Keeyask Generation Project

Aquatic Effects Monitoring Plan

Mercury in Fish Flesh from the Keeyask Reservoir, Stephens Lake, and Split Lake Report

AEMP-2023-11

Manitoba Environment and Climate Client File 5550.00
Manitoba Environment Act Licence No. 3107

2022 - 2023

KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2023-11

MERCURY IN FISH FLESH FROM THE KEEYASK RESERVOIR, STEPHENS LAKE, AND SPLIT LAKE, 2022

Prepared for

Manitoba Hydro

By

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June 2023

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This report should be cited as:

Holm, J., and J. Aiken. 2023. Mercury in fish flesh from the Keeyask reservoir, Stephens Lake, and Split Lake, 2022. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2023-11. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2023. xiv + 83 pp.

SUMMARY

Background

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the Keeyask Generating Station (GS) on the environment. Besides measuring the accuracy of the predictions made and actual effects of the GS on the environment, monitoring results will provide information on how construction and operation of the GS will affect the environment and if more needs to be done to reduce harmful effects.

Construction of the Keeyask GS began in mid-July 2014 and instream work was completed in 2020. The reservoir was impounded with water levels being raised to full supply level between August 31 and September 5, 2020. Commissioning of the powerhouse turbines was initiated after impoundment. They were brought into service one at a time with the final of seven turbines completed on March 9, 2022.

Fish mercury is one of the key components for monitoring because it affects the suitability of fish for consumption by people. Flooding is predicted to increase mercury levels in fish in the Keeyask reservoir and Stephens Lake, though the increase in Stephens Lake will be much less than when the lake was first created by construction of the Kettle GS in the early 1970’s. There are no predicted effects of reservoir flooding on mercury in fish caught from Split Lake, but there is a potential for fish from the Keeyask reservoir to move in and out of it, so monitoring will be carried out to confirm there are no impacts.

This report provides results of mercury concentrations measured in jackfish (Northern Pike), pickerel (Walleye), and whitefish (Lake Whitefish) collected from the Keeyask reservoir, Stephens Lake, and Split Lake in 2022. These data were collected in the second year after final impoundment of the Keeyask reservoir in the fall of 2020. Monitoring will continue annually on all three waterbodies to measure the effect of impoundment on mercury in fish.

Though not targeted for mercury monitoring, Lake Sturgeon that die during Keeyask monitoring work are also analysed for mercury and the results are reported here.

Why is the study being done?

Monitoring in 2022 was done to answer the following questions:

- *What are mercury concentrations in jackfish, pickerel, and whitefish in the Keeyask reservoir, Stephens Lake, and Split Lake after impoundment of the Keeyask reservoir compared to pre-Project?*
- *What are the peak mercury concentrations in the three species and how long does it take to reach these values?*

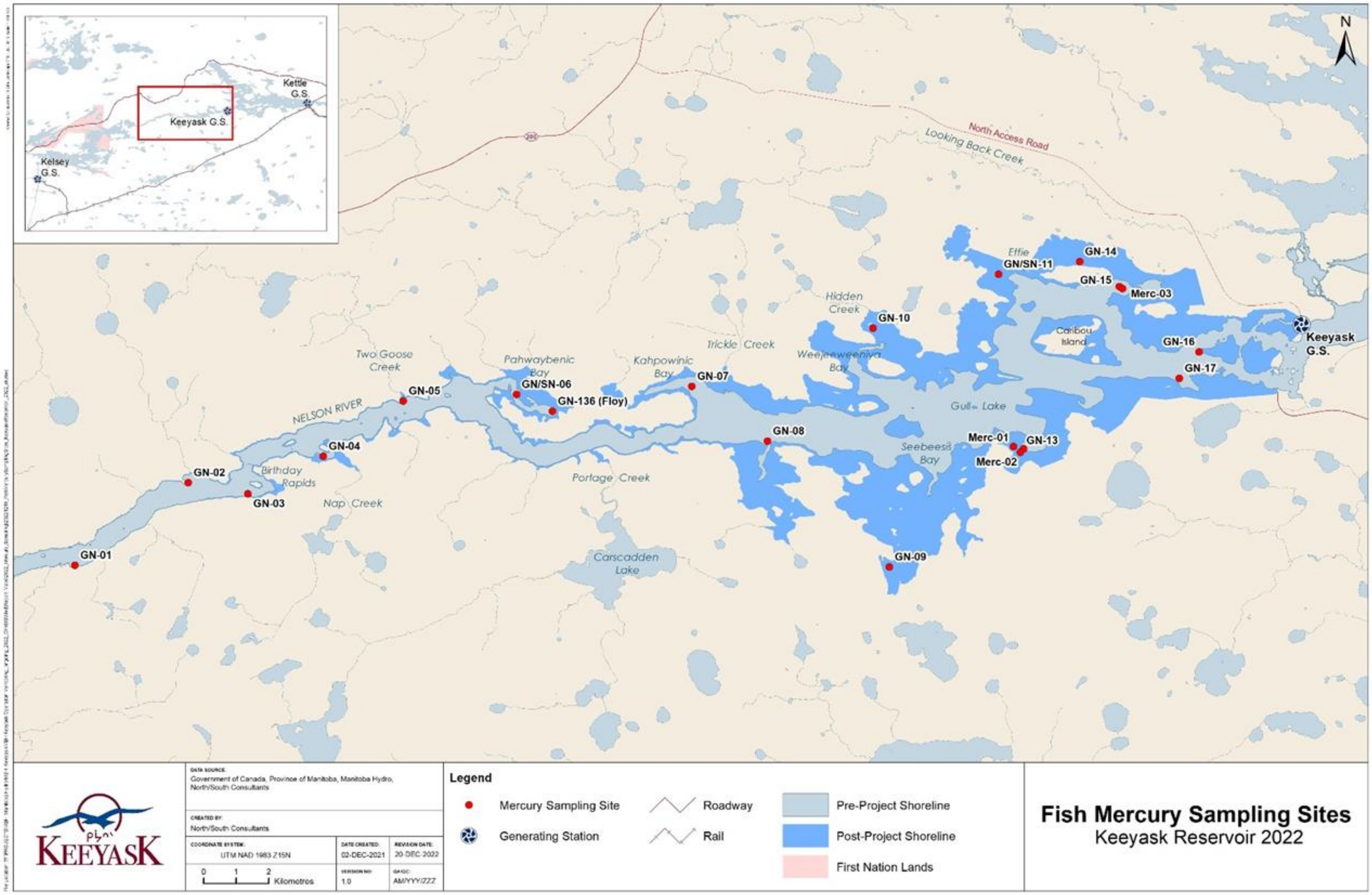
Frozen pickerel muscle sample being prepared for mercury analysis.

What was done?

Mercury was analyzed in 36 jackfish, 36 pickerel, and 20 whitefish from the Keeyask reservoir (see map below), 29 jackfish, 36 pickerel, and seven whitefish from Stephens Lake, and 33 jackfish, 36 pickerel, and 24 whitefish from Split Lake. Nine Lake Sturgeon that died during AEMP monitoring work were also analyzed for mercury. All fish were caught in August and September 2022.

Fish from all three waterbodies were measured for length and weight, and a structure to determine the fish's age was collected. A piece of muscle was taken from each fish for mercury analysis. Mercury was measured at a certified laboratory in Winnipeg.

Using the mercury concentration measured in each fish, the average mercury concentration of all fish from each species was calculated. This concentration is referred to as the **arithmetic mean**. Because the concentration of mercury in fish typically increases with the length of the fish, a second value was calculated that adjusts the concentration to a standard fish length of 550 mm for jackfish, 400 mm for pickerel, and 350 mm for whitefish. Standard fish lengths are based on many years of studies done by scientists and will be used consistently during the Project. This second value is called the **standard mean**. Comparison of mercury concentrations between years and waterbodies based on the standard mean is more meaningful than the arithmetic mean since the standard mean accounts for differences in the size of fish sampled each year. Standard means can only be calculated if the fish that were sampled show an increase in mercury concentration with fish length. Therefore, a standard mean is not always available. A model was also used to see if there were statistical differences in mercury concentrations before and after impoundment.



Map of the Keeyask reservoir showing sampling sites for fish mercury in 2022.

What was found?

Within the Keeyask reservoir:

- Mercury concentrations in individual fish in 2022 were more variable than they have been in previous years.
- The standard mean mercury concentration of a 550 mm jackfish was 0.64 ppm.
- A standard mean could not be calculated for pickerel because there was not a significant relationship between length and mercury concentration, so an arithmetic mean was calculated for fish within 25 mm of the 400 mm standard length and was 0.62 ppm.
- A standard mean could not be calculated for whitefish using all of the fish analyzed for mercury because there was not a significant relationship between length and mercury concentration, but a standard mean could be calculated if only the larger fish were included in the analysis. The standard mean of a 350 mm whitefish was 0.22 ppm.
- The mean mercury concentration in jackfish, pickerel, and whitefish caught in the Keeyask reservoir in 2022 was higher than it has been since 1999, when monitoring began.

For fish from Stephens Lake:

- The standard mean mercury concentrations for fish caught in 2022 were 0.39 ppm in a 550 mm jackfish and 0.50 ppm in a 400 mm pickerel. The mercury concentration of jackfish measured in 2022 was within the range of values observed from 1999 to 2021 and the mercury concentration of pickerel was equal to the highest value recorded since 1999.
- A standard mean could not be calculated for whitefish because very few were caught in 2022, despite extra effort. The mercury concentration of individual whitefish captured in 2022 was comparable to concentrations found in individual whitefish caught in previous years.

For fish from Split Lake:

- The standard mean mercury concentrations in fish collected from Split Lake in 2022 were 0.42 ppm in a 550 mm jackfish, 0.37 ppm in a 400 mm pickerel, and 0.09 ppm in a 350 mm whitefish.
- The mercury concentrations of whitefish and pickerel in 2022 were within the range of values observed since 2001, while that of jackfish was equal to the highest value.

Pickerel captured from the Keeyask reservoir in August 2022.

What does it mean?

Mercury concentrations in jackfish, pickerel, and whitefish caught from the Keeyask reservoir in 2022 were higher than values measured since 1999. The increase in mercury in fish in response to flooding the reservoir was a predicted effect of the Keeyask Project. Concentrations in jackfish and pickerel from the Keeyask reservoir in 2022 were below the predicted peak, and concentrations in whitefish were slightly higher than the predicted peak.

The concentrations found in fish from Split and Stephens lakes continue to fluctuate with no increasing or decreasing pattern. This fluctuation is typically what is observed when measuring mercury in fish on any given lake because of many interacting factors in the environment and in individual fish that affect the results. Overall, the results show there has been no measurable change in mercury concentrations in Stephens or Split lakes caused by the Keeyask Project to date.

What will be done next?

Mercury in fish will be monitored again in the Keeyask reservoir, Stephens Lake, and Split Lake in 2023 to continue to track changes and compare the results to the predictions.

ACKNOWLEDGEMENTS

We would like to thank Manitoba Hydro for the opportunity and resources to conduct this study.

Stewart Anderson and Ray Mayham of Fox Lake Cree Nation and Grant Connell, Kenneth Ouskun, Leslie Flett, and Terry Kitchekeesik of Tataskweyak Cree Nation are thanked for their local expertise and assistance in conducting the field work.

The collection of biological samples described in this report was authorized by Manitoba Natural Resources and Northern Development Fisheries Branch, under terms of the Scientific Collection Permits #41767128 (SCP 08-2022) and /41783559 (SCP 10-2022).

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF APPENDICES

1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station on the lower Nelson River in northern Manitoba. The GS is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam. Construction of the GS began in July 2014 and the seven generating units were all in-service in March 2022.

The *Keeyask Generation Project: Response to EIS Guidelines*, completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the aquatic environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement: Aquatic Environment Supporting Volume* (AE SV). As part of the licensing process for the Project, an *Aquatic Effects Monitoring Plan* (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment. This includes monitoring mercury concentrations in fish flesh of four species during the construction and operation phases of the Project.

The waterbodies included in the fish mercury component of the AEMP are the Keeyask reservoir (formerly known as Gull Lake), Stephens Lake, Split Lake, and the Aiken/Landing River, which is a tributary of Split Lake. In the event that the mercury concentration in fish from Stephens Lake should exceed predicted maximum concentrations by more than 10%, the fish mercury monitoring program will be extended further downstream on the Nelson River by sampling within the Long Spruce Forebay.

Fish mercury is one of the key components of monitoring because it affects the suitability of fish for consumption by people. Flooding of the Keeyask reservoir is predicted to increase mercury levels in fish in the Keeyask reservoir and Stephens Lake, though the increase in Stephens Lake is predicted to be much less than when it was first created by construction of the Kettle GS in the early 1970s. The average concentration of mercury in fish in upstream waterbodies such as Split Lake and the Aiken/Landing River could be affected if a large proportion of the fish in these waterbodies also spend extended periods in the Keeyask reservoir. Given that fish moving out of the Keeyask reservoir are expected to form only a small proportion of the fish in Split Lake and the Aiken/Landing River, no measurable effects to average mercury concentrations of fish collected from these waterbodies are predicted. Sampling will be conducted to confirm these predictions.

The primary parameter of concern for the mercury monitoring program is the concentration of total mercury in fish skeletal muscle (*i.e.*, flesh) from the following species: Lake Whitefish (*Coregonus clupeaformis*), Northern Pike (*Esox lucius*), and Walleye (*Sander vitreus*). These species are sampled because they are important in domestic, commercial, and recreational fisheries and form the primary pathway by which humans ingest (methyl) mercury.

Impoundment of the Keeyask reservoir was completed on September 5, 2020 and sampling in 2022 represents the second year of sampling after the reservoir reached full supply level. Sampling was conducted in 2022 to determine whether concentrations have changed in the reservoir and Stephens Lake, post flooding, as well as to track the changes since monitoring began in 1999, prior to the Project. This report also includes results from Split Lake to provide a regional context for results observed in the reservoir and Stephens Lake, and to monitor for potential increases caused by fish accumulating mercury in the Keeyask reservoir and moving upstream. The sampling in Split Lake in 2022 was conducted under the auspices of the Coordinated Aquatic Monitoring Program (CAMP).

The monitoring in 2022 was done to answer the following questions:

- *What are the concentrations of mercury in Northern Pike, Walleye, and Lake Whitefish caught in the Keeyask reservoir, Stephens Lake, and Split Lake following final impoundment of the Keeyask reservoir in comparison to pre-Project levels?*
- *What are the peak mercury concentrations in Northern Pike, Walleye, and Lake Whitefish and how many years after the start of operation are the peak concentrations reached?*

Results reported herein add to the dataset of mercury concentrations in fish flesh from the Keeyask study area since 1999 (as reported in Jansen 2016a, 2018; Holm 2020; Holm and Aiken 2022).

2.0 STUDY SETTING

The study area encompasses an approximately 110 km long reach of the Nelson River from Split Lake to Stephens Lake (Map 1). This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (range 0–30 m) and velocities.

Split Lake, which is immediately downstream of the Kelsey GS at the confluence of the Burntwood and Nelson rivers, is the second largest waterbody in the Keeyask study area. Due to large inflows from the Nelson and Burntwood rivers, the lake has a detectable current in several locations. Split Lake has maximum and mean depths of 28.0 m and 3.9 m respectively, at a water surface elevation of 167.0 m above sea level (ASL) (Lawrence *et al*. 1999). The surface area of Split Lake was determined to be 26,100 ha (excluding islands), with a total shoreline length, including islands, of 940.0 km (Lawrence *et al*. 1999). The numerous islands in Split Lake represent 411.6 km of the total shoreline.

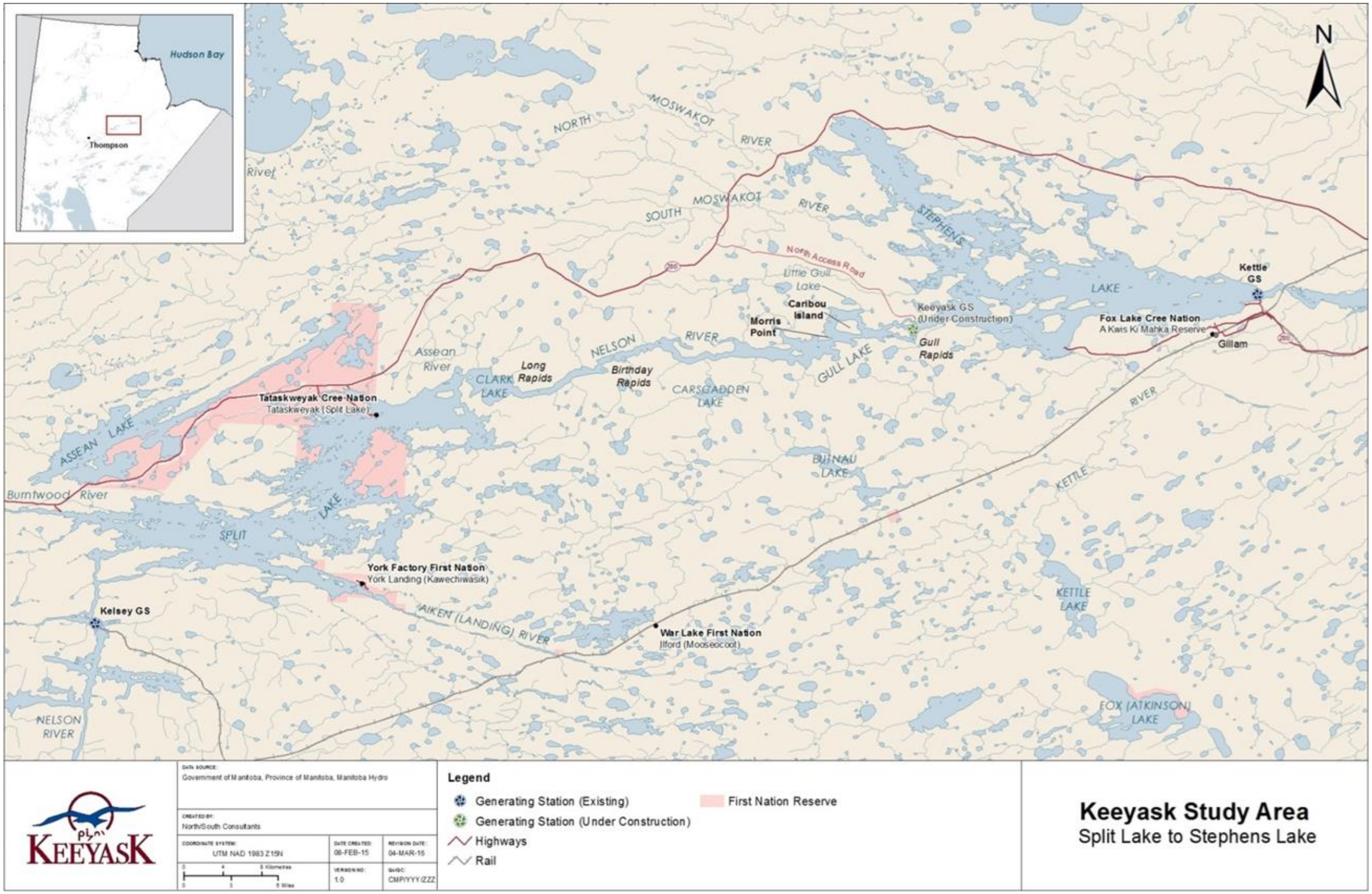
Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of the Keeyask GS. Current is restricted to the main section of the lake, with off-current bays outside the main channel. The Assean River is the only major tributary to Clark Lake and flows into the north side. Downstream from the outlet of Clark Lake, the Nelson River narrows and water velocity increases for a 3 km stretch, known as Long Rapids. For the next 7 km, the river widens, and water velocity decreases. The area between Clark Lake and Birthday Rapids is referred to herein as the upper Keeyask reservoir.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of the Keeyask GS and marks the upstream end of major water level changes because of impoundment by the Keeyask GS. The drop in elevation from the upstream to downstream side of Birthday Rapids was approximately 2 m prior to impoundment but is now nearly level, albeit a fast-flowing section of river. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake was characterized as a large and somewhat uniform channel with medium to high water velocities and a few large bays. This area is now within the Keeyask reservoir, though flooding was limited to mainly shoreline areas, and is referred to herein as the middle Keeyask reservoir.

Prior to impoundment, Gull Lake was a widening of the Nelson River, with moderate to low water velocity beginning approximately 20 km upstream the Keeyask GS. Water levels on Gull Lake increased by several metres following impoundment and flooding along the shoreline and small tributaries entering this reach was extensive. Although this area is larger than prior to impoundment, the portion of the Keeyask reservoir is referred to herein as Gull Lake.

Just below the Keeyask GS, the Nelson River enters Stephens Lake. Stephens Lake was formed in 1971 by construction of the Kettle GS. Construction of the Keeyask GS has altered the flow distribution immediately downstream of the station.

Construction of the Kettle GS flooded Moose Nose Lake (north arm) and several other small lakes that previously drained into the Nelson River, as well as the old channels of the Nelson River that now lie within the southern portion of the lake. Major tributaries of Stephens Lake include the North and South Moswakot rivers that enter the north arm of the lake. Looking Back Creek is a second order stream that drains into the north arm of Stephens Lake. Kettle GS is located approximately 40 km downstream of the Keeyask GS.



Map 1: Map of the Nelson River showing the site of Keeyask Generating Station and the fish mercury study setting.

3.0 METHODS

3.1 FIELD COLLECTIONS

The 2022 sampling program in the Keeyask reservoir and Stephens Lake was conducted using similar methodologies as those used during previous sampling programs conducted between 1999 and 2021. Methodologies and sampling locations for previous years can be found in the reports listed in Table 1. Fish were also captured from the Keeyask reservoir and Stephens Lake in 2022 during the experimental gillnetting program conducted under the AEMP (Slongo and Hrenchuk 2023). Additional gillnetting was conducted during this program specifically to capture the target number of 36 fish of each species for mercury analysis. Sampling locations from the mercury-specific gillnetting are presented in Appendix 1. In addition, one Lake Whitefish mortality from the spring Floy-tagging program in the reservoir was sampled for mercury to increase the sample size (Morrison and Hrenchuk 2023). Mercury samples were also collected from Lake Sturgeon mortalities that occurred during other fish monitoring programs in the Keeyask Study Area.

Lake Whitefish, Walleye, and Northern Pike were captured using gill nets composed of six 22.9 m long and 2.5 m deep panels made of twisted nylon mesh, each 38, 51, 76, 95, 108, and 127 mm stretched. At some sites, small mesh panels consisting of three 10 m long by 1.8 m deep gillnet panels of 16, 20, and 25 mm stretch mesh were attached to the 38 mm end of the gill net.

Lake Whitefish, Northern Pike, and Walleye were collected from 20 sites within the Keeyask reservoir including three sites in the upper reservoir, four in the middle reservoir, and 13 in Gull Lake on June 8 and from August 11–18, 2022 (Map 2). Samples were collected from twelve sites in Stephens Lake from August 25–29, 2022 (Map 3).

The sampling program in Split Lake in 2022 used similar methodologies as those used for the Keeyask reservoir. Fish analysed for mercury were captured at 11 sites in Split Lake from August 28–September 1, 2022 (Map 4).

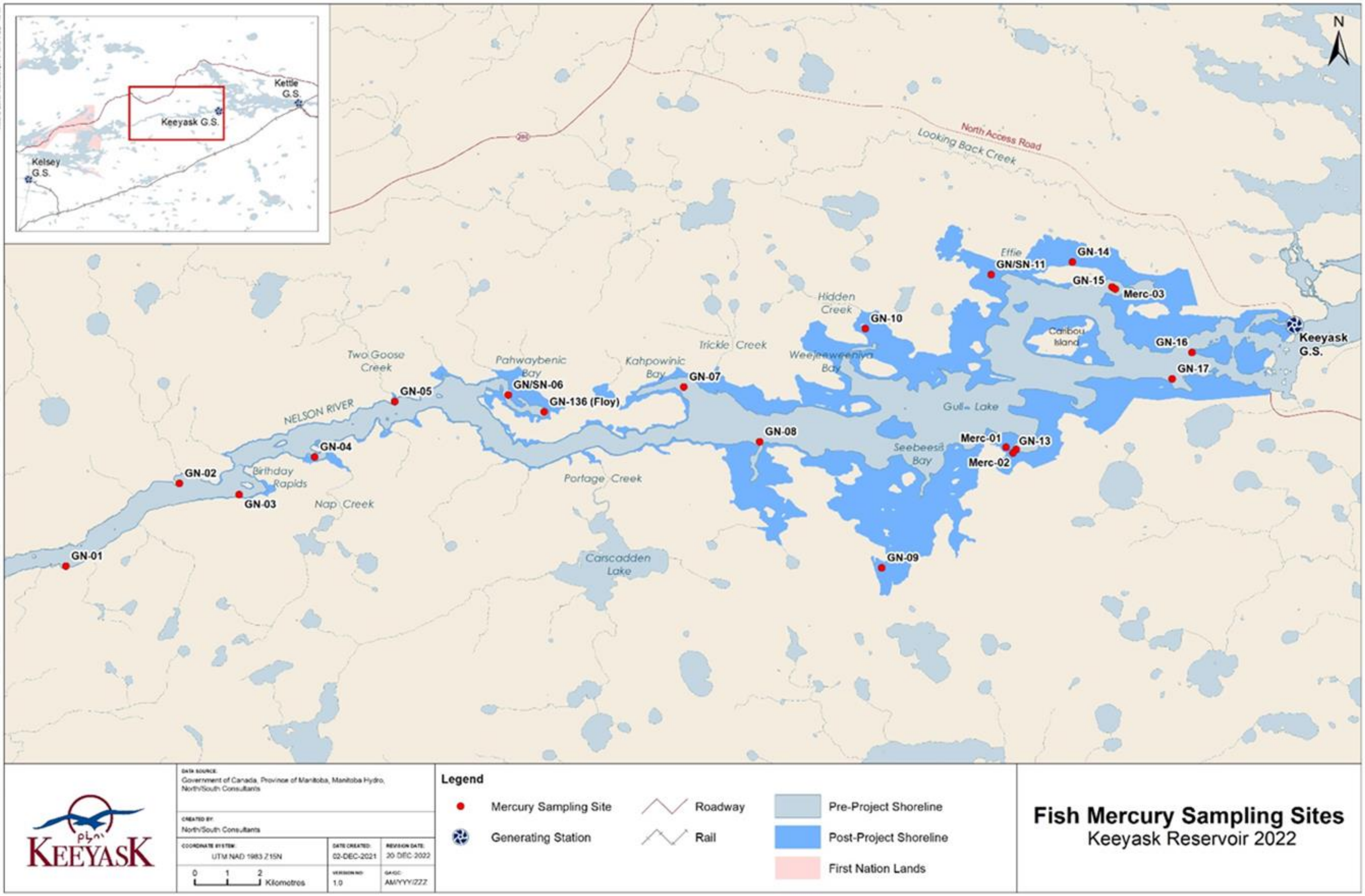
To be consistent with the methodology described in earlier Manitoba fish mercury monitoring programs (Jansen and Strange 2007a), a broad size range of the large-bodied fish was collected. A tally of the fish captured within each consecutive 50 mm length interval (starting at 100 mm) was kept, aiming for an equal distribution of length classes within a target size of 36 fish per species. Upon capture, fish were measured for fork length (±1 mm) and round weight. Small fish that were less than approximately 100 g were weighed using a digital balance (±1 g), while heavier fish were weighed on a mechanical pan balance (±25 g). Bony structures were removed from fish for age analysis: cleithra were collected from Northern Pike, and otoliths were removed from Lake Whitefish and Walleye. A portion of axial muscle weighing between 10 and 40 g was removed from each fish, anterior to the caudal (tail) fin, for mercury analysis of the large-bodied species. The muscle, with the skin attached, was wrapped tightly in commercial "cling-wrap", placed in mercury-free, internally and externally labelled Whirl-Pac bags or Zip-lock bags, and stored on ice until they could be frozen. Frozen tissue samples were shipped to North/South Consultants Inc. in Winnipeg for further processing.

Table 1: Summary of sampling conducted for fish mercury monitoring in Gull Lake/Keeyask reservoir, Stephens Lake, and Split Lake from 1999–2022.

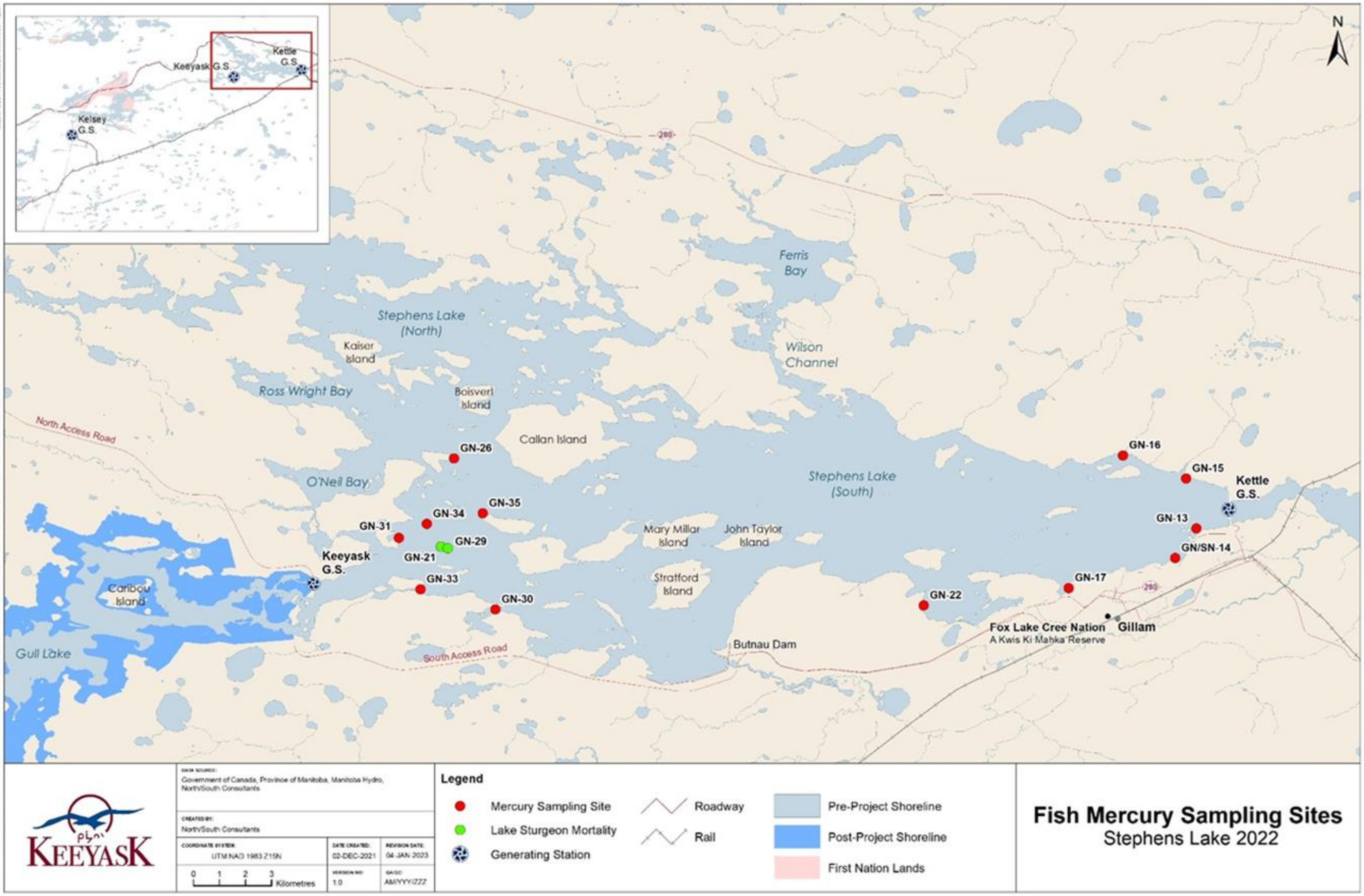
Waterbody	Year	Sampling Dates	# Sites	Sample Source
Gull Lake	1999	6–10 Oct	12	Remnant and Barth 2003
	2001	15–25 Aug	14	Remnant *et al*. 2004; Jansen and Strange 2007b
	2002	6–14 Aug	17	Johnson and Parks 2005; Jansen and Strange 2007b
	2004	6–9 Oct	2	Holm *et al*. 2007
	2006	31 May–30 Jun, 18–27 Aug	21	Jansen and Strange 2009
	2014	1–16 Sep	33	Jansen 2016a
	2016	14–24 Sep	16	Jansen 2018
	2019	8–15 Aug	21	Holm 2020; Burnett and Hrenchuk 2020
Keeyask reservoir	2021	4–14 Aug, 17-22 Sep	24	Holm and Aiken 2022; Burnett *et al*. 2022
	2022	8 Jun, 11–18 Aug	20	This report
Stephens Lake	1999	13–19 Aug	6	Bretecher and MacDonell 2000
	2001	31 Aug, 1–29 Sep	11	Pisiak *et al*. 2004; Jansen and Strange 2007b
	2002	24 Jul–8 Aug	16	Pisiak 2005a; Jansen and Strange 2007b
	2003	23 Jul–5 Aug	42	Pisiak 2005b; Jansen and Strange 2007b
	2004	12–13 Oct	1	Holm *et al*. 2007
	2005	25–27 Aug, 29 Sep, 4–11 Oct	12	Jansen and Strange 2007b
	2007	19 Sep–2 Oct	21	Jansen 2010
	2009	4–17 Sep	8	CAMP 2014
	2012	4–9 Sep	10	CAMP 2017
	2015	7–9 Sep	11	CAMP, unpubl. data
	2018	30 Aug–4 Sep	14	CAMP, unpubl. data

Table 1: Summary of sampling conducted for fish mercury monitoring in Gull Lake/Keeyask reservoir, Stephens Lake, and Split Lake from 1999–2021 (continued).

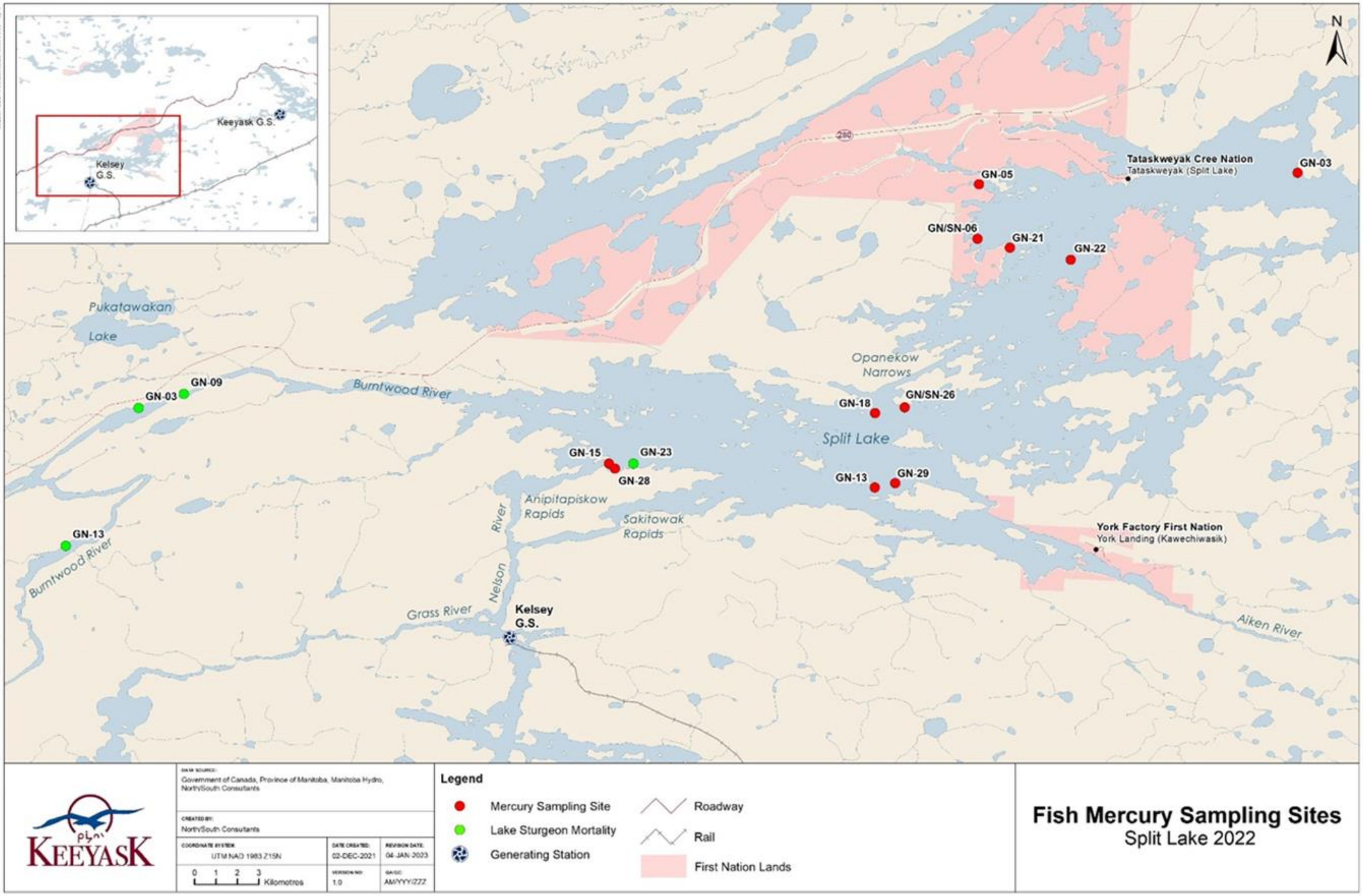
Waterbody	Year	Sampling Dates	# Sites	Sample Source
Stephens Lake	2021	1-4 Sep, 12-13 Oct	10	CAMP, unpubl. data; Funk and Hrenchuk 2022
	2022	25-29 Aug	12	This report
Split Lake	2001	15-26 Aug	13	Dunmall *et al.* 2004; Jansen and Strange 2007b
	2002	13-21 Aug,10 Oct	13	Holm and Remnant 2004; Jansen and Strange 2007b
	2004	6–10 Oct	2	Holm *et al.* 2007
	2005	20-23 Aug, 6-9 Oct	15	Jansen and Strange 2007b
	2007	9 Oct	8	Jansen 2010
	2010	21-25 Aug	8	CAMP 2014
	2013	14-19 Aug	12	CAMP 2017
	2016	14-18 Aug	13	CAMP, unpubl. data
	2019	23-28 Aug, 5-6 Sep	10	CAMP, unpubl. data
	2021	24-27 Aug	11	Holm and Aiken 2022
	2022	28 Aug-1 Sep	11	This report



Map 2: **Map of the Keeyask reservoir showing sites where fish were captured for mercury analysis in 2022.**



Map 3: Map of Stephens Lake showing sampling sites where fish were captured for mercury analysis in 2022.



Map 4: Map of Split Lake showing sampling sites where fish were captured for mercury analysis in 2022.

3.2 LABORATORY DETERMINATIONS

Muscle samples were weighed and shipped frozen to ALS Laboratories in Winnipeg for analysis of total mercury, ensuring the holding time requirement between catching the fish and its analysis was less than one year. Fish muscle samples from the Keeyask reservoir were analyzed for mercury between 6–19 October, 2022, those from Stephens Lake were analyzed between 17–18 November, 2022, those from Split Lake were analyzed on 18–19 October and 3–17 November, 2022, and the samples from the Lake Sturgeon mortalities were analyzed on 17 November and 15 December, 2022. The skin and a thin surface layer of the exposed muscle tissue on the opposite side were sliced away before the remaining sample was homogenized (see below). This procedure helped to ensure that the percentage of water in the muscle sample was representative of the original sample taken from the fish.

Mercury analysis was conducted by cold-vapor atomic absorption spectrometry (CVAAS) applying a modification of EPA Method 200.3/1631E and using a Teledyne Leeman M-7600 mercury analyzer (Teledyne Leeman Labs, Hudson, NH). Quality control results are presented in Appendix 2. The results all fall within the control limits for the QC sample (ALS Data Quality Objective).

Dried ageing structures were prepared and analyzed using a variety of techniques. Northern Pike cleithra were boiled to remove any remaining tissue and typically examined without a microscope (*i.e.*, free hand), although a dissecting microscope or magnified light ring was used when required. Lake Whitefish and Walleye otoliths were aged using the “crack and toast” method and then fixed on glass slides and examined under a microscope with reflected light. Annuli from all fish ageing structures were counted by a single reader without knowledge of length or weight of the fish. Quality assurance and quality control (QA/QC) procedures were conducted, which included re-ageing a random sample of at least 10% of all structures by an ageing technician not involved in the initial age determination.

3.3 DATA ANALYSIS

A condition factor (K) was calculated for each fish as:

$$K = W \times 10^5 / L^3$$

where: W = total weight (g); and

L = fork length (mm).

Fish obtained in different years from a group of lakes will invariably differ in mean size between years and lakes. Because fish accumulate mercury over their lifetime, older and, normally, larger individuals have higher levels than younger, smaller fish (Green 1986; Evans *et al*. 2005). In addition to calculating arithmetic mean mercury concentrations (also referred to as arithmetic means), mean mercury concentrations have been standardized to a common fish length under earlier Manitoba fish mercury monitoring programs (Jansen and Strange 2007a) and CAMP (CAMP 2017) to facilitate comparisons for the same species of fish over time or between waterbodies. The standard lengths used for Northern Pike, Walleye, and Lake Whitefish were 550, 400, and 350 mm, respectively.

Length-standardized mean mercury concentrations (also referred to as standard means) were calculated from unique regression equations, by species and location, based on the analysis of logarithmic transformations of muscle mercury concentration and fork lengths using the following relationship:

$$Log_{10}\ Hg = a + b \times Log_{10}\ L$$

where: Hg = muscle mercury concentration (ppm);

L = fork length (mm);

a = Y-intercept (constant); and

b = slope of the regression line (coefficient).

Standard means were not calculated when the relationship between mercury concentration and fish length was not significant. Linear regression analysis was completed using XLSTAT (Version 2022.1.1; Addinsoft 2022). To present data in more familiar units, all standard means and their measures of variance presented in the tables and figures have been back-transformed to arithmetic values (*i.e.*, inverse log). All fish mercury concentrations were expressed as parts per million (ppm), which is the equivalent of mg/kg or µg/g wet weight muscle tissue.

A second statistical analysis was conducted to compare length-standardized mercury concentrations between pre- and post-impoundment. To remove the effect of fish length on fish total mercury concentration, similar to Eagles-Smith *et al*. (2016), a linear mixed effects model was fit for each species which included log_{10} transformed total mercury concentration as the dependent variable, log_{10} transformed fork length as a fixed covariate and waterbody as a random effect. This analysis removed the typically positive relationship between length and mercury, but retained the variation in mercury concentration.

For each species, a model was fit to all of the data from all of the waterbodies, but included random (*i.e.*, different) intercepts for each waterbody to account for differences between waterbodies, and fixed (*i.e.*, the same) slopes for each waterbody to account for the similar positive slopes observed for each waterbody. To standardize mercury concentrations at standard lengths of 350 mm for Lake Whitefish, 400 mm for Walleye, and 550 mm for Northern Pike, the residuals from each fitted model were then added back to the values predicted by the model at each standard length to calculate standardized mercury values for each individual fish, and standardized means for each sampled waterbody and year. The significance of the effect of total length on total mercury was assessed by calculating p-values using the Satterthwaite approximation for degrees of freedom (Satterthwaite 1941). To present data in more familiar units, all standardized means and their measures of variance presented in the tables and figures were back-transformed to arithmetic values.

For each species, differences in the standardized mercury concentrations for each waterbody were then assessed among years using ridgeline plots. Ridgeline plots graphically summarize the distribution of a numeric variable (*i.e.*, length-standardized mercury concentration) for several groups (*i.e.*, years). Additionally, each species length-standardized mercury concentrations were compared pre- and post-impoundment and among waterbodies. To do this, a model was fit that included three fixed effects: 1) a variable that identified whether the sample was collected pre- or post-impoundment (TimePeriod); 2) a variable that identified which waterbody the sample came from (Waterbody); and 3) an interaction term between these two variables (TimePeriod × Waterbody). In addition, the model also included the year in which the sample was collected as a random effect. The significance of the effect of TimePeriod, Waterbody, and their interaction was assessed by calculating p-values using the Satterthwaite approximation for degrees of freedom (Satterthwaite 1941). Estimated marginal means were then estimated for the six treatment combinations of Waterbody and TimePeriod. All mercury analyses were run using the lme4, lmerTest and emmeans packages (Bates *et al*. 2015; Kuznetsova *et al*. 2017; Lenth 2023) in R version 4.2.2 R Core Team (2022).

3.4 BENCHMARKS

The benchmarks included in the Keeyask AEMP have been dropped as they are no longer relevant and not appropriate to apply to subsistence fishers (discussed in Jansen 2016a, b).

The key reason for measuring mercury in fish is to determine the risk of it to consumers. For this reason, the mercury data collected under the AEMP is shared with the *Keeyask Mercury and Human Health Implementation Group* for use in that process.

4.0 RESULTS

4.1 SAMPLE DESCRIPTION AND BIOLOGICAL DATA

4.1.1 KEEYASK RESERVOIR

The target number of 36 Northern Pike and Walleye were captured for mercury analysis from the Keeyask reservoir in 2022 (Table 2). Only 20 Lake Whitefish were analyzed for mercury in 2022. This species is not abundant in the Keeyask reservoir (KHLP 2012), and it has been difficult to catch the target number for mercury monitoring in previous years, even with additional, targeted sampling.

With a mean length of 376 mm, Lake Whitefish analyzed for mercury were 7% longer than the standard length for the species (350 mm) (Table 2). In contrast, the average length of Northern Pike (460 mm) and Walleye (348 mm) analyzed for mercury were about 14% and 13% shorter than the standard lengths for the species (550 mm and 400 mm) respectively (Table 2).

The Walleye and Northern Pike analyzed for mercury varied in length (183–516 mm and 205–1,020 mm, respectively) and age (2–15 years and 1–12 years, respectively) (Figure 1). The Lake Whitefish sampled showed a wide range of lengths (161–598 mm) and ages (1–20) but no fish measuring between 300–350 mm were captured (Figure 1).

Biological data for individual fish of all species analyzed for mercury in 2022 are presented in Appendix 3 (Table A3-2). Box plots of lengths of Lake Whitefish, Northern Pike, and Walleye captured for mercury analysis from 1999–2022 are presented in Appendix 4. Lake Whitefish analyzed from 2014–2019 had a narrower range of lengths than those from 1999–2002 and in 2021–2022. Prior to impoundment, Lake Whitefish <350 mm in length had not been collected for mercury since 2002. More than half of the Lake Whitefish analyzed for mercury (67%) in 2022 were <350 mm in length. Since 2006, the Northern Pike analyzed for mercury have generally skewed toward smaller fish. There has been some variation in the size of Walleye analyzed each year, but the mean and range has varied less than the other species.

Table 2: Size and age (mean ± SE) and mercury concentration ([Hg], arithmetic mean ± SE and standardized mean ± 95% confidence interval, CI) of Lake Whitefish, Northern Pike, and Walleye sampled for mercury analysis from Gull Lake/Keeyask reservoir from 1999–2022.

Waterbody/ Year	n	Fork Length (mm)	n	Weight (g)	n	Age (y)	n	Arithmetic Mean [Hg] (ppm)	Standard Mean [Hg] (ppm)	95% CI
Lake Whitefish										
1999	22	356 ± 22	21	1018 ± 152	22	5.8 ± 0.7	22	0.098 ± 0.016	0.075	0.055–0.103
2001	21	415 ± 23	21	1585 ± 256	21	7.7 ± 1.1	21	0.088 ± 0.010	0.062	0.053–0.073
2002	26	367 ±30	25	1406 ± 235	26	7.8 ± 1.2	26	0.102 ± 0.014	0.082	0.070–0.097
2014	4	498 ± 17	4	2300 ± 334	4	11.8 ± 1.9	4	0.225 ± 0.052	not significant	
2016	19	500 ± 9	19	2372 ± 129	19	10.6 ± 0.9	19	0.182 ± 0.020	0.034	0.014–0.085
2019	33	491 ± 9	33	2209 ± 118	33	11.1 ± 0.8	33	0.218 ± 0.020	0.038	0.024–0.058
2021	27	368 ± 30	27	1396 ± 235	16	9.5 ± 1.6	27	0.235 ± 0.020	regression not appropriate	
2022	20	376 ± 33	19	1380 ± 314	18	7.8 ± 1.4	20	0.318 ± 0.035	not significant	
Northern Pike										
1999	40	694 ± 27	40	3440 ± 407	39	8.0 ± 0.5	40	0.572 ± 0.048	0.314	0.278–0.355
2001	33	688 ± 30	33	2967 ± 375	31	7.5 ± 0.5	33	0.447 ± 0.059	0.220	0.181–0.268
2002	35	700 ± 29	35	3299 ± 406	35	9.2 ± 0.6	35	0.466 ± 0.049	0.226	0.196–0.261
2004	20	637 ± 10	20	1821 ± 116	20	6.7 ± 0.6	20	0.211 ± 0.014	not significant	
2006	66	552 ± 22	66	1590 ± 164	44	5.3 ± 0.5	66	0.231 ± 0.018	0.208	0.187–0.230
2014	31	707 ± 17	31	2774 ± 227	29	7.1 ± 0.4	31	0.572 ± 0.039	0.338	0.274–0.417
2016	36	554 ± 33	36	1729 ± 294	36	5.5 ± 0.5	36	0.378 ± 0.041	0.342	0.313–0.373
2019	36	541 ± 26	36	1441 ± 196	35	6.4 ± 0.5	36	0.630 ± 0.050	0.611	0.557–0.670
2021	36	377 ± 26	36	650 ± 177	36	3.3 ± 0.3	36	0.403 ± 0.044	0.527	0.438–0.634
2022	36	460 ± 34	36	1220 ± 296	35	4.0 ± 0.5	36	0.608 ± 0.092	0.636	0.538–0.753

Table 2: Size and age (mean ± SE) and mercury concentration ([Hg], arithmetic mean ± SE and standardized mean ± 95% confidence interval, CI) of Lake Whitefish, Northern Pike, and Walleye sampled for mercury analysis from Gull Lake/Keeyask reservoir from 1999–2022 (continued).

Waterbody/ Year	n	Fork Length (mm)	n	Weight (g)	n	Age (y)	n	Arithmetic Mean [Hg] (ppm)	Standard Mean [Hg] (ppm)	95% CI
Walleye										
1999	22	445 ± 13	22	1350 ± 128	22	8.5 ± 0.8	22	0.414 ± 0.041	0.293	0.244–0.353
2001	26	422 ± 20	26	1181 ± 162	24	7.0 ± 1.0	26	0.273 ± 0.045	0.19	0.167–0.217
2002	32	423 ± 23	32	1340 ± 198	32	9.1 ± 1.1	32	0.371 ± 0.050	0.263	0.227–0.304
2006	44	478 ± 16	44	1521 ± 125	34	9.9 ± 0.9	44	0.432 ± 0.044	0.212	0.170–0.253
2014	38	391 ± 18	38	904 ± 128	38	8.6 ± 1.2	38	0.364 ± 0.045	0.325	0.294–0.358
2016	36	394 ± 17	35	862 ± 114	36	9.1 ± 1.5	36	0.369 ±0.057	0.302	0.254–0.358
2019	36	378 ± 15	36	761 ± 138	36	6.8 ± 0.5	36	0.437 ± 0.038	0.438	0.387–0.497
2021	36	343 ± 17	36	569 ± 66	36	6.4 ± 0.4	36	0.506 ± 0.042	0.515	0.424–0.625
2022	36	348 ± 17	35	579 ± 76	35	7.8 ± 0.6	36	0.504 ± 0.040	not significant	

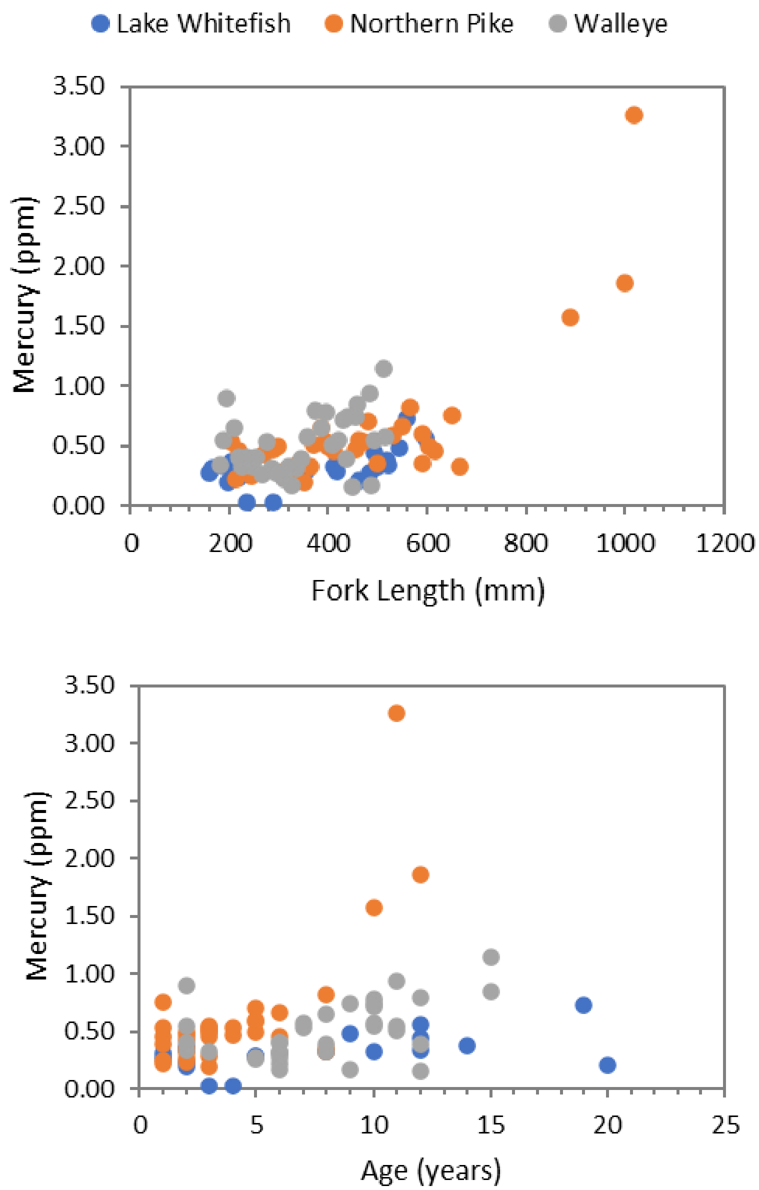


Figure 1: Mercury concentration versus fork length (top) and age (bottom) for Northern Pike, Walleye, and Lake Whitefish captured from the Keeyask reservoir in 2022.

4.1.2 STEPHENS LAKE

Thirty-six Walleye, 29 Northern Pike, and seven Lake Whitefish were captured for mercury analysis from Stephens Lake in 2022 (Table 3). Lake Whitefish have been difficult to catch in Stephens Lake in previous sampling years. Differences in the ability to capture Lake Whitefish is likely related to the timing of sampling and locations fished (refer to the reports listed in Table 1 for information about sampling methodologies used in each year) as Lake Whitefish are known to make spawning migrations in Stephens Lake (KHLP 2012).

Lake Whitefish analysed for mercury in 2022 averaged 380 mm in length and were 9% longer than the standard length for the species (350 mm) (Table 3). In contrast, the average lengths of Northern Pike (426 mm) and Walleye (342 mm) were slightly shorter than the standard lengths for the species by 23% (550 mm) and 15% (400 mm), respectively (Table 3).

Walleye analyzed for mercury varied in age (1–18 years) and length (123–556 mm) (Figure 2). Northern Pike analyzed for mercury measured between 284–734 mm and ranged in age from 2–9 years. Lake Whitefish analyzed for mercury from Stephens Lake ranged from 300–472 mm in length and in age from 4–16 years.

Biological data for individual fish of all species analyzed in 2022 are presented in Appendix 3 (Table A3-3). The lengths of Lake Whitefish, Northern Pike, and Walleye captured for mercury analysis from 1999–2022 are presented as box plots in Appendix 4. The box plots show there has been a considerable amount of variation in the length of Lake Whitefish analyzed for mercury in each year. Until 2021 and 2022, only five Lake Whitefish captured were <250 mm FL. In 2022, very few large Northern Pike were captured compared to what was typically observed in previous years. The length of Walleye analyzed each year has been relatively consistent over time.

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Table 3: Size and age (mean ± SE) and mercury concentration ([Hg], arithmetic mean ± SE and standardized mean ± 95% confidence interval, CI) of Lake Whitefish, Northern Pike, and Walleye sampled for mercury analysis from Stephens Lake from 1999–2022.

Waterbody/ Year	n	Fork Length (mm)	n	Weight (g)	n	Age (y)	n	Arithmetic Mean [Hg] (ppm)	Standard Mean [Hg] (ppm)	95% CI
Lake Whitefish										
1999	6	365 ± 33	0	-	6	4.8 ± 0.9	6	0.091 ± 0.019	0.077	0.050–0.119
2001	15	489 ± 9	15	2180 ± 119	9	13.2 ± 1.3	15	0.153 ± 0.014	not significant	
2002	25	403 ± 23	25	1364 ± 185	25	8.1 ± 0.9	25	0.134 ± 0.013	0.112	0.096–0.131
2003	78	394 ± 15	65	1797 ± 132	75	9.6 ± 0.7	78	0.125 ± 0.008	0.104	0.096–0.113
2004	10	478 ± 10	10	1915 ± 129	10	10.6 ± 1.0	10	0.085 ± 0.006	not significant	
2005	25	488 ± 9	25	2234 ± 136	25	12.2 ± 0.7	25	0.108 ± 0.009	0.029	0.020–0.042
2007	33	463 ± 10	32	1931 ± 123	32	10.1 ± 0.7	33	0.138 ± 0.009	0.069	0.056–0.085
2009	7	483 ± 26	7	2410 ± 397	6	12.7 ± 1.9	7	0.159 ± 0.027	0.046	0.025–0.084
2012	5	526 ± 20	5	2718 ± 307	5	16.0 ± 2.3	5	0.168 ± 0.018	0.053	0.024–0.115
2015	11	302 ± 61	11	1138 ± 361	11	7.2 ± 2.6	11	0.110 ± 0.036	0.107	0.081–0.141
2018	13	441 ± 22	13	1626 ± 226	13	10.8 ± 1.6	13	0.116 ± 0.018	0.059	0.045–0.078
2021	6	457 ± 31	6	1632 ± 251	6	13.5 ± 2.1	6	0.142 ± 0.021	not significant	
2022	7	380 ± 26	7	799 ± 168	7	8.7 ± 1.8	7	0.142 ± 0.026	not significant	
Northern Pike										
1999	14	501 ± 17	14	1620 ± 120	14	4.6 ± 0.4	14	0.369 ± 0.067	0.432	0.316–0.591
2001	27	641 ± 35	27	2377 ± 399	26	6.5 ± 0.5	27	0.573 ± 0.097	0.316	0.276–0.361
2002	35	700 ± 30	35	2955 ± 352	33	9.3 ± 0.7	35	0.663 ± 0.082	0.332	0.280–0.395
2003	76	632 ± 18	76	2277 ± 202	73	9.4 ± 0.5	76	0.448 ± 0.038	0.272	0.246–0.301
2005	52	583 ± 20	52	1743 ± 205	52	6.7 ± 0.4	52	0.250 ± 0.030	0.18	0.165–0.196
2007	40	669 ± 29	20	1828 ± 364	40	8.2 ± 0.6	40	0.521 ± 0.052	0.339	0.302–0.381

Table 3: Size and age (mean ± SE) and mercury concentration ([Hg], arithmetic mean ± SE and standardized mean ± 95% confidence interval, CI) of Lake Whitefish, Northern Pike, and Walleye sampled for mercury analysis from Stephens Lake from 1999–2022 (continued).

Waterbody/ Year	n	Fork Length (mm)	n	Weight (g)	n	Age (y)	n	Arithmetic Mean [Hg] (ppm)	Standard Mean [Hg] (ppm)	95% CI
Northern Pike										
2009	36	526 ± 32	36	1501 ± 224	28	6.8 ± 0.7	36	0.295 ± 0.042	0.261	0.230–0.297
2012	42	511 ± 22	42	1206 ± 143	42	6.0 ± 0.5	42	0.266 ± 0.022	0.275	0.249–0.304
2015	36	532 ± 27	36	1424 ± 220	34	5.9 ± 0.4	36	0.372 ± 0.051	0.333	0.284–0.390
2018	36	540 ± 23	36	1327 ± 180	36	5.0 ± 0.3	36	0.372 ± 0.049	0.329	0.289–0.375
2021	27	512 ± 35	27	1438 ± 294	27	4.9 ± 0.4	27	0.479 ± 0.082	0.448	0.385–0.520
2022	29	426 ± 18	29	591 ± 80	28	3.9 ± 0.3	29	0.315 ± 0.024	0.388	0.317–0.475
Walleye										
1999	24	380 ± 20	17	1504 ± 250	23	7.8 ± 0.8	24	0.444 ± 0.057	0.425	0.356–0.508
2001	29	419 ± 20	29	1217 ± 171	27	8.7 ± 1.0	29	0.373 ± 0.049	0.277	0.243–0.316
2002	34	438 ± 21	33	1342 ± 173	33	10.4 ± 0.9	34	0.469 ± 0.035	0.405	0.378–0.434
2003	70	433 ± 12	69	1240 ± 94	67	10.2 ± 0.6	70	0.418 ± 0.027	0.329	0.298–0.364
2004	1	421	1	900	1	7	1	0.15	too few samples	
2005	69	401 ± 13	69	1141 ± 95	69	10.1 ± 0.7	69	0.249 ± 0.022	0.204	0.183–0.227
2007	18	522 ± 17	15	2113 ± 171	18	14.4 ± 1.0	18	0.685 ± 0.058	0.394	0.282–0.551
2009	36	419 ± 18	36	1241 ± 141	33	11.5 ± 1.2	36	0.315 ± 0.030	0.262	0.236–0.291
2012	41	462 ± 15	41	1425 ± 120	41	9.2 ± 0.9	41	0.431 ± 0.045	0.283	0.248–0.322
2015	36	416 ± 18	36	961 ± 95	36	12.0 ± 1.2	36	0.592 ± 0.050	0.498	0.427–0.582
2018	36	403 ± 19	36	862 ± 106	35	8.7 ± 0.9	36	0.447 ± 0.051	0.38	0.336–0.431
2021	36	344 ± 18	36	571 ± 70	36	7.7 ± 0.7	36	0.372 ± 0.032	0.442	0.401–0.488
2022	36	342 ± 17	36	550 ± 72	35	8.1 ± 0.8	36	0.431 ± 0.047	0.503	0.441–0.574

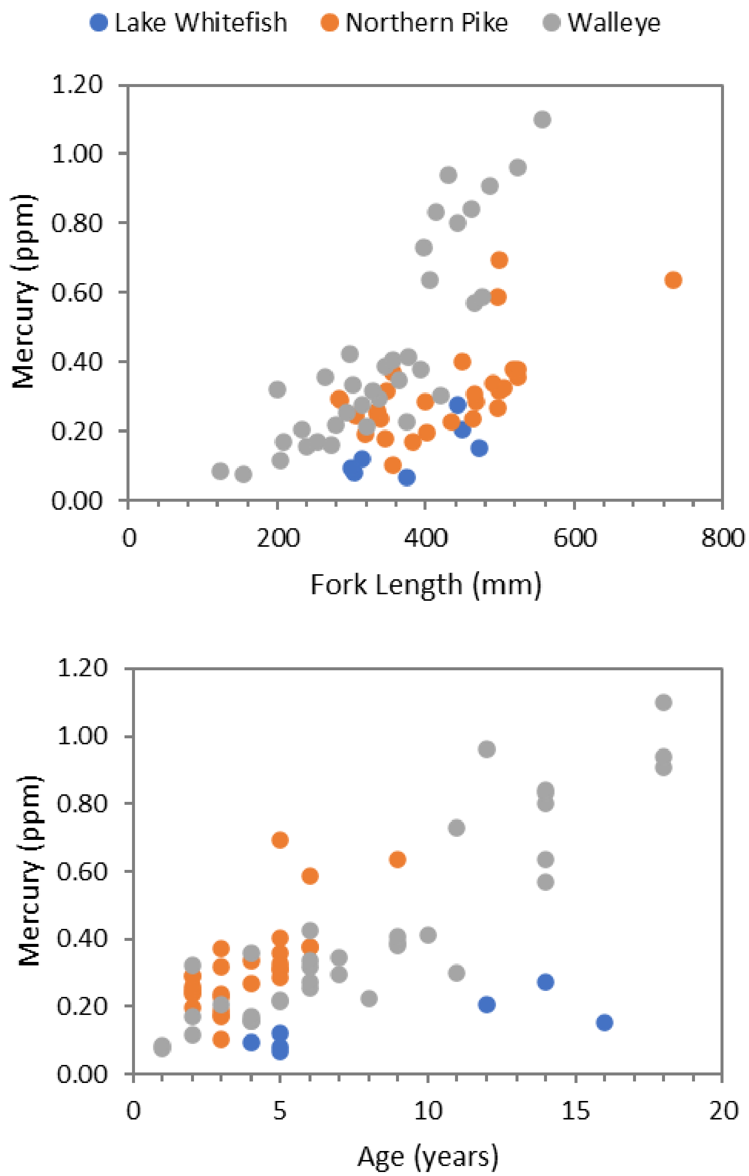


Figure 2: Mercury concentration versus fork length (top) and age (bottom) for Northern Pike, Walleye, and Lake Whitefish captured from Stephens Lake in 2022.

4.1.3 SPLIT LAKE

Thirty-six Walleye, 33 Northern Pike, and 24 Lake Whitefish were collected for mercury analysis from Split Lake in 2022 (Table 4). Lake Whitefish are not as common in Split Lake in the summer compared to the other two species (KHLP 2012).

Lake Whitefish analysed for mercury in 2022 averaged 406 mm in length, which is 16% longer than the standard length for the species (350 mm) (Table 4). In contrast, the average length of

Walleye (341 mm) and Northern Pike (439 mm) were shorter than the standard means for the species by 15% (400 mm) and 20% (550 mm), respectively (Table 4).

Walleye and Northern Pike analyzed for mercury ranged in length from 182–535 mm and 131–826 mm, respectively, and in age from 2–17 and 0–11 years, respectively (Figure 3). Only one small Lake Whitefish was analyzed for mercury (199 mm, 3 years), with the other fish ranging from 325–500 mm and 5–17 years.

Biological data for individual fish of all species analyzed in 2022 are presented in Appendix 3 (Table A3-4). The lengths of Lake Whitefish, Northern Pike, and Walleye captured for mercury analysis from 1999–2022 are presented as box plots in Appendix 4. Since 2004, Lake Whitefish analyzed for mercury have had a narrower range of lengths and have generally been longer than in 2001 and 2002. While there has been some variation in the size of Northern Pike and Walleye collected over time, the means and ranges have been more similar when compared to Lake Whitefish. A narrower range of lengths of both species was collected in 2007 since the samples were obtained from commercial and local fishers (Jansen 2010). Walleye analyzed in 2004 had a very narrow length range because only a small number of adult fish were sampled for trace element analysis (Holm *et al*. 2007).

Table 4: Size and age (mean ± SE) and mercury concentration ([Hg], arithmetic mean ± SE and standardized mean ± 95% confidence interval, CI) of Lake Whitefish, Northern Pike, and Walleye sampled for mercury analysis from Split Lake from 2001–2022.

Waterbody/ Year	n	Fork Length (mm)	n	Weight (g)	n	Age (y)	n	Arithmetic Mean [Hg] (ppm)	Standard Mean [Hg] (ppm)	95% CI
Lake Whitefish										
2001	27	333 ± 22	26	799 ± 140	27	6.6 ± 1.0	27	0.069 ± 0.010	0.066	0.058–0.075
2002	21	391 ± 23	21	1272 ± 194	21	7.8 ± 0.8	21	0.079 ± 0.013	0.054	0.042–0.070
2004	3	449 ± 20	3	1833 ± 412	3	9.0 ± 0.5	3	0.057 ± 0.007	not significant	
2005	37	465 ± 6	37	1930 ± 80	37	11.3 ± 0.4	37	0.075 ± 0.004	0.03	0.021–0.042
2007	17	439 ± 8	17	1725 ± 130	17	9.8 ± 0.6	17	0.128 ± 0.013	0.059	0.035–0.101
2010	16	412 ± 19	16	1324 ± 154	15	17.5 ± 0.9	16	0.092 ± 0.012	0.062	0.049–0.078
2013	20	413 ± 11	20	1177 ± 109	19	8.5 ± 0.7	20	0.150 ± 0.013	0.102	0.082–0.128
2016	22	429 ± 8	22	1409 ± 95	22	8.6 ± 0.5	22	0.072 ± 0.005	0.037	0.030–0.047
2019	21	443 ± 11	21	1640 ± 147	21	10.4 ± 0.6	21	0.102 ± 0.009	0.065	0.048–0.090
2021	25	446 ± 10	25	1489 ± 108	25	12.1 ± 0.6	25	0.155 ± 0.010	0.082	0.066–0.101
2022	24	406 ± 12	24	1088 ± 92	24	11.5 ± 0.7	24	0.131 ± 0.009	0.094	0.080–0.110
Northern Pike										
2001	23	599 ± 23	23	1791 ± 204	23	6.0 ± 0.3	23	0.337 ± 0.041	0.239	0.200–0.285
2002	26	632 ± 31	26	2274 ± 353	22	7.0 ± 0.5	26	0.340 ± 0.054	0.204	0.174–0.239
2005	51	574 ± 17	51	1572 ± 141	51	6.8 ± 0.4	51	0.237 ± 0.023	0.182	0.164–0.202
2007	35	630 ± 13	35	2026 ± 194	35	7.5 ± 0.3	35	0.443 ± 0.024	not significant	
2010	24	584 ± 32	24	1936 ± 313	24	6.0 ± 0.6	24	0.363 ± 0.042	0.289	0.249–0.335
2013	37	506 ± 22	37	1070 ± 146	36	5.3 ± 0.3	37	0.354 ± 0.032	0.375	0.333–0.422
2016	34	504 ± 25	34	1120 ± 166	34	4.7 ± 0.4	34	0.262 ± 0.029	0.278	0.251–0.308
2019	36	446 ± 20	36	714 ± 121	36	4.0 ± 0.3	36	0.312 ± 0.064	0.383	0.381–0.461

Table 4: Size and age (mean ± SE) and mercury concentration ([Hg], arithmetic mean ± SE and standardized mean ± 95% confidence interval, CI) of Lake Whitefish, Northern Pike, and Walleye sampled for mercury analysis from Split Lake from 2001–2022 (continued).

Waterbody/ Year	n	Fork Length (mm)	n	Weight (g)	n	Age (y)	n	Arithmetic Mean [Hg] (ppm)	Standard Mean [Hg] (ppm)	95% CI
Northern Pike										
2021	37	504 ± 27	35	1381 ± 289	37	4.7 ± 0.3	37	0.401 ± 0.044	0.415	0.376–0.458
2022	33	439 ± 24	33	760 ± 153	33	4.4 ± 0.4	33	0.339 ± 0.038	0.416	0.355–0.488
Walleye										
2001	26	392 ± 21	26	981 ± 151	25	7.0 ± 0.7	26	0.209 ± 0.028	0.19	0.166–0.217
2002	28	401 ± 22	27	1098 ± 170	26	7.2 ± 0.8	28	0.212 ± 0.019	0.198	0.171–0.230
2004	15	427 ± 9	15	920 ± 84	15	7.7 ± 0.6	15	0.155 ± 0.010	not significant	
2005	53	330 ± 16	53	634 ± 83	53	6.1 ± 0.3	53	0.099 ± 0.007	0.118	0.108–0.128
2007	66	392 ± 6	66	805 ± 44	66	7.9 ± 0.3	66	0.359 ± 0.023	0.331	0.295–0.372
2010	33	376 ± 19	33	854 ± 120	33	5.2 ± 0.5	33	0.197 ± 0.023	0.196	0.173–0.222
2013	37	345 ± 21	37	689 ± 132	37	6.4 ± 0.8	37	0.368 ± 0.042	0.413	0.355–0.481
2016	36	343 ± 22	36	668 ± 151	35	5.7 ± 0.8	36	0.238 ± 0.032	0.262	0.230–0.298
2019	32	270 ± 12	32	257 ± 32	30	4.6 ± 0.4	32	0.231 ± 0.020	0.37	0.284–0.482
2021	35	322 ± 17	35	461 ± 59	35	6.5 ± 0.5	36	0.351 ± 0.032	0.452	0.397–0.516
2022	36	341 ± 16	36	543 ± 70	36	7.4 ± 0.6	36	0.328 ± 0.027	0.366	0.311–0.431

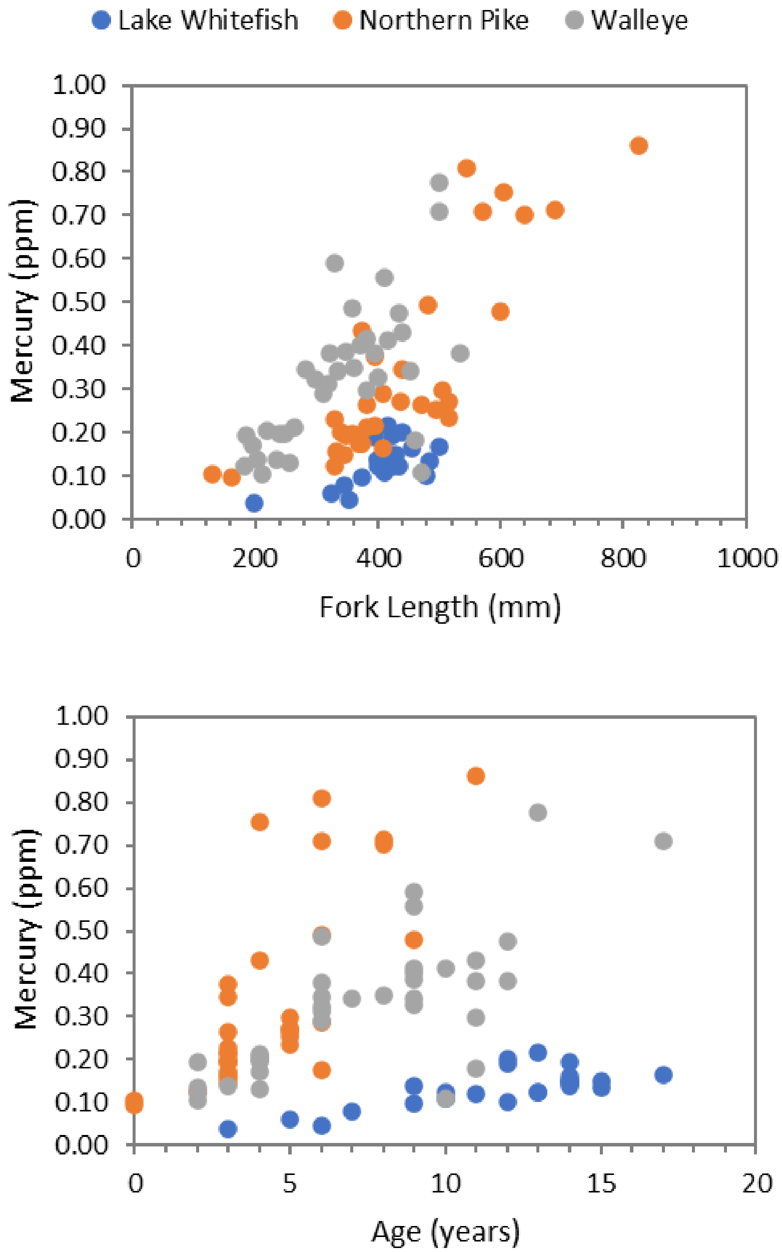


Figure 3: Mercury concentration versus fork length (top) and age (bottom) for Northern Pike, Walleye, and Lake Whitefish captured from Split Lake in 2022.

4.2 MERCURY CONCENTRATIONS

4.2.1 KEEYASK RESERVOIR

4.2.1.1 RESULTS FOR 2022

Only Northern Pike showed a significant, positive relationship between mercury concentration and fork length (Appendix 5), allowing for average concentrations to be standardized by fish length. The average concentration in a 550 mm Northern Pike from the reservoir in 2022 was 0.64 ppm (Table 1) which is below the predicted peak of 1 ppm (KHLP 2012).

There was not a significant relationship between mercury concentration and fork length for Walleye despite the target number being obtained over a wide range of lengths (Figure A5-1).

There was not a significant relationship between mercury concentration and fork length for all Lake Whitefish captured in 2022. However, a standard mean could be calculated for the group of larger Lake Whitefish (>350 mm) since the relationship was significant (Figure A5-2). Calculating the standard mean using only the larger fish is reasonable, since fish <350 mm were rarely caught in Gull Lake prior to impoundment. The standard mean mercury concentration of a 350 mm Lake Whitefish derived using only large fish (>350 mm) was 0.22 ppm and was just above the predicted peak value of 0.19 ppm (KHLP 2012).

4.2.1.2 COMPARISON TO PREVIOUS YEARS

The standard mean mercury concentration of a 550 mm Northern Pike in 2022 (0.64 ppm) was higher than the previous (2021) post-impoundment year (0.53 ppm) and exceeded the pre-Project maximum value (0.61 ppm) measured in 2019 (Figure 4). Prior to 2019, values ranged from 0.21 ppm in 2006 to 0.34 ppm in 2016.

A comparison of the standard mean of larger Lake Whitefish shows that the value in 2022 (0.22 ppm) is well above 2021 (0.06 ppm) and the range observed pre-impoundment (0.03–0.05 ppm) (Figure 5). In individual fish caught in 2021, elevated concentrations were observed in only the smaller Lake Whitefish and not in the larger (>350 mm) fish, whereas, in 2022, there were individuals of all sizes with higher mercury (Figure 6).

Because a standard mean could not be calculated for Walleye, the 2022 data cannot be compared to previous years using standard means. Like the whitefish, there appears to be a difference in the rate of mercury accumulation at different life stages of Walleye. This is evident in Figure 6, where a greater accumulation of mercury in individual Walleye <300 mm compared to pre-Project concentrations can be observed.

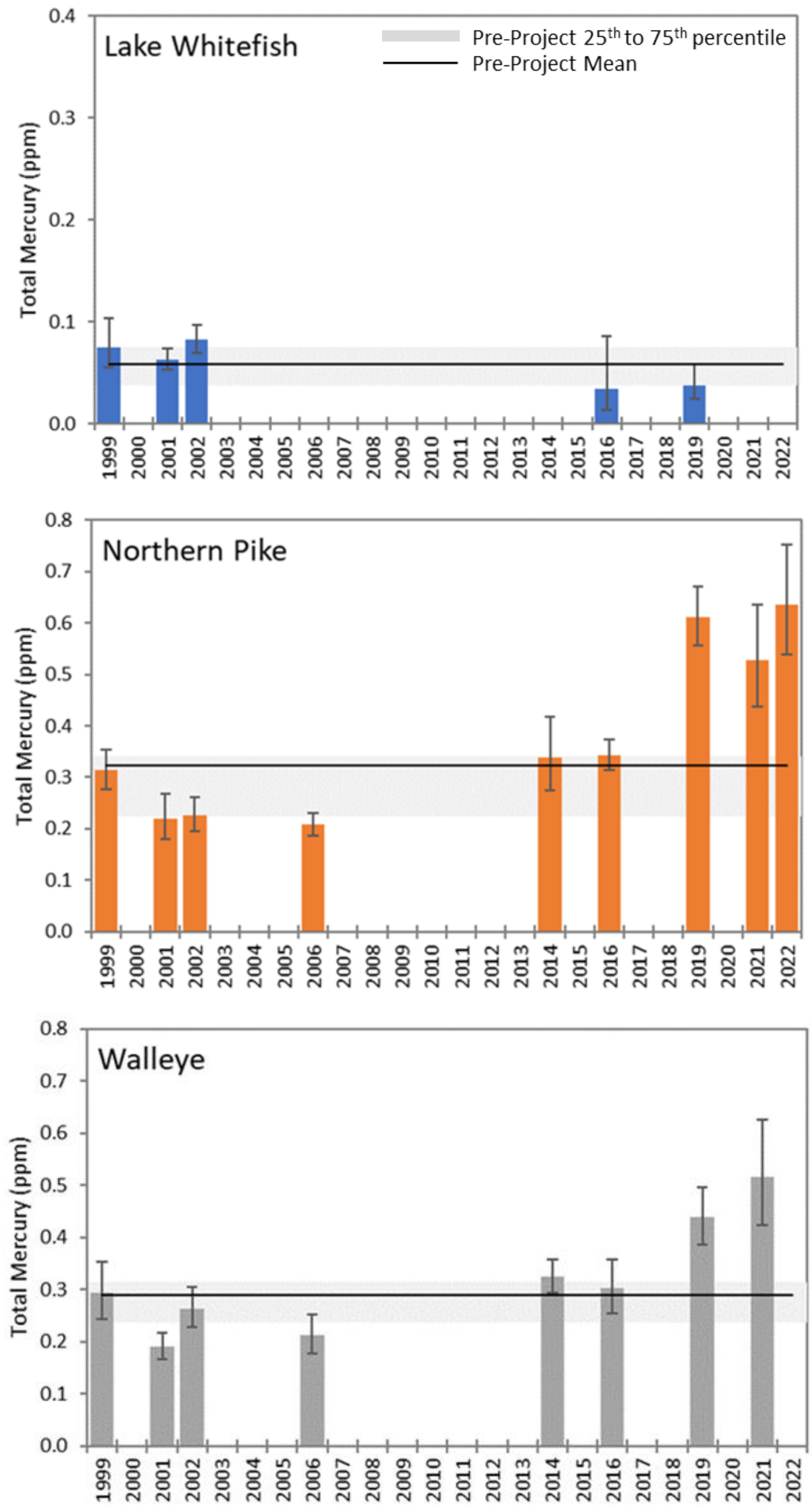


Figure 4: Length-standardized mean (±95% confidence limits) muscle mercury concentrations of a 350 mm Lake Whitefish, a 550 mm Northern Pike, and a 400 mm Walleye from Gull Lake/Keeyask reservoir for 1999–2022.

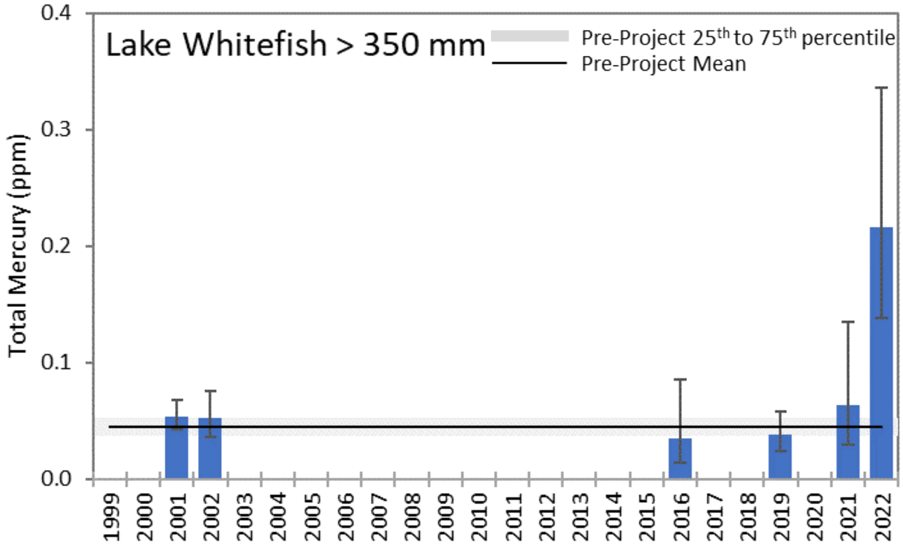


Figure 5: **Length-standardized mean (±95% confidence limits) muscle mercury concentrations of a 350 mm Lake Whitefish from the Keeyask reservoir using only large fish (>350 mm).**

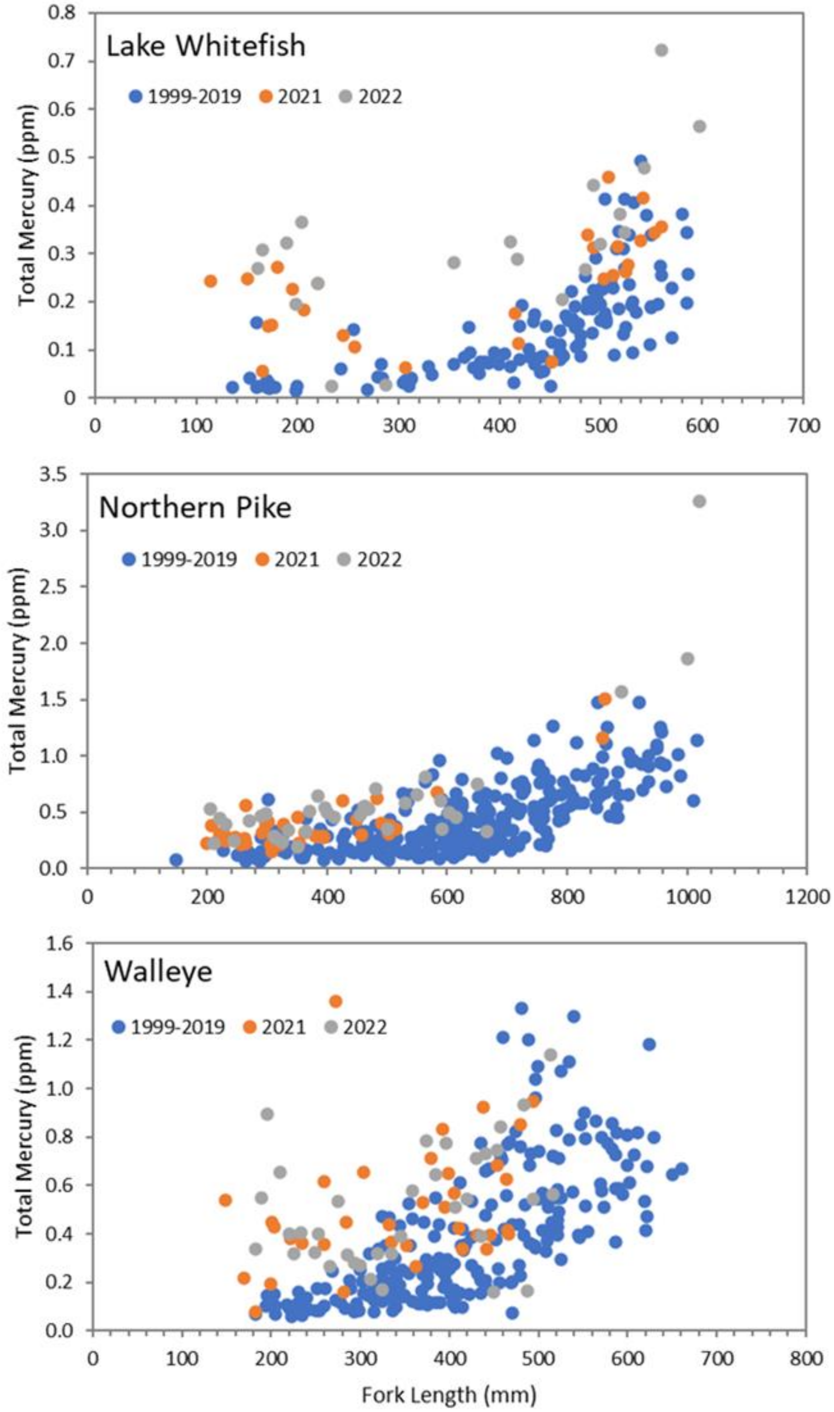


Figure 6: Muscle mercury concentrations of Lake Whitefish, Northern Pike, and Walleye as a function of fork length from the Keeyask reservoir in 2021 and 2022 compared to pre-impoundment (1999–2019).

To facilitate annual comparisons, the arithmetic mean of individual fish in a similar size range as the standard length (±25 mm for Walleye and Lake Whitefish and ±50 mm for Northern Pike) was calculated for each year as an alternative to the standard mean. For Walleye and Northern Pike, this arithmetic mean was generally similar to the standard mean over time (Figure 7). Too few Lake Whitefish of this size class have been sampled from the Keeyask reservoir to calculate an arithmetic mean (Figure 7). The post-impoundment average concentrations of Walleye between 375–424 mm was 0.58 ppm in 2021 and 0.62 ppm in 2022 and were higher than the pre-Project values (≤0.44 ppm). Likewise, Northern Pike between 500–599 mm had an average concentration of 0.43 ppm in 2021 and 0.56 ppm in 2022, which were higher than pre-Project values (≤0.39 ppm), except for 2019 (0.70 ppm). These results suggest that mercury concentrations have increased since impoundment but are still well below the 1 ppm prediction (KHLP 2012).

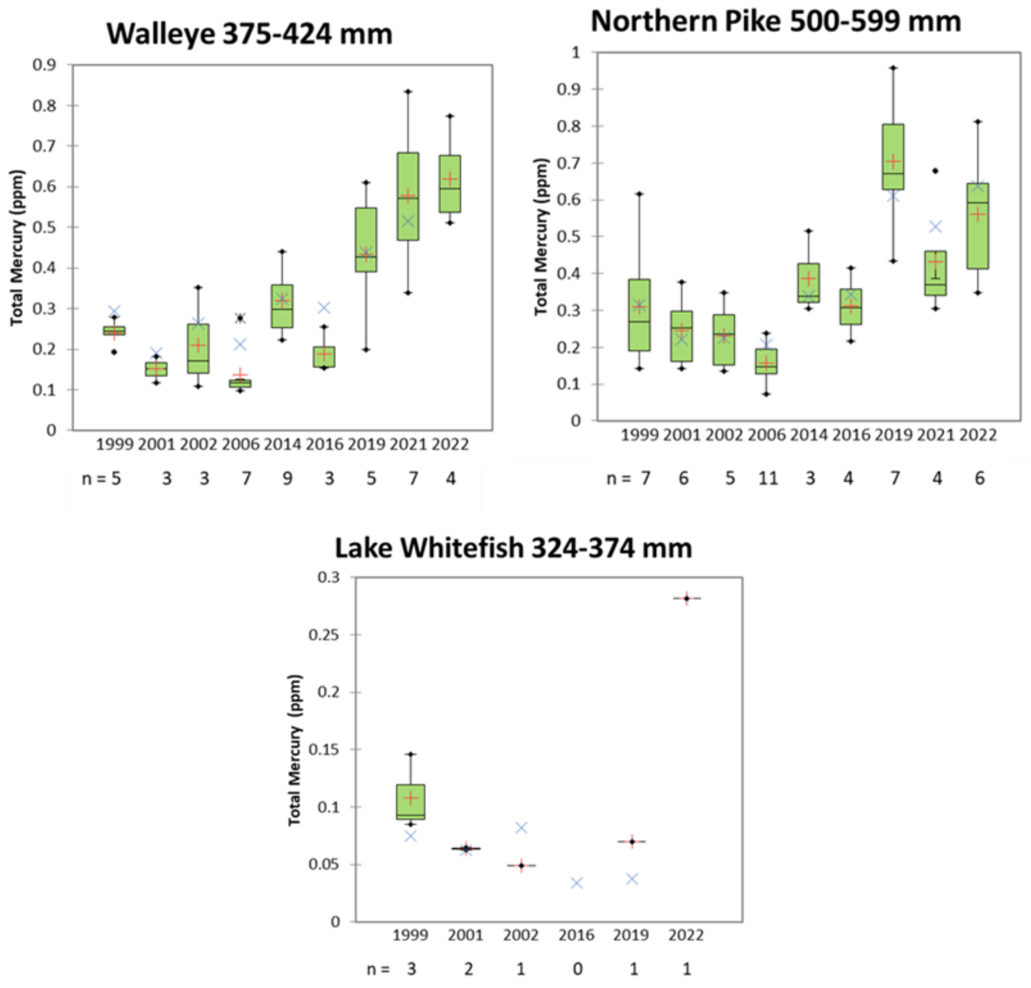


Figure 7: Arithmetic mean mercury concentration (+) of individual Walleye, Northern Pike, and Lake Whitefish of similar lengths as the species-specific standard length in comparison to the length-standardized mean (×) at the Gull Lake/Keeyask reservoir, 1999–2022.

Statistical analysis of the length-corrected dataset indicated that there were significant differences between pre- and post-impoundment mercury concentrations of a 550 mm Northern Pike, 400 mm Walleye, and 350 mm Lake Whitefish from the Keeyask reservoir. Comparisons of all three species showed significantly higher mercury concentrations in 2021 and 2022 (post-impoundment) than in all previous sampling years prior to 2019 (pre-impoundment) (Figure 8).

The length-corrected data were also used to create density ridgeline plots (Figure 9) that show the distribution of mercury concentrations estimated for a 550 mm Northern Pike, a 400 mm Walleye, and a 350 mm Lake Whitefish. Prior to 2019, the curves in Figure 9 were of similar shape and colour, which means mercury concentrations varied little among years. The majority of fish prior to impoundment had mercury concentrations between 0.13–0.38 ppm in Northern Pike, 0.13–0.25 ppm in Walleye, and 0.06–0.13 ppm in Lake Whitefish. Since 2019 for Northern

Pike and since 2021 for Walleye and Lake Whitefish, the shape of the mercury concentration curves has changed; they have flattened out and changed colour, indicating there is more variation in the mercury concentrations in fish of a standard length, with a portion of the fish having higher mercury concentrations since impoundment. The maximum mercury concentrations in 2022 are approximately twice as high as observed pre-impoundment.

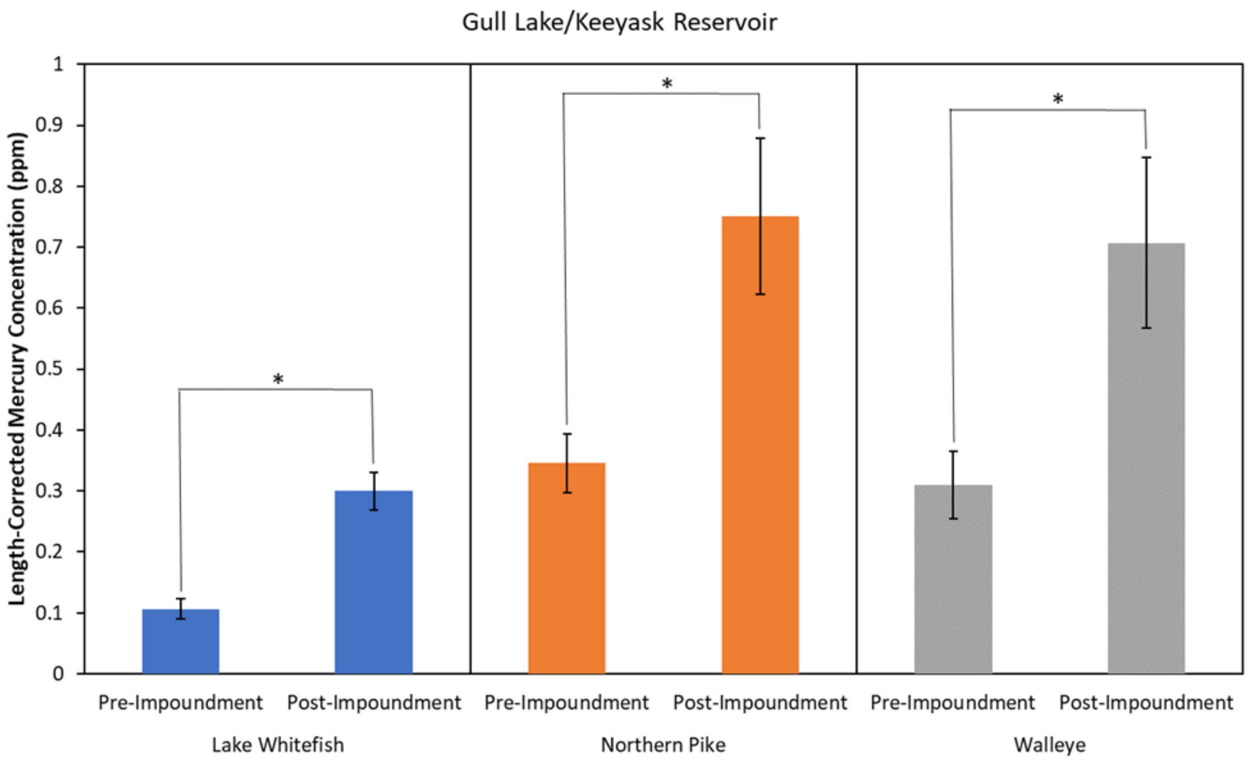


Figure 8: Estimated marginal mean length-corrected mercury concentration (ppm) for a 350 mm Lake Whitefish, a 550 mm Northern Pike, and a 400 mm Walleye from Gull Lake/Keeyask reservoir pre- (1999–2019) and post-impoundment (2021 and 2022). Asterisks indicate statistical significance ($p < 0.05$).

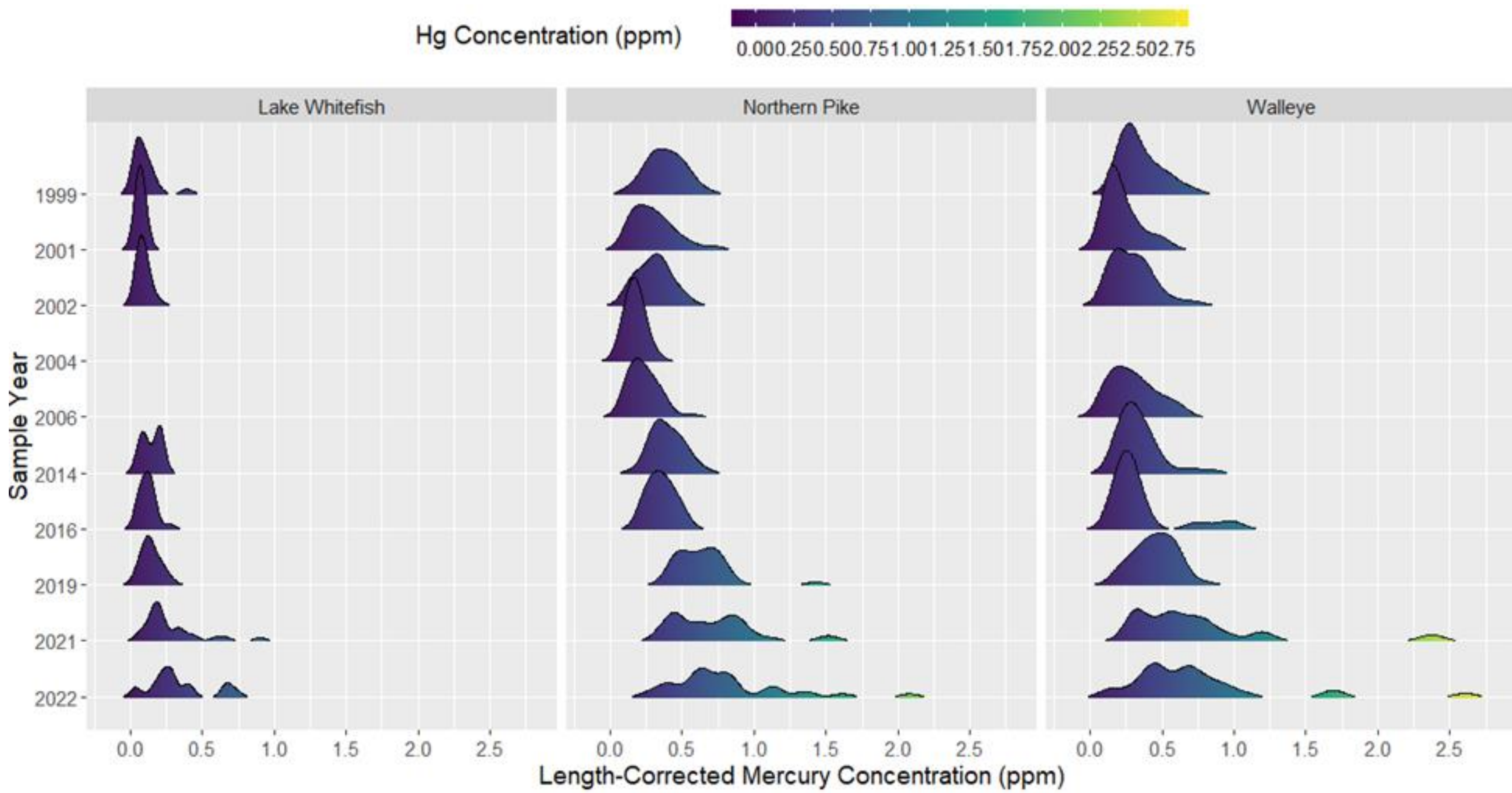


Figure 9: **Ridgeline plot of length-corrected mercury concentration (ppm) estimated for a 350 mm Lake Whitefish, 500 mm Northern Pike, and 400 mm Walleye from Gull Lake/Keeyask reservoir from 1999–2022.**

4.2.2 STEPHENS LAKE

4.2.2.1 RESULTS FOR 2022

Walleye and Northern Pike showed a significant positive relationship between mercury concentration and fork length (Appendix 5), allowing for average concentrations to be standardized by fish length. The standard mean was 0.50 ppm and 0.39 ppm, respectively (Table 3). The standard mean of Northern Pike was below the predicted peak of 0.5 ppm (KHLP 2012) in 2022, while that of Walleye was equal to the predicted peak.

The relationship between mercury and length was not significant for Lake Whitefish, which had a very small sample size (n = 7) and narrow range of lengths.

4.2.2.2 COMPARISONS TO PREVIOUS YEARS

Mercury concentrations in the three large-bodied species from Stephens Lake have fluctuated between 1999 and 2022 without showing a consistent increasing or decreasing trend (Figure 10). Prior to the Project, mercury concentrations in a 550 mm Northern Pike ranged from 0.18 ppm in 2005 to 0.43 ppm in 1999 and from 0.20 ppm in 2005 to 0.50 ppm in 2015 in a 400 mm Walleye. In 2021, the standard mean of Northern Pike (0.45 ppm) exceeded the maximum pre-Project value, but it was lower in 2022 (0.39 ppm) and within the pre-Project range. The standard mean of Walleye in 2022 (0.50 ppm) was higher than in 2021 (0.44 ppm) but was equal to the maximum pre-Project value measured in 2015.

While a standard mean mercury concentration could not be calculated for Lake Whitefish in either 2021 or 2022 (see Section 4.2.2.1), the mercury concentrations of individual fish fell within the range of fish analyzed in previous years (Figure 11). Likewise, the individual Walleye and Northern Pike sampled for mercury post-impoundment have mercury concentrations that are on the higher end, but still within the range of mercury concentrations measured pre-impoundment (Figure 11).

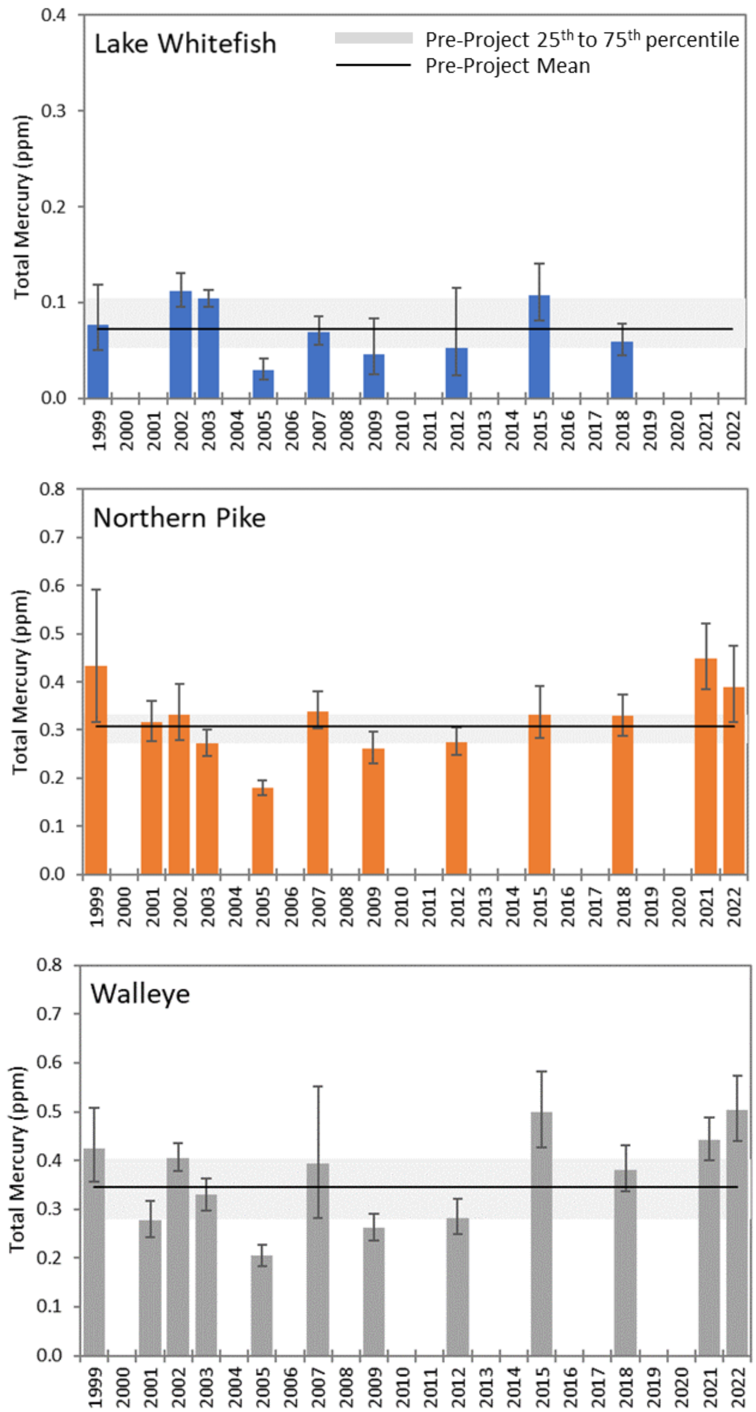


Figure 10: **Length-standardized mean (±95% confidence limits) muscle mercury concentrations of a 350 mm Lake Whitefish, a 550 mm Northern Pike, and a 400 mm Walleye from Stephens Lake for 1999–2022.**

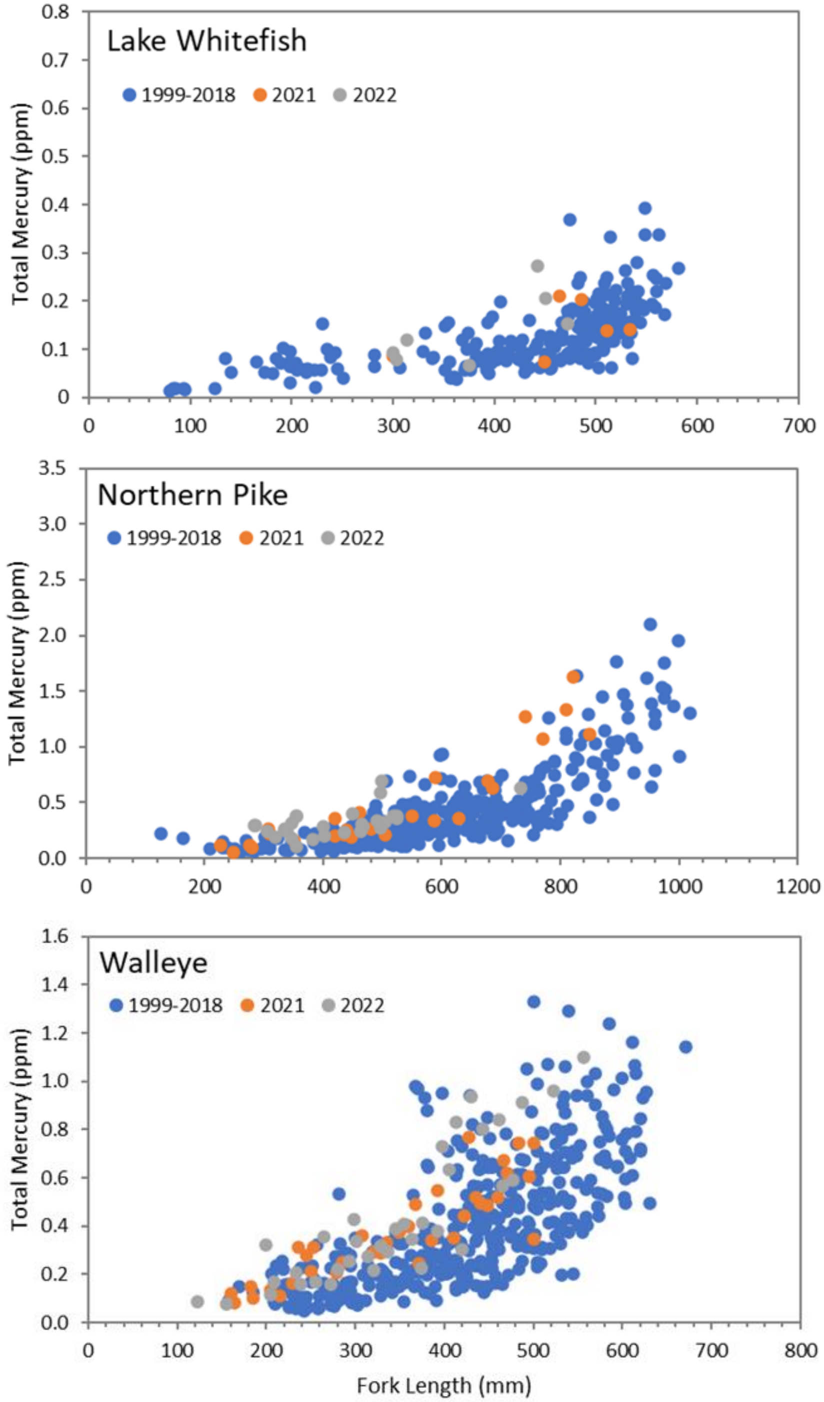


Figure 11: Muscle mercury concentrations of Lake Whitefish, Northern Pike, and Walleye as a function of fork length from Stephens Lake in 2021 and 2022 compared to pre-impoundment (1999–2019).

Statistical analysis of the length-corrected dataset indicated that there were no differences among time periods (pre- versus post-impoundment) in the mercury concentration of a 550 mm Northern Pike, a 400 mm Walleye, or a 350 mm Lake Whitefish from Stephens Lake (Figure 12).

The length-corrected data was also used to create density ridgeline plots that show the distribution of mercury concentrations estimated for a 550 mm Northern Pike, a 400 mm Walleye, and a 350 mm Lake Whitefish from Stephens Lake (Figure 13). Since 1999, most fish have shown similar mercury concentrations ranging from 0.19–0.31 ppm in Northern Pike, from 0.13–0.50 ppm in Walleye, and from 0.06–0.09 ppm in Lake Whitefish. Over time, the curves of all three species have generally been similar in shape and colour, indicating that there have been no obvious changes in mercury concentrations since impoundment.

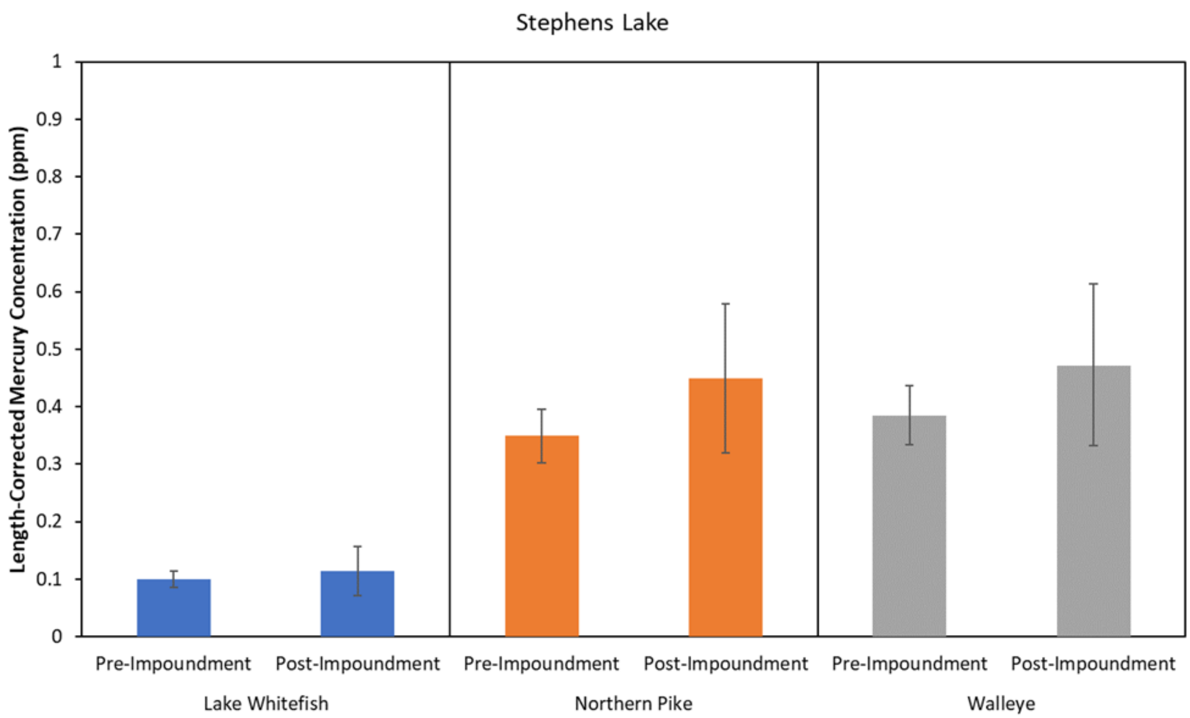


Figure 12: Estimated marginal mean length-corrected mercury concentration (ppm) for a 350 mm Lake Whitefish, 550 mm Northern Pike, and 400 mm Walleye from Stephens Lake pre- (1999–2019) and post-impoundment (2021 and 2022).

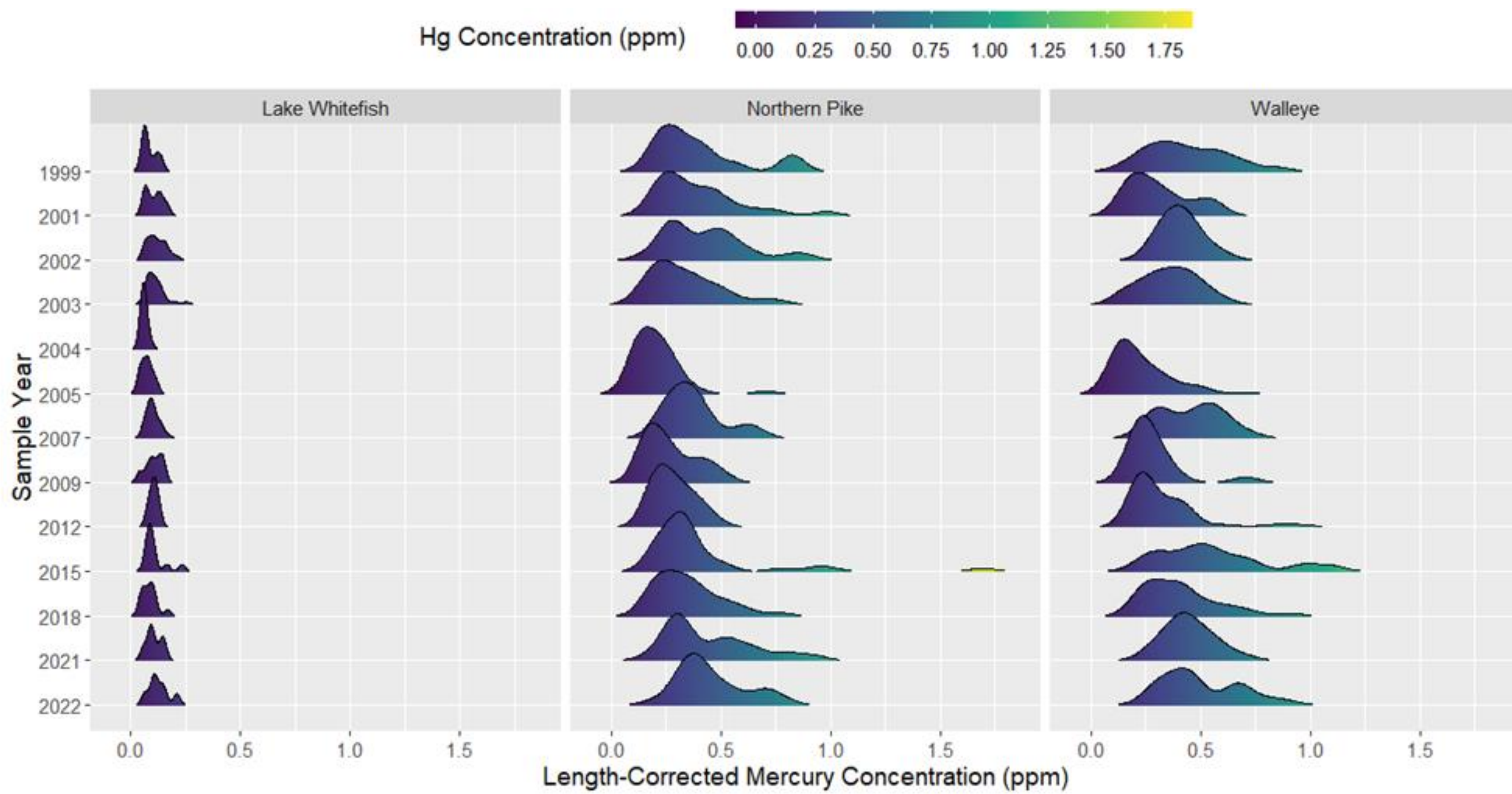


Figure 13: Ridgeline plot of length-corrected mercury concentration (ppm) estimated for a 350 mm Lake Whitefish, 550 mm Northern Pike, and 400 mm Walleye collected from Stephens Lake from 1999–2022.

4.2.3 SPLIT LAKE

4.2.3.1 RESULTS FOR 2022

All three species showed a significant positive relationship between mercury concentration and fork length (Appendix 5), allowing for average concentrations to be standardized by fish length. Standard means were 0.09 ppm for Lake Whitefish, 0.42 ppm for Northern Pike, and 0.37 ppm for Walleye (Table 4).

4.2.3.2 COMPARISONS TO PREVIOUS YEARS

Standard mean mercury concentrations in the three large-bodied species from Split Lake have fluctuated between 2001 and 2022 without showing a consistent increasing or decreasing trend (Figure 14). Prior to impoundment, the standard mean of a 350 mm Lake Whitefish ranged from 0.03 ppm in 2016 to 0.10 ppm in 2013, a 550 mm Northern Pike ranged from 0.18 ppm in 2005 to 0.38 ppm in 2019, and of a 400 mm Walleye ranged from 0.12 in 2005 to 0.41 in 2013. In 2021, the standard mean of Walleye (0.45 ppm) exceeded the maximum pre-Project value, but it was lower in 2022 (0.37 ppm) and within the pre-Project range. The standard mean of Northern Pike was greater than the maximum pre-Project value in both 2021 and 2022 (0.42 ppm). The standard mean of a 350 mm Lake Whitefish in both 2021 and 2022 fell within the range prior to impoundment (0.08 and 0.09 ppm, respectively).

For all three species, mercury concentrations of individual fish in post-impoundment years are on the higher end, but still within the range of mercury concentrations measured in previous years (Figure 15).

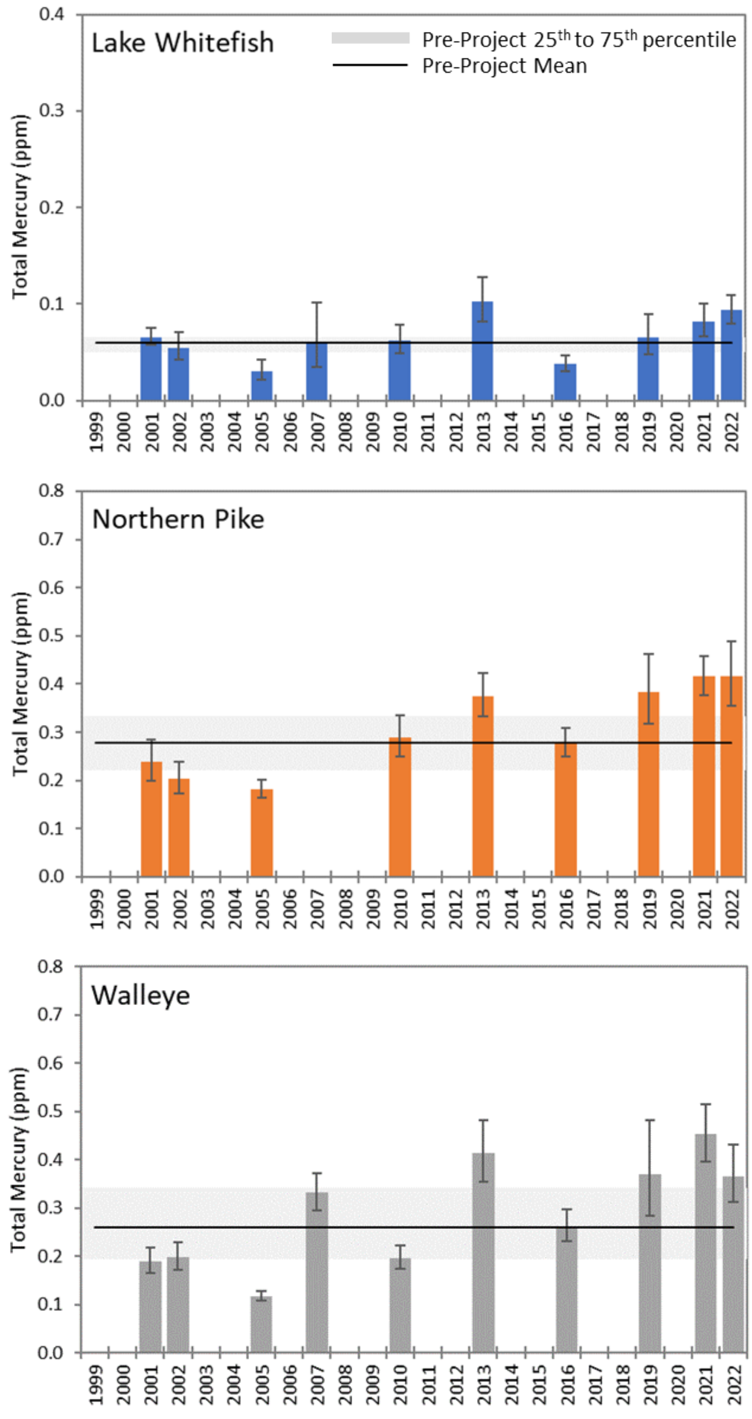


Figure 14: Length-standardized mean (±95% confidence limits) muscle mercury concentrations of a 350 mm Lake Whitefish, a 550 mm Northern Pike, and a 400 mm Walleye from Split Lake for 1999–2022.

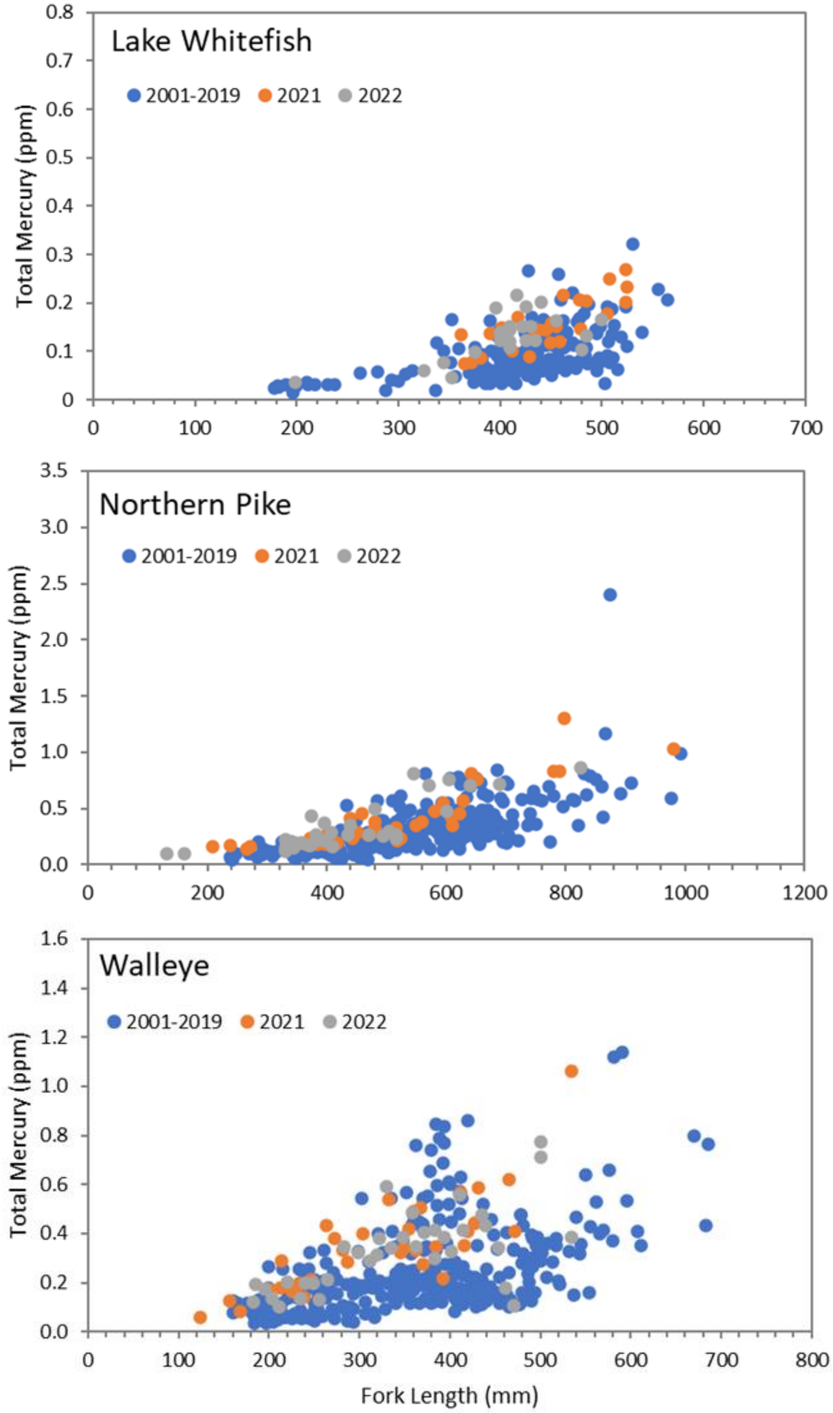


Figure 15: Muscle mercury concentrations of Lake Whitefish, Northern Pike, and Walleye as a function of fork length from Split Lake in 2021 and 2022 compared to pre-impoundment (2001–2019).

Statistical analysis of the length-corrected dataset indicated that there were no significant differences among time periods (pre- versus post-impoundment) in the mercury concentration of a 550 mm Northern Pike, a 400 mm Walleye, or a 350 mm Lake Whitefish from Split Lake (Figure 16).

The length-corrected data was also used to create density ridge plots that show the distribution of mercury concentrations modelled for a 550 mm Northern Pike, a 400 mm Walleye, and a 350 mm Lake Whitefish from Split Lake (Figure 17). The mercury concentration representing the greatest proportion of both Walleye and Northern Pike has shifted higher over time. In Walleye, the most common concentration was 0.13 ppm in the early 2000s, increased to about 0.25 ppm from 2006–2016, and since 2019, was approximately 0.38 ppm. In Northern Pike, the most common concentration increased from approximately 0.19 ppm in the early 2000s to about 0.25 ppm in 2007–2010 and has been about 0.34 ppm since 2012. The most common mercury concentration in Lake Whitefish has varied over time from approximately 0.06–0.13 ppm, without showing a consistent increasing or decreasing trend. Over time, the curves of all three species have generally been similar in shape and colour, which shows there have been no obvious changes in mercury concentrations since impoundment.

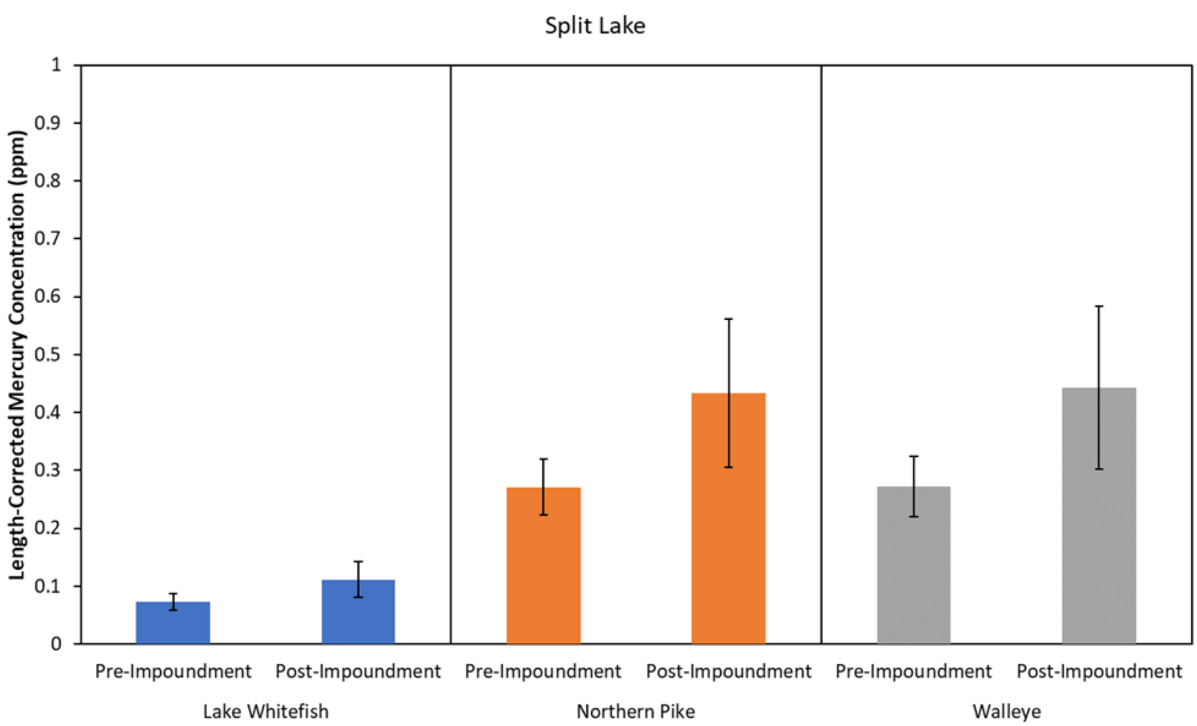


Figure 16: Estimated marginal mean length-corrected mercury concentration (ppm) for a 350 mm Lake Whitefish, 550 mm Northern Pike, and 400 mm Walleye from Split Lake pre- (2001–2019) and post-impoundment (2021 and 2022).

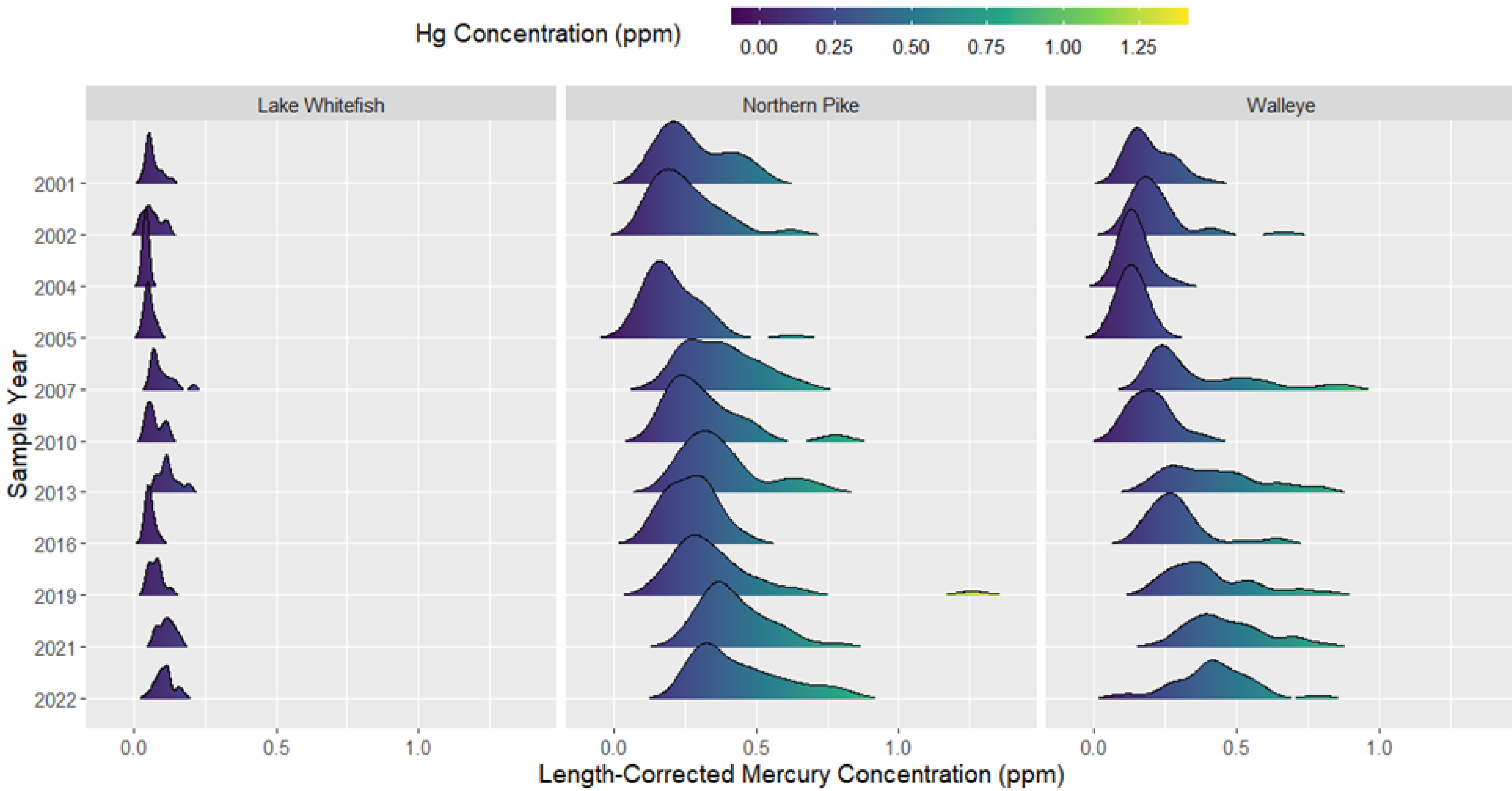


Figure 17: Ridgeline plots of length-corrected mercury concentration (ppm) estimated for a 350 mm Lake Whitefish, 550 mm Northern Pike, and 400 mm Walleye from Split Lake from 2001–2022.

4.3 LAKE STURGEON MORTALITIES

Because Lake Sturgeon are a species of concern and have special cultural significance to the First Nation communities, they are not a target species in the mercury monitoring program to measure the effects of Keeyask. However, should a Lake Sturgeon inadvertently die during other monitoring work, they are analyzed for mercury.

Mercury samples were collected from one Lake Sturgeon mortality collected during the fish community program in Stephens Lake (Slongo and Hrenchuk 2023) and eight Lake Sturgeon from the juvenile population monitoring studies in upper Split Lake/the Burntwood River downstream of First Rapids and Stephens Lake (Ambrose *et al*. 2023). Biological information and mercury concentration of Lake Sturgeon analyzed for mercury in 2022 are summarized in Appendix 3 (Table A3-5). The capture locations of these fish are shown in Maps 3 and 4.

The mercury concentrations of the Lake Sturgeon collected as part of the 2022 juvenile monitoring studies in Stephens Lake ranged from 0.06 to 0.08 ppm and in the upper Split Lake area from 0.04 to 0.05 ppm. The one sturgeon analyzed from Stephens Lake was much larger than the juveniles and had a mercury concentration of 0.32 ppm. The individual mercury concentrations of the incidental mortalities from 1999–2022 are plotted by waterbody in relation to total length[1] (Figure 18).

[1] Total length was used *in lieu* of fork length because several sturgeon samples in 2004 were submitted with only a total length (Jansen and Strange 2007b).

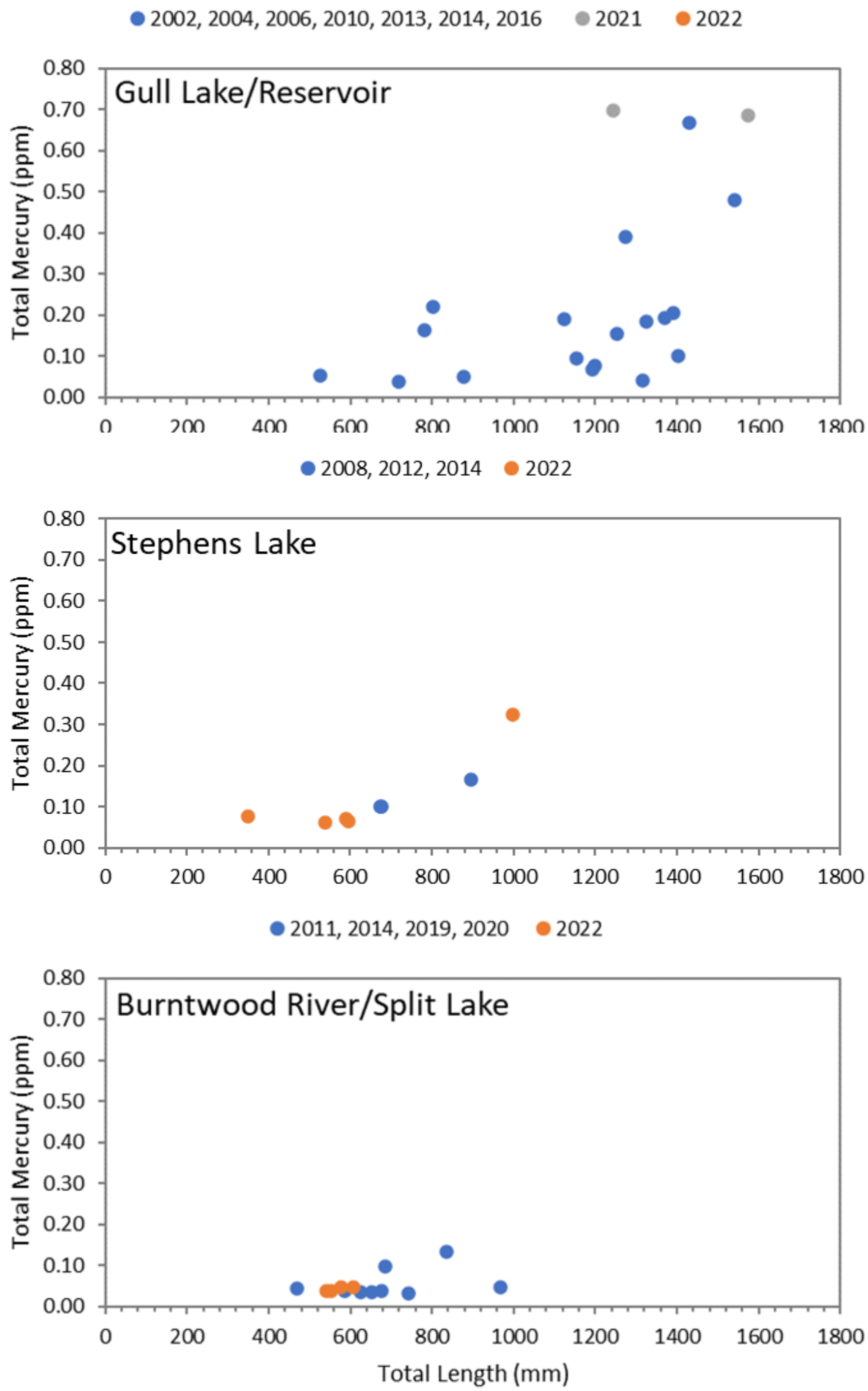


Figure 18: Mercury concentration versus total length for Lake Sturgeon collected from the Keeyask reservoir, Stephens Lake, and upper Split Lake/Burntwood River downstream of First Rapids from 2002–2022.

5.0 DISCUSSION

In the EIS, it was predicted that mercury concentrations in fish would be affected by the Project in response to flooding of wetlands and terrestrial soils associated with the impoundment of the Keeyask reservoir. After flooding, maximum mean mercury concentrations in the reservoir were predicted to be reached within 3–5 years in Lake Whitefish and within 4–7 years in Northern Pike and Walleye of a standard size (350, 550, and 400 mm, respectively). Mercury concentrations are predicted to reach 1 ppm in Northern Pike and Walleye and 0.19 ppm in Lake Whitefish from the reservoir. Some of the mercury generated in the Keeyask reservoir will be transported downstream into Stephens Lake in the water and biota, and average mercury concentrations are predicted to reach a peak of 0.5 ppm in Northern Pike and Walleye and 0.12 ppm in Lake Whitefish. Once the peak mercury levels are reached in the Keeyask reservoir and Stephens Lake, it is predicted that it will take 20 to 30 years for levels to return to pre-impoundment levels or to reach a stable new baseline.

It was predicted that the Project would have no or minimal effect on mercury concentrations in Split Lake. While Split Lake is upstream from the flooding associated with the Keeyask Project, there is a possibility that fish with elevated mercury concentrations from the Keeyask reservoir could move upstream into Split Lake, so monitoring is being conducted to measure changes, if any.

This report presents the results of the second year of monitoring mercury concentrations in fish flesh of Northern Pike, Walleye, and Lake Whitefish from the Keeyask reservoir, Stephens Lake, and Split Lake after final impoundment of the Keeyask reservoir in September 2020.

5.1 KEEYASK RESERVOIR

The standard mean mercury concentration of a 550 mm Northern Pike from the Keeyask reservoir in 2022 (0.64 ppm) was higher than the value recorded in 2021 (0.53 ppm). Mercury concentrations in both post-impoundment years were higher than the range collected between 1999 and 2016. While there has been an increase in mercury concentrations since impoundment, the standard mean in 2022 was still well below the predicted peak of 1 ppm (KHLP 2012).

Walleye collected from the Keeyask reservoir in 2022 did not show a significant positive relationship between fork length and mercury so a standard mean could not be calculated. Walleye showed a wide range of mercury concentrations. Smaller fish (<300 mm) showed considerably higher mercury concentrations compared to those captured pre-impoundment and appear to be accumulating mercury faster than larger fish. Most Walleye in 2022 showed higher mercury concentrations than those captured pre-impoundment, however, three fish with lower mercury concentrations were captured at sites within the reservoir (one upstream of Birthday

Rapids, one in a flooded bay downstream of Birthday Rapids, and one near the inlet of Gull Lake) at the same sites as fish containing higher mercury concentrations.

Since a standard mean could not be calculated for Walleye, an arithmetic mean was calculated using the mercury concentration of fish within 25 mm of the standard length and was 0.62 ppm. This value was slightly higher than concentrations measured in 2021, and both post-impoundment years showed higher values than those observed during pre-impoundment monitoring. This suggests that there has been a Project-related increase in mercury in Walleye in the Keeyask reservoir, however, mercury concentrations are still well below the predicted peak of 1 ppm (KHLP 2012).

Lake Whitefish collected from the Keeyask reservoir in 2022 did not show a significant positive relationship between fork length and mercury so a standard mean could not be calculated and too few fish within 25 mm of the standard length were collected to calculate an arithmetic mean. Since very few small Lake Whitefish (<350 mm) were caught in Gull Lake prior to impoundment, a standard mean mercury concentration was calculated using only larger Lake Whitefish (measuring >350 mm). The standard mean in 2022 (0.22 ppm) was higher than in previous years and was just above the predicted peak of 0.19 ppm (KHLP 2012).

Modelling of the mercury data showed that all three species had significantly higher mercury concentrations post-impoundment (2021 and 2022) compared to pre-impoundment (1999–2019). There were also greater amounts of variation in mercury concentrations, with individuals of each species showing both high and low concentrations.

No Lake Sturgeon mortalities were collected from the Keeyask reservoir in 2022.

5.2 STEPHENS LAKE

Mercury concentrations in a 550 mm Northern Pike and a 400 mm Walleye collected in 2022 were 0.39 and 0.5 ppm, respectively. The standard mean for Northern Pike was within the range of values measured since 1999, while that in Walleye was at the top of the range measured over this period. The length-standardized mercury concentrations for Northern Pike were below, and for Walleye, were equal to the predicted peak of 0.5 ppm (KHLP 2012).

A standard mean could not be calculated for Lake Whitefish from Stephens Lake in 2022 because of the small number of fish collected, combined with the narrow range of lengths available. The concentrations of individual Lake Whitefish in 2022 fell within the range of mercury concentrations measured from 1999 to 2021.

Modelling of the mercury data showed that there was not a statistically significant difference in the mercury concentration in pre- and post-impoundment years for all three species.

Four juvenile Lake Sturgeon mortalities were analyzed from Stephens Lake for mercury in 2022. Concentrations ranged from 0.06 to 0.08 ppm. A single adult analyzed had a mercury concentration of 0.32 ppm.

5.3 SPLIT LAKE

Mercury concentrations in a 550 mm Northern Pike, a 400 mm Walleye, and a 350 mm Lake Whitefish collected from Split Lake in 2022 were 0.42, 0.37, and 0.09 ppm, respectively. The length-standardized mercury concentrations of all three species were within the range of values measured since data collected for the EIS commenced in 2001.

Modelling of the mercury data showed that there was not a statistically significant difference in the mercury concentration in the pre- and post-impoundment years for all three species.

Four juvenile Lake Sturgeon mortalities were analyzed for mercury from the upper Split Lake region in 2022 and had mercury concentrations ranging from 0.04 to 0.05 ppm.

5.4 KEY QUESTIONS

The key questions to be answered about mercury in fish in relation to post-impoundment monitoring are:

What are the concentrations of mercury in Northern Pike, Walleye, and Lake Whitefish caught in the Keeyask reservoir, Stephens Lake, and Split Lake following final impoundment of the Keeyask reservoir in comparison to pre-Project levels?

The standard mean mercury concentrations of a 550 mm Northern Pike caught in the Keeyask reservoir in 2022 was 0.64 ppm and a 350 mm Lake Whitefish was 0.22 ppm. A standard mean could not be calculated for Walleye from the reservoir in 2022, but the arithmetic mean mercury concentrations of individual Walleye within 25 mm of 400 mm was 0.62 ppm. The mercury concentrations of all three species were higher in 2022 than in previous years.

In Stephens Lake, the standard mean mercury concentration in 2022 was 0.39 ppm in Northern Pike and 0.5 ppm in Walleye. These values are equal to or lower than the highest value measured since 1999. A standard mean could not be calculated for Lake Whitefish in 2022. The mercury concentrations of individual Lake Whitefish fell within the range of values measured since 1999.

The standard mean mercury concentrations from Split Lake in 2022 were 0.42 ppm in Northern Pike, 0.37 ppm in Walleye, and 0.09 ppm in Lake Whitefish. These values are equal to or lower than the highest value measured since 2001.

What are the peak mercury concentrations in Northern Pike, Walleye, and Lake Whitefish and how many years after the start of operation are the peak concentrations reached?

The EIS predicted that peak mercury concentrations in the Keeyask reservoir would be reached within 3–5 years following impoundment for Lake Whitefish and within 4–7 years for Northern Pike and Walleye of a standard size (350, 550, and 400 mm, respectively). Because sampling in 2022 represents only the second year of monitoring following reservoir impoundment, it is likely that peak mercury concentrations have not yet been reached.The standard means of Walleye from Split Lake falls within the range of values measured since 2001, while that of Northern Pike was similar to the highest value measured during this period. Standard means of Lake Whitefish from Split Lake have remained consistently low.

6.0 CONCLUSIONS AND NEXT STEPS

The EIS predicted that mercury concentrations in fish would be affected by the Project in response to flooding of wetlands and terrestrial soils associated with the impoundment of the reservoir. Maximum mean mercury concentrations were predicted to be reached after final impoundment within 3–5 years in Lake Whitefish and within 4–7 years in Northern Pike and Walleye of a standard size (350, 550, and 400 mm, respectively). Mercury concentrations were predicted to reach 1 ppm in Northern Pike and Walleye and 0.2 ppm in Lake Whitefish from the reservoir. Average mercury concentrations in Northern Pike and Walleye from the Keeyask reservoir in 2022 were higher than pre-impoundment concentrations but were still below the predicted. Concentrations in Lake Whitefish from the reservoir were also higher in 2022 compared to previous years and slightly exceeded the predicted peak of 0.2 ppm. Mercury concentrations in all three species were more variable in 2022 compared to previous years and the relationship between fork length and mercury concentration was not as robust as pre-Project. Smaller fish appear to be accumulating mercury faster than larger fish, and while most fish have accumulated concentrations higher than pre-impoundment levels, a few individuals still have concentrations similar to pre-impoundment.

The EIS predicted that some of the mercury generated in the Keeyask reservoir would be transported downstream into Stephens Lake. Maximum mean mercury concentrations were predicted to reach 0.5 ppm in Northern Pike and Walleye and 0.12 ppm in Lake Whitefish. Average mercury concentrations in Northern Pike and Walleye in 2022 were equal to or below this predicted peak. An average mercury concentration could not be calculated for a standard length of Lake Whitefish from Stephens Lake in 2022, but the mercury concentrations of individual fish were within the range observed since 1999. To date, there has not been a persistent increase in mercury concentrations above background values in fish downstream of the reservoir since impoundment.

The EIS predicted that the Project would have no or minimal effect on mercury concentrations in Split Lake. The average mercury concentrations in all three species in 2022 were within the range of values measured since data collected for the EIS commenced in 2001.

Monitoring of mercury in fish flesh will take place again in all three waterbodies in 2023. As described in the AEMP, mercury concentrations in fish from the Keeyask reservoir and Stephens Lake will be monitored annually for several years after final impoundment of the reservoir until peak concentrations have been reached. Split Lake will be sampled annually for the first three years following impoundment to confirm that fish containing elevated mercury from the reservoir are not impacting concentrations in fish within Split Lake.

7.0 LITERATURE CITED

Addinsoft (2022). XLSTAT statistical and data analysis solution. New York, USA.

Ambrose, K.M., C.L. Hrenchuk, and D.C. Burnett. 2023. Adult Lake Sturgeon population monitoring in the upper Split Lake and Keeyask areas, 2022. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2023-05. A draft report prepared for Manitoba Hydro by North/South Consultants Inc.

Bates D., M. Mächler, B. Bolker, and S. Walker. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software 67(1): 1-48.

Bretecher, R.L. and MacDonell, D.S. 2000. Lower Nelson River forebay monitoring program 1999. A report prepared for Manitoba Hydro by North/South Consultants Inc. 104 pp.

Burnett, D.C., Hrenchuk, C.L., and P. Nelson. 2023. Juvenile Lake Sturgeon population monitoring, fall 2022: Year 1 Operation. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2023-06. A draft report prepared for Manitoba Hydro by North/South Consultants Inc.

Burnett, D.C., Hrenchuk, C.L., and P. Nelson. 2022. Juvenile Lake Sturgeon population monitoring, fall 2021: Year 8 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2022-06. A draft report prepared for Manitoba Hydro by North/South Consultants Inc.

Burnett, D.C. and Hrenchuk, C.L. 2020. Fish community monitoring in the Nelson River from Split Lake to Stephens Lake, summer 2019. Keeyask Generation Project Aquatic Effects Monitoring Plan Report # AEMP-2020-09. Report prepared for Manitoba Hydro by North/South Consultants Inc., June 2020. 79 pp.

CAMP (Coordinated Aquatic Monitoring Program). 2017. Six year summary report (2008–2013). Report prepared for Manitoba/Manitoba Hydro MOU Working Group by North/South Consultants Inc., Winnipeg, MB.

CAMP (Coordinated Aquatic Monitoring Program). 2014. Three year summary report (2008–2010). Report prepared for the Manitoba/Manitoba Hydro MOU Working Group by North/South Consultants Inc., Winnipeg, MB.

Dunmall, K.M., J.E. MacDonald, and R.L. Bretecher. 2004. Results of summer index gillnetting studies conducted in Split Lake and Clark Lake, and investigation of adult and larval fish populations in portions of the Burntwood River, Grass River, and the Nelson River flowing into Split Lake, Manitoba, 2001. A report prepared for Manitoba Hydro by North/South Consultants Inc. 98 pp.

Eagles-Smith, C.A., J.T. Ackerman, J.J. Willacker, M.T. Tate, M.A. Lutz, J.A. Fleck, A.R. Stewart, J.G. Wiener, D.C. Ever, J.M. Lepak, J.A. Davis, and C.F. Pritz. 2016. Spatial and temporal patterns of mercury concentrations in freshwater fish across western United States and Canada. Science of the Total Environment 568: 1171-1184.

Evans, M.S, Lockhart, W.L., Doetzel, L., Low, G., Muir, D., Kidd, K., Stephens, G., and Delaronde, J. 2005. Elevated mercury concentrations in fish in lakes in the Mackenzie River basin: The role of physical, chemical, and biological factors. Science of the Total Environment 351-352: 479–500.

Funk, B. and C.L. Hrenchuk. 2022. Floy-tag application and recapture information from the Keeyask study area, 2021. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2022-10. A draft report prepared for Manitoba Hydro by North/South Consultants Inc.

Green, D.J. 1986. Summary of fish mercury data collected from lakes on the Rat Burntwood and Nelson River systems, 1983–1985. Manitoba Natural Resources, Fisheries Branch MS Report No. 86-06, 359 pp.

Holm, J. and J. Aiken. 2022. Mercury in fish flesh from the Keeyask reservoir, Stephens Lake, and Split Lake, 2021. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2022-11. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2022, xv + 78 pp.

Holm, J. 2020. Mercury in fish flesh from Gull Lake, 2019. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2020-08. Report prepared for Manitoba Hydro by North/South Consultants Inc., June 2020. 56 pp.

Holm, J., M. Cooley, and E. Shipley. 2007. Trace elements in fish from the Keeyask Study Area: Fall 2004. A report prepared for Manitoba Hydro by North/South Consultants Inc. 30 pp.

Holm, J. and R.A. Remnant. 2004. Results of summer index gillnetting studies conducted in Split Lake and Clark Lake, and spring investigation of adult and larval fish communities in portions of the Burntwood, Grass, and the Nelson rivers flowing into Split Lake, Manitoba, 2002. A report prepared for Manitoba Hydro by North/South Consultants Inc. 113 pp.

Jansen, W. 2018. Mercury in fish flesh from Gull Lake, 2016. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2018-08. Report prepared for Manitoba Hydro by North/South Consultants Inc., June 2018. 63 pp.

Jansen, W. 2016a. Mercury in fish flesh from Gull Lake in 2014. Keeyask Generation Project Aquatic Effects Monitoring Report #AEMP-2016-11. Report prepared for Manitoba Hydro by North/South Consultants Inc., June 2016. 29 pp.

Jansen, W. 2016b. Mercury in fish flesh from the Aiken River in 2015. Keeyask Generation Project Aquatic Effects Monitoring Report #AEMP-2016-10. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2016. 33 pp.

Jansen, W. 2010. Mercury in fish from six Manitoba lakes and reservoirs: Results from 2007-2008 sampling and an update of time trends of monitoring data. Report prepared for Manitoba Hydro by North/South Consultants Inc. 44 pp.

Jansen, W. and Strange, N. 2009. Fish mercury concentrations from the Keeyask Project study area for 2006. Keeyask Project Environmental Studies Program Report #06-11. Report prepared for Manitoba Hydro by North/South Consultants Inc. 55 pp.

Jansen, W. and Strange, N. 2007a. Mercury in fish from northern Manitoba reservoirs: Results from 1999–2005 sampling and a summary of all monitoring data for 1970 2005. Report prepared for Manitoba Hydro by North/South Consultants Inc. 102 pp.

Jansen, W. and Strange, N. 2007b. Fish mercury concentrations from the Keeyask Project study area, 1999–2005. Keeyask Project Environmental Studies Program Report #05-04. Report prepared for Manitoba Hydro by North/South Consultants Inc. 152 pp.

Johnson, M.W. and Parks, C.R. 2005. Results of fish community investigations conducted in the reach of the Nelson River between Clark Lake and Gull Rapids, 2002. Keeyask Project Environmental Studies Program Report #02-20. Report prepared for Manitoba Hydro by North/South Consultants Inc. 198 pp.

KHLP (Keeyask Hydropower Limited Partnership). 2012. Keeyask Generation Project: Environmental Impact Statement. Supporting volume - Aquatic Environment. Keeyask Hydropower Limited Partnership, Winnipeg, MB.

Kuznetsova A., P.B. Brockhoff, and R.H.B. Christensen. 2017. lmerTest package: Tests in linear mixed effects models. Journal of Statistical Software 82(13): 1-26.

Lawrence, M.J., C.R. Fazakas, L. Zrum, C.L. Bezte, and W.J. Bernhardt. 1999. The Split Lake aquatic ecosystem: a synthesis of Split Lake biological and environmental data, January 1997 – October, 1998. A report prepared for the Tataskweyak Environmental Monitoring Agency by North/South Consultants Inc. 87 pp.

Lenth, R. 2023. Emmeans: Estimated Marginal Means, aka Least-Squares Means. R package version 1.8.4-1. URL <https://CRAN.R-project.org/package=emmeans>.

Morrison, S.M. and C.L. Hrenchuk. 2023. Floy-tag application and recapture information from the Keeyask Study Area, 2022. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2023-10. A draft report prepared for Manitoba Hydro by North/South Consultants Inc.

Pisiak, D.J. Kroeker, T., and Remnant, R.A. 2004. Results of summer index gillnetting studies in Stephens Lake, Manitoba, and seasonal investigations of adult and larval fish communities in the reach of the Nelson River between Gull Rapids and Stephens Lake, 2001. Year 1. Gull (Keeyask) Project Environmental Studies Program Report #01-10. Report prepared for Manitoba Hydro by North/South Consultants Inc. 94 pp.

Pisiak, D.J. 2005a. Results of summer index gillnetting studies in Stephens Lake, Manitoba, and seasonal investigations of adult and larval fish communities in the reach of the Nelson River between Gull Rapids and Stephens Lake, 2002. Year 2. Gull (Keeyask) Project Environmental Studies Program Report #02-16. Report prepared for Manitoba Hydro by North/South Consultants Inc. 159 pp.

Pisiak, D.J. 2005b. Results of summer index gillnetting studies in Stephens Lake, Manitoba, and seasonal investigations of fish communities in the reach of the Nelson River between Gull Rapids and Stephens Lake, 2003. Year 3. Keeyask Project Environmental Studies Program Report #03-14. Report prepared for Manitoba Hydro by North/South Consultants Inc. 289 pp.

Remnant, R.A. and Barth, C.C. 2003. Results of experimental gillnetting on the Nelson River between Birthday and Gull rapids, Manitoba, fall 1999. Gull (Keeyask) Project Environmental Studies Program Report #99-01. Report prepared for Manitoba Hydro by North/South Consultants Inc. 59 pp.

Remnant, R.A., Parks, C.R, and MacDonald, J.E. 2004. Results of fisheries investigations conducted in the reach of the Nelson River between Clark Lake and Gull Rapids (including Gull Lake), 2001. Gull (Keeyask) Project Environmental Studies Program Report #01-13. Report prepared for Manitoba Hydro by North/South Consultants Inc. 132 pp.

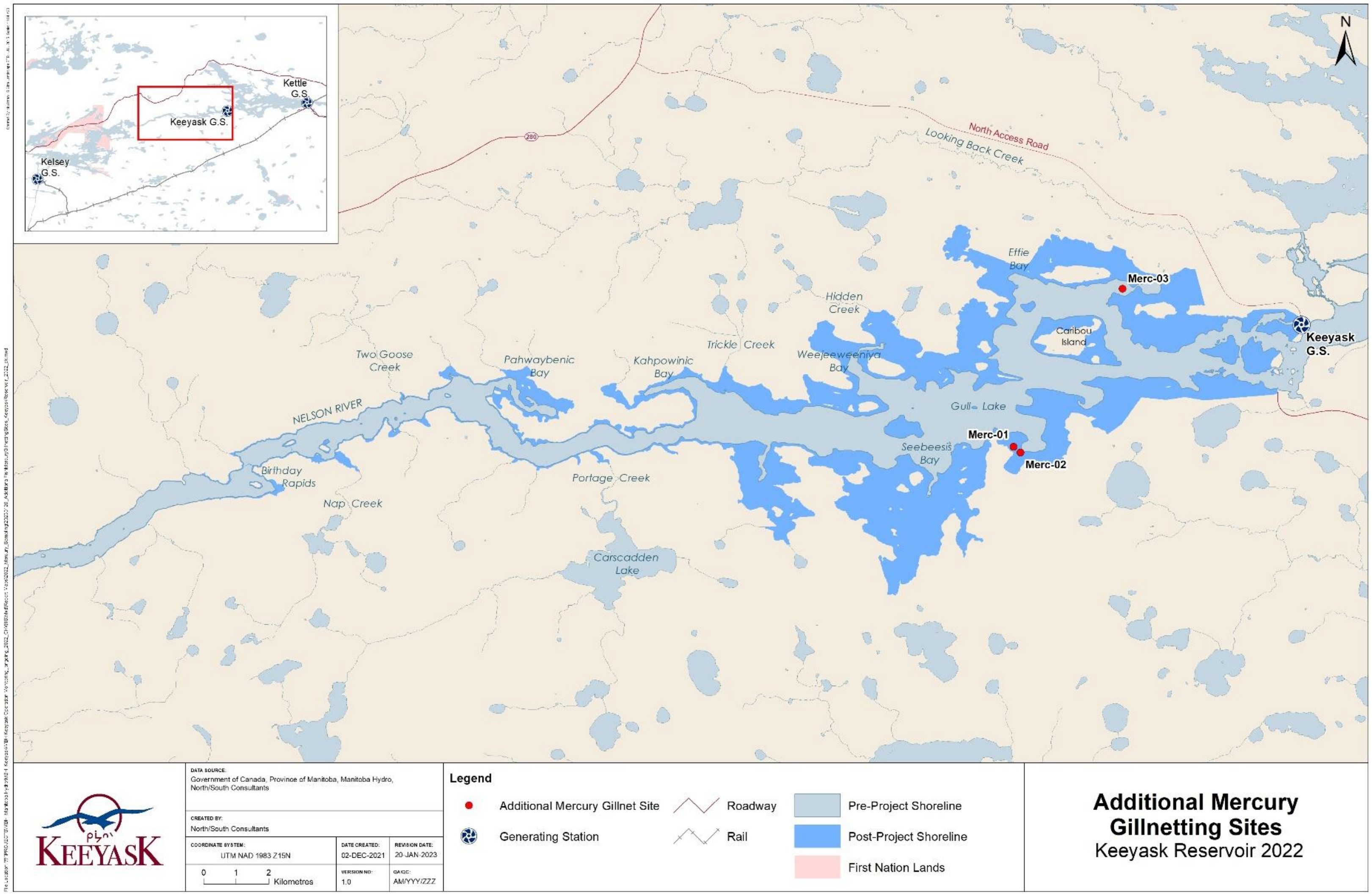
R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Satterthwaite, F.E. 1941. Synthesis of variance. Psychometrika 6(5): 309-316.

Slongo, B. and C.L. Hrenchuk. 2023. Fish community monitoring in the Nelson River from Split Lake to Stephens Lake, summer 2022. Keeyask Generation Project Aquatic Effects Monitoring Report #AEMP-2023-07. A draft report prepared for Manitoba Hydro by North/South Consultants Inc.

APPENDICES

APPENDIX 1: SITE AND CATCH INFORMATION FOR GILLNETTING CONDUCATED IN THE KEEYASK RESERVOIR IN 2022 TO CAPTURE FISH FOR MERCURY ANALYSIS



Map A1-1. Gillnetting sites targeting fish for mercury analysis in the Keeyask reservoir, 2022.

Map A1-2. Gillnetting sites targeting fish for mercury analysis in Stephens Lake, 2022.

Table A1-1. Mercury gillnetting set information and catches in the Keeyask reservoir and Stephens Lake, 2022. See Maps A1-1 and A1-2 for site locations.

Waterbody	Site	Replicate	Gear	UTM Coordinates			Pull Date	Duration (h)	Depth (m)		Catch
				Zone	Easting	Northing			Start	End	
Keeyask Reservoir	Merc-01	1	standard gang	15	355037	6243442	17-Aug-22	18.6	2.7	2.4	4 NRPK
	Merc-02	1	standard gang	15	355244	6243258	17-Aug-22	18.6	5.7	6.2	1 WALL
	Merc-03	1	standard gang	15	358396	6248311	18-Aug-22	21.6	6.9	6.7	1 WALL, 2 LKWH
	Merc-01	2	standard gang	15	355037	6243442	18-Aug-22	24.2	2.7	2.4	-
	Merc-02	2	standard gang	15	355244	6243258	18-Aug-22	24.2	5.7	6.2	1 WALL
Stephens Lake	LKWH-02	1	3.75, 4.25"	15	368071	6248262	28-Aug-22	23.2	16.6	15.2	-
	LKWH-03	1	3, 3.75, 4.25"	15	367735	6247650	28-Aug-22	23.2	16	16.7	-
	LKWH-04	1	4.25, 5"	15	370509	6248461	29-Aug-22	22.1	15.1	15.6	-
	LKWH-05	1	4.25, 5"	15	370310	6248434	29-Aug-22	22.3	17.1	18.1	3 LKST

APPENDIX 2:
ALS LABORATORY REPORTS

North/South Consultants
ATTN: JODI HOLM
83 Scurfield Blvd
Winnipeg MB R3Y 1G4

Date Received: 24-AUG-22
Report Date: 21-OCT-22 12:48 (MT)
Version: FINAL REV. 2

Client Phone: 204-487-5638

Certificate of Analysis

Lab Work Order #: L2730022

Project P.O. #:	NOT SUBMITTED
Job Reference:	KEEYASK FISH - LKWH
C of C Numbers:	
Legal Site Desc:	GULL LAKE

Comments:
21-OCT-2022 Sample IDs corrected for fractions 89-91

Hua Wo
Chemistry Laboratory Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-1 18							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.204		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-2 28							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0253		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-3 122							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0264		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-4 126							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.381		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-5 127							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.343		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-6 180							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.365		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-7 195							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.565		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-8 197							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.442		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-9 229							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.724		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-10 344							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.269		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-11 345 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.308		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-12 352 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.195		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-13 353 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.322		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-14 354 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.237		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-15 363 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.324		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-16 368 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.319		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-17 372 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.477		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-18 374 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.289		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-19 375 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.282		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-20 1143 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.267		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-21 48							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.356		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-22 80							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.330		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-23 115							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.285		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-24 118							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.755		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-25 140							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	1.86		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-26 149							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.473		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-27 156							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.330		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-28 157							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.234		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-29 159							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.341		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-30 160							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.489		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-31 164 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.196		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-32 167 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.269		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-33 194 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	3.26		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-34 211 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.650		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-35 214 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.500		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-36 215 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.539		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-37 216 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.513		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-38 223 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.600		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-39 228 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	1.57		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656
L2730022-40 271 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.582		0.0010	mg/kg wwt	04-OCT-22	06-OCT-22	R5871656

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-41 272							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.661		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-42 273							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.812		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-43 275							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.427		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-44 276							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.451		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-45 281							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.460		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-46 283							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.462		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-47 284							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.534		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-48 288							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.705		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-49 296							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.248		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-50 300							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.223		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-51 301 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.394		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-52 302 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.527		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-53 303 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.552		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-54 321 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.500		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-55 324 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.349		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-56 329 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.454		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-57 10 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.215		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-58 11 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.317		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-59 21 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.279		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-60 30 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.171		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-61 32							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.534		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-62 33							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.320		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-63 40							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.315		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-64 55							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.323		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-65 58							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.265		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-66 60							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.400		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-67 66							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.273		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-68 69							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.337		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-69 79							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.646		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-70 83							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.896		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-71 91 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.321		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-72 96 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.407		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-73 99 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.840		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-74 111 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.545		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-75 132 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.787		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-76 136 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.713		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-77 138 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	1.14		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-78 139 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.160		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-79 145 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.744		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998
L2730022-80 170 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.512		0.0010	mg/kg wwt	06-OCT-22	12-OCT-22	R5872998

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-81 185							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.389		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-82 189							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.164		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-83 198							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.390		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-84 199							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.576		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-85 253							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.400		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-86 261							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.566		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-87 262							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.549		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-88 348							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.655		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-89 364							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.773		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-90 371							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.734		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2730022-91 376							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.545		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467
L2730022-92 377							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.934		0.0010	mg/kg wwt	14-OCT-22	19-OCT-22	R5876467

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
HG-WET-CVAA-WP	Tissue	Mercury in Tissue	EPA 200.3/1631E (mod)

Tissue samples undergo hotblock digestion with nitric and hydrochloric acids, in combination with repeated additons of hydrogen peroxide, followed by cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analysis by CVAAS.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample

mg/kg wwt - milligrams per kilogram based on wet weight of sample

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight

mg/L - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2730022 Report Date: 21-OCT-22

Client: North/South Consultants
83 Scurfield Blvd
Winnipeg MB R3Y 1G4

Contact: JODI HOLM

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
HG-WET-CVAA-WP	**Tissue**							
Batch R5871656								
WG3766214-7 CRM		**DORM-4N**						
Mercury (Hg)			108.0		%		70-130	06-OCT-22
WG3766214-8 CRM		**DORM-4N**						
Mercury (Hg)			110.1		%		70-130	06-OCT-22
WG3766214-3 DUP		**L2730022-1**						
Mercury (Hg)		0.204	0.207		mg/kg wwt	1.6	40	06-OCT-22
WG3766214-6 DUP		**L2730022-21**						
Mercury (Hg)		0.356	0.354		mg/kg wwt	0.4	40	06-OCT-22
WG3766214-1 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	06-OCT-22
WG3766214-4 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	06-OCT-22
Batch R5872998								
WG3766958-3 CRM		**DORM-4N**						
Mercury (Hg)			114.0		%		70-130	12-OCT-22
WG3766958-7 CRM		**DORM-4N**						
Mercury (Hg)			110.8		%		70-130	12-OCT-22
WG3766958-4 DUP		**L2730022-41**						
Mercury (Hg)		0.661	0.830		mg/kg wwt	23	40	12-OCT-22
WG3766958-8 DUP		**L2730022-61**						
Mercury (Hg)		0.534	0.502		mg/kg wwt	6.3	40	12-OCT-22
WG3766958-2 LCS								
Mercury (Hg)			100.4		%		80-120	12-OCT-22
WG3766958-6 LCS								
Mercury (Hg)			102.4		%		80-120	12-OCT-22
WG3766958-1 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	12-OCT-22
WG3766958-5 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	12-OCT-22
Batch R5876467								
WG3768161-4 CRM		**DORM-4N**						
Mercury (Hg)			101.7		%		70-130	19-OCT-22
WG3768161-3 DUP		**L2730022-81**						
Mercury (Hg)		0.389	0.368		mg/kg wwt	5.6	40	19-OCT-22
WG3768161-2 LCS								
Mercury (Hg)			97.6		%		80-120	19-OCT-22
WG3768161-1 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	19-OCT-22

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Cha[in of Custody]

L2730022-COFC

COC # Keeyask GS

Report to:				Service Requested: (rush - subject to availability)
Company:	North South Consultants	☑ Standard ☐ Other		◉ Regular (Default)
Contact:	Jodi Holm	☑ PDF ☑ Excel ☑ Digital		○ Priority (2-3 Business Days) - 50% Surcharge
Address:	83 Scurfield Blvd, Winnipeg	Email 1:	jholm@nscons.ca	○ Emergency (1 Business Day) - 100% Surcharge
		Email 2:		○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS
Phone:	284 3366 ext 227 Fax: 477 4173			Analysis Request
Invoice To:	Same as Report ? ◉ Yes ○ No	Client / Project Information:		Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		Job #:	Keeyask Fish	
Contact:		PO / AFE:		
Address:		Legal Site Description:		
Phone:	284 3366 Fax: 477 4173	Quote #:	Q88945	
Lab Work Order # (lab use only)		ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	SAMPLE DISPOSAL-WP	HG-WET-CVAA-WP	Number of Containers
	Gull Lake: See attached sheet			Tissue	X	X	92
	samples are organized by: Species and Collector's ID						

Special Instructions / Regulations / Hazardous Details

Analyze muscle tissue with skin and scales removed

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)		SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)		
Released by:	Date & Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date & Time:	Observations: Yes / No ? If Yes attach SIF
Kim Many...	Aug 24, 2022	O.A.	AUG 24	11:16am	1.4			

AUG 24 2022

Fish with Hg samples from Keeyask Reservoir in 2022

Submitted 24 Aug 2022

L2730022-COFC

Location	Fish#	Species	FL
Gull Lk	18	LKWH	462
Gull Lk	28	LKWH	234
Gull Lk	122	LKWH	288
Gull Lk	126	LKWH	519
Gull Lk	127	LKWH	523
Gull Lk	180	LKWH	204
Gull Lk	195	LKWH	598
Gull Lk	197	LKWH	493
Gull Lk	229	LKWH	560
Gull Lk	344	LKWH	161
Gull Lk	345	LKWH	165
Gull Lk	352	LKWH	198
Gull Lk	353	LKWH	190
Gull Lk	354	LKWH	220
Gull Lk	363	LKWH	411
Gull Lk	368	LKWH	500
Gull Lk	372	LKWH	543
Gull Lk	374	LKWH	418
Gull Lk	375	LKWH	355
Gull Lk	1143	LKWH	-
Gull Lk	48	NRPK	592
Gull Lk	80	NRPK	666
Gull Lk	115	NRPK	311
Gull Lk	118	NRPK	650
Gull Lk	140	NRPK	1000
Gull Lk	149	NRPK	455
Gull Lk	156	NRPK	364
Gull Lk	157	NRPK	326
Gull Lk	159	NRPK	335
Gull Lk	160	NRPK	298
Gull Lk	164	NRPK	350
Gull Lk	167	NRPK	315
Gull Lk	194	NRPK	1020
Gull Lk	211	NRPK	385
Gull Lk	214	NRPK	400
Gull Lk	215	NRPK	396
Gull Lk	216	NRPK	370
Gull Lk	223	NRPK	590
Gull Lk	228	NRPK	891
Gull Lk	271	NRPK	530
Gull Lk	272	NRPK	550
Gull Lk	273	NRPK	564
Gull Lk	275	NRPK	270

Fish with Hg samples from Keeyask Reservoir in 2022

Submitted 24 Aug 2022

Location	Fish#	Species	FL
Gull Lk	276	NRPK	220
Gull Lk	281	NRPK	412
Gull Lk	283	NRPK	290
Gull Lk	284	NRPK	470
Gull Lk	288	NRPK	480
Gull Lk	296	NRPK	245
Gull Lk	300	NRPK	212
Gull Lk	301	NRPK	230
Gull Lk	302	NRPK	205
Gull Lk	303	NRPK	461
Gull Lk	321	NRPK	604
Gull Lk	324	NRPK	500
Gull Lk	329	NRPK	615
Gull Lk	10	WALL	311
Gull Lk	11	WALL	335
Gull Lk	21	WALL	294
Gull Lk	30	WALL	325
Gull Lk	32	WALL	275
Gull Lk	33	WALL	320
Gull Lk	40	WALL	285
Gull Lk	55	WALL	249
Gull Lk	58	WALL	266
Gull Lk	60	WALL	253
Gull Lk	66	WALL	300
Gull Lk	69	WALL	183
Gull Lk	79	WALL	385
Gull Lk	83	WALL	195
Gull Lk	91	WALL	225
Gull Lk	96	WALL	234
Gull Lk	99	WALL	457
Gull Lk	111	WALL	420
Gull Lk	132	WALL	374
Gull Lk	136	WALL	430
Gull Lk	138	WALL	513
Gull Lk	139	WALL	450
Gull Lk	145	WALL	454
Gull Lk	170	WALL	407
Gull Lk	185	WALL	436
Gull Lk	189	WALL	488
Gull Lk	198	WALL	346
Gull Lk	199	WALL	358
Gull Lk	253	WALL	220
Gull Lk	261	WALL	516

L2730022-COFC

Fish with Hg samples from Keeyask Reservoir in 2022

Submitted 24 Aug 2022

Location	Fish#	Species	FL
Gull Lk	262	WALL	189
Gull Lk	348	WALL	210
Gull Lk	364	WALL	396
Gull Lk	371	WALL	440
Gull Lk	376	WALL	494
Gull Lk	377	WALL	484

L2730022-COFC

North/South Consultants
ATTN: JODI HOLM
83 Scurfield Blvd
Winnipeg MB R3Y 1G4

Date Received: 07-SEP-22
Report Date: 03-JAN-23 12:39 (MT)
Version: FINAL REV. 2

Client Phone: 204-487-5638

Certificate of Analysis

Lab Work Order #: L2731799

Project P.O. #: NOT SUBMITTED
Job Reference: KEEYASK FISH - LKST
C of C Numbers:
Legal Site Desc: STEPHENS LAKE

Comments:
3-JAN-2023 Amended report, fraction 26 result correction.

Hua Wo
Chemistry Laboratory Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-1 194							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.324		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-2 65							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0667		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-3 66							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.120		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-4 85							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.274		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-5 290							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.206		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-6 322							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0787		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-7 340							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.153		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-8 362							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0934		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-9 19							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.238		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-10 29							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.307		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-11 45 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.326		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-12 46 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.378		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-13 53 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.403		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-14 63 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.269		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-15 64 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.287		0.0010	mg/kg wwt	26-OCT-22	17-NOV-22	R5893596
L2731799-16 92 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.228		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-17 93 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.198		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-18 129 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.337		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-19 133 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.357		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-20 168 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.171		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-21 182 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.103		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-22 210 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.238		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-23 235 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.588		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-24 315 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.293		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-25 314 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.289		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-26 316 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.371		0.0010	mg/kg wwt	23-NOV-22	24-NOV-22	R5897389
L2731799-27 317 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.243		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-28 318 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.285		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-29 319 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.378		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-30 329 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters** Mercury (Hg)	0.249		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-31 333							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.693		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-32 341							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.635		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-33 350							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.314		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-34 358							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.318		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-35 359							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.176		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-36 360							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.190		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-37 361							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.259		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-38 12							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.159		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-39 13							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.158		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-40 14							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0769		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-41 15							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.0846		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-42 26							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.275		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-43 27							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.214		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-44 35							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.841		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-45 47							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.910		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-46 48							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.346		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-47 49							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.336		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-48 50							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.169		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-49 55							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.220		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-50 58							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.414		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-51 59 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.318		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-52 60 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.204		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-53 61 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.407		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-54 96 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.357		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-55 99 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.730		0.0010	mg/kg wwt	16-NOV-22	18-NOV-22	R5894726
L2731799-56 108 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.831		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-57 132 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.169		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-58 138 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.635		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-59 139 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.803		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-60 140 Sampled By: CLIENT Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.294		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-61 141 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.301		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-62 165 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.115		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-63 167 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.389		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-64 176 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.379		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-65 178 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.938		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-66 179 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	1.10		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-67 188 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.226		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-68 190 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.254		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-69 191 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.568		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-70 193 Sampled By: CLIENT Matrix: TISSUE **Miscellaneous Parameters**							
Mercury (Hg)	0.588		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2731799-71 220							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.425		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-72 232							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.961		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726
L2731799-73 236							
Sampled By: CLIENT							
Matrix: TISSUE							
Miscellaneous Parameters							
Mercury (Hg)	0.322		0.0010	mg/kg wwt	17-NOV-22	18-NOV-22	R5894726

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
HG-WET-CVAA-WP	Tissue	Mercury in Tissue	EPA 200.3/1631E (mod)

Tissue samples undergo hotblock digestion with nitric and hydrochloric acids, in combination with repeated additons of hydrogen peroxide, followed by cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analysis by CVAAS.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: North/South Consultants
83 Scurfield Blvd
Winnipeg MB R3Y 1G4
Contact: JODI HOLM

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
HG-WET-CVAA-WP	**Tissue**							
Batch R5893596								
WG3770128-7 CRM		**DORM-4N**						
Mercury (Hg)			115.1		%		70-130	17-NOV-22
WG3770128-6 LCS								
Mercury (Hg)			105.6		%		80-120	17-NOV-22
WG3770128-5 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	17-NOV-22
Batch R5894726								
WG3772888-3 CRM		**DORM-4N**						
Mercury (Hg)			114.5		%		70-130	18-NOV-22
WG3772888-7 CRM		**DORM-4N**						
Mercury (Hg)			111.3		%		70-130	18-NOV-22
WG3772897-3 CRM		**DORM-4N**						
Mercury (Hg)			113.1		%		70-130	18-NOV-22
WG3772888-4 DUP		**L2731799-16**						
Mercury (Hg)		0.228	0.213		mg/kg wwt	6.8	40	18-NOV-22
WG3772888-8 DUP		**L2731799-36**						
Mercury (Hg)		0.190	0.175		mg/kg wwt	8.2	40	18-NOV-22
WG3772897-4 DUP		**L2731799-56**						
Mercury (Hg)		0.831	0.904		mg/kg wwt	8.4	40	18-NOV-22
WG3772888-2 LCS								
Mercury (Hg)			99.9		%		80-120	18-NOV-22
WG3772888-6 LCS								
Mercury (Hg)			98.2		%		80-120	18-NOV-22
WG3772897-2 LCS								
Mercury (Hg)			97.1		%		80-120	18-NOV-22
WG3772888-1 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	18-NOV-22
WG3772888-5 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	18-NOV-22
Batch R5897389								
WG3773863-3 CRM		**DORM-4N**						
Mercury (Hg)			96.7		%		70-130	24-NOV-22
WG3773863-2 LCS								
Mercury (Hg)			81.6		%		80-120	24-NOV-22
WG3773863-1 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	24-NOV-22

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # Keeyask GS

Report to:		Report Format / Distribution	Service Requested: (rush - subject to availability)
Company:	North South Consultants	☑ Standard ☐ Other	◉ Regular (Default)
Contact:	Jodi Holm	☑ PDF ☑ Excel ☑ Digital	○ Priority (2-3 Business Days) - 50% Surcharge
Address:	83 Scurfield Blvd, Winnipeg	Email 1: jholm@nscons.ca	○ Emergency (1 Business Day) - 100% Surcharge
		Email 2:	○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS
Phone:	284 3366 ext 227 Fax: 477 4173		Analysis Request
Invoice To:	Same as Report ? ◉ Yes ○ No	Client / Project Information:	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		Job #: Keeyask Fish	
Contact:		PO / AFE:	
Address:		Legal Site Description:	
Phone:	284 3366 Fax: 477 4173	Quote #: Q88945	
Lab Work Order # (lab use only)		ALS Contact: / Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	SAMPLE DISPOSAL-WP	HG-WET-CVAA-WP	Number of Containers
	Stephens Lake: See attached sheet			Tissue	X	X	73
	samples are organized by: Species and Collector's ID						

L2731799-COFC

Special Instructions / Regulations / Hazardous Details

Analyze muscle tissue with skin and scales removed

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)		SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)		
Released by:	Date & Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date & Time:	Observations: Yes / No ? If Yes attach SIF
Kim Mandzy	Sept 7, 2022	[signature]	SEP 07 2022	11:32	-2.9			

Fish with Hg samples from Stephens Lake in 2022

Submitted 7 Sep 2022

Location	Fish#	Species	Length
Stephens Lk	194	LKST	894
Stephens Lk	65	LKWH	375
Stephens Lk	66	LKWH	314
Stephens Lk	85	LKWH	442
Stephens Lk	290	LKWH	450
Stephens Lk	322	LKWH	304
Stephens Lk	340	LKWH	472
Stephens Lk	362	LKWH	300
Stephens Lk	19	NRPK	463
Stephens Lk	29	NRPK	465
Stephens Lk	45	NRPK	504
Stephens Lk	46	NRPK	518
Stephens Lk	53	NRPK	449
Stephens Lk	63	NRPK	496
Stephens Lk	64	NRPK	468
Stephens Lk	92	NRPK	435
Stephens Lk	93	NRPK	402
Stephens Lk	129	NRPK	491
Stephens Lk	133	NRPK	524
Stephens Lk	168	NRPK	382
Stephens Lk	182	NRPK	355
Stephens Lk	210	NRPK	340
Stephens Lk	235	NRPK	497
Stephens Lk	315	NRPK	284
Stephens Lk	314	NRPK	286
Stephens Lk	316	NRPK	355
Stephens Lk	317	NRPK	306
Stephens Lk	318	NRPK	400
Stephens Lk	319	NRPK	524
Stephens Lk	329	NRPK	336
Stephens Lk	333	NRPK	498
Stephens Lk	341	NRPK	734
Stephens Lk	350	NRPK	498
Stephens Lk	358	NRPK	347
Stephens Lk	359	NRPK	346
Stephens Lk	360	NRPK	319
Stephens Lk	361	NRPK	335
Stephens Lk	12	WALL	272
Stephens Lk	13	WALL	239
Stephens Lk	14	WALL	155
Stephens Lk	15	WALL	123
Stephens Lk	26	WALL	314
Stephens Lk	27	WALL	321

L2731799-COFC

Fish with Hg samples from Stephens Lake in 2022

Submitted 7 Sep 2022

Location	Fish#	Species	Length
Stephens Lk	35	WALL	462
Stephens Lk	47	WALL	487
Stephens Lk	48	WALL	364
Stephens Lk	49	WALL	301
Stephens Lk	50	WALL	209
Stephens Lk	55	WALL	280
Stephens Lk	58	WALL	776
Stephens Lk	59	WALL	329
Stephens Lk	60	WALL	234
Stephens Lk	61	WALL	355
Stephens Lk	96	WALL	265
Stephens Lk	99	WALL	397
Stephens Lk	108	WALL	413
Stephens Lk	132	WALL	255
Stephens Lk	138	WALL	405
Stephens Lk	139	WALL	443
Stephens Lk	140	WALL	337
Stephens Lk	141	WALL	420
Stephens Lk	165	WALL	205
Stephens Lk	167	WALL	345
Stephens Lk	176	WALL	393
Stephens Lk	178	WALL	430
Stephens Lk	179	WALL	556
Stephens Lk	188	WALL	374
Stephens Lk	190	WALL	294
Stephens Lk	191	WALL	466
Stephens Lk	193	WALL	441
Stephens Lk	220	WALL	298
Stephens Lk	232	WALL	523
Stephens Lk	236	WALL	200

L2731799-COFC

North/South Consultants
ATTN: JODI HOLM
83 Scurfield Blvd
Winnipeg MB R3Y 1G4

Date Received: 26-OCT-22
Report Date: 23-DEC-22 18:33 (MT)
Version: FINAL

Client Phone: 204-487-5638

Certificate of Analysis

Lab Work Order #: L2738082

Project P.O. #: NOT SUBMITTED
Job Reference: KEEYASK FISH
C of C Numbers:
Legal Site Desc: BURNTWOOD RIVER

Judy Dalmaijer
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2738082-1 20							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0372		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-2 43							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0372		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-3 64							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0772		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-4 70							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0457		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-5 79							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0649		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-6 99							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0707		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-7 100							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0606		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557
L2738082-8 134							
Sampled By: CLIENT							
Matrix: TISSUE - LKST							
Miscellaneous Parameters							
Mercury (Hg)	0.0459		0.0010	mg/kg wwt	13-DEC-22	15-DEC-22	R5907557

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
HG-WET-CVAA-WP	Tissue	Mercury in Tissue	EPA 200.3/1631E (mod)

Tissue samples undergo hotblock digestion with nitric and hydrochloric acids, in combination with repeated additons of hydrogen peroxide, followed by cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analysis by CVAAS.

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The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

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mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
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Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: North/South Consultants
83 Scurfield Blvd
Winnipeg MB R3Y 1G4

Contact: JODI HOLM

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
HG-WET-CVAA-WP	**Tissue**							
Batch R5907557								
WG3776051-7 CRM		**DORM-4N**						
Mercury (Hg)			102.0		%		70-130	15-DEC-22
WG3776051-6 LCS								
Mercury (Hg)			89.9		%		80-120	15-DEC-22
WG3776051-5 MB								
Mercury (Hg)			<0.0010		mg/kg wwt		0.001	15-DEC-22

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Cha[illegible]

L2738082-COFC

COC # Keeyask GS

Page 1 of 1

Report to:		Report Format / Distribution		Service Requested: (rush - subject to availability)
Company:	North South Consultants	☑ Standard ☐ Other		◉ Regular (Default)
Contact:	Jodi Holm	☑ PDF ☑ Excel ☑ Digital		○ Priority (2-3 Business Days) - 50% Surcharge
Address:	83 Scurfield Blvd, Winnipeg	Email 1:	jholm@nscons.ca	○ Emergency (1 Business Day) - 100% Surcharge
		Email 2:		○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS
Phone:	284 3366 ext 227 Fax: 477 4173			**Analysis Request**
Invoice To:	Same as Report ? ◉ Yes ○ No	Client / Project Information:		Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		Job #:	Keeyask Fish	
Contact:		PO / AFE:		
Address:		Legal Site Description:		
Phone:	284 3366 Fax: 477 4173	Quote #:	Q88945	
Lab Work Order # (lab use only)		ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	SAMPLE DISPOSAL-WP	HG-WET-CVAA-WP											Number of Containers
	Lake Sturgeon: See attached sheet			Tissue	X	X											8
	samples are organized by: Collector's ID																

Special Instructions / Regulations / Hazardous Details

Analyze muscle tissue with skin and scales removed

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)		SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)		
Released by: Kim Mundy	Date & Time: Oct 26, 2022	Received by: [signature]	Date: OCT 2 6 2022	Time: 10:20	Temperature: -0.5	Verified by:	Date & Time:	Observations: Yes / No ? If Yes attach SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY   GENF 18.00 Front

Sturgeon with Hg samples from Keeyask Area in 2022

Submitted 26Oct 2022

Collector's fish no.	Location	Common name	Fork length (mm)	
20	Burntwood River	LKST	485	
43	Burntwood River	LKST	490	
64	Stephens Lake	LKST	310	
70	Burntwood River	LKST	531	
79	Stephens Lake	LKST	521	
99	Stephens Lake	LKST	540	
100	Stephens Lake	LKST	478	
134	Burntwood River	LKST	515	

L2738082-COFC

APPENDIX 3: MUSCLE MERCURY CONCENTRATIONS AND BIOLOGICAL DATA FOR INDIVIDUAL FISH FROM THE KEEYASK RESERVOIR, STEPHENS LAKE, AND SPLIT LAKE IN 2022

Table A3-1: Definitions of codes used in Appendix 3 tables.

Term	Code	Definition
Species	LKST	Lake Sturgeon
	LKWH	Lake Whitefish
	NRPK	Northern Pike
	WALL	Walleye
Sex	F	Female
	M	Male
Maturity	IMM	Immature
	MAT	Mature
K		Condition factor

Table A3-2: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from the Keeyask reservoir in 2022.

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
1143	GN-136	08-Jun-22	LKWH	485	-	-	M	MAT	-	0.267
28	GN-02	11-Aug-22	LKWH	234	190	1.48	M	MAT	3	0.0253
18	GN-01	11-Aug-22	LKWH	462	1180	1.20	F	MAT	20	0.204
122	GN-06	13-Aug-22	LKWH	288	280	1.17	M	IMM	4	0.0264
126	GN-06	13-Aug-22	LKWH	519	2600	1.86	F	MAT	14	0.381
127	GN-06	13-Aug-22	LKWH	523	2680	1.87	F	MAT	12	0.343
180	GN-08	14-Aug-22	LKWH	204	130	1.53	M	IMM	2	0.365
197	GN-07	14-Aug-22	LKWH	493	1980	1.65	F	MAT	12	0.442
195	GN-07	14-Aug-22	LKWH	598	4200	1.96	F	MAT	12	0.565
229	GN-13	15-Aug-22	LKWH	560	3710	2.11	F	MAT	19	0.724
344	GN-15	17-Aug-22	LKWH	161	50	1.20	F	IMM	1	0.269
345	GN-15	17-Aug-22	LKWH	165	50	1.11	F	IMM	1	0.308
353	GN-15	17-Aug-22	LKWH	190	70	1.02	F	IMM		0.322
352	GN-15	17-Aug-22	LKWH	198	90	1.16	M	IMM	2	0.195
354	GN-15	17-Aug-22	LKWH	220	120	1.13	M	IMM	2	0.237
363	GN-15	17-Aug-22	LKWH	411	1260	1.81	F	MAT	10	0.324
368	GN-15	17-Aug-22	LKWH	500	2360	1.89	F	MAT	8	0.319
372	GN-15	17-Aug-22	LKWH	543	3480	2.17	M	MAT	9	0.477
375	Merc-03	18-Aug-22	LKWH	355	590	1.32	F	MAT	5	0.282
374	Merc-03	18-Aug-22	LKWH	418	1200	1.64	F	MAT	5	0.289
48	GN-02	11-Aug-22	NRPK	592	1640	0.79	F	MAT	8	0.356
80	GN-05	13-Aug-22	NRPK	666	2620	0.89	F	MAT	8	0.330
115	GN-06	13-Aug-22	NRPK	311	220	0.73	M	IMM	3	0.285
118	GN-06	13-Aug-22	NRPK	650	1880	0.68	F	MAT	1	0.755
140	GN-06	13-Aug-22	NRPK	1000	7550	0.76	F	MAT	12	1.86

Table A3-2: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from the Keeyask reservoir in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
149	GN-10	14-Aug-22	NRPK	455	710	0.75	F	MAT	4	0.473
156	GN-10	14-Aug-22	NRPK	364	360	0.75	M	IMM	2	0.330
157	GN-10	14-Aug-22	NRPK	326	280	0.81	M	MAT	2	0.234
159	GN-10	14-Aug-22	NRPK	335	280	0.74	M	MAT	2	0.341
160	GN-10	14-Aug-22	NRPK	298	200	0.76	M	IMM	2	0.489
164	GN-10	14-Aug-22	NRPK	350	340	0.79	F	MAT	3	0.196
167	GN-10	14-Aug-22	NRPK	315	190	0.61	F	IMM	2	0.269
194	GN-07	14-Aug-22	NRPK	1020	7300	0.69	F	MAT	11	3.26
211	GN-09	15-Aug-22	NRPK	385	430	0.75	M	MAT		0.650
214	GN-09	15-Aug-22	NRPK	400	500	0.78	F	MAT	3	0.500
215	GN-09	15-Aug-22	NRPK	396	500	0.81	M	MAT	3	0.539
216	GN-09	15-Aug-22	NRPK	370	370	0.73	F	IMM	3	0.513
223	GN-13	15-Aug-22	NRPK	590	1300	0.63	M	MAT	5	0.600
228	GN-13	15-Aug-22	NRPK	891	5000	0.71	-	-	10	1.57
271	Merc-01	17-Aug-22	NRPK	530	1140	0.77	F	MAT	5	0.582
272	Merc-01	17-Aug-22	NRPK	550	1310	0.79	M	IMM	6	0.661
273	Merc-01	17-Aug-22	NRPK	564	1530	0.85	M	IMM	8	0.812
275	SN-11	17-Aug-22	NRPK	270	160	0.81	M	IMM	2	0.427
276	GN-11	17-Aug-22	NRPK	220	100	0.94	F	IMM	1	0.451
281	GN-11	17-Aug-22	NRPK	412	520	0.74	M	MAT	3	0.460
283	GN-11	17-Aug-22	NRPK	290	170	0.70	F	IMM	2	0.462
284	GN-11	17-Aug-22	NRPK	470	760	0.73	F	MAT	4	0.534
288	GN-11	17-Aug-22	NRPK	480	860	0.78	F	MAT	5	0.705
296	GN-14	17-Aug-22	NRPK	245	110	0.75	M	IMM	1	0.248
300	GN-14	17-Aug-22	NRPK	212	60	0.63	F	IMM	1	0.223

Table A3-2: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from the Keeyask reservoir in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
301	GN-14	17-Aug-22	NRPK	230	130	1.07	M	IMM	1	0.394
302	GN-14	17-Aug-22	NRPK	205	60	0.70	M	IMM	1	0.527
303	GN-14	17-Aug-22	NRPK	461	870	0.89	M	MAT	3	0.552
321	GN-14	17-Aug-22	NRPK	604	1700	0.77	F	MAT	5	0.500
324	GN-14	17-Aug-22	NRPK	500	940	0.75	F	MAT	2	0.349
329	GN-14	17-Aug-22	NRPK	615	1840	0.79	M	MAT	6	0.454
10	GN-01	11-Aug-22	WALL	311	310	1.03	M	MAT	6	0.215
11	GN-01	11-Aug-22	WALL	335	420	1.12	M	MAT	6	0.317
21	GN-02	11-Aug-22	WALL	294	210	0.83	F	MAT	6	0.279
30	GN-02	11-Aug-22	WALL	325	310	0.90	F	MAT	6	0.171
32	GN-02	11-Aug-22	WALL	275	180	0.87	M	IMM	7	0.534
33	GN-02	11-Aug-22	WALL	320	320	0.98	F	MAT	8	0.320
40	GN-02	11-Aug-22	WALL	285	210	0.91	M	MAT	6	0.315
55	GN-03	11-Aug-22	WALL	249	150	0.97	M	MAT	6	0.323
58	GN-03	11-Aug-22	WALL	266	160	0.85	M	IMM	5	0.265
60	GN-03	11-Aug-22	WALL	253	150	0.93	M	IMM	6	0.400
66	GN-04	13-Aug-22	WALL	300	370	1.37	F	MAT	5	0.273
69	GN-04	13-Aug-22	WALL	183	80	1.31	M	IMM	2	0.337
79	GN-04	13-Aug-22	WALL	385	550	0.96	M	MAT	8	0.646
83	GN-05	13-Aug-22	WALL	195	100	1.35	M	IMM	2	0.896
91	GN-05	13-Aug-22	WALL	225	140	1.23	M	IMM	3	0.321
96	GN-05	13-Aug-22	WALL	234	-	-	M	IMM	6	0.407
99	SN-06	13-Aug-22	WALL	457	1100	1.15	F	MAT	15	0.840
111	GN-06	13-Aug-22	WALL	420	810	1.09	M	MAT	10	0.545
132	GN-06	13-Aug-22	WALL	374	530	1.01	M	MAT	12	0.787

Table A3-2: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from the Keeyask reservoir in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
136	GN-06	13-Aug-22	WALL	430	880	1.11	F	MAT	10	0.713
138	GN-06	13-Aug-22	WALL	513	1630	1.21	F	MAT	15	1.14
139	GN-06	13-Aug-22	WALL	450	910	1.00	F	MAT	12	0.160
145	GN-06	13-Aug-22	WALL	454	1000	1.07	F	MAT	9	0.744
170	GN-08	14-Aug-22	WALL	407	710	1.05	F	MAT	11	0.512
185	GN-08	14-Aug-22	WALL	436	980	1.18	M	MAT	12	0.389
189	GN-08	14-Aug-22	WALL	488	1130	0.97	F	MAT	9	0.164
198	GN-07	14-Aug-22	WALL	346	470	1.13	F	MAT	8	0.390
199	GN-07	14-Aug-22	WALL	358	540	1.18	M	MAT	7	0.576
253	GN-17	16-Aug-22	WALL	220	100	0.94	M	IMM	2	0.400
261	GN-17	16-Aug-22	WALL	516	1540	1.12	F	MAT	10	0.566
262	GN-16	16-Aug-22	WALL	189	60	0.89	M	IMM	2	0.549
348	GN-15	17-Aug-22	WALL	210	100	1.08	M	IMM	-	0.655
364	GN-15	17-Aug-22	WALL	396	630	1.01	M	MAT	10	0.773
371	GN-15	17-Aug-22	WALL	440	960	1.13	F	MAT	10	0.734
377	Merc-02	18-Aug-22	WALL	484	1050	0.93	F	MAT	11	0.934
376	Merc-03	18-Aug-22	WALL	494	1460	1.21	F	MAT	11	0.545

Table A3-3: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Stephens Lake in 2022.

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
65	GN-17	25-Aug-22	LKWH	375	730	1.38	M	MAT	5	0.0667
322	GN-35	29-Aug-22	LKWH	304	320	1.14	F	IMM	5	0.0787
362	GN-31	29-Aug-22	LKWH	300	360	1.33	F	IMM	4	0.0934
66	GN-17	25-Aug-22	LKWH	314	390	1.26	M	IMM	5	0.120
340	GN-31	29-Aug-22	LKWH	472	1320	1.26	M	MAT	16	0.153
290	GN-26	29-Aug-22	LKWH	450	1500	1.65	F	MAT	12	0.206
85	GN-17	25-Aug-22	LKWH	442	970	1.12	F	MAT	14	0.274
182	GN-16	26-Aug-22	NRPK	355	350	0.78	M	MAT	3	0.103
168	GN-15	26-Aug-22	NRPK	382	390	0.70	M	MAT	3	0.171
359	GN-31	29-Aug-22	NRPK	346	260	0.63	F	MAT	3	0.176
360	GN-31	29-Aug-22	NRPK	319	193	0.59	M	IMM	3	0.190
93	GN-13	25-Aug-22	NRPK	402	470	0.72	M	MAT	2	0.198
92	GN-13	25-Aug-22	NRPK	435	550	0.67	M	MAT	3	0.228
210	GN-33	28-Aug-22	NRPK	340	300	0.76	F	IMM	2	0.238
19	GN-14	25-Aug-22	NRPK	463	716	0.72	F	MAT	3	0.238
317	GN-35	29-Aug-22	NRPK	306	190	0.66	M	IMM	2	0.243
329	GN-31	29-Aug-22	NRPK	336	250	0.66	M	IMM	2	0.249
361	GN-31	29-Aug-22	NRPK	335	210	0.56	F	IMM	2	0.259
63	GN-17	25-Aug-22	NRPK	496	830	0.68	F	MAT	4	0.269
318	GN-35	29-Aug-22	NRPK	400	410	0.64	M	MAT	-	0.285
64	GN-17	25-Aug-22	NRPK	468	710	0.69	F	MAT	5	0.287
314	GN-35	29-Aug-22	NRPK	286	160	0.68	M	IMM	2	0.289
315	GN-35	29-Aug-22	NRPK	284	160	0.70	F	IMM	2	0.293
29	GN-14	25-Aug-22	NRPK	465	670	0.67	M	MAT	5	0.307
350	GN-34	29-Aug-22	NRPK	498	810	0.66	F	MAT	5	0.314

Table A3-3: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Stephens Lake in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
358	GN-31	29-Aug-22	NRPK	347	275	0.66	M	IMM	3	0.318
45	GN-17	25-Aug-22	NRPK	504	800	0.62	M	MAT	5	0.326
129	GN-22	26-Aug-22	NRPK	491	750	0.63	M	MAT	4	0.337
133	GN-22	26-Aug-22	NRPK	524	890	0.62	F	MAT	5	0.357
46	GN-17	25-Aug-22	NRPK	518	910	0.65	F	MAT	6	0.378
319	GN-35	29-Aug-22	NRPK	524	980	0.68	F	MAT	6	0.378
53	GN-17	25-Aug-22	NRPK	449	450	0.50	M	MAT	5	0.403
235	GN-30	28-Aug-22	NRPK	497	800	0.65	F	MAT	6	0.588
341	GN-31	29-Aug-22	NRPK	734	2345	0.59	F	MAT	9	0.635
333	GN-31	29-Aug-22	NRPK	498	1000	0.81	M	MAT	5	0.693
316	GN-35	29-Aug-22	NRPK	355	320	0.72	M	MAT	3	0.371
14	SN-14	25-Aug-22	WALL	155	150	4.03	-	IMM	1	0.0769
15	SN-14	25-Aug-22	WALL	123	15	0.81	-	IMM	1	0.0846
165	GN-15	26-Aug-22	WALL	205	100	1.16	F	IMM	2	0.115
13	SN-14	25-Aug-22	WALL	239	150	1.10	F	IMM	4	0.158
12	SN-14	25-Aug-22	WALL	272	230	1.14	F	IMM	4	0.159
50	GN-17	25-Aug-22	WALL	209	100	1.10	M	IMM	2	0.169
132	GN-22	26-Aug-22	WALL	255	150	0.90	M	IMM	4	0.169
60	GN-17	25-Aug-22	WALL	234	150	1.17	M	IMM	3	0.204
27	GN-14	25-Aug-22	WALL	321	360	1.09	F	MAT	5	0.214
55	GN-17	25-Aug-22	WALL	280	270	1.23	F	IMM	5	0.220
188	GN-16	26-Aug-22	WALL	374	550	1.05	M	MAT	8	0.226
190	GN-16	26-Aug-22	WALL	294	340	1.34	M	IMM	6	0.254
26	GN-14	25-Aug-22	WALL	314	360	1.16	M	IMM	6	0.275
140	GN-22	26-Aug-22	WALL	337	400	1.05	M	IMM	7	0.294

Table A3-3: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Stephens Lake in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
141	GN-22	26-Aug-22	WALL	420	800	1.08	M	MAT	11	0.301
59	GN-17	25-Aug-22	WALL	329	440	1.24	M	MAT	6	0.318
236	GN-30	28-Aug-22	WALL	200	73	0.91	M	IMM	2	0.322
49	GN-17	25-Aug-22	WALL	301	300	1.10	M	MAT	6	0.336
48	GN-17	25-Aug-22	WALL	364	530	1.10	M	MAT	7	0.346
96	GN-13	25-Aug-22	WALL	265	170	0.91	F	IMM	4	0.357
176	GN-15	26-Aug-22	WALL	393	650	1.07	F	MAT	9	0.379
167	GN-15	26-Aug-22	WALL	345	500	1.22	M	MAT	9	0.389
61	GN-17	25-Aug-22	WALL	355	470	1.05	F	MAT	9	0.407
58	GN-17	25-Aug-22	WALL	376	550	1.03	F	MAT	10	0.414
220	GN-33	28-Aug-22	WALL	298	300	1.13	M	IMM	6	0.425
191	GN-16	26-Aug-22	WALL	466	1100	1.09	F	MAT	14	0.568
193	GN-16	26-Aug-22	WALL	477	1300	1.20	-	-	-	0.588
138	GN-22	26-Aug-22	WALL	405	750	1.13	M	MAT	14	0.635
99	GN-13	25-Aug-22	WALL	397	520	0.83	F	MAT	11	0.730
139	GN-22	26-Aug-22	WALL	443	720	0.83	M	MAT	14	0.803
108	GN-13	25-Aug-22	WALL	413	790	1.12	M	MAT	14	0.831
35	GN-14	25-Aug-22	WALL	462	1080	1.10	F	MAT	14	0.841
47	GN-17	25-Aug-22	WALL	487	1160	1.00	M	MAT	18	0.910
178	GN-15	26-Aug-22	WALL	430	890	1.12	F	MAT	18	0.938
232	GN-30	28-Aug-22	WALL	523	1740	1.22	F	MAT	12	0.961
179	GN-15	26-Aug-22	WALL	556	1650	0.96	F	MAT	18	1.10

Table A3-4: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Split Lake in 2022.

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
90	GN-18	29-Aug-22	LKWH	199	100	1.27	-	IMM	3	0.0369
99	GN-18	29-Aug-22	LKWH	435	1570	1.91	M	MAT	13	0.122
100	GN-18	29-Aug-22	LKWH	422	960	1.28	F	MAT	15	0.150
101	GN-18	29-Aug-22	LKWH	425	1050	1.37	M	MAT	14	0.193
102	GN-18	29-Aug-22	LKWH	425	1090	1.42	M	MAT	13	0.123
103	GN-18	29-Aug-22	LKWH	325	510	1.49	M	MAT	5	0.0592
110	GN-18	29-Aug-22	LKWH	345	610	1.49	F	MAT	7	0.0774
111	GN-18	29-Aug-22	LKWH	375	820	1.55	M	MAT	9	0.0974
112	GN-18	29-Aug-22	LKWH	400	970	1.52	M	MAT	14	0.138
115	GN-18	29-Aug-22	LKWH	396	750	1.21	F	MAT	12	0.189
116	GN-18	29-Aug-22	LKWH	410	1160	1.68	F	MAT	11	0.120
117	GN-18	29-Aug-22	LKWH	430	940	1.18	M	MAT	14	0.150
118	GN-18	29-Aug-22	LKWH	352	740	1.70	M	MAT	6	0.0449
119	GN-18	29-Aug-22	LKWH	440	1000	1.17	F	MAT	12	0.201
120	GN-18	29-Aug-22	LKWH	400	900	1.41	M	MAT	9	0.137
121	GN-18	29-Aug-22	LKWH	410	1100	1.60	M	MAT	10	0.108
296	GN-06	31-Aug-22	LKWH	485	1810	1.59	F	MAT	15	0.133
303	GN-06	31-Aug-22	LKWH	455	1780	1.89	F	MAT	14	0.162
304	GN-06	31-Aug-22	LKWH	500	2140	1.71	M	MAT	17	0.166
314	GN-06	31-Aug-22	LKWH	416	900	1.25	F	MAT	13	0.216
332	GN-05	31-Aug-22	LKWH	409	1240	1.81	F	MAT	14	0.144
368	GN-05	31-Aug-22	LKWH	410	1070	1.55	-	-	14	0.150
425	GN-22	01-Sep-22	LKWH	480	1790	1.62	M	MAT	12	0.102
479	GN-03	01-Sep-22	LKWH	400	1100	1.72	M	MAT	10	0.122
2	GN-15	28-Aug-22	NRPK	395	390	0.63	M	MAT	3	0.375

Table A3-4: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Split Lake in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
11	GN-15	28-Aug-22	NRPK	600	1650	0.76	F	MAT	9	0.479
35	GN-28	28-Aug-22	NRPK	330	220	0.61	M	MAT	2	0.122
36	GN-28	28-Aug-22	NRPK	471	670	0.64	F	MAT	5	0.265
80	GN-13	28-Aug-22	NRPK	690	2330	0.71	F	MAT	8	0.712
273	SN-06	31-Aug-22	NRPK	605	1450	0.65	M	MAT	4	0.754
274	SN-06	31-Aug-22	NRPK	370	340	0.67	M	MAT	6	0.176
275	SN-06	31-Aug-22	NRPK	345	220	0.54	F	MAT	3	0.147
289	SN-06	31-Aug-22	NRPK	161	33	0.79	-	IMM	0	0.0952
290	SN-06	31-Aug-22	NRPK	131	13	0.58	-	IMM	0	0.104
292	GN-06	31-Aug-22	NRPK	359	270	0.58	M	MAT	3	0.195
294	GN-06	31-Aug-22	NRPK	374	330	0.63	M	MAT	4	0.433
295	GN-06	31-Aug-22	NRPK	381	340	0.61	F	MAT	3	0.263
323	GN-05	31-Aug-22	NRPK	341	310	0.78	M	MAT	3	0.199
324	GN-05	31-Aug-22	NRPK	545	910	0.56	F	MAT	6	0.810
331	GN-05	31-Aug-22	NRPK	330	260	0.72	M	MAT	3	0.229
333	GN-05	31-Aug-22	NRPK	826	4760	0.84	F	MAT	11	0.862
334	GN-05	31-Aug-22	NRPK	639	1850	0.71	F	MAT	8	0.702
335	GN-05	31-Aug-22	NRPK	495	770	0.63	M	MAT	5	0.252
336	GN-05	31-Aug-22	NRPK	505	830	0.64	M	MAT	5	0.297
389	GN-22	01-Sep-22	NRPK	373	350	0.67	M	MAT	3	0.173
390	GN-22	01-Sep-22	NRPK	381	360	0.65	F	MAT	3	0.212
391	GN-22	01-Sep-22	NRPK	515	900	0.66	M	MAT	5	0.270
426	GN-22	01-Sep-22	NRPK	440	670	0.79	M	MAT	3	0.346
427	GN-22	01-Sep-22	NRPK	571	1120	0.60	F	MAT	6	0.710
428	GN-22	01-Sep-22	NRPK	515	840	0.61	F	MAT	5	0.234

Table A3-4: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Split Lake in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
478	GN-03	01-Sep-22	NRPK	395	390	0.63	M	MAT	3	0.215
534	GN-03	01-Sep-22	NRPK	481	550	0.49	M	MAT	6	0.492
535	GN-03	01-Sep-22	NRPK	349	290	0.68	M	MAT	3	0.194
536	GN-03	01-Sep-22	NRPK	331	250	0.69	F	MAT	3	0.156
537	GN-03	01-Sep-22	NRPK	408	460	0.68	M	MAT	6	0.288
538	GN-03	01-Sep-22	NRPK	409	450	0.66	F	MAT	3	0.163
539	GN-03	01-Sep-22	NRPK	436	500	0.60	F	MAT	5	0.270
13	GN-15	28-Aug-22	WALL	394	610	1.00	F	MAT	11	0.384
18	GN-15	28-Aug-22	WALL	235	120	0.92	-	IMM	3	0.137
19	GN-15	28-Aug-22	WALL	249	140	0.91	-	IMM	4	0.196
20	GN-15	28-Aug-22	WALL	240	130	0.94	-	IMM	4	0.197
22	GN-15	28-Aug-22	WALL	211	103	1.10	-	IMM	2	0.103
25	GN-15	28-Aug-22	WALL	283	250	1.10	M	MAT	6	0.347
26	GN-15	28-Aug-22	WALL	383	670	1.19	F	MAT	9	0.414
31	GN-15	28-Aug-22	WALL	182	76	1.26	-	IMM	2	0.123
33	GN-15	28-Aug-22	WALL	203	93	1.11	M	IMM	2	0.136
51	GN-28	28-Aug-22	WALL	415	750	1.05	F	MAT	10	0.413
56	GN-13	28-Aug-22	WALL	358	490	1.07	M	MAT	6	0.486
77	GN-13	28-Aug-22	WALL	322	330	0.99	M	MAT	6	0.381
81	GN-18	29-Aug-22	WALL	255	180	1.09	M	IMM	4	0.131
82	GN-18	29-Aug-22	WALL	195	110	1.48	-	IMM	4	0.172
83	GN-18	29-Aug-22	WALL	220	150	1.41	-	IMM	4	0.204
87	GN-18	29-Aug-22	WALL	320	390	1.19	M	MAT	6	0.312
88	GN-18	29-Aug-22	WALL	185	60	0.95	-	IMM	2	0.193
109	GN-18	29-Aug-22	WALL	535	1790	1.17	M	MAT	12	0.383

Table A3-4: Muscle mercury concentrations (Hg) and biological data for Lake Whitefish, Northern Pike, and Walleye from Split Lake in 2022 (continued).

Fish #	Site	Sampling Date	Species	Fork Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
128	GN-26	29-Aug-22	WALL	411	710	1.02	F	MAT	9	0.558
159	GN-26	29-Aug-22	WALL	501	1240	0.99	M	MAT	17	0.710
176	GN-29	29-Aug-22	WALL	461	960	0.98	F	MAT	11	0.180
178	GN-29	29-Aug-22	WALL	335	440	1.17	M	MAT	7	0.343
218	SN-26	29-Aug-22	WALL	265	230	1.24	M	IMM	4	0.212
220	SN-26	29-Aug-22	WALL	330	390	1.09	M	MAT	9	0.590
226	GN-21	31-Aug-22	WALL	299	240	0.90	M	MAT	6	0.324
254	GN-21	31-Aug-22	WALL	362	550	1.16	M	MAT	8	0.349
257	GN-21	31-Aug-22	WALL	312	360	1.19	M	MAT	6	0.291
280	SN-06	31-Aug-22	WALL	348	510	1.21	M	MAT	9	0.386
283	SN-06	31-Aug-22	WALL	401	700	1.09	M	MAT	9	0.326
284	SN-06	31-Aug-22	WALL	371	590	1.16	M	MAT	9	0.402
302	GN-06	31-Aug-22	WALL	383	590	1.05	M	MAT	11	0.298
321	GN-05	31-Aug-22	WALL	435	1050	1.28	F	MAT	12	0.476
337	GN-05	31-Aug-22	WALL	439	1000	1.18	F	MAT	11	0.431
353	GN-05	31-Aug-22	WALL	500	1400	1.12	F	MAT	13	0.776
429	GN-22	01-Sep-22	WALL	471	1100	1.05	F	MAT	10	0.109
514	GN-03	01-Sep-22	WALL	453	1050	1.13	M	MAT	9	0.341

Table A3-5: Muscle mercury concentrations (Hg) and biological data for Lake Sturgeon mortalities from the Keeyask Study Area in 2022.

Location	Site	Sampling Date	Fish #	Species	Fork Length (mm)	Total Length (mm)	Weight (g)	K	Sex	Maturity	Age (y)	Hg (ppm)
Burntwood River	GN-03	10-Sep-22	20	LKST	485	542	875	0.77	-	-	6	0.0372
Burntwood River	GN-09	12-Sep-22	43	LKST	490	553	775	0.66	-	-	8	0.0372
Burntwood River	GN-13	13-Sep-22	70	LKST	531	606	1000	0.67	-	-	8	0.0457
Split Lake	GN-23	16-Sep-22	137	LKST	515	577	1000	0.73	-	-	8	0.0459
Stephens Lake	GN-21	18-Sep-22	64	LKST	310	349	150	0.50	-	-	2	0.0772
Stephens Lake	GN-29	21-Sep-22	100	LKST	478	539	850	0.78	-	-	6	0.0606
Stephens Lake	GN-21	19-Sep-22	79	LKST	521	596	1000	0.71	-	-	6	0.0649
Stephens Lake	GN-29	21-Sep-22	99	LKST	540	590	1100	0.70	-	-	6	0.0707
Stephens Lake	GN-30	28-Aug-22	194	LKST	894	997*	4300	0.60	F	MAT	15	0.324

* Total length was estimated from fork length using a ratio derived from adult Lake Sturgeon lengths in the lower Nelson River (NSC unpubl. data).

APPENDIX 4: LENGTH OF FISH SAMPLED FOR MERCURY 1999–2022

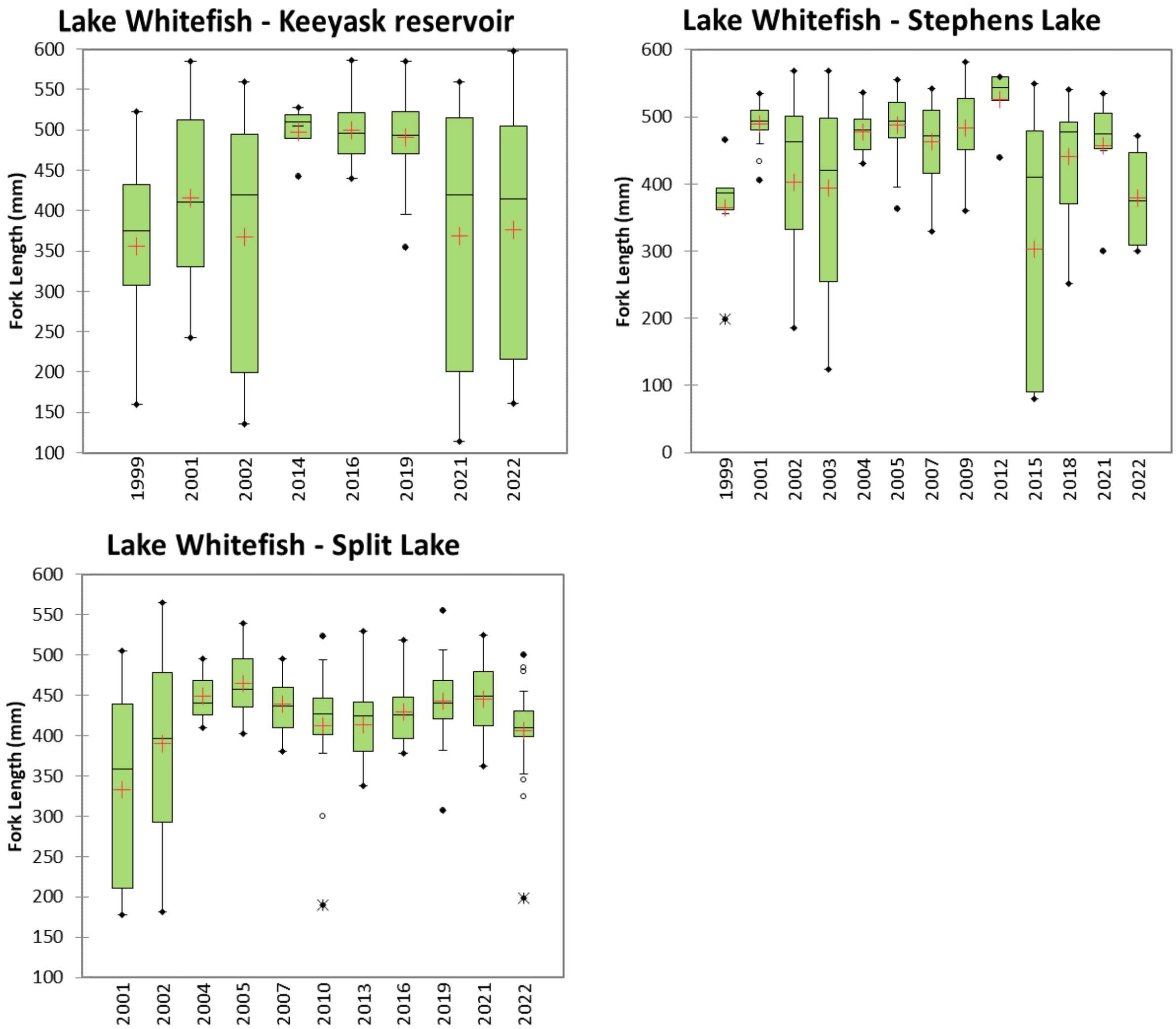

Figure A4-1: Box plots of the fork length of Lake Whitefish analyzed for mercury from the Keeyask reservoir, Stephens Lake, and Split Lake from 1999–2022.

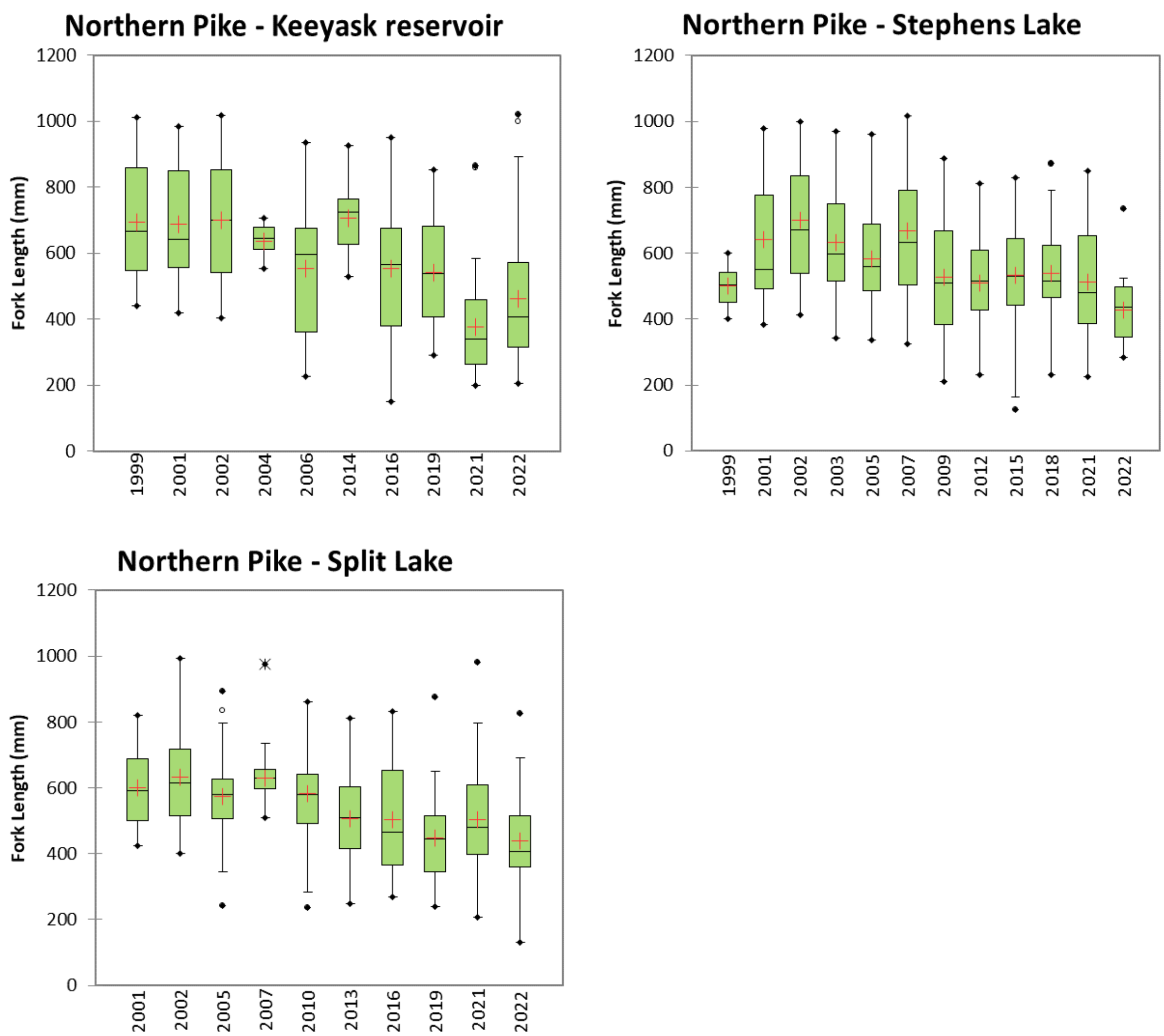

Figure A4-2: Box plots of the fork length of Northern Pike analyzed for mercury from the Keeyask reservoir, Stephens Lake, and Split Lake from 1999–2022.

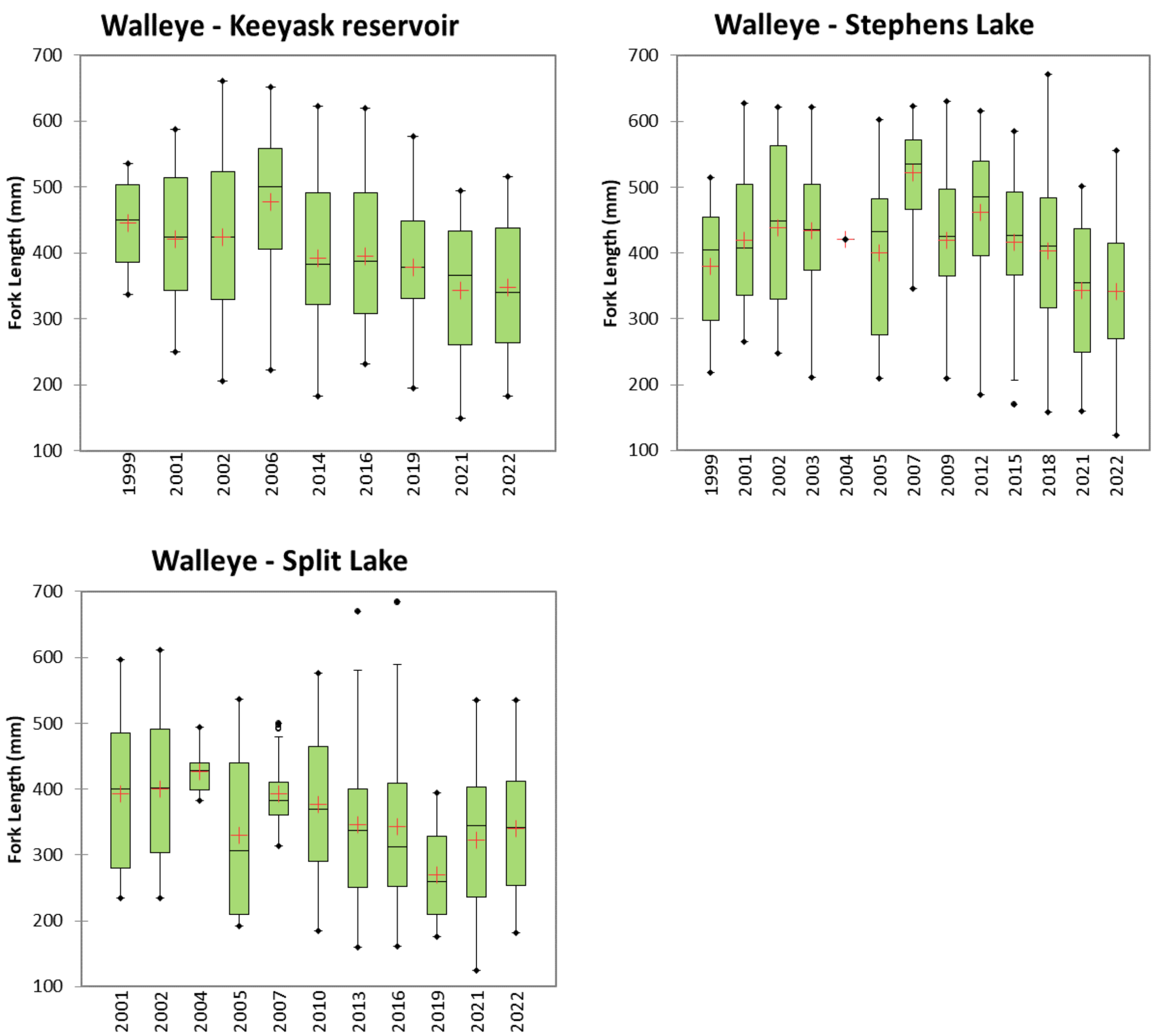

Figure A4-3: Box plots of the fork length of Walleye analyzed for mercury from the Keeyask reservoir, Stephens Lake, and Split Lake from 1999–2022.

APPENDIX 5: RESULTS OF LINEAR REGRESSION ANALYSIS

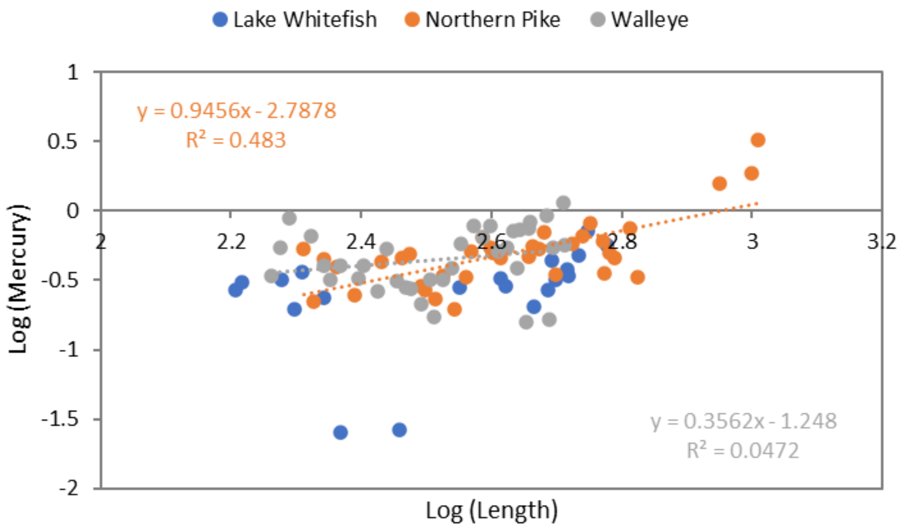

Figure A5-1: Plot of Log_{10} fork length (mm) and Log_{10} total mercury (ppm) in Northern Pike ($p < 0.0001$) and Walleye ($p = 0.203$) collected from the Keeyask reservoir in 2022.

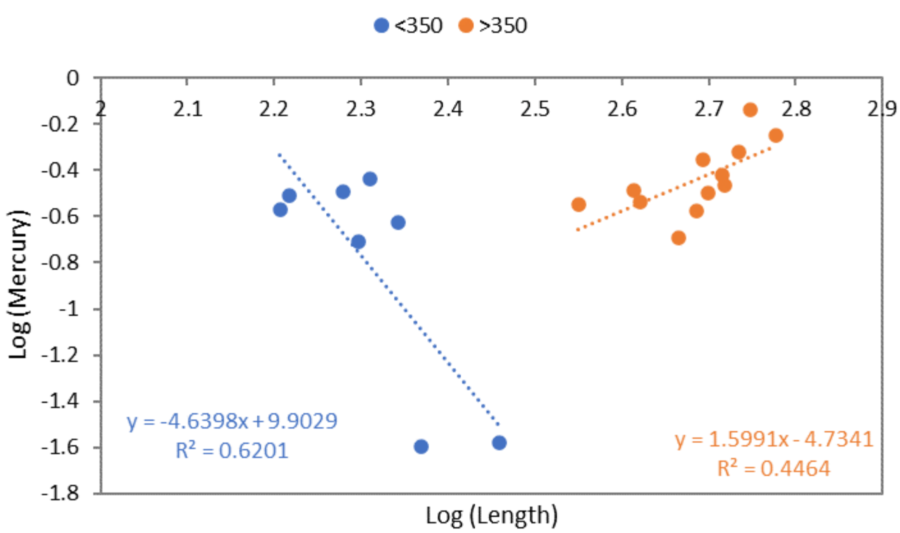

Figure A5-2: Plot of Log_{10} fork length (mm) and Log_{10} total mercury (ppm) in small (<350 mm) and large (>350 mm) Lake Whitefish collected from the Keeyask reservoir in 2022 ($p = 0.020$ and 0.018, respectively).

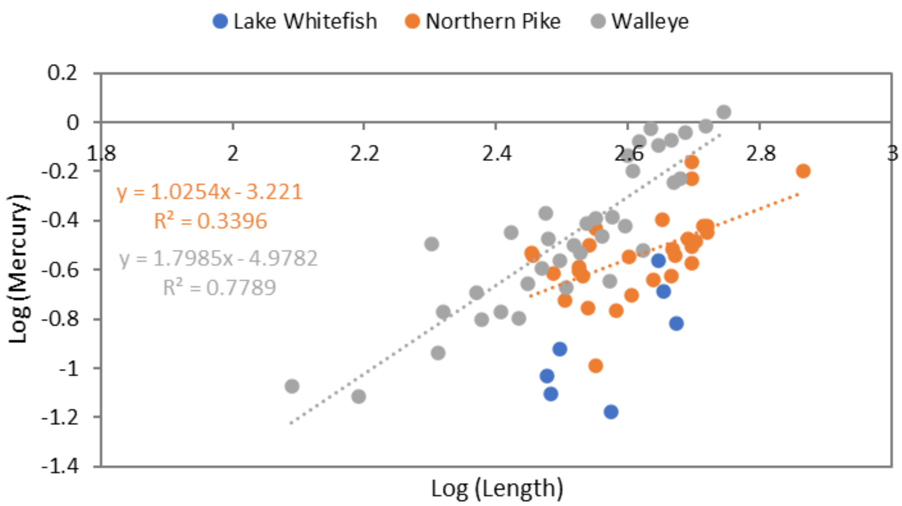

Figure A5-3: Plot of Log_{10} fork length (mm) and Log_{10} total mercury (ppm) in Northern Pike ($p = 0.001$), Walleye ($p < 0.0001$), and Lake Whitefish ($p = 0.076$) collected from Stephens Lake in 2022.

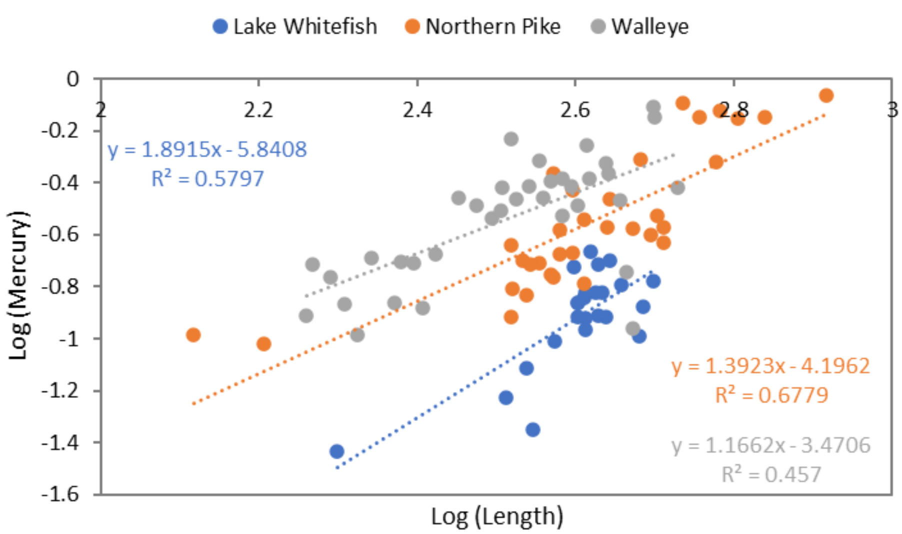

Figure A5-4: Plot of Log_{10} fork length (mm) and Log_{10} total mercury (ppm) in Northern Pike, Walleye, and Lake Whitefish collected from Split Lake in 2022 ($p < 0.0001$).