MUNICIPALITY OF NORTH COWICHAN SERVICE AGREEMENT WITH THE SOMENOS MARSH WILDLIFE SOCIETY

ANNUAL REPORT 2023

Prepared for: Municipality of North Cowichan

Prepared By Gina Hoar, R.P.Bio.,
and Phaedra Douglass, BA.

1 TABLE OF CONTENTS

1 Table of Contents 2
2 Executive Summary 4
3 Water Quality Monitoring Program 6
3.1 The S'amunu | Somenos Watershed 6
3.2 Purpose of the Water Quality Monitoring Program 6
3.3 Water Quality Parameters Collected 7
3.4 Method of Water Quality Data Collection 7
3.5 Water Quality Data and Charts 8
3.6 Water Quality Test Results 8
4 Parrot's Feather Survey Work 10
4.1 Survey of Area 10
4.1.1 Purpose 10
4.1.2 Methods 10
4.1.3 Results 11
4.2 Recommendations 15
5 Parrot's Feather Control Project Phase 1 16
5.1 Introduction 16
5.2 Methods 16
5.2.1 Project Location 16
5.2.2 Work Procedures 17
5.3 Cutting 17
5.3.1 Collecting 18
5.3.2 Water Quality testing 19
5.4 Results 19
5.4.1 Mitigations 19
5.4.2 Cutting Removal and Drying 20
5.4.3 Water Quality 21
5.5 Recommendations 22
5.6 Conclusions 23
6 Riparian Planting and Invasive Plant Control 23
6.1 Purpose and Area of Project 23
6.2 Acquisition and Storage of Plant Materials 24
6.3 Hayfield South of Lakes Road Footbridge 25

6.3.1 Purpose 25
6.3.2 Methods 26
6.3.3 Results 27
6.4 West of Lakes Road 28
6.4.1 Purpose 28
6.4.2 Methods 28
6.4.3 Results 28
6.5 Municipality Right of Way and Haycroft Chase Strata Property 29
6.5.1 Purpose 29
6.5.2 Methods 29
6.5.3 Results 30
6.6 North Side of Somenos Creek along Municipal Park 30
6.6.1 Purpose 30
6.6.2 Methods 31
6.6.3 Results 31
6.7 Conclusion 31
7 Appendix A – Water Quality Results for Somenos Lake 33
8 Appendix B - Water Quality Results for the Somenos Watershed Tributaries 50
9 Appendix C - Data Tabulations for Somenos Lake data 59
10 Appendix D - Data Tabulations for Somenos Tributaries 65
11 Appendix E – Beverly Wetland Water Quality Results 76
12 Appendix F – Parrot's Feather Control Project 78
13 Appendix G - Riparian Restoration: planting information tables 79
14 Appendix H - References 86

2 EXECUTIVE SUMMARY

This report describes work completed in 2023 by the Somenos Marsh Wildlife Society (the Society) on behalf of the Municipality of North Cowichan (MNC). The scope of work is described in the 2023 Service Agreement between the Society and the Municipality. The 2023 Service Agreement is the third such agreement between the parties and has proven to be an excellent method of defining and tracking important environmental projects in the largest watershed in the Municipality. North Cowichan Environment Staff and the Society established the service agreement in 2021 to support North Cowichan Council's 2020 Strategic Plan goal of leading "…in environmental policies and practices to support the future health of our community." Specifically, the Society-MNC service agreement provides monitoring and data that supports the Council Strategic Plan action of evaluating "…options for environmental improvements to Quamichan and Somenos Lakes." Furthermore, environmental work done through the Society-MNC service agreement such as tree planting, riparian habitat restoration, and aquatic invasive removal are practical examples of environmental improvement in Somenos Lake and its watershed. This restoration work relies on collaboration between staff from SMWS and MNC and the support of dozens of volunteers from our community.

The Somenos Marsh Wildlife Society is a non-profit society founded in 1987. The SMWS mission statement includes these words: "to operate, maintain, manage, restore and preserve areas for research, nature study, observance of flora and fauna, protection of wildlife habitat, instruction in natural history and other purposes of a like nature". The Society's activities are fully funded by grants and donations. Currently the Society has two full time staff, and the fieldwork is mostly carried out by staff, volunteers, and Society directors. The Society has carried out many projects on behalf of the Municipality over the years.

The first section of this report describes the water quality data collection work completed in 2023 in the Somenos watershed. Water quality is important for human health and for the flora and fauna that live in and next to our lakes and streams. The data collected informs the Municipality's Environmental Services Department about the condition of Somenos Lake. The lake is shallow and has elevated levels of nutrients, leading to algae blooms in the summer. The lake used to support recreational fishing. Tracking water quality throughout the watershed is a valuable tool in finding the way back to a healthier lake.

Water quality measurements in the creeks flowing into and out of Somenos Lake are also covered in the report. These measurements help identify where contaminants come into the watershed, and where water conditions support healthy biodiversity. The Somenos Watershed has a population of salmon that return to spawn each year. This year was a difficult year for returning salmon populations as poor water quality and heavy parrot's feather growth in Somenos Creek persisted until late November. The watershed can support a much greater population of spawning salmon than is currently seen.

The second section of the Service Agreement report documents how the Society monitored the 2023 growth of the invasive aquatic weed parrot's feather, a vigorous weed introduced into Somenos Creek eight years ago. This section describes how parrot's feather has once again spread out to cover most of the water surface of the creek in early summer, peaking early November. High water levels and flow rates in winter flush most of the parrot's feather into the Cowichan River, with regrowth occurring the following spring. Parrot's feather appears to be an impediment to water quality and spawning salmon migration in Somenos Creek due to its characteristic of reducing water oxygen levels, along with the large amount of biomass that is produced by this plant. It also creates a barrier to recreational use of the creek in the summer.

The third section of the report describes the Society's Parrot's Feather Control Project (PFC) which began in 2023 after other methods of reducing parrot's feather coverage in Somenos Creek explored in 2022 proved to not be effective when scaled. The project spanned 600 meters of the creek between the head of the creek at Somenos Lake and the end of Seine Road; it included cutting of the parrot's feather with an aquatic mower, then removing it from the creek to create a channel free of the vegetation. The project lasted from June till September, with continued monitoring into December; the results showed potential for expansion and improvement of this work.

The last section of the Service Agreement report describes the restoration work done along Somenos Creek in four sections between Seine Road and Tzouhalem Road. There are large sections of the riparian area do not have any taller trees or shrubs. This lack of shade along the Creek leads to increased growth of aquatic weeds like parrot's feather. The Society planted tall trees and shrubs along these sections to shade the Creek as a long-term solution to control growth of parrot's feather and other aquatic weeds and help to improve water quality. These projects spanned most of the year and included spring, summer and fall planting as well as continued maintenance and monitoring.

The projects completed by the Society for the Municipality through the NCSA agreement had a total operating budget of $106,449.00. The Municipality provided $59,880.00, the Society contributed $46,569.00 which included $38,019.00 in operating, staffing and equipment costs, and $8,550.00 in volunteer hours.

The Somenos Marsh Wildlife Society has a long working relationship with the Municipality of North Cowichan. The Society appreciates the support of the Municipality, and in return carries out efficient, low-cost restoration and monitoring work in the unique Somenos watershed. North Cowichan is fortunate in having such a diverse geography and biodiversity within its boundaries. The Somenos Marsh Wildlife Society looks forward to continuing our joint efforts to maintain and restore this precious environment for the residents of this valley.

3 WATER QUALITY MONITORING PROGRAM

3.1 THE S'AMUNU | SOMENOS WATERSHED

The S'amunu | Somenos Watershed (the Watershed) covers 71 km^2 within unceded Cowichan Tribes Territory and is mostly located within the boundaries of the Municipality of North Cowichan (MNC). Portions of the Watershed encompass Cowichan Tribes land, land within the City of Duncan, and the Cowichan Valley Regional District (CVRD). The watershed includes tributaries that flow from Mt. Prevost and Mt. Richards at Crofton Lake. The major tributaries are Richards, Averill, and Bings Creeks which flow into Somenos Lake, and exit into Somenos Creek. The end of the watershed study area is where Somenos Creek meets the Cowichan River. The Society has conducted water quality monitoring in Somenos Lake for the MNC since 2014 and, beginning in 2020, added monitoring of the four major tributaries: Richards, Averill, Bings, and Somenos Creeks (Figure 1).

FIGURE 1: SOMENOS WATERSHED REGULAR WATER QUALITY 2023 YSI TESTING LOCATIONS

3.2 PURPOSE OF THE WATER QUALITY MONITORING PROGRAM

The Somenos Watershed is being impacted by agriculture, development, and a growing demand for more housing developments and supporting infrastructure. Runoff and airborne precipitation from these impacts can discharge into the watershed and may contain compounds that can harm the watershed's aquatic ecology. Monitoring water quality allows us to understand the current state of Somenos Lake and the watershed's health allowing us to identify impacts over time as well as the location of anthropogenic sources from land-water connections. The monitoring results allow the Society to provide recommendations of future monitoring requirements, additional sampling parameters, and land use mitigations to the MNC and appropriate governing bodies.

3.3 Water Quality Parameters Collected

Under the Municipality of North Cowichan Service Agreement for 2023, the Somenos Marsh Wildlife Society Water Quality Monitoring physical, chemical and biological parameters include:

- Monthly (Winter: Oct 01 – Apr 30) and Weekly (Summer: May 01- Sep 30):
    - T (temperature), DO (dissolved oxygen), pH (acid balance), SPC (specific conductivity) and TDS (total dissolved solids at Bings Creek (Somenos Conservation Area and Mary St.), Averill Creek, Richards Creek (Herd Road and Richards Trail), Somenos Creek and Somenos Lake
    - Nutrients: total phosphate, ammonia, nitrate, nitrite, total nitrogen at Bings Creek (Somenos Conservation Area), Averill Creek, Richards Creek (Herd Road and Richards Trail), Somenos Creek at Somenos Lake (surface and 6m)
- Hourly (data loggers): Somenos Lake for T (depths 0m, 3m, 6m), Somenos Creek for T + DO (2 sites: Lakes road, Seine Road)
- Bi-monthly (June-September): Somenos lake phytoplankton community
- 10 weeks Beverly Wetland Monitoring (August to November)
- Weekly (fall: October 1-Dec 31): T, DO, SPC, pH, TDS to test for anomalies that may prevent salmon migration.

3.4 Method of Water Quality Data Collection

Year-round nutrient samples and parameters are tested regularly for any anomalies over time in the creeks and lake outlined in Section3.3. Nutrients are tested by taking a water sample of each waterbody and using a YSI 9300 Photometer to test for each parameter. Preservatives are not required if samples are tested the same day. Reagents specific to each nutrient being tested are added to a 10ml glass sample vial and left to react with the water for 10 minutes. The vial is then placed in the Photometer to obtain a result. A control vial without a reagent is also tested to obtain a background result for each creek. All results are given in mg/L.

In the fall, weekly testing of temperature and dissolved oxygen was included to determine when the tributaries were within the accepted range of values for salmon spawning migration. Specifically, Somenos Creek at Lakes Road and Richards Creek at Herd Road were below survivable levels in the summer and were monitored closely. The dissolved oxygen (DO) and temperature (T) probe installed in 2022 continued to record fluctuations throughout 2023 every 10 minutes at the Lakes Road bridge on Somenos Creek. Another DO and T probe was installed at Seine Road for the parrot's feather experiment and was frequently checked as well.

The equipment used for collecting the water quality data parameters for temperature, pH, dissolved oxygen, turbidity, and specific conductivity in all the waterbodies was a new YSI Professional Series Multi-meter purchased in 2023. In spring to fall the probe was used twice a week in the lakes and creeks, and once a month in winter. The meter was fully calibrated once a month, to ensure accurate readings the dissolved oxygen membrane was replaced every 2 months.

The Van Dorn is a sampler that is used in deep waterbodies to capture a grab sample at a certain depth. In 2023, it was used in the lake to collect the nutrient water samples at the surface and bottom for total phosphate, ammonia, nitrate, and nitrite. When sampling, the Van Dorn is rinsed and sent down to the desired depth (surface and 6m). Once there, the user triggers the instrument to close and is pulled up to the surface. Sample jars are cleaned with the water from the Van Dorn three times, then filled. This is repeated for both depths.

Due to concerns of cyanobacteria toxic outbreaks, a new parameter was added to the program in spring of 2023 to sample for the phytoplankton community in Somenos Lake. Field and lab methods were done the same as the Municipality of North Cowichan on Quamichan Lake. This will enable the two lakes to be compared over time. A new sampling device was made using about three meters of plastic tubing, with a 10-pound weight attached with hose clamps to one end. The weight is meant to keep the tubing vertical in the water column to obtain a sample a composite between 0-3m and a comprehensive picture of the algal community in the photic zone of the lake. The tubing was lowered into the water column to the desired depth of 3m. The top end at the surface was sealed by hand to capture the composite sample. This trapped the water sample within the tube, which was pulled to the surface, and emptied into a clean mixing bucket. A 250ml bottle was filled with the sample water and 25 drops (25%) of lugol's solution was added to preserve it for shipping.

Beverly Wetland Monitoring started in 2022 and continued this year. A location map is included in Figure 1. The purpose is to test the successful functioning of the wetland. Water samples are tested for total metals, phosphorus, and turbidity at MB Laboratories Ltd. SMWS collected water samples at two upstream locations (BWQ1US, BWQ2US) where storm water runs into the wetland off Beverly Street, and one downstream site (BWQ1DS) where the water flows out of the wetland through the dike to Somenos Creek. Samples were collected during the dry season for five weeks, and wet season for another five weeks. Samples were frozen and shipped after the 10-week sampling period was completed.

3.5 Water Quality Data and Charts

Refer to the appendices to review the results of the water quality data collection program.

3.6 Water Quality Test Results

The results of this year's annual water quality monitoring program show us a glimpse of what is happening in the Somenos Watershed regarding water quality health and what the potential impacts are on aquatic life. Some key conclusions made during the Somenos Lake water quality sampling season in 2023 are as follows, along with comparisons to previous years:

- Somenos Lake stratification occurred in early April and turned over by late September which coincided with a profile change of temperature and dissolved oxygen. Interestingly, in late September when mixing occurred, dissolved oxygen dropped dramatically throughout the lake. This is the first recorded occurrence of this event. One possibility is this is due to peak temperatures at 6m releasing Phosphate from the bottom, feeding biological or phytoplankton activity at the end of the season. This low oxygen event didn't last long and by October the lake oxygen levels normalized for this time of year. Data tables and charts of 2023 results are in Appendix C.
- In 2021 stratification occurred in March whereas in 2022 and 2023 respectively turned over in May and April. Fall turnover in all three years was in September.
- Somenos lake dissolved oxygen was low (<6mg/L) at the bottom (6m depth) by May 10, and by August 25 the entire water column was anoxic to fish. There was a fish kill of Coho smolts observed in the morning of August 18. Dissolved oxygen levels were good at the surface (>6mg/L) however temperatures were over 25C. It is possible hot temperatures in the lake was the cause however it is not conclusive since our only test was taken that day and results from overnight physical conditions are unknown.
- The Somenos Lake algae bloom was observed on the surface of the lake by mid-summer and into the fall as late as October. The surface of the lake fluctuated between 'brown' and 'green' throughout July. Early to late August the lake had turned a thick green soup consistency. By late august the lake was brown with green flecks with bubbles forming on the surface throughout September. October to November was brown with a green scum on

the surface. By December The lake was clear of visible algae. Further algae analysis shows the phytoplankton community month to month. Data tables and charts of 2023 results are in Appendix C.

- The SMWS Salmon Watch event in the fall of 2023 observed that the salmon migration up Somenos Creek to the upper tributaries of Averill, Bings creek was delayed until November. This has become a common occurrence similar to previous years (2020-2021). Coho spawning salmon were first observed by a Society member on November 23, 2023, in all three tributaries. This coincides with unfavorable water quality conditions in Somenos Creek, their migration route, prior to November 19 (Section 5.3.3 Chart 2).
- Somenos Lake data tables and charts of 2023 results are in Appendix A and C.
- Tributary data tables and charts of 2023 results are in Appendix B and D.
- Beverly wetland data tables of 2023 results are in Appendix E.

4 PARROT'S FEATHER SURVEY WORK

Parrot's feather (*Myriophyllum aquaticum*) is an invasive aquatic plant that has been taking a hold of Somenos Creek ever since being first found back in 2014 (Preikshot, 2019). It is a plant that has been introduced from the Amazon River in South America and has spread throughout North America. Parrot's feather thrives in warm, freshwater and is commonly found in relatively shallow and slow-moving water and is well adapted to nutrient-rich environments (Washington State Department of Ecology, 2001). Unfortunately, these conditions exist in Somenos Creek for parrot's feather growth in the summer months.

Although introduced in 2014, parrot's feather has quickly taken a hold of Somenos Creek, a roughly 3km long stretch of water that drains Somenos Lake into the Cowichan River. Somenos Creek is high in nutrients, in part because the watershed is host to extensive agriculture that includes both crop growth and livestock leading to nutrient-rich runoff that ends up in Somenos Lake and Somenos Creek.

The immediate concern is that Somenos Creek is the gateway from the Cowichan River to the Somenos Watershed, a watershed that has supported substantial populations of salmon throughout history. Populations of Coho (*Oncorhynchus kisutch*) and Chum (*Oncorhynchus mykiss*) salmon use the watershed's tributaries (Richards Creek, Averill Creek, and Bings Creek) as their spawning grounds (Burns 2002). However, in recent years the only salmon observed has been Coho, which have a longer migration time than chum.

While the exact impacts are still under investigation, it has been posited that the mats of parrot's feather in the creek present annual physical and water quality barriers to fish migration until fall break-up occurs, and fall rainy season begins. At that time, high flows will cause the parrot's feather to die off and get flushed down the creek, into Cowichan River and out to the ocean.

It is reasonable to think that with incoming drier and hotter summers attributed to anthropogenic climate change, the growth season of parrot's feather will increase in length, thus leading to greater coverage, thicker mats, and more permanent changes to the ecology of the creek system. This creates a large threat to the local ecology and necessitates monitoring of the plant over time.

4.1 SURVEY OF AREA

4.1.1 Purpose

The Somenos Marsh Wildlife Society (SMWS) has been formally surveying and cataloguing the extent of the parrot's feather from the summer of 2020 to 2023. The surveys are aimed at monitoring the fluctuation of parrot's feather coverage in Somenos Creek annually, and month-to-month. The intention of the monthly survey schedule was to monitor the plant's growth throughout the growing season, identify peak growth, determine how much remains over winter vs how much washes downstream, and annual trends.

4.1.2 Methods

The surveys were completed by SMWS staff and volunteers through streambank observations or instream observations by kayak or canoe. The abundance of parrot's feather was determined by visual inspection and the percentage recorded was based on the area of channel covered. Channel areas were calculated using a combination of Google Earth Pro and Gaia GPS. As the SMWS staff surveyed Somenos Creek, waypoints were taken (Gaia GPS Android app) where there was an obvious change in the amount of parrot's feather coverage observed. The change in coverage was noted at each of these points, and the data (in KML) was then input into Google Earth Pro to create polygons of the percent areas at each point.

For these surveys, Somenos Creek was split into three reaches (Figure 2):

- Reach 1: Somenos Lake to Lakes Road Footbridge (Municipality of North Cowichan)
- Reach 2: Lakes Road Footbridge to Tzouhalem Road (Municipality of North Cowichan)
- Reach 3: Tzouhalem Road to Cowichan River (Cowichan Tribes)

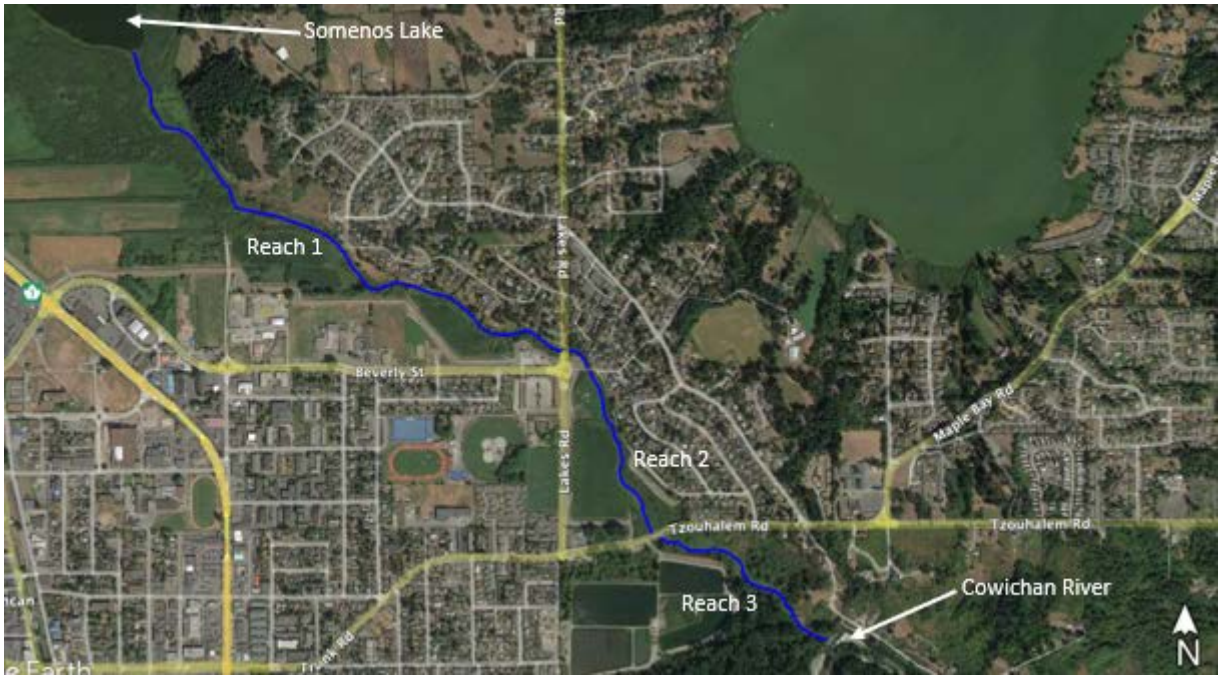


FIGURE 2: SOMENOS CREEK SURVEY REACHES 1-3

4.1.3 Results

In 2023, the following describes major observations observed:

- This is the first year we have noticed a few small patches of parrot's feather have migrated up toward Somenos Lake, but still has not reached the lake yet.
- At the two U26 probes in Somenos creek (Seine Road and Lakes Road) it was observed that dissolved oxygen levels started fluctuating at both sites to around 5mg/L for periods of 5+ hours at a time daily from November 19th to December 2, 2023 when conditions improved consistently to >6mg/L. This created migratory conditions for salmon which was confirmed by the first sightings of Salmon in the tributaries during the second salmon watch date on November 23rd (Chart 2, Section 5.3.3 Water Quality). Two weeks prior (on November 9) during the Salmon watch survey no fish were observed in the creeks. Dissolved oxygen in Richards Creek (Herd Road) was taken only weekly using a YSI which showed levels were passible on December 11th in Richards Creek; however, migrating fish must have found conditions improved earlier than was recorded since they were observed on November 19 spawning in Richards Creek upstream.
- The monthly monitoring showed that parrot's feather reached its peak growth by late fall which was usually seen in August. By December the creek's banks were flooded and parrot's feather was breaking off and migrating downstream. SMWS will continue to monitor when the parrot's feather is flushed out of Somenos Creek over the winter, where it ends up, and how much remains.
- Areas with over 75% build-up of parrot's feather in the creek are shown in figure 3. This includes dense mats where parrot's feather starts in Reach 1, and the highest area in Reach 2, and at the start of Reach 3.

- Reach 2 is adjacent to active farmland on the western shoreline and exposed to full sun. One idea is the sun exposure creates perfect conditions for growth. SMWS's long term plan is to add a treed riparian zone on the west side, to shade parrot's feather and reduce its growth, planting begun in this area this year.
- Reach 3 heavy buildup of parrot's feather is likely to be caused by a slow section downstream of the pipeline crossing. At the end of the green highlighted area in Reach 3, there is a wide, backwater which slows the creek down provides perfect conditions for parrot's feather to grow and creates a 100% covered area.

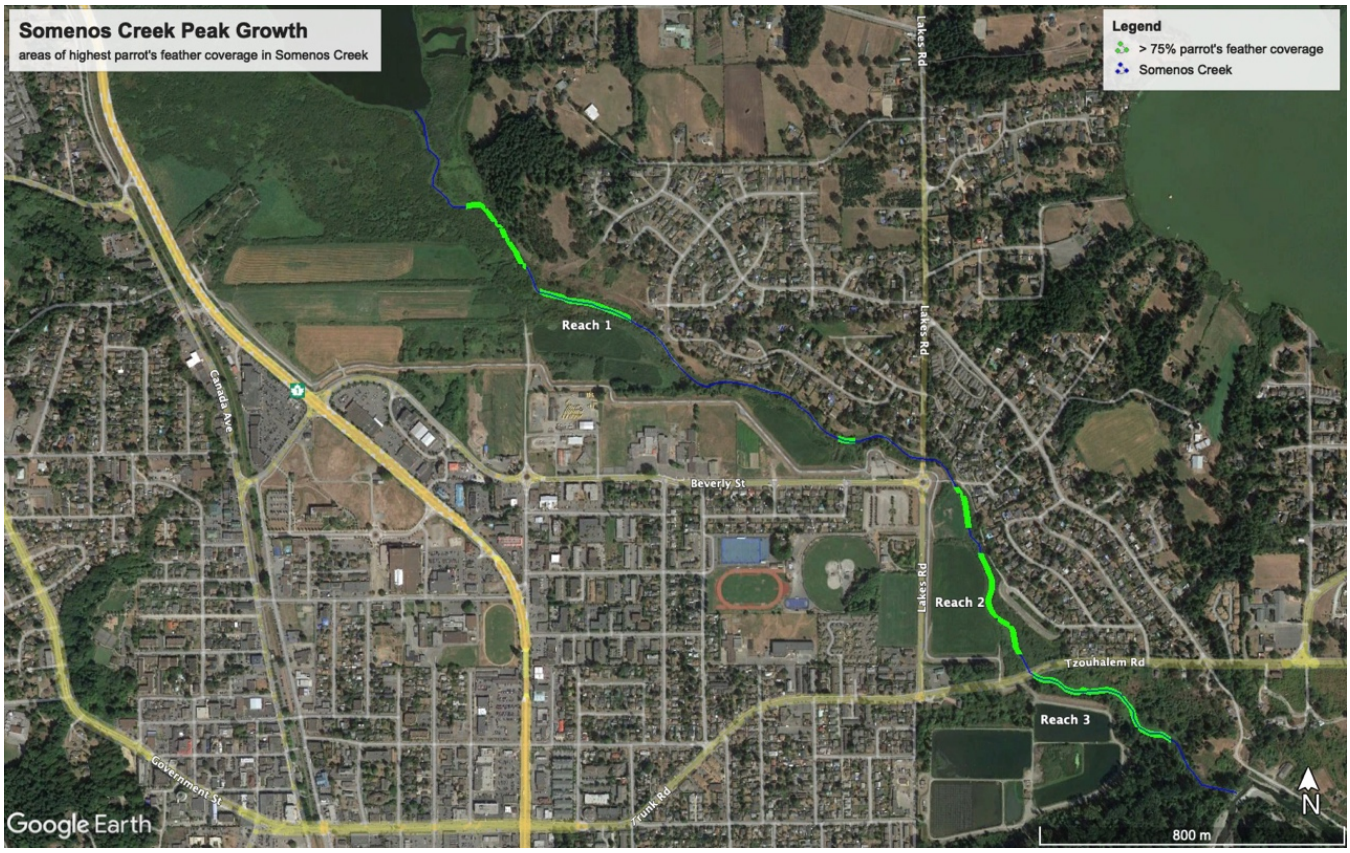


FIGURE 3: SOMENOS CREEK PEAK GROWTH 2023

The overall amount of parrot's feather peak growth in 2021, 2022 and 2023 in all the reaches are shown below in Table 2. The results of peak growth this year are similar to last year at 54% coverage, but much lower than in 2021. It is likely due to 2021 being an unusually warmer winter and spring with high water temperatures for that time of year (Chart 1), and a heat dome in June kickstarted parrot's feather growth earlier than expected. Another supporting observation is that in 2023, water temperatures were higher in fall, and could have contributed to a later peak growth in November, vs August in 2021 and 2022. Results are shown in Table 1 and Chart 1. In 2023, growth was lower than previous years in Reaches 1 and 3, however reach 2 was a lot higher.

CHART 1: MEAN MONTHLY WATER TEMPERATURE IN SOMENOS CREEK BETWEEN 2021-2023

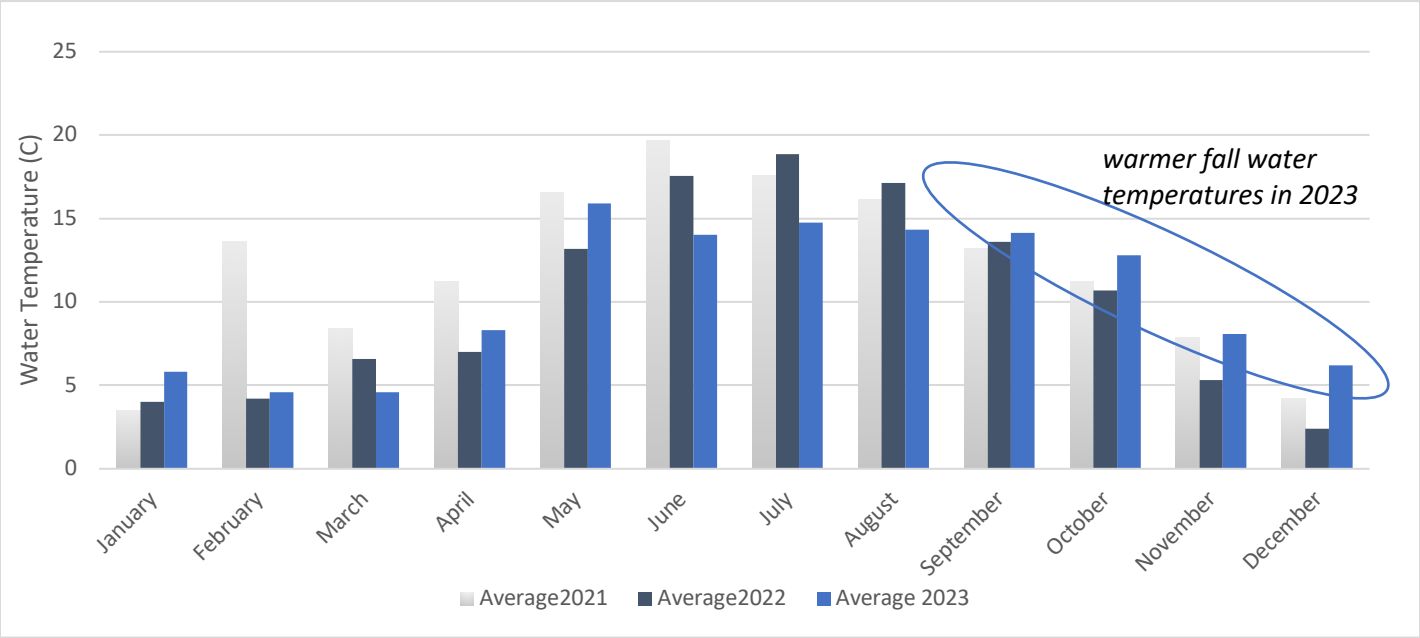


TABLE 1: PERCENT GROWTH OF PARROT'S FEATHER COMPARISON OF 2021-2023

Location	2021 peak growth (August)	2022 peak growth (August)	2023 peak growth (early November)
Reach 1	68%	44%	41%
Reach 2	96%	67%	78%
Reach 3	70%	63%	57%
Overall Somenos Creek	73%	53%	54%

Photo 1: Typical parrot's feather growth in Reach 1 covers most of the channel. June 2023

Photo 2: Typical parrot's feather growth in Reach 2 spans entire channel in multiple sections. September 2023

Photo 3: downstream view of typical parrot's feather coverage in Reach 3 that spans the entire channel within Cowichan Tribes land. June 2023

Photo 4: Upstream view from Beaver dam at the end of Reach 3 shows water levels are still low in October, 2023

Photo 5: Upstream view from Tzouhalem Bridge, Reach 3, shows growth in June, 2023.

Photo 6: Upstream view from Tzouhalem Bridge, Reach 3, shows dying parrot's feather being pushed downstream in higher flows in December, 2023

4.2 RECOMMENDATIONS

Future monitoring should include:

1. SMWS will continue to monitor migration of parrot's feather to the Lake in spring to see if it grows back where it was observed.
2. Conduct further investigations of environmental parameters that may influence parrot's feather growth. For example, water quality parameters (dissolved oxygen, temperature, conductivity, pH, total dissolved solids), substrate type, ground water locations, percent shade, depths, and the location of other aquatic plants present.
3. Include monitoring of parrot's feather on Cowichan River to ensure it all washes out to the ocean during high flows in winter.

5 PARROT'S FEATHER CONTROL PROJECT PHASE 1

5.1 INTRODUCTION

Based on the recommendations from a 2019 report on M. aquaticum (parrot's feather) management options (Preikshot, 2019) the Society proposed a control program in partnership with the Municipality of North Cowichan with the support of Cowichan Tribes to determine the effects and benefits of cutting the M. aquaticum to maintain a channel clear in the Creek. In the summer of 2023, the society began year one of the Parrot's Feather Control project (PFC), with plans to continue into 2024. This section will outline the methodologies and preliminary results from the first year's control project as well as some recommendations for next season's phase of the PFC.

5.2 METHODS

5.2.1 Project Location

The Parrot's Feather Control project took place in Somenos Creek extending downstream from where *M. aquaticum* is established for a total distance of 600m (Figure 4). This area was chosen due to its accessibility both by road to the Creek, and the presence of an open field which was used to dry the *M. aquaticum* after it was removed from the Creek. The Society conducted parrot's feather clearing operations 300m from the head of the creek as a precaution against spreading parrot's feather to the lake. Surveys by the Society in 2021 and 2022 show that the dense growth of other aquatic plants, especially Water Lily (*Nuphar polysepala*), and Smartweed (*Polygonum* spp.) at the head of the creek appear to be a barrier to the spread of Parrots Feather to the lake. The section of Creek in which the project took place is relatively wide, measuring about 4-5 meters in some sections, with few sections any narrower than 3 meters during the dry season. The banks are quite steep, and the water is approximately 1.5 to 2 meters deep. The Creek has very limited observable flow, if any, during dry summer months (Preikshot, 2019), which along with the Creek's dimensions and other characteristics, facilitated manageable maneuvering of the boat and other tools. The main barrier to movement within the Creek was overhanging vegetation along the banks and the *M. aquaticum* and other aquatic vegetation which established quickly in the Creek.

FIGURE 4: MAP OF PFC ACTIVITY LOCATIONS IN SOMENOS CREEK.

5.2.2 Work Procedures

To begin the process of the Parrot's Feather Control Project, The Society received letters from Dave Preikshot with the Municipality of North Cowichan, Sonia Furstenau MLA, and Larry George with Cowichan Tribes in support of the proposed mechanical removal of *M. aquaticum* in Somenos Creek. The Society then proceeded with permitting process. The provincial Section 11 (file no: 1005704), provincial (permit no: NA23-798592) and federal (permit no: XHAB 199 2023) fishing permits were granted. The Society also sent in a Department of Fisheries and Oceans (DFO) request for review of project which was accepted in consideration of recommendations. Letters of support, permits and other documents can be requested from the Society if required. Prior to the beginning of the PFC residents of Seine Road and other nearby houses were informed of the work to be done in the Creek through a letter and a staff canvas. Signs informing passersby of the PFC project were placed at the boat launch and next to the *M. aquaticum* drying area to ensure those who were curious knew what work was being completed.

The PFC project consisted of three main aspects: cutting, collecting and water quality monitoring. First, the leading edge of the *M. aquaticum* would be cut, removing it from the rest of the plant, then it would be collected and removed from the Creek, water quality monitoring took place prior to all cutting events and some removal events, with additional monitoring taking place during the monthly *M. aquaticum* surveys.

A 14' aluminum boat powered by an electric motor, and equipped with the aquatic mower was used for all activity in the Creek. A containment boom and seine net were put in place downstream from the project area to prevent the movement of *M. aquaticum* fragments downstream during cutting events, as was outlined in the DFO permit. The seine net was only used during the cutting events and was left in for 24 hours to ensure no movement of *M. aquaticum* downstream, when removed, it was checked for entrained *M. aquaticum* fragments and trapped fish. The containment boom was left in for the duration of the project to ensure collection of any floating *M. aquaticum* fragments, this was checked weekly.

When not actively using the boat, it was stored in the Creek, tied, and locked to shore. All other tools and equipment were taken off site and stored separately, except for the containment boom which was left in the Creek until October 26th and the Hobo onset U26 dissolved oxygen logger which was left in the Creek until December 18th, to monitor water quality and movement of *M. aquaticum* into the rainy season. Precautions were taken to ensure no contamination of other water sources by *M. aquaticum* fragments from the equipment brought off site when required. These precautions included keeping most of the equipment used for the project within the drainage area of Somenos Creek, maintaining cleanliness of all equipment and washing and disinfecting any equipment that had to be taken off site. The boat was kept in the creek for the duration of the project and thoroughly washed and inspected before being removed from the creek. Additional precautions included signage on site of the project, and staff education on the importance of the precautions taken.

5.3 CUTTING

M. aquaticum cutting took place on the dates shown in Appendix F, Table 1 with a total of 5 cutting events from June 28th to August 22nd. Each cutting event was monitored by a qualified environmental professional, who ensured minimal impact on the Creek and that appropriate procedures were used.

Tools used during cutting events included the 14" aluminum boat, electric motor, gunwale mounted aquatic mower, paddles, and the water quality measuring equipment. The seine net was deployed prior to any *M. aquaticum* cutting to ensure containment of cut fragments, it was then removed and examined the next day. Personnel included a boat driver, the aquatic mower operator, and two extra people to keep the boat steady, on course and record water quality information.

The aquatic mower was mounted on the right side of the boat onto the reinforced gunwale (photo 7) which meant that the NE side of the Creek was cut while moving upstream and the SW side while moving downstream. Originally the proposal was to limit the cutting to the leading edge of the *M. aquaticum;* however, as the PFC did not begin until late June, there were sections where larger clumps had to be cut off in order to create and maintain a channel.

Photo 7: The aquatic mower in action on Somenos Creek.

5.3.1 Collecting

Collecting of *M. aquaticum* took place on the dates shown in Appendix F, Table 1 with a total of 14 removal events from July 19th to September 21st. Precautions were taken when removing *M. aquaticum* particularly the large mats to ensure no harm came to any fish or other animals in the Creek.

Tools used during collection events included the boat, electric motor, 5 plastic totes for *M. aquaticum* collection, a hand saw to cut any *M. aquaticum* that was partially attached, hay and manure pitchforks and rock rakes for collection. Waterproof gloves, waders, and waterproof shoes were also needed. The seine net was not deployed during *M. aquaticum* collection efforts. Personnel included a driver, and at least two others to collect and maintain balance in the boat.

The team would work their way upstream in the boat, stopping to collect the cut *M. aquaticum* which floated freely in the Creek It was collected in the boat in 5 large totes, (photo 8) which, once full of *M. aquaticum* would then be hauled out of the creek and dumped out on the greenway to dry. Most of the *M. aquaticum* was spread out about 20cm thick while some was left in a pile to determine which method was most effective at killing the plant over the summer and winter months.

Photo 8: Parrot's feather collection in Somenos Creek.

5.3.2 Water Quality testing

Water quality testing took place on the dates shown in Appendix F, Table 1, with a total of 13 events from June 23 to October 26. Of the 6 water quality testing locations (Figure 4) the points that were tested regularly were points 3, 4, 5, and 6. Locations 1 and 2 were not accessible via boat during the project and therefore were tested less frequently, and only when accessed from the Lake.

A YSI ProQuatro MultiParameter Meter (YSI) was used to measure temperature, dissolved oxygen, pH, specific conductivity, and total dissolved solids. These measurements were taken at 0.5 m below the surface of the Creek at each water quality testing location. Measurements were taken prior to cutting events and on our monthly *M. aquaticum* surveys. On-going water quality was monitored by two Hobo Onset U26 dissolved oxygen logger's (data logger) that measured temperature and dissolved oxygen every 10 minutes throughout the project's duration. The first logger was left in the Creek 0.5 m below the surface, mid-channel, and attached to a buoy near the boat launch and boom at water quality point 6. A second data logger was left at Lakes Road bridge, 0.5 m under the surface, mid-channel, and served as a control site for water quality in the Creek. Data was collected from this logger weekly.

Turbidity was tested twice during the project to ensure the activities in the Creek did not significantly change the turbidity levels as outlined by the British Columbia Approved Water Quality Guidelines (Singleton, 2021) The tests were completed with a turbidity tube and secchi disk before and after trimming on August 22nd and similarly on September 6th before and after removal.

5.4 Results

5.4.1 Mitigations

Minnow traps were deployed prior to the PFC project to determine what fish species were present in the Creek to ascertain the potential impact of the PFC project. The only fish caught in the minnow traps were 52 *Gasterosteus aculeatus* (three spined stickleback). However, additional sightings of *Lepomis gibbosus* (pumpkinseed fish) were observed by staff while working on the Creek and should also be considered.

When the seine net was taken out of the Creek after every cutting event, it was examined for fish and other entrained animals or aquatic weeds. No fish or *M. aquaticum* were found entangled in the net after any of the cutting events. *Lemna minor* (common duckweed) was the only material found to be entrained in the seine net, and as *L. minor* is highly

common in the Creek, including where the seine net was placed, it is assumed this was simply caught in the net while it was placed and removed.

The boom was left in the Creek to catch any additional *M. aquaticum* fragments that may have floated downstream between work events. No collection of *M. aquaticum* at the boom was observed until the Creek began flowing at the end of October. The Society believes that due to the lack of flow in Somenos Creek during the summer, none of the cut *M. aquaticum* ever floated down the Creek to get entrained in and on the seine net or boom during the project. Any *M. aquaticum* that may have established itself at the boat launch site was most likely due to its natural growth from the bank and downstream of the boom. Overall, the boom and seine net proved to be mostly precautionary for the project at this stage, limited flow in the Creek was shown to be a much more effective barrier to the transport of cut *M. aquaticum.* If the project is scaled up and work is completed further down the Creek, the boom and seine net may become more effective.

5.4.2 Cutting Removal and Drying

Removal of *M. aquaticum* proved to be effective in Somenos Creek. The Society was able to navigate upstream in the boat, cutting the leading edge and some larger mats off the growth coming in from the banks of the Creek. Then were able to go out again in the boat to collect and remove the mats and floating cut *M. aquaticum.* This process was successful at creating a 2-3-meter-wide channel free of *M. aquaticum* in the Creek. Once the initial clearing was done, maintaining it was more manageable. Initially it took 3 cutting events to clear the desired channel, (Appendix F, Table 1) and 5 removal events to remove most of what was cut. A more vigorous schedule is proposed in the recommendations, Section 5.4, below to increase effectiveness of maintaining the channel in the Creek.

Overall, *M. aquaticum* survey results from June to September demonstrate the results of the PFC as less coverage of *M. aquaticum* on the project section of the Creek compared to previous years. *M. aquaticum* survey results of reach 1 from 2023 during the PFC project show 18% coverage in July, 25% coverage in August and 29% coverage in September. Survey results from 2021 show 58% coverage in July and 68% coverage in August. Even though 2022 was not as comparable a year as the growing season began much later, reach 1 was 34% covered in July and 44% in August. Based on these data, it is shown that the PFC project had a substantial impact on growth and coverage of *M. aquaticum* in Somenos Creek.

The Society removed, in total, 15.191m^3 of *M. aquaticum* from Somenos Creek over the duration of the PFC*,* as measured by 194 mid-sized storage totes. This material was dumped and spread out on the park greenway near the boat launch site (Photo 9), and some was piled in another area to compare results. The *M. aquaticum* dried well over 2 months in the summer heat having a crispy consistency that fell apart when crushed; however, it was observed that some of the *M. aquaticum* began sprouting as soon as the wet season began in September (Photo 10). It is surmised that even though the layer of *M. aquaticum* was laid out to dry in a thin layer of 20cm, not all of it dried and would have needed more time to fully desiccate. Half of the *M. aquaticum* that was laid out to dry was turned over in September to discern if flipping it may make any difference in the drying process, no discernable difference was observed and *M. aquaticum* continued to produce new growth after being flipped. After observing the *M. aquaticum* piles until December, it was noted that most of the plant had turned black/brown and appeared to be dead, with only one observable still green plant (Photo 11). The society found that both the spread-out *M. aquaticum* and the pile had significantly decomposed by mid-December, which demonstrates that both methods were effective at killing the plant. The M. aquaticum will continue to be observed through the winter.

Photo 9: Parrot's feather pile at the end of August, 2023.

Photo 10: Parrot's feather pile, on September 29th 2023.

Photo 11: Parrot's feather pile December 18th 2023.

5.4.3 Water Quality

Water quality measurements in Somenos Creek have produced highly variable results during the summer months since the Society began regularly recording data. Results have continued to be variable through the first phase of the PFC project. There is a possibility that low flow, ground water influence, decomposition and aquatic vegetation play important roles in the Creek and therefore causes some uncertainty in the results. This variability combined with the fact that phase 1 of the PFC was a trial that took place in only a small section of the Creek, leads to water quality results that are inconclusive.

The initial purpose of testing water quality with the YSI was to gather additional information and potentially see changes in water quality, specifically dissolved oxygen over the project duration in Somenos Creek. One interesting result is that dissolved oxygen levels varied inversely with changes in conductivity. Here, it is possible that ground water is influencing the dissolved oxygen results.

The data logger results in the project and control locations (Figure 4) are displayed in Chart 2 which compares the results. At both sites, oxygen levels dropped in June and stayed low for the summer creating no discernible difference between sites when looking at the timing of the removal and trimming dates. However, temperatures became similar between control and project sites after the parrot's feather was removed from the creek in August.

To ensure work did not impact turbidity negatively, turbidity was recorded before and after the trimming and removal dates and measurements did not exceed the British Columbia Approved Water Quality Guidelines (Singleton, 2021), see Table 2.

TABLE 2: TURBIDITY RESULTS IN SOMENOS CREEK BEFORE AND AFTER TRIMMING AND REMOVAL EVENTS

Trimming		**Removal**	
August 22, 2023		September 6, 2023	
before	*after*	*before*	*after*
60 cm	53 cm	60 cm	60 cm
6 NTU	7 NTU	6 NTU	6 NTU

Due to the uncertainty of the water quality results and the limitations of the first phase of the PFC, the Society concludes that the PFC, at this scale, had no observable effect on the water quality in Somenos Creek. Detailed water quality data is available at Somenos Marsh Wildlife Society upon request.

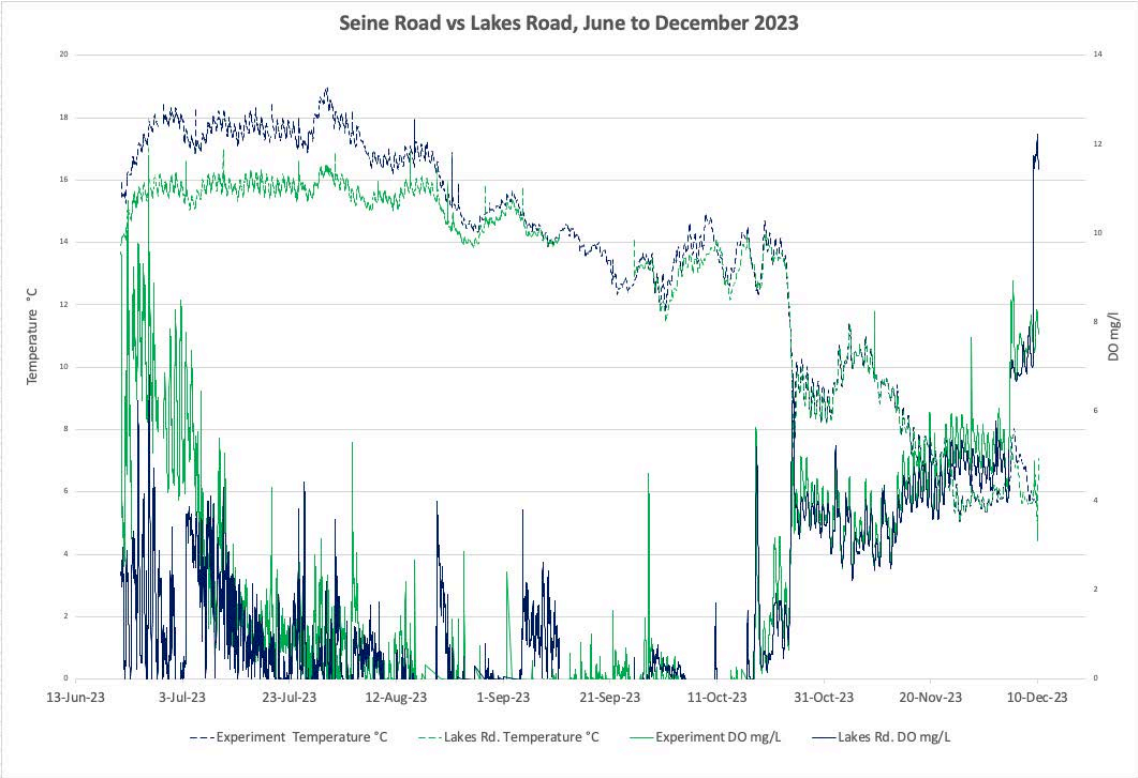


CHART 2: PROJECT VS CONTROL DISSOLVED OXYGEN AND TEMPERATURE FROM BEGINNING OF PROJECT TILL MID-DECEMBER.

5.5 RECOMMENDATIONS

The PFC work began at the end of June in 2023. This was not ideal because the *M. aquaticum* had already grown considerably by this time. For 2024, trimming of *M. aquaticum* should be timed to start either on June 1 or earlier to better control the plant growth. An earlier start date (before June 1) would only be considered if water quality conditions in Somenos Creek are non-survivable for salmonids.

Work to control *M. aquaticum* in the Creek should extended into September and even October. The Society believes that removing *M. aquaticum* until the end of its growing season is important to generate the best results, and previous

years surveys have shown growth peaks during these months. This will be conditional on the beginning and length of the growing season in 2024 and therefore will require some flexibility.

After observing the M. aquaticum that was left on the greenway to die it was noted that both spreading the plant out and piling it proved effective in killing it. But, with consideration of removing more volume and expanding the project length in 2024 it has been shown that piling it will be the most effective. This option will reduce the need for larger open areas to dry the removed *M. aquaticum* which would be difficult to locate farther down the creek. The other option would be to truck the *M. aquaticum* off site and compost it somewhere else. However, the effectiveness of trucking may be limited by the ability to safely transport the cut *M. aquaticum* and the ability to locate a suitable site to compost it. In communications with DFO staff, this could be an option if a plan is provided for approval.

Improving and increasing, the water quality testing will be an important aspect of phase 2 of the PFC project. This may include beginning testing before the project begins and, if possible, finding another comparable control site. Potential other options for understanding the water quality results include, discharge transects of the Creek or monitoring groundwater influence.

Improvements in equipment will be another important upgrade for 2024, the largest of which will be a new boat and better storage. The boat that was used was not sturdy enough or strong enough, therefore the Society believes a flat bottom boat with a flat bow and reinforced gunwales and transom would be ideal. For the equipment storage, a Seacan or other facility with power and running water that is also close to the work area would be ideal. Power to charge the batteries for the mower and motor, and running water to make sure equipment and workers are clean. Smaller equipment improvements will include uniform collection totes with drainage holes and a few more collection tools.

5.6 Conclusions

Overall, the Society believes it was a positive first year of the PFC project, showing promising results and the possibility for improvement and expansion during the next phase of the PFC project. Our work showed that maintaining a 2-3-meter-wide channel clear of *M. aquaticum* in the Creek was effective, and scalable. This was the main goal for phase 1 of the PFC project. As the PFC project took place in an isolated 600m section of the Creek and, as this was the first year, the results below are preliminary and should not be viewed as indicative of a project spanning the whole Creek. Therefore, the product of this year's phase of the PFC will be preliminary results and recommendations for the 2024 season of the PFC as shown above.

The Somenos Marsh Wildlife Society, with support from its partners, is ready to pursue phase 2 of the Parrot's Feather Control project in 2024. The long-range goal is to continue this project and create a continuous open channel through the *M. aquaticum* and other aquatic weeds, from Somenos Lake to the Cowichan River. It is hoped that a continuous open channel will improve water quality significantly and allow salmonids to access spawning sites earlier in the fall migratory period. This will be accomplished through applying the knowledge gained through year 1 of the project and feedback from the Municipality of North Cowichan and Cowichan Tribes.

6 Riparian Planting and Invasive Plant Control

6.1 Purpose and Area of Project

Functioning riparian areas are imperative for healthy rivers and streams in many ways (Hilliard, 2020), most importantly for the issues present in Somenos Creek (Preikshot, 2019) taller trees and shrubs in the riparian area provide shading.

Parrot's feather grows best in bright conditions (Wersal, R., 2013), in hopes of reducing the parrot's feather coverage in Somenos Creek, riparian areas were planted with a mix of shrubs and taller shading trees. The goal is to block sunlight and reduce growing season temperatures and light penetration into the creek to limit parrot's feather growth and biomass, ultimately increasing dissolved oxygen in the creek, thus allowing earlier fish migration in the fall.

Four locations were chosen and maintained in 2023 to provide riparian shading (Figure 5). They include:

1. The hayfield south of the Lakes Road footbridge (hayfield).
2. The open section on the north side of Somenos Creek, just west of Lakes Road (west of Lakes Road)
3. The southwest side of the Haycroft Chase Strata Property and MNC Right of Way (strata)
4. The north side of Somenos Creek along the municipal park between Lakes Road and Seine Road (parkside).

FIGURE 5: MAP OF FOUR LOCATIONS WHERE RIPARIAN PLANTING WAS DONE IN 2023.

6.2 Acquisition and Storage of Plant Materials

Plants were purchased from Peel's Nursery on the mainland and delivered on April 12th, 2023. For a complete list of plants purchased see Appendix G, Tables 3-6. The plants were stored at the Cowichan Green Community's Cowichan Farm and Food Hub where they were watered every other day with an automated sprinkler system. They were then moved on April 27th, 2023, to the southern section of the hayfield in which they would be planted, they were stored in the vegetated area near the culvert at Chesterfield Creek (see Photo 12 and Figure 6), where they were mostly shaded. During planting the stored plants were watered alongside the planted ones, one to two times a week. Plants that did not get planted at the hayfield were moved to the Strata property planted there or moved back to the Cowichan Farm and

Food Hub until they were planted alongside Somenos Creek. Nutrient 'tea bags' were purchased from Spectrum Pacific Products, specifically the Defender – High Sulphur, Browse Deterrent Fertilizer and the Aquazorb – Water Absorbent Fertilizer. Additional tree plugs were donated by the Ministry of Transportation Infrastructure (MOTI), some were planted west of Lakes Road. Additional plants were purchased on November 28th from Streamside Native Plants, as part of our monitoring program, to replace plants which were browsed on at the hayfield and to replace dead plants along the parkside of Somenos Creek. 10 plants were also bought for the strata to fill in gaps. The browsed plants at the Hayfield will be replaced in the spring of 2024 as the area will be flooded until then.

Photo 12: The southern section of the hayfield where plants were stored during planting and the crew who moved them.

Photo 13: Image of the hayfield riparian planting location, taken from the southern section of the field looking north.

TABLE 3: OVERVIEW OF RIPARIAN PLANTING PROJECTS ALONG SOMENOS CREEK.

Project	Volunteer Hours	Invasives Removed (m^2)	Number of Trees Planted	Amount of Habitat Restored (m^2)
Hayfield	190	75 (yellow flag iris and canary grass)	588	876
West Lakes	89.75	374 (Himalayan blackberry and morning glory)	64	274
Strata	24	30 (Himalayan blackberry)	49	maintenance
Somenos Parkside	56	0	52	maintenance
Total	**357.75**	**479**	**805**	**1150**

6.3 Hayfield South of Lakes Road Footbridge

6.3.1 Purpose

The municipal right of way along Somenos Creek in this section has historically been farmed and had little to no riparian vegetation, it has also been notably one of areas of Somenos Creek in which parrot's feather has had high coverage (see Section 4 on parrot's feather survey). The MNC hired Madrone Environmental Services Ltd. (Madrone) to provide a

riparian planting plan for this area and the riparian area on the corn field to the south, the purpose of the prescribed riparian planting along the creek in this section is to improve riparian health and function and to increase shading of the creek in order to reduce parrot's feather coverage. The hayfield portion of the riparian area was planted in 2023.

In April three site visits with SMWS, MNC and the Farmer (Aaron Van Boven) were completed to confirm the MNC right of way and the planting area, the area agreed upon is shown in Figure 6 below. Based on the meetings with the MNC, Aaron Van Boven and additional correspondence with Greg Howard (Madrone), the planting plan was updated to consider the change in area.

FIGURE 6: MAP OF HAYFIELD PLANTING LOCATION WITH MNC PROPERTY LINE AND PLANT STORAGE AREA.

6.3.2 Methods

See Appendix G, Table 1 for full overview of methods suggested by Madrone and work completed by SMWS.

Site prep began the first week of May 2023 and planting commenced on May 4th, large posts delineating the planting area were installed and planting began on the southern section of the Hayfield. Yellow flag iris (*Iris pseudacorus*) was present on site, see figure 6, and some removal was done, however, this proved futile due to the amount that was present, reed canary grass (*Phalaris canariensis*) was also present on site, particularly in the northern section, this was mowed down to allow for easier access. Plants were planted one plant per square meter which follows the riparian restoration rule of thumb (DNV, date unknown), and suggestions from Greg Howard, where vegetation was already established, new plants were planted one meter away. Based on suggestions in the Madrone report and requests from the Farmer, a planting zone system was established: shorter, drought resistant shrubs and trees were planted closest to the hayfield (zone 1), tall trees were planted in the middle (zone 2) and shorter wetland plants were planted along the bank (zone 3), see figure 7.

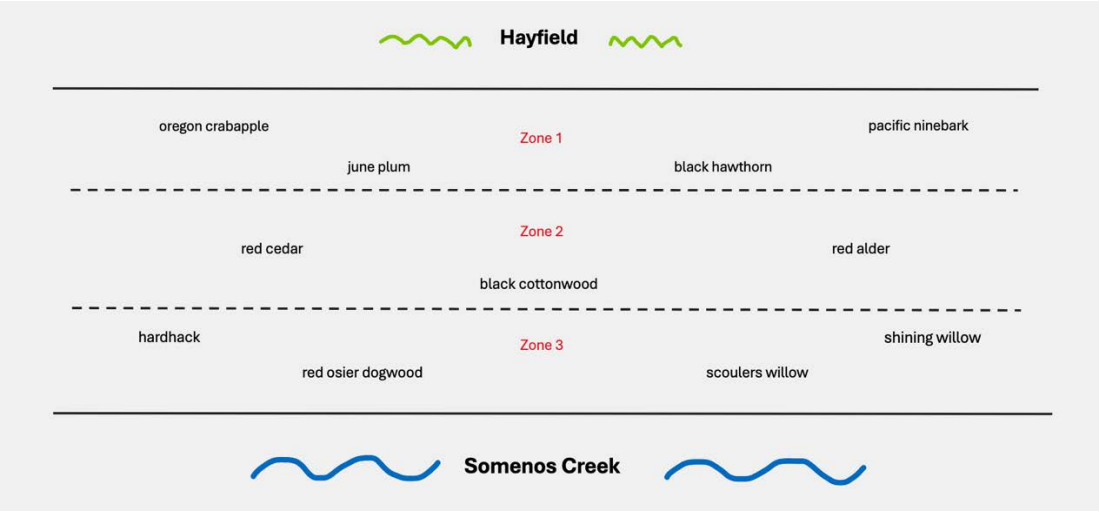


FIGURE 7: GRAPHIC SHOWING ZONES OF RIPARIAN PLANTING AT HAYFIELD ON SOMENOS CREEK.

In total 588 plants were planted see Appendix G, Table 1 and 3 for full plant list, most of the planting was completed by volunteers, some by SMWS staff, see Table 2. Plants were planted in accordance with the Madrone reports recommendations: appropriately sized holes were dug, the nutrient 'tea bags' were placed at the bottom of the hole, plants were removed from pots and root balls loosened then placed in the holes, ensuring that the base of the plant was flush with the surrounding ground. The holes were then filled in with the previously removed soil and compressed to ensure no air pockets remained. Once planted the plants were watered until the soil around each plant was saturated. One to two times a week, newly planted plants were watered alongside the plants that were not yet planted. Planting continued for 8 weeks and completed on June 22nd. Watering continued throughout the dry season on this site, one to three times a week depending on the weather (Appendix G, Table 2).

Initial monitoring for survival rates was done in late August, then again in mid-November to determine preliminary results, both times obstacles were encountered: vegetation coverage in August made it difficult to locate the plants, and lack of foliage in November made it difficult to identify them. A more comprehensive inventory of the plants will take place in the spring of 2024. Initial monitoring results showed some browsing from unknown animals, and pear slugs (*Caliroa cerasi*) on some of the hawthorns and crabapples. The browsing was mainly focused on the taller trees (red alder, black cottonwood, and red cedar), to curtail future browsing, caging was set around select trees, a potential control solution for the pear slugs is sprinkling wood ash/potash over the trees. It was also noted that the June plum had extremely low survival rates, this will be confirmed during the next monitoring event and taken into account when ordering plants for the next phase of this riparian planting project in 2024.

6.3.3 Results

The outcome of the Somenos Creek Restoration work at the hayfield includes the following:

- 75m^2 of invasives removed, including some yellow flag iris and reed canary grass.
- 190 volunteer hours.
- 588 native plants planted.
- 876m^2 restored.

6.4 West of Lakes Road

6.4.1 Purpose

This section of riparian area along Somenos Creek is one SMWS has worked on before, however none of the trees had survived and the Himalayan blackberry present on site had taken over the area once again, this is most likely due to lack of staffing time and funding to maintain the area. This area is devoid of any native vegetation and therefore SMWS has been eager to try and revegetate it with native trees and shrubs. This will in turn shade Somenos Creek and reduce parrot's feather coverage within the creek in this section. Initial visits to the site in the winter showed heavy Himalayan blackberry and field bindweed (*Convolvulus arvensis*) coverage, and trees previously planted being smothered (Photo's 14 & 15). Site visits in the spring after some blackberry removal showed native trees had not survived. After consulting the MNC, it was decided that left-over trees from the hayfield planting would replace the dead ones at this location.

Photo 14: Image of planting area looking east, before invasive removal.

Photo 15: Image of planting area looking east, after invasive removal.

6.4.2 Methods

After an initial site visit on March 1st, 2023, invasive removal began on March 2nd, with three clearing events 274m^2 of Himalayan blackberries and field bindweed were removed (Photo's 14 & 15). The site was then left for the spring to allow any remaining alive trees to grow as survival rates were not determinable before spring regrowth. On July 26th another site visit was completed, it was noted that none of the native trees had survived, and the invasive plants had somewhat regrown. From July 26th till August 31st the invasive plants were removed, the removal mostly focused on getting the blackberry roots out to ensure a better success rate, totaling about 100m^2 (photo's 16 & 17), then 64 native trees and shrubs were planted, see Appendix G, Table 4 for full list. Mulch was also spread around the base of the planted trees to ensure the soil was protected after having all vegetation removed. Planting methods followed those used at the hayfield, described in Section 6.3.2. Watering occurred one to three times a week during the dry season.

6.4.3 Results

The outcome of the restoration work at the west side of lakes Road location on Somenos Creek includes the following:

- 374m^2 invasives were removed.
- 89.75 volunteer hours.
- 64 native plants planted.
- 274m^2 restored.

Photo 16: Image of planting area, looking east before summer invasive removal and planting.

Photo 17: Image of planting area, looking east after summer invasive removal, planting and mulch spreading.

6.5 Municipality Right of Way and Haycroft Chase Strata Property

6.5.1 Purpose

In 2022 SMWS gained permission from the MNC as well as the Haycroft Chase Strata to complete invasive removal and riparian planting to increase the riparian area's function and to shade out parrot's feather in Somenos Creek. Work was completed by early summer of 2022 and maintenance of the site continued till the end of August, however, warm dry weather continued well into October, and due to a lack of resources, watering was ceased in August. It was noted in the 2022 NCSA final report that this may lead to lower survivability rates (see NCSA Final Report 2022). Some sections did show high mortality rates, and therefore SMWS replaced the dead trees in the summer and fall of 2023.

6.5.2 Methods

Monitoring of the site in the spring and summer of 2023 indicated that survivability rates were low, most of the willows and red alders planted in the drier, more rocky section of the bank did not survive, however, hardhack, sitka spruce and red osier dogwood were still growing well, it was also noted that the Himalayan blackberries had encroached once again into the planting area. After consulting the MNC, on August 7th, 39 plants left over from the hayfield planting were used to replace the dead willows and red alders, (see Appendix G, Table 5). Additionally, on November 30th invasive removal was completed, 30m^2 Himalayan blackberries were removed and 10 plants purchased from Streamside were planted to fill in a few gaps. Planting methods followed those used at the hayfield, described in Section 6.3.2, and watering of the site occurred through the dry season, one to three times a week depending on the weather.

Photo 18: Image of strata planting area looking north from the Lakes Road footbridge.

Photo 19: Image of sitka spruce near the edge of Somenos Creek at the strata.

6.5.3 Results

The outcome of the restoration work at the Haycroft Chase Strata and MNC property on Somenos Creek includes the following:

- 30m^2 invasive plants removed.
- 24 volunteer hours.
- 49 native plants planted.

6.6 North Side of Somenos Creek along Municipal Park

6.6.1 Purpose

Restoration planting was completed historically in this section of the riparian area along Somenos Creek by SMWS to increase riparian area function and to shade out parrot's feather, the planting was mostly successful with many of the trees upwards of 15 ft tall but after some rudimentary monitoring in the summer of 2023 some gaps in the riparian foliage were noted. Plants purchased from Streamside Native Plants were used to fill in the gaps.

Photo 20: Image looking south over Somenos Creek at a western hemlock that was planted in December.

Photo 21: Image looking south over Somenos Creek and a sitka spruce SMWS planted.

6.6.2 Methods

After initial site visits in the summer and fall of 2023, locations where riparian vegetation had not fully established itself were noted and plants were ordered from Streamside Native Plants on November 28th, 52 trees were then planted on December 7th, (see Appendix G, Table 6 for full list of plants) with help from the Cowichan Secondary School's Environmental Stewardship Program. Planting methods followed those used at the hayfield, described in Section 6.3.2, no watering occurred as the plants were planted during the wet season and the ground was already saturated.

6.6.3 Results

The outcome of the restoration work on the north side of Somenos Creek along the municipal park includes the following:

- 52 native trees planted.
- 56 volunteer hours.

6.7 Conclusion

The riparian restoration projects undertaken by SMWS in 2023 focused entirely on improving riparian area function by planting tall shrubs and trees in order to shade the creek and reduce parrot's feather growth. Three of the four sites were previously planted sites which needed maintenance, the one new site, at the hayfield is phase one of two-year project which will continue in 2024. The areas that were planted were chosen due to their lack of tall riparian vegetative cover and their potential for future shading of Somenos Creek. Over the 2023 planting season, SMWS removed 479m^2 of invasive plants to prep riparian areas, planted 805 native plants and restored 1,150m^2 of riparian area, all this work was completed largely with the help from our wonderful community of volunteers through 357.75 volunteer hours. Moving

forward into 2024, in addition to continuing the riparian planting project south of the hayfield the Society will have two main areas of focus:

1) Monitoring:
    a. Monitor survival rates of planted trees in early spring, and late summer at all project sites completed in 2023 and select previous years projects.
    b. The Society will also monitor browsing activities by animals or presence of other pests and respond where necessary, for example: caging, spray on deterrent or potash.
2) Maintenance:
    a. Some replacement trees have been purchased for the hayfield planting location based on the preliminary monitoring done in the summer and fall of 2023. They will be planted once the field is no longer flooded.
    b. Early spring trimming of invasive reed canary grass will be required to complete the spring monitoring to identify where the trees are planted and survival success.
    c. After the initial spring monitoring is completed in 2024 of all sites, more replacement plants will be purchased and planted if needed.
    d. Watering will commence on all sites planted in 2023 once the dry season begins in 2024 and will continue one to three times a week, weather dependent until the dry season ends.

7 APPENDIX A – WATER QUALITY RESULTS FOR SOMENOS LAKE

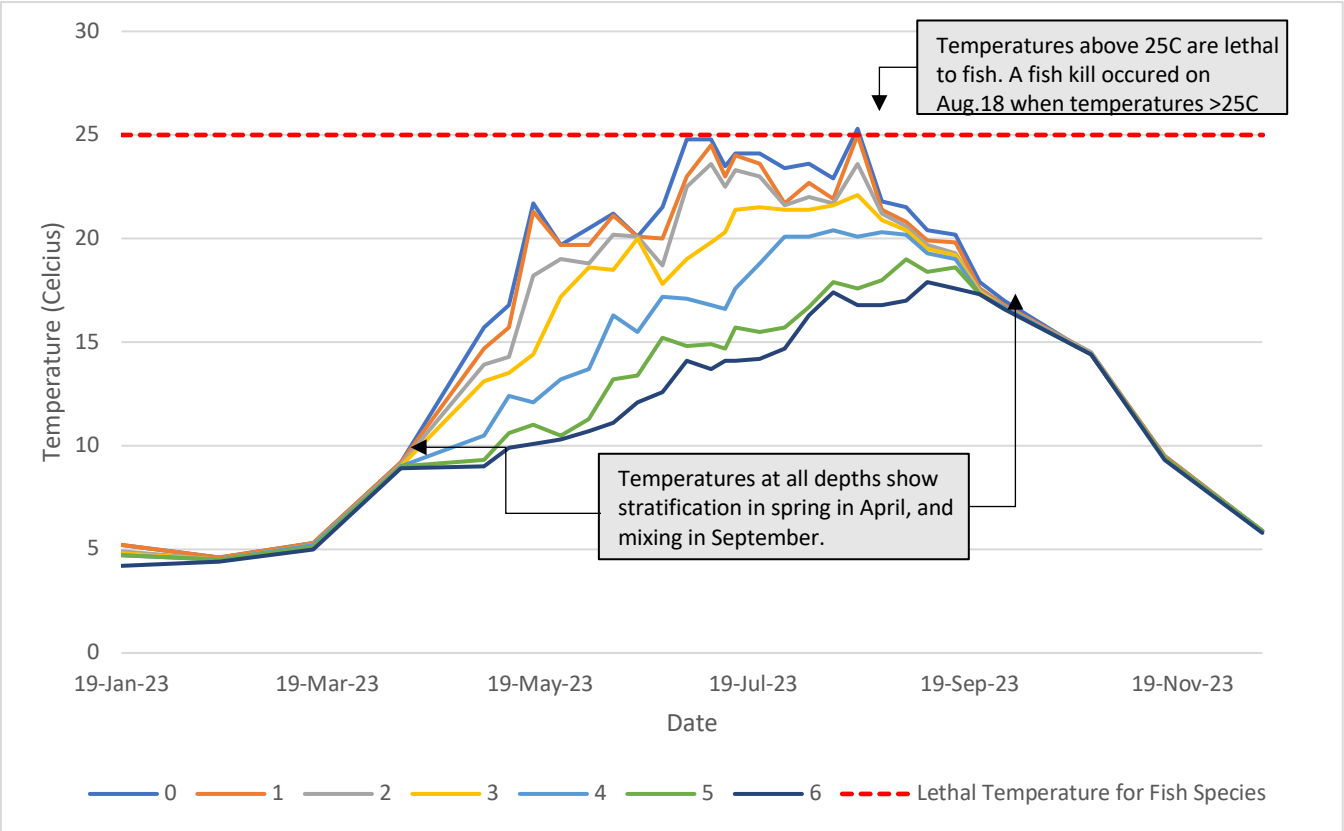
The weekly, monthly measurements of dissolved oxygen (DO), temperature, conductivity profiles are represented in Charts 1 to 5. The monthly nutrient sampling of total phosphate, ammonia (and pH), nitrate, nitrite, total nitrogen is shown in Chart 6-12. Lake depths and hourly temperature data logger recordings are shown in Charts 13-14.

TEMPERATURE AND DISSOLVED OXYGEN IN SOMENOS LAKE

Dissolved oxygen levels and temperatures are important to monitor as an indicator of biological activities, lake stratification and fish habitat. Thus, looking at these two parameters will help us understand the biological activity in the lake and if fish are able to inhabit the lake at certain times of the year.

Dissolved oxygen and temperatures indicated that stratification occurred in early April and turned over by late September (Chart 1 and 2). Interestingly, in late September when mixing occurred, dissolved oxygen dropped dramatically throughout the lake. This likely occurred when the anoxic conditions at the bottom of the lake mixed with the top layers, and created low oxygen environment throughout. This low oxygen event didn't last long and by October the lake oxygen levels normalized as fall rains and cool temperatures began.

Chart 1 Somenos Lake Temperature Profile from the surface to 6 m depth, 2023.



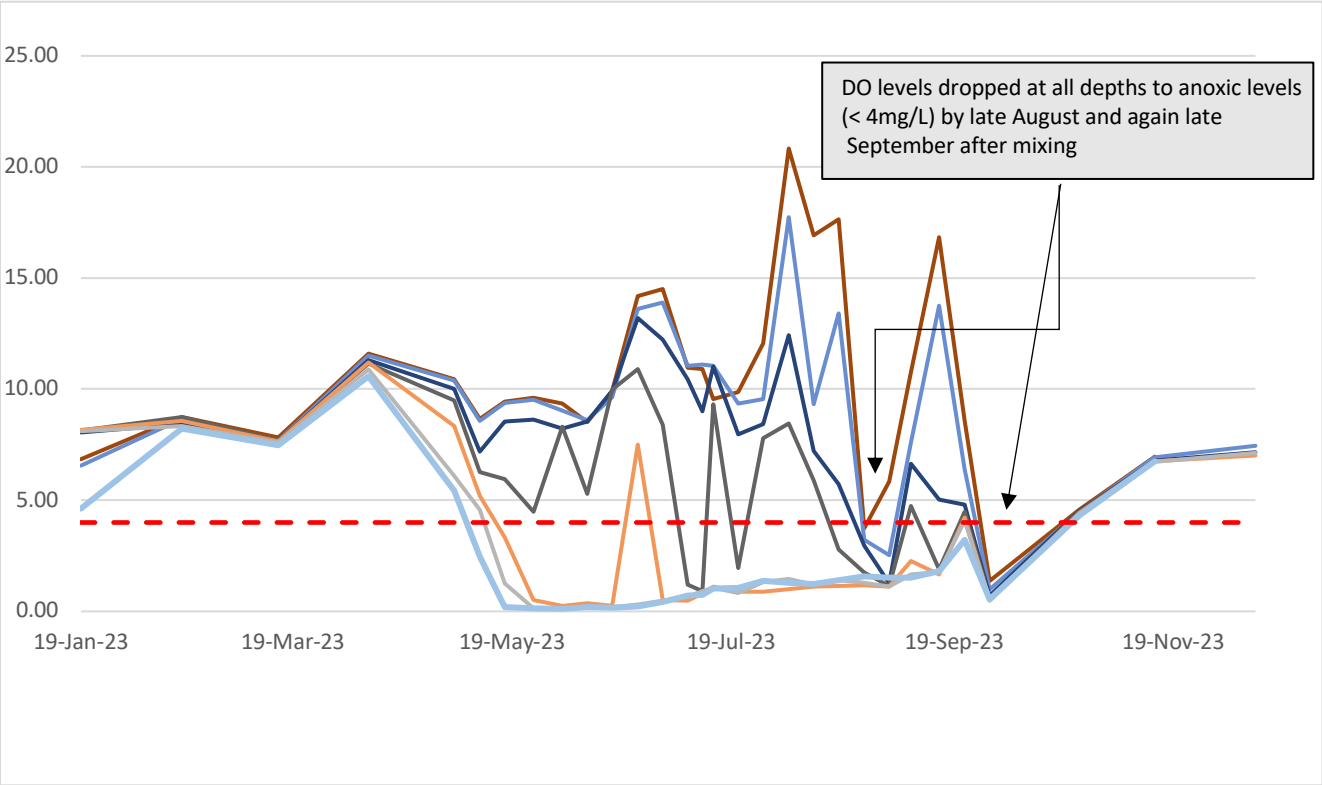
One main importance of lake stratification observations is to determine where pockets of adequate temperature and dissolved oxygen levels exist in the lake, allowing fish to survive. Salmonids are known to use Somenos Lake as a migratory pathway and a refuge; however, fish kills have occurred in the past due to summer anoxic conditions. Their dissolved oxygen thresholds range from: anoxia 0-4 mg/L; hypoxia 4.1-7 mg/L, sub-optimal 7.1-10 mg/L and optimal oxygen above 10 mg/L (Davis 1975). Salmonids consistently avoid concentrations below 6mg/L (Carter 2005).

Dissolved oxygen levels in Somenos Lake were lower in the summer (except the first few meters at the surface) and somewhat recovered in the fall with a lake turn-over occurring in September. Specifically, dissolved oxygen was anoxic-hypoxic below 3 m depth starting late May just after stratification, with some variability of oxygen at 3m throughout the summer. By August 25 the entire water column dropped < 4mg/L, then recovered above 2m early September to >6mg/L. By September 29, at the time of mixing, for about a month, conditions returned to anoxic at all depths until October 24, then recovered (Chart 2).

During the summer, when oxygen was sufficient for salmonid species survival from the surface to 3meters, the temperatures averaged from 20 to 23°C, exceeding optimum temperatures for most salmonids at any life stage (Carter 2005; BCMOE 2001) (Table 1). Some salmonids even avoid temperatures above 15.6°C (Table 1, BCMOE 2001). So when oxygen was good for salmonids (near the surface) the temperatures were too high, and where temperatures were tolerable deeper in the lake (cooler), the oxygen was too low (Chart 2). This makes the lake uninhabitable in the summer for salmonids.

These conditions could have caused the fish kill observed on August 18th, 2023. The majority of the dead fish were observed floating along the shoreline of the lake. It is assumed that overnight, there was enough of a reduction of algae photosynthesis to reduce oxygen to cause a fish kill. That in addition to warm temperatures around that time (>25C) during the day, and shallow depths, the fish may not have been able to escape this anoxic zone. Chart 2 shows that oxygen reduced to below 4mg/L in all layers of the lake around this time and Chart 1 shows that temperatures were extremely high on the surface.

Chart 2: Somenos Lake Water Quality Profile of Dissolved Oxygen, 2023



CONDUCTIVITY AND TDS IN SOMENOS LAKE

Conductivity and TDS have a correlated relationship and is linked to changes in temperatures. (EMS 2019). As such, an increase in temperature will dissolve minerals (creating total dissolved solids) mobilize ions, and thus increase conductivity (EMS 2019). That is why in the warmer months as temperatures within the water column heat up, the TDS and conductivity increases at the bottom of the lake where it is in contact with the sediment. Charts 3 and 4 show similar results of these two parameters.

Due to its direct relationship to temperature, conductivity and TDS can be another way to see when mixing and stratification occurs in the lake. Charts 3 and 4 show similar timing with temperature for stratification in spring and turn over in fall. One mixing event may have occurred in the summer on July 7th as shown as a sharp decline on that date.

Chart 3: Somenos Lake Monthly Conductivity Depth Profile, 2023

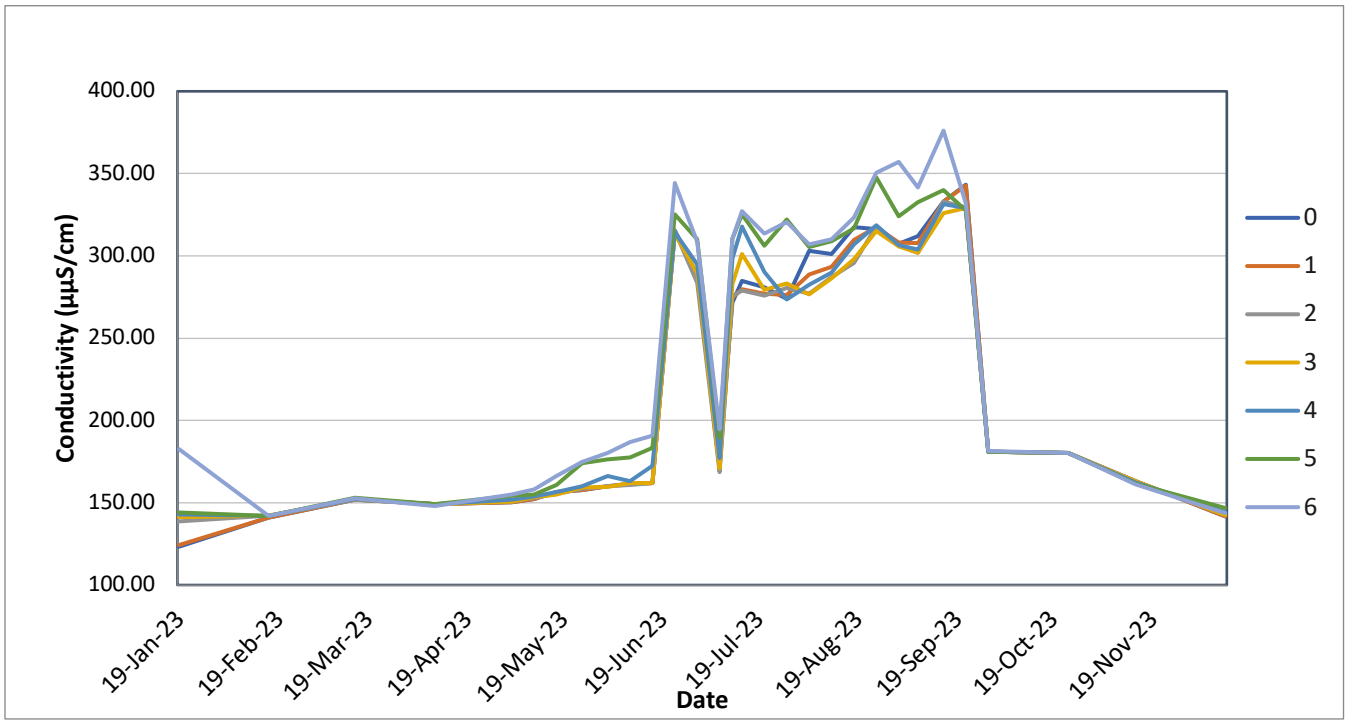
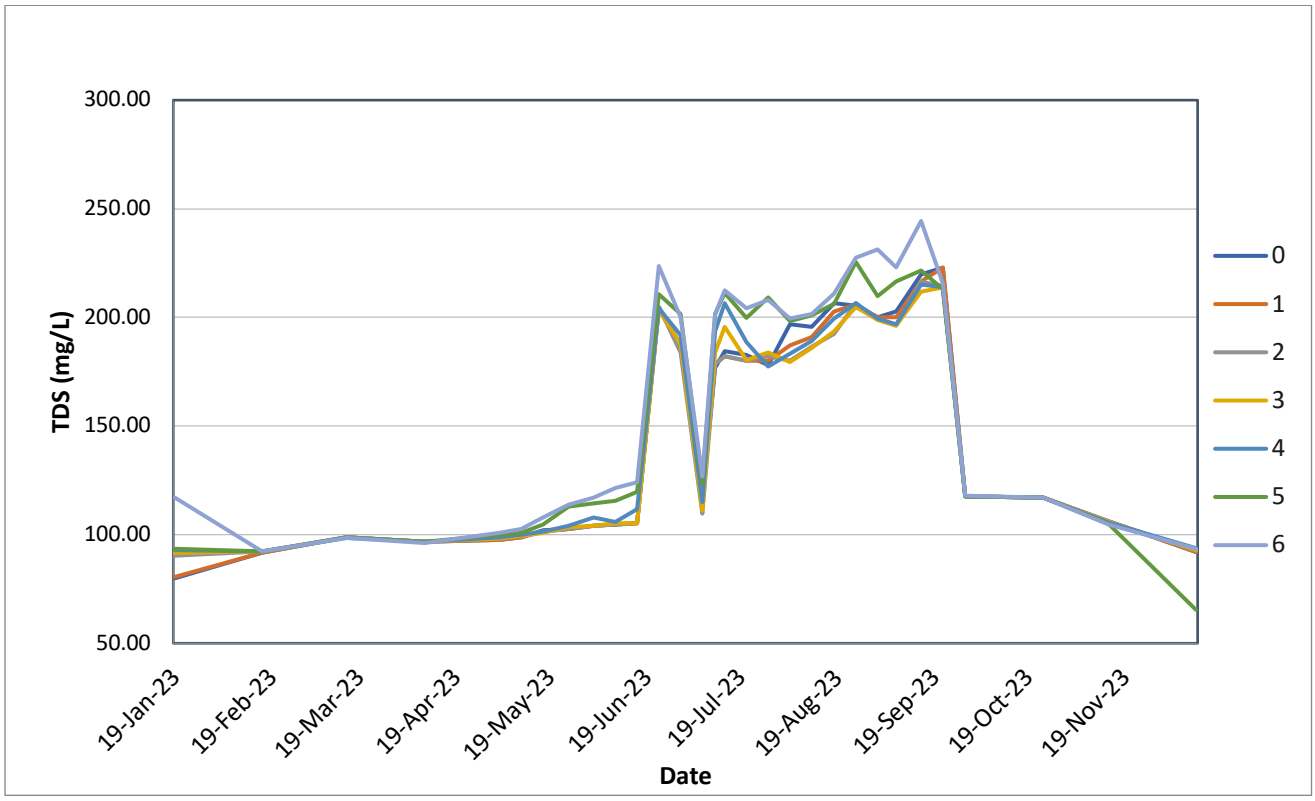


Chart 4: Somenos Lake Monthly Total Dissolved Solids Depth Profiles, 2023



NUTRIENTS IN SOMENOS LAKE

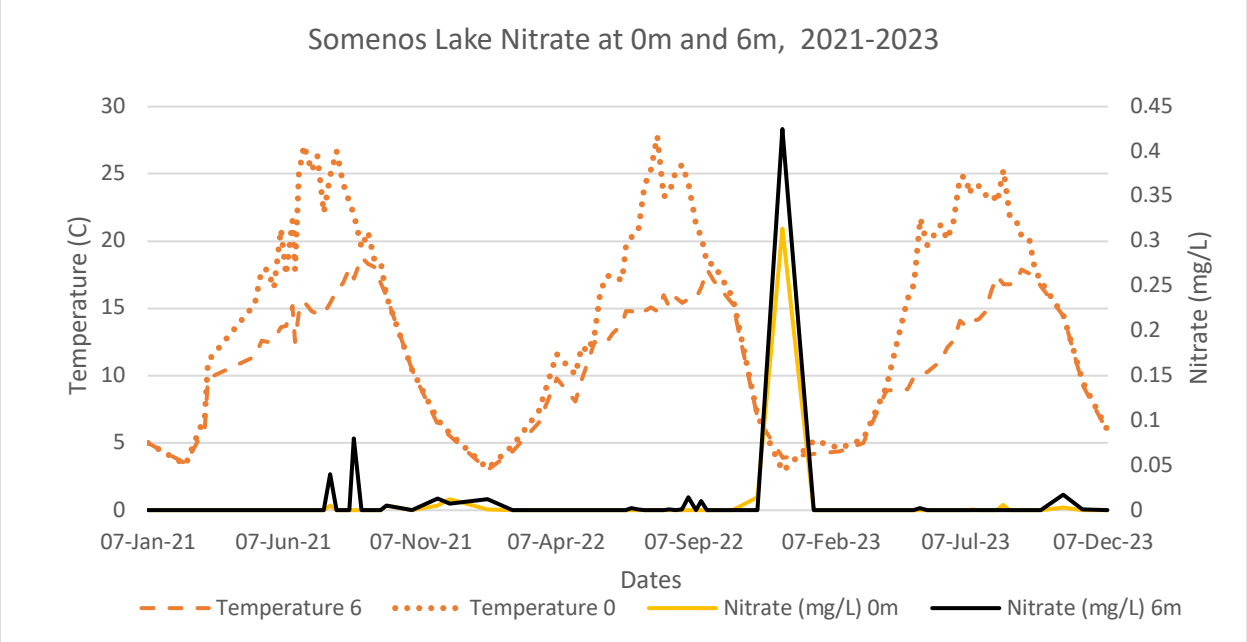
Somenos Lake is known as a eutrophic lake due to its enrichment of nutrients. As part of the monitoring program the nutrients studied were nitrate, ammonia, nitrite, and phosphate. These nutrients accumulate in the lake and have the potential to increase growth of aquatic plants and algae, which can deplete oxygen levels.

NITRATE IN SOMENOS LAKE

Nitrate levels in 2023 do not exceed BCMOE (2023) guidelines for aquatic life at the top or bottom of the lake for acute (32.8 mg/L) or chronic exposures (3 mg/L) (Chart 5). Nitrate levels are the lowest until after the peak summer temperatures on the surface, showing it was likely consumed first by algae and other microbes. The small spike in late fall have more to do with a drop in temperature, a die off and settling of organisms that used Nitrate to grow over the summer. In addition, farming best practices for fall nutrient loading on fields are to have a manure application on before the end of September. After this time, the rains begin and, in some cases, may come early and cause runoff of nitrogen rich material to occur. This can also be attributed to any increase in nitrogen in fall.

The cause of the spike in Nitrate in early winter of 2023 is unknown but likely is due to a slow start to the rainy season in fall of 2022, keeping precipitation and flows low until January of 2023.

Chart 5: Somenos Lake Nitrate (NO_3) and Temperature Levels at the surface and bottom, 2021-2023

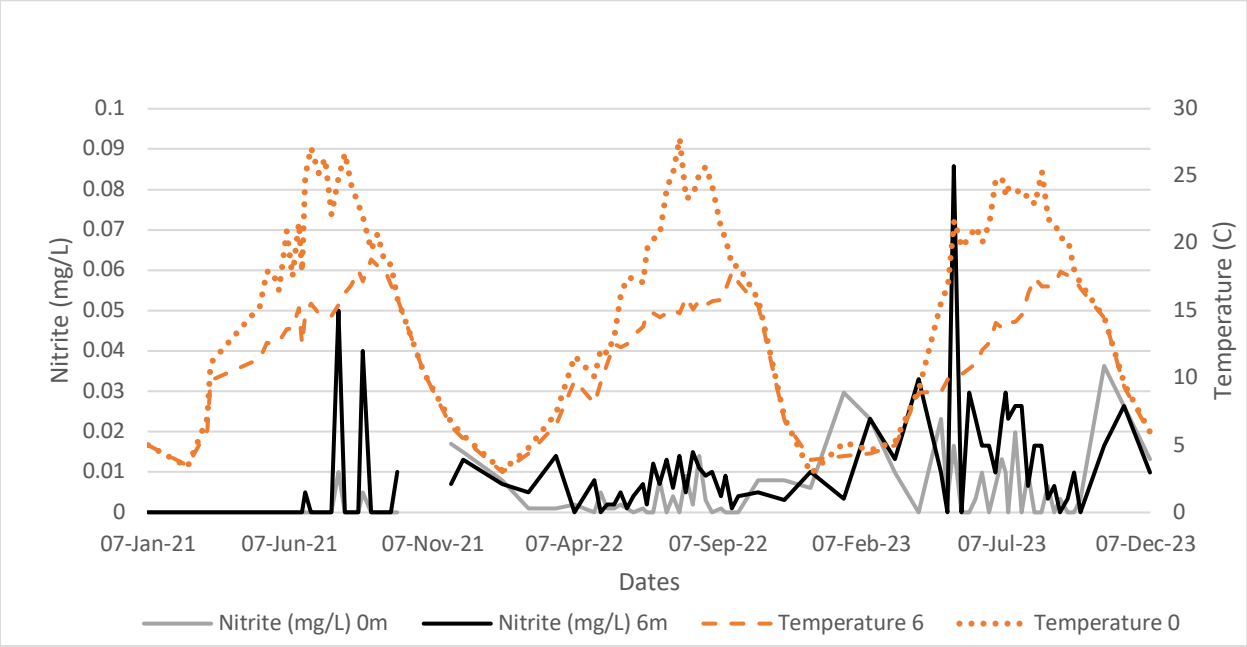


NITRITE IN SOMENOS LAKE

Nitrite levels in 2023 exceeded BCMOE (2023) guidelines at the top and bottom of the lake periodically in the summer of 2021 and throughout the year in 2023 at chronic (0.02 mg/L) exposures. Only May 17, 2023 was nitrite recorded at acute (0.06 mg/L) levels at 6m (Chart 6).

A rise in nitrite levels at surface and at the bottom directly correlates with a rise in temperature. This can be observed when temperatures rise in the summer at the surface and peak in the fall at the bottom of the lake. This can be seen over 3 years in Chart 6, however, in 2022 the fall rise in nitrite didn't occur until later in January. This could be due to a slow start to the rainy season, keeping flows low until January of 2023. As water temperatures increase in spring, spike in Nitrite is released from the sediment as seen at the start of April, 2023 and as temperatures decline, and biological activities, so does the Nitrite in the water column in late fall.

Chart 6: Somenos Lake Nitrite (NO_2) and Temperature at the Surface and Bottom, 2021-2023

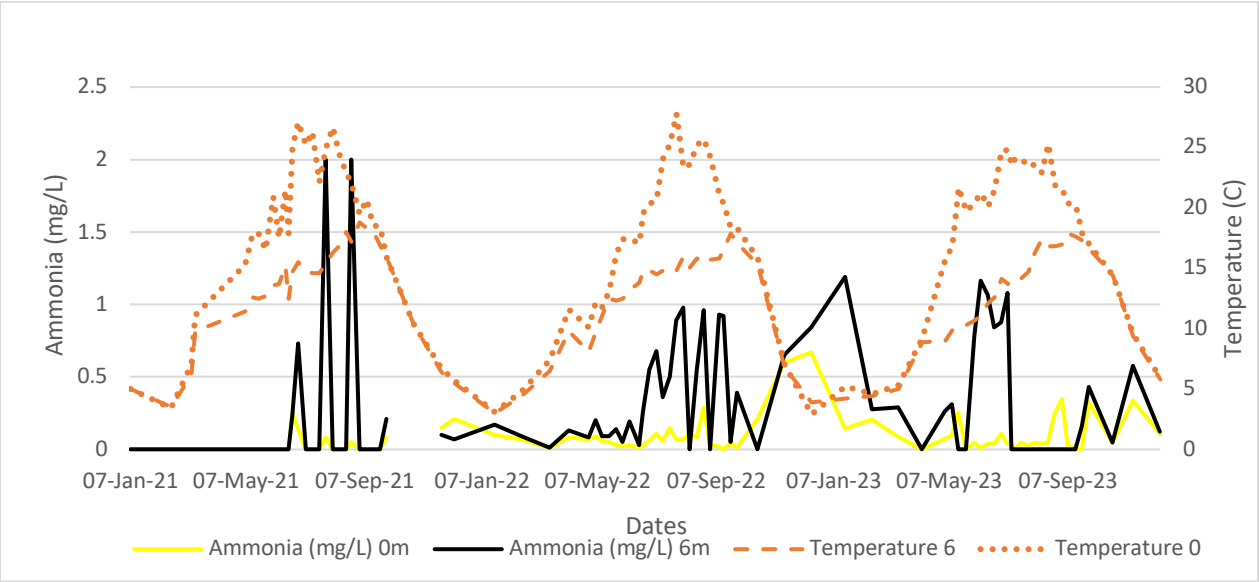


AMMONIA IN SOMENOS LAKE

Ammonia is an important compound to measure because it is principally used in the production of nitrogenous fertilizers (CCME 2010), and the Somenos watershed is abundant in agriculture activities. Ammonia is also an important component of the nitrogen cycle and because it is oxidized in the environment by microorganisms (i.e., nitrification), it is a large source of available nitrogen in the environment (CCME 2010).

Chart 7 shows the ammonia levels at 1m and 6m lake depths, and how they correlate with temperature. In general, in the summer as temperatures rise on the surface, ammonia does as well. The same happens when temperatures peak at the bottom of the lake in fall, ammonia spikes again as it is released from the sediment. This can be seen over 3 years in Chart 7.

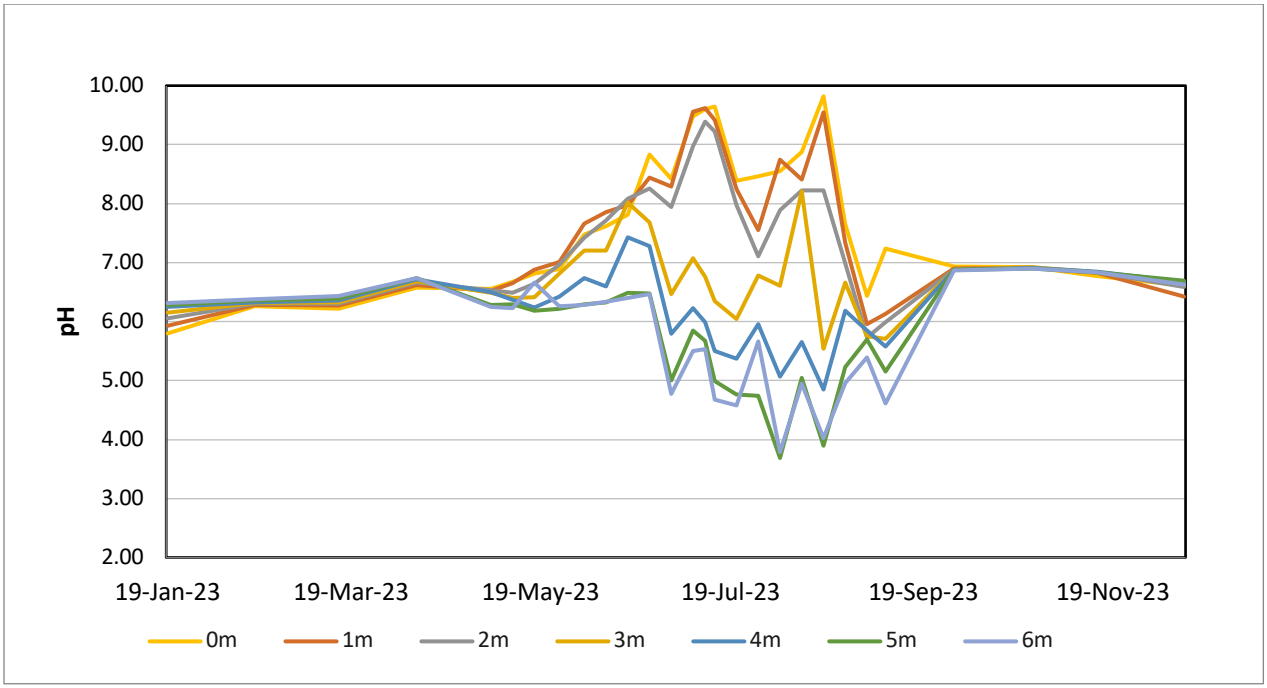
Chart 7: Somenos Lake Ammonia Levels with Temperature at the Lake surface and bottom, 2021-2023



PH IN SOMENOS LAKE

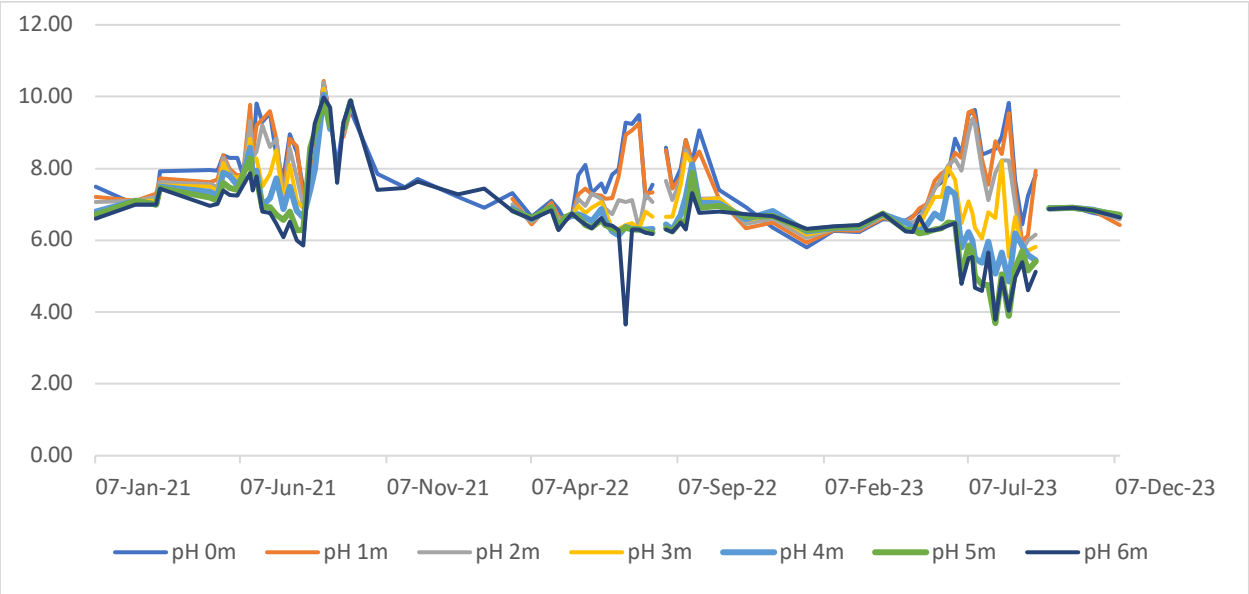
Chart 8 shows the pH depth profile in 2023, and Chart 9 over 3 years at the surface of the lake to 6 meters depth.

Chart 8: Somenos Lake pH Levels (0-6m depth profile), 2023



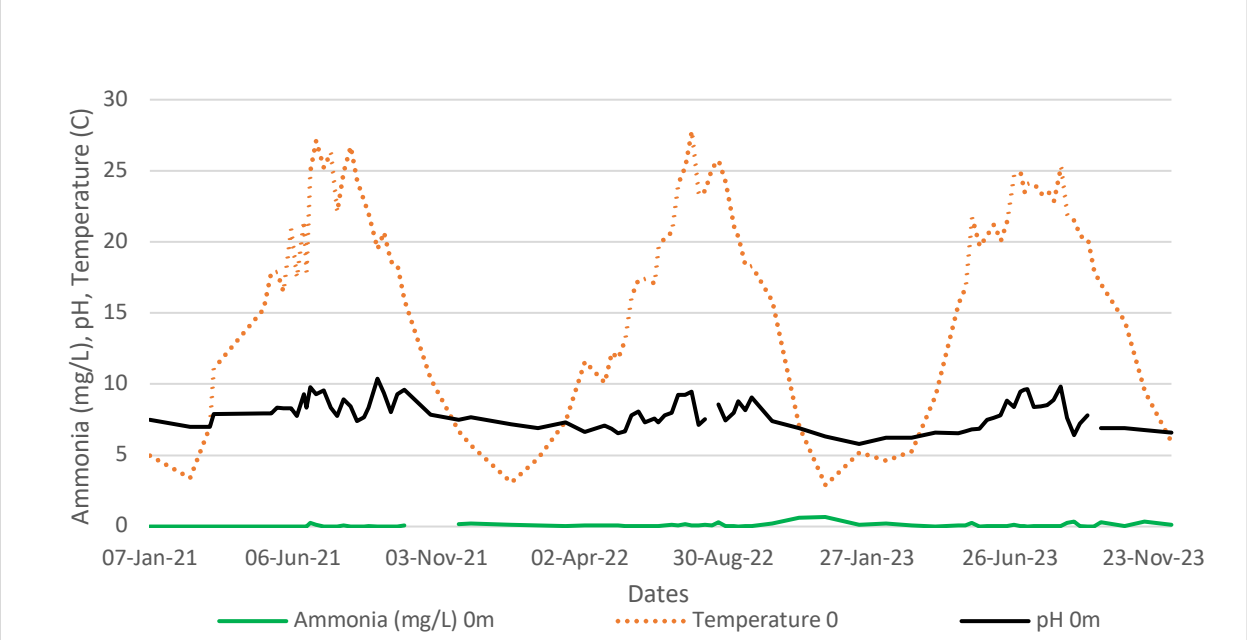
Similar pH results are observed in 2021 to 2023 showing an increase in acidification at the deepest depths, and high alkalinity at the surface in summer (Chart 9).

Chart 9: Somenos Lake pH YSI Profile Levels, 2021-2023



A major factor to consider when monitoring pH is that ammonia toxicity increases with more alkaline water, which occurs on the surface in summer. In the summer at the lake surface, when pH was between 8-9, ammonia levels did not exceed guidelines (1.94 mg/L BCMOE, 2023) (Chart 10). Thankfully where alkalinity is high at the surface, the concentrations of ammonia were low, which is likely due to high algae activity (blooms) in the epilimnion in summer (Chart 10).

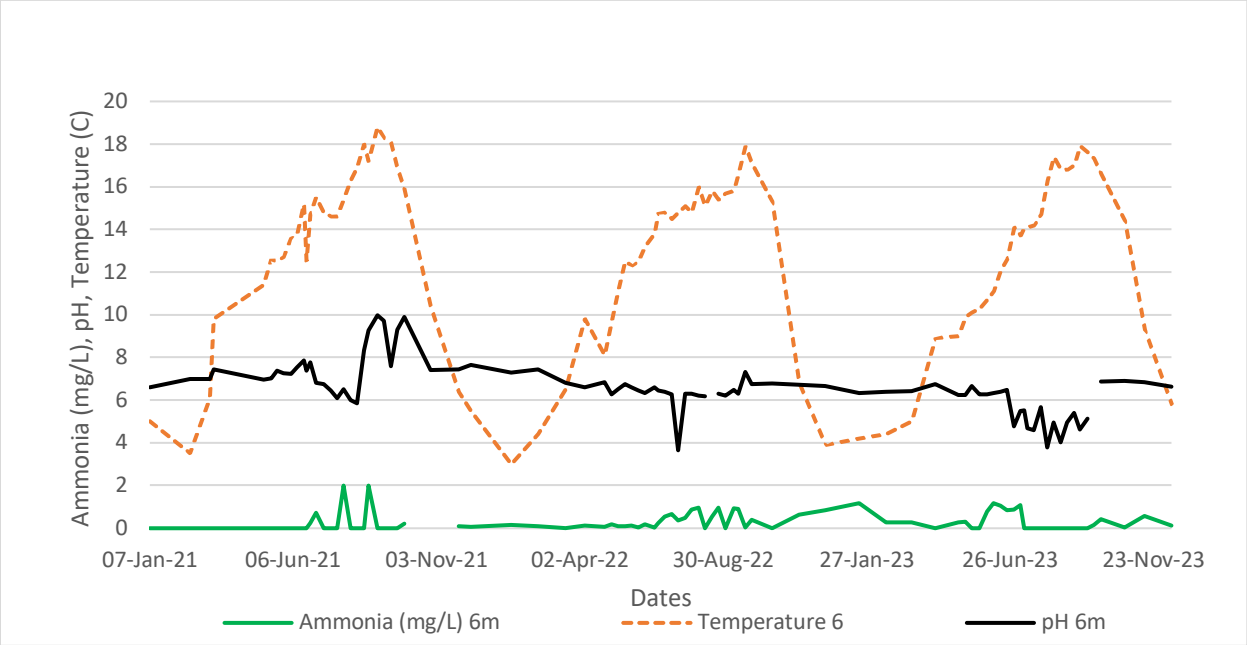
Chart 10: Somenos Lake pH, Temperature (C), and Ammonia Surface Levels, 2021-2023



Conversely, at the lake bottom the pH is low (more acidic), which can reduce ammonia's toxicity. This is seen at 6 m depths (Chart 11) in summer when pH decreased to a range of 3.8-6, and ammonia guidelines were not exceeded (approximately 1.81 mg/L, BCMOE, 2023) in 2023. However, in 2021 there

may have been an exceedance of ammonia (2mg/L) late August, when temperatures peaked at 6m, and pH was alkaline. At this high alkalinity exceedance limits would be ~ 1.97mg/L. Due to this, in late summer early fall during peak bottom temperatures turn-over will be closely monitored for future exceedences.

Chart 11: Somenos Lake pH, Temperature (C), and Ammonia Bottom (6m) Levels, 2021-2023



PHOSPHATE IN SOMENOS LAKE

Phosphate is important nutrient in the growth of aquatic plants and organisms. Excessive levels of phosphate can cause further degradation of conditions in eutrophic lakes (CCME 2004). Chart 12 shows the phosphate levels from 2021- 2023 at the surface and bottom of the lake.

Chart 12: Somenos Lake total phosphate at the surface and bottom from 2021-2023

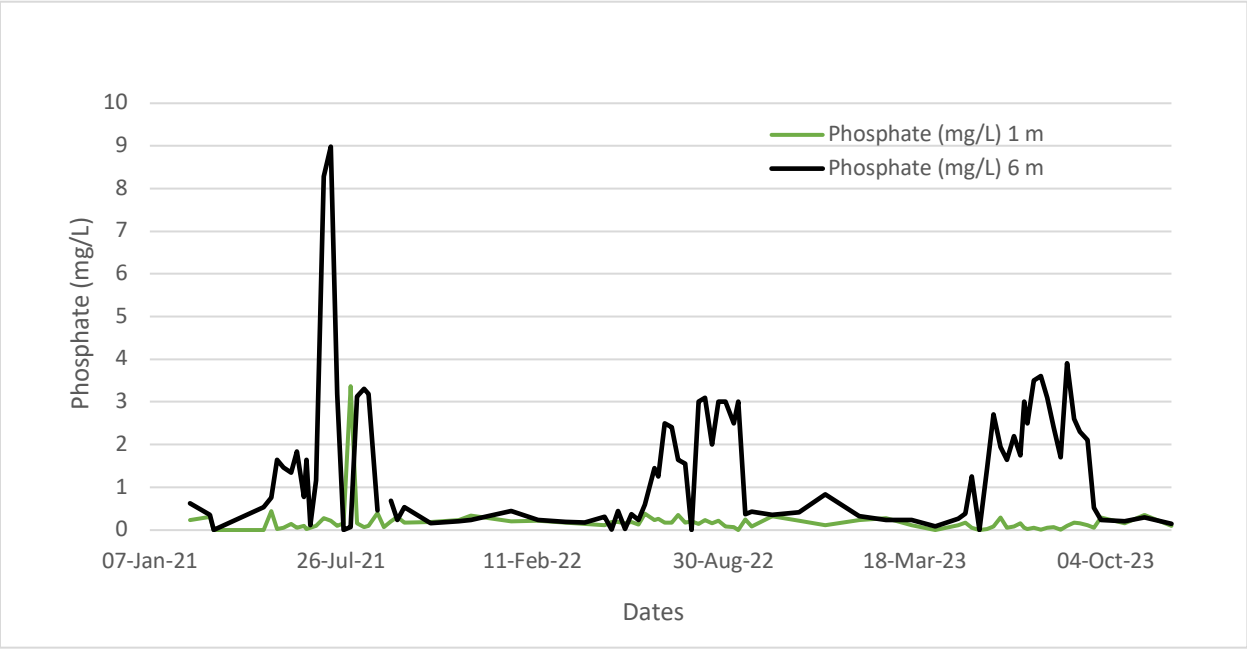
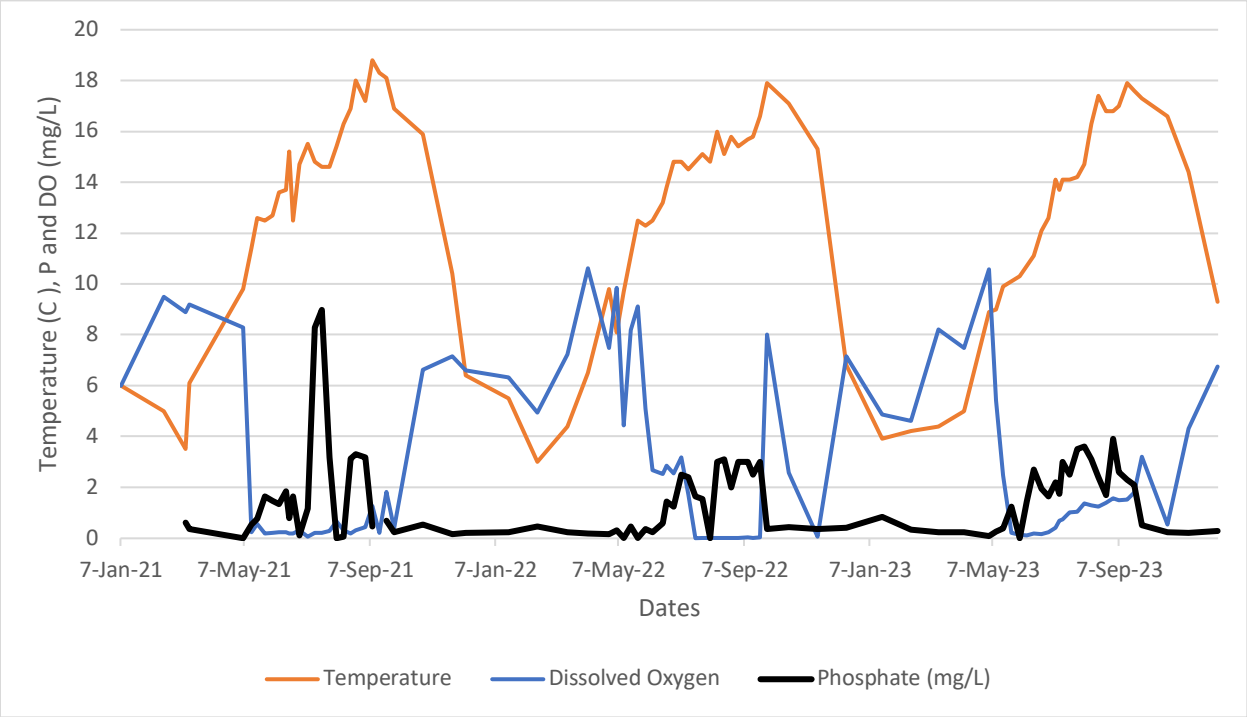


Chart 13 shows the relationship of phosphate with temperature and dissolved oxygen levels at the bottom of the lake. It is consistently observed that phosphate is released from the bottom of the lake when dissolved oxygen declines as summer approaches and temperatures rise. As fall approaches, temperature and phosphate levels drop, and dissolved oxygen recovers.

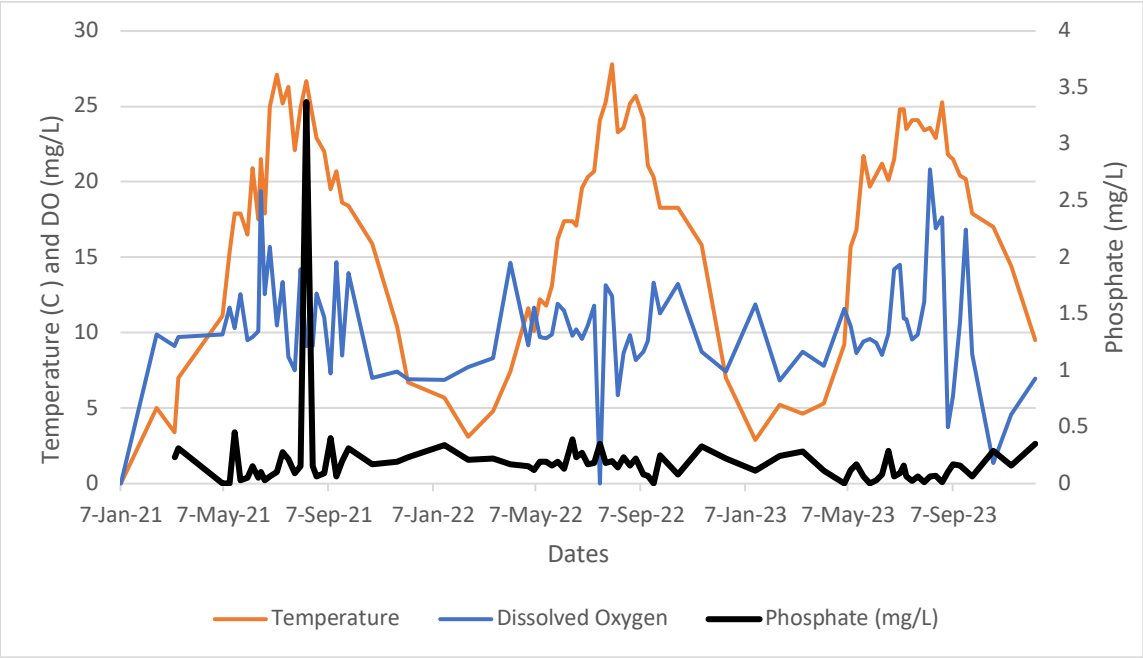
It is a complicated system, but to keep in general terms, increased temperatures and light in spring/summer will initiate aquatic plant growth and microorganism activity. This can use up the oxygen during the growing season, which is why we see a decline. Phosphate accumulated in the sediment will be released during low oxygen conditions which we see in Chart 13 (Schindler and Vallentyne 2008). It is likely, dissolved oxygen began to sharply rise by late-September due to algae, plant die-off (Schindler and Vallentyne 2008).

Chart 13: Somenos Lake total phosphate, temperature and dissolved oxygen at the bottom from 2021-2023



Phosphate is low at the surface as it is used up by the algae blooms, which produce more oxygen at the surface as seen in Chart 14. This can be also seen as phosphate consistently declines when oxygen is produced at the surface, suggesting it is used for energy by the surface algae and micro-organisms.

Chart 14: Somenos Lake total phosphate, temperature and dissolved oxygen at the surface, 2021-2023



SOMENOS LAKE PHYTOPLANKTON COMMUNITY

The phytoplankton community sampling in the summer of 2023 revealed a high amount of blue-green algae present in Somenos Lake (Chart 15). When we look closer at when these communities thrived, blue- green algae is the dominate phytoplankton community in summer. This corresponds with field observations of green-pea soup on the surface in July and August. There is also a notably large population of green algae that blooms during the hot months of July, however only secondary to the blue-green algae. After the blue-greens die off in September, Cryptomonads dominate the community profile (Table 1, Chart 16). Due to the high recreational use of the area the high blue-green algae is a concern since some species produce toxins that can kill wildlife and may be harmful to humans.

Table 1: Somenos Lake Total Phytoplankton Community Abundance by Taxon, 2023.

Taxon	**June 16**	**June 30**	**July 14**	**July 28**	**August 11**	**August 25**	**September 7**	**September 22**	***Grande Total Biovolume (µL/L)***
Total Diatoms	2.19	-	-	-	-	0.15	0.14	0.14	2.61
Total Green Algae	0.66	-	1.83	2.89	0.09	0.03	0.51	0.25	6.26
Total Cryptomonads	0.01	0.05	-	-	0.34	0.12	20.12	20.32	40.95
Total Euglenoids	-	0.40	-	-	0.13	0.02	-	-	0.55
Total Blue-green Algae	4.88	19.94	2.68	6.57	19.74	9.15	-	0.28	63.24
Total Dinoflagellates	-	-	-	-	-	-	0.16	0.40	0.56

Chart 15: Somenos Lake total Phytoplankton Community Abundance by Taxon, 2023

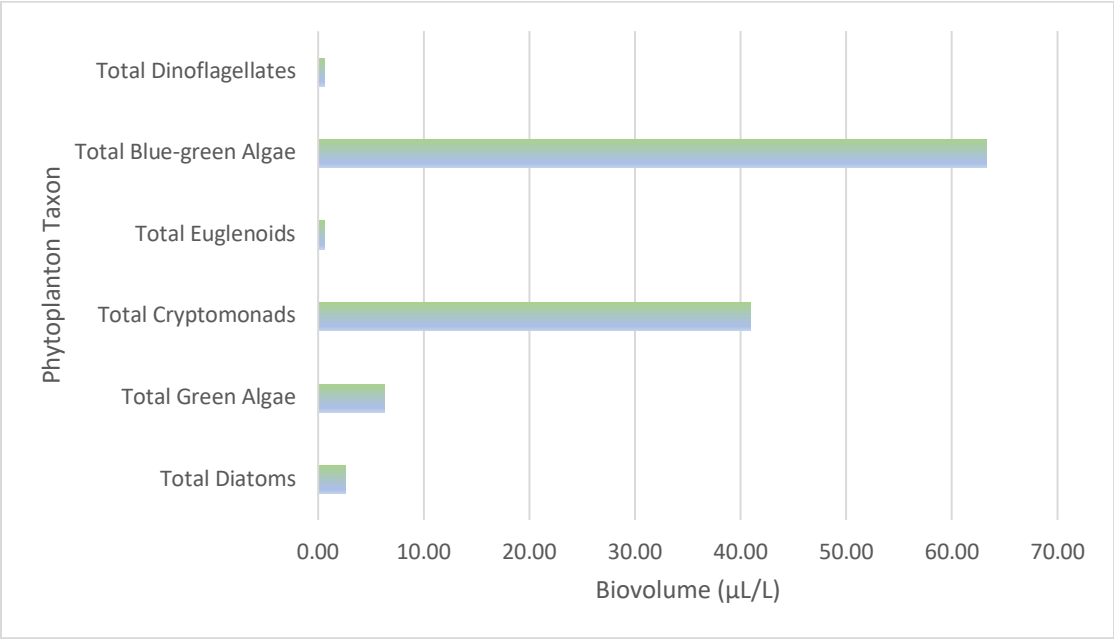
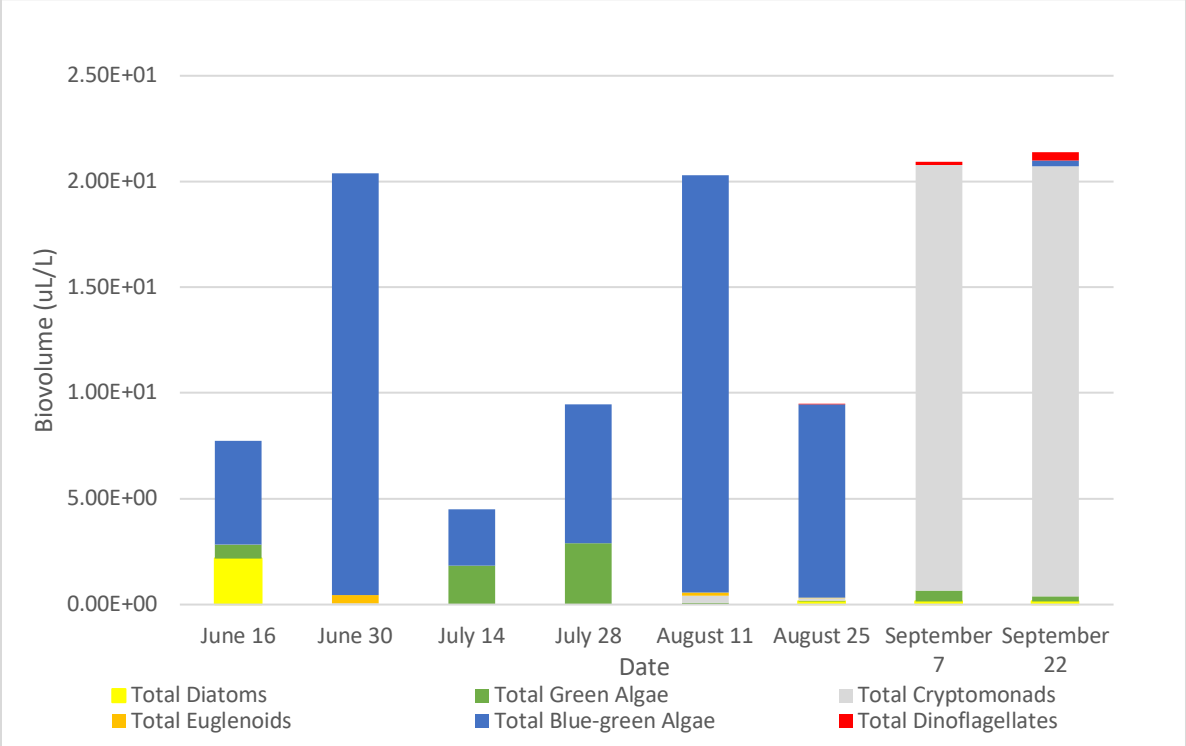


Chart 16: Somenos Lake Phytoplankton Community Bi-Monthly Abundance, 2023



In summer, the blue-green algae community was predominately Dolichospermum (formally Anabaena), followed by Woronichinia, Microcystis and lastly Pseudanabaena species, which was only present early

June. By late September, the blue-green algae community reduced to only Microcystis (Chart 17, Table 2). *Microcystis, Dolichospermum*, and *Woronichinia* are all considered to be problematic and produce various toxins (Rosen, et. Al 2015).

Chart 17: Somenos Lake Blue-Green Algae Bi-Monthly Species Abundance, 2023

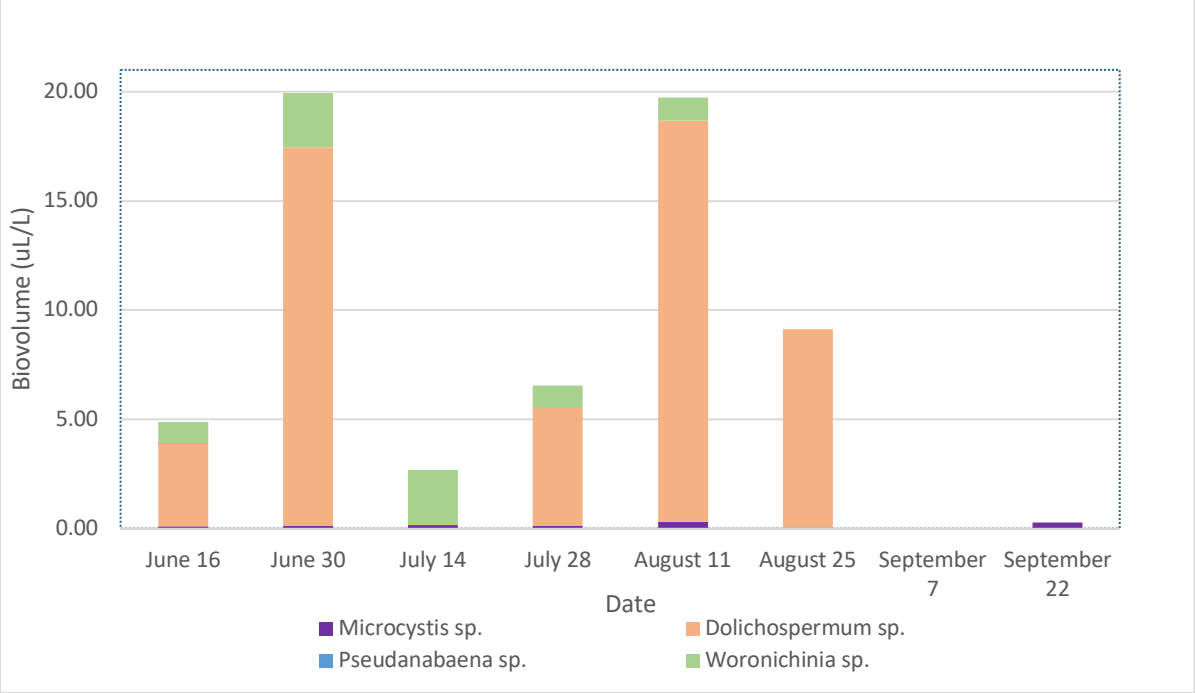


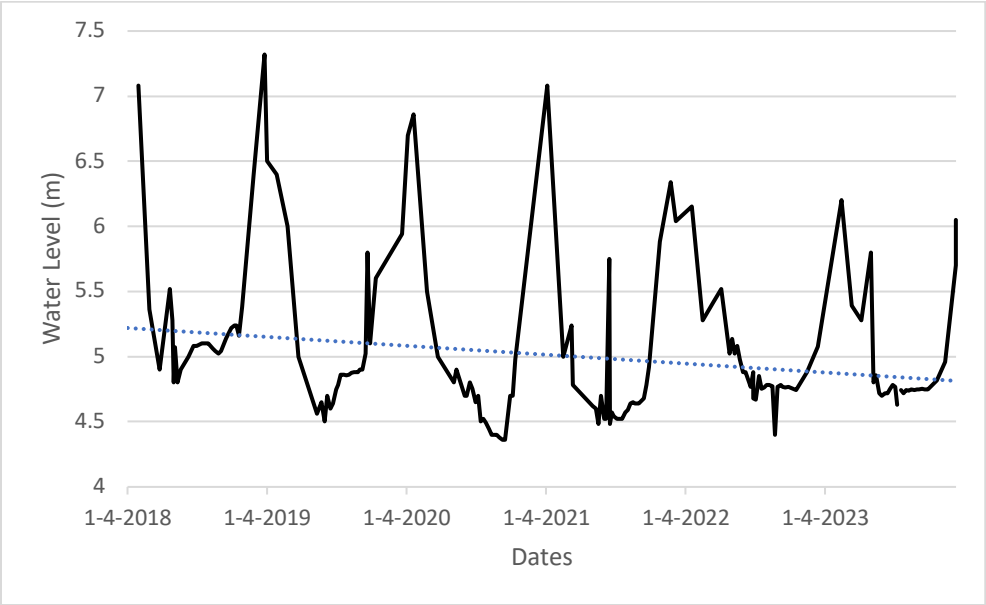
Table 2: Somenos Lake Blue-Green Algae Bi-Monthly Species Abundance, 2023

Blue Green Algae by Species	June 16	June 30	July 14	July 28	August 11	August 25	September 7	September 22	*Grande Total Biovolume (µL/L)*
Microcystis sp.	0.11	0.14	0.17	0.13	0.31	0.05	-	0.28	1.18
Dolichospermum sp.	3.78	17.32	-	5.39	18.38	9.10	-	-	53.97
Pseudanabaena sp.	0.01	-	-	-	-	-	-	-	0.01
Woronichinia sp.	0.98	2.49	2.51	1.04	1.05	0.00	-	-	8.08

SOMENOS LAKE DEPTH ANNUAL TRENDS

A review of Somenos Lake depths from 2018 to 2023 was completed to see any changes over time. The results are presented in Chart 18 below. There appears to be a slight linear trend in a decrease in water levels over time.

Chart 18: Somenos Lake Monthly Lake Level Measurements, 2018 to 2023



HOURLY DATA LOGGERS IN SOMENOS LAKE

Data loggers (tidbit hobos) were deployed in Somenos Lake to measure hourly temperatures at the surface, 3m and 6m depths (Chart 19). Generally the surface temperature (0m) is warmer than at 3m, and 6m depths are colder than the upper layers during the warmer months when it was stratified. When turnover occurs in fall you can see when temperatures at multiple layers mix and become similar.

Chart 19: Somenos Lake Temperatures recorded at surface, middle, bottom of the lake, 2023.

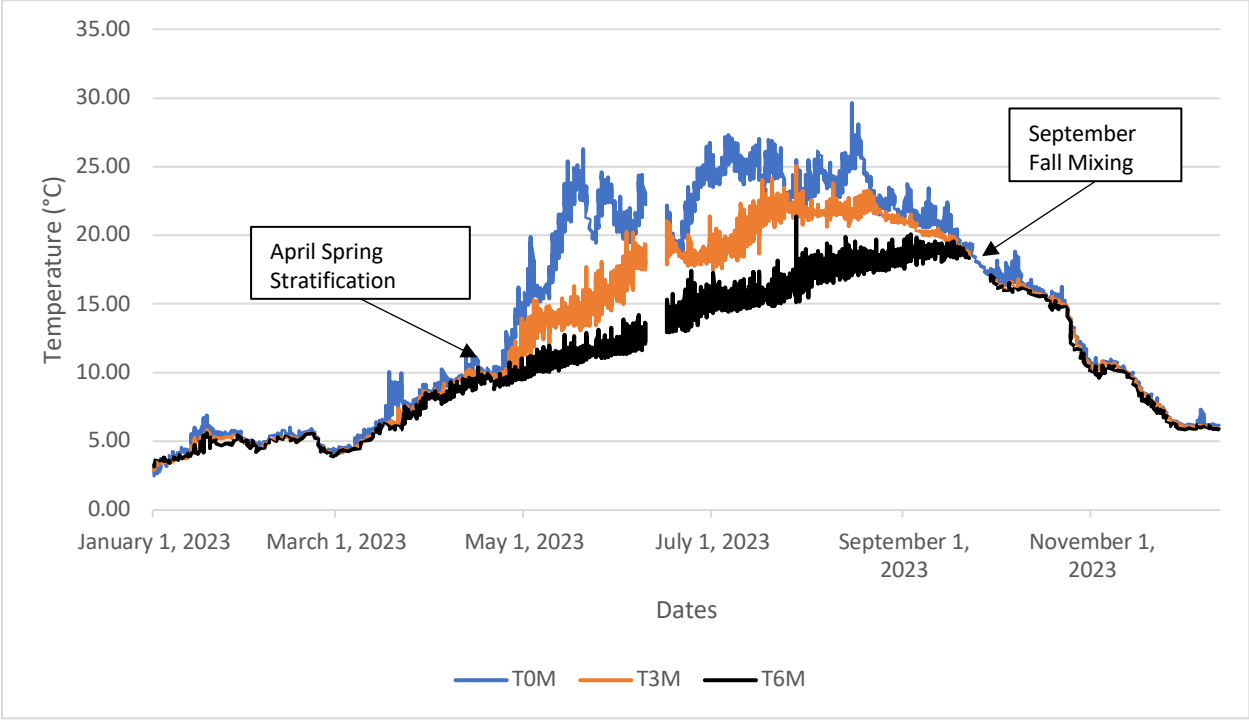
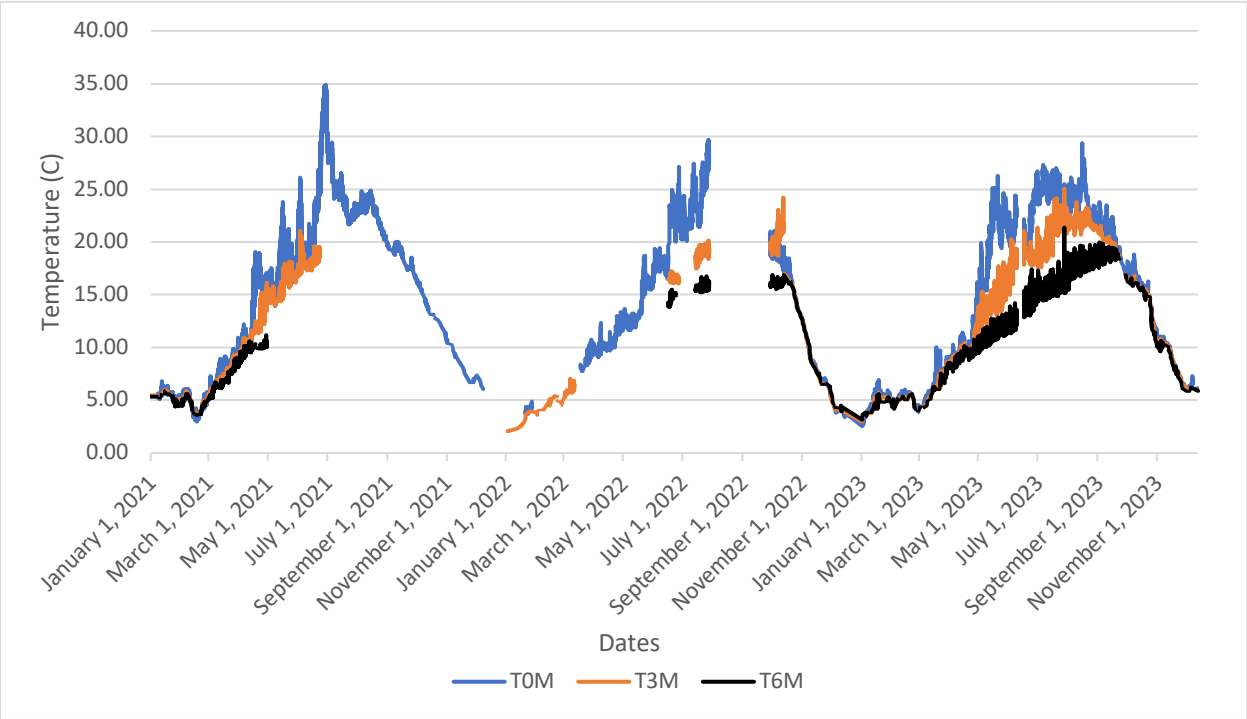


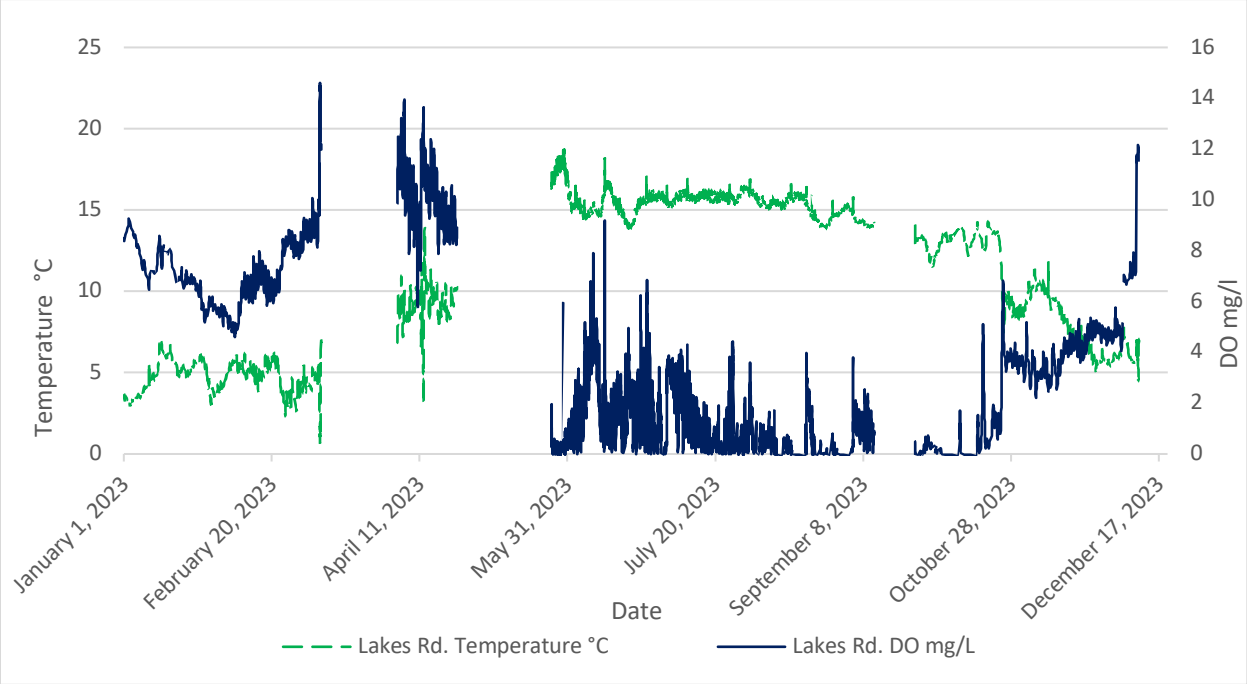
Chart 20: Somenos Lake Temperatures recorded at surface, middle, bottom of the lake, 2021-2023.



SOMENOS CREEK

A U26 Data Logger was installed at Somenos Creek lakes road to measure dissolved oxygen and temperature. Results can be seen in Chart 21. Gaps in the data are due to initial launching errors that required their removal for a period of time. The chart shows temperature remained consistent through the spring and summer, and dissolved oxygen was variable but on average dropped slowly to anoxic levels at this time. By fall temperatures dropped and dissolved oxygen recovered to above 6mg/L on December 5.

Chart 21: Somenos Creek Annual Temperature and Dissolved Oxygen Data Logger, 2023



8 Appendix B - Water Quality Results for the Somenos Watershed Tributaries

The main tributaries in the Somenos Watershed are Somenos Creek, Bings Creek (Mary/Phillips Street and Reach 1), Richards Creek (Richards Trail and Herd Road), and Averill Creek. They were all monitored for various water chemistry parameters to determine patterns and potential changes over time. These parameters were temperature, dissolved oxygen, pH, specific conductivity and dissolved oxygen, measured weekly in summer and monthly the rest of the year. Monthly parameters measured were total phosphate, ammonia, nitrate, and nitrite. The charts below show the results of testing in 2023.

TOTAL DISSOLVED SOLIDS AND SPECIFIC CONDUCTIVITY IN THE SOMENOS TRIBUTARIES

The more TDS the more conductivity of materials (mineral salts dissolved in water that are conductive) in the water column. Elevated total dissolved solids and conductivity coincided with water temperatures in summer. This makes sense since warmer temperatures can release some minerals into the creek.

The tributary total dissolved solids (TDS) and specific conductivity levels in Charts 1 and 2 match very closely, except for an event in July 19th where there was a large spike in TDS in Bings Creek downstream of the highway in Reach 1. It is possible an ionic compound that does not have conductivity entered the system from the highway run-off.

Chart 1: Somenos Watershed Tributary Total Dissolved Solids, 2023

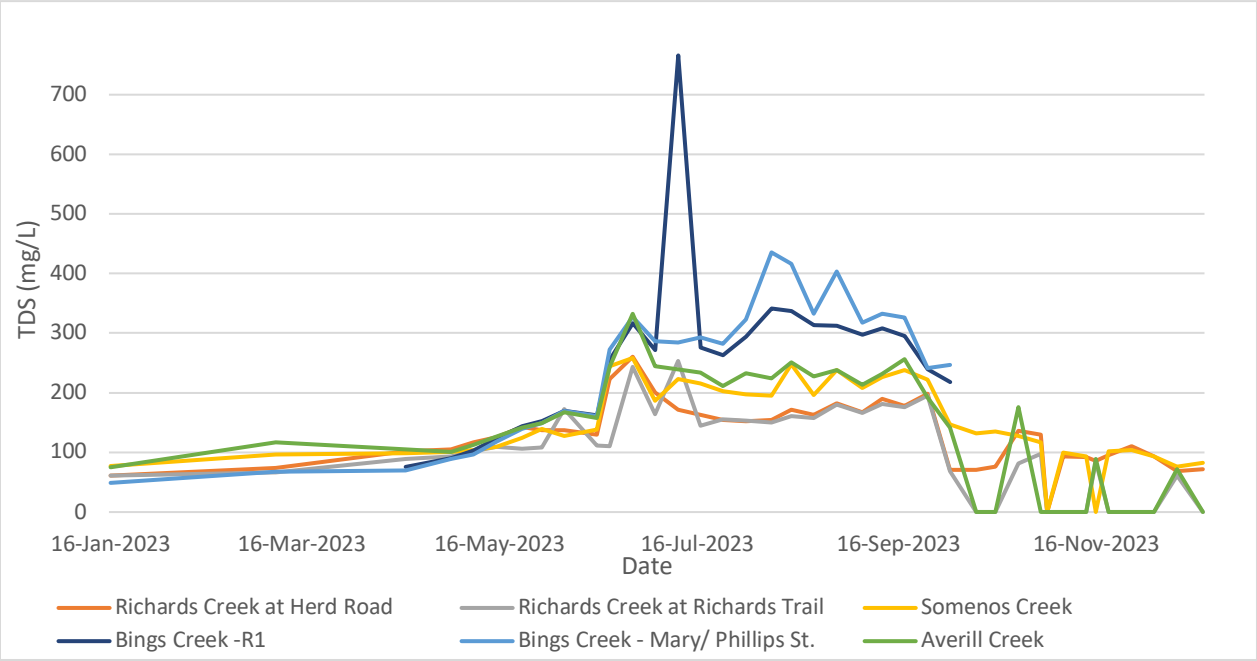
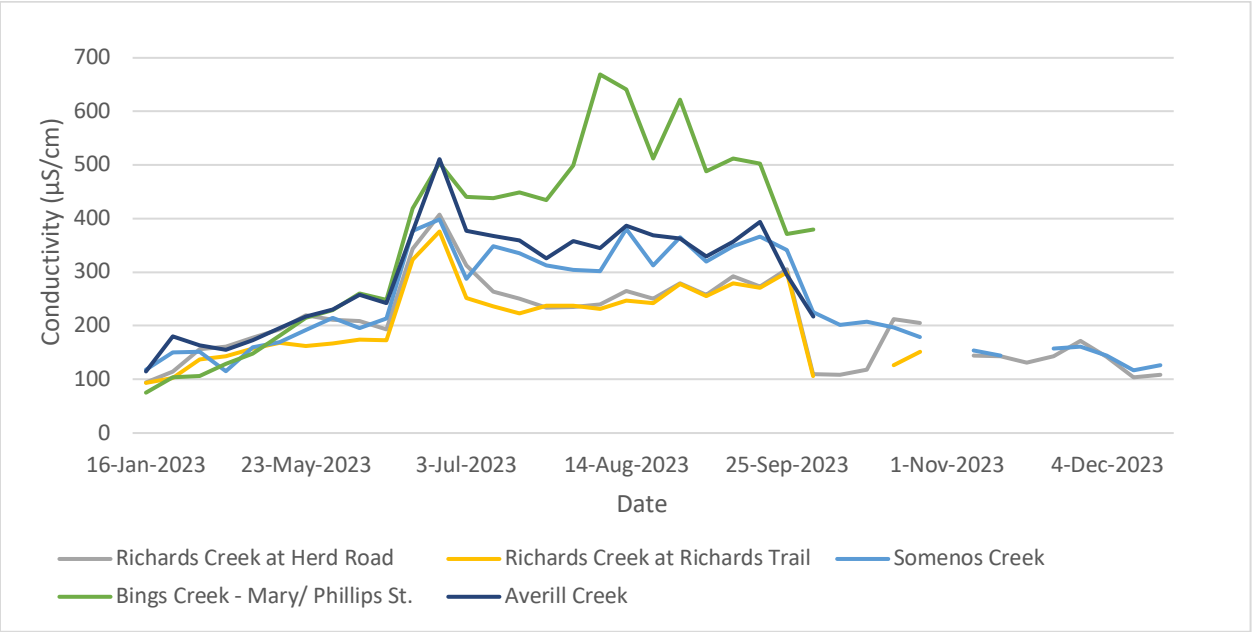


Chart 2: Somenos Watershed Tributary Specific Conductivity Levels, 2023

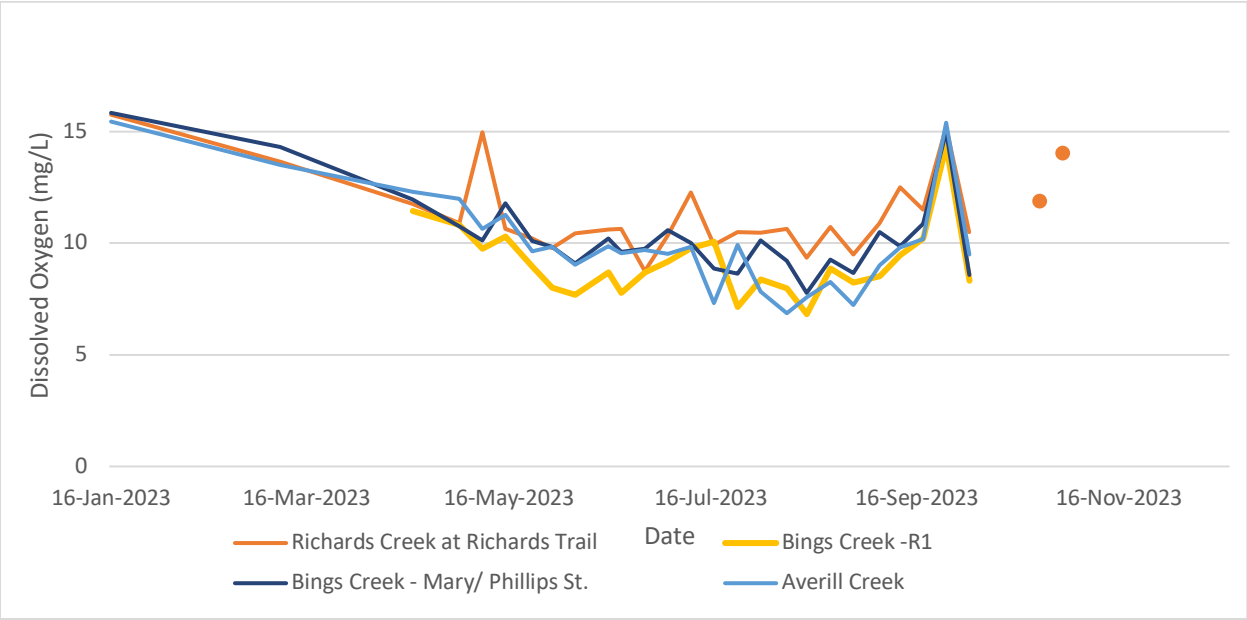


DISSOLVED OXYGEN IN THE SOMENOS TRIBUTARIES

Dissolved oxygen was measured at a 1 m depth in Richards creek at Herd road and Somenos Creek. All other locations were shallow and sampled just below surface.

Dissolved oxygen levels were similar between the spawning creeks: Bings, Averill and upper Richards Creek (Richards Trail) (Chart 3). All three creeks remained between sub-optimal to optimal range for the entire year, with only two occurrences of hypoxic levels in August. The highest dissolved oxygen was 15.86 mg/L in January and lowest was 6.82 mg/L on August 14, 2023.

Chart 3: Somenos Watershed Tributary Dissolved Oxygen Levels, 2023

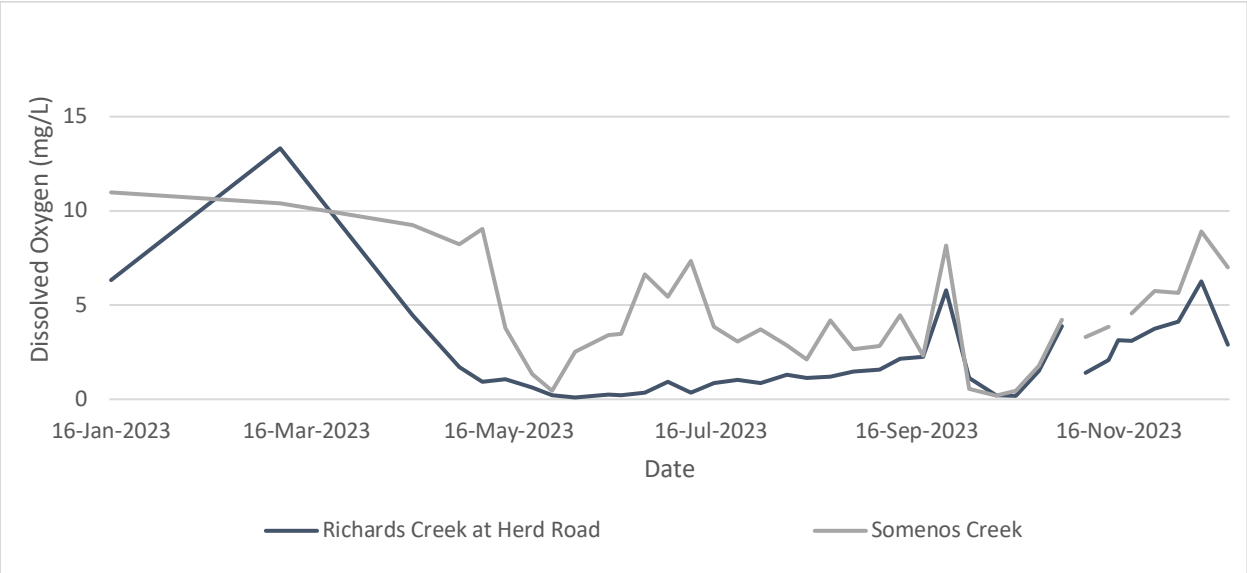


On the other hand, Richards Creek at Herd Road and Somenos Creek are much lower than the other locations (Chart 4). Somenos Creek had low oxygen conditions for salmonids from May until December that varied between 0.19 - 6.64 mg/L (with one occurrence of good dissolved oxygen in September at 8.16mg/L). By December 11, levels started to recover to sub-optimal levels (8.89 mg/L) which would allow salmon to migrate up to the tributaries to spawn (Charts 25-26).

Richards Creek at Herd Road has anoxic conditions for salmonids (trout and salmon) from late May until December between 0.2-3.89 mg/L (with one occurrence at 5.78 mg/L in September). In December levels started to rise with but did not rise above hypoxic levels (6.25mg/L).

According to these weekly results, salmon that have been waiting until December for dissolved oxygen levels to rise to be able to migrate upstream to their annual spawning grounds.

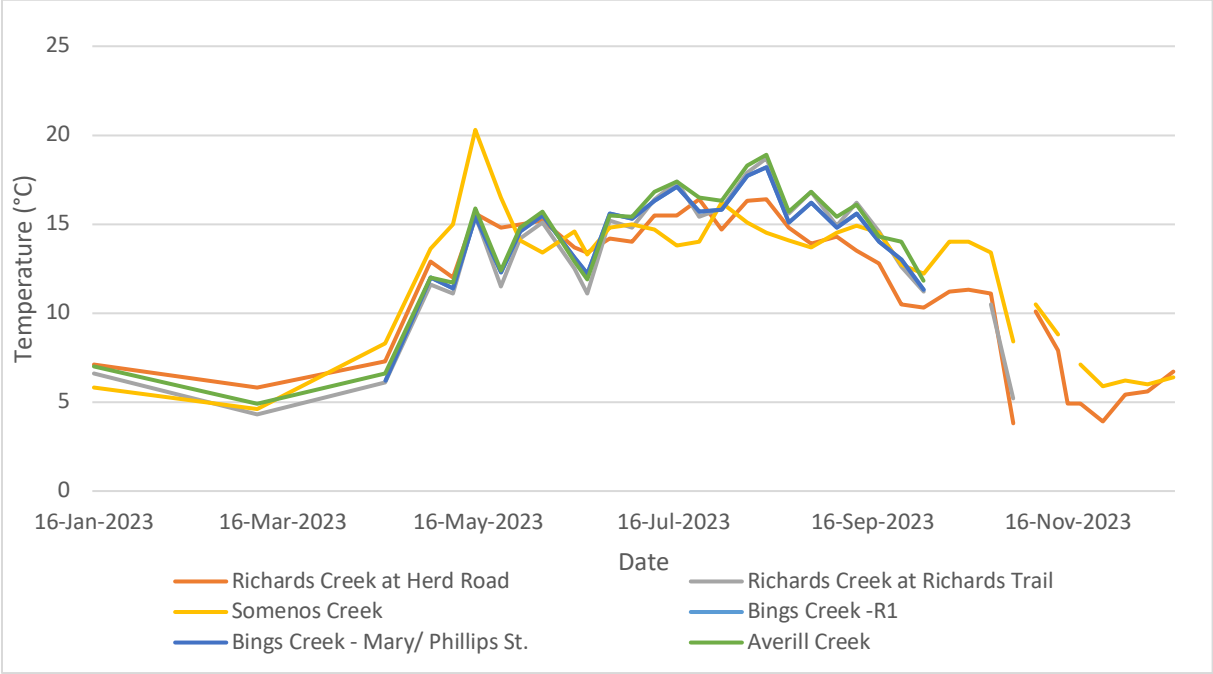
Chart 4: Somenos Creek at Lakes Rd. and Richards Creek at Herd Rd. Dissolved Oxygen, 2023



TEMPERATURE IN THE SOMENOS TRIBUTARIES

Richards Creek at Richards Trail, Averill Creek and Bings Creek had similar temperatures over the year (Chart 5). Somenos Creek had the highest temperature value of 20.3°C in May 15 compared to the other creeks and peaked first. Richards Creek at Richards Trail, Bings Creek and Averill Creek highest temperatures were about the same, peaking on August 14 between 18.2-18.9°C. Surprisingly, Richards Creek at Herd Road and Somenos Creek at this time were much lower at 16.4, and 14.54°C respectively. It is suspected these creeks were influenced by groundwater influx causing cooler temperatures. Creek temperatures gradually declined in the fall but more dramatically by October 30.

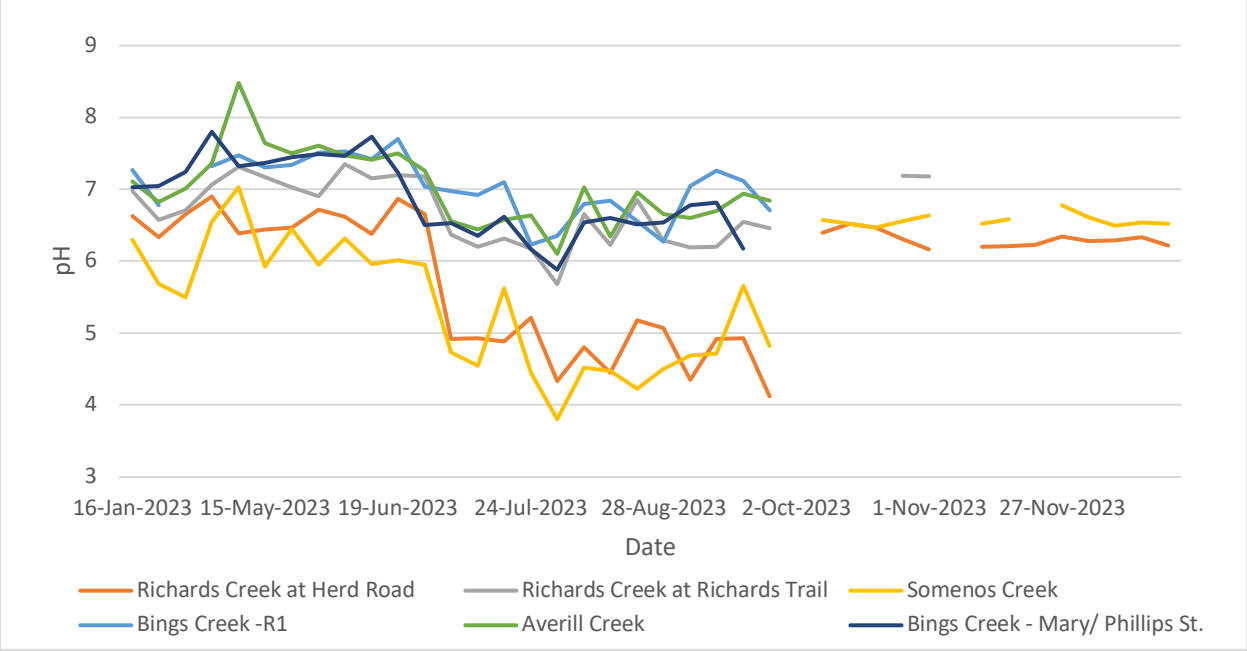
Chart 5: Somenos Watershed Tributary Temperature Levels, 2023



ACIDITY IN THE SOMENOS TRIBUTARIES

In spring, the acidity in the tributaries varied between acidic and basic (5.5- 8.48), where the most basic being in Averill Creek. By early July, pH dropped quickly in Somenos Creek and Richards Creek at Herd Road as low as 3.8 and 4.12, respectively, over the summer (Chart 6). The other tributaries remained between slightly acidic (5.68) and basic (7.26) in summer. By fall, Somenos creek and Richards Creek at Herd road recovered to a neutral pH.

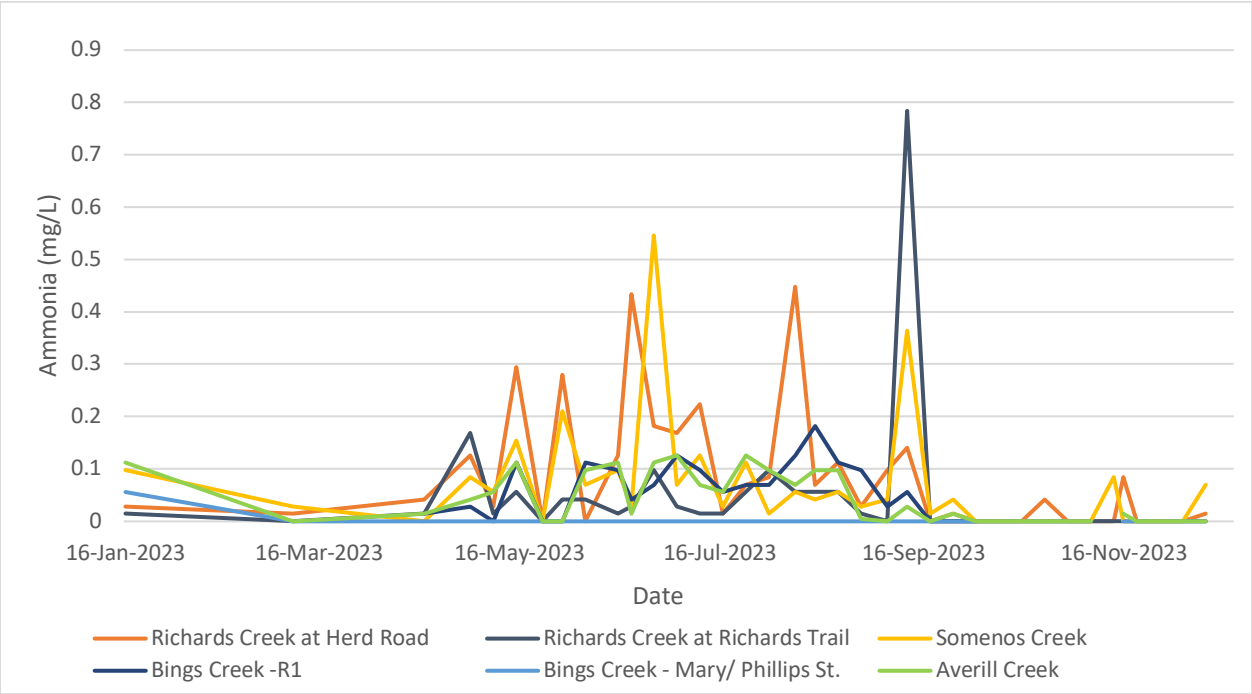
Chart 6: Somenos Watershed Tributary Monthly Ammonia Levels, 2023



AMMONIA IN THE SOMENOS TRIBUTARIES

As mentioned, when temperatures and pH increase (alkaline), ammonia toxicity concentration guidelines decrease becoming more stringent. Thus, summer temperatures, and creeks with higher alkalinity were monitored closely. In spring, temperatures were between 5-10C, and pH between 5.5 and 8.48 (Chart 7). Even with the high alkaline results ammonia did not exceed guidelines for these conditions (0.370-1.94 mg/L, BCMOE, 2023). In summer, as temperatures rose between 12 and 20C, pH declined between 3.8-5.5 in the tributaries and ammonia guidelines were not exceeded (approximately 1.81 mg/L, BCMOE, 2023).

Chart 7: Somenos Watershed Tributary Monthly Ammonia Levels, 2023



NITRITE AND NITRATE IN THE SOMENOS TRIBUTARIES

The Nitrate BCMOE 2023 guidelines for acute (32.8 mg/L) and chronic exposures (3.0 mg/L) are higher than the results at the tributaries in 2023, and thus are too high to show on Chart 8. However, the BCMOE 2023 Nitrite guidelines for acute (0.06 mg/L) and chronic exposures (0.02 mg/L) were observed in Chart 9. The chronic exposures were not long enough to be considered an issue (e.g. less than 5 samples in 30days) however the chronic exposures occurred frequently in all the creeks at least once over the year. The biggest spikes in Nitrite were in May-June and August, 2023. Nitrate levels were noticed more in the fall.

Chart 8: Somenos Watershed Tributary Monthly Nitrate Levels, 2023

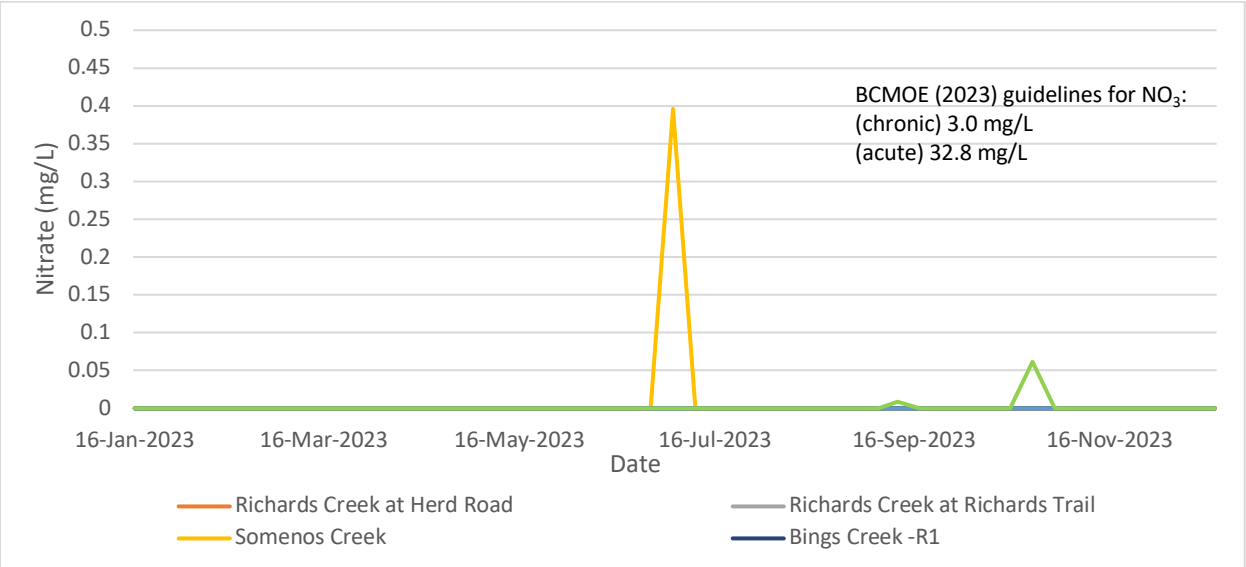
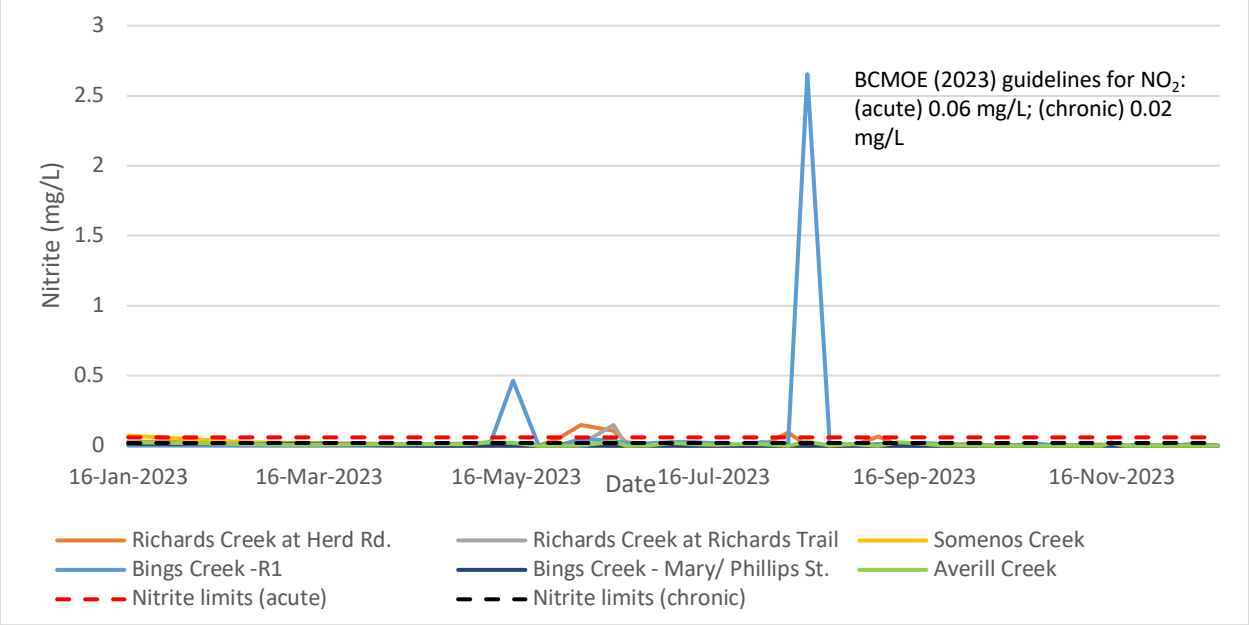


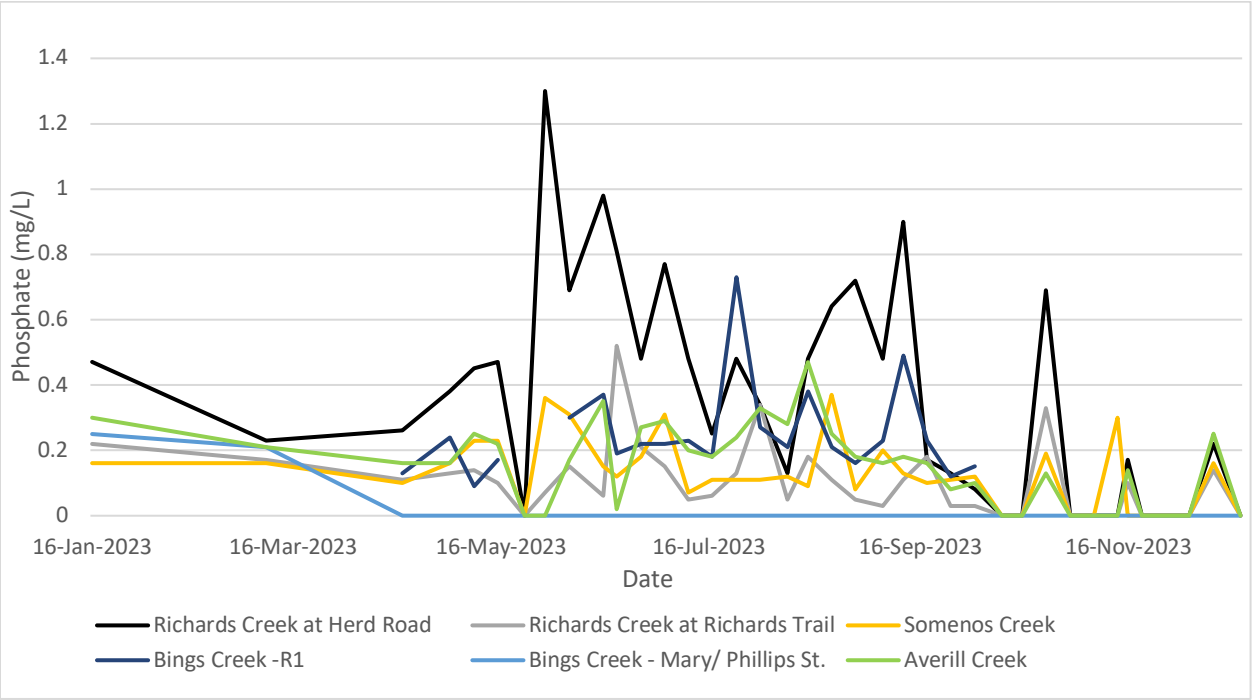
Chart 9: Somenos Watershed Tributary Monthly Nitrite Levels, 2023



PHOSPHATE IN THE SOMENOS TRIBUTARIES

In Chart 10, all the tributaries had an increase in phosphate from spring into fall. This is likely due to warming temperatures and potentially spikes when fertilizing occurs in the upstream farming fields in spring and fall. This can be easily seen in spring, and more significantly in Richards Creek at Herd Road, where phosphate spikes in May 15, and October 23.

Chart 10: Tributary Phosphate Levels, 2023



9 APPENDIX C - DATA TABULATIONS FOR SOMENOS LAKE DATA

Month	Temperature						
	0m	1m	2m	3m	4m	5m	6m
19-Jan-23	5.2	5.2	4.9	4.8	4.7	4.7	4.2
16-Feb-23	4.6	4.6	4.5	4.5	4.5	4.5	4.4
15-Mar-23	5.3	5.3	5.2	5.2	5.2	5.1	5
09-Apr-23	9.2	9.2	9.1	9	9	9	8.9
03-May-23	15.7	14.7	13.9	13.1	10.5	9.3	9
10-May-23	16.8	15.7	14.3	13.5	12.4	10.6	9.9
17-May-23	21.7	21.3	18.2	14.4	12.1	11	10.1
25-May-23	19.7	19.7	19	17.2	13.2	10.5	10.3
02-Jun-23	20.5	19.7	18.8	18.6	13.7	11.3	10.7
09-Jun-23	21.2	21.1	20.2	18.5	16.3	13.2	11.1
16-Jun-23	20.1	20.1	20.1	20	15.5	13.4	12.1
23-Jun-23	21.5	20	18.7	17.8	17.2	15.2	12.6
30-Jun-23	24.8	23	22.5	19	17.1	14.8	14.1
07-Jul-23	24.8	24.5	23.6	19.8	16.8	14.9	13.7
11-Jul-23	23.5	23	22.5	20.3	16.6	14.7	14.1
14-Jul-23	24.1	24	23.3	21.4	17.6	15.7	14.1
21-Jul-23	24.1	23.6	23	21.5	18.8	15.5	14.2
28-Jul-23	23.4	21.7	21.6	21.4	20.1	15.7	14.7
04-Aug-23	23.6	22.7	22	21.4	20.1	16.7	16.3
11-Aug-23	22.9	21.9	21.7	21.6	20.4	17.9	17.4
18-Aug-23	25.3	25	23.6	22.1	20.1	17.6	16.8
25-Aug-23	21.8	21.4	21.2	20.9	20.3	18	16.8
01-Sep-23	21.5	20.8	20.6	20.4	20.2	19	17
07-Sep-23	20.4	19.9	19.7	19.5	19.3	18.4	17.9
15-Sep-23	20.2	19.8	19.3	19.2	19	18.6	17.6
22-Sep-23	17.9	17.6	17.5	17.4	17.3	17.3	17.3
29-Sep-23	17	16.8	16.7	16.7	16.7	16.6	16.6
24-Oct-23	14.4	14.5	14.5	14.4	14.4	14.4	14.4
14-Nov-23	9.5	9.5	9.4	9.4	9.4	9.4	9.3
12-Dec-23	5.9	5.9	5.9	5.9	5.9	5.9	5.8

Month	Dissolved Oxygen						
	0m	1m	2m	3m	4m	5m	6m
19-Jan-23	6.84	6.55	8.06	8.13	8.16	8.12	4.61
16-Feb-23	8.75	8.66	8.44	8.75	8.57	8.35	8.22
15-Mar-23	7.81	7.68	7.66	7.67	7.66	7.60	7.48
09-Apr-23	11.59	11.52	11.31	11.15	11.20	10.89	10.58
03-May-23	10.43	10.37	10.02	9.50	8.33	6.08	5.42
10-May-23	8.67	8.57	7.20	6.27	5.20	4.56	2.47
17-May-23	9.43	9.39	8.55	5.96	3.33	1.25	0.20
25-May-23	9.60	9.53	8.63	4.49	0.50	0.14	0.13
02-Jun-23	9.34	9.04	8.21	8.31	0.24	0.13	0.11
09-Jun-23	8.52	8.60	8.55	5.30	0.36	0.22	0.19
16-Jun-23	9.93	9.64	9.93	9.97	0.26	0.18	0.17
23-Jun-23	14.20	13.60	13.20	10.90	7.50	0.29	0.23
30-Jun-23	14.50	13.90	12.22	8.40	0.51	0.47	0.41
07-Jul-23	10.95	11.05	10.43	1.20	0.47	0.65	0.70
11-Jul-23	10.89	11.11	9.01	0.92	0.78	0.91	0.75
14-Jul-23	9.54	11.04	11.01	9.32	1.11	1.04	1.01
21-Jul-23	9.87	9.35	7.97	1.95	0.89	0.82	1.04
28-Jul-23	12.05	9.55	8.42	7.78	0.88	1.32	1.36
04-Aug-23	20.83	17.74	12.43	8.46	0.99	1.45	1.29
11-Aug-23	16.92	9.33	7.23	5.88	1.10	1.20	1.23
18-Aug-23	17.65	13.42	5.73	2.79	1.13	1.39	1.39
25-Aug-23	3.74	3.20	2.95	1.73	1.16	1.29	1.57
01-Sep-23	5.82	2.52	1.26	1.15	1.11	1.12	1.50
07-Sep-23	10.75	7.59	6.65	4.75	2.25	1.65	1.51
15-Sep-23	16.83	13.74	5.04	1.90	1.65	1.78	1.80
22-Sep-23	8.57	6.39	4.79	4.49	4.22	4.09	3.20
29-Sep-23	1.36	0.98	0.70	0.55	0.49	0.53	0.54
24-Oct-23	4.56	4.48	4.50	4.48	4.41	4.39	4.31
14-Nov-23	6.97	6.92	6.79	6.78	6.75	6.74	6.76
12-Dec-23	7.54	7.44	7.15	7.16	7.01	7.12	6.46

Month	pH						
	0m	1m	2m	3m	4m	5m	6m
19-Jan-23	5.80	5.93	6.06	6.15	6.25	6.28	6.32
16-Feb-23	6.26	6.28	6.31	6.32	6.33	6.36	6.38
15-Mar-23	6.22	6.27	6.31	6.33	6.36	6.39	6.43
09-Apr-23	6.58	6.62	6.66	6.68	6.72	6.74	6.74
03-May-23	6.55	6.52	6.53	6.49	6.50	6.28	6.25
10-May-23	6.67	6.65	6.49	6.40	6.37	6.29	6.23
17-May-23	6.82	6.88	6.64	6.41	6.24	6.19	6.66
25-May-23	6.89	7.01	6.97	6.81	6.42	6.22	6.26
02-Jun-23	7.48	7.66	7.42	7.21	6.74	6.29	6.28
09-Jun-23	7.62	7.86	7.72	7.20	6.60	6.33	6.34
16-Jun-23	7.81	7.98	8.08	8.02	7.43	6.49	6.40
23-Jun-23	8.83	8.44	8.26	7.68	7.28	6.48	6.47
30-Jun-23	8.42	8.29	7.94	6.47	5.79	5.00	4.78
07-Jul-23	9.48	9.56	8.97	7.08	6.23	5.85	5.50
11-Jul-23	9.60	9.62	9.39	6.76	5.99	5.68	5.53
14-Jul-23	9.64	9.42	9.22	6.35	5.50	4.99	4.68
21-Jul-23	8.39	8.25	7.98	6.04	5.37	4.77	4.58
28-Jul-23	8.46	7.55	7.11	6.78	5.96	4.74	5.66
04-Aug-23	8.55	8.75	7.89	6.61	5.07	3.69	3.79
11-Aug-23	8.88	8.41	8.22	8.21	5.65	5.05	4.95
18-Aug-23	9.82	9.55	8.22	5.54	4.85	3.90	4.03
25-Aug-23	7.65	7.34	6.99	6.66	6.19	5.23	4.96
01-Sep-23	6.44	5.96	5.73	5.75	5.85	5.70	5.39
07-Sep-23	7.24	6.13	5.99	5.71	5.58	5.15	4.61
15-Sep-23	7.82	7.93	6.16	5.82	5.44	5.40	5.12
22-Sep-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Sep-23	6.93	6.90	6.88	6.88	6.88	6.88	6.87
24-Oct-23	6.92	6.91	6.91	6.92	6.91	6.90	6.90
14-Nov-23	6.77	6.83	6.84	6.84	6.85	6.84	6.84
12-Dec-23	6.61	6.42	6.59	6.65	6.67	6.70	6.63

Month	Conductivity						
	0m	1m	2m	3m	4m	5m	6m
19-Jan-23	123.30	124.30	138.70	141.30	142.80	144.10	182.70
16-Feb-23	141.00	141.00	142.00	142.00	142.00	142.00	142.00
15-Mar-23	151.90	151.90	152.00	152.20	152.30	152.90	152.80
09-Apr-23	149.30	149.10	149.20	149.00	149.10	149.10	148.10
03-May-23	150.40	150.40	150.70	150.90	151.70	154.10	155.00
10-May-23	152.40	152.10	153.10	153.50	154.00	154.80	158.20
17-May-23	156.60	156.40	155.30	155.00	156.50	160.80	166.10
25-May-23	157.70	157.70	158.40	159.20	160.20	174.00	174.80
02-Jun-23	160.10	160.10	159.90	159.80	166.40	176.30	180.40
09-Jun-23	161.50	161.40	161.00	162.00	163.00	177.60	186.90
16-Jun-23	161.80	161.80	161.80	161.90	172.30	183.50	190.60
23-Jun-23	315.50	314.70	315.00	313.40	314.20	325.10	344.20
30-Jun-23	288.30	287.70	283.60	289.30	295.10	310.10	308.50
07-Jul-23	179.60	170.70	168.50	170.90	177.10	189.60	194.80
11-Jul-23	271.60	274.70	275.60	282.80	298.40	310.60	310.40
14-Jul-23	284.80	279.70	279.10	301.10	317.80	325.10	327.00
21-Jul-23	281.10	276.90	275.90	279.20	290.40	306.10	313.50
28-Jul-23	273.90	276.40	280.40	283.20	273.40	322.30	320.40
04-Aug-23	303.10	288.60	277.00	276.60	282.50	305.30	307.00
11-Aug-23	301.10	293.20	287.10	286.50	290.00	309.10	310.10
18-Aug-23	317.60	309.80	295.70	298.00	307.10	316.70	323.20
25-Aug-23	316.20	317.60	317.80	315.20	318.60	347.70	350.60
01-Sep-23	307.20	308.10	306.30	305.80	306.60	324.00	357.00
07-Sep-23	312.00	307.80	302.10	302.00	303.70	332.60	341.40
15-Sep-23	333.00	333.10	333.00	326.20	331.50	340.20	376.10
22-Sep-23	343.30	342.80	329.70	329.10	329.00	327.70	332.00
29-Sep-23	181.10	180.90	180.90	180.90	181.00	181.10	181.30
24-Oct-23	180.20	180.20	180.20	180.10	180.20	180.20	180.20
14-Nov-23	163.30	163.30	163.30	163.30	162.50	161.70	161.30
12-Dec-23	141.80	141.60	142.50	142.60	144.40	146.80	143.90

Month	TDS						
	0m	1m	2m	3m	4m	5m	6m
19-Jan-23	79.95	80.60	90.35	91.65	92.95	93.60	117.00
16-Feb-23	91.70	91.70	92.30	92.30	92.30	92.30	92.30
15-Mar-23	98.80	98.80	98.80	98.80	98.80	98.45	98.45
09-Apr-23	96.85	96.85	96.85	96.85	96.85	96.85	96.20
03-May-23	97.50	97.50	98.15	98.15	98.80	100.10	100.75
10-May-23	98.80	98.80	99.45	99.45	100.10	100.75	102.70
17-May-23	102.05	101.40	101.40	100.75	101.40	104.66	107.90
25-May-23	102.70	102.70	102.70	103.40	104.00	113.10	113.80
02-Jun-23	104.00	104.00	104.00	104.00	107.90	114.40	117.00
09-Jun-23	104.65	104.65	104.65	105.30	105.95	115.70	121.55
16-Jun-23	105.30	105.30	105.30	105.30	111.80	119.60	124.20
23-Jun-23	204.80	204.10	204.80	203.50	204.10	210.60	223.60
30-Jun-23	187.20	186.55	183.95	187.85	191.75	201.50	200.20
07-Jul-23	117.00	116.65	109.85	111.15	115.05	123.50	126.75
11-Jul-23	176.80	178.75	178.75	183.95	193.70	201.50	201.50
14-Jul-23	184.60	182.00	182.00	195.65	206.70	211.25	212.55
21-Jul-23	182.65	180.05	180.05	180.35	188.50	199.90	204.10
28-Jul-23	178.10	180.05	182.00	183.95	177.45	209.30	208.00
04-Aug-23	196.95	187.20	180.20	179.40	183.30	198.25	199.55
11-Aug-23	195.65	191.10	186.55	185.90	189.15	200.85	201.50
18-Aug-23	206.70	202.80	192.40	193.70	199.55	206.40	210.95
25-Aug-23	205.40	206.05	206.70	204.75	206.70	225.55	227.50
01-Sep-23	200.00	200.00	198.90	198.90	199.55	209.95	231.40
07-Sep-23	202.80	200.00	196.30	196.30	196.95	216.45	222.95
15-Sep-23	219.70	216.45	216.45	211.90	215.16	221.65	244.40
22-Sep-23	222.95	222.95	214.50	213.85	213.85	213.20	215.80
29-Sep-23	117.80	117.60	117.60	117.60	117.70	117.70	117.90
24-Oct-23	117.10	117.10	117.10	117.10	117.10	117.10	117.10
14-Nov-23	106.20	106.20	106.10	106.00	105.60	105.10	104.80
12-Dec-23	92.10	92.00	92.70	92.90	93.90	95.40	93.50

Month	Phosphate (mg/L)		Ammonia (mg/L)		Nitrite (mg/L)		Nitrate (mg/L)	
	0m	6 m	0m	6m	0m	6m	0m	6m
19-Jan-23	0.24	0.33	0.14	1.19	0.0297	0.0033	<<	<<
16-Feb-23	0.28	0.23	0.20	0.28	0.0231	0.0231	<<	<<
15-Mar-23	0.11	0.24	0.08	0.29	0.0099	0.0132	<<	<<
09-Apr-23	0.00	0.09	0.00	<<	0	0.033	0	<<
03-May-23	0.12	0.27	0.07	0.26	0.0231	0.0099	<<	<<
10-May-23	0.17	0.39	0.10	0.31	0.0033	0	<<	<<
17-May-23	0.06	1.25	0.25	>>	0.0165	0.0858	<<	0.0088
25-May-23	0.00	0.00	0.00	0.00	0	0	0	0
02-Jun-23	0.03	1.45	0.05	0.78	0	0.0297	<<	<<
09-Jun-23	0.08	2.70	0.01	1.16	0.0033	0.0231	<<	<<
16-Jun-23	0.29	1.95	0.04	1.07	0.0099	0.0165	<<	<<
23-Jun-23	0.06	1.65	0.04	0.84	0	0.0165	0	<<
30-Jun-23	0.09	2.20	0.11	0.88	0.0066	0.0099	<<	<<
07-Jul-23	0.16	1.75	0.04	1.08	0.0132	0.0231	<<	<<
11-Jul-23	0.06	3.00	0.04	>>1	0.0099	0.0297	<<	<<
14-Jul-23	0.02	2.50	0.00	>>1	0	0.0231	0.0044	<<
21-Jul-23	0.06	3.50	0.05	>>1	0.0198	0.0264	<<	<<
28-Jul-23	0.01	3.60	0.02	>>1	0	0.0264	<<	<<
04-Aug-23	0.06	3.10	0.05	>>1	0.0099	0.0066	0	<<
11-Aug-23	0.07	2.40	0.04	>>1	0	0.0165	0	<<
18-Aug-23	0.01	1.70	0.05	>>1	0	0.0165	0.0264	<<
25-Aug-23	0.10	3.90	0.25	>>1	0.0066	0.0033	<<	<<
01-Sep-23	0.17	2.60	0.35	>>1	0	0.0066	<<	<<
07-Sep-23	0.16	2.30	0.02	>>1	0.0033	<<	<<	<<
15-Sep-23	0.11	2.10	0.00	>>1	0	0.0033	<<	<<
22-Sep-23	0.06	0.52	0.00	0.16	0	0.0099	<<	<<
29-Sep-23	0.29	0.23	0.32	0.43	0.0033	0	<<	0.0748
24-Oct-23	0.16	0.20	0.05	0.05	0.0363	0.0165	0.0132	0.0044
14-Nov-23	0.35	0.29	0.34	0.58	0.0264	0.0264	<<	<<
12-Dec-23	0.10	0.15	0.11	0.12	0.0132	0.0099	<<	0

<< = less than 0.001 mg/L

10 Appendix D - Data Tabulations for Somenos Tributaries

Date	Dissolved Oxygen (mg/L)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	10.98	6.33	15.76	10.98	14.93	15.84	15.45
March 8, 2023	10.4	13.32	13.66	10.4	-	14.3	13.52
April 17, 2023	9.26	4.45	11.77	9.26	11.44	11.97	12.31
May 1, 2023	8.24	1.71	10.9	8.24	10.8	10.75	12
May 8, 2023	9.04	0.92	14.96	9.04	9.74	10.13	10.63
May 15, 2023	3.79	1.07	10.64	3.79	10.3	11.8	11.28
May 23, 2023	1.32	0.61	10.2	1.32	8.96	10.1	9.65
May 29, 2023	0.45	0.22	9.77	0.45	8	9.85	9.85
June 5, 2023	2.51	0.09	10.44	2.51	7.68	9.08	9.03
June 15, 2023	3.41	0.25	10.6	3.41	8.69	10.2	9.87
June 19, 2023	3.46	0.2	10.65	3.46	7.76	9.61	9.56
June 26, 2023	6.64	0.36	8.75	6.64	8.7	9.76	9.68
July 3, 2023	5.44	0.92	10.35	5.44	9.18	10.57	9.53
July 10, 2023	7.35	0.35	12.27	7.35	9.78	10.01	9.84
July 17, 2023	3.85	0.84	9.91	3.85	10.07	8.86	7.32
July 24, 2023	3.07	1.04	10.5	3.07	7.15	8.62	9.92
July 31, 2023	3.72	0.85	10.48	3.72	8.38	10.11	7.84
August 8, 2023	2.85	1.3	10.63	2.85	7.96	9.21	6.86
August 14, 2023	2.11	1.12	9.34	2.11	6.82	7.77	7.57
August 21, 2023	4.2	1.2	10.74	4.2	8.85	9.26	8.26
August 28, 2023	2.66	1.45	9.5	2.66	8.23	8.65	7.24
September 5, 2023	2.83	1.57	10.9	2.83	8.51	10.49	9.01
September 11, 2023	4.45	2.15	12.5	4.45	9.47	9.88	9.8
September 18, 2023	2.32	2.25	11.5	2.32	10.21	10.88	10.19
September 25, 2023	8.16	5.78	15.2	8.16	14.37	15	15.4
October 2, 2023	0.56	1.12	10.5	0.56	8.31	8.58	9.48
October 10, 2023	0.19	0.2	-	0.19	-	-	-
October 16, 2023	0.46	0.18	-	0.46	-	-	-
October 23, 2023	1.77	1.49	11.9	1.77	8.4	10.42	11.13
October 30, 2023	4.22	3.89	14.05	4.22	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	3.3	1.41	-	3.3	-	-	-
November 13, 2023	3.84	2.09	-	3.84	-	-	-
November 16, 2023	-	3.13	14.07	-	13.3	13.12	12.75
November 20, 2023	4.55	3.08	-	4.55	-	-	-
November 27, 2023	5.75	3.73	-	5.75	-	-	-
December 4, 2023	5.64	4.13	-	5.64	-	-	-
December 11, 2023	8.89	6.25	12.26	8.89	11.47	12.3	12.3
December 19, 2023	7.01	2.88	-	7.01	-	-	-

Date	Temperature °C						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	7.1	6.6	5.8	6.5	6.5	7
March 8, 2023	-	5.8	4.3	4.6	-	4.5	4.9
April 17, 2023	-	7.3	6.1	8.3	6.2	6	6.6
May 1, 2023	-	12.9	11.6	13.6	12	11.9	12
May 8, 2023	-	12	11.1	15	11.4	11.3	11.7
May 15, 2023	-	15.6	15.5	20.3	15.4	15.8	15.9
May 23, 2023	-	14.8	11.5	16.5	12.3	12	12.4
May 29, 2023	-	15	14.2	14.1	14.6	14.7	14.8
June 5, 2023	-	15.2	15.1	13.4	15.5	15.7	15.7
June 15, 2023	-	13.7	12.5	14.6	13.1	13.3	12.9
June 19, 2023	-	13.4	11.1	13.3	12.2	11.8	11.9
June 26, 2023	-	14.2	15.2	14.8	15.6	15.9	15.5
July 3, 2023	-	14	14.8	15	15.3	15.4	15.4
July 10, 2023	-	15.5	16.4	14.7	16.3	16.6	16.8
July 17, 2023	-	15.5	17.4	13.8	17.1	17.8	17.4
July 24, 2023	-	16.4	15.4	14	15.7	16	16.5
July 31, 2023	-	14.7	15.9	16.2	15.8	16.4	16.3
August 8, 2023	-	16.3	17.9	15.1	17.7	18	18.3
August 14, 2023	-	16.4	18.7	14.5	18.2	18.7	18.9
August 21, 2023	-	14.8	15.6	14.1	15.1	15.4	15.7
August 28, 2023	-	13.9	16.8	13.7	16.2	16.4	16.8
September 5, 2023	-	14.3	14.9	14.5	14.8	15.2	15.4
September 11, 2023	-	13.5	16.2	14.9	15.6	15.7	16.1
September 18, 2023	-	12.8	14.6	14.5	14	14	14.3
September 25, 2023	-	10.5	12.6	12.7	13	13	14
October 2, 2023	-	10.3	11.2	12.2	11.3	11.3	11.8
October 10, 2023	-	11.2	-	14	-	-	-
October 16, 2023	-	11.3	-	14	-	-	-
October 23, 2023	-	11.1	10.5	13.4	11.3	11	11.2
October 30, 2023	-	3.8	5.2	8.4	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	-	10.1	-	10.5	-	-	-
November 13, 2023	-	7.9	-	8.8	-	-	-
November 16, 2023	-	4.9	5.8	-	5.5	5.7	5.8
November 20, 2023	-	4.9	-	7.1	-	-	-
November 27, 2023	-	3.9	-	5.9	-	-	-
December 4, 2023	-	5.4	-	6.2	-	-	-
December 11, 2023	-	5.6	6.9	6	6.8	6.8	7.2
December 19, 2023	-	6.7	-	6.4	-	-	-

Date	pH						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	6.33	6.57	5.68	6.78	7.03	6.82
March 8, 2023	-	6.65	6.71	5.5	-	7.05	7.01
April 17, 2023	-	6.9	7.06	6.55	7.32	7.24	7.36
May 1, 2023	-	6.39	7.31	7.03	7.47	7.8	8.48
May 8, 2023	-	6.44	7.17	5.92	7.3	7.32	7.64
May 15, 2023	-	6.47	7.03	6.45	7.34	7.37	7.5
May 23, 2023	-	6.72	6.9	5.95	7.51	7.45	7.61
May 29, 2023	-	6.62	7.35	6.32	7.53	7.49	7.47
June 5, 2023	-	6.38	7.15	5.96	7.42	7.46	7.41
June 15, 2023	-	6.87	7.2	6.01	7.7	7.73	7.5
June 19, 2023	-	6.65	7.18	5.95	7.04	7.23	7.26
June 26, 2023	-	4.92	6.37	4.73	6.97	6.5	6.56
July 3, 2023	-	4.93	6.2	4.54	6.92	6.53	6.44
July 10, 2023	-	4.88	6.32	5.62	7.1	6.35	6.57
July 17, 2023	-	5.21	6.17	4.45	6.23	6.62	6.64
July 24, 2023	-	4.33	5.68	3.8	6.35	6.16	6.1
July 31, 2023	-	4.8	6.65	4.52	6.8	5.88	7.03
August 8, 2023	-	4.45	6.23	4.47	6.84	6.54	6.34
August 14, 2023	-	5.18	6.85	4.22	6.56	6.6	6.96
August 21, 2023	-	5.07	6.29	4.5	6.27	6.51	6.65
August 28, 2023	-	4.35	6.19	4.69	7.05	6.54	6.6
September 5, 2023	-	4.92	6.2	4.71	7.26	6.78	6.7
September 11, 2023	-	4.93	6.55	5.66	7.12	6.81	6.94
September 18, 2023	-	4.12	6.46	4.82	6.71	6.17	6.84
September 25, 2023	-	-	-	-	-	-	-
October 2, 2023	-	6.4	7.37	6.57	7.24	7.17	7.41
October 10, 2023	-	6.52	-	6.52	-	-	-
October 16, 2023	7.47	6.47	-	6.47	-	-	-
October 23, 2023	-	6.31	7.19	6.56	7.2	7.19	7.34
October 30, 2023	6.97	6.16	7.18	6.64	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	6.9	6.2	-	6.52	-	-	-
November 13, 2023	6.81	6.21	-	6.58	-	-	-
November 16, 2023	-	6.23	7.07	-	6.91	7.04	7.09
November 20, 2023	6.86	6.34	-	6.78	-	-	-
November 27, 2023	6.78	6.28	-	6.61	-	-	-
December 4, 2023	6.72	6.29	-	6.49	-	-	-
December 11, 2023	-	6.33	7.01	6.54	6.94	7.07	7.09
December 19, 2023	6.53	6.22	-	6.52	-	-	-

Date	Specific Conductivity (µS/cm)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	94.2	93.4	118.4	79.5	75	114.7
March 8, 2023	-	113.9	103	149.7		104	180.4
April 17, 2023	-	155.9	136.7	151.2	116.5	106.5	163.4
May 1, 2023	-	160.5	143.3	115.2	137.8	128.6	154.9
May 8, 2023	-	177.6	157	160	157.6	147.8	173.4
May 15, 2023	-	193.4	168.5	169	189.5	180.9	195.5
May 23, 2023	-	219.3	162.8	192	220.6	214.8	216.6
May 29, 2023	-	210.7	166.8	214.2	233.7	229.1	230
June 5, 2023	-	209.2	173.6	195.8	260.8	259.6	257.6
June 15, 2023	-	193.1	172.5	213.5	249.3	248.4	242.3
June 19, 2023	-	343.6	323.5	377.7	393.1	419	375.8
June 26, 2023	-	407.5	376	398.5	487	503.5	511
July 3, 2023	-	312.2	252	287.6	416.9	440.5	376.7
July 10, 2023	-	264.2	236	349	408.8	438	367.8
July 17, 2023	-	250.3	223.4	335	423.8	449.4	359.4
July 24, 2023	-	234.4	237.7	312.2	404.4	434.6	326.3
July 31, 2023	-	235.2	236.9	303.9	451.9	498.6	358.6
August 8, 2023	-	239.6	231.2	301.6	524.2	669	345.4
August 14, 2023	-	264.8	246.9	380.9	5195	641	386.5
August 21, 2023	-	250.2	242.2	313	481.6	511.5	369.3
August 28, 2023	-	279.4	278	365	480.1	622	363.4
September 5, 2023	-	258.2	255.3	319.6	458.3	488.2	329.3
September 11, 2023	-	292.6	279.3	348.7	473.4	511.8	356.4
September 18, 2023	-	273.2	270.6	366.3	452.2	502.8	394.4
September 25, 2023	-	305.1	299.4	341.6	367.7	371.6	295.3
October 2, 2023	-	109.5	105.6	225.7	335.6	379.4	217.2
October 10, 2023	-	108.5	-	202	-	-	-
October 16, 2023	178.9	118.2	-	207.2	-	-	-
October 23, 2023	-	212.2	126	197.4	326.8	348.2	270.4
October 30, 2023	176.5	205	151	179.4	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	172.2	144.6	-	153.5	-	-	-
November 13, 2023	165.5	143.6	-	144.1	-	-	-
November 16, 2023	-	131.7	130.3	-	100.2	94.3	136.2
November 20, 2023	158	143	-	157.1	-	-	-
November 27, 2023	157	171.4	-	161.5	-	-	-
December 4, 2023	151.4	142.5	-	144.3	-	-	-
December 11, 2023	-	103.7	93.7	116.5	73.2	68	111
December 19, 2023	126.1	108	-	126.3	-	-	-

Date	Total Dissolved Solids (mg/L)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	61.1	61.1	76.7	52	48.75	74.75
March 8, 2023	-	74.1	66.9	96.5	-	67.6	117
April 17, 2023	-	102.1	89.1	98.2	75.4	69.6	105.2
May 1, 2023	-	105	92.9	100.8	89.7	88.9	100.8
May 8, 2023	-	116.4	102.1	104	102.7	96.2	112.5
May 15, 2023	-	125.45	109.8	109.85	123.5	117.65	126.75
May 23, 2023	-	142.4	105.9	124.8	143.6	139.8	141
May 29, 2023	-	137.5	108.6	139.8	152.1	148.9	149.5
June 5, 2023	-	137.2	173.1	127.8	169	169	167.7
June 15, 2023	-	129.4	111.8	138.5	161.8	161.2	157.3
June 19, 2023	-	223.6	110	245.1	255.5	272.4	243.3
June 26, 2023	-	260.5	243.7	258.4	316.6	326.9	332.5
July 3, 2023	-	200.2	163.8	186.6	271	286	245
July 10, 2023	-	171.6	253.4	223.6	765.85	284.7	239.2
July 17, 2023	-	162.5	144.95	216	275.6	292.9	234
July 24, 2023	-	154.7	155.35	202.8	262.6	282.1	211.25
July 31, 2023	-	152.75	153.4	196.95	293.8	323.05	232.7
August 8, 2023	-	154.7	150.15	195	341.6	435.5	224.25
August 14, 2023	-	171.6	160.55	247.65	337.35	416	250.9
August 21, 2023	-	162.5	157.3	196.3	313.3	332.82	227.25
August 28, 2023	-	182	180.1	238.55	312	403	238.55
September 5, 2023	-	167.7	165.8	208	297.4	317.2	213.9
September 11, 2023	-	189.8	181.4	226.2	307.4	332.8	231.4
September 18, 2023	-	177.5	176.2	237.9	294.5	326.3	256.75
September 25, 2023	-	198.2	195	222.3	239.2	241.2	191.7
October 2, 2023	-	71.2	68.1	146.4	218.2	246.6	141.2
October 10, 2023	-	70.4	-	131.5	-	-	-
October 16, 2023	116.3	76.3	-	134.9	-	-	-
October 23, 2023	0	136.5	81.8	128.1	212.2	226.4	175.8
October 30, 2023	114.7	130	98	116.9	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	111.9	93.3	-	99.8	-	-	-
November 13, 2023	107.6	92.3	-	93.7	-	-	-
November 16, 2023	-	85.4	84.7	-	65.1	61.3	88.5
November 20, 2023	102.7	95	-	101.9	-	-	-
November 27, 2023	102.1	110.2	-	104.5	-	-	-
December 4, 2023	98.5	93.1	-	93.7	-	-	-
December 11, 2023	-	68.2	60.5	75.9	47.6	44.2	72.1
December 19, 2023	81.8	72	-	82.2	-	-	-

Date	Phosphate (mg/L)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	0.47	0.22	0.16	-	0.25	0.3
March 8, 2023	-	0.23	0.17	0.16	-	0.21	0.21
April 17, 2023	-	0.26	0.11	0.1	0.13	-	0.16
May 1, 2023	-	0.38	0.13	0.16	0.24	-	0.16
May 8, 2023	-	0.45	0.14	0.23	0.09	-	0.25
May 15, 2023	-	0.47	0.1	0.23	0.17	-	0.22
May 23, 2023	-	-	-	-	-	-	-
May 29, 2023	-	1.3	0.07	0.36	-	-	0
June 5, 2023	-	0.69	0.15	0.31	0.3	-	0.17
June 15, 2023	-	0.98	0.06	0.15	0.37	-	0.35
June 19, 2023	-	0.81	0.52	0.12	0.19	-	0.019
June 26, 2023	-	0.48	0.21	0.18	0.22	-	0.27
July 3, 2023	-	0.77	0.15	0.31	0.22	-	0.29
July 10, 2023	-	0.48	0.05	0.07	0.23	-	0.2
July 17, 2023	-	0.25	0.06	0.11	0.18	-	0.18
July 24, 2023	-	0.48	0.13	0.11	0.73	-	0.24
July 31, 2023	-	0.34	0.34	0.11	0.27	-	0.33
August 8, 2023	-	0.13	0.05	0.12	0.21	-	0.28
August 14, 2023	-	0.48	0.18	0.09	0.38	-	0.47
August 21, 2023	-	0.64	0.11	0.37	0.21	-	0.25
August 28, 2023	-	0.72	0.05	0.08	0.16	-	0.18
September 5, 2023	-	0.48	0.03	0.2	0.23	-	0.16
September 11, 2023	-	0.9	0.11	0.13	0.49	-	0.18
September 18, 2023	-	0.17	0.18	0.1	0.23	-	0.16
September 25, 2023	-	0.13	0.03	0.11	0.12	-	0.08
October 2, 2023	-	0.08	0.03	0.12	0.15	-	0.1
October 10, 2023	-	-	-	-	-	-	-
October 16, 2023	-	-	-	-	-	-	-
October 23, 2023	-	0.69	0.33	0.19	0.16	0	0.13
October 30, 2023	-	-	-	-	-	-	-
November 1, 2023	-	0	0	0	-	-	-
November 6, 2023	-	-	-	-	-	-	-
November 13, 2023	-	-	-	0.3	-	-	-
November 16, 2023	-	0.17	0.1	0	0.08	-	0.14
November 20, 2023	-	-	-	-	-	-	-
November 27, 2023	-	-	-	-	-	-	-
December 4, 2023	-	-	-	-	-	-	-
December 11, 2023	-	0.22	0.14	0.16	0.14	0	0.25
December 19, 2023	-	-	-	-	-	-	-

Date	Ammonia (mg/L)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	0.028	0.014	0.098	-	0.056	0.112
March 8, 2023	-	0.014	0	0.028	-	<<	0
April 17, 2023	-	0.042	0.014	<<	0.014	-	0.014
May 1, 2023	-	0.126	0.168	0.084	0.028	-	0.042
May 8, 2023	-	0.028	0.014	0.056	<<	-	0.056
May 15, 2023	-	0.294	0.056	0.154	0.112	-	0.112
May 23, 2023	-	-	-	-	0	-	-
May 29, 2023	-	0.28	0.042	0.21	0	-	0
June 5, 2023	-	>>	0.042	0.07	0.112	-	0.098
June 15, 2023	-	0.126	0.014	0.098	0.098	-	0.112
June 19, 2023	-	0.434	0.028	0.028	0.042	-	0.014
June 26, 2023	-	0.182	0.098	0.546	0.07	-	0.112
July 3, 2023	-	0.168	0.028	0.07	0.126	-	0.126
July 10, 2023	-	0.224	0.014	0.126	0.098	-	0.07
July 17, 2023	-	0.014	0.014	0.028	0.056	-	0.056
July 24, 2023	-	0.07	0.056	0.112	0.07	-	0.126
July 31, 2023	-	0.084	0.098	0.014	0.07	-	0.098
August 8, 2023	-	0.448	0.056	0.056	0.126	-	0.07
August 14, 2023	-	0.07	0.056	0.042	0.182	-	0.098
August 21, 2023	-	0.112	0.056	0.056	0.112	-	0.098
August 28, 2023	-	0.028	0.014	0.028	0.098	-	0.0042
September 5, 2023	-	0.098	<<	0.042	0.028	-	<<
September 11, 2023	-	0.14	0.784	0.364	0.056	-	0.028
September 18, 2023	-	0	<<	0.014	<<	-	<<
September 25, 2023	-	0.014	0	0.042	<<	-	0.014
October 2, 2023	-	<<	<<	<<	<<	-	<<
October 10, 2023	-	-	-	-	-	-	-
October 16, 2023	-	-	-	-	-	-	-
October 23, 2023	-	0.042	<<	<<	<<	-	<<
October 30, 2023	-	-	-	-	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	-	-	-	-	-	-	-
November 13, 2023	-	-	-	0.084	-	-	-
November 16, 2023	-	0.084	0	-	0.014	-	0.014
November 20, 2023	-	-	-	-	-	-	-
November 27, 2023	-	-	-	-	-	-	-
December 4, 2023	-	-	-	-	-	-	-
December 11, 2023	-	0.014	<<	0.07	<<	0	<<
December 19, 2023	-	-	-	-	-	-	-

Date	Nitrite (mg/L)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	0.0297	0.00726	0.0726	-	0.0132	0.0264
March 8, 2023	-	0.0198	0.0033	0.005	-	0.0132	0.0066
April 17, 2023	-	0.0099	0.0033	0.004	0	-	0.0132
May 1, 2023	-	0.0165	0.0033	0.004	0.0099	-	0.0132
May 8, 2023	-	0.0198	0.0132	0.009	0.0264	-	0.0231
May 15, 2023	-	0.0066	0.0066	0.012	0.462	-	0.0198
May 23, 2023	-	-	-	-	-	-	-
May 29, 2023	-	0.0528	-	0.016	0	-	-
June 5, 2023	-	0.1485	0.0132	0.016	0.0495	-	0.0033
June 15, 2023	-	0.1089	0.1485	0	0.033	-	0.0297
June 19, 2023	-	0.0264	0	0.002	0.0165	-	0
June 26, 2023	-	0.0099	0.0066	0.003	0.0165	-	0.0033
July 3, 2023	-	0.0198	0.0033	0.003	0.0231	-	0.0198
July 10, 2023	-	0.0132	0	0.004	0.0264	-	0.0132
July 17, 2023	-	0	0.0033	0.004	0.0165	-	0.0066
July 24, 2023	-	0	0.0033	0.002	0.0033	-	0.0132
July 31, 2023	-	0	0.0033	0.001	0.0231	-	0.0099
August 8, 2023	-	0.0957	0	0	0.0099	-	0
August 14, 2023	-	0.0033	0.0132	0	2.6532	-	0.0297
August 21, 2023	-	0.0033	0.0033	0	0.0165	-	0.0033
August 28, 2023	-	0	0.0099	0	0.0033	-	0.0132
September 5, 2023	-	0.066	0	0.004	0.0099	-	0
September 11, 2023	-	0.0033	0.0132	0.002	0.0099	-	0.0231
September 18, 2023	-	0	0	0	0.0198	-	0.0165
September 25, 2023	-	0.0066	0.0066	0	0.0099	-	0.0033
October 2, 2023	0	0.0099	0.0033	0.002	0.0033	-	0.0033
October 10, 2023	-	-	-	-	-	-	-
October 16, 2023	-	-	-	-	-	-	-
October 23, 2023	0	0.0066	0.0033	0.001	0.0165	-	0
October 30, 2023	-	-	-	-	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	-	-	-	-	-	-	-
November 13, 2023	-	-	-	0.013	-	-	-
November 16, 2023	0	0.0231	0.0033	-	0.0099	-	0.0198
November 20, 2023	-	-	-	-	-	-	-
November 27, 2023	-	-	-	-	-	-	-
December 4, 2023	-	-	-	-	-	-	-
December 11, 2023	0	0.0132	0.0132	0	0.0033	-	<<
December 19, 2023	-	-	-	-	-	-	-

Date	Nitrate (mg/L)						
	Somenos Lake Dock	Richards Creek at Herd Road	Richards Creek at Richards Trail	Somenos Creek	Bings Creek, Reach 1	Bings Creek, Mary-Phillips St.	Averill Creek
January 16, 2023	-	<<	<<	<<	-	-	<<
March 8, 2023	-	<<	<<	<<	<<	-	<<
April 17, 2023	-	<<	<<	<<	<<	<<	<<
May 1, 2023	-	<<	<<	<<	<<	<<	0
May 8, 2023	-	<<	<<	<<	<<	<<	<<
May 15, 2023	-	<<	<<	<<	<<	<<	<<
May 23, 2023	-	0	0	0	0	0	0
May 29, 2023	-	<<	<<	<<	0	0	0
June 5, 2023	-	<<	<<	<<	<<	<<	<<
June 15, 2023	-	<<	<<	<<	<<	<<	<<
June 19, 2023	-	<<	<<	<<	<<	<<	<<
June 26, 2023	-	<<	<<	<<	<<	<<	<<
July 3, 2023	-	<<	<<	0.396	<<	<<	<<
July 10, 2023	-	<<	<<	<<	<<	<<	<<
July 17, 2023	-	<<	<<	<<	<<	<<	<<
July 24, 2023	-	<<	<<	<<	<<	<<	<<
July 31, 2023	-	<<	<<	<<	<<	<<	<<
August 8, 2023	-	<<	<<	<<	<<	<<	<<
August 14, 2023	-	<<	<<	<<	<<	<<	<<
August 21, 2023	-	<<	<<	<<	<<	<<	<<
August 28, 2023	-	<<	<<	<<	<<	<<	<<
September 5, 2023	-	<<	<<	<<	<<	<<	<<
September 11, 2023	-	<<	<<	<<	<<	<<	0.0088
September 18, 2023	-	<<	0	<<	<<	<<	<<
September 25, 2023	-	<<	<<	<<	<<	<<	<<
October 2, 2023	-	-	-	-	<<	-	-
October 10, 2023	-	-	-	-	-	-	-
October 16, 2023	-	-	-	-	-	-	-
October 23, 2023	-	<<	<<	<<	<<	<<	0.0616
October 30, 2023	-	-	-	-	-	-	-
November 1, 2023	-	-	-	-	-	-	-
November 6, 2023	-	-	-	-	-	-	-
November 13, 2023	-	-	-	0	-	-	-
November 16, 2023	-	<<	<<	-	<<	<<	<<
November 20, 2023	-	-	-	-	-	-	-
November 27, 2023	-	-	-	-	-	-	-
December 4, 2023	-	-	-	-	-	-	-
December 11, 2023	-	<<	0	<<	<<	<<	<<
December 19, 2023	-	-	-	-	-	-	-

11 APPENDIX E – BEVERLY WETLAND WATER QUALITY RESULTS

	Dry Season															units	Max.for Aquatic Life	
	30-Aug-23			06-Sep-23			13-Sep-23			20-Sep-23			27-Sep-23					
sample location	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM			
sample name	BWQ1US.1	BWQ2US.1	BWQ1DS.1	BWQ1US.2	BWQ2US.2	BWQ1DS.2	BWQ1US.3	BWQ2US.3	BWQ1DS.3	BWQ1US.4	BWQ2US.4	BWQ1DS.4	BWQ1US.5	BWQ2US.5	BWQ1DS.5			
time sampled	13:41	13:35	13:20	14:54	14:44	14:37	13:37	13:26	13:17	15:01	14:57	14:49	14:11	14:05	13:55		Freshwater	In Effluent '*
Elements	1	2	3	4	S	6	7	8	9	10	11	12	13	14	15			
1) Aluminium	0.365	0.322	0.209	0.206	16.300	0.194	0.168	4.800	0.251	0.280	0.254	0.325	0.237	1.380	0.263	mg/L	n/a	4
2) Antimony	0.55	0.66	<0.500	<0.500	1.25	<0.500	<0.500	1.62	<0.500	0.90	<0.500	2.28	0.60	1.05	0.67	ug/L	n/a	5
3) Arsenic	2.140	1.960	1.160	3.060	4.740	0.780	0.657	4.890	2.210	0.761	1.300	0.880	0.515	1.690	0.644	ug/L	5	250
4) Barium	0.066	0.044	0.034	0.097	0.191	0.023	0.021	0.079	0.084	0.018	0.031	0.031	0.012	0.053	0.O]7	mg/L	n/a	1
5) Beryllium	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	mg/L	0.01	no limit listed
6) Boron	0.568	0.525	0.465	0.553	0.559	0.575	0.477	0.5l9	0.588	0.500	0.525	0.513	0.513	0.504	0.481	mg/L	n/a	5
7) Cadmium	<0.010	<0.010	<0.010	<0.010	0.608	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ug/L	1.05-2.11	10
8) Calcium	23.900	12.700	16.900	35.000	14.800	22.200	24.800	11.300	31.900	6.170	26.900	10.300	4.690	11.900	B.10	mg/L	n/a	no limit listed
9) Chromium	<0.003	<0.003	<0.003	<0.003	0.044	<0.003	<0.003	0.014	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	mg/L	0.1	0.03
10) Cobalt	<0.005	<0.005	<0.005	<0.005	0.014	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	mg/L	1.32	0.5
ll) copper	0.029	0.019	<0.008	<0.008	0.200	<0.008	<0.008	0.071	<0.008	0.015	<0.008	0.026	0.009	0.038	<0.008	mg/L	0.030-0.127	0.5
12) Gold	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	mg/L	n/a	no limit listed
13) Iron	9.380	4.000	7.140	15.100	37.600	3.990	3.390	14.300	11.900	1.610	10.600	0.563	0.955	3.000	1.120	mg/L	1	1
14) Lanthanum	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	mq/L	n/a	no limit listed
15) Lead	<0.500	1.030	<0.500	<0.500	77.300	<0.500	<0.500	21.600	<0.500	<0.500	<0.500	0.752	<0.500	<0.500	<0.500	uq/L	30	100
16) Magnesium	5.310	2.100	6.200	8.930	7.510	6.770	8.710	3.290	8.420	1.230	6.980	1.410	0.910	2.280	2.060	mg/L	n/a	no limit listed
17) Manganese	0.663	0.208	0.155	0.796	0.434	0.225	0.291	0.264	0.709	0.170	0.316	0.052	0.071	0.147	0.091	mg/L	n/a	0.05
18) Mercury	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ug/L	2	5
19) Molybdenum	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	mg/L	n/a	0.5
20) Nickel	<0.004	0.005	<0.004	<0.004	0.026	<0.004	<0.004	0.009	<0.004	<0.004	<0.004	0.004	<0.004	0.004	<0.004	mg/L	n/a	0.5
21) Phosphorus	0.362	0.191	0.168	0.282	2.340	0.073	0.044	1.060	0.179	0.072	0.199	0.131	0.077	0.295	0.096	mg/L	n/a	1.5
22) Potassium	1.900	0.840	0.290	2.380	1.080	0.290	0.170	0.740	2.220	0.710	0.260	0.770	0.430	1.750	1.850	mg/L	n/a	no limit listed
23) Scandium	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	mg/L	n/a	no limit listed
24) Selenium	<0.500	<0.500	<0.500	<0.500	0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	10	100
25) Silicon	2.380	1.520	1.820	2.460	13.700	2.680	2.630	4.980	2.680	1.030	1.840	1.010	0.688	1.740	1.140	mg/L	n/a	no limit listed
26) Silver	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	mg/L	0.01	1
27) Sodium	55.800	11.200	13.500	74.700	10.300	13.200	15.900	12.800	67.200	10.200	12.100	12.600	9.170	11.400	9.790	mg/L	n/a	no limit listed
28) Strontium	0.110	0.050	0.070	0.170	0.070	0.090	0.100	0.050	0.160	0.030	0.110	0.040	0.020	0.050	0.030	mg/L	75	no limit listed
29) Tin	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	mg/L	n/a	no limit listed
30) Titanium	<0.010	<0.010	<0.010	<0.010	0.412	<0.010	<0.010	0.141	<0.010	<0.010	<0.010	<0.010	<0.010	0.041	<0.010	mg/L	n/a	no limit listed
31) Tungsten	<0.050	<0.050	<0.050	<0.050	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	mg/L	n/a	no limit listed
32) Vanadium	<0.010	<0.010	<0.010	<0.010	0.063	<0.010	<0.010	0.021	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	mg/L	n/a	no limit listed
33) Zinc	0.061	0.227	0.004	0.020	0.991	0.003	<0.001	0.450	0.017	0.046	0.004	0.205	0.039	0.259	0.028	mg/L	0.490-1.35	5
Hardness mg/L (CaCO3)	81.500	40.400	67.700	124.000	67. 9	83.300	97.800	41.800	114	20.S	95.900	31.500	15.500	39.100	28.700	mg/L	0-75 mg/L = soft	
pH	6.850	6.560	6.650	6.320	6.090	6.980	6.860	6.l9	6.44	7.390	6.680	6.350	6.670	6.370	6.780	[H+]	6.5-9.0	5.5-11.0

	Wet Season															units	Max.for Aquatic Life	
	25-Oct-23			01-Nov-23			08-Nov-23			16-Nov-23			22-Nov-23					
sample location	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM	UPSTREAM1	UPSTREAM2	DOWNSTREAM			
sample name	BWQ1US.6	BWQ2US.6	BWQ1DS.6	BWQ1US.7	BWQ2US.7	BWQ1DS.87	BWQ1US.8	BWQ2US.8	BWQ1DS.8	BWQ1US.9	BWQ2US.9	BWQ1DS.9	BWQ1US.10	BWQ2US.10	BWQ1DS.10		Freshwater	In Effluent '*
time sampled	14:41	14:46	14:57	14:03	13:37	13:47	13:16	13:20	13:27	12:33	12:29	12:22	14:10	14:05	13:58			
Elements	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
1) Aluminium	0.301	0.434	0.205	0.184	1.600	0.185	0.197	0.937	0.189	0.179	0.211	0.158	0.211	0.316	0.196	mg/L	n/a	4
2) Antimony	<0.500	0.66	<0.500	<0.500	0.65	<0.500	<0.500	0.83	<0.500	<0.500	<0.500	<0.500	<0.500	0.62	<0.500	ug/L	n/a	5
3) Arsenic	2.600	<0.500	<0.500	1.690	2.070	<0.500	1.530	1.460	0.574	1.270	1.370	<0.500	1.500	1.170	<0.500	ug/L	5	250
4) Barium	0.054	0.017	0.011	0.063	0.089	0.025	0.066	0.065	0.027	0.053	0.055	0.023	0.065	0.041	0.021	mg/L	n/a	1
5) Beryllium	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	mg/L	0.01	no limit listed
6) Boron	0.464	0.490	0.546	0.456	0.5l9	0.491	0.462	0.516	0.527	0.499	0.507	0.464	0.524	0.468	0.450	mg/L	n/a	5
7) Cadmium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ug/L	1.05-2.11	10
8) Calcium	28.300	4.760	5.220	33.700	42.800	21.300	36.700	23.200	19.300	30.100	31.000	18.600	35.300	19.200	15.000	mg/L	n/a	no limit listed
9) Chromium	<0.003	<0.003	<0.003	<0.003	0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	mg/L	0.1	0.03
10) Cobalt	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	mg/L	1.32	0.5
ll) copper	<0.008	0.011	<0.008	<0.008	0.034	<0.008	<0.008	0.010	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	mg/L	0.030-0.127	0.5
12) Gold	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	mg/L	n/a	no limit listed
13) Iron	4.280	0.524	0.631	6.720	10.500	2.930	6.150	2.400	2.590	4.570	1.820	2.000	6.760	1.270	1.130	mg/L	1	1
14) Lanthanum	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	mq/L	n/a	no limit listed
15) Lead	<0.500	1.660	<0.500	<0.500	<0.500	<0.500	<0.500	1.760	<0.500	<0.500	<0.500	<0.500	<0.500	1.450	<0.500	uq/L	30	100
16) Magnesium	5.920	0.650	1.200	8.500	9.220	6.030	8.390	3.590	5.000	6.560	6.250	4.950	8.230	3.260	3.850	mg/L	n/a	no limit listed
17) Manganese	0.340	0.022	0.041	0.460	0.536	0.329	0.585	0.297	0.309	0.365	0.360	0.209	0.556	0.136	0.055	mg/L	n/a	0.05
18) Mercury	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	ug/L	2	5
19) Molybdenum	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	mg/L	n/a	0.5
20) Nickel	<0.004	<0.004	<0.004	<0.004	0.005	<0.004	<0.004	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	mg/L	n/a	0.5
21) Phosphorus	0.070	0.045	0.028	0.097	0.241	0.051	0.111	0.068	0.056	0.077	0.025	0.044	0.108	0.034	0.024	mg/L	n/a	1.5
22) Potassium	1.460	0.390	0.310	1.870	1.120	0.480	1.740	1.700	0.690	1.350	1.060	0.590	1.740	1.230	0.940	mg/L	n/a	no limit listed
23) Scandium	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	mg/L	n/a	no limit listed
24) Selenium	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	ug/L	10	100
25) Silicon	2.680	0.871	0.908	3.110	2.900	2.150	4.310	2.070	1.860	3.880	2.070	2.140	4.650	1.260	1.710	mg/L	n/a	no limit listed
26) Silver	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	mg/L	0.01	1
27) Sodium	39.100	10.500	3.670	52.300	62.500	11.100	51.600	22.400	11.400	38.600	27.600	10.000	49.400	25.900	24.800	mg/L	n/a	no limit listed
28) Strontium	0.130	0.020	0.020	0.160	0.170	0.080	0.160	0.100	0.080	0.130	0.130	0.070	0.160	0.080	0.060	mg/L	75	no limit listed
29) Tin	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	mg/L	n/a	no limit listed
30) Titanium	<0.010	<0.010	<0.010	<0.010	0.049	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	mg/L	n/a	no limit listed
31) Tungsten	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	mg/L	n/a	no limit listed
32) Vanadium	<0.010	<0.010	<0.010	<0.010	0.013	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	mg/L	n/a	no limit listed
33) Zinc	0.030	0.145	0.022	0.005	0.137	0.018	0.007	0.515	0.028	0.022	0.126	0.020	0.010	0.182	0.014	mg/L	0.490-1.35	5
Hardness mg/L (CaCO3)	95.000	14.600	18.000	119.000	145.000	78.000	126.000	72.700	68.800	102.000	103.000	66.800	122.000	61. 4	53.300	mg/L	0-75 mg/L = soft	
pH	6.560	6.860	6.230	6.610	6.240	6.460	6.490	6.380	6.340	6.620	6.330	6.460	6.460	6.640	6.670	[H+]	6.5-9.0	5.5-11.0

12 APPENDIX F – PARROT'S FEATHER CONTROL PROJECT

TABLE 1: DATES OF ALL MAJOR ACTIVITY COMPLETED IN SOMENOS CREEK DURING THE PARROT'S FEATHER CONTROL PROJECT.

Date	Cutting *M. aquaticum*	Removing *M. aquaticum*	Water quality (YSI, and Hobo data download)
23-Jun-23			*
28-Jun-23	*		*
05-Jul-23	*		*
19-Jul-23	*	*	*
20-Jul-23		*	
25-Jul-23		*	
26-Jul-23			*
28-Jul-23		*	*
01-Aug-23		*	
02-Aug-23	*		*
04-Aug-23		*	
10-Aug-23		*	
11-Aug-23		*	
15-Aug-23		*	*
17-Aug-23		*	
22-Aug-23	*		*
29-Aug-23		*	
31-Aug-23		*	
06-Sep-23		*	
13-Sep-23			*
21-Sep-23		*	*
03-Oct-23			*
26-Oct-23			*

13 APPENDIX G - RIPARIAN RESTORATION: PLANTING INFORMATION TABLES

TABLE 1: MADRONE ENVIRONMENTAL SERVICES LTD. RECOMMENDATIONS AND OBSERVATIONS VS WHAT WAS COMPLETED FOR THE RIPARIAN RESTORATION PROJECT ALONG SOMENOS CREEK PHASE ONE HAYFIELD.

Treatment Area 1	**Recommendations and observations from Madrone 2023 Report**	**How recommendations were applied on site**
Timeline	Site prep: spring/summer 2023, spring 2024 Planting: summer/fall 2023, spring 2024, spring 2025 Watering: for 2 summers after planting Maintenance and reporting: spring 2024 through to fall 2025	Treatment area 1 site prep began in April 2023, planting took place May to the end of June 2023. Management of site (watering) continued through the summer of 2023. Monitoring and maintenance of treatment area 1 took place over the fall and winter of 2023. Planned planting of Treatment areas 3 through 5 will commence in Spring 2024. Monitoring and maintenance of treatment areas 1 though 5 will continue into 2026.
Site conditions and prep	Remove Rubus armeniacus Myriophyllum aquaticum to prepare site for planting.	Rubus armeniacus was not present at site therefore no removal was necessary. Presence of Iris pseudacorus and tall canary grasses caused issues while planting, limited removal and cutting of both were undertaken. Myriopyllum aquaticum was only present on and in the water on Somenos Creek at summer flow levels, therefore it was determined that no removal was necessary to carry out the prescribed restoration.

<table>
<tr>
<td>Recommended species type and amount</td>
<td>
<table>
<tr><th>Species</th><th>Amount</th></tr>
<tr><td>Crataegus douglasii</td><td rowspan="2">Total plants 1-gallon pots 797, total trees 2-gallon pots 212</td></tr>
<tr><td>Spirea douglasii</td></tr>
<tr><td>Oemleria cerasiformus</td><td rowspan="2">Total 1009 plants</td></tr>
<tr><td>Rosa nutkana</td></tr>
<tr><td>Physocarpus capitatus</td><td></td></tr>
<tr><td>Cornus sericea</td><td></td></tr>
<tr><td>Malus fusca</td><td></td></tr>
<tr><td>Salix lucida</td><td></td></tr>
<tr><td>Salix Scouleriana</td><td></td></tr>
<tr><td>Alnus rubra</td><td></td></tr>
</table>

Later correspondence with Greg Howard indicated somewhere between 700-800 trees would be better suited as the treatment area changed after meeting with the adjacent landowner and the Municipality of north Cowichan.
</td>
<td>
<table>
<tr><th>Species</th><th>Amount Bought</th><th>Amount Planted</th></tr>
<tr><td>Populus trichocarpa</td><td>75</td><td>73</td></tr>
<tr><td>Alnus rubra</td><td>50</td><td>48</td></tr>
<tr><td>Thuja plicata</td><td>75</td><td>38</td></tr>
<tr><td>Malus fusca</td><td>46</td><td>35</td></tr>
<tr><td>Crataegus douglasii</td><td>75</td><td>51</td></tr>
<tr><td>Salix lucida</td><td>50</td><td>48</td></tr>
<tr><td>Salix Scouleriana</td><td>50</td><td>48</td></tr>
<tr><td>Physocarpus capitatus</td><td>75</td><td>40</td></tr>
<tr><td>Cornus sericea</td><td>50</td><td>40</td></tr>
<tr><td>Oemleria cerasiformus</td><td>75</td><td>68</td></tr>
<tr><td>Spirea douglasii</td><td>100</td><td>99</td></tr>
<tr><td></td><td>Total: 721</td><td>Total: 588</td></tr>
</table>

Due to the change in planting area, fewer plants than initially suggested, were purchased. Out of the 750 plants ordered 29 were not delivered, 25 C. sericea and 4 M. fusca.

52 plants died in total, either having arrived weak or dying in storage: 7 O. cerasiformis, 10 C. cericea, 1 S. douglasii, and 30 P. capitatus. An additional 4 died in storage after planting was completed.

The remaining 81 plants not planted at the Hayfield were planted in other riparian areas along Somenos Creek, on the Haycroft Chase Strata and MNC property and east of Lakes Road bridge.
</td>
</tr>
</table>

Location of planting	S. douglasii buffer along creek, no trees higher than 5m, drier soil compared to other treatment areas. Plant native trees and shrubs along unvegetated areas, plant trees closer to established vegetation.	Only small sections of treatment area had established vegetation, two areas had some S. douglasii and willows established. Northern portion of planting area dry, southern section was very wet and flooded during the fall of 2023.
	Planting location in relation to Somenos Creek **Near:** *S. douglasii, Salix* **Neutral:** *C. douglasii, O. ceraciformus, P. capitatus, C. sericea, A, rubra* **Far:** *R. nutkana, M. fusca*	Planting location in relation to Somenos Creek **Near:** S*. douglassi, Salix, C. sericea* **Middle:** *T. plicata, A. Rubra, P. trichocarpa* **Far:** *O. cerasiformis, P. capitatus, M. fusca, C. douglasii*
		Note: after speaking with farmer and Madrone staff this planting order was determined to limit vegetation interfering with working field.
Planting methods and suggestions	Shrubs should be 1-gallon size, trees 2-gallon.	Due to limited availability at nursery where plants were purchased, both 1-gallon and 2-gallon size shrubs and trees were planted. This was reviewed and confirmed by Madrone.
	Madrone 2023 Report: Plants should be planted 1 per $1m^2$ except for those closest to Somenos Creek which should be planted in increased density. **Email correspondence with Greg Howard:** plant all 1-gallon plants every $1m^2$ and 2- gallon plants every $5m^2$.	All plants were planted one plant every $1m^2$ to maintain simplicity in the process and ensure adequate vegetation coverage.
	Planting should take place in spring, before the end of May, weather depending.	Planting took place in May and June of 2023; the later start was caused by a delay in permissions to access the site and a delay in the plant order arriving.
	Ensure root ball is in correct condition to plant, planting at correct depth and cover in mulch.	All planting followed planting depth and root ball conditions guidelines. No mulch was used, due to the flooding that occurs on site this was not a viable option. Instead, it was observed that already established vegetation provided adequate protection for the plants base.
Plant watering	Water plants deeply (30cm) once per week during dry season.	From May 25th to September 29th plants were watered deeply (30cm) 1 – 3 times a week depending on weather (see watering schedule).

Fencing and browse deterrent	Caging and cones or browse protectors were suggested but not required.	Due to the price and time required to fence each plant this was not done when planted, however, in the fall of 2023 monitoring was completed and some damage to the plants was observed. In response select trees (A. rubra and P. trichocarpa) were fenced.
	Spray on browse deterrent like Plantskydd suggested.	Nutrient and browse deterrent 'tea bags' from Spectrum Pacific Products were used in place of spray on deterrent. Specifically, the Defender and the Aqua-Zorb packs.
Monitoring	Quarterly site visits after planting completed, with ongoing management of plants, protection, and replacement. Target of 80% survivorship.	Treatment area 1 was monitored in late August 2023 and Winter (November 2023) but due to surrounding vegetation and difficulty in locating plants, survivorship percentage was not calculated. Survivorship percentage will be calculated in the spring of 2024. Monitoring of the locatable plants was done in November and some animals browsing was noted, those plants were caged to prevent further browsing. It was noted that some plants had been eaten completely, replacement plants have been purchased and will be planted in the spring of 2024. Planned future monitoring will be quarterly for 2 years after planting for treatment area 1 and 2 years for treatment areas 3 through 5 after planting is completed. Protection methods will be utilized, and replacements will be purchased where applicable.

Table 2: Hayfield Watering Schedule - Summer 2023			
Month	**Day**	**Run time/minutes**	**Personnel**
May	25	120	1
June	1	120	1
	8	140	1
	20	150	1
	22	150	1
	27	170	1
	29	200	1
July	5	200	1
	7	200	1
	10	45	2
	12	30	2
	14	50	2
	17	50	3
	19	60	3
	21	45	3
	26	50	2
	28	55	2
August	1	50	2
	4	60	2
	8	30	3
	11	45	3
	14	50	3
	16	60	3
	21	65	2
	23	50	2
	25	50	2
	28	60	2
	30	70	2
September	1	180	1
	6	195	1
	15	190	1
	18	200	1

TABLE 3: THE HAYFIELD SOUTH OF THE LAKES ROAD FOOTBRIDGE (HAYFIELD).

Species Common Name	Species Scientific Name
Black cottonwood	*Populus trichocarpa*
Alder	*Alnus rubra*
Western red cedar	*Thuja plicata*
Oregon crabapple	*Malus fusca*
Black Hawthorn	*Crataegus douglasii*
Pacific willow	*Salix lucida*
Scoulers Willow	*Salix scouleriana*
Pacific ninebark	*physocarpus capitatus*
Red osier dogwood	*Cornus sericea*
June plum	*Omleria cerasiformus*
hardhack	*Spirea douglasii*

TABLE 4: THE OPEN SECTION ON THE NORTH SIDE OF SOMENOS CREEK, JUST WEST OF LAKES ROAD (WEST OF LAKES ROAD)

Species Common Name	Species Scientific Name
oregon grape	*Mahonia aquifolium*
sitka spruce (MOTI)	*Picea sitchensis*
black cottonwood	*Populus trichocarpa*
black hawthorn	*Crataegus douglasii*
pacific ninebark	*physocarpus capitatus*
hardhack	*Spirea douglasii*
red flowering currant	*Ribes sanguineum*
oregon crabapple	*Malus fusca*
red alder	*Alnus rubra*
red osier dogwood	*Cornus sericea*
willow	unknown

june plum	*Omleria cerasiformus*
sitka spruce	*Picea sitchensis*

TABLE 5: THE SOUTHWEST SIDE OF THE HAYCROFT CHASE STRATA PROPERTY AND MNC RIGHT OF WAY (STRATA)

Species Common Name	Species Scientific Name
oregon Crabapple	*Malus fusca*
black Hawthorn	*Crataegus douglasii*
hardhack	*Spirea douglasii*
pacific ninebark	*physocarpus capitatus*
june plum	*Omleria cerasiformus*
red alder	*Alnus rubra*
black cottonwood	*Populus tricocarpa*
red osier dogwood	*Cornus sericea*
sitka spruce	*Picea sitchensis*

TABLE 6: THE NORTH SIDE OF SOMENOS CREEK ALONG THE MUNICIPAL PARK BETWEEN LAKES ROAD AND SEINE ROAD (PARKSIDE).

Species Common Name	Species Scientific Name
sitka Spruce	*Picea sitchensis*
western hemlock (MOTI)	*Tsuga heterophylla*
red Alder	*Alnus rubra*
black cottonwood	*Populus trichocarpa*

14 APPENDIX H - REFERENCES

Burns, T. (2000). Lower Bings Creek Restoration 2000: A Report for Somenos Marsh Wildlife Society and Nature Trust. September 10, 2000. 1-7.

Burns, T. (2002). A Salmonid Productions Plan for the Cowichan Valley Regional District and Cowichan Fish and Habitat Renewal. March 2002. 1-616.

BC Ministry of Environment (BCMOE). 2001. Water Quality Guidelines for Temperature: Overview Report. Retrieved January 18, 2022 from https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/temperature-or.pdf

British Columbia Ministry of Environment and Climate Change Strategy (BCMOE). 2023. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture - Guideline Summary. Water Quality Guideline Series, WQG-20. Prov. B.C., Victoria B.C.

Somenos Marsh Wildlife Society (SMWS 2022). Annual Water Quality Report for the Municipality of North Cowichan. 1-48.

Canadian Council of Ministers of the Environment. 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment. 2004. Canadian water quality guidelines for the protection of aquatic life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems. In: Canadian environmental quality guidelines, 2004, Canadian Council of Ministers of the Environment, Winnipeg.

Carter, K. (2005). The Effects of Dissolved Oxygen on Steelhead Trout, Coho Salmon, and Chinook Salmon Biology and Function by Life Stage. California Regional Water Quality Control Board, North Coast Region. 7pp.

Davis, J. C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: A Review. Journal of the Fisheries Research Board of Canada, 32(12), 2295–2332. https://doi.org/10.1139/f75-268

District of North Vancouver (DNV). unknown. Planting Criteria and Recommended Native Tree and Shrub Species for Restoration and Enhancement of Fish and Wildlife Habitat. Environment Department. Retrieved February 14, 2022, from https://www.dnv.org/sites/default/files/edocs/native-tree-and-shrub-list-for-restoration-planting.pdf

Environment and Climate Change Canada. 2022. Weather Dashboard for Duncan. Retrieved January 26, 2022, from https://duncan.weatherstats.ca/charts/rain-weekly.html.

Environmental Measurement Systems (EMS). 2019. Water temperature. Retrieved January 18, 2022, from https://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature/#watertemp6

Hilliard, C. & Reedyk, S. (2020, July 29). Government of Canada. Agriculture and Agri-Food Canada. *Riparian Area Management.* https://agriculture.canada.ca/en/agricultural-production/soil-and-land/riparian-area-management

Mazumder A, Taylor WD, McQueen DJ, Lean DR. 1990. Effects of fish and plankton and lake temperature and mixing depth. Science. 247(4940):312-5. doi: 10.1126/science.247.4940.312. PMID: 17735850.

Preikshot, D. (2019). Management Options, Monitoring Programs, and Research Designs for Controlling Parrot's Feather in Somenos Creek. Prepared by Somenos Marsh Wildlife Society and Madrone Environmental Services for The Municipality of North Cowichan. https://static1.squarespace.com/static/5bf5e80b4eddecf99a694748/t/5e1cb30a59e9f01e93c128d9/1578939150727/Somenos+Basin+Parrots+Feather+Monitoring+and+Management+Plan.pdf

Rosen, B.H., and St. Amand, Ann. 2015. Field and laboratory guide to freshwater cyanobacteria harmful algal blooms for Native American and Alaska Native Communities: U.S. Geological Survey Open-File Report 2015–1164, 44 p., http://dx.doi.org/10.3133/ofr20151164.

Schindler, D. W., & Vallentyne, J. R. 2008. The Algal Bowl: Overfertilization of the world's freshwaters and Estuaries. University of Alberta Press.

Singleton, H. (2021) *Ambient Water Quality Guidelines (Criteria) for Turbidity, Suspended Solids and benthic Sediments. Overview Report*. Ministry of Environment and Parks. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/bc_env_working_water_quality_guidelines.pdf

U.S. Environmental Protection Agency (EPA). 2013. Aquatic Life water quality criteria for Ammonia (Freshwater). Office of Water. Retrieved January 4, 2023, from https://www.epa.gov/sites/default/files/2015-08/documents/fact_sheet_aquatic-life-ambient-water-quality-criteria-for-ammonia-freshwater-2013.pdf

U.S. Environmental Protection Agency (EPA). 1986. Ambient Aquatic Life water quality criteria for Dissolved Oxygen (Freshwater). Office of Research and Development Environmental Research Laboratories. Retrieved January 18, 2022, from https://www.epa.gov/sites/default/files/2019-03/documents/ambient-wqc-dissolved-oxygen-1986.pdf

Washington State Department of Ecology. (2001). Non-native Invasive Freshwater Plants: Parrot's Feather. Washington State Government. Retrieved December 2021, from https://web.archive.org/web/20110130222140/http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua003.html.

Wersal, R. & Madsen, J. (2013) Influences of Light Instensity Variations on Growth Characteristics of Myriophyllum aquaticum, Journal of Freshwater Ecology, 28:2, 147-164, https://doi.org/10.1080/02705060.2012.722067