Jemseg Grand Lake Watershed Association

Water Quality Monitoring, Education and Climate Change Adaptation in the Jemseg Grand Lake Watershed

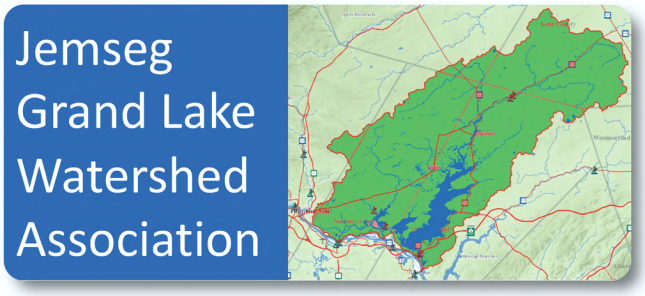
NBETF Project 230254 Final Report

by

Mary Murdoch, Mikael Gyllström, Eric Luiker,
Laura Lavigne, Michael Kelly, Greg Gillis

February 28, 2024

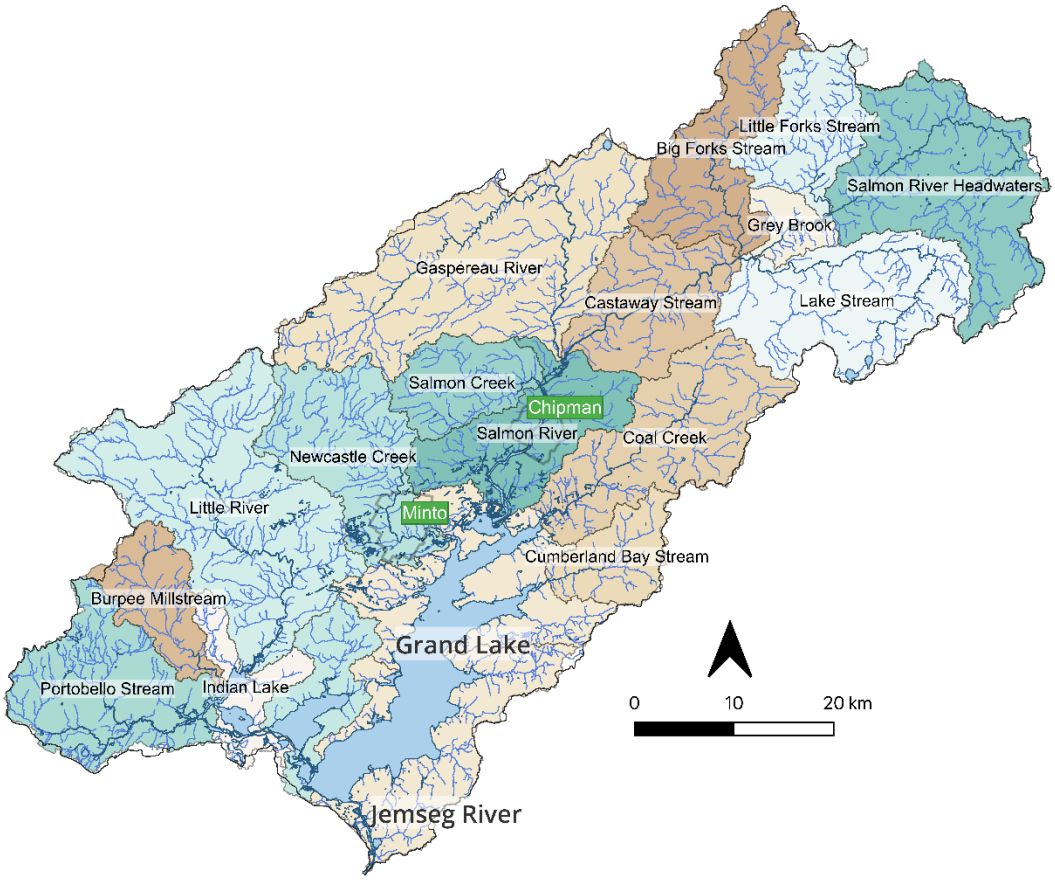
Jemseg Grand Lake Watershed Association Report 24-02



www.jemseggrandlakewatershed.ca

New Nouveau Brunswick
Your Environmental Trust Fund at Work

cite as
Murdoch, M. Gyllström, M. Luiker, E. Lavigne, L. Kelly, M. and Gillis, G. " Water Quality Monitoring, Education and Climate Change Adaptation in the Jemseg Grand Lake Watershed", Jemseg Grand Lake Watershed Association report 24-02, February 28, 2024, 38 pages.



Water Quality Monitoring, Education and Climate Change Adaptation in the Jemseg Grand Lake Watershed

A Report to the New Brunswick Environmental Trust Fund for
the 2023 – 2024 Fiscal Year
Project 230-254

February 28, 2024

Prepared by:

Jemseg Grand Lake Watershed Association

Jemseg Grand Lake Watershed Association

www.jemseggrandlakewatershed.ca

Table of Contents

1.0 OVERVIEW 1

2.0 WATER MONITORING PROGRAM 2
2.1 INTRODUCTION 2
2.2 METHODS 2
2.2.1 Water Quality 2
2.2.2 Cyanobacteria and Cyanotoxins 4
2.2.3 Temperature Loggers 4
2.2.4 Escherichia coli 5
2.2.5 Algae Tracker 5
2.3 DATA ANALYSIS 5
2.4 RESULTS 6
2.4.1 Grand Lake Surface Water Biophysical Characteristics 6
2.4.2 Temperature 7
2.4.3 Vertical Profiles 9
2.4.4 Water Quality 9
2.4.5 Water Quality Index 13
2.4.6 Trophic State Index 14
2.4.7 Escherichia coli 16
2.4.8 Algae Tracker 16
2.5 DISCUSSION 18
2.6 RECOMMENDATIONS 19
2.7 ACKNOWLEDGEMENTS 19
2.8 REFERENCES 19

3.0 MONITORING AND REMOVAL OF EURASIAN WATERMILFOIL WITHIN GRAND LAKE 21
3.1 INTRODUCTION 21
3.2 METHODS 21
3.2.1 Survey 21
3.2.2 Removal 23
3.3 RESULTS 24
3.3.1 Survey 24
3.3.2 Removal 25
3.4 DISCUSSION 25
3.4.1 Survey 25
3.4.2 Removal 26
3.5 RECOMMENDATIONS 27
3.6 ACKNOWLEDGEMENTS 27
3.7 REFERENCES 27
3.8 PHOTO APPENDIX OF EWM MONITORING AND REMOVAL, SEPTEMBER 2023 28

3.9 DATA APPENDIX FOR EWM MONITORING AND REMOVAL, SEPTEMBER 2023 31
3.9.1 EWM Survey Plots 31
3.9.2 EWM Removal Plots 32

4.0 ENVIRONMENTAL DNA PILOT STUDY 33
4.1 INTRODUCTION 33
4.2 METHODS 33
4.3 RESULTS 35
4.4 DISCUSSION 36
4.5 RECOMMENDATIONS 36
4.6 REFERENCES 36

5.0 EDUCATION AND OUTREACH 37
5.1 RECOMMENDATIONS 38

1.0 OVERVIEW

The Jemseg Grand Lake Watershed Association (JGLWA) was formed in the fall of 2019 by committed volunteers to initiate activities to build public interest and to work together for the benefit of our environment and the watershed area. In the 2023-2024 fiscal year, JGLWA received $60,000 from NBETF to conduct several activities, focused on water quality monitoring, education, and climate change adaptation in the Jemseg Grand Lake watershed. We are proud of what we have accomplished in this past year, and we provide a summary of our activities in this report. Each chapter profiles a program we conducted and includes a summary of methods, results, and recommendations for future work.

Chapter 2 provides a summary of our water quality monitoring program in 2023, including chemical parameters at sites in Grand Lake and three rivers, *E. coli* at several locations, temperature logger, cyanotoxin sampling, and use of an Algae T for algal blooms.

Chapter 3 summarizes our program to survey for and remove Eurasian watermilfoil, which is an invasive aquatic plant species first noticed in the watershed in 2022.

Chapter 4 describes our pilot environmental DNA study to learn more about the fish community in the watershed.

Chapter 5 provides an overview of our education and outreach activities.

We had big plans for the 2023-2024 fiscal year and, for the most part, we delivered on these plans. We rely on our volunteers to plan and conduct our activities, and to secure the financial resources to hire contractors for specialized work. We made a few adjustments based on available funding and volunteer capacity, as follows. The climate change activity involving planting of red-tip willow to reduce shoreline erosion was postponed due to the lack of resources to carry out the field work and report plantings to NBDELG. Also, although we planned to install “Clean, Drain, Dry” signs, we were unable to secure a contractor with an excavator to install the large format signs before ground freeze up. We will endeavour to do the installations in 2024.

2.0 WATER MONITORING PROGRAM

This chapter was prepared by Mikael Gyllström and Eric Luiker.

2.1 INTRODUCTION

In 2020, the JGLWA (the association) initiated a water quality monitoring program that was funded through the NBETF program. During the following years the sites and monitoring components have been continuously tweaked to allow us to better assess the water quality of Grand Lake.

Our program was designed to examine the water quality of Grand Lake, its main inflows as well as the outflow (Jemseg River). Feedback from the results of previous years continue to guide the evolution and improvement of the program. During 2020 some of the water chemistry parameters were highest near sections of Grand Lake close to river inflows. Therefore, three river stations were added to the program in 2021 to determine the quality of waters inflowing to the lake. During 2022 the investigation into the nature of the influence of the different tributaries focused on the lakes in the southwestern tributaries. The goal was to see if more light could be shed on sources of the relatively high nutrient levels entering Grand Lake from these sub catchments. During 2023 the program was further tailored to focus on monitoring of the stations that have emerged as the key ones to maintain the base program. These stations are the three river sites used to gauge the state in, and influence of, the three main tributary systems as well as three sites in Grand Lake itself. Based on the lack of any indication of problems related to *Escherichia coli* (*E. coli*) during the intensified sampling program during 2022, the program was restricted to four sites during 2023. To assess algal blooms and learn about the potential for cyanobacteria blooms, an Algae Tracker was obtained from the Hammond River Angling Association and deployed at Cumberland Point from June to October 2024.

The sampling program was led by Eric Luiker and Mary Murdoch from the association, and they also performed the river site monitoring. Lake sampling was conducted by Aaron Fraser (Willowbrook Watershed Services), Mikael Gyllström (Meekoi Ecological Consultancy), and Mike Kelly from the association. Mikael Gyllström performed the data analyses and prepared the report with input and review from Eric Luiker and Mary Murdoch.

2.2 METHODS

2.2.1 Water Quality

Grand Lake is the largest lake in New Brunswick and is fed by three main inflows: Salmon River, New Castle Creek, and the Maquapit Thoroughfare Exit (Maquapit Exit). Outflow is through the Jemseg River to the Saint John River. Three river stations at Salmon River, Newcastle Creek, and Lakeville Corner are designed to capture the influence of these inflows (Figure 2.1). To get a better picture of the dynamics in the catchments feeding into the Maquapit Thoroughfare Exit four stations were established, one in the outlet of Indian Lake, two on French Lake and one on Maquapit Lake (Figure 2.1).

Site ID	Location	Depth (m)
JGLP04	Grand Point Bar	25
JGLP05	Jemseg River	8
JGLP06	Maquapit Exit	4
JGLR02	Newcastle Creek	
JGLR03	Lakeville Corner	
JGLR05	Chipman Marina	

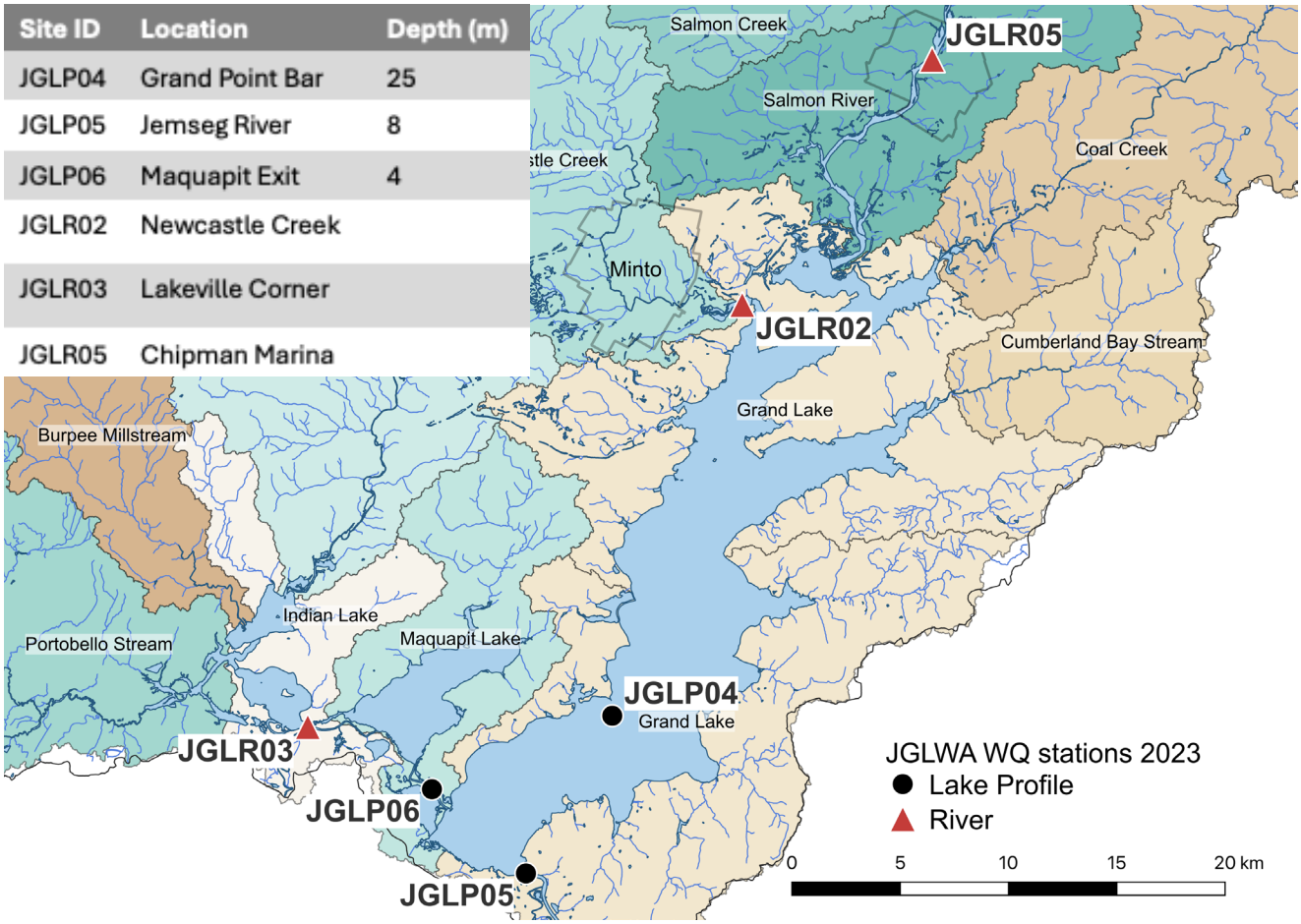


Figure 2.1 Jemseg Grand Lake Watershed water quality sampling stations. Legend indicates station site name, location, and depth at lake sites. Hydrography: NB DERD (2022, open government license) Sub-watersheds are colour shaded (NCC, 2019 CC BY-NC 3.0).

In Grand Lake three of the six established stations were monitored during 2023 (Figure 2.1). The Maquapit Exit station near the inflow of the southwestern tributaries was sampled so that it could be related to conditions in those tributaries. The Grand Point Bar station was sampled to represent the conditions in the central, deeper part of the lake. The station near the outlet to Jemseg river was sampled to give an idea of the quality of the water discharged from the lake. In addition to this samples were taken from the three main tributaries to Grand Lake to capture the influence of these sub-catchments (Figure 2.1). All stations were sampled four times during the summer of 2023 (June 29 or 30, July 25, August 22, and September 28).

Lake stations were accessed using a boat and positioned using a Garmin GPS/depth sounder. At each station pH, conductivity, temperature, and oxygen were measured at one metre intervals using a YSI multimeter. During the first sampling in June the YSI multimeter was out for repair and the substitute did not have a cable long enough to sample the entire profile at the deep station (JGLP04). In June the flow at the Jemseg site (JGLP05) was very strong, preventing sampling of a profile. During the August and September sampling, the YSI Oxygen meter was not working, and results were only obtained for some stations. Secchi disk depth was taken at each site, except for JGLP05 in June when water flow was too strong. Surface water samples were collected for general water chemistry, nutrients, metals, chl *a*. At the deep-water station (JGLP04), during the August sampling, we took one sample at 20 m using a 2L Niskin water sampler to determine whether water chemistry was different below the thermocline. Water samples were kept cold and transported to the Research and Productivity Council

Laboratories (RPC) within 24 hours of collection for analysis. Surface water samples and YSI measurements were taken at the three river sites, with similar methods to those used at the lake stations. Oxygen readings were not taken in September due to issues with the YSI probe.

2.2.2 Cyanobacteria and Cyanotoxins

The Association works with Atlantic Canada Action Plan (ACAP) Saint John to find an effective, safe approach to providing feedback on potential cyanotoxins to those reporting a suspected cyanobacteria bloom. Two observations of significant blooms were reported this year, one in early and one in late September. In response to citizen concerns, nine samples from six sites in the Jemseg Grand Lake Watershed were collected in late August and early September (Figure 2.2). No toxins were detected in any of the samples. Tests were performed by John Welsman of the association, following the "Collaborative Cyanotoxin Monitoring Using Test Strips Procedure and Testing Overview Manual" written by Roxanne MacKinnon.

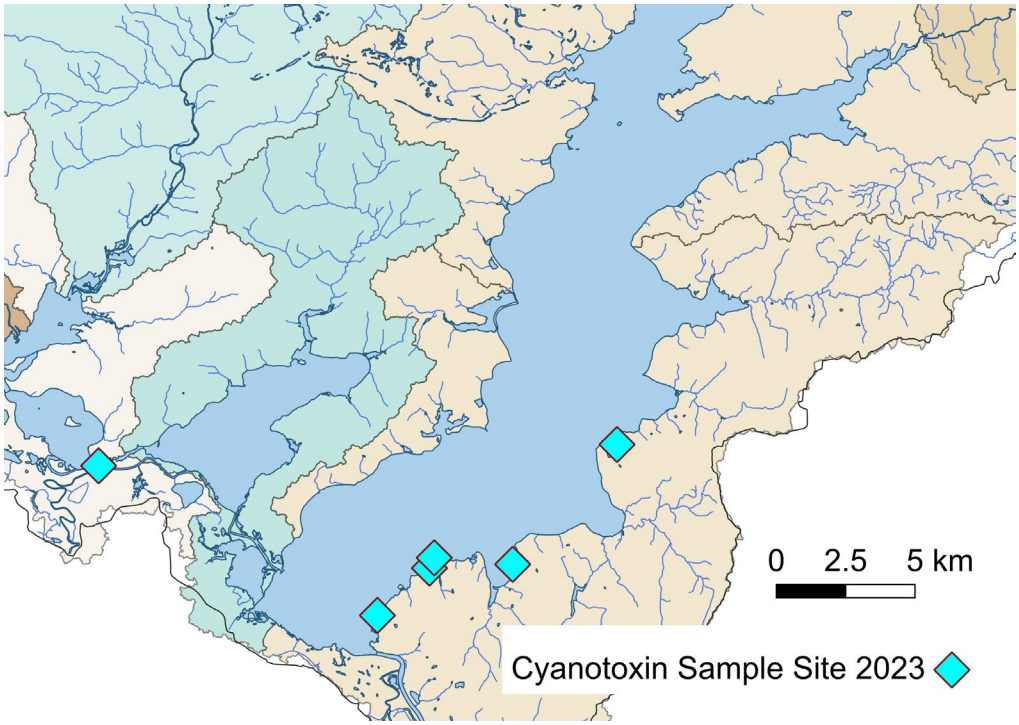


Figure 2.2 Locations where Cyanotoxin samples were collected during 2023. Hydrography: NB DERD (2022, open government license). Sub-watersheds are colour shaded (NCC, 2019 CC BY-NC 3.0).

2.2.3 Temperature Loggers

The Association integrates the results of water temperature information that is collected by the New Brunswick Alliance of Lake Associations (NBALA). Aaron Fraser deployed a string of three data loggers to measure water temperature continuously at site JGLP04 at Grand Point in Grand Lake on June 20, 2023. The loggers were deployed at depths of 2 and 13 metres below the surface, and 2 metres above the bottom (at a depth of 21 metres). Data from these loggers were retrieved on September 28, 2023. No temperature logger was deployed in the Jemseg River in 2023.

2.2.4 Escherichia coli

To test freshwater for faecal material from sewage discharge, stormwater, or agricultural runoff, water the association collect and analyze samples for *E. coli*. Elevated levels of *E. coli* do not necessarily cause health issues in humans. It is, however, used as an indicator of faecal contamination and signals the potential presence of pathogenic microorganisms. (CCME, 1999). The recreational water quality guideline for *E. coli* established by Canadian Council of Ministers of the Environment (CCME) is $\leq$ 400 MPN/100 ml.

During the initial three years of monitoring no exceedance of the *E. coli* guideline was encountered. The highest concentration found previously was 140 MPN/100 ml in 2021. A more detailed survey of Douglas Harbour in 2022 showed no notable concentrations. Consequently, the extent of the *E. coli* monitoring was reduced to four sites in 2023. The sites investigated in 2023 were JGLR03 and JGLR05 in tributaries and JGPL05 and Douglas Harbour in Grand Lake itself. On September 28, surface water from these four sites were sampled for analysis of *E. coli* content by RPC.

2.2.5 Algae Tracker

The Association collaborated with the Hammond River Angling Association to deploy an Algae Tracker, which monitors water quality parameters in real time, including chlorophyll *a* (pigment associated with green algae), phycocyanin (pigment associated with cyanobacteria), solar light, wind, rain, turbidity, and geographic positioning system (GPS) coordinates. The Algae Tracker was deployed in Cumberland Bay in Grand Lake, anchored nearshore at a water depth of approximately 1.3 m, from June to October 2023, with a short removal period due to an impending tropical storm.

2.3 DATA ANALYSIS

To display the range of parameters sampled with the YSI probe (Conductivity, oxygen, pH, and temperature), results were summarized as average, maximum and minimum values. Oxygen concentration is also plotted along with temperature against depth to display the temperature and oxygen distribution during stratification. The temperature logger data from the surface were summarized as an average per month for the period July to September to provide comparison with previous years.

Water chemistry results were also used to generate a water quality index for each individual station, as well as an overall water quality index for the whole lake, using the Canadian Council of Ministers of the Environment (CCME) approach (CCME, 2001). The CCME water quality index (WQI) provides a method to summarize water quality data to facilitate communication about water quality to a general audience. The WQI incorporates three elements: scope - the number of variables not meeting water quality objectives; frequency - the number of times these objectives are not met; and amplitude - the amount by which the objectives are not met. The WQI produces a score between 0 (worst water quality) and 100 (best water quality). These scores are divided into five descriptive categories to simplify presentation (CCME, 2001). We made a change to which parameters and guidelines we used in the WQI compared to previous years to harmonize with those currently being used by the New Brunswick Department of Environment and Local Government (NBDELG, personal comm.). We added copper which has been analyzed also during previous years but not included in the WQI. We also changed the parameter used to look at dissolved reduced nitrogen from total ammonium-N (NH4+) to ammonia-N (un-ionized, NH3) which is what the DELG uses in their calculation of WQI. In addition to the new parameters and their new guideline values we also changed the guidelines levels of concern for dissolved oxygen, nitrate, turbidity, and zinc. A full listing of parameters and guidelines can be found in Table 2.1. To make comparisons with earlier results we also recalculated the WQI from earlier years using the new set of parameters and guidelines.

To determine trophic status of the lake, we adapted a trophic state index (TSI) equation originally developed by Carlson and Simpson (1996) and commonly used for lake management, using, phosphorus and chlorophyll *a* (chl *a*). TSI provides an estimate of relative biological productivity of the aquatic ecosystem. Some varieties of the index exist. The original TSI concept included total phosphorus, chl *a* and secchi transparency. Secchi transparency is excluded from the analysis of Grand Lake because the transparency is affected by the relatively brown water from its tributaries which, while not being a sign of increased productivity, would affect the results negatively.

Table 2.1 Parameters and guideline concentrations used in the calculation of WQI.

Parameter Name	Lower limit	Upper limit	Unit	Reference / Comment
Ammonia (un-ionized)	0	0.0156	mg/L	CWQG; CCME, 1999
Arsenic	0	0.005	mg/L	CWQG; CCME, 1999
Chloride	0	120	mg/L	CWQG; CCME, 1999
Copper	0	0.002	mg/L	CWQG; CCME, 1999
Dissolved oxygen (DO)	6.5	Infinite	mg/L	CWQG; CCME, 1999
Iron	0	0.3	mg/L	CWQG; CCME, 1999
Nitrate	0	3	mg/L	CWQG; CCME, 1999
pH	6.5	9	-	CWQG; CCME, 1999
Phosphorus	0	0.02	mg/L	Provincial guideline (Culp et al. 2006)
Turbidity	0	10	NTU	Provincial guideline (DELG 2023)
Zinc	0	0.0075	mg/L	B.C. Ministry of Environment and Climate Change Strategy 2022

2.4 RESULTS

2.4.1 Grand Lake Surface Water Biophysical Characteristics

Biophysical characteristics of Grand Lake surface water taken during our four sampling sessions are provided in Table 2.2 and summarized in the following bullet points.

Lake sites:

- The deep site in Grand Lake was cooler than the inlet from Maquapit and the outlet to Jemseg.
- Average pH for most stations was just under neutral, from 6.1 to 7.2. The lowest pH measured with the YSI was 5.94 at Maquapit exit (JGLP06) in September. However, the pH measured on the lab using the water sample collected at the same time read 6.6 which is more in line with previous years' data. It is possible that the YSI was underestimating the pH. Maquapit exit also had the lowest buffering capacity against acidification (measured as alkalinity; Table 2.3) of the three lake stations.
- Due to the malfunction of the oxygen meter no readings were taken at depth during August, a month when oxygen has been low previous year. Oxygen concentration in surface waters ranged from 7 to 9 mg/L in both lake and river stations.
- Conductivity at Maquapit exit is influenced by the inflow from the southwestern tributaries and is much lower than that of the deep Grand Lake site and the outlet to Jemseg river.
- Transparency in Grand Lake was lower than in previous years. Secchi disk readings averaged 1.5 m in the deep site at Grand Point Bar and 2 m at the outlet to Jemseg River (Table 2.2).

River Sites:

- Like in previous years, the warmest average temperature was found at Lakeville Corner. Temperatures were lower than in 2021 in all three rivers stations.
- Average pH ranged from 6.1 to 6.4 which is slightly lower than in the lake.
- Like in previous years Newcastle Creek had a much higher conductivity than in the two other river sites. All values are within the range of background levels.

Table 2.2 Summary statistics of Grand Lake Surface Water Biophysical Characteristics in 2023. Due to problems with the YSI probe, few measures of Oxygen concentration were made, hence only averages from sites with at least three readings are presented here.

Station ID	Station Name	Oxygen mg/L	Water Temp ° C			pH			Conductivity µS/cm			Secchi (m)		
		Avg	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
JGLP04	Grand Point Bar	8.5	18.4	23.8	14.2	6.9	7.3	6.4	67	70	58	1.5	1.75	1.2
JGLP05	Jemseg River	-	20.6	24.1	17.4	7.2	7.4	6.7	64	67	60	2.0	2.5	1.5
JGLP06	Maquapit Exit	-	20.6	25.8	16.7	6.3	6.7	5.9	34	37	31	1.0	1.25	0.75
JGLR02	Newcastle Creek	9.0	19.5	27.1	12.1	6.3	6.7	6.0	73	90	53	-	-	-
JGLR03	Lakeville Corner	-	21.0	25.6	15.6	6.1	6.4	5.8	32	34	28	-	-	-
JGLR05	Chipman Marina	8.7	18.2	23.0	11.8	6.4	6.5	6.2	34	37	28	-	-	-

2.4.2 Temperature

When the temperature loggers at Grand Point Bar were deployed, mid-June, the stratification appears to just have started to form (Figure 2.3). Surface temperature kept rising until mid-July and then showed a generally slow decline until the end of September when there was greater variation in temperature followed by a more rapid decline at the start of October. The temperatures below the thermal stratification only increased by a couple of degrees between June until the strong winds of the post-tropical storm Lee led to the collapse of the stratification in mid-September.

In 2023, the overall average surface temperature in central Grand Lake was 22 ºC for the period of July 1 to the end of September (Figure 2.4), similar to the average temperature of previous years with July being the warmest month on average in 2023. Apart from an uncharacteristically high reading of 29 ºC in late September, the maximum temperature (26 ºC) was reached in late July. During the recorded period, there were a total of 41 days during which temperatures reached above 23 ºC, most of these (23 days) during July.

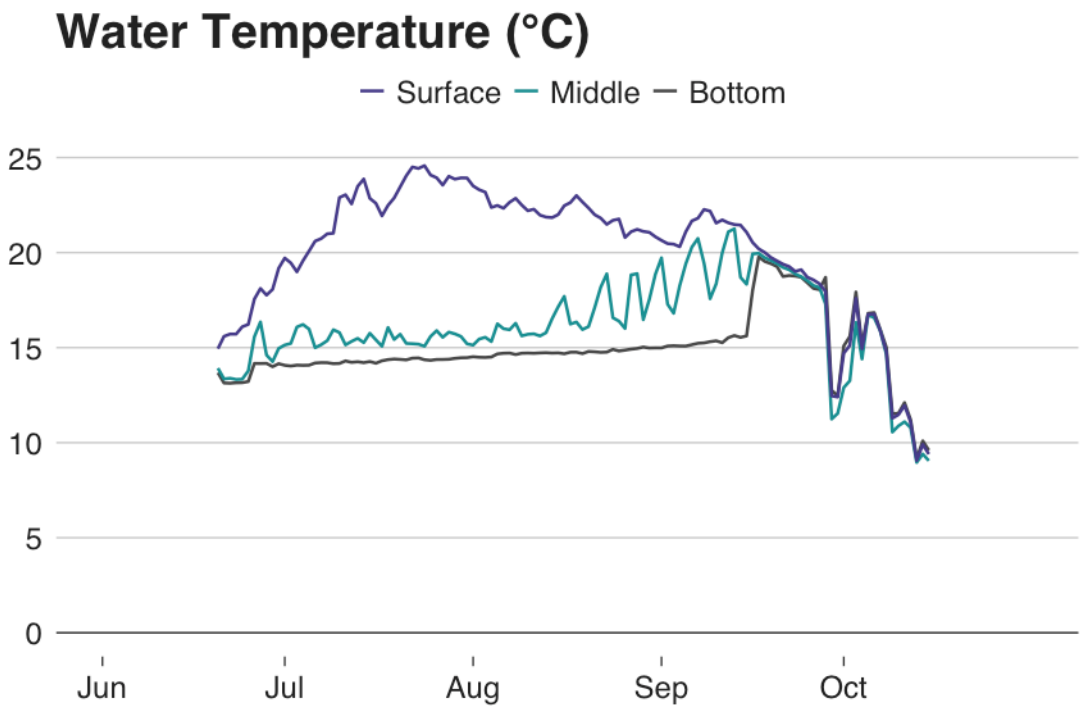


Figure 2.3 Daily average temperature from June 20 to October 15 at Grand Point Bar (JGLP04). Temperature shown from three depths: surface (2 m), mid (13 m), and bottom (21m).

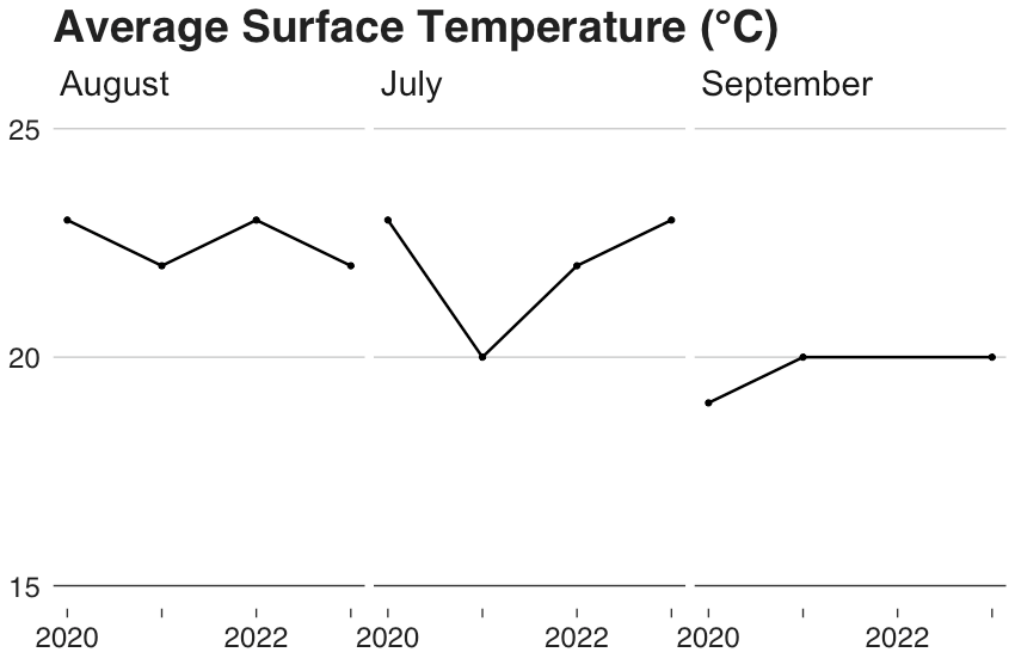


Figure 2.4 Average surface temperature for July, August, and September in the central parts of Grand Lake (Data for 2020-2022 are from Cumberland Point and for 2023 from Grand Point Bar).

2.4.3 Vertical Profiles

Temperature logger data suggests that the thermal stratification began already in June. Due to the YSI being on repair we could not measure a profile in June. During the July sampling a stratification was found at the deep station in Grand Lake (JGLP04, Grand Point Bar, >25 m). The metalimnion was unusally large stretching all the way from 5 m depth down to about 15 m depth. In August a more typical sharp decline in temperatures was found between 12 and 16 metres depth. At the time of the sampling in late september the stratification was broken and the lake water overturning completely (Figure 2.5).

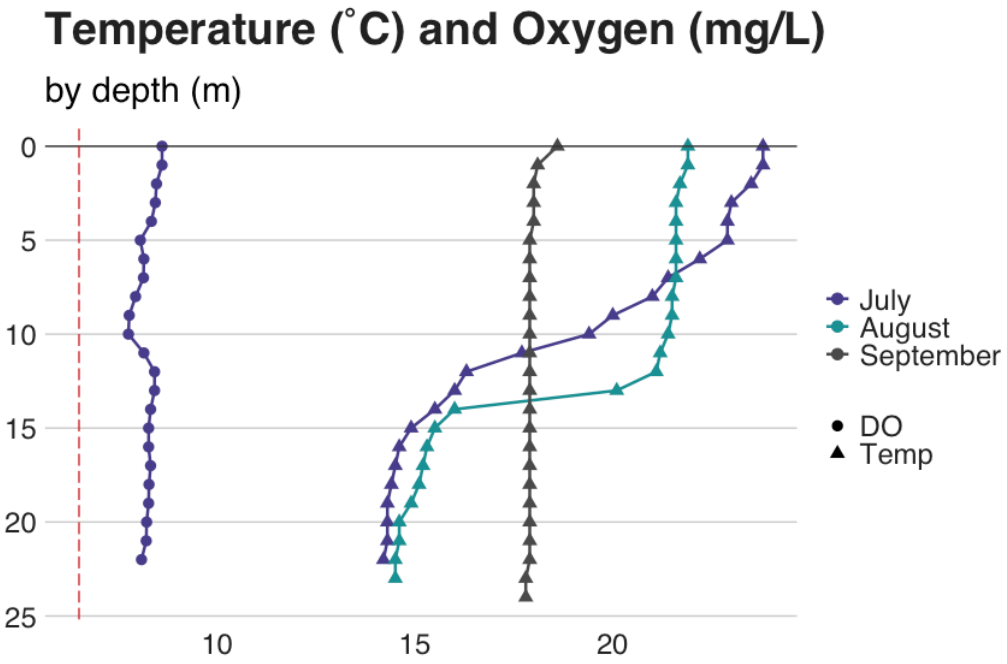


Figure 2.5 Vertical profiles of temperature and oxygen concentrations versus depth at Grand Point Bar for July, August and September, 2023. Oxygen is only available for July due to issues with the YSI probe. Red dashed line indicates critical oxygen concentration of 6.5 mg/L (CCME 1999).

In July oxygen concentrations were still high under the thermocline, just over 8 mg/L. During previous years oxygen has dropped below the CCME guidelines towards the end of the summer. Unfortunately the YSI oxygen probe was not working during the August sampling so we have no information on whether this was the case again in 2023. By the end of September the thermocline was completely gone, and temperature, conductivity, and oxygen concentrations were more or less uniform from surface to bottom.

2.4.4 Water Quality

Water quality sampling results for parameters used to score the WQI and a few other key parameters. are found in Table 2.3. In the surface water samples, two parameters had exceedances of the guideline limit of concern. Total phosphorus and iron exceeded guidelines at all river sites and in the Grand Lake site Maquapit Exit, a site which is influenced by the water inflow from the southwestern tributaries. There were no exceedances at the deep mid-lake station, or at the outlet Jemseg River site, except for the high zinc concentrations found under the thermal stratification at 20 m depth at the Grand Point Bar site. Iron is a parameter that frequently exceeds the CWQG in freshwater bodies across Canada. Although exceeding the CWQG, the iron concentrations seen in Grand Lake are unlikely to have strong, directly negative effects on aquatic life. Increases in iron can, however,

Table 2.3 Average water quality results from surface water samples collected during June – September 2023. CWQG = Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG; CCME, 1999). 1We used proposed total nitrogen and total phosphorus guidelines for the Saint John River Watershed instead of CWQG (Culp et. al. 2005). For zinc B.C. guidelines were used (B.C. Ministry of Environment and Climate Change Strategy 2022). Shaded values denote exceedance of guidelines.

Analytes	Units	Reporting Limit	CWQG	Used in WQI?	Grand Lake sites				River sites		
					JGLP04	JGLP04D	JGLP05	JGLP06	JGLR02	JGLR03	JGLR05
Alkalinity	mg/L	2		N	12.3	14.0	12.0	6.3	9.5	5.8	8.8
Aluminum	mg/L	0.001	Equation	N	0.07	0.06	0.07	0.17	0.22	0.26	0.20
Ammonia (as N) Un-ionized at 20 ˚C	mg/L	0.05	0.0156	Y	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Arsenic	mg/L	0.001	0.005	Y	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chloride	mg/L	0.5	120	Y	4.2	4.1	4.1	3.0	4.7	3.1	3.2
Chlorophyll-a	µg/L	0.5		N	2.8	1.9	2.5	3.2	5.5	5.6	1.7
Colour	TCU	5		N	62	63	60	121	172	177	177
Copper	mg/L	0.001	0.002	Y	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Oxygen	mg/L	-	6.5	Y	8.8	NA	9.0	7.8	9.0	7.8	8.7
Iron	mg/L	0.02	0.3	Y	0.18	0.16	0.17	0.56	0.85	0.80	0.73
Nitrate (as N)	mg/L	0.05	3	Y	0.10	0.08	0.10	0.03	0.04	0.03	0.03
Nitrogen – Total	mg/L	0.2	0.5[1]	N	0.30	0.50	0.28	0.45	0.48	0.45	0.48
Phosphorus – Total	mg/L	0.002	0.03[1]	Y	0.01	0.01	0.01	0.03	0.05	0.04	0.03
Turbidity	NTU	0.1	10	Y	0.7	1.0	0.9	1.9	4.4	2.5	1.8
Zinc	mg/L	0.001	0.0075[2]	Y	0.001	0.009	0.001	0.003	0.003	0.003	0.002

indirectly affect the ecosystem by contributing to the “browning” of lake water resulting in decreased visibility and primary productivity. Iron can also bind other toxins and contribute to their mobility. The exceedances for phosphorus are a concern as they can lead to eutrophic conditions in the lake. Phosphorus is further discussed under the TSI section.

2.4.5 Water Quality Index

Using the CCME Water quality index (WQI) manual (CCME, 2001), the WQI of the three sites in Grand Lake was calculated using the following parameters: arsenic, ammonia (un-ionized), chloride, copper, dissolved oxygen (surface measurement), iron, nitrate, pH, total phosphorus, turbidity, and zinc.

The average water quality index for all three Grand Lake stations was 94.5 putting the lake in the “excellent” category (Figure 2.6). Comparing the recalculated WQI scores from the three lake stations from which data is available since the beginning of the JGLWA monitoring in 2020 confirms previous observations that the water quality in central Grand Lake and the water leaving the lake through Jemseg river is better than that of the water entering the lake (exemplified by data from Maquapit exit, JGLP06)(Figure 2.7).

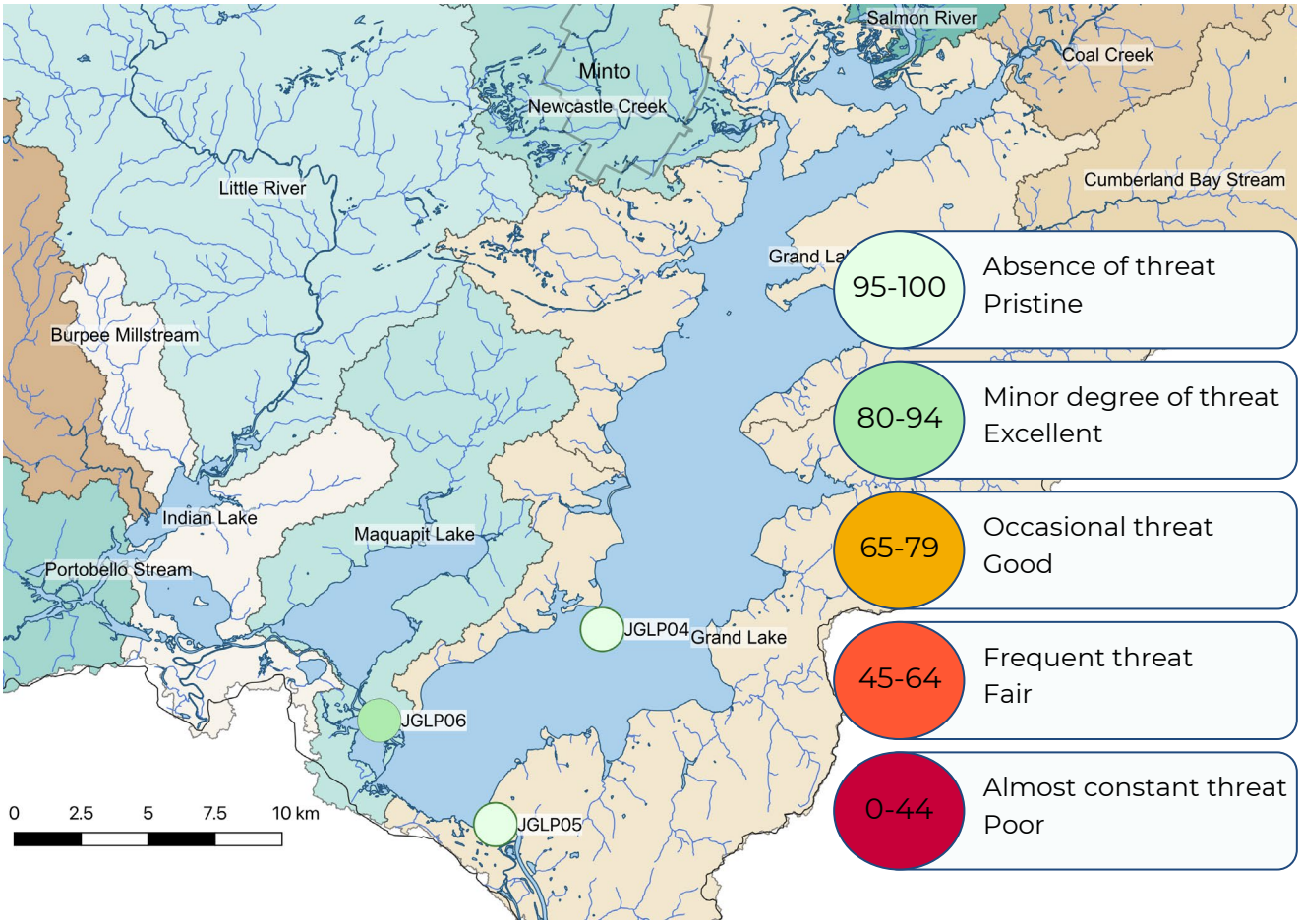


Figure 2.6 Water quality index class for the three lake sites.

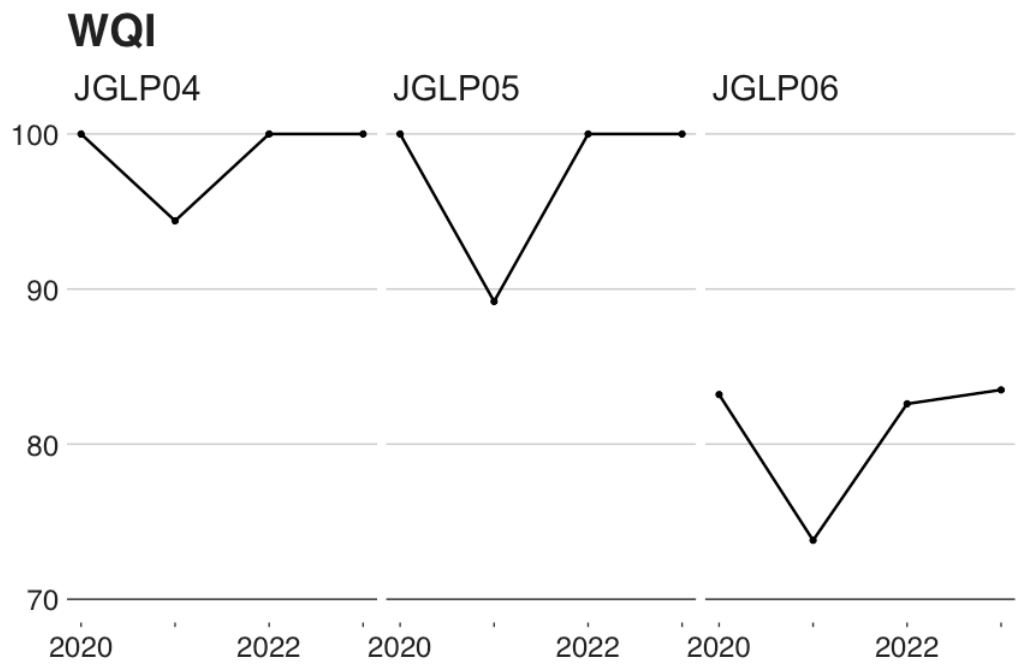


Figure 2.7 Water Quality Index scores from three Grand Lake Stations from the four years of JGWLA monitoring.

2.4.6 Trophic State Index

The trophic state index (TSI) score is intended to reflect the biological productivity of a lake. Each trophic class supports different aquatic ecosystems, including fish and other organisms.

- Hyper Eutrophic lakes (TSI >70) are rarely found naturally and can be considered severely nutrient polluted. They have frequent algal blooms and can during periods, depending on depth and season, display either very low or very high oxygen concentrations.
- Eutrophic lakes (TSI 50-70) have a high-level biological productivity. Due to excessive nutrients, especially nitrogen and phosphorus, these water bodies can support an abundance of aquatic plants.
- Mesotrophic lakes (TSI 40-50) have a moderate level of productivity and fair water quality. Attributes include clear water with increasing probability of low oxygen levels (anoxia) during the summer.
- Oligotrophic lakes (TSI <40) have low primary productivity due to low nutrients. They generally have good water quality.

We determined the TSI score for each station using total phosphorus and chl *a* measurements. The outlet station in Grand Lake at Jemseg River had a score of 39.5 indicating oligotrophic conditions but bordering on mesotrophic conditions (Figure 2.8). The other two Grand Lake stations, Grand Point Bar and Maquapit Exit, were both in the mesotrophic range but on opposite ends of the range, with Grand Point bar (JGLP04) close to oligotrophic conditions with a score of 42, and Maquapit Exit near the limit for eutrophic conditions

with a score of 47. A comparison of the last four years of TSI scores from these three lake stations shows that Grand Point Bar and Jemseg River have scores on and just under the mesotrophic/oligotrophic cutoff whereas Maquapit Exit scores are straddle the mesotrophic/eutrophic limit (Figure 2.9).

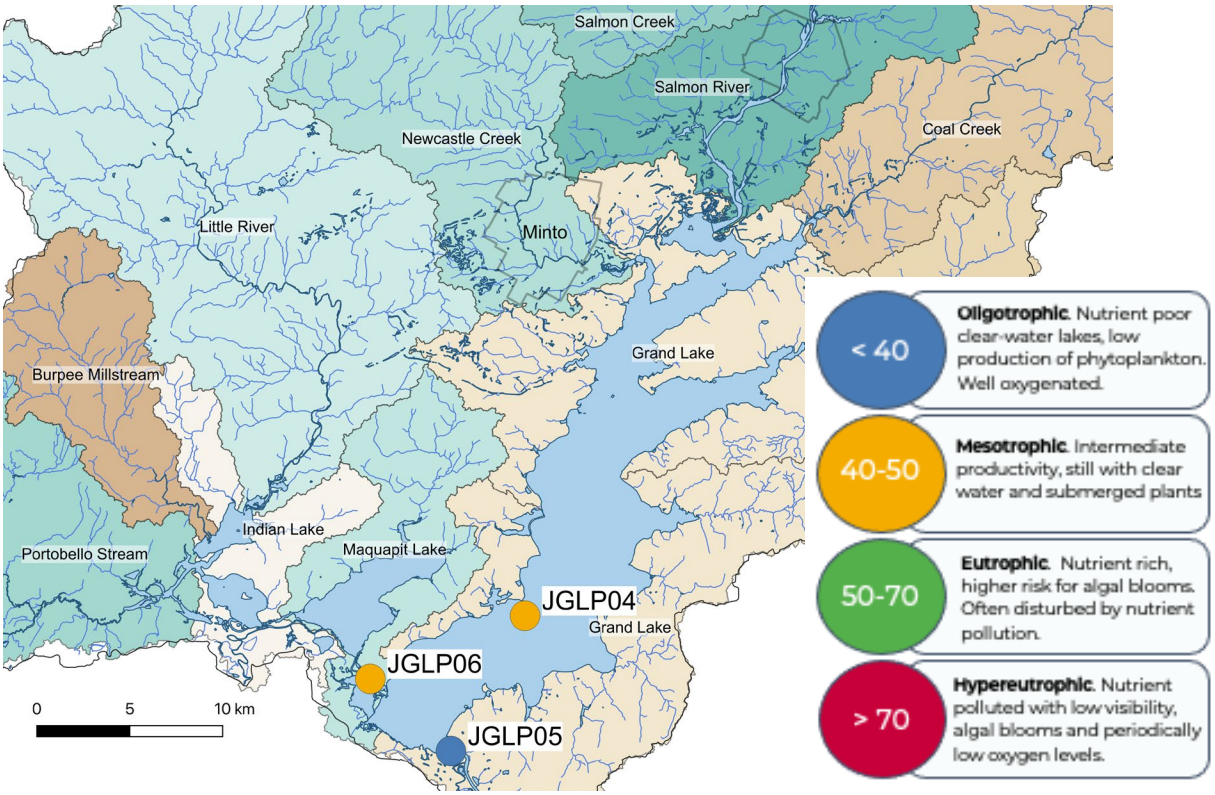


Figure 2.8 Trophic State Index colour score for the three lake sites on Grand Lake in 2023.

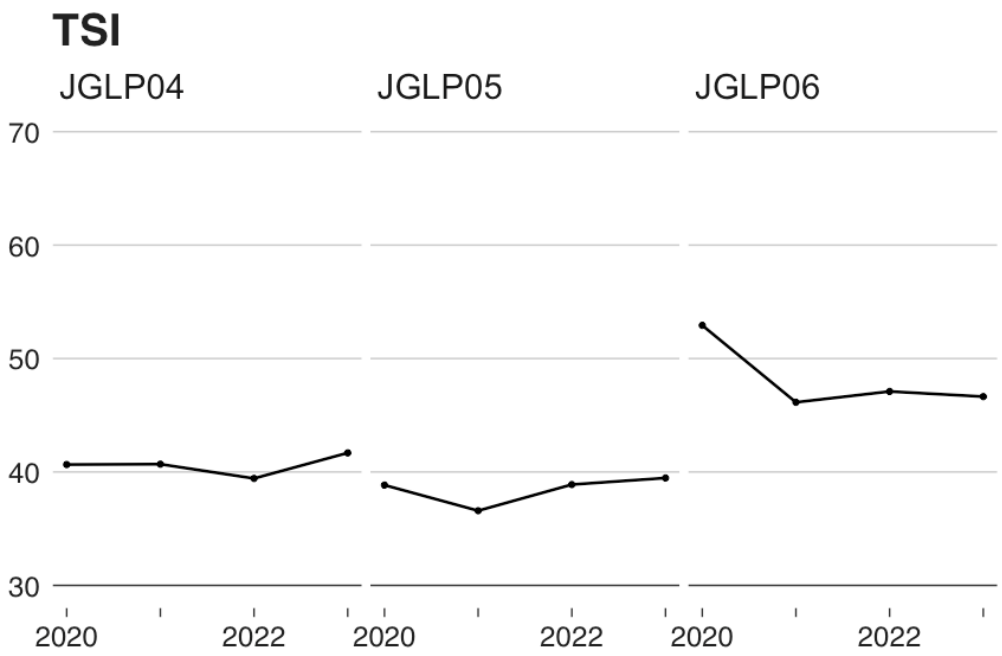


Figure 2.9 Time series of TSI scores for the three lake stations in Grand Lake that have data from the inception of the monitoring by the JGLWA.

2.4.7 Escherichia coli

E. coli concentrations in all samples were well below the CCME guideline for Canadian recreational water quality of less than 400 per 100 ml of sample. Of the four samples, the highest concentration of 14.4 MPN/100 ml was found at Lakeville corner (JGLR03), and the only other sample that had levels above the reporting limit was Douglas Harbour (9.7 MPN/100 mL)

It should be noted that *E. coli* concentrations vary substantially and rapidly over time, and it is easy to miss an increase in *E. coli* concentrations without an intensive monitoring program. The samples taken by the association only provide a spot check, which does not necessarily give a representative picture of the situation in Grand Lake.

2.4.8 Algae Tracker

Results from the Algae Tracker will be compared by the Hammond River Angling Association with five other algae trackers deployed elsewhere in the Wolastoq (Saint John River) drainage basin. The present report includes a summary of results for the Algae Tracker in Cumberland Bay (Figure 2.10). There is a data gap for three weeks in September when the Algae Tracker was removed due to an impending tropical storm.

We observe three main peaks for phycocyanin: early August, and two peaks in September. This pattern is mirrored for turbidity. The only trend for chl a is an overall reduction from July to mid-September, which may be related to water temperature or light intensity.

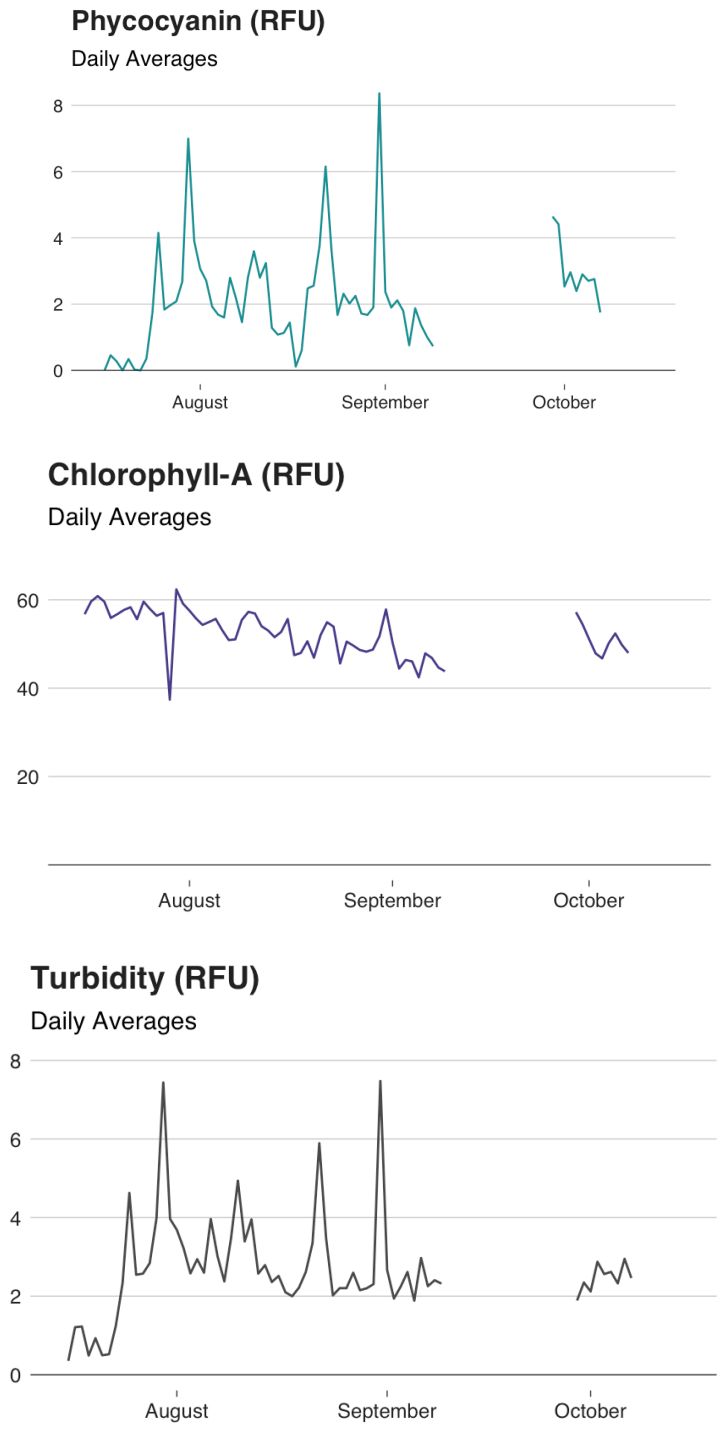


Figure 2.10 Daily averages of Phycocyanin, Chlorophyll-a, and Turbidity recorded by the algae tracker from mid-July to early October. Results are expressed in relative fluorescence units (RFU).

2.5 DISCUSSION

Results from the fourth year of the Grand Lake watershed water quality monitoring program once again indicate that Grand Lake has reasonably good water quality with only a couple of parameters that indicate potential for concern.

Maquapit Exit, the site affected by the inlet from the southwestern tributaries continue to have a lower water quality than the other two lake sites, indicated by lower WQI and TSI scores. However, the mid-lake water sampling station and the outlet to Jemseg River had high WQI scores, indicating no or few exceedances of parameters that have CCME guidelines. TSI scores at the same two stations indicate status around the border between oligotrophic and mesotrophic. The results suggest that biological productivity is relatively low, limited by the nutrient concentrations in the lake water. Despite this the transparency of the lake water is limited which is likely due to browning of the water from humic substances and possibly iron.

During the late summer a thermocline was observed at the deep mid-lake station. This is a natural occurrence that has been observed during all four years of the program. Oxygen concentrations below the thermocline have in previous years declined below 5 mg/L in August, which is below the CWQG for warm- and cold-water biota of 5.5 mg/L and 6.5 mg/L respectively, indicating that the hypolimnion does not serve as a good habitat for fish during the end of summer. This year oxygen measurements were not possible during August due to problems with the YSI meter. Previous years increases in nitrate, turbidity and zinc and decreases in pH in deep water compared to surface samples have also been observed. However, in 2023 the only notable difference was the increase in zinc concentrations in the sample from deep waters.

Overall water quality in Grand Lake is good, and sampling in the inflow rivers provide additional information to allow for better assessment. The three river stations, introduced into the program in 2021 again showed a lower water quality than that of Grand Lake, as exemplified by the exceedance of the CWQG for iron and phosphorus in all river sites, and a generally lower pH. The water that flows into Grand Lake typically has higher nutrient concentrations, higher colour, and turbidity, as well as lower pH. That the water flowing out of Grand Lake has a better quality than that which enters it is indicative of the ecosystem services that the lake provides. During 2022 the association started to look into whether the source(s) of the lower water quality in the southwestern tributaries could be pinpointed more accurately. The results were inconclusive and if the association has the capacity to improve further on these measurements it could be a good way to better understand the watershed and how to keep it healthy.

Very low concentrations of *E. coli* were found again in 2023, and therefore the association will continue to limit its efforts to a spot check of a few stations. Should the need arise, the scope can always be increased again in the future.

For the Algae Tracker, it is interesting to track in real time the algal pigments and turbidity. However, as a single point in a very large watershed and large lake, it has diminished value. Its value would be enhanced if there were several more Algae Trackers deployed in the watershed, and we paired this with testing for cyanotoxins when peaks in phycocyanin are observed. This would help us to link algal pigment trends with cyanobacteria blooms and potential for cyanotoxins.

2.6 RECOMMENDATIONS

For 2024, we recommend the following:

- Water quality monitoring:
  - continue to monitor the same set of parameters at the three lake and three river sites that were monitored in 2023
  - add monitoring stations in the southwestern tributaries to examine the potential source(s) of nutrient inputs to Grand Lake
  - add monitoring stations along Newcastle Creek to examine a potential influence of historical coal mining on pH and other parameters
- *E. coli*:
  - monitor in locations where a source may be present
- Cyanobacteria and cyanotoxins:
  - aim to get the word more to the public to report algal blooms and bring us a sample so we can use test kits to determine if cyanotoxins are present; not many requests or reports came in during the summer-fall, despite appeals on the website and in the newsletter. The low number of requests for testing for cyanotoxins may reflect few cyanobacteria blooms or (more likely) that more outreach is needed to inform residents and visitors about the possibility to use this service.

2.7 ACKNOWLEDGEMENTS

The authors would like to thank the New Brunswick Environmental Trust Fund, ACAP Saint John and New Brunswick Alliance of Lake Associations for supporting this program. Special thanks to Mike Kelly, John Welsman, Aaron Fraser, Mikael Gyllström, Eric Luiker, and Mary Murdoch for being part of the sampling program.

2.8 REFERENCES

B.C. Ministry of Environment and Climate Change Strategy 2022. Zinc Water Quality Guidelines (Reformatted from: British Columbia Ministry of Environments, Land and Parks, 1997. Ambient water quality criteria for zinc). Water Quality Guideline Series, WQG-19. Prov. B.C., Victoria B.C.

CCME (Canadian Council of Ministers of the Environment) 1999. Canadian Environmental Quality Guidelines. www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html

CCME (Canadian Council of Ministers of the Environment) 2001. Water Quality Index User Manual - Canadian Environmental Quality Guidelines. https://www.ccme.ca/files/Resources/calculators/WQI%20User%27s%20Manual%20(en).pdf

Carlson, R.E. and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society. 96 pp. https://www.nalms.org/secchidipin/monitoring-methods/defining-trophic-state/

Culp, J.M, Luiker, E.A., Noel, L, Foster, E., Curry, R.A. and Hryn, D. 2005. Status and Effects of Nutrient Loading on the Saint John River: Final Report. Prepared for the New Brunswick Environmental Trust Fund. New Brunswick Cooperative Fish and Wildlife Research Unit Report #06-03.

New Brunswick Department of Environment and Local Government. 2023. River sample collection and lab submission standard procedures for watershed groups in New Brunswick.

Department of Energy and Resource Development, Government of New Brunswick. 2022. Hydrographic Network (NBHN). Retrieved from http://www.snb.ca/geonb1/e/DC/catalogue-E.asp

Ejsmont-Karabin, J. & Karabin, A. 2013. Polish Journal of Ecology. 61 (3), 561-573.

Noseworthy, J., Millar, W. & Nussey, P. (2019). An Aquatic Connectivity Tool for the Northern Appalachian–Acadian Region of Canada. Nature Conservancy of Canada, Atlantic Regional Office. Fredericton, New Brunswick. Retrieved from https://2c1forest.databasin.org/datasets/a2097617294f49529f87c3630149d63c/

3.0 MONITORING AND REMOVAL OF EURASIAN WATERMILFOIL WITHIN GRAND LAKE

This chapter was written by Laura Lavigne.

3.1 INTRODUCTION

Throughout New Brunswick, various native milfoil species inhabit lakes, rivers, creeks, wetlands, and ponds, however, recently an invasive milfoil species has been identified within the province. *Myriophyllum spicatum*, more commonly known as Eurasian watermilfoil (EWM) is an invasive milfoil species that is invading North American freshwater. Within New Brunswick, it was first identified in the Wolastoq / Saint John River and has since spread to the Kennebecasis River, Darlings Lake and was discovered in Grand Lake in the summer of 2022. This species has various environmental impacts and can affect recreational activities and property values (New Brunswick Invasive Species Council, No Date, and Olden & Tamayo, 2014).

In 2022, John Welsman, a volunteer at the time for the JGLWA mapped individual plants located within Dykeman Cove. In the fall of 2022, the JGLWA applied for funding from the New Brunswick Environmental Trust Fund to gain a better understanding of the distribution of the species throughout Grand Lake and to determine the best management practices to contain it. In the spring of 2023, the JGLWA gained funding to conduct two studies focusing on EWM: 1) examining an EWM survey tool to search for EWM presence, and 2) conducting a pilot EWM removal study in Dykeman Cove.

When examining survey tools to search for EWM, the team decided to determine the effectiveness of using an aquatic remote-operated vehicle (ROV) for detection. The surveys occurred in four coves across Grand Lake. Douglas Harbour was chosen since it experiences high levels of boat traffic due to its boat launch and sheltered areas. Dykeman Cove was reevaluated along with the coves adjacent to it to determine the extent to which EWM has spread (Figure 3.1). The EWM study took place within Dykeman Cove since it was the only confirmed sighting of the species at the time. This is year one of two, to examine the effectiveness of two removal techniques, hand-pulling and cutting the plants. Through this funding, the JGLWA hopes to determine the best form of surveying for the species, and species distribution within key harbours, and begin examining the effectiveness of removal techniques.

3.2 METHODS

3.2.1 Survey

Grand Lake is the largest lake in New Brunswick with a size of 171 km^2 (Jemseg Grand Lake Watershed Association, No Date). Due to its large size, the JGLWA cannot search all viable habitats where EWM could be growing in one season, this would take weeks if not months. The team decided to limit the search area to Douglas Harbour, Dykeman Cove, Whites Cove and the next cove to the South of Dykeman Cove (Figure 3.1). Douglas Harbour was chosen as a survey site due to its high human activity. This harbour has a boat launch, cottages, a wharf, and an area called the ‘Bedroom’ where boats moor. Dykeman Cove was revisited to determine the extent of the spread since the last time it was surveyed. Both Whites Cove and

the cove that is due South of Dykeman Cove were also covered to determine if the adjacent coves contained individuals.

Two surveying techniques were used, an ROV equipped with an underwater camera and visual observations. Photos of the ROV are provided in the Photo Appendix at the end of this chapter.

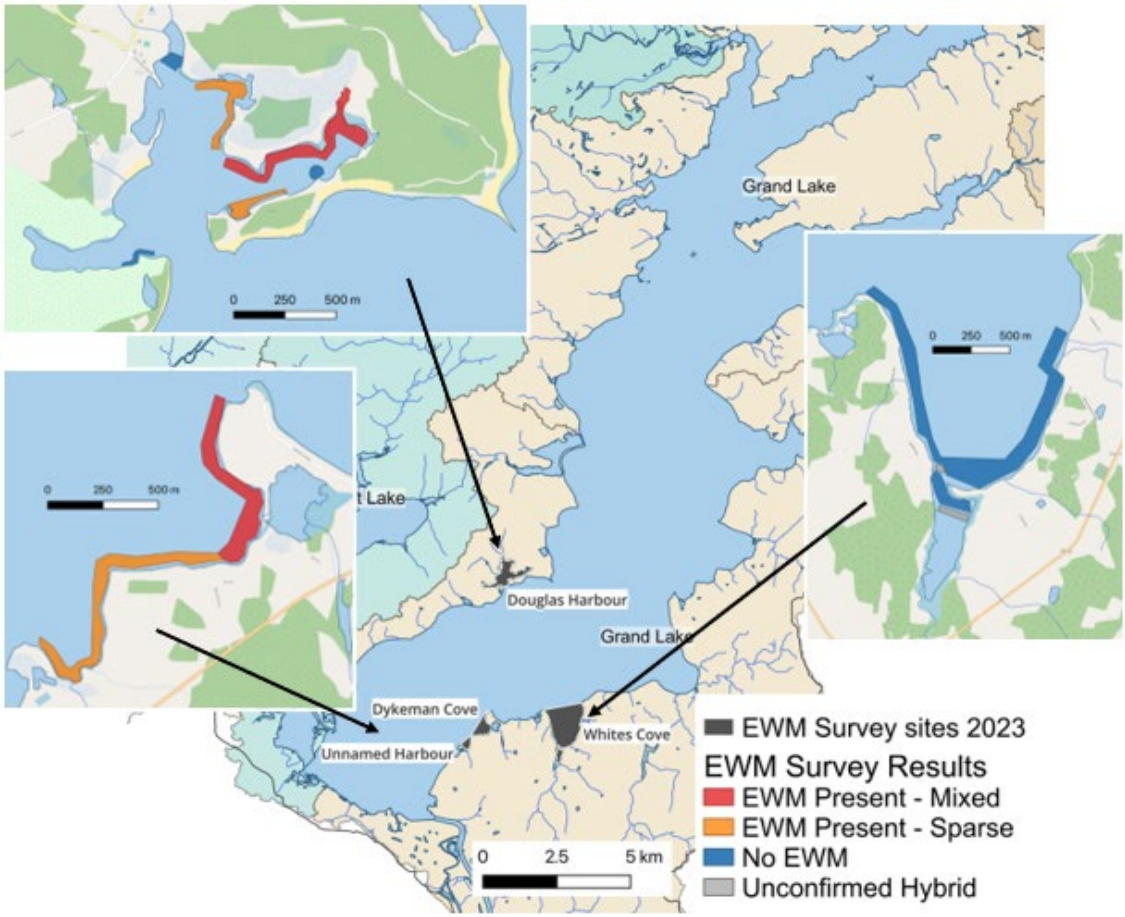


Figure 3.1. Eurasian watermilfoil survey sites 2023. Results of the survey are displayed in the three detailed insets. Hydrography: NB DERD (2022, open government license) Colour shading in the overview map indicate sub-watersheds (NCC, 2019 CC BY-NC 3.0). Background in details from © OpenStreetMap contributors.

When completing the surveys (September , the team focused on shallow areas where EWM growth would be suitable (1 m – 10 m (Smith & Barko, 1990)), areas where EWM was identified through previous visual observations and areas where aquatic vegetation was present. Several attributes were recorded when using the ROV such as depth (provided through the live feed), survey time, location, vegetation identifiable through the live feed, substrate type, and location. When completing visual surveys there were additional observations recorded such as EWM distribution type (small patches, individual plants). At times during visual surveys a bathyscope was used to help identify substrate type, this was water depth and water clarity dependent. EWM samples were taken when the team suspected a positive EWM identification. The samples were labelled with the location and date of the collection.

Once back at the office, the information from the field was inputted into an Excel spreadsheet. Using Google Maps the area searched during each survey was calculated, this is a rough estimate since the ROV is not

equipped with a tracking device to monitor its movements. Estimates were also used for the area covered by visual surveys based on the initial location start and end location. All survey sites were then mapped using QGIS to develop maps with scales. The JGLWA acquired the footage taken from the ROV from Mako Diving and was then analyzed for EWM presence. All samples collected were brought to Dr. Meghann Bruce of the Canadian Rivers Institute to confirm species identification.

3.2.2 Removal

The JGLWA took a management approach rather than a scientific approach due to the small space contaminated and sparsely populated individuals. Two removal techniques were used; hand removal which involves removing whole individuals including as much of the roots as possible and clipping which uses scissors to cut the stem of individuals at their base. The goal of these techniques was to determine the success of two non-invasive manual techniques. Two of the plots contained removal methods while the other site was used as a control. The control site was elected to have no disturbance to determine the effectiveness of the sites with removal methods. Photos showing EWM on site are provided in the Photo Appendix at the end of this chapter.

The three 20 m x 20 m (400 m^2) plots are set up in Dykeman Cove approximately 3 – 5 m from the shore at varying depths, this depends on the tidal cycle. Each plot was placed where EWM was visibly noticeable from the surface. These plots were set up using four cork-screw dog stakes with 20 m of rope between each anchor. These were left in place to ensure the sites can be identifiable in the next removal season. At each plot, the coordinate of the Northeast corner was recorded. Each plot and method are as follows, Plot 1 was the control site, Plot 2 was removed by cutting stems, and Plot 3 was removed by pulling the specimens (Figure 3.2).



Figure 11 Site for the Eurasian watermilfoil removal test in Dykeman Cove, Grand Lake. The black dot in one corner of each plot indicates the location of the recorded coordinate for that plot. Hydrography: NB DERD (2022, open government license) Background: © OpenStreetMap contributors.

3.3 RESULTS

3.3.1 Survey

The total area searched using both methods was 46 ha of this area 8 ha was in Douglas Harbour, 8 ha was in Dykeman Cove, 4 ha was in the unnamed harbour, and 27 ha was in Whites Cove. Of the 46 ha searched 19 ha had a mixture of individual specimens and small groups of 3 – 10 specimens (Figure 3.1). There was no indication of large dense mats forming but rather evidence of newly established populations. There were two locations identified in Whites Cove that have unconfirmed hybrids of EWM and a native milfoil species.

Within Douglas Harbour the distribution of EWM was inconsistent. There were smaller inlets that had no EWM while areas such as the bedroom had EWM distributed throughout (Figure 3.1). When comparing this year's map of Dykeman Cove EWM distribution to the 2022 distribution map, there were no noticeable changes in its distribution. The unnamed harbour below Dykeman Cove contained individual EWM specimens distributed sparsely throughout its potential growth depth. When searching White's Cove there was no evidence of EWM other than two unconfirmed hybrids.

Raw data from the surveys can be found in Data Appendix at the end of this chapter.

3.3.2 Removal

On average, it took the team 32 minutes to set up a plot, count, and remove (if prescribed to) EWM. A total of 105 individuals were removed from Dykeman Cove, of the individuals removed 62 were from the cutting method and 43 individuals were removed by pulling. Although there were species removed, not all were the target species. Approximately half of the individuals were native species. There were 76 individuals counted in the control plot, it is unknown how many species were native species mistaken for the target species.

Raw data from the removal trials can be found in Data Appendix at the end of this chapter.

3.4 DISCUSSION

3.4.1 Survey

When comparing the effectiveness of the two methods used for surveying, visual surveying was the most efficient. The ROV had difficulty capturing EWM on its camera even when placed in an area with the species. Even when reviewing the video captured and still shots the most beneficial use of the ROV was to capture the substrate type. The vegetation that was captured was hard to identify if it was anything other than eelgrass or pondweed due to their signature leaf shape. The ROV often captured photos of the stem of the plant where there were no leaves. When there was a milfoil identified it was impossible to determine if it was a native or the invasive species.

The ROV had difficulty navigating through vegetation, the vegetation would get caught in its propellors causing it to become bound, tangled, or reduce navigation ability. This caused a lot of stops when exploring with it and more time was spent removing the vegetation from the propellors than actual water use. The propellors also spliced the vegetation causing fragmentation of the species. This is particularly of concern when navigating through EWM since fragmentations lead to the spread of the species. The purpose of the exercise is to survey the current distribution, not increase the spread of the species.

It was difficult to determine where underwater the ROV had been as well as difficult to survey a large area at once. Each area explored was small and time-consuming to search. Often a visual survey before deploying the ROV was used to determine if the area was suitable or if there was vegetation worth examining with the unit. Although several drawbacks were experienced when using this method, the ability of the unit to consistently measure the depth was convenient and it was easy to identify the substrate type.

It was not surprising that the bulk of the EWM in Douglas Harbour was found in the ‘Bedroom’ since it experiences high boat activity. There is constant boat traffic from them entering, exiting, and mooring throughout the summer months. EWM fragments could easily be transported in and around the lake due to this activity. There is also no telling where the boats have been before entering Grand Lake and whether owners follow the Clean, Drain, Dry protocol before entering new water bodies or if they empty black water at the facilities in Douglas Harbour or release it untreated to the water.

At each plot, a diver was used to count all EWM individuals and, in plot two and three, remove individuals using the corresponding removal method. The diver was equipped with scuba equipment and an above team was in place to ensure the safety of the diver. Burlap sacks were used to collect removed EWM individuals to prevent fragmentation and prevent contributing to the spread of EWM. Once the collected

specimens were on the boat, a sample from each removal plot was kept for identification confirmation. The burlap sacks were then placed in a sealable tote to prevent the sacs from re-entering the water by mistake.

Before the diver entered the water the biologist on site explained how to identify the species, providing examples within the water and examples on the boat. While the diver was in the water setting up and removing and/or counting the EWM the time spent at each plot for each activity was recorded. The diver used a handheld GoPro to record a portion of the removal process. While on the boat the biologist took a photo of the burlap sacks with the removed EWM inside. Substrate type was also provided by the diver and recorded.

At the office, each bag was sorted to determine the approximate number of native species collected and counted in the removal process. All species were then transferred to durable black garbage bags and picked up by the local collection. The team planned to weigh the removed EWM by plot however the removed matter was less than 0.8 lbs, so the scale was unable to produce a reading. All the data collected were transferred to Excel and a map was created to show the plot locations. All footage from the GoPro was received through Dropbox and transferred to the team's Google Drive.

Both a Wetland and Watercourse Alteration (WAWA) Permit from New Brunswick DELG and a Section 52 Permit from DFO were required to complete the EWM Removal. The permits took approximately one month to acquire.

When observing White’s Cove, the team recovered a sample of the potential hybrid species to be later verified. Although we intended to get a professional opinion on the sample, the sample had degraded before this could occur. It was not surprising that there was no EWM found throughout the cove due to its very rocky substrate. The cove itself lacked any other vegetation apart from the sheltered inner part that was shallow. This area does not seem to experience boating traffic reducing the likelihood of transporting floating plant material to the cove.

It is worth noting that both Douglas Harbour and White’s Cove had native milfoil species and a variety of other native rooted vegetation species. Eelgrass and pondweed were found in all four locations surveyed. It is promising that there is such diversity of native species that provide many benefits to the local environment.

3.4.2 Removal

Although the team effectively removed EWM from the two plots the execution process was flawed. Approximately half of the removed species from the plots were native species (i.e., not EWM). This leads us to believe that these also occurred in the control plot. We extrapolate that about half of the counted species in the control plot were native species however there is no way to confirm this.

It is recommended that next year there should be more training for the divers. An example of how to increase the accuracy of divers and perfect identification is to have the diver collect multiple species underwater and then bring them to the surface. When at the boat compare all the specimens and point out key identifying features as well as differences between EWM and native species. The biologist on board should also search through the burlap sack once on board rather than peering into the sac. This will improve the accuracy of the study for the next field season.

In the future when conducting another study or replicating this study there should be more surveys completed in the work area. There were confirmed EWM species in Dykeman Cove however the sparseness of the individuals made it difficult to capture species within a 20 m x 20 m plot. We were constricted to Dykeman Cove due to the WAWA permit and Section 52 Permit. It is suggested that an area with more EWM be used in the future for other studies. A larger study area would allow for multiple repetitions of removal practices and multiple control plots. Several other factors could also be examined in removal method success as well such as substrate type and water depth.

Although there were a few setbacks, these are all learning opportunities, and this first phase of EWM removal in Dykeman Cove was a success. We were able to learn from this year and can refine our EWM removal approaches. Since this was the first study within New Brunswick, other organizations can learn from what we have done.

It is worth noting that complete eradication of EWM is impossible due to the size of the lake as well as its distribution throughout the lake. This pilot study was conducted to examine ways to manage and control the species in areas of high recreation and areas that will potentially increase the spread of the species.

3.5 RECOMMENDATIONS

It will be important to revisit the 2023 removal plots in Grand Lake to evaluate the success and communicate what we find. For surveys, we recommend expanding the survey area using a citizen science approach by inviting members of the public to adopt a shoreline section to survey, and set up online reporting of results.

3.6 ACKNOWLEDGEMENTS

The JGLWA would like to thank the New Brunswick Environmental Trust Fund for supporting this study, plus the following people and contractors who helped in the planning, organization, execution, and reviewing of the EWM project: New Brunswick Environmental Trust Fund, Mako Diving and Marine Services, Dr. Meghann Bruce (Canadian Rivers Institute), New Brunswick Invasive Species Council, Elizabeth Kwiecien (Landowner), John Welsman (JGLWA Member), Mary Murdoch (JGLWA Member), and Mikael Gyllström (Biologist).

3.7 REFERENCES

Jemseg Grand Lake Watershed Association. (No Date). About Us. *Jemseg Grand Lake Watershed.* https://jemseggrandlakewatershed.ca/about-us/

Olden, J. D., & Tamayo, M. (2014). Incentivizing the Public to Support Invasive Species Management: Eurasian Milfoil Reduces Lakefront Property Values. *PLoS ONE*, *9*(10), e110458. https://doi.org/10.1371/journal.pone.0110458

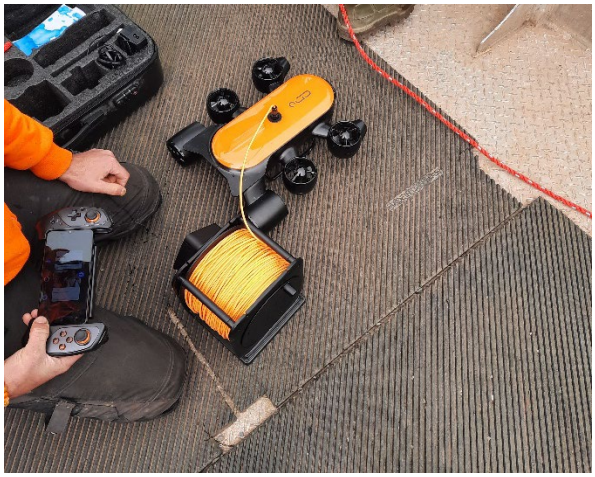
New Brunswick Invasive Species Council. (No Date). Eurasian watermilfoil. *NB Invasives.*https://www.nbinvasives.ca/eurasian-watermilfoil

Smith, C. S., & Barko, J. W. (1990). Ecology of Eurasian watermilfoil. *Journal of Aquatic Plant Management*, *28*(2), 55-64.

3.8 PHOTO APPENDIX OF EWM MONITORING AND REMOVAL, SEPTEMBER 2023



Mako Diving employee (left) and Mikael Gyllström (biologist, right) watching live feed from the camera attached to the ROV unit to determine if EWM is present in the area being surveyed.



The ROV used in underwater surveys.

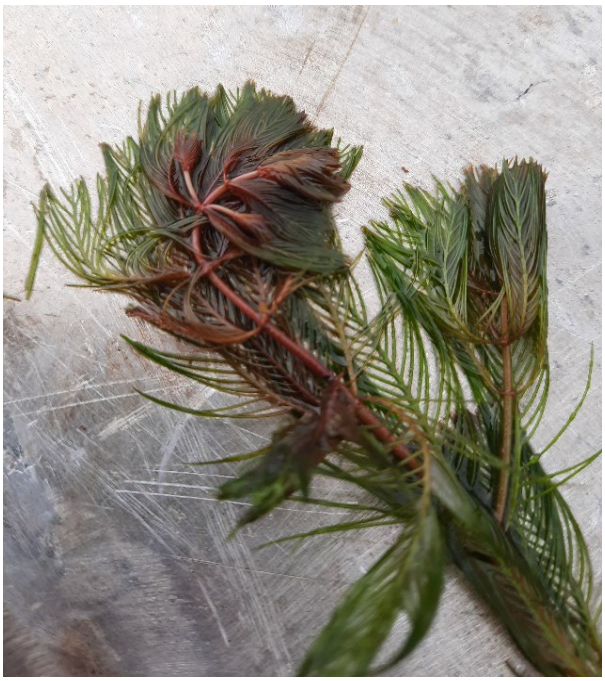




Images captured by the ROV while completing an underwater dive in Douglas Harbour. No EWM is visual in this image although there are various native species identifiable.



The ROV searching for EWM and other native species in Douglas Harbour.



EWM found in Douglas Harbour during ROV and visual surveys.



The ROV control mechanism and live camera feed.



Installation of a removal plot using rope and cork-screw dog anchors.



EWM that was removed by the diver using scissors in Plot 2.



The diver counting EWM species in the control plot (Plot 1).

3.9 DATA APPENDIX FOR EWM MONITORING AND REMOVAL, SEPTEMBER 2023

3.9.1 EWM Survey Plots

Date	Plot ID	Location	Coordinates	Corner Marked	Plot Size	Plot Area	Duration of Set-up	Duration of Removal	Removal Method
25-Oct-23	Plot #1	Dykeman Cove	45.8682, -66.10317	South-West	20 m x 20 m	400m2	15 mins	7 mins	Control
30-Oct-23	Plot #2	Dykeman Cove	45.86945, -66.10571	North-West	20 m x 20 m	400m2	20 mins	30 mins	Cutting at stem
30-Oct-23	Plot #3	Dykeman Cove	45.86867, -66.10477	West	20 m x 20 m	400m2	10 mins	15 mins	Pulling

Date	Plot ID	Location	Substrate	EWM Removed	By-Catch	Weight	Notes
25-Oct-23	Plot #1	Dykeman Cove	Muddy/Sandy	76 (counted)	unknown	N/A	Based on further investigation it is unknown if all the species counted are EWM
30-Oct-23	Plot #2	Dykeman Cove	Rocky/Bedrock	62	rox. 1/2 of coun	<0.6 lbs	The anchors were difficult to get into the substrate. Approximately 1/2 of the 62 removed plants were native species
30-Oct-23	Plot #3	Dykeman Cove	Pebbles/Cobble	43	rox. 1/2 of coun	<0.6 lbs	Approximately 1/2 of the 62 removed plants were native species

3.9.2 EWM Removal Plots

Date	Plot Name	Location	Coordinates (From approximate middle of search area)	Start Time	End Time	Duration	Area Surveyed (Rough Estimate)	Depth	Survey Method	EWM Presence	Substrate Type	Notes
27-Sep-23	North-East Branch 1	Douglas Harbour	45.91943, -66.09773	9:45	10:25	40 min	380 m2	1 - 2 m	ROV	None	Silty/Organic	observed eelgrass
27-Sep-23	North-East Branch 2	Douglas Harbour	45.9194, -66.09692	10:40	11:00	15 min	200 m2	1 - 2 m	ROV	None	Silty	took 5 min to free up ROV. Observed eelgrass
27-Sep-23	North-East Branch 3	Douglas Harbour	45.91905, -66.09692	11:10	11:45	35 min	450 m2	2 - 3 m	ROV	None	Fine Sediments	observed eelgrass
27-Sep-23	North-West Branch 4	Douglas Harbour	45.91049, -66.09981	12:55	13:30	35 min	480 m2	2.5 m - 7.5 m	ROV	None	silty, cobble, pebble	
27-Sep-23	North-West Branch 5	Douglas Harbour	45.91078, -66.09906	13:35	14:12	37 min	460 m2	0.8 m - 1.3 m	ROV	None	sandy, pebble, organic matter, fine sediments	A range of substrate types were observed. Thought to be sampling some terrestrial land. Eelgrass observed
27-Sep-23	North-West Branch 6	Douglas Harbour	45.91083, -66.09962	14:17	14:24	7 min	10 m2	0.7 m - 1.1 m	ROV	None		Determined this was only terrestrial area that was flooded
29-Sep-23	Bedroom 1	Douglas Harbour	45.91624, -66.08721	9:50	10:25	25 min	290 m2	1.6 m	ROV	EWM Present	Soft/Organic	Total of 10 min breaks for ROV. Although EWM was present it was not viewed using the ROV but rather from the boat. Other species including pondweed and eelgrass were present. ROV has a hard time navigating in dense vegetation.
29-Sep-23	Bedroom 2	Douglas Harbour	45.91612, -66.08658	10:45	11:02	17 min	190 m2	-	ROV	EWM Present	Soft/Organic	Native milfoil species present. ROV visuals not great, surface visual gave most detail.
29-Sep-23	Bedroom 3	Douglas Harbour	45.91524, -66.08775	11:17	11:35	18 min	190 m2	2.3 m - 3.5 m	ROV	EWM Present	Soft/Organic	No vegetation at 3.5m - 3m deep.
29-Sep-23	Bedroom 4	Douglas Harbour	45.91438, -66.08837	11:38	12:08	30 min	790 m2	1.9 m - 4 m	ROV	None	Silty	Once the ROV reached a depth of 1.9m eel grass was observed.
29-Sep-23	Bedroom 5	Douglas Harbour	45.91249, -66.09354	13:48	14:04	16 min	220 m2	1.8 m	ROV	EWM Present	Silty/Clay	Eel grass and pondweed were evident through ROV. EWM was observed from the surface.
29-Sep-23	Cruise 1	Douglas Harbour	45.91574, -66.08566	-	-	-	4900 m2	Unknown	Visual Observations	EWM Present	Unknown	Native and non-native milfoil species mixed in this area. Small patches and satellite plants of EWM.
29-Sep-23	Cruise 2	Douglas Harbour	45.91514, -66.08864	-	-	-	35530 m2	Unknown	Visual Observations	EWM Present	Unknown	EWM was present among native milfoil species, the EWM was in small patches and as single individuals.
29-Sep-23	Cruise 3	Douglas Harbour	45.91292, -66.09282	-	-	-	10700 m2	Unknown	Visual Observations	EWM Present	Silty/Clay	EWM was observed from the surface, there was a few small matches and some individuals
29-Sep-23	Cruise 4	Douglas Harbour	45.91726, -66.09381	-	-	-	20800 m2	1 - 3 m	Visual Observations	EWM Present	Unknown	EWM was observed from the surface, there was a few small matches and some individuals
11-Oct-23	Cruise 1	Dykeman Cove	45.86619, -66.10427	-	-	-	79700 m2	Unknown	Visual Observations	EWM Present	Large Mix throughout Cove	Lots of native vegetation throughout the cove. EWM was present in different densities. There were small cluster and individuals throughout. Went 10-20m at times without EWM then it showed back up.
11-Oct-23	Dive 1	Dykeman Cove	45.86986, -66.10626	10:10	10:35	25 min	>10 m2	1.2 m - 2.2 m	ROV	EWM Present	Rocky/Bedrock	Eel grass was present, and EWM was visible at the surface. There were some clusters around and individuals.
11-Oct-23	Cruise 2	Unname Cove	45.86144, -66.11281	-	-	-	38900 m2	Unknown	Visual Observations	EWM Present	Unknown	There were scattered individuals with very few clusters. The distribution through the cove was uneven.
11-Oct-23	Cruise 3	Whites Cove	45.86207, -66.07185	-	-	-	269030 m2	Unknown	Visual Observations	None (potential hybrid)	Mainly gravel/pebble	Potentially a few hybrid stems of EWM in the marshy area where it was mucky. Could not confirm if it was a hybrid species. Native milfoils were present.

4.0 ENVIRONMENTAL DNA PILOT STUDY

This chapter was written by Mary Murdoch.

4.1 INTRODUCTION

Biomonitoring and biodiversity studies are increasingly using environmental DNA (eDNA) analysis as a way to learn about species that are present in the habitat being sampled. eDNA is genetic material that is released from organisms into their environment, such as from bodily waste, reproduction, injury, and shedding of cells. If we think about our watershed, just by sampling water, we can learn what fish species are present by having that sample analyzed for eDNA. This new approach provides a rapid and efficient way to survey a large watershed area, such as we have, to examine the fish community and learn about the ecological health of our watershed. This method will detect fish species that are not easily seen or captured by traditional fishing methods, such as fish that live in deeper water, fish that are in low numbers or migrating through the lake, and small-bodied species that live in shallower waters.

Information received from eDNA can be used for public engagement to learn more about the fish community by asking residents and visitors about what they are catching and by interviewing commercial gaspereau fisher people about their by-catch.

In addition to the eDNA pilot study described in this chapter, we also worked with the New Brunswick Invasive Species Council (NBISC) for their study with Fisheries and Oceans Canada to evaluate the presence of zebra mussel (*Dreissena polymorpha*) in the Wolastoq watershed. Mary Murdoch and Eric Luiker undertook eDNA sampling at four locations in our watershed in September 2023 and provided the samples to NBISC for processing.

4.2 METHODS

We conducted an eDNA pilot study in winter 2024 on the western side of the watershed. The sampling design was developed based on guidance from Abbott et al. (2021). Mary Murdoch and Greg Gillis traveled to several ice fishing locations in February 2024 and sampled water under the ice or in open water beside the ice. Mary has experience with sampling for eDNA from water and she led the sampling effort.

Water samples were collected from four sites as shown in Figure 4.1. At each site, two water samples were collected.

- For Douglas Harbour – McInnis Arm and The Keyhole, an ice auger was used by local ice fishers to drill a fresh hole through the ice. Ice depth was approximately 50 – 70 cm. Water samples were collected from the opening using a 2L Niskin sampler (Douglas Harbour – McInnis Arm) or a fresh plastic cup (The Keyhole) to obtain a total volume of 2-4 L of water, placed into a large single-use Whirl Pak bag.
- For the Maquapit Lake and Lakeville Corner (outlet of French Lake), samples were collected from open water by tossing a bucket attached to a rope. The Maquapit Lake site was at the outflow of the causeway culvert at Hunters Ferry Cove while the Lakeville Corner site was just east of the

bridge at Lakeville Corner. At each site, approximately 3-4 L of water was transferred from the bucket into a large Whirl Pak bag.

For quality control, sampling was conducted by a biologist experienced in collecting eDNA samples following a sampling plan based on published guidance. To avoid contamination and cross-contamination of samples, fresh gloves were worn at each site to collect water samples. Containers used to hold water prior to filtration were either new and used only once or cleaned between samples by spraying with 5% bleach solution then rinsed with site water before sampling. To evaluate the potential of eDNA carry-over (i.e., contamination) from sampling equipment and between sites, one negative field control was collected on the day of sampling. This negative field control was collected using store-purchased spring water and the same filtration technique as used for the lake water samples. Filters were preserved and stored in a freezer until shipment to the eDNA laboratory, within two weeks of collection.

Quality assurance and quality control (QC) practices are used by the eDNA laboratory, NatureMetrics, to reduce the risk of sample contamination.

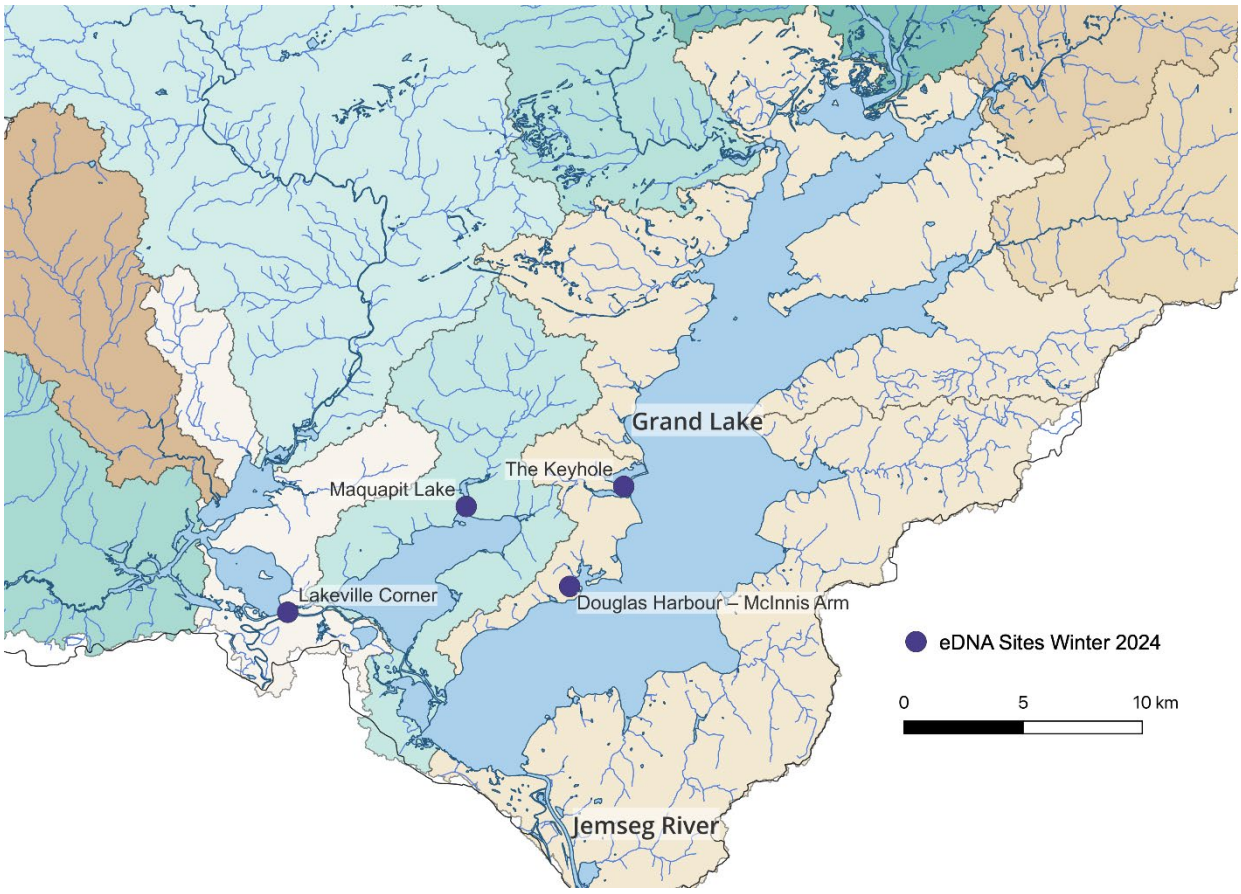


Figure 4.1. Sites where environmental DNA samples were collected from water sample collected under or beside ice in February 2024.

To collect the eDNA from water samples, 600 mL of water from each Whirl Pak bag was filtered at site or within six hours of collection using a 0.8 µm pore size polyethersulfone disk filter and a Luer Lock plastic

syringe. A DNA preservative was then added, and the sample was placed into a secure bag with a unique sample ID. Samples were frozen prior to shipment to the eDNA testing laboratory, NatureMetrics, based in Guelph, ON. Methods for sample filtration, preservation, storage, and shipment followed the sample processing instructions and kits provided by NatureMetrics. Processing of the negative control followed the same steps as the eDNA samples. Photos 4.1 and 4.2 show water sampling for eDNA collection.

Samples will be analyzed by NatureMetrics using a method called “metabarcoding”, focusing on DNA from vertebrates, and specifically fish, in the samples. At the NatureMetrics laboratory, eDNA metabarcoding analysis of the water samples will be performed by extracting DNA from the filters and sequencing two DNA markers that recover bony fish biodiversity. The eDNA sequences from the two DNA markers will be bioinformatically processed to identify the unique DNA sequences recovered from each sample matched with taxonomic information to the level of species or family. The results will be a fish biodiversity inventory for each sample. Samples will be processed within approximately ten weeks of sample submission.

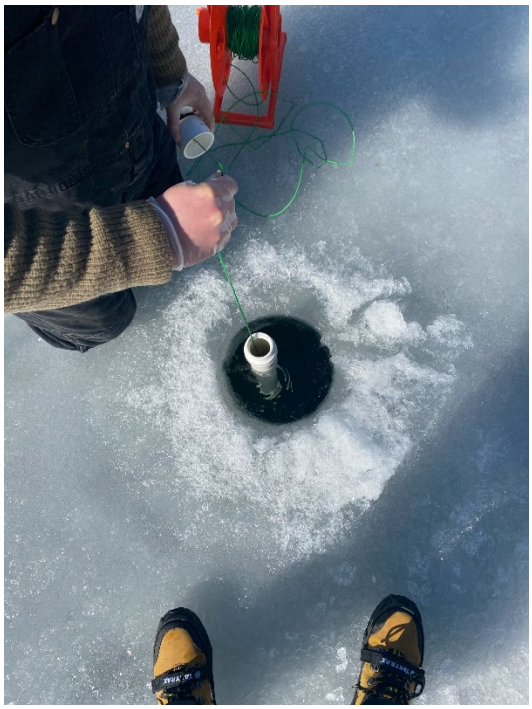


Photo 4.1 Water sampling for eDNA through ice.



Photo 4.2 A eDNA sample, showing particulate collected on a filter from a water sample.

4.3 RESULTS

Results will be a fish species inventory for each site, which will be available when the laboratory report has been received. An addendum to this report will be submitted to NBETF and a summary provided on our website, likely by June or July 2024.

4.4 DISCUSSION

From meeting with ice fishers during collection of the eDNA samples, we can see the value of this study in fostering engagement, capturing the public's interest, showing them what we are finding and using this to talk about what they are catching and what they value in the watershed. This is a pilot study to whet our appetite, and that of the public, to learn more about the fish community in the watershed, and how we can keep the watershed healthy.

At the Douglas Harbour site, we met Lindsay Glen, a teacher at Minto High School, who has invited us to speak with her class in March 2024 about the study and what we are learning about aquatic health of our watershed.

Additional discussion will be added once results have come in from the laboratory.

4.5 RECOMMENDATIONS

For 2024, we recommend building on this pilot study to conduct a broader eDNA study to learn more about aquatic life in our watershed. Given the large size of our watershed, for practical reasons, the focus will be on sampling at the six water quality monitoring stations (three river sites, three lake sites) and at multiple sampling times for analysis of fish species present. The results will be used for engagement and paired with an initiative to learn more about the fish community in our watershed via local knowledge gained in meeting with residents, visitors, and commercial fishers. This is an ideal pairing of local knowledge and science.

4.6 REFERENCES

Abbott, C., M. Coulson, N. Gagne, A. Lacoursiere-Roussel, G.J. Parent, R. Bajno, C. Dietrich, and S. May-McNally. 2021. Guidance on the Use of Targeted Environmental DNA (eDNA) Analysis for the Management of Aquatic Invasive Species and Species at Risk. Fisheries and Oceans Canada. Canadian Science Advisory Secretariat Research Document 2021/019.

NatureMetrics. 2024. NatureMetrics Sampling Protocol Document: Aquatic Kit. NatureMetrics. Available at: https://www.naturemetrics.com/protocols/standard-aquatic-edna-kit-sampling-protocol

5.0 EDUCATION AND OUTREACH

This chapter was authored by Mike Kelly and Greg Gillis.

Education and outreach are really important for our association. We reach out to residents and visitors to hear what they value about the watershed, share what we are learning, and invite participation in our activities. Education and outreach are accomplished by in-person events, hosting webinars, posting information on our webpage, distribution of newsletters and "newsbytes", and via social media.

We hold membership drives at public events, such as Douglas Harbour public breakfast (July 8, 2023) and "Life on the Lakes" at Cambridge Narrows (August 12, 2023). Depending on attendance of these events, this gets us in front of between 200 and 500 people. We have a "soccer tent" set up with brochures and banners, which draws attention. We also held a volunteer appreciation, engagement, and outreach event at Berties Café in Douglas Harbour on October 6, 2023, with about 25 people showing up, demonstrations on cyanotoxin testing, maps of the watershed, information about our activities, plenty of good discussion and connection over food.

We also gave presentations to two newly established local councils in 2023. We met with the Mayor and Council of the new village of Arcadia on July 24, 2023, and with the Mayor and Council of the new village of Grand Lake on August 28, 2023. We have an excellent slide deck that we presented that was well received and provided an overview of our association and activities. The Arcadia event had around ten attendants and the Grand Lake civic meeting had nearly forty attendants. We plan to continue to give annual updates to the Councils to share what we are learning, build awareness about the health of the watershed, and invite participation in Association activities. Hopefully this can also lead to future cooperation, strengthening the work of our association.

Additional engagement activities will occur as opportunities arise during the winter. For example, during the eDNA surveys in February 2024, we met with several residents who were ice fishing at various locations. This provided the opportunity to learn what they ice fishers were catching and talk about how we are using new DNA-based tools to learn about the fish community without using a hook or a net. As described in Section 4.4, this led to an invitation from Lindsay Glen, a high school teacher in Minto, to come to her class in March to talk about the health of our watershed. This will be a great opportunity to get young adults engaged, learn what they are interested in, talk about what we are doing, and encourage them to get involved.

Our Association continues to issue a regular newsletter, available at https://jemseggrandlakewatershed.ca/resources/newsletters/. Our newsletters and smaller "newsbytes" are sent to all our association members via email, posted on our Facebook page, as well as Instagram and X (formerly Twitter). We are currently preparing a newsletter that will be distributed by Canada Post to all mailboxes in the watershed area in March-April 2024. This is a significant investment that we hope will be effective in drawing more interest to what we do.

Our website https://jemseggrandlakewatershed.ca/ continues to serve as a useful and up to date portal to information about the Jemseg Grand Lake Watershed Association's and its ongoing activities.

Two webinars will be hosted in the March 2024:

- 'Testing for Cyanotoxins' is scheduled for March 14, 2024 at 8pm Atlantic Time, hosted by Brad Nickerson, with presentation by Colin Forsythe of the Belleisle Bay Watershed Association.
- ‘Eurasian Watermilfoil - An Invasive Species Update’ is scheduled for March 20, 2024 at 7pm Atlantic Time, hosted by Mikael Gyllström, with presentations by Laura Lavigne of the Jemseg Grand Lake Watershed Association and Ben Whalen of the Kennebecasis Watershed Restoration Committee.

The webinars will be advertised in print media, on social media, and through neighbouring watershed associations. Webinars are recorded and posted on our website where they can be viewed at any time by members of the public who land on our webpage.

To wrap this up, we are always looking for more ways to engage the people who enjoy this watershed, to hear what they value, stimulate their interest, and let them know what we are learning.

5.1 RECOMMENDATIONS

We look forward to doing more intentional outreach and education in the coming year to help us achieve our goals of reaching more people who live in and enjoy the watershed, increasing awareness about the health of our watershed, and conducting activities to learn more about the watershed. As the saying goes, “Many hands make light work”, and we are keenly aware of how important it is for us to recruit new members who want to get involved by lending a hand, leading an activity, helping out with planning, organizing and reporting. We know we can learn many things about our watershed by talking with people who live and work in and visit the watershed. We will continue to make outreach a central part of what we do.

In the coming year we will continue to host virtual meetings and maintain an active website and social media profile through regular postings about our watershed. We will meet with people at local community gatherings. We would like to invite Wolastoqey First Nation people to participate in our activities, from Sitansisk (St. Mary’s) and Welamuktok (Oromocto). Meeting with community leaders in Grand Lake and Arcadia will be important to find ways to work together. Finally, we will install additional Clean-Drain-Dry Signs and Zebra Mussel signs, provided by NBISC, around public boat launches to reduce introduction and spread of invasive species