total organic carbon (B), total Kjedahl nitrogen (C), and total phosphorus (D) in Fairy Lake sediments, 2008 (AECOM, 2009) and 2021.

4.4.2 Metals

Sediment metal content reflects the composition of the parent material but can also reflect additional inputs to the lake. Metals can enter aquatic environments through anthropogenic sources like aerial deposition, runoff, industrial and wastewater inputs. Many metals are essential elements but can be toxic to aquatic biota at elevated concentrations. Lake sediments were not analysed for metals concentrations as part of the AECOM (2009) study and so no comparisons could be made to the current results. The focus of the discussion that follows is where results from the 2021-2022 study did not comply with the PSQGs.

Overall, metal concentrations at SQ2 were lowest while higher concentrations were observed at the other two stations, particularly at SQ1 in the north basin where an area of deposition from Black Creek has been noted in past studies (**Appendix B Table 2**). The relatively low metal concentrations at SQ2 are reflective of what's likely an area of reduced deposition and the heavily vegetated nature of SQ2 where macrophytes may be attenuating metals. Metals that were above the PSQG lowest effects levels (LEL) but below the severe effects levels (SEL) at all sampling stations are lead, phosphorus, and zinc. Arsenic, cadmium, chromium, manganese, and nickel were above the LEL but below the SEL at SQ1 and SQ3. A PSQG is not available for copper; however, copper was above the Federal Sediment Quality Guideline at the interim sediment quality guideline (ISQG) level but below the probable effect level (PEL) at SQ1 and SW3. No metal concentrations were observed at levels greater than the PSQG severe effects level in any of the samples collected.

4.5 Vegetation

4.5.1 Site Description

Land use immediately surrounding Fairy Lake is primarily residential (seasonal and permanent), recreational, and open space/parkland. Natural or naturalized areas along the lake are the result of secondary succession following disturbance and restoration efforts. One of these communities is along the shoreline, west of the lake's central basin and adjacent to an agricultural field. This site is under private ownership and land access was not available for pedestrian survey during field investigations. Natural areas are also found along the eastern edge of the lake from south of the Royal Canadian Legion to Mill Street, behind residential properties. Maintenance of the parks and Royal Canadian Legion through mowing has resulted in a narrow band of riparian vegetation along the remaining edge of the lake. The residential properties that back on to Fairy Lake generally have mowed grass to the edge of the shoreline. There is also a maintained area directly behind the fence line of residences along Birchway Place and a few trails/paths have been cleared to gain access to the water. Aquatic vegetation throughout the lake is particularly abundant in the southern portion. Although aquatic macrophytes have not been quantified throughout the lake in this study or AECOM

(2009), ELC delineation can be qualitatively compared and is described in Section 4.5.2 below.

4.5.2 Ecological Land Classification (ELC)

The terrestrial vegetation communities surrounding Fairy Lake are comprised of forests in varying degrees of succession, plantations, cultural woodlands, thickets and meadows (**Figure 8**). The forested communities consist of White Cedar coniferous forest (FOC2-2), Ash (FOD7-2), Willow (FOD7-3), Poplar (FOD8-1) and deciduous lowland forest (FOD7). Cultural communities are either maintained or have naturalized following previous disturbance. Some of the communities, particularly south of the Royal Canadian Legion, have evidence of plantings. Cultural communities consist of old field cultural meadow (CUM1-1), Silver Grass meadow (CUM1-1a), Raspberry cultural meadow (CUT1-5), Dogwood cultural thicket (CUT1-a), cultural woodland (CUW1) and Scots Pine (CUP3-3) and White Spruce (VUP3-8) coniferous plantations. Wetland and aquatic communities dominate the lake and shoreline of Fairy Lake. Macrophyte vegetation and shallow/submerged communities cover most of the southern portion of the lake later in the growing season. The lake contains several submerged aquatic communities such as: Pondweed mixed shallow aquatic (SAM1-4), Water Milfoil Mixed shallow aquatic (SAM1-7), submerged shallow aquatic (SAS1), stonewort submerged aquatic (SAS1-3), White Water-lily shallow aquatic (SAS1-a), and Yellow Water-lily submerged shallow aquatic (SAS1-b). Swamp thicket communities are also present and consist of an Alder thicket swamp (SWT2-1), Willow thicket swamps (SWT2-2) and a Red-osier thicket swamp (SWT2-5). Vegetation communities identified here are delineate in **Figure 9** and described in further detail in **Table 9**.

Based on a comparison of the ELC mapping between AECOM (2009) and the 2022 study, the geographic extent of the open water area of the lake appears larger with less aquatic macrophyte cover in 2022. Particularly, in the north arm of the lake there is reduced coverage of aquatic macrophytes around the edge of the lake and the open water area in the central basin extends further south in 2022.

Fairy Lake Water Quality Study

Ecological Land Classification, Invasive and Rare Species

Ecological Land Classification
Watercourse (LIO)
Waterbody (LIO)

LGL LIMITED
Est. 1971
environmental research associates

Project	TA9122	Figure	9
Date	February 2023	Prepared By	KC
Scale	1:5,000	Verified By	LKR

Table 9. Summary of Ecological Land Classification Vegetation Communities

ELC Code	Vegetation Type	Species Association	Community Characteristics
TERRESTRIAL – NATURAL/SEMI-NATURAL			
FOC	CONIFEROUS FOREST		
FOC2	Dry – Fresh Cedar Coniferous Forest		
FOC2-2	Dry – Fresh White Cedar Coniferous Forest	Canopy: Eastern White Cedar (*Thuja occidentalis*)	Coniferous trees > 75 % of canopy cover (C). Dry to fresh moisture regime Dominated by Cedar (2)
FOD	DECIDUOUS FOREST		
FOD7	Fresh – Moist Lowland Deciduous Forest		
FOD 7	Lowland Deciduous Forest	Canopy: Manitoba Maple (*Acer negundo*), Trembling Aspen (*Populus tremuloides*), Eastern Cottonwood (*Populus deltoides*), Red Ash (*Fraxinus pensylvanica*), Siberian Elm (*Ulmus pumila*), White Spruce (*Picea glauca*), Willow (*Salix* sp.), Silver Maple (*Acer saccharinum*), Eastern White Cedar, Black Walnut (*Juglans nigra*), European Birch (*Betula pendula*)	Tree cover > 60 % (FO). Deciduous trees > 75 % of canopy cover (D). Moist to fresh soils with well to poor drainage typically occurring in the lower slope, bottomlands such as floodplains (7). Mixture of trees naturalized along the edge of the lake and west of Birchway Place
FOD7-2	Fresh – Moist Lowland Deciduous Forest	Canopy: Red Ash, Willow, and White Elm (*Ulmus americana*) Understorey: large presence of Riverbank Grape (Vitis riparia), Common Buckthorn (*Rhamnus cathartica*) and Alder-leaved Buckthorn (*Rhamnus alnifolia*)	Tree cover > 60 % (FO). Deciduous trees > 75 % of canopy cover (D). Moist to fresh soils with well to poor drainage typically occurring in the lower slope, bottomlands such as floodplains (7). Ash dominated community (2) Many of the ash within the study area are showing signs of decline due to the Emerald Ash Borer (*Agrilus planipennis*).

ELC Code	Vegetation Type	Species Association	Community Characteristics
FOD7-3	Fresh – Moist Lowland Deciduous Forest	Canopy: Willow and Eastern Cottonwood Understorey: regenerating Red Ash (*Fraxinus pensylvanica*), with White Elm and Alder-leaved Buckthorn	Tree cover > 60 % (FO). Deciduous trees > 75 % of canopy cover (D). Moist to fresh soils with well to poor drainage typically occurring in the lower slope, bottomlands such as floodplains (7). Willow dominant (3) Was once a Red Ash dominated community that has transitioned into a willow community.
FOD8	Fresh-Moist Poplar Deciduous Forest		
FOD8-1	Fresh- Moist Poplar Deciduous Forest	Canopy: Eastern Cottonwood and Balsam Poplar (*Populus balsamifera*) dominant with Black Walnut and Norway Maple (*Acer platanoides*)	Tree cover > 60 % (FO). Deciduous trees > 75 % of canopy cover (D). Moist to fresh soils with well to poor drainage typically occurring in the lower slope, bottomlands such as floodplains (8). Dominated by Poplar (1)
TERRESTRIAL – CULTURAL			
CUP	Cultural Plantation		
CUP3	Cultural Coniferous Plantation		
CUP3-3	Scots Pine Coniferous Plantation	Canopy: Scots Pine (*Pinus sylvestris*), White Pine (*Pinus strobus*)	Communities resulting from or maintained by cultural or anthropogenic-based disturbances (CU). Tree Cover >60% (P). Coniferous Plantation (3) Dominated by Scots Pine (3)
CUP3-8	White Spruce Coniferous Plantation	Canopy: White Spruce (*Picea glauca*) and Norway Spruce (*Picea abies*)	Communities resulting from or maintained by cultural or anthropogenic-based disturbances (CU). Tree Cover >60% (P). Coniferous Plantation (3) dominated by White Spruce (8).

ELC Code	**Vegetation Type**	**Species Association**	**Community Characteristics**
			Result of secondary growth arising from heavily managed and disturbed sites.
CUM	CULTURAL MEADOW		
CUM1	Mineral Cultural Meadow		
CUM1-1	Dry-Moist Old Field Meadow	Ground Cover: Canada Goldenrod (*Solidago canadensis*), Awnless Brome (*Bromus inermis ssp. inermis*), White Sweet Clover (*Melilotus alba*), Stonecrop (*Sedum* sp.), Blueweed (*Echium vulgare*)	Tree cover and shrub cover < 25 % (CUM). This community can occur on a wide range of soil moisture regimes (Dry-Moist) (1-1). Grass and forb dominant. Community resulting from, or maintained by, anthropogenic-based influences.
CUM1-a	Silver Grass Meadow	Ground Cover: Chinese Silver Grass (*Miscanthus sinensis*) dominant	Tree cover and shrub cover < 25 % (CUM). This community can occur on a wide range of soil moisture regimes (Dry-Moist) (1-1). Dominant by non native Chinese Silver Grass. Community resulting from, or maintained by, anthropogenic-based influences.
CUT	CULTURAL THICKET		
CUT1	Mineral Cultural Thicket		
CUT1-5	Raspberry Cultural Thicket	Canopy: Black Raspberry (*Rubus occidentalis)* dominant with Virginia Creeper (*Parthenocissus quinquefolia*) Ground cover: sparse with occasional Canada Goldenrod (*Solidago canadensis*)	Tree cover < 25 % and shrub cover > 25 % (CUT). Mineral Cultural Thicket (1) dominated by Black Raspberry (-5). Community resulting from, or maintained by, anthropogenic-based influences.
CUW	CULTURAL WOODLAND		
CUW1	Mineral Cultural Woodland		

ELC Code	Vegetation Type	Species Association	Community Characteristics
CUW1	Mineral Cultural Woodland	Canopy: White Pine (*Pinus strobus*), Black Walnut (*Juglans nigra*), Silver Maple (*Acer saccharinum*), Little Leaf Linden (*Tilia cordata*), Norway Maple (*Acer platanoides*) Understorey: Multiflower rose (*Rosa multiflora*), Common Buckthorn (*Rhamnus cathartica*), Red Raspberry (*Rubus idaeus ssp. Idaeus*), Staghorn Sumac (*Rhus hirta*)	Cultural communities (CU). Tree cover between 35 and 60 % (W). This community can occur on a wide range of soil moisture regimes (Dry-Moist) (1). Community resulting from, or maintained by, anthropogenic-based influences.
WETLAND – NATURAL/SEMI-NATURAL			
SWT	THICKET SWAMP		
SWT2	Mineral Thicket Swamp		
SWT2-1	Alder Mineral Thicket Swamp	Canopy: Speckled Alder (*Alnus incana ssp. rugosa*) with Red-osier Dogwood Ground Cover: Rough Leaved Goldenrod (Solidago rugosa), Creeping Jenny (*Lysimachia nummularia*)	Seasonally flooded and dominated by hydrophytic trees and shrubs > 25% cover (SW) Tree cover ≤25% and >25% shrub cover (T). Mineral soils (2). Dominated by Alder (1).
SWT2-2	Willow Mineral Thicket Swamp	Canopy: Slender Willow (*Salix petiolaris*)	Seasonally flooded and dominated by hydrophytic trees and shrubs > 25% cover (SW) Tree cover ≤25% and >25% shrub cover (T). Mineral soils (2). Dominated by Willow (2).
SWT2-5	Red-osier Mineral Thicket Swamp	Canopy: Red-osier Dogwood (*Cornus sericeae*) and Meadowsweet (*Spiraea alba*) Ground Cover: Sensitive Fern (*Onoclea sensibilis*),	Seasonally flooded and dominated by hydrophytic trees and shrubs > 25% cover (SW) Tree cover ≤25% and >25% shrub cover (T). Mineral soils (2).

ELC Code	Vegetation Type	Species Association	Community Characteristics
		Reed Canary Grass (*Phalaris arundinaceae*)	Dominated by Red-osier Dogwood (5).
MAM	MEADOW MARSH		
MAM2	Mineral Meadow Marsh		
MAM2-12	Common Reed Mineral Meadow Marsh	Ground Cover: Common Reed (*Phragmites australis*)	Seasonally flooded and dominated by emergent hydrophytic macrophytes (MAM). Mineral soil (2). Dominated by a mixture of Common Reed (-12).
OAO	OPEN WATER AQUATIC		
OAO	Open Aquatic	No macrophyte vegetation cover	Permanently flooded area water greater than >2 m in depth (OAO) Associated with a dug feature within the larger restoration area.
SAS	SHALLOW AQUATIC		
SAS1	Submerged Shallow Aquatic	Dominated by Fragrant Water-lily (*Nymphaea odorata*) and Bullhead Pond-lily (*Nuphar variegata*)	Permanently flooded area of water up to 2 m in depth. Dominated by submergent macrophytes.
SAS1-A	White Water Lily Shallow Aquatic	Dominated by Fragrant Water-lily (*Nymphaea odorata*)	Permanently flooded area of water up to 2 m in depth. Dominated by submergent macrophytes.
SAS1-B	Yellow Water Lily Shallow Aquatic	Dominated by Bullhead Pond-lily (*Nuphar variegata*), Fennel-leaved Pondweed (*Stuckenia pectinatus*)	Permanently flooded area of water up to 2 m in depth. Dominated by Yellow Water Lily submergent macrophytes.
SAS1-3	Stonewort Submerged Shallow Aquatic	Dominated by Stonewort (Chara sp.) with occasional Water Lilies	Permanently flooded area of water up to 2 m in depth. Dominated by submerged algae which was overtaken by water lilies late in the season.
SAM	MIXED SHALLOW AQUATIC		
SAM1-4	Pondweed Mixed	Cover: Large-leaved Pondweed (*Potamogeton*	Permanently flooded area of water up to 2 m in depth.

ELC Code	Vegetation Type	Species Association	Community Characteristics
	Shallow Aquatic	*amplifolius*), Common Floating Pondweed (*Potamogeton natans*), Star duckweed (*Lemna trisulca*)	Dominated by a mixture of submerged and floating-leaved macrophytes.
SAM1-7	Water Milfoil Mixed Shallow Aquatic	Cover: Whorled Water-milfoil (*Myriophyllum verticillatum*) and Large-leaved Pondweed (*Potamogeton amplifolius*) and Muskgrass (*Chara* sp.)	Permanently flooded area of water up to 2 m in depth. Dominated by Water Milfoil submergent macrophytes.

4.5.3 Flora

A total of 163 vascular plant species were recorded within and surrounding Fairy Lake as shown in **Appendix D**. Sixty-one of these plant species, which represents 37% of the total flora, are considered introduced and non-native to Ontario. Many are found within the cultural and young forest communities throughout the study area.

4.5.4 Invasive Plant Species

Several non-native species were documented throughout the study area (indicated by a * in **Appendix D**). Some of these species are garden escapes and/or planted but others can cause significant impacts to biodiversity if not monitored or maintained. Of these species, Common Reed (*Phragmites australis*), is a problem throughout southern Ontario and is currently concentrated near Rotary Park and the northern tributary. A small pocket of Silver Grass (*Miscanthus sinensis*) is also located in the same general area and should be monitored to keep it from spreading. The locations of these invasive species are shown on **Figure 9**.

4.6 Rare Species and Species at Risk (SAR)

Available records for species considered rare and/or at risk across the broader study area are summarized in **Table 2**. Habitat for two additional species at risk were confirmed over the duration of the 2022 study. The presence of SAR individuals and their habitat needs to be taken into consideration when determining how best to manage the terrestrial and aquatic habitats within and surrounding Fairy Lake.

Butternut (*Juglans cinerea*), a tree species considered endangered (END) and regulated under the *Endangered Species Act*, was observed within the study area during the 2021 botany inventory. Review of background information (CVC 2021) indicated that Black Ash (*Fraxinus nigra*), a species recently listed as threatened (THR), has been documented within the study area. This species may be present as site conditions are suitable, however it was not observed during the 2021 botany inventories. Ten species considered locally rare were observed within the study area

(**Table 10**). Many of these species are located within the submerged aquatic communities of Fairy Lake as shown in **Figure 9**.

Table 10. Locally Rare and Species at Risk

Scientific Name	Common Name	GRank	SRank	ESA	SARA	Local Status (CVC)
Juniperus virginiana	eastern red cedar	G5	S5			Rare
Nuphar variegata	bulhead pond-lily	G5	S5			Rare
Nymphaea odorata	fragrant water-lily	G5	S5			Rare
Myriophyllum verticillatum	whorled water-milfoil	G5	S5			Rare
Rhamnus alnifolia	alder-leaved buckthorn	G5	S5			Rare
Utricularia macrorhiza	greater bladderwort	G5	S5			Rare
Galium boreale	northern bedstraw	G5	S5			Rare
Potamogeton amplifolius	large-leaved pondweed	G5	S5			Rare
Lemna trisulca	star duckweed	G5	S5			Rare
Juglans cinerea	butternut	G3G4	S3?	END	END	

Table 10 Notes:

ESA - Ontario *Endangered Species Act, 2007*
END-Endangered; a species facing imminent extinction or extirpation in Ontario which is candidate for regulation under Ontario's ESA.

SARA - *Species at Risk Act* Schedule 1- official list of wildlife species at risk
END-endangered; a wildlife species facing imminent extirpation or extinction

G-Rank (Global Rank): assigned by a consensus of the network of Conservation Data Centres (CDCs), scientific experts and The Nature Conservancy to designate a rarity rank based on the range-wide status of species, subspecies or variety, according to the following.
G3- rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences but with a large number of individuals in some populations or may be susceptible to large-scale disturbances
G4-common; usually more than 100 occurrences, usually not susceptible to immediate threats
G5-very common; demonstrably secure under present conditions

S-Rank (Provincial or Subnational ranks): used by NHIC to set protection priorities for rare species and communities. Provincial ranks are assigned in a manner similar to that described for global ranks but consider only those factors within the political boundaries of Ontario.
S3-vulnerable; typically, 21 to 80 extant occurrences;
S5-secure; common, widespread and abundant

4.7 Waterfowl

In Canada, there is a migratory population of Canada Geese that nest in subarctic and arctic Canada and spend the winter in the United States. Geese from this population are only present in southern Canada during the spring and fall migration. There is also a more sedentary population that nest in southern Canada and may be present throughout the year. The geese around Fairy Lake are the latter "temperate-breeding" Canada Geese. Numbers of geese in southern Canada have increased substantially since the 1970s (Canadian Wildlife Service, 2017). In southern Ontario, the temperate-breeding population increased steadily from 1980 to 2005, and the estimated abundance in 2017 was 81,800 pairs (Canadian Wildlife Service, 2017).

Canada Geese are herbivores, and their diet includes grass and other tender plants. They prefer open terrain, and are particularly attracted to lawns, especially those near water (Canadian Wildlife Service, 2010). Canada Geese are attracted to lawns for two main reasons: they can digest grass, and when they are feeding with their young, manicured lawns give them a wide, unobstructed view of any approaching predators (Cornell Lab of Ornithology, 2022). Canada Geese nest on the ground near water, and usually prefer an area with an unobstructed view; the female selects the site and does most of the nest construction and all the incubation while her mate guards her and the nest (Cornell Lab of Ornithology, 2022). Canada Geese lay an average of 5 - 6 eggs but can lay up to 10 or more eggs (Canadian Wildlife Service, 2010); the incubation period is 25 - 28 days (Cornell Lab of Ornithology, 2022). Once eggs hatch, the goslings are mobile and will leave the nest at 1 - 2 days old when they begin to feed themselves while remaining with their parents (Cornell Lab of Ornithology, 2022). Once geese have nested successfully, encouraging them to leave an area can be difficult, and their numbers tend to increase in future years (Canadian Wildlife Service, 2010).

Canada Geese moult from mid-May/early June to late July. During this period of moulting, geese are unable to fly, and this period lasts for four to six weeks. Non-breeders congregate during this time, and breeders stay near their nest to rear their young during this time. Once moulting ends and their young can fly, Canada Geese begin heavily feeding to build fat reserves for the winter (Canadian Wildlife Service, 2010).

4.7.1 Habitat Assessment

An initial assessment of the Fairy Lake shoreline was conducted by pedestrian survey on June 23, 2021 under sunny skies and light winds (9 km/h W) with a temperature of 21°C. Subsequent to that survey, property access was granted to other privately owned lands surrounding the lake and a second habitat survey was conducted on July 22, 2021 under a mix of sun and cloud (70% cover) at temperatures of 25 - 26°C. Data was collected for each habitat polygon shown in **Figure 10.** Representative photos of each polygon are included in **Appendix A**. Results of the habitat assessment and descriptions of the conditions within each polygon are provided in **Table 11**. Areas of manicured grass, with sloping topography to the lake that were free of visual or physical barriers at the shoreline-lake interface generally showed either direct (geese presence) or indirect evidence (scat, feathers) of use at the time of survey.

Areas with favourable habitat conditions for Canada Geese and with a high potential for use include the public beach and Prospect Point in Polygon 1a where there is easy access to the lake (**Table 11**). Areas in Polygons 1b, 1c, 3a, and 5 with manicured grass have a high potential for use, this includes the sports field and adjacent park in Polygon 1b, the Royal Canadian Legion in 3a, and manicured areas within the trailer parks part of Polygons 5, 6 and 8 (**Table 11**).

4.7.2 Goose Survey

A survey of Canada Geese spanned the duration of the Fairy Lake Water Quality Study (June 2021 to April 2022) in order to capture conditions through all life stages and allow for a nesting survey to be completed. Although other waterfowl were observed on the lake, the Canada Goose was the predominant species and the focus of the detailed surveys conducted. Data collection included locations, numbers, and behaviours of geese. Nest locations and number of eggs were documented as part of the annual egg oiling program on Fairy Lake conducted by the Town.

Areas around the lake where geese were frequently observed include the northwest arm of the lake (Polygons 1a and 1c) and the area around the Royal Canadian Legion in Polygon 3a (**Figure 10**). Geese were commonly observed traveling in water and grazing or loafing on shore (**Table 12**). The highest numbers of geese were documented from mid-June to the end of July in 2021 during the moulting period, fewer geese were observed during the nesting season in April 2022 (**Table 12**). This is similar to the findings from the previous report that also found the highest numbers of geese during the moulting period (AECOM, 2009).

There were four geese nests found on Fairy Lake in spring 2022: one along the east side of the lake (FLN1) in Polygon 4 where there is natural vegetation along the shoreline; two near the Royal Canadian Legion (FLN2 and FLN3) where there is manicured grass in Polygon 3a; and one at the end of Cameron Street (FLN4) where there is hardened shoreline in Polygon 2 (**Figure 10**). In the PSW area there were five nests found nestled in cattails in the wetland, and two additional nests were found in the nearby Fairview Cemetery (**Figure 10**). Eggs from all nests were oiled over several weeks in April 2022, and the number of eggs per nest varied from one to ten eggs (**Figure 9**). For some of the nests, the number of eggs decreased between visits, presumably due to nest predation. For at least one of the nests, FLN1 on Fairy Lake, there was direct evidence of nest predation, as two broken eggs were found outside the nest on April 20, 2022.

A pair of breeding mute swans nested on the south shore of the lake near Mill St W in spring 2022 in the same area as the previous year. There were two cygnets in 2021, and four in 2022. The swans are highly aggressive towards the geese, and they were observed chasing them away from the lake and immediate shoreline. The presence of the pair of swans may have changed the nesting behaviour of the geese on Fairy Lake in recent years, since the swans aggressively chase and patrol the southern end of the lake, preventing any geese nesting near their nest (R. Vanderham, pers. comm.).

Table 11. Summary of habitat conditions for Waterfowl (see Figure 10 for polygon locations, Appendix A for photos)

Polygon	Area	Photo #	**Habitat Conditions affecting Geese use and/or access** (Type/length of vegetation, proximity/accessibility to water)	Potential for Use
1a	Prospect Park loop	2	Survey follows loop beginning at playground and walking SW to point and NE to boat ramp, lots of manicured grass, openings show evidence of high activity (feathers, feces). No geese observed on baseball fields, which have short perimeter fencing typical of baseball diamonds.	See below
1a	At beach (WQ5)	4	No geese observed but lots of evidence it is a hot spot (tracks, feces). Trees on either side of beach provide buffer to lake but ~35m of open beach/shoreline.	High
1a	Prospect Point	1,3	Feathers and lots of feces in proximity to openings to lake. Openings have gentle slope from lake with short grasses.	High
1b	Area behind the Community Centre	6	Fenced off leash dog park, tennis courts and fenced small cemetery, open manicured grasses surrounding these areas, narrow opening between facilities to access area by ground, distant from lake edge, no geese observed, or any indirect evidence of high geese activity noted. Fencing and dog presence may be limiting use in this area.	Low
1b	Sports field and adjacent park	5,7,8	Manicured grasses, soccer field is not fenced, no geese observed at the time of survey but evidence of where geese access field from lake opening (feces) and local resident of 50 years says the field is a hot spot of geese activity.	High
1c	Northwest shoreline, from soccer fields to WQ4	9	Town is maintaining a shrubby buffer from soccer field south to Tyler storm inlet, no activity noted, and not much indirect evidence of use found.	Low
1c	South of WQ4 (Tyler Ave.)	10	Opening to lake on west shoreline, manicured grasses, geese observed (30 juveniles, 8 adults)	High

Polygon	Area	Photo #	**Habitat Conditions affecting Geese use and/or access** (Type/length of vegetation, proximity/accessibility to water)	Potential for Use
1c	Between WQ4 and WQ8 (Elmore Ave.)	11	Opening to lake on west shoreline, manicured grasses, evidence of use in form of feces and feathers	Medium - High
1c	At Elmore Ave (WQ8) and to the south	12	Manicured grass (narrow and limited vegetated buffer to lake), lots of feces and feathers observed, several openings available to the lake	High
2	North shoreline - from Cameron St., along Mill St.	14	Private property, manicured lawns with shrubs, long grasses or hardened shorelines at lake edge for majority of properties. No geese observed.	Low
2	South shoreline - at end of Lake Avenue	13 15	Private property with mix of shrubs and manicured lawn along lake edge. Local resident believes lake level has risen since dam replaced, swamping what was once a sandy area on his property, sump pump runs more often. Landowner has strung rope low across openings to deter geese from accessing the property. Area available is relatively small.	Low
3a	Royal Canadian Legion	21-25	Manicured grass, with open grown trees and some shrubs along shoreline. Large openings to the lake. Large numbers of geese (60+) observed here June 5 and June 23.	High
3b	School yard and private property to south	17 18 20	Manicured grass, sports field bordered by chain link fence including north limit of school yard adjacent to the Royal Canadian Legion. Private residence has wood fence and both properties are buffered from lake edge by 50-90m of trees and shrubs. No geese observed June 23, 2021; indirect evidence of use in school yard on July 22, 2021. Student use of playground may limit use early in season, distance from water and fencing may limit use overall.	Low
3c	Town shoreline	16 19	Manicured grass, buffered from lake by mature trees. CUM along east shoreline between the Royal Canadian Legion and apartment building is comprised of trees, narrowing the opening/asphalt trail to apartment. No direct or indirect evidence of use. Vegetated buffer likely limits use.	Low
4/8	Smallwood Acres Trailer Park – southern limits as observed from WQ1	26	Private property with manicured lawns along edge of Smallwood Acres Park, has vegetated buffers and boulder reinforced shoreline, but some openings to lake. A handful of geese were observed on the lawns during the survey at WQ1. The remainder of Polygon 4 is Town owned property along the eastern shoreline of the lake. The area is a mix of deciduous forest, and treed swamp making the shoreline less accessible for	Low

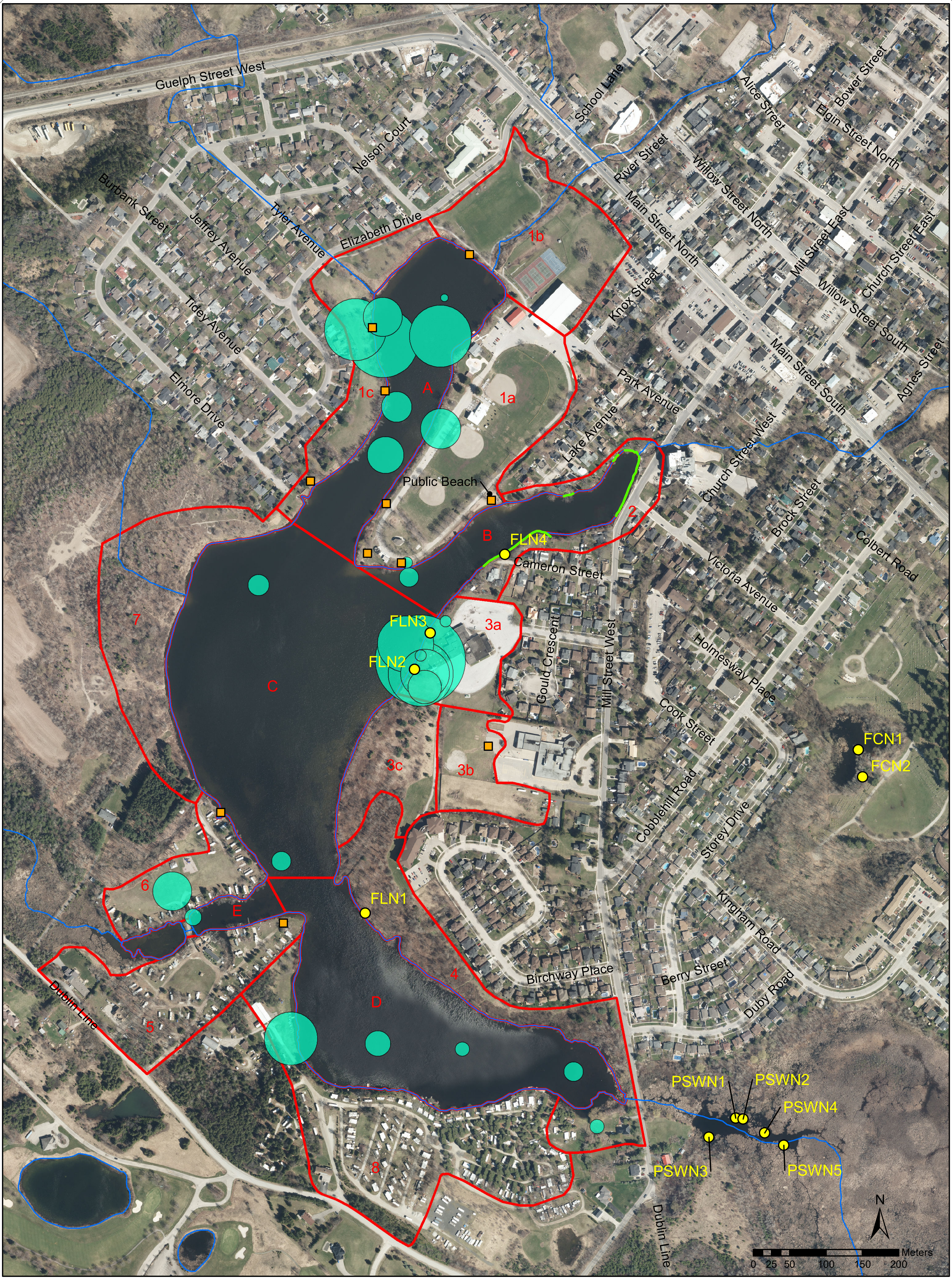
Polygon	Area	Photo #	Habitat Conditions affecting Geese use and/or access (Type/length of vegetation, proximity/accessibility to water)	Potential for Use
			geese, although a nest (FLN1) was found in April 2022 at that location.	
8	Smallwood Acres Trailer Park – day use area (northern portion of property)	27-29	Much of the shoreline of the Smallwood Acres Park has vegetated buffers or a boulder reinforced shoreline. The day use area is comprised of ~120m of open gentle sloping lawn to lake with a small dock. Area was covered in goose feces (dock, grassed area) and 29 adults were loafing on shoreline during the survey. Mute swan was aggressive toward geese, came flying off the open water and chased/drove off a large group of geese. The pair of swans were rearing two young and were observed in the open water areas throughout the June 23 survey. Filamentous algae and lily pads dominated the shoreline of the trailer park.	High
5	Breezes Trailer Park – south side of open water Polygon E near the point	30	The long-time landowner (the site is now under new ownership) was available and showed LGL what was once maintained as a Town dock in use in past when swans were kept on the lake and a pump was used to keep the water open over winter. The dock is currently in poor shape and not safe as a platform for WQ sampling. The point is open to the lake where grass is manicured, and a picnic area and horseshoe pit are located. Five geese were observed at time of survey. Easy access to point, less than 15 cm drop from manicured grass to lake. Lots of evidence of use (feces, feathers).	High
6	Breezes Trailer Park – north side of open water Polygon E	31	The western shoreline of the lake in this area is occupied by seasonal and permanent homes many of which have docks. Access is not great for geese given that much of the area is bordered by treed and shrubby vegetation; however, feces on docks indicate those are in use. Although the open manicured field near the playground was free of feathers and feces in June 2021 and no geese were observed, two adults and 15 juvenile geese were observed feeding in this area in August 2022.	Medium

Table 12. Summary of goose survey results (see Figure 10 for polygon and nest locations)

Date	Location	Numbers of Geese	Behaviour	Comments	Total geese	Surveyed by:
2021-06-16	3	25 adults	Feeding, resting		57	LGL Limited
	C	32 adults	Travel in water			
2021-06-23	1	11 adults; 45 juveniles	Grazing on land, travel in water		278	LGL Limited
	3	74 adults; 40 juveniles	Grazing on land, loafing, dabbling in water			
	4	3 adults	Grazing on land			
	5	29 adults	Grazing on land, loafing, dabbling in water, travel in water			
	A	30 adults; 35 juveniles	Grazing on land, loafing, dabbling in water, travel in water			
	D	11 adults	Travel in water			
2021-07-22	3b	-	Indirect evidence	scat/feathers	23	LGL Limited
	5	-	Indirect evidence	scat/feathers		
	6	-	Indirect evidence	scat/feathers		
	B	18 adults	Grazing on land, travel in water			
	C	5 adults	Dabbling in water, travel in water			
2021-07-27	1a	184 adults	Grazing on land, loafing	ball diamond beach	184	Community
2021-07-29	1c	15 adults	Grazing on land		15	Community
2021-07-31	1a	2 adults	Travel in water	Swimming over buoys at beach	2	Community
2021-08-11	A	17 adults	Loafing, travel in water		17	LGL Limited
2021-09-22	A	46 adults	Dabbling in water, travel in water		46	LGL Limited
2022-03-28	A	22 adults	Travel in water	near creek	22	Community
2022-03-29	1b	12 adults	Loafing		12	Community
2022-03-31	3a	2 adults	Grazing on land		2	Community
2022-04-08	FCN1	2 adults	Nesting	5 eggs oiled	6	Town
	1c	4 adults	Grazing on land			Community
2022-04-12	FCN1	2 adults	Nesting	7 eggs oiled	10	Town

Date	Location	Numbers of Geese	Behaviour	Comments	Total geese	Surveyed by:
	FLN1	2 adults	Nesting	6 eggs oiled		
	FLN2	2 adults	Nesting	4 eggs oiled		
	FLN3	2 adults	Nesting	5 eggs oiled		
	FLN4	2 adults	Nesting	7 eggs oiled		
2022-04-14	PSWN1	2 adults	Nesting	1 egg oiled	10	Town
	PSWN2	2 adults	Nesting	5 eggs oiled		
	PSWN3	2 adults	Nesting	6 eggs oiled		
	PSWN4	2 adults	Nesting	6 eggs oiled		
	PSWN5	2 adults	Nesting	6 eggs oiled		
2022-04-20	FCN1	2 adults	Nesting	10 eggs oiled	45	Town/LGL Limited
	FLN1	2 adults	Nesting	2 eggs oiled, 2 eggs predated		
	FLN2	2 adults	Nesting	6 eggs oiled		
	FLN3	2 adults	Nesting	5 eggs oiled		
	FLN4	2 adults	Nesting	8 eggs oiled		
	PSWN1	2 adults	Nesting	0 eggs, presumed nest predation		
	PSWN2	2 adults	Nesting	5 eggs oiled		
	PSWN3	2 adults	Nesting	0 eggs, presumed nest predation		
	PSWN4	2 adults	Nesting	4 eggs oiled		
	PSWN5	2 adults	Nesting	5 eggs oiled		
	1a	4 adults	Grazing on land, travel in water, flying overhead			
	4	11 adults	Travel in water, flying overhead			
	C	6 adults	Travel in water			
	E	4 adults	Travel in water			
2022-04-28	1c	15 adults	Loafing		15	Community

Date	Location	Numbers of Geese	Behaviour	Comments	Total geese	Surveyed by:
2022-04-29	FCN1	2 adults	Nesting	10 eggs oiled	22	Town
	FCN2	2 adults	Nesting	1 egg oiled		
	FLN1	2 adults	Nesting	0 eggs, presumed nest predation		
	FLN2	2 adults	Nesting	0 eggs, presumed nest predation		
	FLN3	2 adults	Nesting	5 eggs oiled		
	FLN4	2 adults	Nesting	7 eggs oiled		
	1c	20 adults	Loafing			Community
2022-04-30	C	10 adults	Travel in water		10	Community
2022-05-16	3b	28 adults	Loafing		28	Community
2022-05-30	4	1 adult	Loafing		1	Community



Fairy Lake Water Quality Study

Goose Survey Results

- Nest Location (2022)
- Goose Monitoring Area
- Watercourse (LIO)
- Waterbody (LIO)
- Hardened Shoreline
- Geese Activity - Indirect Evidence (scat, feathers)

Geese Activity - Number of Individuals

- 1
- 10

LGL LIMITED Est. 1971 environmental research associates

Project	TA9122	Figure	10
Date	March 2023	Prepared By	KC
Scale	1:5,000	Verified By	LKR

4.8 Summary of Results

4.8.1 Bathymetry and Vegetation

The southern portion of the lake is dominated by shallow areas with good light penetration. This results in aquatic plant growth with a species composition characteristic of wetland habitats (submerged shallow aquatic vegetation), where demands on oxygen are high during periods of plant respiration and decomposition. The bathymetry data identified deeper basins (> 7 metres) that demonstrate some degree of thermal stratification in the shoulder seasons. The bathymetry data was applied to the modelling study (Water's Edge, 2023) completed in tandem to the water quality study.

A number of plant species considered locally rare are found in the Fairy Lake study area. These species should be considered when identifying suitable best management practices relating to water quality to apply in any particular area. Locations of invasive plants (phragmites and miscanthus) have also been identified for consideration of removal. Invasive species tend to result in monocultures limiting local biodiversity.

4.8.2 Water and Sediment Quality

The baseline Fairy Lake Water Quality Study completed in 2008 (AECOM, 2009) included similar analyses of samples collected at stations WQ1 through WQ6 as the current study. However, the water chemistry data collection completed for stations WQ7 through WQ10 included only five test parameters (DOC, TP, TSS, TKN and *E.coli*). Some changes in methodology in the intervening years have resulted in lower reportable detection limits (RDLs) for the lab analysis conducted in the current study. As well, AECOM (2009) found no difference in the water chemistry results based on the sampling event type (wet or dry); and therefore, much of the analysis presented in their report was based on pooled data and mean concentrations. This was not the case in the current study (i.e., nutrient sources and loading were found to fluctuate with event type); therefore, data is presented in time-series plots to allow for comparisons between sampling events. Despite these variations in the data collection, reporting and analysis, some notable differences were found between the two datasets. A number of the differences noted between years were found at WQ2. In 2008 it appears that this station was sampled at the mouth of an inlet to the lake near the Breezes Trailer Park shoreline. However, WQ2 flows into the lake inlet through a culvert approximately 60 metres upstream of where the 2008 samples were collected. The inlet between the culvert and the WQ2 sample location in 2008 is densely vegetated and surface water is relatively stagnant here in summer. Given all of this, the decision was made to sample WQ2 at the end of the culvert that conveys stormwater flows to the lake inlet to get a more representative sample for the 2021-2022 study.

Where NO_2-N, NO_3-N and TKN data were available in AECOM (2009), total nitrogen could be calculated and compared to results from the current study. Overall, the mean total nitrogen concentrations have reduced compared to the baseline conditions reported in AECOM (2009). The exception to this was at WQ2 where the mean total nitrogen concentration was more than double what was reported in AECOM (2009). The mean TP concentrations observed in the current study were found to have declined in the lake stations but increased at the stormwater and creek inlets. Of particular note, was WQ2 where the mean TP concentration was more than three times what was observed in AECOM (2009). Concentrations of Ortho-P (the soluble, inorganic fraction of phosphorus that is directly taken up by plant cells) were observed to be at similar or reduced mean concentrations in surface water compared to AECOM (2009), and at non-detect levels (<0.0010 mg/L) in lake samples. It is recommended that the catchment of WQ2 be further investigated during wet weather events as part of a long-term surface water quality monitoring program for the lake given the high concentrations of nutrients observed at that location.

Nuisance level cyanobacteria was not observed during any of the sampling events conducted by LGL; nor was microcystin found at measurable levels in early August 2021. However, Halton Region Public Health data indicates that an algal bloom was visually evident at the public beach in late summer 2022 and persisted into early September at this location. Summer 2022 was outside the timeframe of the study results reported herein, however, it is noted that drought conditions were experienced in southern Ontario in 2022 which likely contributed to the conditions documented by Halton Region Public Health. Generally, conditions of high nutrient loading, and warm, shallow waters with good light penetration are conducive to the formation of algal blooms. Research in Ontario indicates that phosphorus is the key nutrient driver of BGA in lake environments since nitrogen deficits can be made up through nitrogen fixation, something that many BGA species are capable of (Higgins et al., 2018). The site-specific contributing factors and mechanisms of HABs are complex and beyond the scope of this current study; however, the data collected as part of this study (bathymetry, water chemistry, modelling) is intended to support the detailed multi-year study of HABs in Fairy Lake led by researchers from the University of Guelph that began in the spring of 2022.

Nutrient modelling presented under separate cover (Water's Edge, 2023) demonstrates elevated loading of phosphorus to the lake through various inlets (Black Creek, Elmore Avenue and Tyler Avenue storm sewers) and presents a number of recommendations to reduce phosphorus loading to the lake, some of which are further discussed in Section 6.0 Management Recommendations.

TAN, TOC, TKN and phosphorus in SQ3 sediments from the deep central basin were found in similar concentrations to the AECOM (2009) study. At station SQ2 (shallow area in south part of the lake) increases in TAN and TKN were observed and at SQ1 (northwest arm) increases in TOC and TKN were found. TKN concentrations in sediments collected at SQ1 and SQ2 exceeded the PSQG SEL. This summary of results is based on single sampling events, one in 2008 and one in 2021. Additional sediment sampling in the lake would help identify how much of the apparent difference between stations and between years is attributable to the natural variation inherent in sediments in wetland and depositional habitats and clarify where trends are significant. Metal concentrations were analysed as part of the 2022 study and all of the samples collected from the lake met the provincial sediment quality guidelines for metals.

4.8.3 Waterfowl

Canada Geese are present at Fairy Lake and based on the survey results they are frequently found in polygons 1a, 1c and 3a. The habitat assessment indicated high potential for use by Canada Geese in Prospect Park, Town owned land on the west side of the lake, and the Royal Canadian Legion property (Polygons 1b, 1c, 3a and 5). Canada Geese were most numerous during the moulting period from mid-June to the end of July when they are unable to fly. During this period, geese select open areas near a food source, precisely what the shoreline of Fairy Lake offers. Nesting by Canada Geese was relatively limited in the areas accessed during the spring nest survey; four nests were found on the lake, two nests in Fairview Cemetery and five nests in the PSW area east of Mill Street. Quantifying and determining the extent to which geese feces are contributing nutrients and *E.coli* to the lake was not part of the current scope of work; however, microbial source tracking part of the ongoing University of Guelph led study in the lake is intended to help resolve that matter. Nevertheless, some strategies are recommended in Section 6.0 in the event the Town is looking to deter geese during certain periods (e.g., moulting period in summer), or from certain locations where geese presence is interfering with recreational uses (e.g., public beach, soccer fields).

5.0 Importance of Fairy Lake

5.1 Valued Natural Asset

The open water and wetland habitats present within Fairy Lake are valued natural assets that provide a variety of ecological services including the attenuation of peak flow rates and maintenance of baseflow downstream of the lake during low flow periods, removal/capture of contaminants/nutrients, carbon sequestering, and the provision of habitat for vegetation, fish, and wildlife (including rare species and species at risk). Species at risk habitats are protected by the *Endangered Species Act, 2007* and any proposed management activities within SAR habitat must adhere to the provisions of the Act which protects individuals of the species listed provincially as threatened, endangered or extirpated as well as their habitat.

Fairy Lake is also part of a provincially significant wetland. Wetlands are unique in their capacity to store carbon compared to other land cover types (CVC et al., 2022). Like other natural features, wetlands store carbon in vegetation, in soils below ground, and in decaying biomass. The anoxic conditions present within wetlands slow the decomposition of organic material, thus resulting in longer term carbon storage. Carbon storage is a key factor in regulating greenhouse gases and buffering the impacts of climate change. Wetlands also provide habitat for a wide diversity of species including aquatic invertebrates, fish, migratory and resident birds, fish, frogs, and turtles. In particular, Fairy Lake supports a number of provincially significant wildlife habitat functions (e.g., seasonal concentration areas, habitat for species of conservation concern).

5.2 Recreation

Information provided by the Town of Halton Hills and observations made by LGL Limited during field surveys is summarized below to characterize recreational use of the lake and the adjacent Town owned facilities. This information was assembled to support the Fairy Lake Water Quality Study, therefore the summary that follows focuses on recreational uses that depend upon and/or have the potential to affect water quality in the lake.

Fairy Lake and the surrounding parks and open spaces provide residents and visitors to the area with an abundance of passive and active recreational opportunities. Park land and recreational fields border the lake and residents and visitors to the area are using these areas for picnicking, walking/hiking, dog walking, viewing wildlife, and playing sports (the park includes a soccer pitch, baseball diamond, and lots of open space for informal sports activity). Trails and boardwalks in the park and naturalized areas support these activities and allow users to experience the lake from the shoreline. The lake itself is used for recreational boating (fishing and row boats, kayaks, paddle boards, pedal boats and canoes were all observed), swimming, and fishing during the open water season. Some controls on these recreational uses are in place. There is a Parks Bylaw enforced which prohibits motorized boat use on the lake. The beach areas are monitored by Public Health to restrict swimming during times of high bacteria counts or harmful algal blooms. Grasses are maintained/manicured for supported recreational uses and a stoop and scoop program is in place for pet owners. Though skating and ice fishing are not allowed under the Parks Bylaw, these activities were observed in winter. A study was conducted in 2022 to develop an outdoor ice strategy for the Town which included a feasibility review for the operation of a natural rink on the lake (AE, 2022). At the time of reporting, no decision had been made on next steps in the implementation of the recommendations that came out of that study.

The potential for impacts to water quality as a result of recreational use of the lake and its shoreline primarily relate to the actions of those participating in the above-mentioned recreational activities (e.g., littering, transfer/release of unwanted materials into the lake). These materials can be transferred through fishing activities, on boats and trailers (e.g., transfer of viruses such as viral hemorrhagic septicemia which affects fish health, and non-native plants and animals between water bodies). The province provides guidance on these matters as it pertains to recreational fishing including use of live bait (Ontario Fishing Regulations Summary | Ontario.ca). The actions of landowners living along the shoreline of Fairy Lake may also contribute unwanted chemicals to the lake through use of sprays and fertilizers on their properties. Alterations made to the shoreline by property owners can affect runoff rates of stormwater as well. Openings have also been created along the shoreline of the lake which facilitate geese access by providing gradual slopes to the manicured grass areas for feeding. Infrastructure could be designed to focus certain activities to certain locations in order to minimize damage to naturalized lake edges (e.g., fishing platforms).

Currently, the recreational use most affected by stressors/existing water quality in Fairy Lake is primary contact water recreation (e.g., swimming) due to high bacteria counts and the incidence of BGA in summer. Management and continued use of the public beach should focus on reducing bacteria loads contributed through fouling of the shoreline by geese (see Section 6.0) and further investigating sources of bacteria conveyed through stormwater during wet weather events.

6.0 Management Recommendations

Human activities can negatively impact surface water quality, even when the activity is far removed from the waterbody. The many types of pollution generated by human activities may seem insignificant when viewed separately, but when taken as a whole they can result in significant cumulative impacts on aquatic ecosystems. Water quality stressors are identified when impacts have been noted to biological communities or when water quality standards/guidelines have been violated. Sources of stressors are most often associated with land use in a watershed.

Based on the results of the field investigations, stressors to Fairy Lake water quality and recreational use of the lake were identified to include nutrients (phosphorus, and nitrogenous compounds in some locations), and bacteria (*E.coli.*). Data provided by others (Halton Region Public Health) identify BGA as another stressor. Data collection for the Fairy Lake Water Quality Study points to non-point sources (i.e., contaminants originating from a broad range of land use activity and carried to the lake by rainfall, runoff, and snowmelt) of these stressors. Specifically, the non-point stressors identified through data analysis and modelling are urban or impervious surface runoff via storm sewers and overland drainage, and agricultural runoff through Black Creek/Bovis Creek and other stormwater flows. Data suggests that internal nutrient loading from lakebed sediments, failing septic systems and wildlife waste may also be a source of nutrients and *E.coli*.; however, additional study is required to better understand the loads associated with each source should that be the case.

Many of the ecological and recreational services that Fairy Lake provides rest on the long-term protection of the lake and wetland ecosystems that are present. By definition, an ecosystem includes both a community of interacting biological organisms and the physical environment they depend on. The water quality of Fairy Lake is influenced by the complex relationships between those organisms and their environment as well as anthropogenic activities that affect their surroundings. The management recommendations that follow are intended to improve water quality in the lake through the reduction of nutrient loadings at their source and/or attenuation of nutrients prior to release to the lake (e.g., stormwater). A number of the recommended BMPs serve to protect other functions of the lake and surrounding parkland (e.g., recreational uses, quality of habitat for fish and wildlife). For example, methods to deter geese from gathering in large numbers not only improves water quality by decreasing fecal matter and the associated bacteria and nutrients that feces contribute, but also leaves parks, sports fields and beaches more desirable for recreational use.

Recommendations for management have been identified with the goal to improve water quality by targeting the source of the stressors identified in order to support the recreational uses of the lake while maintaining its ecological functions. The Black Creek Subwatershed Study (CVC, 2009) identified a number of objectives for the watershed. A number of those objectives align with the goals of the management activities recommended to improve Fairy Lake surface water quality:

- reducing the toxicity of contaminants in water and the concentrations of nutrients in water to sustain healthy aquatic communities;
- improving water quality levels toward the achievement of Provincial Water Quality Objectives to protect public health and ecosystems;
- re-establishing the water cycle (groundwater recharge, stream flows and precipitation/runoff characteristics) toward a more natural condition to protect natural stream characteristics, aquatic habitats, wetlands and forest habitats; and,
- re-establishing the water cycle (as above) and reduce the erosive forces of instream flows to more natural levels to minimize erosion and flooding, and protect life and property.

The sections that follow describe the recommended management options to improve Fairy Lake water quality in more detail.

6.1 Reducing Nutrient Loading

Nutrient loadings from agriculture and urban intensification can lead to severe degradation of inland waterbodies including lakes, reservoirs, wetlands, and streams.

Waterbodies retain and transform nutrients and, in part, regulate the delivery of nutrients to downstream watercourses.

6.1.1 Agricultural Best Management Practices (BMPs)

Agricultural production can include the application of manure, fertilizers, pesticides and herbicides to arable lands. Practices to minimize runoff of these materials to surrounding waterbodies is the goal of many agricultural BMPs. BMPs improve the rate at which the soil absorbs and stores water, reduce runoff, and protects water quality by retaining nutrients (e.g., phosphorus, nitrogen) on the land. A number of BMPs are promoted by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and rural incentives and tools are in place at the provincial level to support those programs (e.g., Environmental Farm Plan and Farmland Health Check Up). The following BMPs are often encouraged as part of watershed management plans and included in rural incentive programming but assessment of erosion risk and farm operations is key to determining which ones are most suitable on a site-specific basis (OMAFRA, 2022):

- Minimize soil disturbance by adopting no-till or conservation tillage practices to help reduce soil loss through erosion.
- Keep the soil covered using either living plants (cover crops and perennial crops) or plant residue to retain organic matter (by improving water holding capacity) and prevent erosion and other degradation.
- Increase vegetative buffers around watercourses (and potentially provide transverse bioswales) to reduce quantity and rate of storm flows to waterbodies.
- Develop and employ a nutrient management plan to consider:
    - Separating nitrogen applications from other nutrients so that it’s applied when the plant needs it most;
    - improving soil moisture retention with additional organics (thereby minimizing nitrogen loss);
    - using tile drainage to control water table levels to retain nitrogen in the soil profile; and,
    - using nitrogen-fixing plants, or vegetated field edges to capture nitrates.

Recognizing that agricultural BMPs are not fully under the Town’s control (i.e., on private lands) it is recommended that the Town, Region and CVC (e.g., members of the Technical Advisory Committee) prioritize BMPs based on current and ongoing initiatives in the watershed to synergize efforts to improve water quality in the Fairy Lake catchment specifically.

6.1.2 Urban BMPs

6.1.2.1 Storm Sewer Retrofits

To date, the Town has put in place a number of oil and grit separators (OGS) and jellyfish filters to reduce the water quality impact of storm flows from certain suburban neighbourhoods. Some of these installations were part of the Region’s phosphorus offsetting strategy as it relates to the Acton WWTP. Effectively controlling the runoff quality from residential areas is important to Fairy Lake since, as demonstrated in the nutrient modelling exercise, stormwater results in the highest phosphorus export of all land uses in the catchment (see Black Creek and stormwater inlets in **Figure 7**). The ongoing verification and monitoring of the OGS and jellyfish filters part of the offsetting strategy should be reviewed to consider best applications for phosphorus removal in the Fairy Lake catchment. Although these installations are currently underperforming compared to the phosphorus load reduction that was anticipated (CVC, 2022), the Region is in the process of investigating solutions for improved performance. It's recommended that those improvements be applied to any storm sewers equipped with OGS that outlet directly to the lake (e.g., Tyler Avenue and Elmore Drive).

6.1.2.2 LID Measures & Retrofits

The strength of Low Impact Development (LID) is that it mimics the natural hydrologic cycle. Development and creation of impermeable surfaces primarily interferes with the ability of stormwater to soak into the ground. Use of LID is increasing in Ontario and includes practices that differ from traditional stormwater management. Examples of LID include the use of permeable pavement, bioretention and rain gardens, rainwater harvesting, soakaway pits, infiltration chambers, and green roofs. LIDs can be incorporated into new designs, but existing residential communities can also be retrofitted with LID planning (CVC, 2022b). For example, road right of ways, residential, industrial or commercial lands, or public land (Town owned parks and facilities, schools, etc.) can be used as locations to host retrofits. Opportunities to retrofit with LID also present themselves when failing infrastructure is in need of replacement (Shafique and Kim, 2017).

6.1.2.3 Natural Channel Design

Natural Channel Design (NCD) is an approach to watercourse restoration and realignment which attempts to reconstruct channels to mimic the natural physical form of the river or stream. In theory, the result should be a channel that is in balance with the natural processes of erosion and deposition so that the ecological function can be maintained or restored. For example, restoring "hardened" (concrete) channels using NCD principles will help to attenuate flow quantity and flow rate which can improve water quality downstream. Although no supporting studies have been completed to date, the Black Creek/Bovis Creek channel between Division Street and McDonald Boulevard is a potential candidate for NCD.

Rivers and streams naturally improve water quality through natural stream functions of uptake and processing; however, incorporating NCD has the potential to provide significant denitrification. Many river restorations do not include the use of the hyporheic zone for water quality improvements. Natural rivers have hyporheic zones where subsurface river zones mix with the groundwater. This zone acts to provide biotic life to the river housing microorganisms, crustaceans, and bugs. Ammonia is converted to nitrous oxide or nitrogen gas where it can be released into the atmosphere. This zone can also help to moderate the temperature in the river throughout the seasons. As watercourses and watersheds become urbanized, erosion, increased sedimentation, and aggregation can alter the bed of the river, thus reducing or cutting off the connection to the hyporheic zone (Water's Edge, 2023). As a result, there are fewer chemical reactions and pollutants remain intact in their initial form. Restoring watercourses in the Fairy Lake catchment using NCD principles should consider restoring the hyporheic zone as well.

A review of the Black Creek/Bovis Creek channel upstream of Fairy Lake is recommended to assess site conditions, topography, fluvial geomorphology, etc. in the context of natural channel design to determine where the most benefit (nutrient reduction) can be achieved. Following this, plans for NCD can be developed for key locations to attenuate flows and improve water quality as part of the implementation planning process. Features such as constructed riffles, meandering of the river channel, J-hook and rock vanes, root wads, toe-of-slope wood structures, connection to floodplains and floodplain pools can be used to force the river water into the hyporheic zone to activate biochemical reactions and increase the lag time of contaminants into Fairy Lake. Designs should be supported by groundwater studies which would determine the effects of well water on the hyporheic zones.

6.1.2.4 Wetland Design

Wetlands are nature's way of filtering water. Studies have been completed showing that creating wetlands can be more affordable than removing phosphorus through water treatment (Land, 2016). There are several wetlands providing this service for stormwater from the southeast (WQ1) and west (W10) of Fairy Lake. The reduction of total phosphorus through these existing wetlands could be calculated through sample collection upstream and downstream to quantify the effectiveness of TP removal. Micro wetlands could be designed at stormwater inlets to the lake to target specific TP removal quantities. It is possible that wetlands could be engineered at the Tyler Avenue storm outfall and the mouth of Black Creek/Bovis Creek to reduce TP loading. Land (2016) estimates that 10g/m^2 year of phosphorus could be removed from a watershed using created or restored freshwater wetlands. For Tyler Avenue, that would translate to a wetland of 1,700 m^2 in order to eliminate the estimated 17 kg TP/year (**Figure 7**). Most likely, this method would not fully eliminate phosphorus, but it would be a relatively affordable method that requires little maintenance over the long term.

6.2 Vegetation Management

As noted above, creek restoration is a key management tool used for the reduction of nutrient loading to waterbodies. Planted riparian buffers or buffer strips of native plants along tributaries reporting to Fairy Lake and around the lake shoreline can improve water quality by providing a means of effective runoff and sediment control, thus preventing stream bank erosion, reducing nutrient concentrations in runoff water, increasing water infiltration into the soil, and improving wildlife and fish habitat. Recommended buffer widths are dependent on a number of factors including: the sensitivity and functions of the feature being "buffered"; the function the buffer is expected to perform; the setting (e.g., slopes, soils, surface drainage); and, the adjacent land use. Beacon (2012) provides a review of the literature and common practices with regard to buffer widths and recommends buffer strips of 10 to 50 metres in width where the protection of water quality is the main function being targeted.

As an added ecological benefit, native seed mixes for buffer strips could consider inclusion of pollinator species to create meadow habitat in areas currently mowed and maintained (e.g., Polygon 1c) as an option for deterring geese where desired (see further discussion in Section 6.3). The creation of a pollinator garden could also be used as an opportunity to educate residents and visitors to the community of the importance of pollinators to biodiversity.

Aquatic vegetation removal in Fairy Lake is not recommended at this time. As additional data is collected in the coming years (as recommended through a long-term monitoring program) options for selective sediment or vegetation removal could be reassessed. Where this is considered in future the presence and protection of species at risk turtles would need to be prioritized. Given that this practice requires ongoing intensive effort it is not something that should be embarked upon lightly. Reducing nutrients at their source is the preferred method of control recommended at this time.

Conversely, where non-native invasive plant species are present vegetation removal is recommended (e.g., *Miscanthus sinensis* and *Phragmites australis)*. Stands of invasive *Phragmites* decrease biodiversity and destroy habitat for other species, including SAR (OMNR, 2011). Similarly, invasive plants like *Miscanthus sinensis* are relatively fast growing, form dense bunches, and displace native plant communities. The dense, dry stands that results are highly flammable, reduce light availability to other plants at the soil surface, and slowly decompose on the ground, limiting the amount of nutrients returned to the soil. The province of Ontario provides guidance on management of invasive species (OMNR, 2011; http://www.ontario.ca/page/invasive-species-ontario; and http://www.invadingspecies.com/invaders). Locations of invasive species are identified in **Figure 9**.

6.3 Waterfowl Management

The current geese egg oiling program at Fairy Lake is recommended to continue. The numbers of geese nesting on the lake appear to be relatively low which is likely due to the success of the egg oiling program. Geese nesting locations and the number of eggs oiled each year should continue to be documented as these records can provide valuable insight into the success of the program. Engaging local owners of large properties where geese may also be nesting (e.g., the golf course) and then moving to the lake during the moulting period, could also be considered.

There are several geese management options that relate to habitat modification around Fairy Lake. One of these is making changes to grass mowing frequency and/or mower height. Geese prefer younger grass shoots found on mowed lawns. As grass is allowed to grow, the young shoots become harder to find. On private property, reducing fertilizer use may also reduce the attractiveness to geese, as well as watering less frequently, since both actions are likely to decrease the growth of grass and make it less palatable for geese. When a mowing height of six inches or greater is used, the tender young shoots of grass preferred by geese are less abundant and more difficult for geese to find (Doncaster and Keller, 2009). This recommendation could be implemented in areas around Fairy Lake where manicured grass is present but is not maintained for any particular purpose. Examples include the area around the Royal Canadian Legion in Polygon 3a (outside of the maintained picnic and horseshoe pit area), and the area in Polygon 1c where a meadow or pollinator garden might be desirable.

Landscape design around the shoreline to reduce sightlines to the point where geese are uncomfortable (<9 m) and impede access to foraging areas (Doncaster and Keller, 2009) is another option for geese management. Some examples of landscape design from Doncaster and Keller (2009) include an aquatic bench of emergent vegetation along shorelines and low shrubs and native grassland/wildflower meadows, to create a physical and visual barrier for geese. The area in Polygon 1c (see photo below) is an example of where manicured grass could be replaced by low shrubs and/or a native grassland meadow. The prevalence of ticks and mosquitos in taller grasses and natural areas can be of concern for municipalities considering the potential health risks they represent (e.g., Lyme Disease, West Nile Virus). Education is the best path forward to ensure users of the park are informed of the necessary precautions to protect themselves. Some municipalities (e.g., Kingston, ON) apply a natural, garlic based deterrent at dog parks or high use areas to deter ticks and mosquitos; these products are also purported to deter geese (Kingston tests secret weapon against ticks: garlic | CBC News).

Photo 1: Polygon 1c on the northwest shoreline of Fairy Lake – example of an area that could benefit from a planted buffer or no mow approach (left), and where effective planted buffers have been created and maintained (right).

Retractable fencing in areas where easy access to the lake is available may be another useful technique for deterring geese at Fairy Lake. For example, retractable fencing could be installed at the public beach to prevent geese from loafing/roosting and contributing to the feces observed at that location in spring/summer 2021. The fencing would require some maintenance (e.g., potentially opening/closing on a daily basis, seasonal storage) but could be aligned with a daily beach grooming plan to support the current recreational use and avoid beach closures.

Photo 2: Example of retractable fencing and signage in use at beaches in Whistler B.C. in Summer 2022 to deter geese from accessing the shoreline.

Hazing techniques are another mechanism that is used to routinely scare off geese from recreational areas. Hazing using trained dogs under the command of a handler is used in some Canadian municipalities (Toronto City Council, 2002; City of Whistler pictured above). Using dogs does not require a permit; however, dogs must be kept under control at all times and no geese can be injured or killed as a result of hazing (Canadian Wildlife Service, 2010). Raptors (falcons, eagles and other birds of prey) under the supervision of trained handlers can also be used to scare away geese (Toronto City

Council, 2002). Using raptors requires a federal permit and a falconer must conduct the work (Canadian Wildlife Service, 2010).

Another option that the Town has considered is strobe lighting to disrupt geese roosting (see https://www.awaywithgeese.com/). Canadian Wildlife Service (2010) describes use of strobe lights or lasers as a technique used to disturb geese after dark or just before dawn that does not require a permit. However, an LGL biologist with technical expertise in bird deterrents does not expect this method to be very effective in Prospect Park, where geese are accustomed to living in urban environments with a variety of light stimuli (pers. comm. Rolph Davis, PhD. in avian ecology).

The relocation of geese during the moulting season is another option for management, however, this can only be carried out under authority of a permit issued by Environment and Climate Change Canada and release sites must be approved (Canadian Wildlife Service, 2010). Several municipalities in the Greater Toronto Area have used this technique in the past, while others continue to use it (City of St. Catharines, 2004; Town of Oakville, 2021; https://www.insauga.com/mississauga-and-oakville-get-ready-to-gather-geese-for-annual-trip-out-of-town). However, relocation is considered to be a short-term solution as geese tend to return after they regain their flight feathers (Canadian Wildlife Service, 2010). Therefore, habitat modifications (like the techniques described above and in Section 6.2) are often the preferred long-term solution that's recommended (Canadian Wildlife Service, 2011b).

6.4 Monitoring the Effectiveness of Management Practices

To date, the Town has employed some management practices along the shoreline of Fairy Lake (e.g., plantings and vegetated buffers, "no mow" areas). However, the extent and effectiveness of these practices has never been tested through monitoring of lake water quality. In order to identify appropriate management practices for the protection of surface water quality in Fairy Lake, to monitor the effectiveness of those practices and also allow for adaptive management to occur over time, a long-term water quality monitoring program is needed. A recommended surface water and sediment quality monitoring program has been provided to the Town under separate cover. The program identifies the recommended locations and frequency of sample collection and a list of the parameters to consider for lab analysis. As supporting studies are completed (e.g., the detailed multi-year study of HABs in Fairy Lake led by researchers from the University of Guelph), additional analytes may be warranted. For long-term management of Fairy Lake, a cross agency and disciplinary technical group should be established that will review the results of emerging studies (e.g., University of Guelph HABs study), plan future studies, and develop and prioritize management approaches accordingly.

According to Seresh and Kuchmak (2017), part of the Region's Beach Monitoring Program includes an environmental survey for each recreational water site prior to the beach monitoring season to inspect the physical beach, identify any changes to structures and landscapes, and identify potential pollution sources and/or any other factors that may affect public health and safety. It is recommended that waterfowl data be collected as part of this initial inspection and on a weekly basis thereafter for the duration of the beach monitoring season to measure the effectiveness of any goose deterrents that are employed at the beach. This data could also help to identify adaptive management of those deterrents as needed.

6.5 Compliance with Regulations

Given that the Fairy Lake study area supports a diversity of species and habitat types, there are a number of provincial and federal regulations intended to protect terrestrial and aquatic plants and animals that should be considered as the Town identifies and implements management recommendations. Although an exhaustive review of environmental regulations and policies is outside the scope of this study, the more relevant protections that may be triggered by Fairy Lake management activities are summarized in **Table 13**.

Table 13. Protection Regulations to Consider

Act/Regulation	Who to Consult	Examples of Works Requiring Consultation
Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses (O.Reg. 160/06)	CVC	Works within mapped Regulated areas or deemed to interfere with wetlands or watercourses.
Endangered Species Act, 2007	MECP	Works impacting aquatic or terrestrial species at risk individuals or their habitat.
Fisheries Act	DFO	Works impacting fish and fish habitat and not meeting the defined criteria outlined by DFO ((http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html)
Migratory Birds Convention Act, 1994	Environment Canada	Works requiring any vegetation removal or disturbance to nests during the breeding bird season
Fish and Wildlife Conservation Act, 1997	MNDNRF	Collecting fish or wildlife including efforts to move/relocate during any restoration or management activities.

7.0 Communications Strategy

A communications strategy was developed in 2009 and the tools recommended for community engagement, information sharing, and education have been implemented by the Town to varying degrees since that time. As part of the 2021-2022 Fairy Lake Water Quality Study Update, the Town's current practices around community engagement were reviewed and some additional strategies recommended. The communications strategy specific to Fairy Lake is intended to reflect the values of the community as they relate to the lake's recreational uses, aesthetic value, and ecosystem services. The strategy includes efforts to solicit input from residents, inform the community of what actions the Town is taking to manage Fairy Lake and the surrounding area, and educate users on their role in supporting the ecosystem services provided by the lake. The main use of Fairy Lake currently is recreation, to include passive recreation whereby people enjoy the aesthetic value of the lake, and active recreation in the form of boating, fishing, and swimming as well as organized sports, running, and walking within the adjacent parks and open areas. The area is also a popular spot for bird watching and viewing other wildlife and plants.

7.1 Communication Tools

The Fairy Lake Water Quality Study completed in 2009 (AECOM, 2009) presented a number of recommendations for the Town's communication strategy including use of different media tools such as the Town's website, installation of educational signage, lake stewardships campaigns, partnerships with local interest groups that could support stewardships programs, and potential funding sources.

7.1.1 Project Information and Updates

Currently, the Town of Halton Hills website has 'Let's Talk' and 'Explore and Play' sites that present information on Fairy Lake and initiatives. The website has information on the ongoing water quality study. Through the 'Let's Talk' site, e-blasts can be sent out regarding any project updates. The Town has presence in four social media platforms including Facebook, Twitter, Instagram and LinkedIn, which can be used to disseminate notices and project information. There are three e-newsletters (i.e., corporate, economic development and recreation) which can include project information and promotions as they are circulated on a regular basis. In addition, the Town's facility screens present in areas throughout its jurisdiction can be used to promote Town initiatives and projects.

7.1.2 Education

In addition to the current signage posted in Prospect Park (see examples in **Figure 11**), Fairy Lake water quality and efforts to maintain recreational uses in Prospect Park and the lake would benefit from additional signage to inform users of the ecological services the lake provides and how best to protect the lake from water quality stressors. For example, signage identifying Fairy Lake as part of a provincially significant wetland and educating the community as to what that provincial designation means. Although certain aspects of the wetland (e.g., aquatic plant growth) may be viewed as conflicting with recreational uses of the lake on a seasonal basis, the general public may not be aware of the role that wetlands play in supporting fish and other aquatic and terrestrial species. In addition to the Let's Talk platform, this signage could be used to communicate the Town's current and future efforts to manage conditions around the lake (e.g., controlling the local geese population and nutrient loading to the lake) and engage the local community and visitors from surrounding areas to support those efforts. Educational signs could be part of a broader interpretive signage strategy in the park that includes cultural and historical information.

Figure 11. Examples of educational signage at Fairy Lake

Several information campaigns related to lake stewardship, such as on water conservation and protection, have already been implemented. Examples of water conservation and protection include messaging on the benefits of not using pesticides and stormwater management initiatives such as property landscaping with vegetation requiring less water, and permeable surfaces. Additional messaging on lawn care, benefits of buffer strips, and choice of plantings targeting landowners directly adjacent to the lake (particularly for larger properties such as the two trailer parks and the Royal Canadian Legion) is recommended.

7.1.3 Local Partnerships

The Town has ongoing initiatives with various local interest groups supporting volunteer activities. Any stewardship initiatives for Fairy Lake could benefit from these existing relationships with local interest groups. For example, the implementation of various educational activities and public awareness campaigns, clean up and monitoring activities could be carried out collaboratively with these groups. Currently, the following local interest groups have been identified:

- Credit Valley Conservation
- Protecting our Water and Environmental Resources (POWER)
- Halton Environmental Network (HEN)
- Acton Community Garden (HEN and POWER collaboration)
- Acton District High School
- Halton-Peel Naturalist Club
- Halton-Peel Woodland & Wildlife Stewardship
- Halton Hill Turtle Guardians
- Trees for Halton Hills
- Friends of Fairy Lake Facebook Group

7.2 Public Surveys

A public survey conducted from February to April 2020, showed that a great number of respondents have an interest in improving the water quality of the lake. The desire to improve the lake's water quality appeared to be closely tied with an interest in swimming, fishing and boating activities and a concern for wildlife. The main perceived causes of the deteriorating water quality expressed by the respondents were the high quantities of waterfowl feces (in particular, in the beach area) and perceived low management of vegetation (including invasive species such as phragmites). A review of the comments received through the survey suggests that many respondents are not well informed of the resources available at Fairy Lake. For example, a large proportion of the respondents were not aware of the outdoor ice rink at Prospect Park and those who were aware noted that the maintenance of the facility requires improvements. A large proportion of the responses were positive regarding the construction of trails and docks/boardwalks. A public survey will be conducted following the presentation of the 2021-2022 water quality study results to the public, the results of which will be provided to the Town under separate cover.

8.0 Climate Change

In 2020 the Town of Halton Hills developed a Climate Change Adaptation Plan (CCAP) "in order to minimize the negative impacts of climate change, as well as take advantage of opportunities to strengthen the Town's resilience to climate change" (Canadian Urban Institute, 2020). A geospatial natural capital assessment was completed in support of the CCAP to identify significant natural areas and environmental features that provide crucial ecosystem services (e.g., flood mitigation, carbon sequestering, temperature regulation) which, if conserved, enhanced and restored, could improve overall resiliency to climate change (LGL, 2019). The study also identified natural assets most vulnerable to the effects of climate change. Fairy Lake was identified in the assessment as primarily a wetland unit part of the provincially significant Eramosa River – Blue Springs Creek wetland complex. The combination of wetland type (marsh), wetland site type (lacustrine), surface and baseflow contribution resulted in a rating of “low” vulnerability to climate change. That does not mean that Fairy Lake is not vulnerable to the effects of climate change, just that Fairy Lake has a higher resilience to the effects of climate change when compared with other wetlands located within the Town of Halton Hills.

One of the five goals identified in the CCAP is that the Town be resilient to increased precipitation and flooding that might result from the larger rain events and increased precipitation associated with climate change. Larger precipitation events, especially in spring when the ground is still frozen and soil infiltration is limited, have the potential to reduce water quality in local waterbodies through the introduction of suspended solids, nutrients and other contaminants during storm events. Managing stormwater on-site is one of the objectives in place to meet the Town’s goal of increased resiliency during these periods. Fairy Lake is a receptor of stormwater drainage through Black Creek, municipal storm sewers and stormflows from privately owned properties and, as such, would benefit from plans to better manage stormwater on-site. Infiltrating stormwater into soils is an effective way to improve stormwater quality while also mitigating the impact of it reaching the lake untreated (see Section 6.0 Management Recommendations).

Riparian vegetation along streambanks and shorelines of lakes not only improves surface water quality but also provides shading to the stream, generally reducing solar loading and water temperatures. Streams with a low percentage of shading are considered more vulnerable to climate change than streams with a high percentage of shading. Planting of riparian areas and maintenance of vegetative buffers along streams and shorelines of lakes as recommended in Section 6.0 can help to attenuate storm flows while also providing shading and cooling of aquatic habitats.

Thus, many of the management recommendations made in Section 6.0 will support the resilience of the lake to the future effects of climate change.

9.0 Conclusion

Fairy Lake water quality was last studied in detail in 2009. The 2021-2022 study was intended to update that information through an assessment of the current conditions of water and sediment quality, bathymetry, vegetation communities, and geese presence in the study area. Phosphorus loading to the lake was also modelled through the creation of a hydrologic and water quality model to simulate a 13-year continuous period as well as design storms (Water's Edge, 2023).

9.1 Fairy Lake Water Quality

Generally, Fairy Lake can be described as a mix of shallow water supporting abundant aquatic vegetation in the southern portion of the lake with deeper open water areas in the central and northern portions of the lake where flows are received from Black Creek. Fairy Lake and its surrounding wetlands support warmwater fish species, amphibians, reptiles, breeding birds and other wildlife, including SAR and locally rare species. As such, the management activities the Town employs need to consider these ecological services and adhere to the protections provided through various types of legislation (see Section 6.5).

Water quality data collection from 2021-2022 illustrates that:

- nutrients are contributed to the lake from surrounding land uses (urban and agricultural);
- wet weather events (storms, spring melt) contribute the bulk of the nutrient loading through storm runoff;
- phosphorus loading from storm flows exceeds the provincial water quality objective (PWQO) on a regular basis, whereas lake samples generally met the PWQO in 2021-2022;
- phosphorus concentrations observed in the current study were found to have declined in the lake stations but increased at the stormwater and creek inlets compared to AECOM (2009);
- nitrogen containing compounds at WQ2 are found in relatively high concentrations compared to AECOM (2009) and to other inputs to the lake monitored in 2021-2022; and,
- reduced concentrations of chloride were evident in stormwater flows compared to AECOM (2009) conditions.

9.2 Study Limitations

An attempt was made to compare the results of the current study to the AECOM (2009) results, however the following limited the ability to do so:

- No UTM location data for the 2008 stations was available to the current project team; therefore, sampling locations in 2021-2022 were estimated based on available PDF mapping from the AECOM (2009) report.
- Sediment chemistry comparisons were limited to single sampling events (one in 2008 and one in 2021), additional data is required to understand data variability and allow for trend analysis.
- Laboratory detection limits were lower for some analytes in 2021-2022 compared to the current study which makes comparing across the two studies difficult for some analytes, especially those found in small concentrations.
- Water chemistry data collection completed for stations WQ7 through WQ10 in AECOM (2009) included only five test parameters (DOC, TP, TSS, TKN and *E.coli*).
- AECOM (2009) found no difference in the water chemistry results based on the sampling event type (wet or dry); and therefore, much of the analysis presented in their report was based on pooled data and mean concentrations.
- A number of the differences noted between years were found at WQ2. In 2008 it appears that this station was sampled at the mouth of an inlet to the lake however in 2021 the decision was made to sample WQ2 approximately 60 metres upstream of where flows outlet to the lake inlet through a culvert to collect a more representative sample at this station.

9.3 Recommendations for Next Steps

Given that surface water quality is impacted by climate and local weather conditions within any given year, a long-term, routine monitoring program is recommended to track changes in water chemistry at stormwater inlets and Fairy Lake stations to understand variation in the dataset and improve upon the ability to accurately track trends over time. Recommendations have been made under separate cover for a long-term water quality monitoring program, including:

- Some additional sampling of lakebed sediments (more locations, increased frequency). For example, collect samples from areas in proximity to the dam to track nutrient concentrations over time and determine extent of nutrient deposition. This will help to determine if sediment removal might be warranted.
- Investigation into the potential for internal phosphorus loading from lakebed sediments. Elevated phosphorus found in surface water collected from the deepest lake basin in summer 2021 where low DO was also observed (see Figure 4A) suggests the potential for internal loading of phosphorus from sediments under anoxic conditions. It's recommended that this be further investigated to quantify this source of phosphorus so that it can be considered in the phosphorus model.
- Investigation into the high nutrient concentrations observed at WQ2 through more intensive sampling during wet weather events and interviews with landowners regarding source of flows across Dublin Line and septic sewer design and function.

- Monitoring of the culverts that outlet at Cameron Street and Wright Avenue (to include stormwater flows from the Royal Canadian Legion property where high geese activity was noted in 2021-2022).
- Incorporation of the findings from the University of Guelph led study specific to HABs and BGA dynamics in Fairy Lake into the long-term monitoring water quality monitoring program and the prioritization of management recommendations.
- Additional studies to determine what improvements in the hydraulic qualities of Fairy Lake could be implemented to improve water quality.
- Additional data collection to improve the nutrient model:
    - Additional streamflow and water chemistry data
    - Continuous monitoring of phosphorus through installation of instrumentation at key locations upstream of the lake and at the dam
    - Groundwater monitoring to estimate flow and impact of ground water into and out of Fairy Lake (municipal wells located at Prospect Park)

Creation of a database to house raw data and associated metadata is also crucial to tracking changes in and around Fairy Lake over time, particularly where data is being collected by various parties. This, along with a routine monitoring program will not only allow for trend analysis but also allow the Town and other users to assess the effectiveness of mitigation/management strategies moving forward.

9.4 Summary of Key Recommendations

A number of recommendations to improve water quality in Fairy Lake are provided in Section 6.0. The recommendations identified to reduce nutrient and bacteria loading to the lake are also consistent with best management practices aimed at reducing the frequency of HABs in lake ecosystems. **Table 14** summarizes the key recommendations and target goals of each. Given that stormwater design, the phosphorus offsetting plan currently underway for Black Creek, watershed health and Fairy Lake management are the responsibility of various groups (Town, Region, CVC), it is recommended that the TAC (or a similar group comprised of representatives from each group) meet to prioritize and determine the next steps/actions and responsibilities of each party. This collaboration will also allow groups to synergize their efforts and finances to attain the shared goal of improved water quality in the Fairy Lake catchment.

Recommendations focus on reducing/removing the source of stressors to the extent feasible; and, where not feasible, infiltrating runoff and capturing contaminants before flows reach watercourses and storm sewers reporting to the lake.

For long-term management of Fairy Lake, a cross agency and disciplinary technical group should be established to review the results of emerging studies, plan future studies, develop and prioritize management approaches to align with the collective goals of the group and make the best use of available resources.

Table 14. Key Recommendations to improve Fairy Lake water quality

Recommendation	Goal/Targeted Stressor	Example
Review existing agricultural best management practices part of the watershed rural incentives program and introduce new or enhanced BMPs	Reduce nutrient loading to nearby waterbodies as a result of soil disturbance and erosion	No-till or conservation tillage practices, cover crops, vegetative buffers to creeks, nutrient management plans
Storm sewer retrofits	Reduce contaminants in stormwater flows before they reach the lake	Oil grit separators, filters, adaptive management solutions being investigated for the Region’s phosphorus offsetting plan
Low impact development design and retrofits	Reduce contaminants in stormwater flows before they reach the lake	Incorporate LID features in new development – inclusion of green roof, permeable pavement, bioretention/rain gardens, rainwater harvesting, soakaway pits, and infiltration chambers Retrofit existing neighbourhoods, hosting LID features in road right of ways, within residential, industrial or commercial, or public land (Town owned parks and facilities, schools, etc.)
Natural Channel Design	Attenuate stormwater flow rate and quality, moderate water temperature, reduce nitrogen loading	Restore concrete channel upstream of Fairy Lake Restore the hyporheic zone of rivers

Recommendation	Goal/Targeted Stressor	Example
Wetland Design	Attenuate stormwater flow rate and quality, reduce contaminant loading	Tyler Avenue stormwater outfall and mouth of Black Creek/Bovis Creek at Fairy Lake
Vegetation Management	Attenuate stormwater flow rate and quality Reduce erosion, increase infiltration, reduce nutrient loading, improve habitat Limit access to the lake shoreline (reducing goose activity and human disturbance)	Use of planted riparian buffers with, native seed mixes along the lake shoreline and adjacent to Black Creek/Bovis Creek upstream of the lake
Waterfowl Management	Reduce bacteria source Improve conditions at recreational facilities	Daily beach grooming Habitat modification along lake shoreline Changing maintenance practices in grassed areas Using natural applications to open grassed areas to deter geese (e.g., garlic based) Use barriers (retractable fencing) to keep geese from loafing and fouling the beach Use of hazing techniques (dogs or raptors)
Engage local property owners and businesses adjacent to, or with a surface water connection to the lake	Reduce water quality stressors from private properties adjacent to the lake	Promote stewardship initiatives through education and incentives (e.g., use of LID design and retrofits, vegetative and waterfowl management techniques)

Recommendation	Goal/Targeted Stressor	Example
Monitor the effectiveness of management activities at meeting targeted goals	Identifying adaptive management to align with changing conditions over time	Long-term monitoring program
Coordinate efforts of various stakeholders to align goals and share available resources	Allow for adaptive management to align with changing conditions over time and shifting priorities/goals for the Fairy Lake catchment.	Establish a cross agency and disciplinary technical group that meets regularly to review the results of emerging studies, plan future studies, and develop and prioritize management approaches to align with the collective goals of the group and make the best use of available resources.

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Appendices

Appendix A Site Photos

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Photo Appendix

Geese

Photo 1: Polygon 1a habitat near Prospect Park point, June 23, 2021.

Photo 2: Polygon 1a habitat in Prospect Park near ball field, June 23, 2021.

Photo 3: Polygon 1a geese on park driveway/trail, June 23, 2021.

Photo 4: Polygon 1a goose tracks and feces on beach, June 23, 2021.

Photo 5: Polygon 1b habitat - lawn with fenced cemetery, June 23, 2021.

Photo 6: Polygon 1b habitat - fenced courts near community centre, June 23, 2021.

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Photo 7: Polygon 1b at fenced off-leash dog park, June 23, 2021.

Photo 8: Polygon 1b goose feces on park path, June 23, 2021.

Photo 9: Polygon 1c habitat - lawn and shoreline, June 23, 2021.

Photo 10: Polygon 1c habitat - residential south of WQ4, June 23, 2021.

Photo 11: Polygon 1c geese in manicured area, June 23, 2021.

Photo 12: Polygon 1c goose feces and feathers, small openings to lake, June 23, 2021.

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Photo 13: Polygon 2 habitat along shoreline, June 23, 2021.

Photo 14: Polygon 2 habitat at terminus of Cameron Street, June 23, 2021.

Photo 15: Polygon 2 open water, June 23, 2021.

Photo 16: Polygon 3c habitat near condo building and town property, June 23, 2021.

Photo 17: Polygon 3b goose feces on basketball court - St. Joseph Elementary, June 2021.

Photo 18: Polygon 3b goose feces on walking path at school – June 23, 2021.

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Photo 19: Polygon 3c walking path between school yard and lake, June 2021.

Photo 20: Polygon 3b Legion lawn and fence line facing school property, June 2021.

Photo 21: Polygon 3a habitat - lawn at Royal Canadian Legion, June 23, 2021.

Photo 22: Polygon 3a habitat - manicured lawn at Legion, June 23, 2021.

Photo 23: Polygon 3a abundant goose feathers and feces at horseshoe pits, June 23, 2021.

Photo 24: Polygon 3a goose on nest, April 20, 2022.

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Photo 25: Polygon 3a geese in water, June 23, 2021.

Photo 26: Polygon 4 nest FLN1 along shoreline, April 20, 2022.

Photo 27: Polygon 8 habitat – shoreline at day use area Smallwood Acres, June 2021.

Photo 28: Polygon 8 habitat - Smallwood Acres lawn and playground, June 2021.

Photo 29: Polygon 8 geese on shore at day use area of Smallwood Acres, June 2021.

Photo 30: Polygon 8 geese on manicured lawn near trailers, June 23, 2021.

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Photo 31: Polygon 6 habitat – manicured area and playground at The Breezes Trailer Park.

Photo 32: Polygon E – adult mute swans and cygnets, August 2022.

Photo 33: Polygon 6 docks in use by geese, July 22, 2021.

Photo 34: Polygon 6 The Breezes point/ recreational area at edge of lake, June 2021.

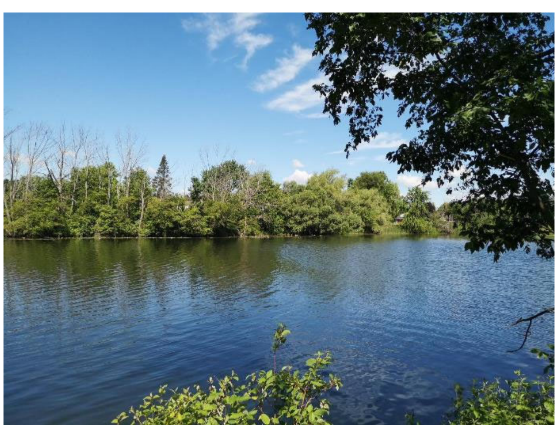

Photo 35: Polygon A habitat - north arm of Fairy Lake with residential along shoreline.

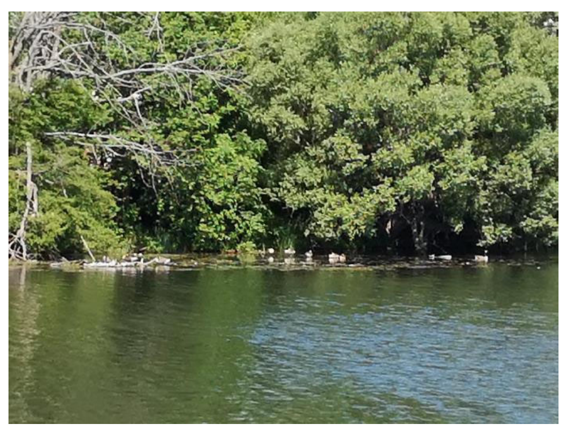

Photo 36: Polygon A geese in water along shore, June 23, 2021.

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Photo 37: Polygon A (open water habitat) - geese near boat launch, June 23, 2021.


Photo 38: Polygon B (open water) facing southwest from Mill Street near dam.


Photo 39: Polygon B – an example of hardened shoreline on north side, near the dam.


Photo 40: Polygon C habitat - central basin Fairy Lake open water, June 23, 2021.


Photo 41: Polygon D habitat – southern limit of lake, abundant macrophytes, June 2021.

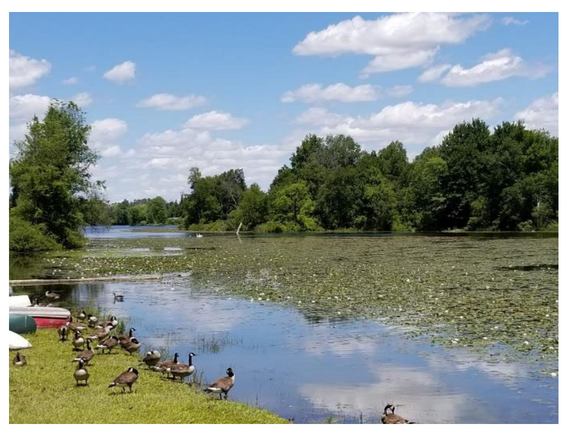
Photo 42: Polygon D habitat facing north, June 23, 2021.

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Photo 43: Station WQ1 south basin wetland inlet with algae, April 20, 2022.

Photo 44: WQ1 wetland inlet facing west toward lake, September 22, 2021.

Photo 45: Station WQ1 during early spring melt, February 17, 2022.

Photo 46: Station WQ2 inlet at trailer park, September 22, 2021.

Photo 47: Station WQ2 outlet to lake, February 17, 2022.

Photo 48: Sampling at station WQ2 outlet to lake, September 22, 2021.

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Photo 49: Station WQ2 water colour at outlet to lake, September 22, 2021.

Photo 50: Station WQ3 sampling with Van Dorn sampler in central basin, August 3, 2021.

Photo 51: Station WQ4 stormwater inlet during wet weather event, Sept. 22, 2021

Photo 52: Station WQ4 Tyler Ave. storm outfall facing downstream, Sept. 22, 2021.

Photo 53: Station WQ5 Prospect Park old beach, June 23, 2021.

Photo 54: Station WQ6 outlet to Black Creek facing upstream to dam, August 3, 2021.

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Photo 55: Station WQ6 facing downstream of dam, August 3, 2021.

Photo 56: Station WQ6 outlet to Black Creek in wet weather, Sept. 22, 2021.

Photo 57: Station WQ6 facing downstream to Mill Street, September 22, 2021.

Photo 58: Station WQ6 conditions during early spring melt, February 17, 2022.

Photo 59: grassed channel of Black Creek upstream of WQ7, June 23, 2021.

Photo 60: Station WQ7 Black Creek at outlet to lake, September 22, 2021.

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Photo 61: Station WQ7 collecting in-situ data, February 17, 2022.


Photo 62: Facing station WQ7 (footbridge over Black Creek), February 17, 2022.


Photo 63: Station WQ8 Elmore Dr. storm outfall in wet weather, February 17, 2022.


Photo 64: Station WQ8 Elmore Dr. storm outfall in wet weather, Sept. 22, 2021.


Photo 65: conditions at WQ10 west inlet facing west to wetland, August 3, 2021.


Photo 66: Station WQ10 facing east (downstream), August 3, 2021.

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Photo 67: Station WQ10 west inlet looking west, February 17, 2022.

Photo 68: Station WQ10 west inlet looking east (downstream).

Photo 69: In-situ data collection on lake, August 3, 2021.

Photo 70: Painted turtle, April 2022.

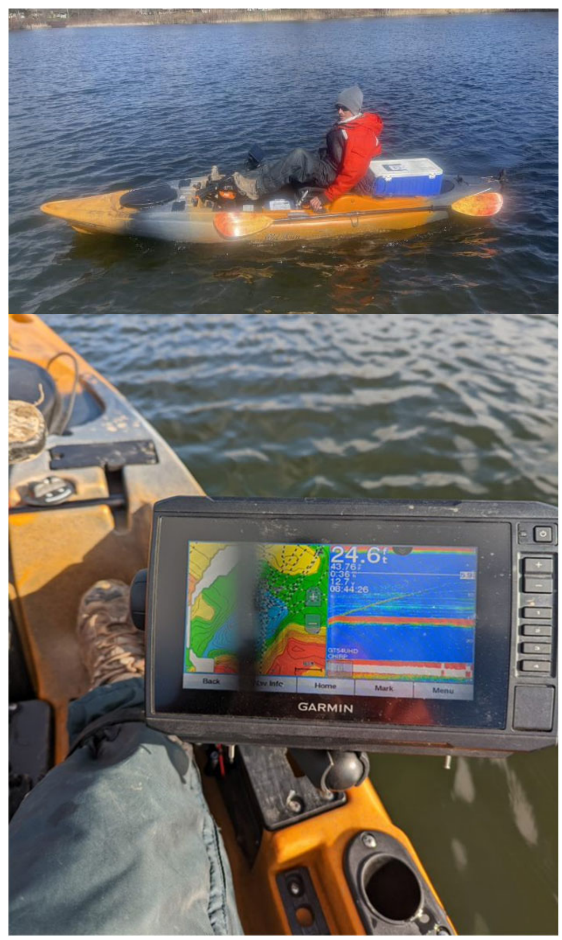

Photo 71: Kayaking setup for water quality monitoring and bathymetry, April 2022.

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Photo Appendix

Sediment Quality

Photo 72: Station SQ1/WQ11 view of lake, November 12, 2021.

Photo 73: Station SQ1 sediment sample, November 12, 2021.

Photo 74: Station SQ2/WQ9 view of lake at central south basin - November 12, 2021.

Photo 75: Geese using open water areas, April 20, 2022.

Photo 76: Station SQ3/WQ3 view of lake at central basin- November 12, 2021.

Photo 77: Station SQ3 sediment sample - November 12, 2021.

Appendix B Surface Water & Sediment Chemistry

Appendix B Table 1: Fairy Lake Water Quality Data, 2021-2022

		Provincial Water Quality Objective (PWQO)	Canadian Council of Ministers of Environment (CCME)			WQ1 - South Basin Inlet at Mill St.							WQ2 - Stormwater Inlet at Trailer Park					
Parameter	Unit	Aquatic Life	Aquatic Life		Livestock Health	2008 (AECOM)**	2021-08-03	2021-09-22	2022-04-20	Min	Max	Mean	2008 (AECOM)**	2021-09-22	2022-02-17	Min	Max	Mean
			Acute	Chronic														
Field Measured																		
Field Water Temperature	°C	-	-	-	-	-	16.4	16.5	3.5	3.50	16.50	12.13	-	16.4	0.1	0.1	16.4	8.3
Field Dissolved Oxygen	mg/L	>4.0	>5.5		-	-	**0.59**	**1.40**	8.13	0.59	8.13	3.37	-	7.16	11.87	7.16	11.87	9.52
Field Specific Conductivity	µS/cm	-	-	-	-	0.549	0.577	0.581	0.508	0.508	0.581	0.555	0.626	0.791	0.479	0.479	0.791	0.635
Field pH		6.5-8.5	-	6.5-9.0	-	8.10	6.99	7.49	7.47	6.99	7.49	7.32	8.10	7.48	7.57	7.48	7.57	7.53
General Chemistry																		
Total Ammonia-N	mg/L	-	-	-	-	0.05[(<RDL)]	0.06	0.06	0.19	0.06	0.19	0.10	0.05[(<RDL)]	0.27	0.54	0.27	0.54	0.41
Total Carbonaceous BOD	mg/L	-	-	-	-	2[(<RDL)]	2[(<RDL)]	2[(<RDL)]	2[(<RDL)]	<RDL	<RDL	<RDL	6	2[(<RDL)]	4	<RDL	4	3
Total Dissolved Solids	mg/L	-	-	-	-	356	320	310	235	235	320	288	401	485	210	210	485	348
Total Nitrogen (N)	mg/L	-	-	-		1.21	0.83	1.3	0.46	0.46	1.30	0.86	1.11	1.5	4.3	1.5	4.3	2.9
Dissolved Organic Carbon	mg/L	-	-	-	-	-	15	13	6.7	6.7	15.0	11.6	-	22	11	11	22	17
Orthophosphate (P)	mg/L	-	-	-	-	0.02	0.0043	0.047	0.0044	0.0043	0.0470	0.0186	0.04	0.04	0.062	0.040	0.062	0.051
Dissolved Phosphorus	mg/L	-	-	-	-	0.032	0.018	0.065	0.009	0.009	0.065	0.031	0.048	0.052	0.066	0.052	0.066	0.059
Total Phosphorus	mg/L	0.020 lakes; 0.030 rivers	-	-	-	**0.054**	**0.03**	**0.14**	0.014	0.014	0.140	0.061	**0.033**	**0.075**	**0.14**	0.08	0.14	0.11
Total Suspended Solids	mg/L	25 mg/L (as per CVC et.al. 2009)	-	-	-	2	3	7	1[(<RDL)]	<RDL	7	4	13	3	**28**	3	28	16
Total Kjeldahl Nitrogen, calculated	mg/L	-	-	-	-	1.1	0.89	1.28	0.424	0.424	1.280	0.865	1	1.11	1.25	1.11	1.25	1.18
Alkalinity (Total as $CaCO_3$)	mg/L	-	-	-		229	250	170	200	170	250	207	236	250	100	100	250	175
Dissolved Chloride (Cl-)	mg/L	-	640	120		39	40	59	40	40	59	46	52	100	69	69	100	85
Nitrite (N)	mg/L	-	-	0.06	10	0.01[(<RDL)]	0.0012	0.0032	0.004	0.0012	0.0040	0.0028	0.01[(<RDL)]	0.0069	0.018	0.0069	0.0180	0.0125
Nitrate (N)	mg/L	-	124	3.0	-	0.1[(<RDL)]	0.0020[(<RDL)]	0.011	0.002	<RDL	0.011	0.0051	0.1	0.39	3	0.39	3.00	1.70
Nitrite + Nitrate (N), calculated	mg/L	-	-	-	100	0.1[(<RDL)]	0.0022[(<RDL)]	0.014	0.033	<RDL	0.033	0.0164	0.1	0.4	3	0.4	3.0	1.7
Unionized Ammonia-N, calculated	µg N/L	16.5	16.0			-	0.2	0.6	0.6	0.2	0.6	0.5	-	2.4	1.7	1.7	2.4	2.1
Microbiology																		
Escherichia coli	CFU/100 ml	400 *E.coli* /100 mL (Ministry of Health)	-	-	-	-	100	**3500**	50	50	3500	1217	-	**3300**	80	80	3300	1690
Metals																		
Total Aluminum (Al)	µg/L	15 (pH 4.5-5.5, clay free samples) 75 (pH 6.5-9.0, clay free samples)	100 (pH ≥6.5)		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Antimony (Sb)	µg/L	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Arsenic (As)	µg/L	100		5	25	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Barium (Ba)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Beryllium (Be)	µg/L	11 ($CaCO_3$<75 mg/L); 1100 ($CaCO_3$>75 mg/L)	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Bismuth (Bi)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Boron (B)	µg/L	200	29000	1500	5000	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Cadmium (Cd)	µg/L	0.2	a	a	80	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Chromium (Cr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Cobalt (Co)	µg/L	0.9	-	-	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Copper (Cu)	µg/L	5	-	a	500-5000	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Iron (Fe)	µg/L	300	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Lead (Pb)	µg/L	5 ($CaCO_3$<20 mg/L) 10 ($CaCO_3$=20-40 mg/L) 20 ($CaCO_3$ 40-80 mg/L) 25 ($CaCO_3$ >80 mg/L)	-	a	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Lithium (Li)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Manganese (Mn)	µg/L	-	b	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Hg), filtered sample	µg/L	0.2 (filtered sample)	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Molybdenum (Mo)	µg/L	40		73	500	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nickel (Ni)	µg/L	25		65.8[a]	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Selenium (Se)	µg/L	100	-	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Silicon (Si)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Silver (Ag)	µg/L	0.1	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Strontium (Sr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Thallium (Tl)	µg/L	0.3	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Tin (Sn)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Titanium (Ti)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Uranium (U)	µg/L	5	33	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Vanadium (V)	µg/L	6	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Zinc (Zn)	µg/L	30	c	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Zirconium (Zr)	µg/L	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Sulphur (S)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ID	Source	Conditions
a - calculated, specific to sampling event	CCME	used [$CaCO_3$] in CCME calculator to determin CWQG; available at: https://www.ccme.ca/en/current-activities/canadian-environmental-quality-guidelines
b - total manganese, calculated specific to sampling event	CCME	used CCME excel spreadsheet (available at: https://www.ccme.ca/en/current-activities/canadian-environmental-quality-guidelines) to calculate for each reported lab result
c - total zinc, calculated specific to sampling event	CCME 2018	acute: If hardness is 13.8>150.5 mg/L and dissolved organic carbon is 0.3>17.3 mg/L, use: (exp(0.833[ln(hardness)] + 0.240[ln(DOC)] + 0.526); chronic: If hardness is 23.4>399 mg/L, pH is 6.5>8.13 and dissolved organic carbon is 0.3>22.9 mg/L, use: (exp(0.947[ln(hardness)] – 0.815[pH] + 0.398[ln(DOC)] + 4.625)
RDL - reportable detection limit		
<RDL - result below RDL		
- no results available		
** Not included in min/max/mean calculations, represents average of 4 events as presented in AECOM (2009)		

Bold values do not meet the Provincial Water Quality Objective

Credit Valley Conservation (CVC), Environmental Water Resources Group, Geomorphic Solutions, and XCG Consultants Limited. 2009. Black Creek Subwatershed. Study Background Report.

Appendix B Table 1: Fairy Lake Water Quality Data, 2021-2022

		Provincial Water Quality Objective (PWQO)	Canadian Council of Ministers of Environment (CCME)			WQ3 - Lake Central Basin								WQ4 - Stormwater Inlet at Tyler Avenue						WQ5 - Prospect Park Beach						
Parameter	Unit	Aquatic Life	Aquatic Life		Livestock Health	2008 (AECOM)**	2021-08-03	2021-09-22	2022-01-24	2022-04-20	Min	Max	Mean	2008 (AECOM)**	2021-09-22	2022-02-17	Min	Max	Mean	2008 (AECOM)**	2021-08-03	2021-09-22	2022-04-20	Min	Max	Mean
			Acute	Chronic																						
Field Measured																										
Field Water Temperature	°C	-	-	-	-	-	22.2	20.3	3.2	7.5	3.2	22.2	13.3	-	16.8	0.4	0.4	16.8	8.6		22.5	20.3	7.6	7.6	22.5	16.8
Field Dissolved Oxygen	mg/L	>4.0	>5.5		-	-	7.62	7.53	8.23	11.43	7.53	11.43	8.70	-	8.03	13.69	8.03	13.69	10.86		6.95	7.82	11.65	6.95	11.65	8.81
Field Specific Conductivity	µS/cm	-	-	-	-	0.627	0.646	0.632	0.885	0.805	0.632	0.885	0.742	1.242	0.436	0.491	0.436	0.491	0.464	0.521	0.643	0.626	0.791	0.626	0.791	0.687
Field pH		6.5-8.5	-	6.5-9.0	-	8.40	8.14	7.93	7.56	8.00	7.56	8.14	7.91	8.30	7.92	8.14	7.92	8.14	8.03	8.40	8.02	8.05	7.99	7.99	8.05	8.02
General Chemistry																										
Total Ammonia-N	mg/L	-	-	-	-	0.73	0.04	0.05	0.09	0.22	0.04	0.22	0.10	$0.05^{(<RDL)}$	0.06	0.26	0.06	0.26	0.16	$0.05^{(<RDL)}$	0.04	0.03	0.06	0.03	0.06	0.04
Total Carbonaceous BOD	mg/L	-	-	-	-	$2^{(<RDL)}$	$2^{(<RDL)}$	$2^{(<RDL)}$	$2^{(<RDL)}$	$2^{(<RDL)}$	<RDL	<RDL	<RDL	8	$2^{(<RDL)}$	3	<RDL	3	<RDL	3	$2^{(<RDL)}$	$2^{(<RDL)}$	$2^{(<RDL)}$	<RDL	<RDL	<RDL
Total Dissolved Solids	mg/L	-	-	-	-	408	345	345	455	420	345	455	391	805	255	195	195	255	225	339	365	330	350	330	365	348
Total Nitrogen (N)	mg/L	-	-	-		1.61	0.5	0.68	1.3	1.2	0.50	1.30	0.92	2.25	0.82	1.3	0.82	1.30	1.06	1.32	0.52	0.63	0.99	0.52	0.99	0.71
Dissolved Organic Carbon	mg/L	-	-	-	-	-	5.8	5.9	7.1	4.0	4.0	7.1	5.7	-	5.5	5.1	5.1	5.5	5.3		6.4	5.9	4.2	4.2	6.4	5.5
Orthophosphate (P)	mg/L	-	-	-	-	$0.01^{(<RDL)}$	0.0012	0.0013	$0.0010^{(<RDL)}$	$0.0010^{(<RDL)}$	<RDL	0.0013	0.0011	0.045	0.016	0.057	0.016	0.057	0.037	$0.01^{(<RDL)}$	$0.0010^{(<RDL)}$	0.0014	$0.0010^{(<RDL)}$	<RDL	0.0014	0.0011
Dissolved Phosphorus	mg/L	-	-	-	-	0.009	0.007	0.007	0.005	0.005	0.005	0.007	0.006	0.016	0.02	0.062	0.020	0.062	0.041	0.01	0.006	0.007	0.004	0.004	0.007	0.006
Total Phosphorus	mg/L	0.020 lakes; 0.030 rivers	-	-	-	**0.033**	0.014	0.015	0.014	0.015	0.014	0.015	0.015	**0.058**	**0.052**	**0.15**	0.052	0.150	0.101	**0.021**	0.013	0.013	0.010	0.010	0.013	0.012
Total Suspended Solids	mg/L	25 mg/L (as per CVC et.al. 2009)	-	-	-	3	3	3	2	2	2	3	3	10	14	**45**	14	45	30	5	2	3	2	2	3	2
Total Kjeldahl Nitrogen, calculated	mg/L	-	-	-	-	1	0.51	0.671	0.757	1.13	0.510	1.130	0.767	0.9	0.466	0.83	0.466	0.830	0.648	0.8	0.55	0.624	0.321	0.321	0.624	0.498
Alkalinity (Total as $CaCO_3$)	mg/L	-	-	-	-	202	170	170	260	220	170	260	205	261	120	63	63	120	92	167	160	160	210	160	210	177
Dissolved Chloride (Cl-)	mg/L	-	640	120		65	-	-	-	-	-	-	-	223	56	100	56	100	78	52	-	-	-	-	-	-
Nitrite (N)	mg/L	-	-	0.06	10	0.01	0.0013	0.0022	0.0083	0.0040	0.0013	0.0083	0.0040	0.05	0.0076	0.013	0.0076	0.0130	0.0103	0.02	0.0014	0.0014	0.0078	0.0014	0.0078	0.0035
Nitrate (N)	mg/L	-	124	3.0	-	0.6	$0.0020^{(<RDL)}$	0.012	0.51	0.029	<RDL	0.51	0.1383	1.3	0.35	0.47	0.35	0.47	0.41	0.5	0.0044	0.0042	0.66	0.0042	0.6600	0.2229
Nitrite + Nitrate (N), calculated	mg/L	-	-	-	100	0.6	$0.0022^{(<RDL)}$	0.014	0.52	0.033	<RDL	0.52	0.1433	1.3	0.36	0.48	0.36	0.48	0.42	0.5	0.0058	0.0056	0.67	0.0056	0.6700	0.2271
Unionized Ammonia-N, calculated	µg N/L	16.5	16.0			-	2.4	1.7	0.3	3.3	0.3	3.3	1.9	-	1.5	5.5	1.5	5.5	3.5		1.9	1.3	0.9	0.9	1.9	1.4
Microbiology																										
Escherichia coli	CFU/100 ml	400 *E.coli* /100 mL (Ministry of Health)	-	-	-	-	$10^{(<RDL)}$	20	$10^{(<RDL)}$	$10^{(<RDL)}$	20	20	20		**9700**	230	230	9700	4965		30	110	$10^{(<RDL)}$	<RDL	110	50
Metals																										
Total Aluminum (Al)	µg/L	15 (pH 4.5-5.5, clay free samples) 75 (pH 6.5-9.0, clay free samples)	100 (pH ≥6.5)		-	-	-	-	-	-	-	-	-	72	**285**	**987**	285	987	636	-	-	-	-	-	-	-
Total Antimony (Sb)	µg/L	20	-	-	-	-	-	-	-	-	-	-	-	$0.5^{(<RDL)}$	0.175	0.272	0.175	0.272	0.224	-	-	-	-	-	-	-
Total Arsenic (As)	µg/L	100		5	25	-	-	-	-	-	-	-	-	1	1.57	1.53	1.53	1.57	1.55	-	-	-	-	-	-	-
Total Barium (Ba)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	59	31.7	18.8	18.8	31.70	25.25	-	-	-	-	-	-	-
Total Beryllium (Be)	µg/L	11 ($CaCO_3$<75 mg/L); 1100 ($CaCO_3$>75 mg/L)	-	-	100	-	-	-	-	-	-	-	-	$0.5^{(<RDL)}$	0.016	0.065	0.016	0.065	0.041	-	-	-	-	-	-	-
Total Bismuth (Bi)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	$1^{(<RDL)}$	0.013	0.028	0.013	0.028	0.021	-	-	-	-	-	-	-
Total Boron (B)	µg/L	200	29000	1500	5000	-	-	-	-	-	-	-	-	30	20	14	14	20	17	-	-	-	-	-	-	-
Total Cadmium (Cd)	µg/L	0.2	a	a	80	-	-	-	-	-	-	-	-	$0.1^{(<RDL)}$	0.0229	0.0597	0.0229	0.0597	0.0413	-	-	-	-	-	-	-
Total Chromium (Cr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	$5^{(<RDL)}$	1.45	2.38	1.45	2.38	1.92	-	-	-	-	-	-	-
Total Cobalt (Co)	µg/L	0.9	-	-	1000	-	-	-	-	-	-	-	-	$0.5^{(<RDL)}$	0.195	0.663	0.195	0.663	0.429	-	-	-	-	-	-	-
Total Copper (Cu)	µg/L	5	-	a	500-5000	-	-	-	-	-	-	-	-	4	2.97	**10.7**	2.97	10.70	6.84	-	-	-	-	-	-	-
Total Iron (Fe)	µg/L	300	-	300	-	-	-	-	-	-	-	-	-	255	**517**	**1610**	517	1610	1064	-	-	-	-	-	-	-
Total Lead (Pb)	µg/L	5 ($CaCO_3$<20 mg/L) 10 ($CaCO_3$=20-40 mg/L) 20 ($CaCO_3$ 40-80 mg/L) 25 ($CaCO_3$ >80 mg/L)	-	a	100	-	-	-	-	-	-	-	-	1	0.857	4.5	0.857	4.500	2.679	-	-	-	-	-	-	-
Total Lithium (Li)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	$5^{(<RDL)}$	1.83	2.69	1.83	2.69	2.26	-	-	-	-	-	-	-
Total Manganese (Mn)	µg/L	-	b	b	-	-	-	-	-	-	-	-	-	34	49.7	127	49.7	127.0	88.4	-	-	-	-	-	-	-
Mercury (Hg), filtered sample	µg/L	0.2 (filtered sample)	-	-	3	-	-	-	-	-	-	-	-	-	$0.10^{(<RDL)}$	$0.10^{(<RDL)}$	<RDL	<RDL	<RDL	-	-	-	-	-	-	-
Total Molybdenum (Mo)	µg/L	40		73	500	-	-	-	-	-	-	-	-	-	0.669	0.658	0.658	0.669	0.664	-	-	-	-	-	-	-
Total Nickel (Ni)	µg/L	25		65.8[a]	1000	-	-	-	-	-	-	-	-	$1^{(<RDL)}$	0.72	1.87	0.72	1.87	1.30	-	-	-	-	-	-	-
Total Selenium (Se)	µg/L	100	-	1	50	-	-	-	-	-	-	-	-	$2^{(<RDL)}$	0.097	0.107	0.097	0.107	0.102	-	-	-	-	-	-	-
Total Silicon (Si)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	3125	3070	2330	2330	3070	2700	-	-	-	-	-	-	-
Total Silver (Ag)	µg/L	0.1	-	0.25	-	-	-	-	-	-	-	-	-	$0.1^{(<RDL)}$	$0.010^{(<RDL)}$	0.011	0.011	0.011	0.011	-	-	-	-	-	-	-
Total Strontium (Sr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	185	101	88.5	88.5	101.00	94.75	-	-	-	-	-	-	-
Total Thallium (Tl)	µg/L	0.3	-	0.8	-	-	-	-	-	-	-	-	-	0	0.0066	0.0167	0.0066	0.0167	0.0117	-	-	-	-	-	-	-
Total Tin (Sn)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	$1^{(<RDL)}$	$0.20^{(<RDL)}$	0.29	<RDL	0.29	<RDL	-	-	-	-	-	-	-
Total Titanium (Ti)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	$5^{(<RDL)}$	8.6	32.2	8.6	32.2	20.4	-	-	-	-	-	-	-
Total Uranium (U)	µg/L	5	33	15	-	-	-	-	-	-	-	-	-	1	0.196	0.138	0.138	0.196	0.167	-	-	-	-	-	-	-
Total Vanadium (V)	µg/L	6	-	-	100	-	-	-	-	-	-	-	-	1	0.99	2.42	0.99	2.42	1.71	-	-	-	-	-	-	-
Total Zinc (Zn)	µg/L	30	c	c	-	-	-	-	-	-	-	-	-	18	**32.9**	**40.1**	32.9	40.1	36.5	-	-	-	-	-	-	-
Total Zirconium (Zr)	µg/L	4	-	-	-	-	-	-	-	-	-	-	-	$1^{(<RDL)}$	0.2	0.39	0.20	0.39	0.30	-	-	-	-	-	-	-
Total Sulphur (S)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	6250	3620	3620	6250	4935	-	-	-	-	-	-	-

Appendix B Table 1: Fairy Lake Water Quality Data, 2021-2022

		Provincial Water Quality Objective (PWQO)	Canadian Council of Ministers of Environment (CCME)			WQ6 - Fairy Lake Dam Outlet							WQ7 - Black Creek Inlet							WQ8 - Stormwater Inlet at Elmore Drive					
Parameter	Unit	Aquatic Life	Aquatic Life		Livestock	2008	2021-08-03	2021-09-22	2022-02-17	Min	Max	Mean	2008	2021-08-03	2021-09-22	2022-02-17	Min	Max	Mean	2008	2021-09-22	2022-02-17	Min	Max	Mean
			Acute	Chronic	Health	(AECOM)**							(AECOM)**							(AECOM)**					
Field Measured																									
Field Water Temperature	°C	-	-	-	-	-	23.7	20.4	2.3	2.3	23.7	15.5	-	16.8	16.3	-0.1	-0.1	16.8	11.0	-	17.0	1.5	1.5	17.0	9.3
Field Dissolved Oxygen	mg/L	>4.0	>5.5		-	-	7.62	8.47	7.56	7.56	8.47	7.88	-	7.75	8.86	7.56	7.56	8.86	8.06	-	8.78	13.20	8.78	13.20	10.99
Field Specific Conductivity	µS/cm	-	-	-	-	0.519	0.645	0.627	0.779	0.627	0.779	0.684	-	0.685	0.468	0.617	0.468	0.685	0.590	-	0.131	0.495	0.131	0.495	0.313
Field pH		6.5-8.5	-	6.5-9.0	-	8.40	8.18	8.12	7.60	7.60	8.18	7.97	-	8.07	7.75	7.85	7.75	8.07	7.89	-	8.18	8.03	8.03	8.18	8.11
General Chemistry																									
Total Ammonia-N	mg/L	-	-	-	-	0.05 (<RDL)	0.05	0.03	0.18	0.03	0.18	0.09	-	0.02	0.02	0.64	0.02	0.64	0.23	-	0.05	0.39	0.05	0.39	0.22
Total Carbonaceous BOD	mg/L	-	-	-	-	3	2 (<RDL)	2 (<RDL)	2 (<RDL)	<RDL	<RDL	<RDL	-	2 (<RDL)	2 (<RDL)	3	<RDL	3	2	-	2 (<RDL)	3	<RDL	3	3
Total Dissolved Solids	mg/L	-	-	-	-	340	380	345	355	345	380	360	-	350	280	295	280	350	308	-	95	170	95	170	133
Total Nitrogen (N)	mg/L	-	-	-		1.22	0.76	0.84	1.3	0.76	1.30	0.97	-	0.59	0.74	1.9	0.59	1.90	1.08	-	0.78	2	0.78	2.00	1.39
Dissolved Organic Carbon	mg/L	-	-	-	-	-	6	6.1	6.2	6.0	6.2	6.1	9	6.3	6.1	5.4	5.4	6.3	5.9	2	1.3	3.7	1.3	3.7	2.5
Orthophosphate (P)	mg/L	-	-	-	-	0.01 (<RDL)	0.0026	0.0010 (<RDL)	0.0026	<RDL	0.0026	0.0021	-	0.0018	0.035	0.033	0.0018	0.0350	0.0233	-	0.024	0.12	0.024	0.120	0.072
Dissolved Phosphorus	mg/L	-	-	-	-	0.008	0.007	0.007	0.006	0.006	0.007	0.007	-	0.007	0.038	0.037	0.007	0.038	0.027	-	0.025	0.1	0.025	0.100	0.063
Total Phosphorus	mg/L	0.020 lakes; 0.030 rivers	-	-	-	0.019	0.014	**0.021**	0.019	0.014	0.021	0.018	0.019	0.02	**0.086**	**0.093**	0.020	0.093	0.066	**0.034**	**0.04**	**0.19**	0.04	0.19	0.12
Total Suspended Solids	mg/L	25 mg/L (as per CVC et.al. 2009)	-	-	-	2	3	6	2	2	6	4	4	3	21	25	3	25	16	1 (<RDL)	4	**32**	4	32	18
Total Kjeldahl Nitrogen, calculated	mg/L	-	-	-	-	0.8	0.55	0.816	0.692	0.550	0.816	0.686	0.8	0.56	0.519	1.17	0.519	1.170	0.750	1.6	0.202	1.19	0.202	1.190	0.696
Alkalinity (Total as $CaCO_3$)	mg/L	-	-	-	-	167	160	160	240	160	240	187	-	170	130	81	81	170	127	-	40	49	40	49	45
Dissolved Chloride (Cl-)	mg/L	-	640	120		53	-	-	-	-	-	-	-	95	58	130	58	130	94	-	20	110	20	110	65
Nitrite (N)	mg/L	-	-	0.06	10	0.02	0.0011	0.0019	0.012	0.0011	0.0120	0.0050	-	0.0013	0.0042	0.017	0.0013	0.0170	0.0075	-	0.0056	0.012	0.0056	0.0120	0.0088
Nitrate (N)	mg/L	-	124	3.0	-	0.4	0.0033	0.019	0.56	0.0033	0.5600	0.1941	-	0.0057	0.21	0.71	0.0057	0.7100	0.3086	-	0.57	0.76	0.57	0.76	0.67
Nitrite + Nitrate (N), calculated	mg/L	-	-	-	100	0.4	0.0044	0.021	0.57	0.0044	0.5700	0.1985	-	0.0070	0.22	0.72	0.0070	0.7200	0.3157	-	0.58	0.77	0.58	0.77	0.68
Unionized Ammonia-N, calculated	µg N/L	16.5	16.0			-	3.6	1.5	0.7	0.7	3.6	2.0	-	0.7	0.3	3.7	0.3	3.7	1.6	-	2.3	3.9	2.3	3.9	3.1
Microbiology																									
Escherichia coli	CFU/100 ml	400 *E.coli* /100 mL (Ministry of Health)	-	-	-		220	150	10 (<RDL)	<RDL	220	127	-	10 (<RDL)	**5600**	390	390	5600	2995	-	**3900**	**8600**	3900	8600	6250
Metals																									
Total Aluminum (Al)	µg/L	15 (pH 4.5-5.5, clay free samples) 75 (pH 6.5-9.0, clay free samples)	100 (pH ≥6.5)		-	-	-	-	-	-	-	-	-	n/a	**906**	**357**	357.0	906.0	631.5	-	76.5	**521**	76.5	521.0	298.8
Total Antimony (Sb)	µg/L	20	-	-	-	-	-	-	-	-	-	-	-	n/a	0.218	0.261	0.218	0.261	0.240	-	0.07	0.296	0.070	0.296	0.183
Total Arsenic (As)	µg/L	100		5	25	-	-	-	-	-	-	-	-	n/a	1.03	1.39	1.03	1.39	1.21	-	0.144	1.47	0.144	1.470	0.807
Total Barium (Ba)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	24	22.7	22.7	24.0	23.4	-	6.28	12	6.28	12.00	9.14
Total Beryllium (Be)	µg/L	11 ($CaCO_3$<75 mg/L); 1100 ($CaCO_3$>75 mg/L)	-	-	100	-	-	-	-	-	-	-	-	n/a	0.049	0.019	<RDL	0.049	<RDL	-	0.010 (<RDL)	0.033	<RDL	0.033	<RDL
Total Bismuth (Bi)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	0.010 (<RDL)	0.076	<RDL	0.076	<RDL	-	0.010 (<RDL)	0.037	<RDL	0.037	<RDL
Total Boron (B)	µg/L	200	29000	1500	5000	-	-	-	-	-	-	-	-	n/a	44	12	12	44	28	-	10 (<RDL)	10 (<RDL)	<RDL	<RDL	<RDL
Total Cadmium (Cd)	µg/L	0.2	a	a	80	-	-	-	-	-	-	-	-	n/a	0.0295	0.0376	<RDL	0.0376	<RDL	-	0.0238	0.0403	0.0238	0.0403	0.0321
Total Chromium (Cr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	1.54	2.87	<RDL	2.87	<RDL	-	0.35	3.72	0.35	3.72	2.04
Total Cobalt (Co)	µg/L	0.9	-	-	1000	-	-	-	-	-	-	-	-	n/a	0.476	0.317	<RDL	0.476	<RDL	-	0.054	0.509	0.054	0.509	0.282
Total Copper (Cu)	µg/L	5	-	a	500-5000	-	-	-	-	-	-	-	-	n/a	**6.24**	4.82	4.82	6.24	5.53	-	1.24	**8.66**	1.24	8.66	4.95
Total Iron (Fe)	µg/L	300	-	300	-	-	-	-	-	-	-	-	-	n/a	**1080**	**728**	728	1080	904	-	90.7	**1080**	90.7	1080.0	585.4
Total Lead (Pb)	µg/L	5 ($CaCO_3$<20 mg/L) 10 ($CaCO_3$=20-40 mg/L) 20 ($CaCO_3$ 40-80 mg/L) 25 ($CaCO_3$ >80 mg/L)	-	a	100	-	-	-	-	-	-	-	-	n/a	1.56	1.95	<RDL	1.95	<RDL	-	0.318	2.58	0.318	2.580	1.449
Total Lithium (Li)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	4.77	1.53	1.53	4.77	3.15	-	0.50 (<RDL)	1.56	<RDL	1.56	<RDL
Total Manganese (Mn)	µg/L	-	b	b	-	-	-	-	-	-	-	-	-	n/a	48.5	84	48.5	84.0	66.3	-	8.49	72.4	8.49	72.40	40.45
Mercury (Hg), filtered sample	µg/L	0.2 (filtered sample)	-	-	3	-	-	-	-	-	-	-	-	0.10 (<RDL)	0.10 (<RDL)	0.10 (<RDL)	<RDL	<RDL	<RDL	-	0.10 (<RDL)	0.10 (<RDL)	<RDL	<RDL	<RDL
Total Molybdenum (Mo)	µg/L	40		73	500	-	-	-	-	-	-	-	-	n/a	1.6	0.696	0.696	1.600	1.148	-	0.317	0.375	0.317	0.375	0.346
Total Nickel (Ni)	µg/L	25		65.8[a]	1000	-	-	-	-	-	-	-	-	n/a	1.28	1.04	1.04	1.28	1.16	-	0.24	1.26	0.24	1.26	0.75
Total Selenium (Se)	µg/L	100	-	1	50	-	-	-	-	-	-	-	-	n/a	0.098	0.114	<RDL	0.114	<RDL	-	0.04 (<RDL)	0.095	<RDL	0.095	<RDL
Total Silicon (Si)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	4700	1700	1700	4700	3200	-	631	1200	631	1200	916
Total Silver (Ag)	µg/L	0.1	-	0.25	-	-	-	-	-	-	-	-	-	n/a	0.010 (<RDL)	0.010 (<RDL)	<RDL	<RDL	<RDL	-	0.010 (<RDL)	0.010 (<RDL)	<RDL	<RDL	<RDL
Total Strontium (Sr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	180	95.3	95.3	180.0	137.7	-	24.6	64.5	24.6	64.5	44.6
Total Thallium (Tl)	µg/L	0.3	-	0.8	-	-	-	-	-	-	-	-	-	n/a	0.0125	0.0099	<RDL	0.0125	<RDL	-	0.0025	0.0123	0.0025	0.0123	0.0074
Total Tin (Sn)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	0.20 (<RDL)	0.32	<RDL	0.32	<RDL	-	0.20 (<RDL)	0.25	<RDL	0.25	<RDL
Total Titanium (Ti)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	26.5	13.7	<RDL	26.5	<RDL	-	2.0 (<RDL)	16.5	<RDL	16.5	<RDL
Total Uranium (U)	µg/L	5	33	15	-	-	-	-	-	-	-	-	-	n/a	0.191	0.205	0.191	0.205	0.198	-	0.0686	0.107	0.0686	0.1070	0.0878
Total Vanadium (V)	µg/L	6	-	-	100	-	-	-	-	-	-	-	-	n/a	1.91	1.03	1.03	1.91	1.47	-	0.52	1.52	0.52	1.52	1.02
Total Zinc (Zn)	µg/L	30	c	c	-	-	-	-	-	-	-	-	-	n/a	10.8	**218**	10.8	218.0	114.4	-	7.4	**38.7**	7.4	38.7	23.1
Total Zirconium (Zr)	µg/L	4	-	-	-	-	-	-	-	-	-	-	-	n/a	0.76	0.29	<RDL	0.76	<RDL	-	0.10 (<RDL)	0.47	<RDL	0.47	<RDL
Total Sulphur (S)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	n/a	6490	4220	4220	6490	5355	-	1570	3190	1570	3190	2380

Appendix B Table 1: Fairy Lake Water Quality Data, 2021-2022

Parameter	Unit	Provincial Water Quality Objective (PWQO)	Canadian Council of Ministers of Environment (CCME)			WQ9 - Lake South Basin								WQ10 - West Arm Inlet							WQ11 - Lake North Basin			
		Aquatic Life	Aquatic Life Acute	Aquatic Life Chronic	Livestock Health	2008 (AECOM)**	2021-08-03	2021-09-22	2022-01-24	2022-04-20	Min	Max	Mean	2008 (AECOM)**	2021-08-03	2021-09-22	2022-02-17	Min	Max	Mean	2022-01-24	Min	Max	Mean
Field Measured																								
Field Water Temperature	°C	-	-	-	-	-	20.8	19.3	3.1	6.5	3.1	20.8	12.4	-	25.2	19.2	0.6	0.6	25.2	15.0	1.8	1.8	1.8	1.8
Field Dissolved Oxygen	mg/L	>4.0	>5.5		-	-	4.34	**2.91**	**0.60**	11.43	0.60	11.43	4.82	-	12.11	4.44	**2.77**	2.77	12.11	6.44	11.81	11.81	11.81	11.81
Field Specific Conductivity	µS/cm	-	-	-	-	-	0.655	0.639	0.769	0.691	0.639	0.769	0.689	-	0.422	0.553	0.795	0.422	0.795	0.590	0.949	0.949	0.949	0.949
Field pH		6.5-8.5	-	6.5-9.0	-	-	7.57	7.44	7.27	7.88	7.27	7.88	7.54	-	8.90	7.73	7.32	7.32	8.90	7.98	7.93	7.93	7.93	7.93
General Chemistry																								
Total Ammonia-N	mg/L	-	-	-	-	-	0.02	0.03	0.24	0.09	0.02	0.24	0.10	-	0.03	0.12	0.4	0	0	0	0.05	0.05	0.05	0.05
Total Carbonaceous BOD	mg/L	-	-	-	-	-	2(<RDL)	2(<RDL)	2(<RDL)	2(<RDL)	<RDL	<RDL	<RDL	-	2	2(<RDL)	2(<RDL)	<RDL	2	2	2(<RDL)	<RDL	<RDL	<RDL
Total Dissolved Solids	mg/L	-	-	-	-	-	380	365	415	330	330	415	373	-	265	310	340	265	340	305	465	465	465	465
Total Nitrogen (N)	mg/L	-	-	-		-	0.51	0.64	0.99	0.64	0.51	0.99	0.70	-	0.91	0.89	1.1	0.89	1.10	0.97	1.7	1.7	1.7	1.7
Dissolved Organic Carbon	mg/L	-	-	-	-	9	6.8	7.3	8	4.7	4.7	8.0	6.7	8.5	11	8	7.8	7.8	11.0	8.9	6.2	6.2	6.2	6.2
Orthophosphate (P)	mg/L	-	-	-	-	-	0.0012	0.0017	0.0013	0.0010(<RDL)	<RDL	0.0017	0.0013	-	0.0024	0.0013	0.0036	0.0013	0.0036	0.0024	0.0010(<RDL)	<RDL	<RDL	<RDL
Dissolved Phosphorus	mg/L	-	-	-	-	-	0.007	0.009	0.009	0.005	0.005	0.009	0.008	-	0.009	0.01	0.012	0.009	0.012	0.010	0.005	0.005	0.005	0.005
Total Phosphorus	mg/L	0.020 lakes; 0.030 rivers	-	-	-	**0.053**	0.014	0.017	**0.023**	0.012	0.012	0.023	0.017	**0.049**	0.021	0.03	**0.034**	0.021	0.034	0.028	0.015	0.015	0.015	0.015
Total Suspended Solids	mg/L	25 mg/L (as per CVC et.al. 2009)	-	-	-	3	2	2	8	2	2	8	4	2	3	4	3	3	4	3	2	2	2	2
Total Kjeldahl Nitrogen, calculated	mg/L	-	-	-	-	0.8	-	0.635	0.886	0.371	0.371	0.886	0.631	0.6	0.87	0.869	1.06	0.869	1.060	0.933	0.699	0.699	0.699	0.699
Alkalinity (Total as $CaCO_3$)	mg/L	-	-	-	-	-	170	170	270	210	170	270	205	-	150	170	280	150	280	200	270	270	270	270
Dissolved Chloride (Cl-)	mg/L	-	640	120		-	0.53	-	-	-	0.53	0.53	0.53	-	45	74	76	45	76	65	-	-	-	-
Nitrite (N)	mg/L	-	-	0.06	10	-	0.0010(<RDL)	0.0015	0.0083	0.0076	0.0015	0.0083	0.0058	-	0.0014	0.0016	0.0063	0.0014	0.0063	0.0031	0.0087	0.0087	0.0087	0.0087
Nitrate (N)	mg/L	-	124	3.0	-	-	0.0020(<RDL)	0.004	0.096	0.27	0.0040	0.2700	0.1233	-	0.01	0.016	0.023	0.010	0.023	0.016	1	1	1	1
Nitrite + Nitrate (N), calculated	mg/L	-	-	-	100	-	0.0022(<RDL)	0.0055	0.1	0.27	0.0055	0.2700	0.1252	-	0.011	0.017	0.03	0.011	0.030	0.019	1	1	1	1
Unionized Ammonia-N, calculated	µg N/L	16.5	16.0			-	0.3	0.3	0.5	0.9	0.3	0.9	0.5	-	9.4	2.4	0.7	0.7	9.4	4.2	0.4	0.4	0.4	0.4
Microbiology																								
Escherichia coli	CFU/100 ml	400 *E.coli* /100 mL (Ministry of Health)	-	-	-	-	10(<RDL)	30	10(<RDL)	30	30	30	30	-	10	**460**	10(<RDL)	<RDL	460	<RDL	10(<RDL)	<RDL	<RDL	<RDL
Metals																								
Total Aluminum (Al)	µg/L	15 (pH 4.5-5.5, clay free samples) 75 (pH 6.5-9.0, clay free samples)	100 (pH ≥6.5)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Antimony (Sb)	µg/L	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Arsenic (As)	µg/L	100		5	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Barium (Ba)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Beryllium (Be)	µg/L	11 ($CaCO_3$<75 mg/L); 1100 ($CaCO_3$>75 mg/L)	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Bismuth (Bi)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Boron (B)	µg/L	200	29000	1500	5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Cadmium (Cd)	µg/L	0.2	a	a	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Chromium (Cr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Cobalt (Co)	µg/L	0.9	-	-	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Copper (Cu)	µg/L	5	-	a	500-5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Iron (Fe)	µg/L	300	-	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Lead (Pb)	µg/L	5 ($CaCO_3$<20 mg/L) 10 ($CaCO_3$=20-40 mg/L) 20 ($CaCO_3$ 40-80 mg/L) 25 ($CaCO_3$ >80 mg/L)	-	a	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Lithium (Li)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Manganese (Mn)	µg/L	-	b	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Hg), filtered sample	µg/L	0.2 (filtered sample)	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Molybdenum (Mo)	µg/L	40		73	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Nickel (Ni)	µg/L	25		65.8[a]	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Selenium (Se)	µg/L	100	-	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Silicon (Si)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Silver (Ag)	µg/L	0.1	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Strontium (Sr)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Thallium (Tl)	µg/L	0.3	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Tin (Sn)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Titanium (Ti)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Uranium (U)	µg/L	5	33	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Vanadium (V)	µg/L	6	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Zinc (Zn)	µg/L	30	c	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Zirconium (Zr)	µg/L	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Sulphur (S)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix B Table 2: Fairy Lake Sediment Quality Data, 2021

Parameter	Unit [dry wt.]	RDL	Federal SQ Guidelines		Provincial SQ Guidelines		11/12/2021 10:57	11/12/2021 12:00	11/12/2021 11:33
			ISQG	PEL	LEL	SEL	SQ1	SQ2	SQ3
Inorganics									
Total Ammonia-N	ug/g	20	na	na			20(RDL)	57	20(RDL)
Moisture	%	1	na	na			73	90	52
Nitrogen (N)	%	0.01	na	na			0.53	1.3	0.3
Total Organic Carbon	mg/kg	500	na	na	10000	100000	61000	94000	42000
Total Kjeldahl Nitrogen	ug/g	100	na	na	550	4800	**5300**	**13500**	**2970**
Nitrite (N)	ug/g	0.5	na	na			0.5(RDL)	0.8	0.5(RDL)
Nitrate (N)	ug/g	2	na	na			2(RDL)	2(RDL)	2(RDL)
Nitrate + Nitrite (N)	ug/g	3	na	na			3(RDL)	3(RDL)	3(RDL)
Metals									
Acid Extractable Aluminum (Al)	ug/g	50	na	na			10000	6100	10000
Acid Extractable Antimony (Sb)	ug/g	0.2	na	na			0.58	0.2(RDL)	0.33
Acid Extractable Arsenic (As)	ug/g	1	5.9	17	6	33	**7.9**	3.8	**7.8**
Acid Extractable Barium (Ba)	ug/g	0.5	na	na			92	120	85
Acid Extractable Beryllium (Be)	ug/g	0.2	na	na			0.44	0.24	0.43
Acid Extractable Bismuth (Bi)	ug/g	1	na	na			1.0(RDL)	1.0(RDL)	1.0(RDL)
Acid Extractable Boron (B)	ug/g	5	na	na			7.3	5.3	6.8
Acid Extractable Cadmium (Cd)	ug/g	0.1	0.6	3.5	0.6	10	**0.7**	0.51	**0.64**
Acid Extractable Calcium (Ca)	ug/g	50	na	na			91000	220000	98000
Acid Extractable Chromium (Cr)	ug/g	1	37.3	90	26	110	**35**	15	**33**
Acid Extractable Cobalt (Co)	ug/g	0.1	na	na			6.9	3.4	7.1
Acid Extractable Copper (Cu)	ug/g	0.5	35.7	197			**60**	29	**53**
Acid Extractable Iron (Fe)	ug/g	50	na	na	2%	4%	21000	12000	21000
Acid Extractable Lead (Pb)	ug/g	1	35	91.3	31	250	**57**	**34**	**45**
Acid Extractable Lithium (Li)	ug/g	1	na	na			14	7.7	16
Acid Extractable Magnesium (Mg)	ug/g	50	na	na			16000	7400	13000
Acid Extractable Manganese (Mn)	ug/g	1	na	na	460	1100	**1000**	400	**910**
Acid Extractable Molybdenum (Mo)	ug/g	0.5	na	na			0.85	1.4	0.6
Acid Extractable Nickel (Ni)	ug/g	0.5	na	na	16	75	**16**	9.6	**16**
Acid Extractable Phosphorus (P)	ug/g	50	na	na	600	2000	**930**	**640**	**1000**
Acid Extractable Potassium (K)	ug/g	200	na	na			1200	860	1300
Acid Extractable Selenium (Se)	ug/g	0.5	na	na			0.74	0.93	0.69
Acid Extractable Silver (Ag)	ug/g	0.2	na	na			0.2(RDL)	0.2(RDL)	0.2(RDL)
Acid Extractable Sodium (Na)	ug/g	50	na	na			450	600	510
Acid Extractable Strontium (Sr)	ug/g	1	na	na			96	190	110
Acid Extractable Thallium (Tl)	ug/g	0.05	na	na			0.13	0.096	0.15
Acid Extractable Tin (Sn)	ug/g	1	na	na			4.1	1.3	2.1
Acid Extractable Titanium (Ti)	ug/g	5	na	na			120	88	120
Acid Extractable Uranium (U)	ug/g	0.05	na	na			0.55	0.99	0.57
Acid Extractable Vanadium (V)	ug/g	5	na	na			23	11	23
Acid Extractable Zinc (Zn)	ug/g	5	123	315	120	820	**560**	**160**	**410**
Acid Extractable Mercury (Hg)	ug/g	0.05	0.17	0.486	0.2	2	0.076	0.064	0.077

Table Notes

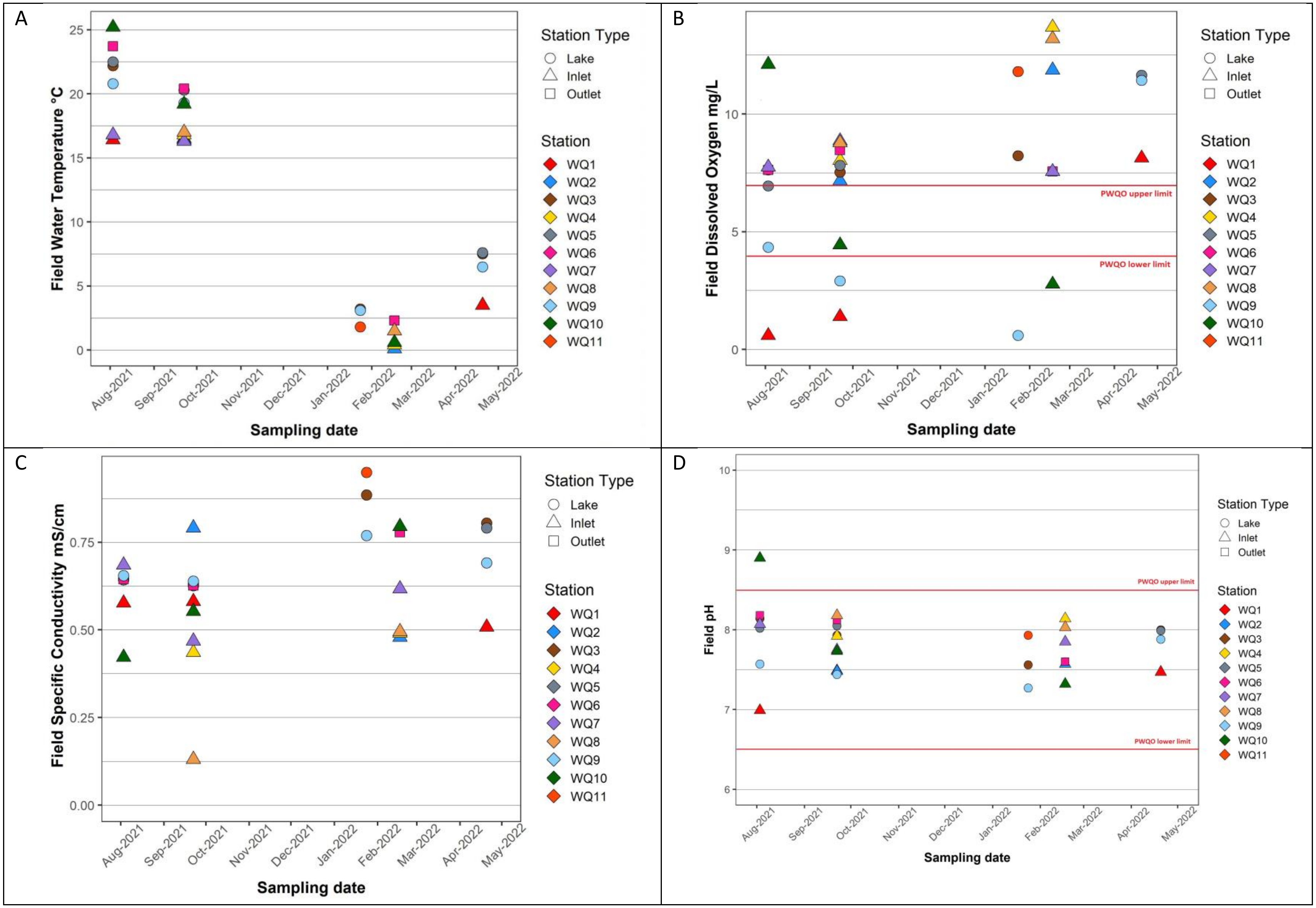
RDL	reportable detection limit
ISQG	interim sediment quality guideline; below which adverse effects rarely occur
PEL	probable effect level; above which adverse effects frequently occur
LEL (lowest effect level)	level of contamination that can be tolerated by the majority of sediment-dwelling organisms
SEL (severe effect level)	level of contamination expected to be detrimental to the majority of sediment-dwelling organisms
Below the ISQG/LEL	results displayed in regular font
Between the ISQG/LEL and PEL/SEL	results displayed in bold - the possible effect range where adverse effects occasionally occur
Above the PEL/SEL	results are shaded - the probable effect range where adverse effects frequently occur
na	no guideline established

Provincial SQ Guidelines used where available; otherwise, Federal guidelines were applied.

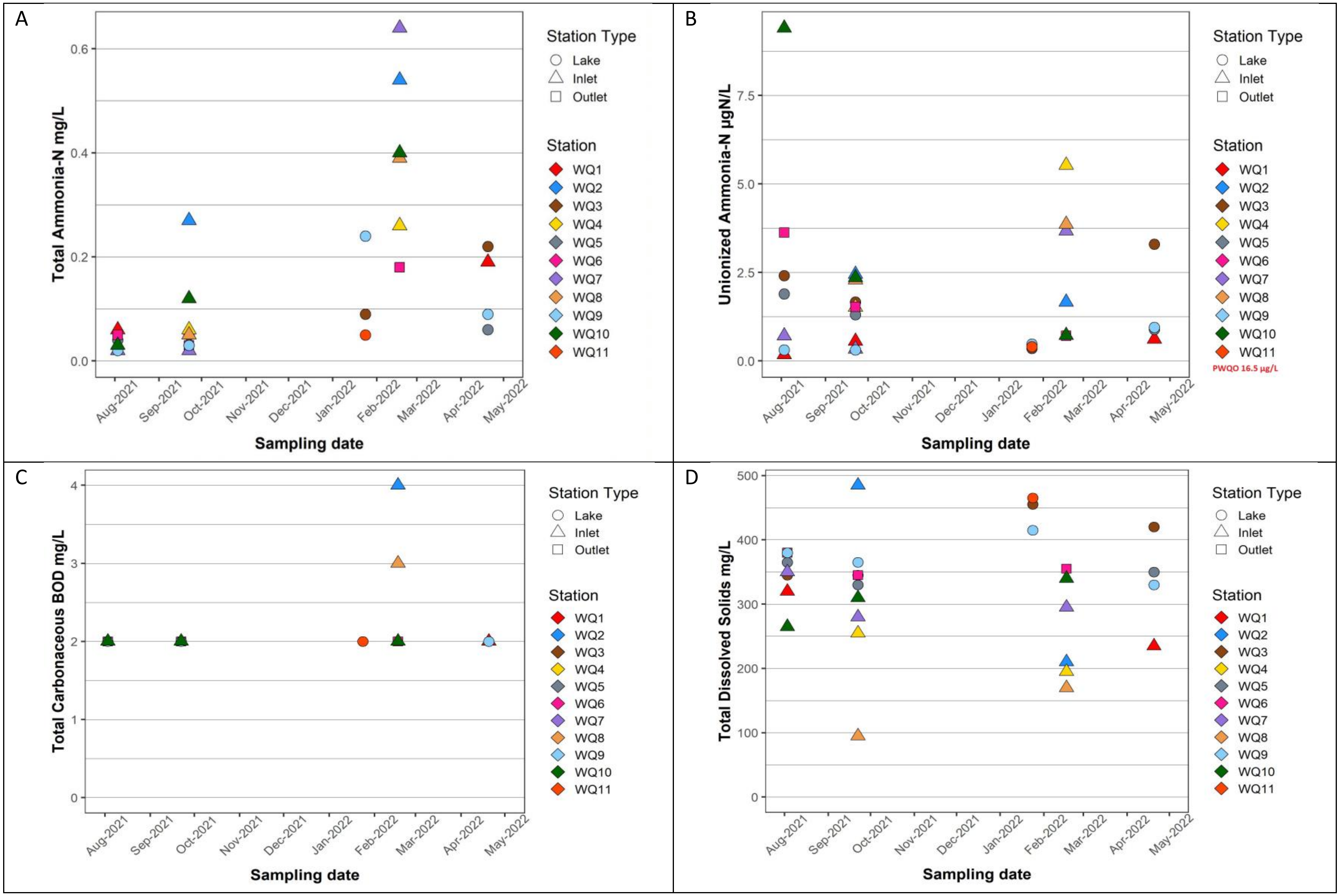
Appendix B, Table 3: Fairy Lake Water Quality Blind Duplicate Results

Sampling Date	STATION NAME	Total Ammonia-N	Total Dissolved Solids	Total Nitrogen (N)	Orthophos-phate	Dissolved Phosphorus	Total Phosporus	Total Suspended Solids	Total Kjeldalh Nitrogen	Nitrite (N)	Nitrate (N)	Nitrite + Nitrate	No. of RPDs	No. of RPDs >20%
	RDL	**0.01**	**10**	**0.02**	**0.001**	**0.004**	**0.004**	**1**	**0.02**	**0.001**	**0.002**	**0.0022**		
8/3/21 2:15 PM	WQ10 - West Arm Inlet	0.03	265	0.91	0.0024	0.009	0.021	3	0.87	0.0014	0.01	0.011		
8/3/21 2:15 PM	WQ20 Duplicate	0.03	245	0.89	0.0012	0.008	0.019	2	0.87	0.001	0.003	0.003		
	Relative Percent Difference	na	7.8	2.2	na	na	na	na	0.0	na	na	na	3	0
9/22/21 10:45 AM	WQ1-South Basin Inlet @ Mill St	0.06	310	1.3	0.047	0.065	0.14	7	1.28	0.0032	0.011	0.014		
9/22/21 10:45 AM	WQ30 Duplicate	0.07	295	1.2	0.067	0.077	0.15	7	1.2	0.0035	0.006	0.0095		
	Relative Percent Difference	15.4	5.0	8.0	35.1	16.9	6.9	0.0	6.5	na	na	na	8	1
2/17/22 11:30 AM	WQ6 Fairy Lake Dam	0.18	355	1.3	0.0026	0.006	0.019	2	0.692	0.012	0.56	0.57		
2/17/22 11:30 AM	WQ20 Duplicate	0.18	330	1.3	0.0018	0.007	0.018	3	0.684	0.012	0.57	0.59		
	Relative Percent Difference	0.0	7.3	0.0	na	na	na	na	1.2	0.0	1.8	3.4	7	0
4/20/22 9:45 AM	WQ1-South Basin Inlet @ Mill St	0.19	235	0.46	0.0044	0.009	0.014	1	0.424	0.004	0.002	0.033		
4/20/22 9:45 AM	WQ20 Duplicate	0.09	210	0.44	0.003	0.01	0.014	1	0.209	0.0034	0.032	0.035		
	Relative Percent Difference	71.4	11.2	4.4	na	na	na	na	67.9	na	na	5.9	5	2
													23	3
												% RPD <20		**86.96**

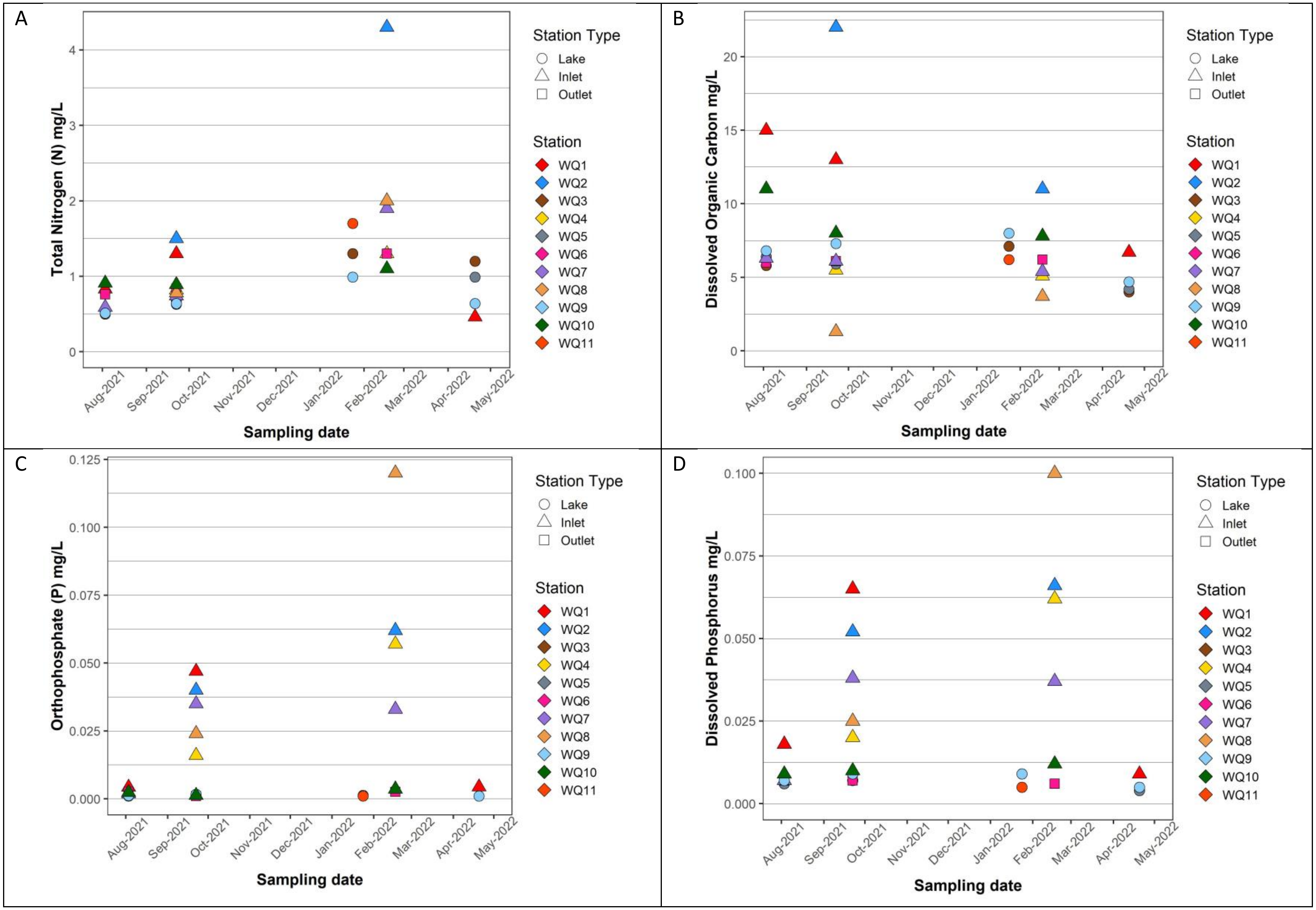
Appendix C Surface Water Quality Time Series Plots



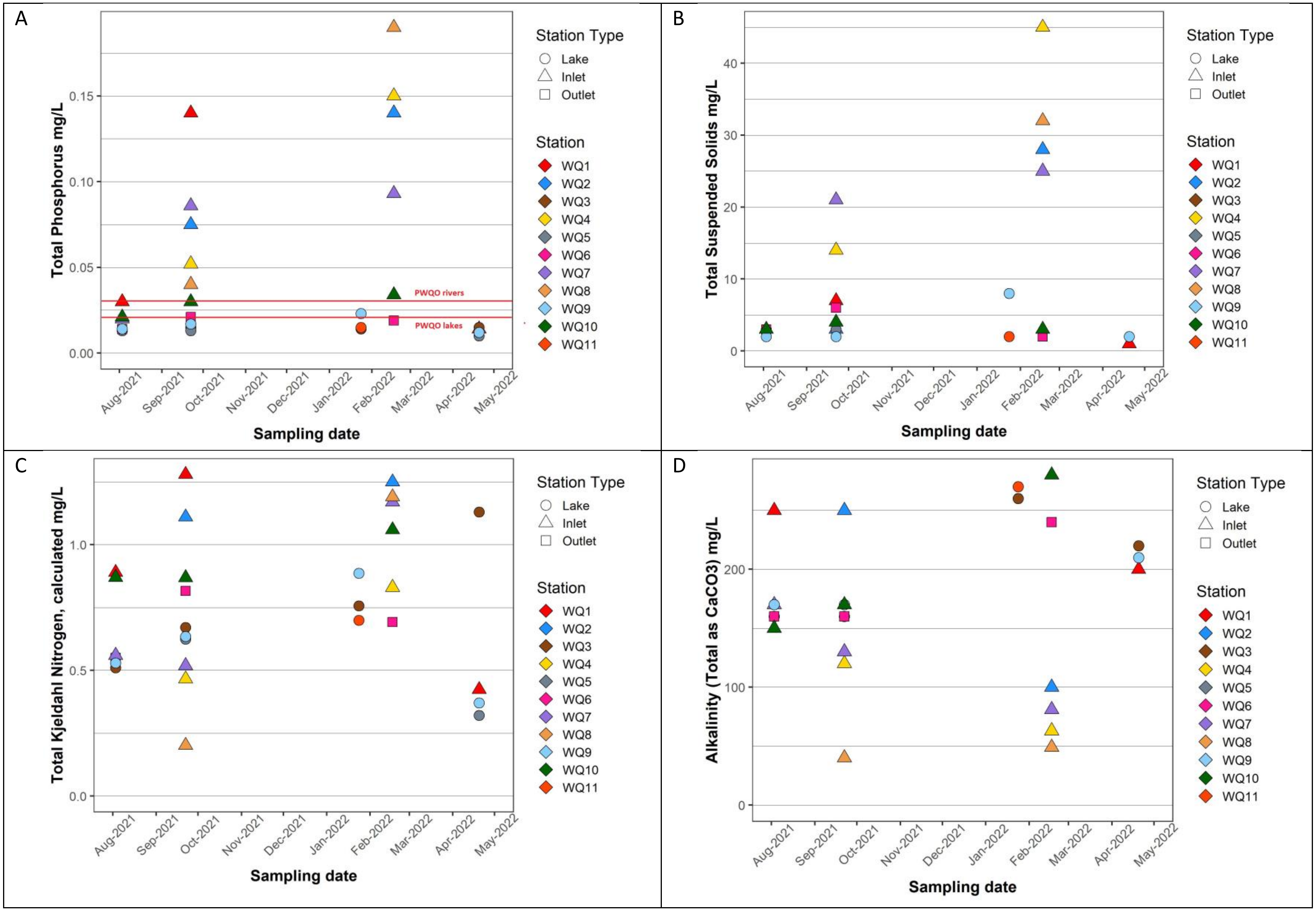
Appendix C Figure 1. Results for field water temperature, field dissolved oxygen, field specific conductivity, and field pH of current (2021-2022) data for Fairy Lake water quality stations.



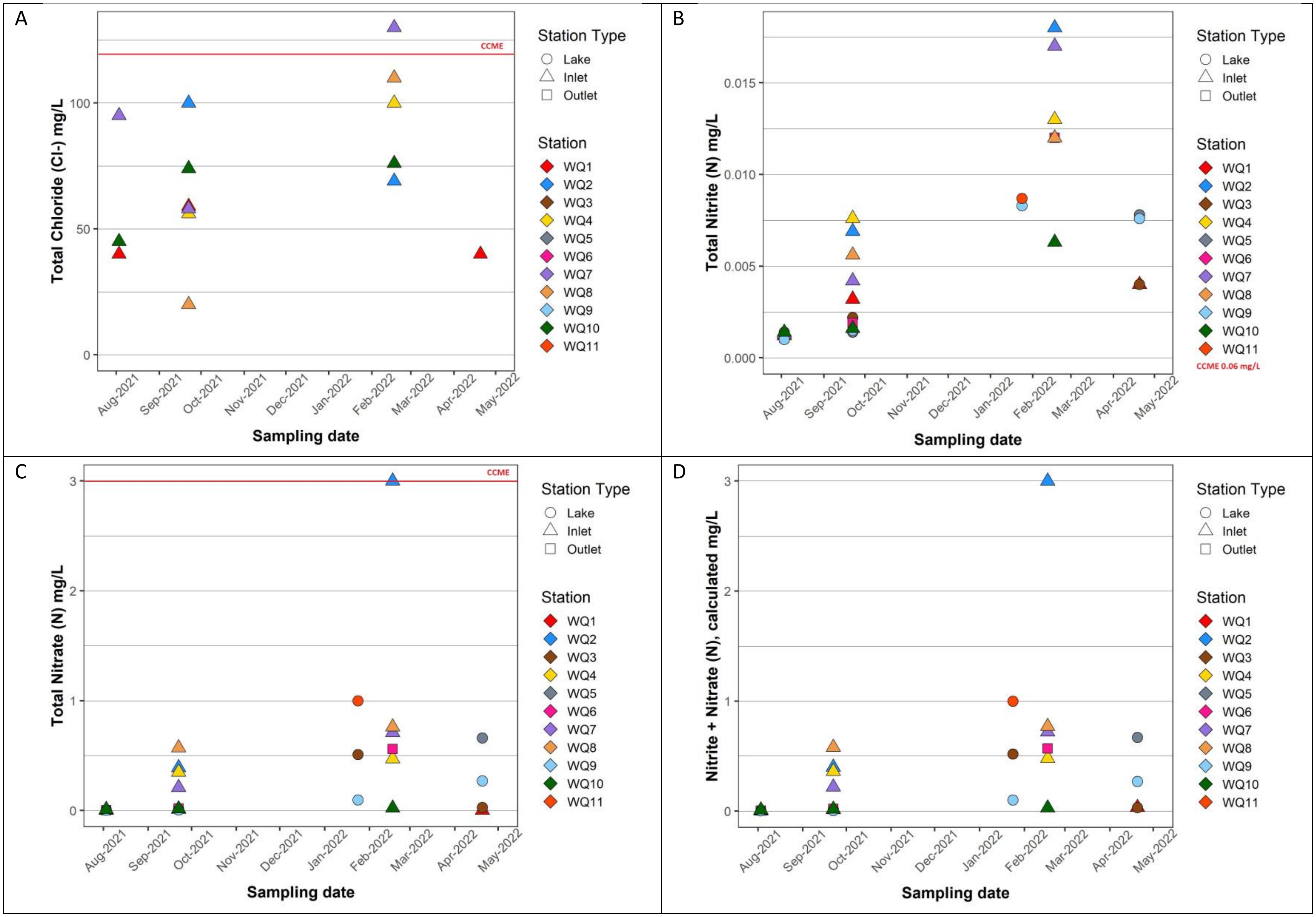
Appendix C Figure 2. Results for laboratory total Ammonia-N, calculated unionized Ammonia-N, laboratory total Carbonaceous BOD, and laboratory total dissolved solids of current (2021-2022) data for Fairy Lake water quality stations.



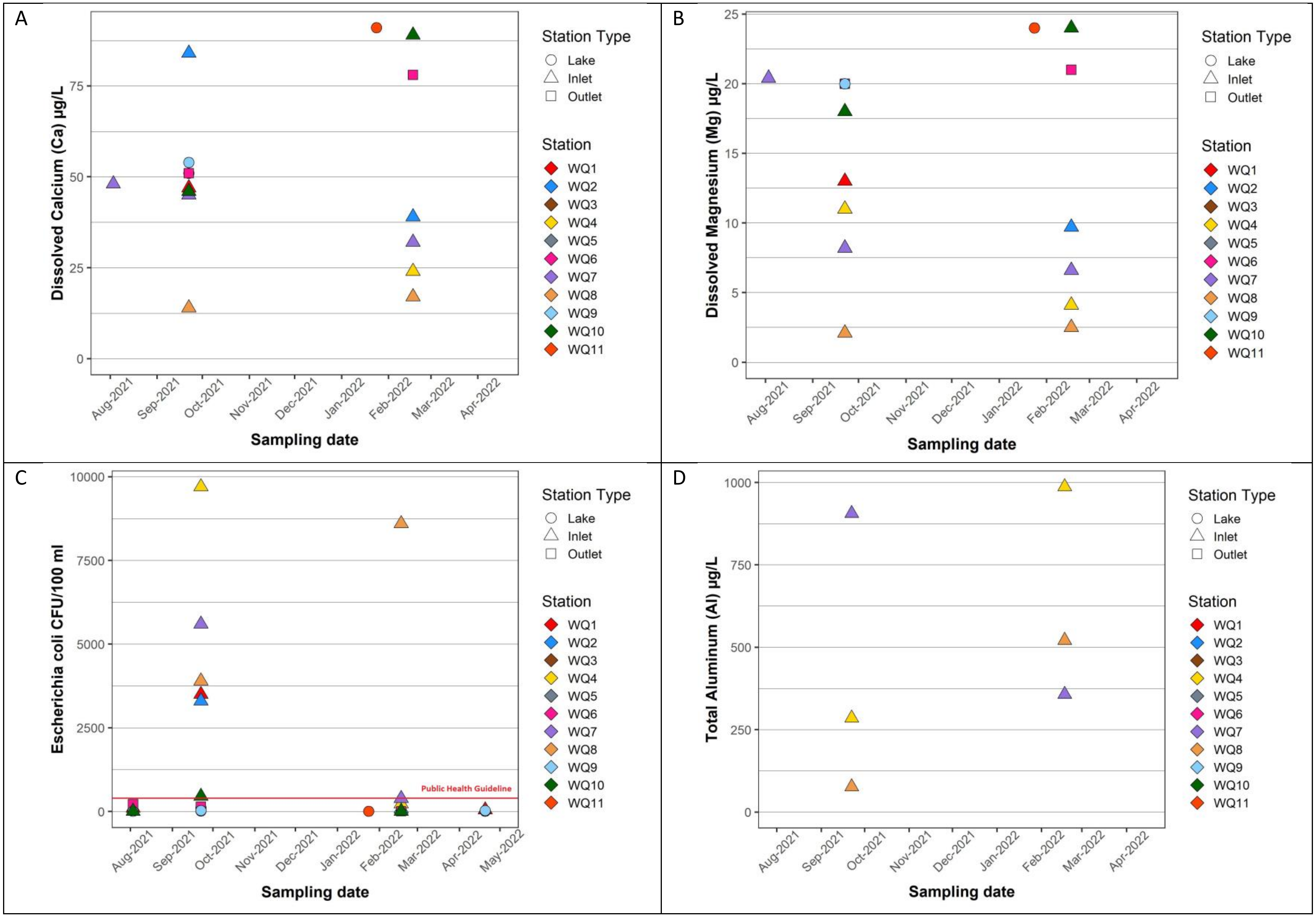
Appendix C Figure 3. Results for laboratory total Nitrogen (N), laboratory dissolved organic Carbon, laboratory Orthophosphate (P), and laboratory dissolved Phosphorus of current (2021-2022) data for Fairy Lake water quality stations.



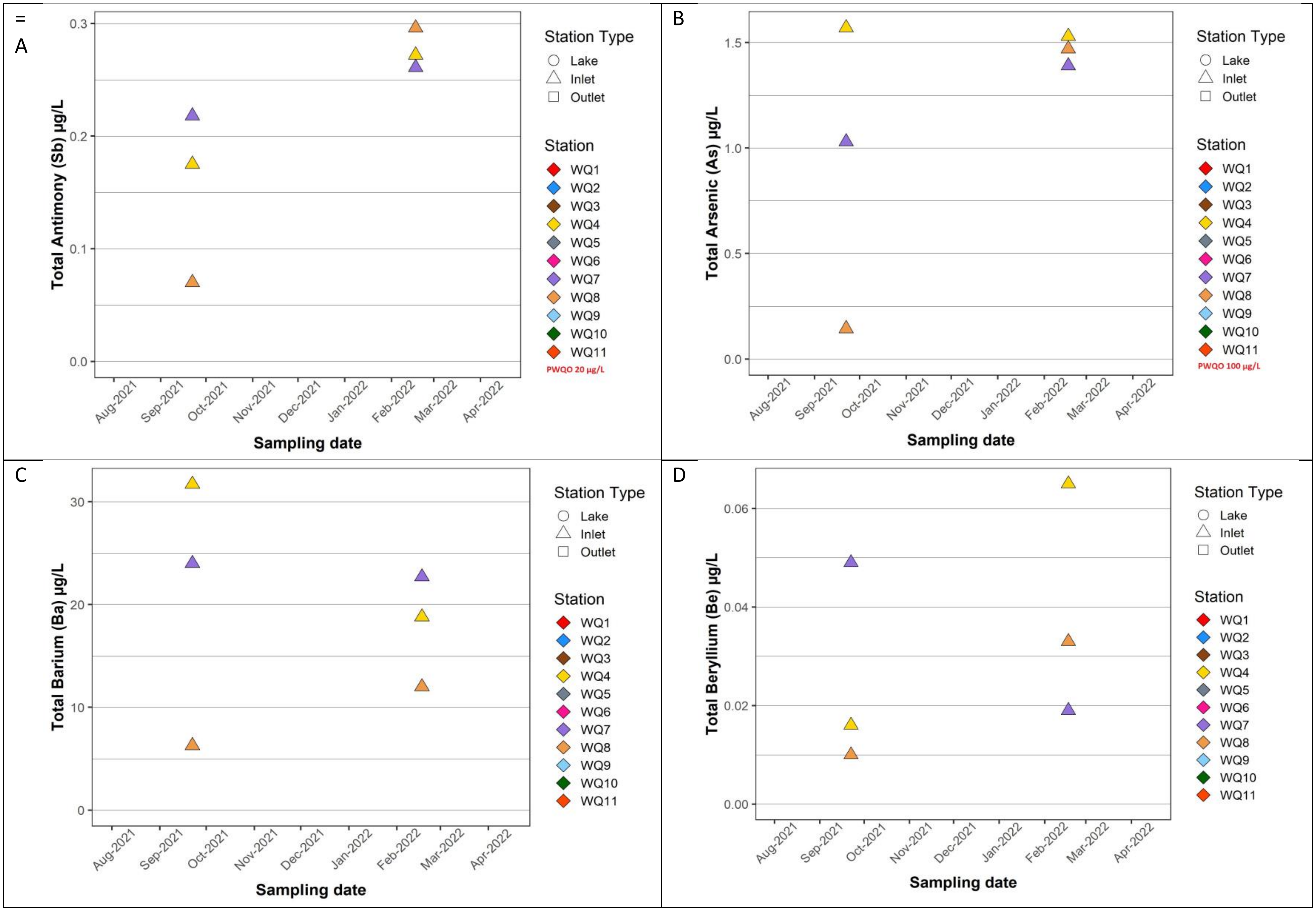
Appendix C Figure 4. Results for laboratory total Phosphorus, laboratory total suspended solids, laboratory total Kjeldahl Nitrogen (calculated), and laboratory alkalinity (total as $CaC0_3$) of current (2021-2022) data for Fairy Lake water quality stations.



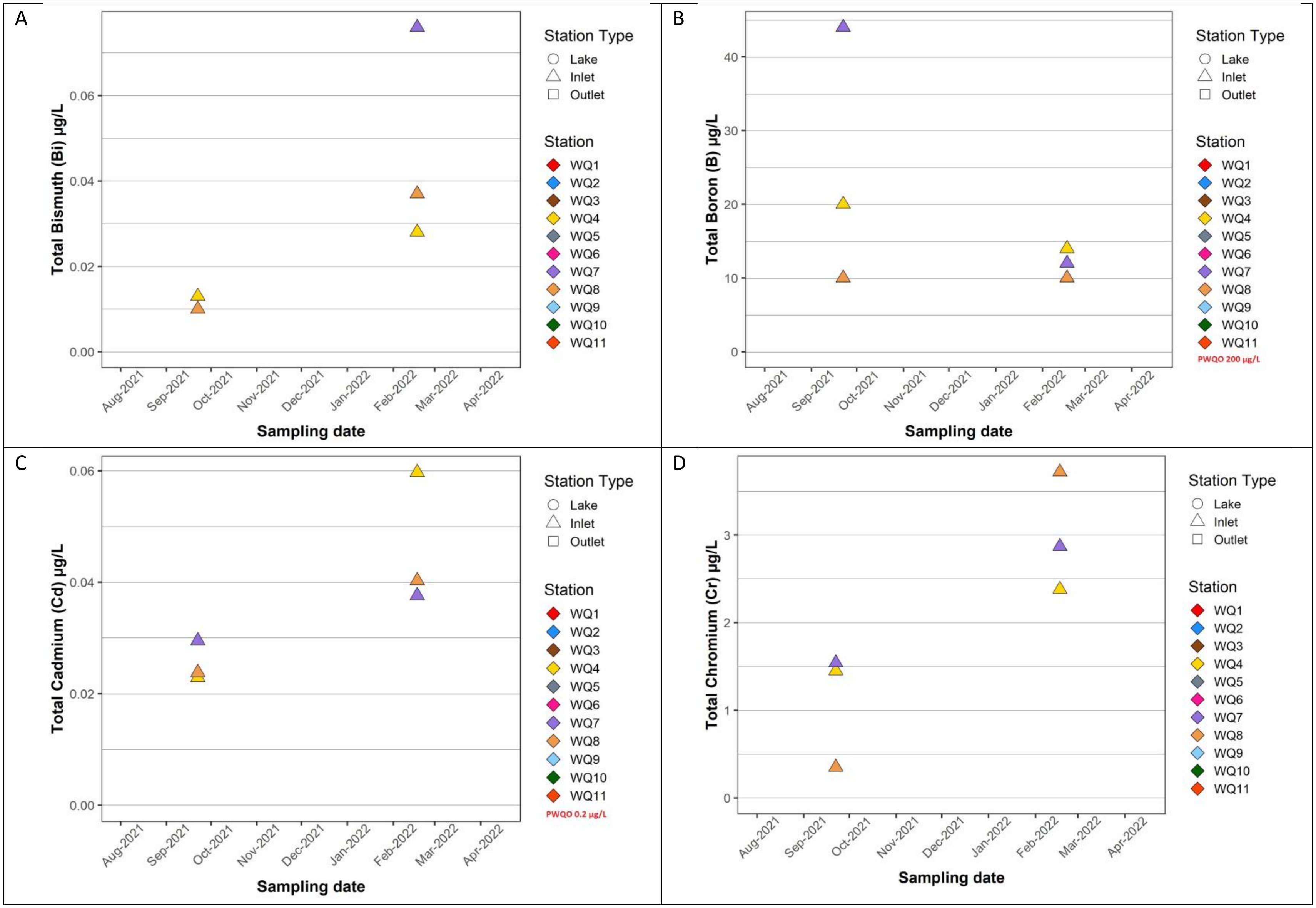
Appendix C Figure 5. Results for total dissolved Chloride (Cl-), laboratory total Nitrite (N), laboratory total Nitrate (N), and laboratory Nitrite + Nitrate [(N) calculated] of current (2021-2022) data for Fairy Lake water quality stations.



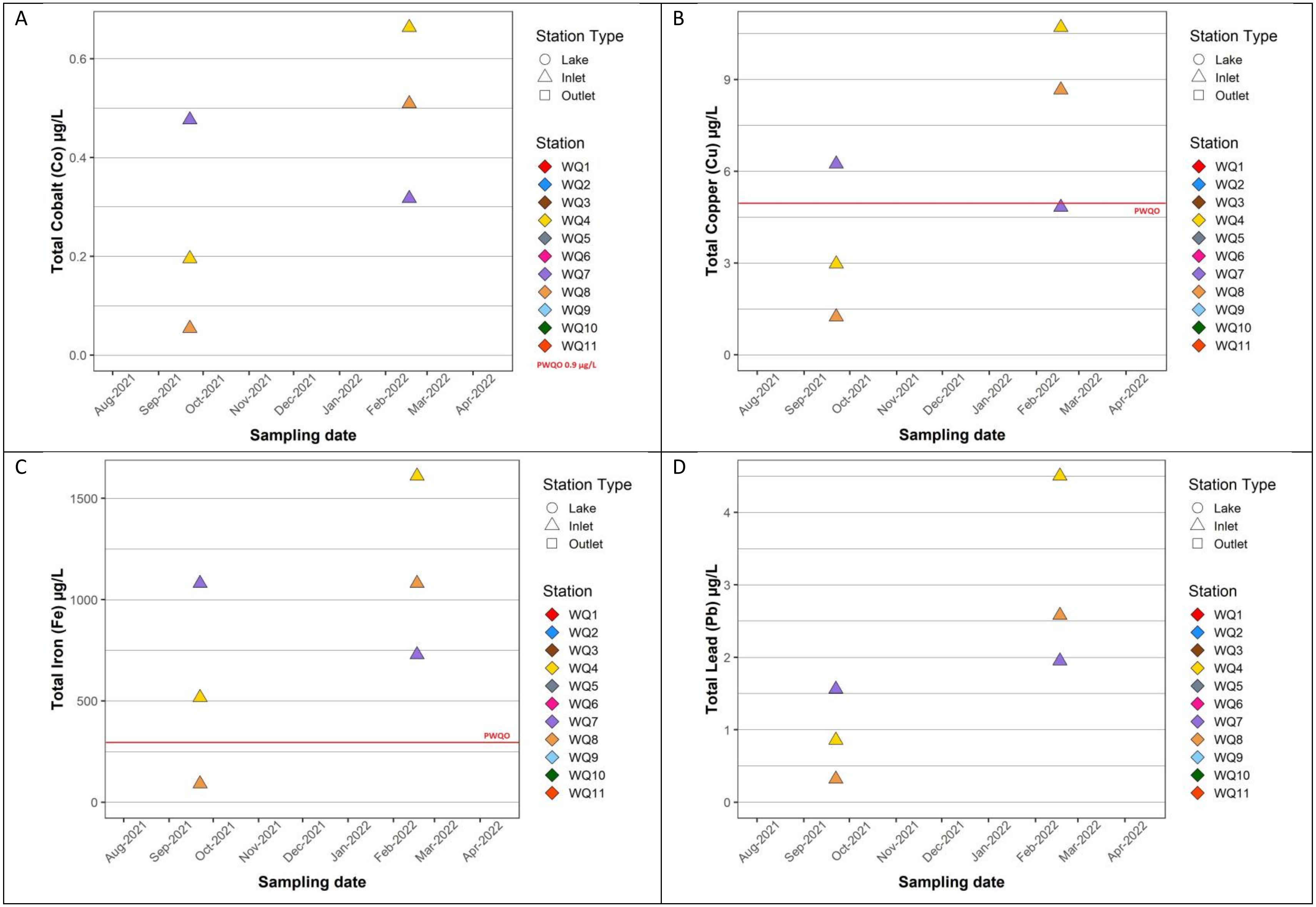
Appendix C Figure 6. Results for dissolved Calcium (Ca), laboratory dissolved Magnesium (Mg), microbiological *Escherichia coli,* and total Aluminum (Al) of current (2021-2022) data for Fairy Lake water quality stations.



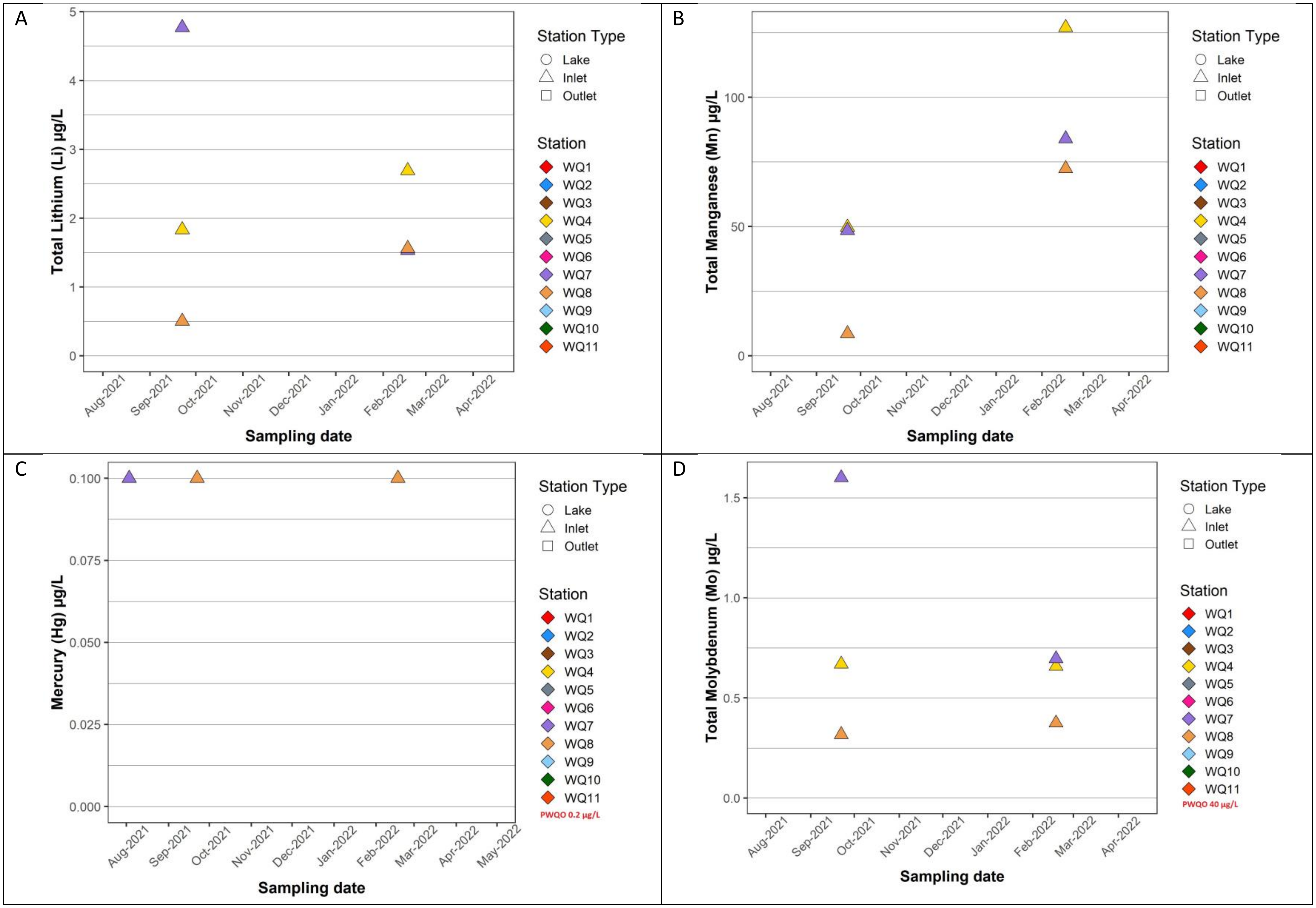
Appendix C Figure 7. Results for total Antimony (Sb), total Arsenic (As), total Barium (Ba), and total Beryllium (Be) of current (2021-2022) data for Fairy Lake water quality stations.



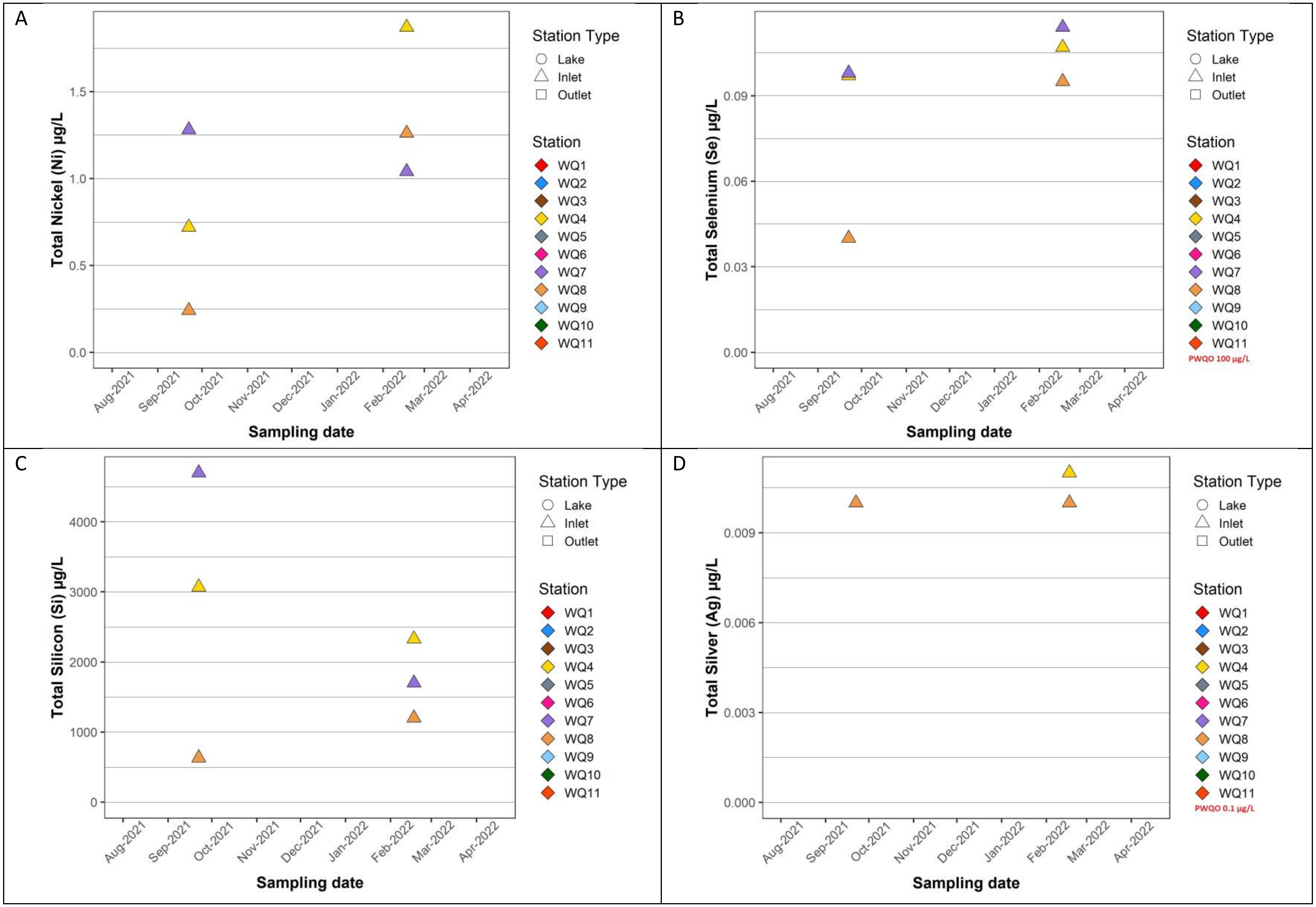
Appendix C Figure 8. Results for total Bismuth (Bi), total Boron (B), total Cadmium (Cd), and total Chromium (Cr) of current (2021-2022) data for Fairy Lake water quality stations.



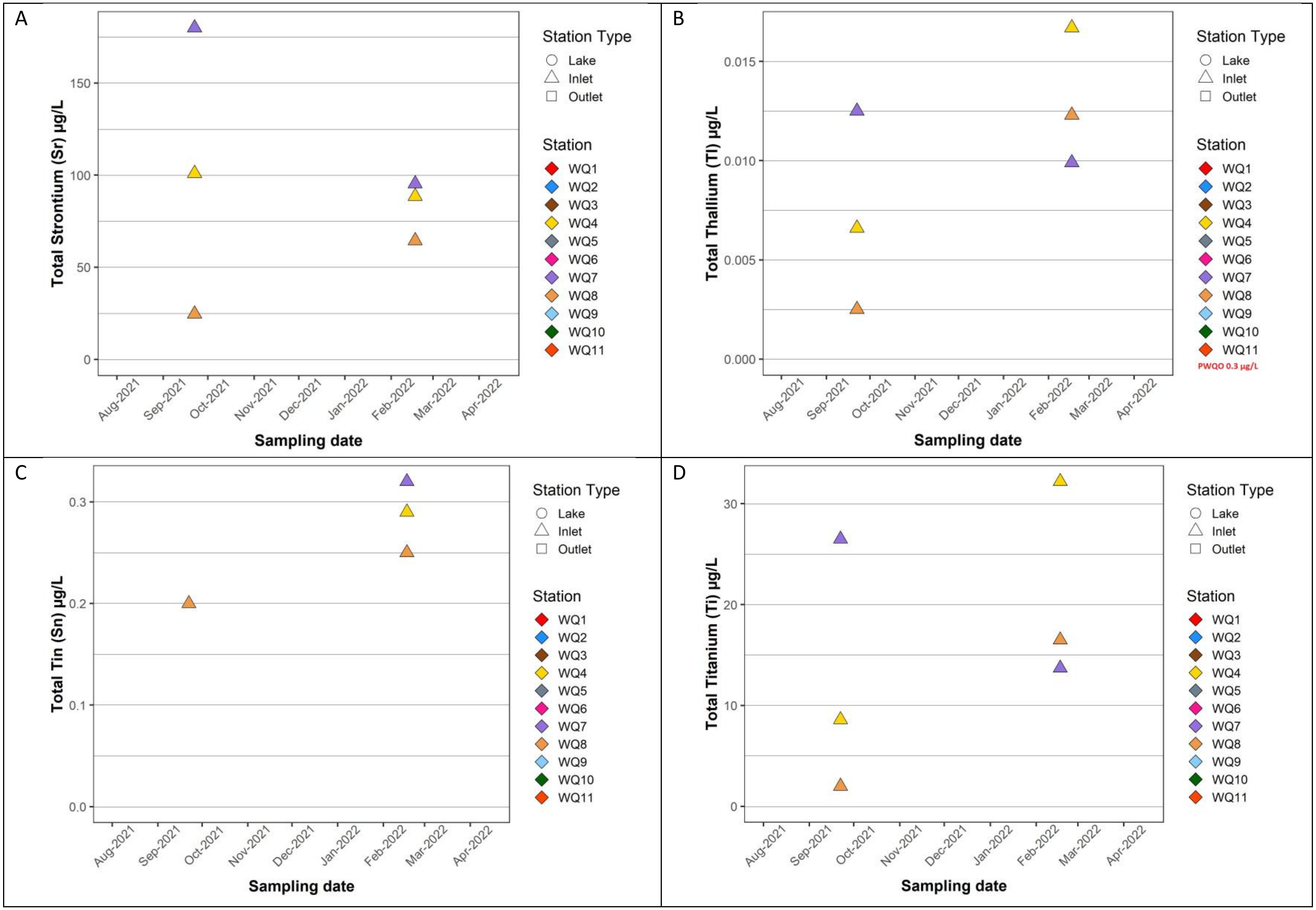
Appendix C Figure 9. Results for total Cobalt (Co), total Copper (Cu), total Iron (Fe), and total Lead (Pb) of current (2021-2022) data for Fairy Lake water quality stations.



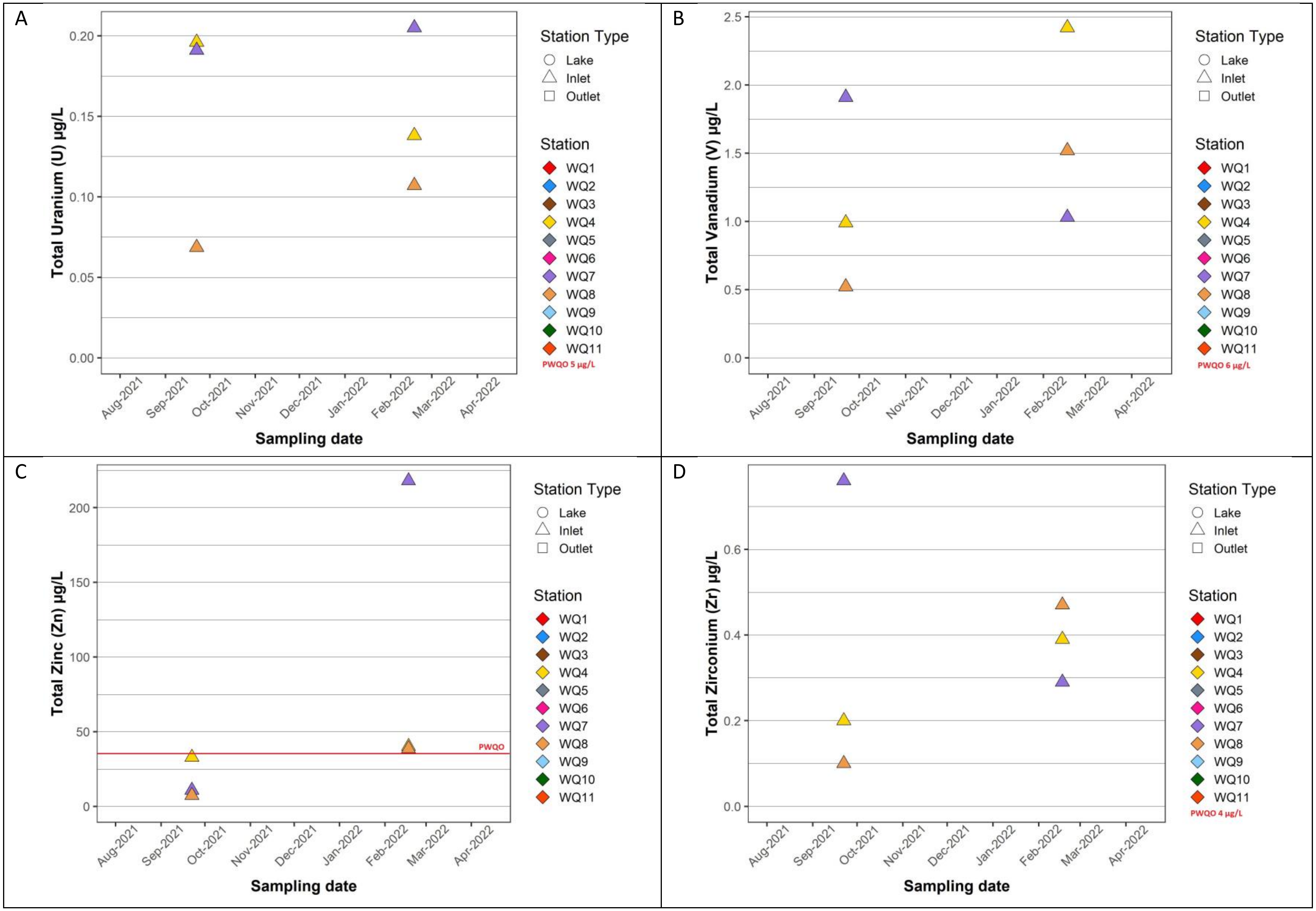
Appendix C Figure 10. Results for total Lithium (Li), total Manganese (Mn), total Mercury [(Hg) filtered sample], and total Molybdenum (Mo) of current (2021-2022) data for Fairy Lake water quality stations.



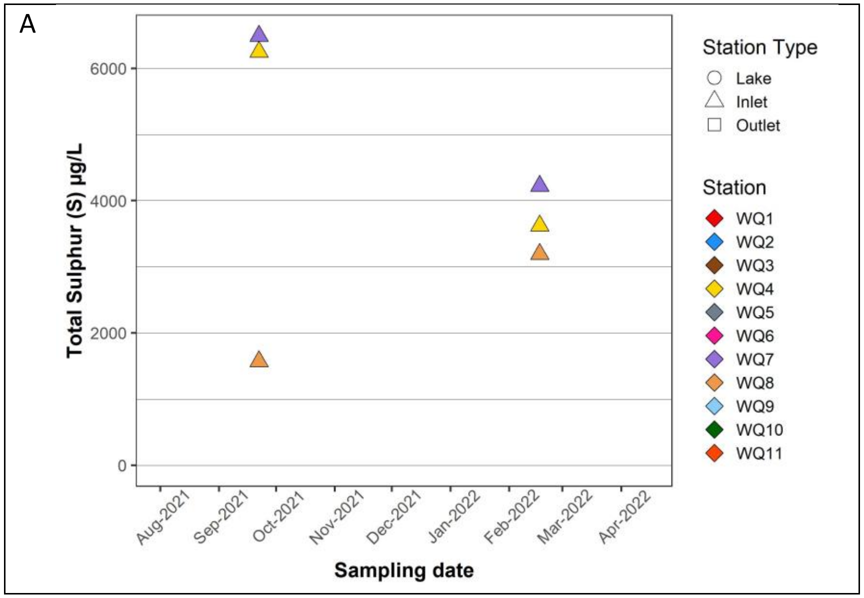
Appendix C Figure 11. Results for total Nickel (Ni), total Selenium (Se), total Silicon (Si), and total Silver (Ag) of current (2021-2022) data for Fairy Lake water quality stations.



Appendix C Figure 12. Results for total Strontium (Sr), total Thallium (Tl), total Tin (Sn), and total Titanium (Ti) of current (2021-2022) data for Fairy Lake water quality stations.



Appendix C Figure 13. Results for total Uranium (U), total Vanadium (V), total Zinc (Zn), and total Zirconium (Zr) of current (2021-2022) data for Fairy Lake water quality stations.



Appendix C Figure 14. Results for total Sulphur (S) of current (2021-2022) data for Fairy Lake water quality stations.

Appendix D Vascular Plant List

Appendix D: Vascular Plant List, Fairy Lake

	Scientific Name	Common Name	GRank	SRank	ESA	SARA	Local Status (CVC)	ELC Communities																					
								CUM1-1	CUT1-5	CUT1-a	CUP3-3	CUP3-8	CUW1	FOC2-2	FOD7	FOD7-2	FOD7-3	FOD8-1	MAM2-12	SAS1-a	SAS1-b	SAS1-3	SWT2-1	SWT2-2	SWT2-5	SAS1	OAO	SAM1-4	SAM1-7
	CHARACEAE	**STONEWORT FAMILY**																											
	Chara sp.	muskgrass																		x		x							x
	EQUISETACEAE	**HORSETAIL FAMILY**																											
	Equisetum arvense	field horsetail	G5	S5						X			x			x		x											
	Equisetum hyemale var. affine	scouring-rush	G5	S5											x		x												
	DRYOPTERIDACEAE	**WOOD FERN FAMILY**																											
	Athyrium filix-femina var. angustum	northern lady fern	G5T5	S5									x												x				
	Onoclea sensibilis	sensitive fern	G5	S5									x			x		x							x				
	THELYPTERIDACEAE	**MARSH FERN FAMILY**																											
	Thelypteris palustris var. pubescens	marsh fern	G5T?	S5												x													
	PINACEAE	**PINE FAMILY**																											
*	*Picea abies*	Norway spruce	G?	SE3							x	x																	
	Picea glauca	white spruce	G5	S5							x	x	x																
*	*Picea pungens*	Colorado spruce	G5	SE1														x											
	Pinus strobus	eastern white pine	G5	S5							x	x	x																
*	*Pinus sylvestris*	scotch pine	G?	SE5							x	x	x				x	x											
	CUPRESSACEAE	**CEDAR FAMILY**																											
	Juniperus virginiana	eastern red cedar	G5	S5			Rare						x	x															
	Thuja occidentalis	eastern white cedar	G5	S5									x					x											
	NYMPHAEACEAE	**WATER-LILY FAMILY**																											
	Nuphar variegata	bulhead pond-lily	G5	S5			Rare														x					x			
	Nymphaea odorata	fragrant water-lily	G5	S5			Rare													x	x	x				x			
	RANUNCULACEAE	**BUTTERCUP FAMILY**																											
	Anemone canadensis	Canada anemone	G5	S5													x		x										
	Anemone virginiana var. virginiana	thimbleweed	G5T	S5												x		x											
	Clematis virginiana	virgin's-bower	G5	S5												x													
	ULMACEAE	**ELM FAMILY**																											
	Ulmus americana	white elm	G5?	S5									x			x													
*	*Ulmus pumila*	Siberian elm	G?	SE3				x										x											
	MORACEAE	**MULBERRY FAMILY**																											
*	*Morus alba*	white mulberry	G?	SE5									x				x	x											
	JUGLANDACEAE	**WALNUT FAMILY**																											
	Juglans cinerea	butternut	G3G4	S3?	END	END													x										

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	Scientific Name	Common Name	GRank	SRank	ESA	SARA	Local Status (CVC)	ELC Communities																					
								CUM1-1	CUT1-5	CUT1-a	CUP3-3	CUP3-8	CUW1	FOC2-2	FOD7	FOD7-2	FOD7-3	FOD8-1	MAM2-12	SAS1-a	SAS1-b	SAS1-3	SWT2-1	SWT2-2	SWT2-5	SAS1	OAO	SAM1-4	SAM1-7
	Juglans nigra	black walnut	G5	S4				x					x			x	x	x											
	FAGACEAE	**BEECH FAMILY**																											
	Fagus grandifolia	American beech	G5	S5														x											
	Quercus macrocarpa	bur oak	G5	S5									x																
	BETULACEAE	**BIRCH FAMILY**																											
*	Alnus glutinosa	Euopean Black Alder	G?	SE?																			x	x					
	Alnus incana spp. rugosa	speckled alder	G5T5	S5																			x	x					
	Betula alleghaniensis	yellow birch	G5	S5													x												
	Betula papyrifera	white birch	G5	S5									x																
*	*Betula pendula*	European weeping birch	G?	SE4									x			x		x	x										
	Carpinus corlinana ssp. virginiana	blue beech	G5T	S5						x																			
	Corylus cornuta ssp. cornuta	beaked hazel	G5	S5											x		x												
	GUTTIFERAE	**ST. JOHN'S-WORT FAMILY**																											
*	*Hypericum perforatum*	common St. John's-wort	G?	SE5															x										
	TILIACEAE	**LINDEN FAMILY**																											
	Tilia americana	basswood	G5	S5												x		x											
	Tilia cordata	Little Leaf Linden	G	SE1									x				x												
	MALVACEAE	**MALLOW FAMILY**																											
	Malva neglecta	cheeses	G5T	S5				x					x		x														
	VIOLACEAE	**VIOLET FAMILY**																											
	Viola pubescens	downy yellow violet	G5	S5																									
	Viola sp.	violet																	x										
	CUCURBITACEAE	**GOURD FAMILY**																											
	Echinocystis lobata	prickly cucumber	G5	s5									x					x											
	SALICACEAE	**WILLOW FAMILY**																											
	Populus balsamifera ssp. balsamifera	balsam poplar	G5T?	S5									x			x		x											
	Populus deltoides	cottonwood	G5T?	S5									x			x													
	Populus tremuloides	trembling aspen	G5	S5												x		x											
	Salix discolor	pussy willow	G5	S5									x																
	Salix petiolaris	slender willow	G4	S5															x										
*	*Salix X rubens*	reddish willow	HYB	SE4									x			x	x	x						x					
	BRASSICACEAE	**MUSTARD FAMILY**																											
*	Alliaria pertiolata	garlic mustard	G5	SE5									x																
*	*Hesperis matronalis*	dame's rocket	G4G5	SE5									x				x												

Appendix D: Vascular Plant List, Fairy Lake

	Scientific Name	Common Name	GRank	SRank	ESA	SARA	Local Status (CVC)	ELC Communities																					
								CUM1-1	CUT1-5	CUT1-a	CUP3-3	CUP3-8	CUW1	FOC2-2	FOD7	FOD7-2	FOD7-3	FOD8-1	MAM2-12	SAS1-a	SAS1-b	SAS1-3	SWT2-1	SWT2-2	SWT2-5	SAS1	OAO	SAM1-4	SAM1-7
	CRASSULACEAE	**STONECROP FAMILY**																											
*	*Sedum sp.*	stonecrop	G?	SE1				x									x												
	PRIMULACEAE	**PRIMROSE FAMILY**																											
*	*Lysimachia nummularia*	moneywort	G?	SE5																			x						
	ROSACEAE	**ROSE FAMILY**																											
	Agrimonia gryposepala	tall hairy agrimony	G5	S5				x																					
	Crataegus sp.	hawthrorn															x												
	Fragaria virginiana ssp. glauca	scarlet strawberry											x			x	x	x											
	Geum canadense	white avens	G5	S5									x																
*	*Malus baccata*	Siberian crabapple	G?	SE1			Rare						x																
*	*Malus pumila*	common apple	G5	SE5									x																
	Physocarpus opulifolius	ninebark	G5	S5						x			x		x		x	x											
*	*Potentilla recta*	rough-fruited cinquefoil	G?	SE5				x																					
*	*Prunus avium*	sweet cherry	G?	SE?													x												
	Prunus serotina	black cherry	G5	S5									x				x	x											
	Prunus virginiana var. virginiana	choke cherry	G5T?	S5									x			x	x	x							x				
*	*Rosa multiflora*	multiflora rose	G?	SE4				x					x					x											
*	*Rubus idaeus ssp. idaeus*	red raspberry	G5T5	SE1				x					x			x	x												
	Rubus occidentalis	black raspberry	G5	S5					x									x							x				
	Spiraea alba	narrow-leaved meadow-sweet	G5	S5																					x				
	Sorbus aucuparia	European mountain-ash	G5	SE4											x		x												
	FABACEAE	**PEA FAMILY**																											
*	*Coronilla varia*	variable crown-vetch	G?	SE5									x																
*	*Lotus corniculatus*	bird's-foot trefoil	G?	SE5				x					x																
*	*Melilotus alba*	white sweet-clover	G?	SE5				x										x	x										
*	*Robinia pseudo-acacia*	black locust	G5	SE5									x		x		x												
*	*Trifolium pratense*	red clover	G?	SE5									x																
*	*Vicia cracca*	tufted vetch	G?	SE5									x																
	ELAEAGNACEAE	**OLEASTER FAMILY**																											
*	*Elaeagnus umbellata*	Autumn olive	G?	SE3						x							x												
	HALORAGACEAE	**WATER-MILFOIL FAMILY**																											
	Myriophyllum verticillatum	whorled water-milfoil	G5	S5			Rare													x	x	x							x
	LYTHRACEAE	**LOOSESTRIFE FAMILY**																											
*	*Lythrum salicaria*	purple loosestrife	G5	SE5									x							x			x		x				

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	Scientific Name	Common Name	GRank	SRank	ESA	SARA	Local Status (CVC)	ELC Communities																					
								CUM1-1	CUT1-5	CUT1-a	CUP3-3	CUP3-8	CUW1	FOC2-2	FOD7	FOD7-2	FOD7-3	FOD8-1	MAM2-12	SAS1-a	SAS1-b	SAS1-3	SWT2-1	SWT2-2	SWT2-5	SAS1	OAO	SAM1-4	SAM1-7
	ONAGRACEAE	**EVENING-PRIMROSE FAMILY**																											
	Circaea lutetiana ssp. canadensis	yellowish enchanter's nighshade	G5T5	S5									x																
	Oenothera biennis	common evening-primrose	G5	S5				x								x													
	CORNACEAE	**DOGWOOD FAMILY**																											
	Cornus alternifolia	alternate-leaved dogwood	G5	S5									x			x		x											
	Cornus racemosa	red panicled dogwood	G5?	S5									x																
	Cornus rugosa	round-leaved dogwood	G5	S5														x											
	Cornus sericea ssp. sericea	red-osier dogwood	G5	S5						x			x			x	x	x	x				x						
	CELASTRACEAE	**STAFF-TREE FAMILY**																											
*	*Euonymus sp.*	euonymus																x											
	RHAMNACEAE	**BUCKTHORN FAMILY**																											
	Rhamnus alnifolia	alder-leaved buckthorn	G5	S5			Rare									x													
*	*Rhamnus cathartica*	common buckthorn	G?	SE5						x			x			x		x											
	VITACEAE	**GRAPE FAMILY**																											
	Parthenocissus quinquefolia	five-leaved Virginia-creeper	G5	S4?					x				x			x	x	x							x				
	Vitis riparia	riverbank grape	G5	S5				x					x			x	x	x	x				x		x				
	ACERACEAE	**MAPLE FAMILY**																											
*	Acer ginnala	Amur maple	G5T	S5						x																			
	Acer negundo	Manitoba maple	G5	S5									x			x	x												
*	*Acer platanoides*	Norway maple	G	SE5									x				x	x											
	Acer saccharinum	silver maple	G5	S5									x		x														
	Acer saccharum var. saccharum	sugar maple	G5T?	S5									x			x		x											
	ANACARDIACEAE	**SUMAC FAMILY**																											
	Rhus hirta	staghorn sumac	G5	S5									x				x												
	OXALIDACEAE	**WOOD SORREL FAMILY**																											
	Oxalis stricta	upright yellow wood-sorrel	G5	S5									x																
	BALSAMINACEAE	**TOUCH-ME-NOT FAMILY**																											
	Impatiens capensis	spotted touch-me-not	G5	S5												x	x												
	APIACEAE	**PARSLEY FAMILY**																											
	Cicuta bulbifera	bulb-bearing water-hemlock	G5	S5																					x				

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*	*Daucus carota*	wild carrot	G?	SE5				x					x				x	x	x										
	APOCYNACEAE	**DOGBANE FAMILY**																											
*	*Vinca minor*	preiwinkle	G?	SE5														x											
	ASCLEPIADACEAE	**MILKWEED FAMILY**																											
	Asclepias syriaca	common milkweed	G5	S5									x						x						x				
	SOLANACEAE	**POTATO FAMILY**																											
*	*Solanum dulcamara*	bitter nightshade	G?	SE5												x													
	POLEMONIACEAE	**PHLOX FAMILY**																											
	Phlox paniculata	garden phlox	G5	SE2				x																					
	BORAGINACEAE	**BORAGE FAMILY**																											
*	*Echium vulgare*	blueweed	G?	SE5				x					x																
	LAMIACEAE	**MINT FAMILY**																											
	Clinopodium vulgare	wild basil	G?	S5														x	x										
*	*Glechoma hedeacea*	creeping charlie	G?	SE5				x							x		x												
*	*Leonurus cardiaca ssp. cardiaca*	common motherwort	G?T?	SE5									x																
	Lycopus americanus	cut-leaved water-horehound	G5	S5																x									
	Lycopus uniflorus	northern water-horehound	G5	S5															x										
*	*Mentha X piperita*	pepper mint	HYB	SE4														x	x										
*	*Nepeta cataria*	catnip	G?	SE5															x										
	Prunella vulgaris ssp. lanceolata	heal-all	G5T?	S5									x																
	PLANTAGINACEAE	**PLANTAIN FAMILY**																											
*	*Plantago lanceolata*	ribgrass	G5	SE5													x		x										
*	*Plantago major*	common plantain	G5	SE5									x																
	OLEACEAE	**OLIVE FAMILY**																											
	Fraxinus americana	white ash	G5	S5									x				x	x	x										
	Fraxinus pennsylvanica	red ash	G5	S5									x			x													
	Syringa vulgaris	common lilac	G?	SE5														x											
	SCROPHULARIACEAE	**FIGWORT FAMILY**																											
*	Linaria vulgaris	butter-and-eggs	G?	SE5									x																
*	*Verbascum thapsus*	common mullein	G?	SE5				x					x																
*	*Veronica serpyllifolia ssp. serpyllifolia*	thyme-leaved speedwell	G?T?	SE5														x											
	LENTIBULARIACEAE	**BLADDERWORT FAMILY**																											

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								CUM1-1	CUT1-5	CUT1-a	CUP3-3	CUP3-8	CUW1	FOC2-2	FOD7	FOD7-2	FOD7-3	FOD8-1	MAM2-12	SAS1-a	SAS1-b	SAS1-3	SWT2-1	SWT2-2	SWT2-5	SAS1	OAO	SAM1-4	SAM1-7
	Utricularia macrorhiza	greater bladderwort	G5	S5			Rare														x								
	RUBIACEAE	**MADDER FAMILY**																											
	Galium boreale	northern bedstraw	G5	S5			Rare						x																
	CAPRIFOLIACEAE	**HONEYSUCKLE FAMILY**																											
*	*Lonicera tatarica*	tartarian honeysuckle	G?	SE5						x			x					x	x				x						
*	*Viburnum lantana*	bending wayfaring-tree	G?	SE2									x																
	Viburnum lentago	nannyberry	G5	S5									x			x	x												
*	*Viburnum opulus*	guelder rose	G5	SE4									x			x							x						
	ASTERACEAE	**ASTER FAMILY**																											
	Achillea millefolium var. occidentalis	woolly yarrow	G5T5	S5									x																
	Ambrosia artemisiifolia	common ragweed	G5	S5									x						x										
*	*Arctium minus*	common burdock	G?T?	S5				x		x			x				x												
	Aster ericoides var. ericoides	white heath aster	G5T?	S5															x										
	Aster lanceolatus ssp. lanceolatus	tall white aster	G5T?	S5				x					x				x		x										
	Aster lateriflorus var. lateriflorus	calico aster	G5T5	S5												x													
	Aster puniceus var. puniceus	purple-stemmed aster	G5T?	S5												x													
*	*Cichorium intybus*	chicory	G?	SE5									x																
	Conyza canadensis	horseweed	G5	S5				x																					
	Euthamia graminifolia	flat-topped bushy goldenrod	G5	S5									x				x			x									
	Erigeron annuus	daisy fleabane	G?	S5				x					x					x											
*	*Helianthus tuberosus*	Jerusalem artichoke	G5	SE5											x		x												
	Hieracium sp.	hawkweed						x										x											
*	*Lapsana communis*	nipplewort	G?	SE5														x											
*	*Leucanthemum vulgare*	ox-eye daisy	G?	SE5									x																
	Solidago canadensis	canada goldenrod	G5	S5				x	x				x			x	x	x						x					
	Solidago nemoralis var. nemoralis	gray goldenrod	G5T?	S5														x					x						
	Solidago rugosa ssp. rugosa	rough goldenrod	G5T?	S5												x	x	x											
*	*Sonchus arvensis ssp. arvensis*	field sow-thistle	G?T?	SE5				x		x									x										

Appendix D: Vascular Plant List, Fairy Lake

	Scientific Name	Common Name	GRank	SRank	ESA	SARA	Local Status (CVC)	ELC Communities																					
								CUM1-1	CUT1-5	CUT1-a	CUP3-3	CUP3-8	CUW1	FOC2-2	FOD7	FOD7-2	FOD7-3	FOD8-1	MAM2-12	SAS1-a	SAS1-b	SAS1-3	SWT2-1	SWT2-2	SWT2-5	SAS1	OAO	SAM1-4	SAM1-7
	Symphyotrichum novae-angliae	New England aster	G5	S5									x				x		x										
*	*Tussilago farfara*	coltsfoot	G?	SE5									x						x										
	POTAMOGETONACEAE	**PONDWEED FAMILY**																											
	Potamogeton amplifolius	large-leaved pondweed	G5	S5			Rare													x	x							x	x
	Potamogeton natans	common floating pondweed	G5	S5																	x							x	
	Stuckenia pectinatus	fennel-leaved pondweed	G5	S5																	x		x						
	LEMNACEAE	**DUCKWEED FAMILY**																											
	Lemna trisulca	star duckweed	G5	S5			Rare														x							x	
	Spirodela polyrhiza	greater duckweed	G5	S5																	x								
	CYPERACEAE	**SEDGE FAMILY**																											
	Schoenoplectus tabernaemontani	American great bulrush	G?	S5									x							x			x						
	Scirpus atrovirens	dark-green bulrush	G5?	S5															x										
	POACEAE	**GRASS FAMILY**																											
*	*Bromus inermis ssp. inermis*	awnless brome	G4G5T?	SE5				x					x				x		x										
*	*Dactylis glomerata*	orchard grass	G?	SE5				x					x		x		x												
	Danthonia spicata	poverty oat grass	G5	S5									x																
*	*Elymus repens*	quack grass	G?	SE5				x																					
	Leersia oryzoides	rice cut grass	G5	S5															x						x				
	Miscanthus sinensis	Japanese plume grass	G?	SE1				x																					
	Phalaris arundinacea	reed canary grass	G5	S5									x			x		x	x						x				
*	*Phleum pratense*	timothy	G?	SE5									x				x		x										
*	*Phragmites australis*	common reed	G5	S5														x											
	Poa pratensis ssp. pratensis	Kentucky bluegrass	G5T	S5				x					x					x											
*	*Setaria viridis*	green foxtail	G?	SE5				x																					
	TYPHACEAE	**CATTAIL FAMILY**																											
	Typha angustifolia	narrow-leaved cattail	G5	S5												x				x									
	LILIACEAE	**LILY FAMILY**																											
	Allium cernuum	nodding wild onion	G5	S2									x																
	IRIDACEAE	**IRIS FAMILY**																											
	Iris versicolor	multi-coloured blue-flag	G5	S5																x									
	SMILACACEAE	**CATBRIER FAMILY**																											
	Smilax herbaceae	herbaceous carrion flower	G5	S4									x																

Appendix E Goose Survey Results

Date	Monitoring Area	Observer_group	# of Adults	# of Juveniles	# of eggs	Behaviour	x-coordinate	y-coordinate	Comments
2021-6-16 19:07	Area 3	LGL Limited	25	0		Feeding, resting	-80.04717853	43.62543424	
2021-6-16 19:07	Area C	LGL Limited	32	0		travel_in_water	-80.04750136	43.62580716	
2021-6-23 18:26	Area 3	LGL Limited	64	9		grazing_(on_land),dabbling_in_water	-80.04725262	43.62560615	
2021-6-23 18:26	Area 3	LGL Limited	10	31		grazing_(on_land),loafing	-80.04725481	43.62543487	
2021-6-23 18:26	Area 2	LGL Limited	0	0		N/A	-80.0456792	43.62676	
2021-6-23 18:26	Area B	LGL Limited	0	0		N/A	-80.0435471	43.6275213	
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.0475615	43.62680853	
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04813579	43.62693153	
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04780803	43.62754315	
2021-6-23 18:26	Area A	LGL Limited	6	9		travel_in_water,grazing_(on_land)	-80.0478058	43.62814553	traveled in water to grassy land in polygon 1 (prospect park)
2021-6-23 18:26	Area 1	LGL Limited	3	15		grazing_(on_land),travel_in_water	-80.04686608	43.62846151	traveling geese from polygon A joined group on grass. total numbers are (10 adults and 24 juv)
2021-6-23 18:26	Area A	LGL Limited	11	0		dabbling_in_water,loafing,travel_in_water	-80.04760932	43.62873784	
2021-6-23 18:26	Area A	LGL Limited	1	0		travel_in_water	-80.04677657	43.63008179	
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04634143	43.63061118	
2021-6-23 18:26	Area A	LGL Limited	12	26		travel_in_water	-80.04685134	43.62960986	may have comprised of several geese from previous group count in same polygon
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04800752	43.62972181	
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04769844	43.62892452	
2021-6-23 18:26	Area 1	LGL Limited	8	30		grazing_(on_land)	-80.0482969	43.629699	previously was travellling in water
2021-6-23 18:26	Area 1	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04909454	43.62783014	
2021-6-23 18:26	Area 5	LGL Limited	29	0		dabbling_in_water,travel_in_water,grazing_(on_land),loafing	-80.0495577	43.6207027	
2021-6-23 18:26	Area D	LGL Limited	8	0		travel_in_water	-80.04805602	43.62086835	
2021-6-23 18:26	Area D	LGL Limited	3	0		travel_in_water	-80.04661755	43.62078704	
2021-6-23 18:26	Area 4	LGL Limited	3	0		grazing_(on_land)	-80.04434244	43.61980872	manicured grass
2021-7-22 18:43	Area 5	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.04964351	43.62237198	
2021-7-22 18:43	Area C	LGL Limited	5	0		dabbling_in_water,travel_in_water	-80.04965892	43.62313629	
2021-7-22 18:43	Area 6	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.05068382	43.62374773	
2021-7-22 18:43	Area 6	LGL Limited	0	0		N/A	-80.051531	43.6228379	
2021-7-22 18:43	Area 3b	LGL Limited	0	0		indirect_evidence_scat_feathers	-80.0461165	43.6245278	Despite chainlink fence geeses are still accessing sports field, asphalt playground also covered in feces
2021-7-22 18:43	Area B	LGL Limited	13	0		grazing_(on_land)	-80.04718651	43.62527139	Lawn cutting may have impacted use, horseshoe pits covered in feathers and feces
2021-7-22 18:43	Area B	LGL Limited	5	0		travel_in_water	-80.0474314	43.62662884	
2021-8-11 15:44	Area A	LGL Limited	17	0		travel_in_water,loafing	-80.04782855	43.62985377	
2021-9-22 17:32	Area A	LGL Limited	46	0		dabbling_in_water,travel_in_water	-80.04782668	43.62952838	
2022-4-20 14:51	Area 4	LGL Limited	5	0		travel_in_water,aggressive_behaviour	-80.04472559	43.62049102	
2022-4-20 14:51	Area 4	LGL Limited	6	0		flying_overhead	-80.04431946	43.62032958	
2022-4-20 14:51	Area 1a	LGL Limited	2	0		grazing_(on_land),travel_in_water	-80.04746438	43.62681099	
2022-4-20 14:51	Area 1a	LGL Limited	2	0		flying_overhead	-80.04501394	43.6293697	
2022-4-20 15:43	Area 3a	LGL Limited	2	0		nesting,grazing_(on_land)	-80.04681547	43.62608407	
2022-4-20 15:43	Area 3a	LGL Limited	2	0		grazing_(on_land),nesting	-80.04724906	43.62565757	
2022-4-20 15:43	Area 1a	LGL Limited	0	0		N/A	-80.04614195	43.62755672	Beach is free of goose evidence; freshly groomed
2022-4-20 17:44	Area C	LGL Limited	6	0		travel_in_water	-80.04999742	43.62655658	
2022-4-20 17:44	Area E	LGL Limited	4	0		travel_in_water	-80.05117141	43.62245689	
2022-4-20 17:44	Area 4	LGL Limited	2	0	4	nesting	-80.047989	43.622296	2 eggs oiled, 2 eggs predated
2022-4-20 17:44	Area 3c	LGL Limited	2	0	5	nesting	-80.0471578	43.6257502	5 eggs
2022-4-20 17:44	Area 3a	LGL Limited	2	0	5	nesting	-80.0470813	43.625935	5 eggs
2022-4-20 17:44	Area 2	LGL Limited	2	0	8	nesting	-80.0457953	43.6268992	8 eggs
2022-4-20 17:44	Area 4	LGL Limited	2	0	5	nesting	-80.0418346	43.6196977	5 eggs oiled
2022-4-20 17:44	Area 4	LGL Limited	2	0	5	nesting	-80.0412935	43.6196413	5 eggs oiled
2022-4-20 17:44	Area 4	LGL Limited	2	0	5	nesting	-80.0411009	43.6196126	5 eggs oiled
2021-7-27 10:00		Community	184			grazing_(on_land), loafing			20°C, 25% cloud
2021-7-29 19:00		Community	15	0		grazing_(on_land)			23°C, 20% cloud
7/31/2021 PM		Community	2	0		travel_in_water, indirect_evidence_scat_feathers			Cool temperature, 20%
2022-3-28 7:00		Community	22	0		loafing			minus 18°C, partly cloudy, extremely sunny
2022-3-29 10:00		Community	10	0		loafing			minus 8°C, 0% cloud, light snow
2022-3-29 17:00		Community	2	0		loafing			minus 10°C, 50% cloud, slight wind
2022-3-31 8:00		Community	2	0		grazing_(on_land)			6°C, 50% cloud, snow and rain
2022-4-8 15:00		Community	4	0		grazing_(on_land)			8°C, 90% cloud, it was warming up
2022-4-28 14:00		Community	15	0		loafing			10°C, 50% cloud

Date	Monitoring Area	Observer_group	# of Adults	# of Juveniles	# of eggs	Behaviour	x-coordinate	y-coordinate	Comments
2022-4-29 14:15		Community	20	0		loafing			14°C, 0% cloud
2022-4-30 18:00		Community	10	0		travel_in_water			12°C, 75% cloud
2022-5-16 10:00		Community	28	0		loafing			16°C, 60% cloud
2022-5-30 18:00		Community	1	0		loafing			24°C, 20% cloud
2022-4-12 0:00	Area 4	Town			6	nesting			Nest 1 - 6 eggs (Apr12), then 2 left (Apr20), then 0 (Apr 29).
2022-4-12 0:00	Area 3c	Town			5	nesting			Nest 2 - 5 eggs (Apr12), then 6 (Apr20), then 0 (Apr 29).
2022-4-12 0:00	Area 3c	Town			4	nesting			Nest 3 - 4 eggs (Apr12), then 5 (Apr20), then 5 (Apr 29).
2022-4-12 0:00	Area 2	Town			7	nesting			Nest 4 - 7 eggs (Apr12), then 8 (Apr20), then 7 (Apr 29).
2022-4-20 0:00	Area 4	Town			2	nesting			
2022-4-20 0:00	Area 3c	Town			6	nesting			
2022-4-20 0:00	Area 3c	Town			5	nesting			
2022-4-20 0:00	Area 2	Town			8	nesting			
2022-4-29 0:00	Area 4	Town			0	nesting			
2022-4-29 0:00	Area 3c	Town			0	nesting			
2022-4-29 0:00	Area 3c	Town			5	nesting			
2022-4-29 0:00	Area 2	Town			7	nesting			
2022-4-8 0:00	Fairview N1	Town			5	nesting			Fairview Nest 1 - 5 eggs (Apr8), then 7 (Apr 12), then 10 (Apr20) and still 10 (Apr29)
2022-4-11 0:00	Fairview N1	Town			7	nesting			
2022-4-20 0:00	Fairview N1	Town			10	nesting			
2022-4-29 0:00	Fairview N1	Town			10	nesting			
2022-4-29 0:00	Fairview N2	Town			1	nesting			Fairview Nest 2 - 1 egg(Apr29)
2022-4-14 0:00	PSW1	Town			1	nesting			PSW1 - 1 egg (Apr14), then 0 (Apr20)
2022-4-14 0:00	PSW2	Town			5	nesting			PSW2 - 5 eggs (Apr14), then still 5 (Apr20)
2022-4-14 0:00	PSW3	Town			6	nesting			PSW3 - 6 eggs (Apr14), then 0 (Apr20)
2022-4-14 0:00	PSW4	Town			6	nesting			PSW4 - 6 eggs (Apr14), then 4 (Apr20)
2022-4-14 0:00	PSW5	Town			6	nesting			PSW5 - 6 eggs (Apr14), then 5 (Apr20)
2022-4-20 0:00	PSW1	Town			0	nesting			
2022-4-20 0:00	PSW2	Town			5	nesting			
2022-4-20 0:00	PSW3	Town			0	nesting			
2022-4-20 0:00	PSW4	Town			4	nesting			
2022-4-20 0:00	PSW5	Town			5	nesting			
	All areas	Town			58	total eggs oiled			
	All areas	Town			19	total eggs lost			