Updated summary report with PHASE 2 research results

2023

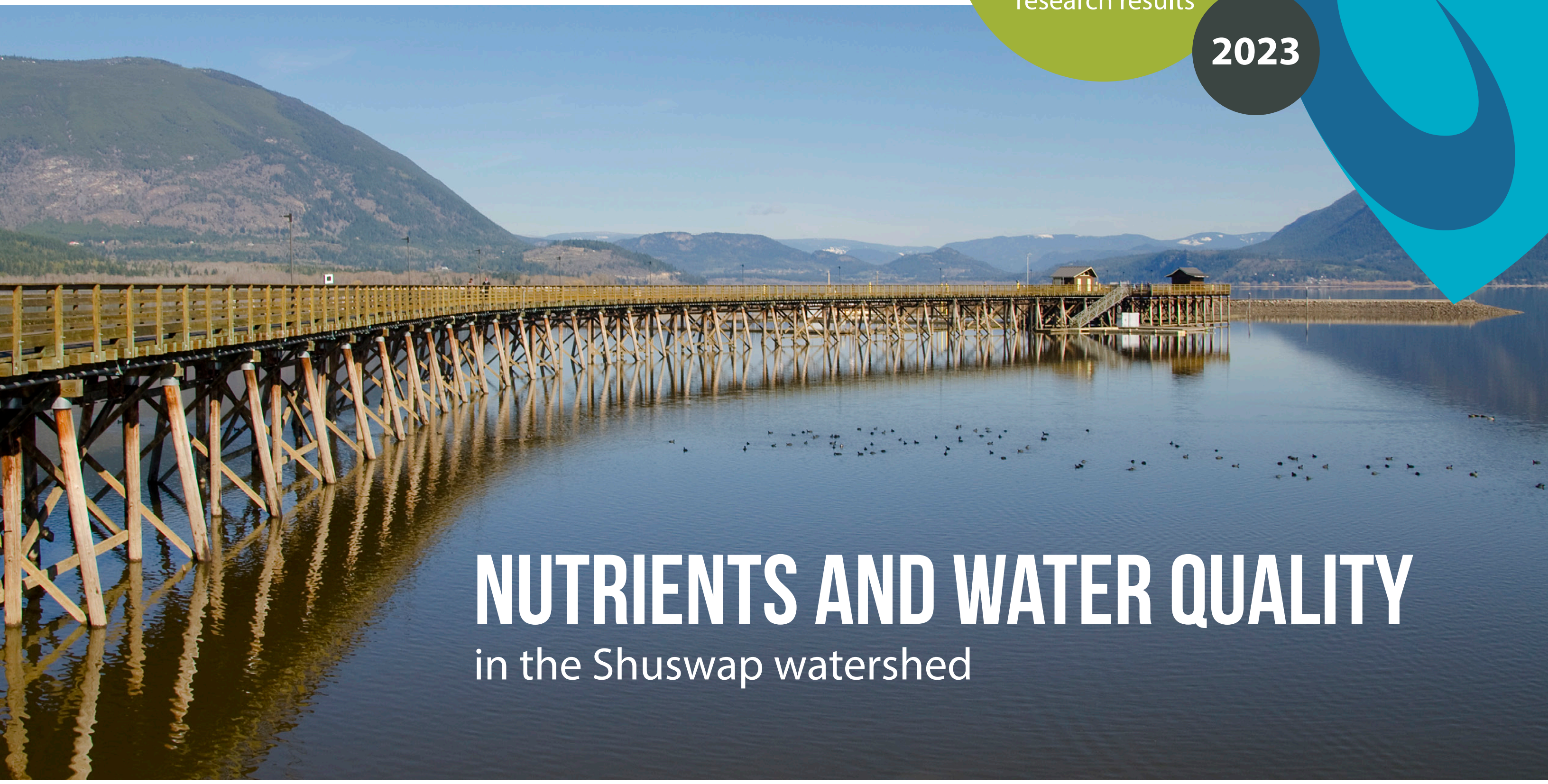


Photo Credit: Darren Robinson Photography

NUTRIENTS AND WATER QUALITY

in the Shuswap watershed

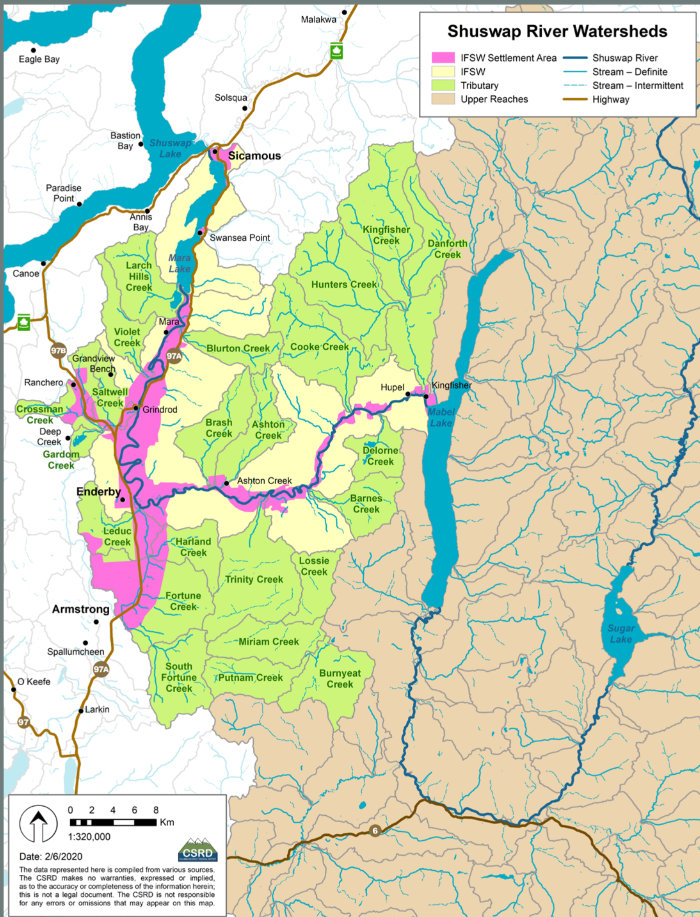
A research project by UBC Okanagan and the Shuswap Watershed Council

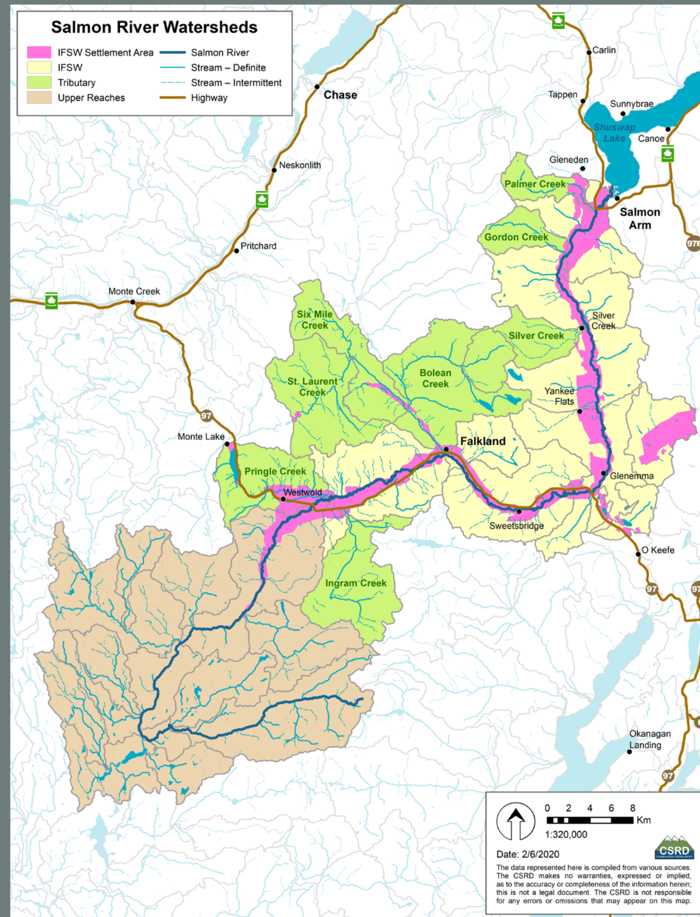
Nutrients have long been of interest in the Shuswap because of their importance to lake health and productivity, and their ability to trigger an algal bloom. Water quality monitoring has indicated that generally, water quality is good in most locations in the Shuswap watershed at most times of year. It has also shown us that the largest loads of nutrients to the lakes are coming from the Shuswap and Salmon Rivers. The Shuswap Watershed Council wanted to better understand if there is an excessive amount of nutrients in the two rivers not from the natural environment; and if so, where the nutrients are coming from and how they are getting into the rivers. Having clearer answers to these questions could inform the SWC's future work on incentives, education, and advocacy to protect water quality in the Shuswap.

From 2016–2020, the Shuswap Watershed Council worked with researchers at UBC Okanagan **to better understand the quantities of nutrients flowing into Shuswap and Mara Lakes via the Salmon and Shuswap Rivers and how that has impacted water quality in the lakes.** Two phases of research were carried out that involved the collection and analysis of water samples from over 100 sites in the watershed and the analysis of a sediment core collected from the bottom of Mara Lake. The results of the research are summarized on the following pages.

shuswapwater.ca

Phosphorus (P) is a key nutrient in an aquatic ecosystem. Aquatic life such as algae, invertebrates and fish need P to grow and reproduce. Therefore, it's important for supporting a healthy ecosystem. But, excessive nutrients and algae growth can reduce water clarity, create odours, and reduce the quality of water for drinking and recreation. Furthermore, P is considered a "limiting nutrient" in most lakes in our region. That means that P levels are holding back algae and other plant life; if more P is added, more plant life and algae will grow.





PHASE 1

Phase 1 of the nutrient research project took place from 2016–2019. The purpose of the study was to understand where the phosphorus in Shuswap and Mara Lakes is coming from. It involved the collection and analysis of water samples by the research team from 20 different sites on the Shuswap and Salmon Rivers, and from over 80 additional sites at ditches, seasonal streams, and wells within the watershed.

This work created 'nutrient budgets' for the two rivers, illustrating the changing concentrations of nutrients in the water as the rivers flow through their watersheds and accumulate nutrients off the landscape, ultimately flowing into Mara and Shuswap Lakes.

What we learned

The research data were compiled and evaluated according to which **region of the watershed** it is from:

The **upper reaches**, indicated by the darker brown areas on the maps, are mostly forested and are minimally impacted by agriculture, housing, and development. These reaches of the Shuswap River and Salmon River have very low nutrient concentrations, but—because they drain such vast areas of land—the nutrient load (i.e., kilograms of nutrients per year from these regions of the watershed) is significant.

The major **tributaries**, indicated by the green areas on the maps, are streams that flow into the Shuswap River and Salmon River year round. Most of the tributaries drain a forested upland area, and a small proportion of valley bottom, before flowing into the river. The tributaries drain a much smaller area than the upper reaches, and their nutrient concentrations are low. Consequently, they contribute the a small load of nutrients.

In the valley bottoms, there are seasonal streams, ditches, groundwater, and surface run-off flowing directly into the Shuswap River and Salmon River. These areas are known as **incremental flow sub-watersheds, or IFSWs.** Some of these only run in the spring and are dry the rest of the year. They are represented by the pale yellow and pink areas on the maps, the latter of which are the settled parts of the IFSWs. The IFSWs are the areas with the most impacts from agriculture, housing, and development. Although they account for the smallest percentage of land, these water sources are rich in nutrients. Consequently, the nutrient load from IFSWs is very significant.

Nutrient values are expressed in terms of **concentration** (kg/ha/year) and **load** (kg/year).

The Shuswap River. Photo credit: Erin Vieira

These tables show the concentrations, total load, and percentage of load for the upper reaches, tributaries, and IFSWs for the Shuswap River and Salmon River during the study period:

Shuswap River—total P

Source	Concentration (kg/ha/year)	Total loading (kg/year)	Percent total loading
Upper Reaches	0.08–0.072	30,200	48%
Tributaries	0.07	4090	6%
IFSW	1.46–14.3	29,200	46%
Totals	—	63,490	

Salmon River—total P

Source	Concentration (kg/ha/year)	Total loading (kg/year)	Percent total loading
Upper Reaches	0.068–0.32	10,200	23%
Tributaries	0.0287	3820	9%
IFSW	0.091–0.583	30,700	69%
Totals		44,720	

The research data was also compiled and evaluated according to which **land type** it is from.

Data from the Shuswap River and Salmon River watersheds were analyzed to determine the total P loadings from different land types:

Forested land contributed an average of 0.035 kg/ha/yr to the rivers. The researchers compared this to data for forested land that's reported in other scientific literature they reviewed, and they found this concentration to be relatively very low.

Urban land contributed an average of 3.83 kg/ha/yr. This value was found to be within the range of what's reported about urban land in other scientific literature.

Agricultural land contributed an average of 13.5 kg/ha/yr. This value was found to be within the range, but on the high side, of what's reported about agricultural land in other scientific literature.

PHASE 1 conclusions

Phosphorus (P) is a key contributor to the formation of algal blooms. It enters Shuswap and Mara Lakes from the landscape: there are natural sources of P, and there are sources created by people. Phase 1 of the nutrient study showed that human-modified landscapes (areas impacted by agriculture and settlement) yield substantially more phosphorus than natural, undisturbed landscapes.

The naturally very low nutrient concentrations in the upper reaches of the watershed mean that the Shuswap River, Salmon River, and downstream Mara and Shuswap Lakes are sensitive to nutrient inputs. Put another way, only small additional loads of P would double or quadruple the total amounts.

From a management perspective, the most important conclusion is that the highest concentration of nutrients is coming from the regions of the watershed that are impacted by agriculture and settlement (i.e., the incremental flow sub-watersheds, or IFSWs). Even though this covers a very small percentage of the watershed, these areas are contributing 46% and 69% of the nutrient load to the Shuswap River and Salmon River, respectively. Therefore, these are the areas where management action will be most effective.

What the data don't tell us

- Which specific areas are contributing the highest loadings. This study looked at land uses and regions of the watershed, it did not examine specific parcels of land or point sources.
- Whether the nutrient loadings from the IFSWs are from current activities or past activities. The high concentrations of P in the IFSWs are partly attributable to '**Legacy Phosphorus'**—that is, P that has accumulated in agricultural soils over decades at a rate faster than it could be used by plants or seeped out via groundwater. This is a 'legacy' of a bygone era of farming practices less nutrient-efficient than modern farming.

PHASE 2

Dr. Ian Walker, a member of the UBC Okanagan research team, with one of the Mara Lake sediment core samples.

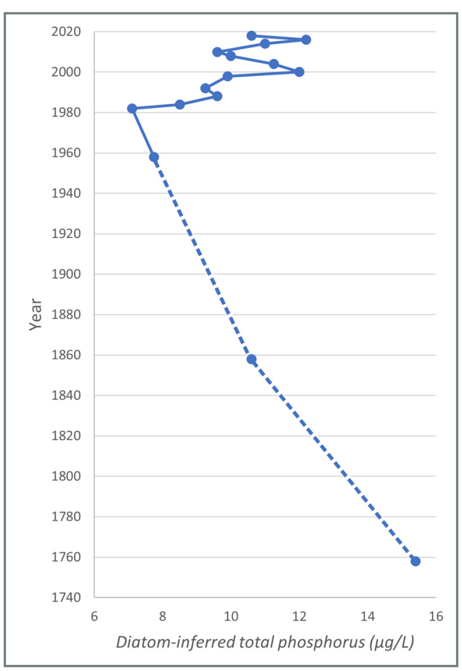
Phase 2 of the nutrient research project took place from 2019–2020. The purpose of the study was to understand how nutrient levels have changed in Mara Lake over the past two centuries, since before the time of major human-caused land use changes in the watershed (e.g., agriculture, forestry and settlement). It involved the collection and analysis of **two sediment core samples** from the bottom of Mara Lake. A sediment core is a vertical 'tube' of mud—older mud is at the bottom and younger mud at the top.

Segments of the sediment core were dated and analyzed for nutrient contents. The research team directly measured phosphorus in the sediment using spectrophotometry. They also analyzed fossils in the sediment from of a group of algae called diatoms to determine the historic nutrient levels in the lake. By pairing diatom abundances with their phosphorus optimums (see side-bar text) the research team was able to infer the phosphorus levels in Mara Lake over the study period. The results of these analyses reflect lake conditions at different periods of time in Mara Lake's history.

What we learned

The Mara Lake sediment core sample spanned a period of about 250 years, from approximately 1750 to modern times. The research team found over 300 species of diatoms in the core sample. The abundances of different diatoms changed over time, implying that environmental conditions also changed over that time.

The results show that phosphorus concentrations in Mara Lake have ranged from 7 µg/L to 15 µg/L over the study period. While these numbers seem small, it demonstrates that P concentrations have more than doubled over the course of the study period. Historically (~ year 1750), the P levels in the lake were relatively high. The results also show that P levels at the onset of major land use changes in the watershed in the 1900s were lower than today. Most importantly, results show that P levels in the lake have increased significantly in recent decades, since about the 1980s.



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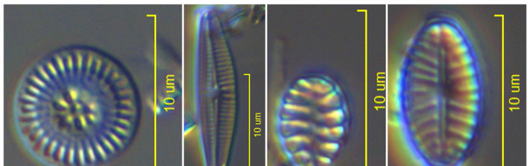
What can you learn from mud?

Water quality monitoring has been taking place regularly in Mara Lake—and the greater Shuswap watershed—for at least a few decades. But, little was known about phosphorus levels in the lake before that. To learn about past phosphorus levels in Mara Lake, scientists can look to 'natural archives'. Mud or sediment at the bottom of the lake provide such a natural record of the lake's biological and chemical history. Sequential layers of sediment—oldest at the bottom and youngest at the top—can tell a story about a lake's conditions over time. The study of historical environmental conditions in lakes and lake sediments is called **paleolimnology**.

Diatoms are a large group of algae species. They are used in paleolimnological studies for a few reasons. They are sensitive indicators of environmental conditions including how much phosphorus is in their environment. Some like a lot of P and others, only a little; in fact, there are 'phosphorus optimums' which are the levels of P ideally suited to species that allow them to grow in abundance. Additionally, diatoms preserve very well in lake bottom sediment because they are made of silica (a natural type of glass). They live, die, sink to the bottom, and accumulate in sediments to be preserved naturally for thousands of years. Diatoms have shapes and patterns in their silica shells unique to their species, and this allows scientists to identify them. Because of these attributes, diatoms are very useful for learning about past phosphorus levels in lakes. The abundance of certain species at certain times in the distant past, as measured in sediment, allows scientists to infer what the conditions were in a lake at that time.



Discostella stelligera *Achnanthidium minutissumum* *Staurosirella pinnata* *Geissleria acceptata*

Diatoms of Mara Lake

Photo credit: Nick Hebda

PHASE 2 conclusions

Phosphorus levels in Mara Lake today are not unprecedented in its history. However, it is also apparent that P levels at the onset of major land use changes in the 1900s were likely much lower than today and have increased considerably since about the 1980s. The low P levels seen throughout the mid 20th century form the baseline condition of the lake within living memory. In other words, in the lifetime of Shuswap residents, P levels in Mara Lake have only increased.

What the data don't tell us

- Why P levels were higher in the 1700s and 1800s. This research doesn't answer that question, but the researchers speculate that it could be due to higher discharge from the Shuswap River into Mara Lake or increased erosion throughout the 20th century due to land use changes. It could also be due to larger salmon returns during that time period, bringing an abundance of marine nutrients back to their spawning streams.

What's Next?

This research project has shown us which areas of the watershed are contributing the highest concentrations and loads of nutrients to the lakes. Those are the areas where we should focus our efforts at improving nutrient management so that less phosphorus flows into the Shuswap Salmon Rivers and ultimately into Mara and Shuswap Lakes. It has also shown us that the time to intervene with new and improved nutrient strategies is now—because the levels of phosphorus in the rivers and lakes has been steadily increasing for about four decades.

New nutrient management strategies are needed reduce the flow of P-rich waters and effluents from farms and urban areas. Several different methods can achieve this including **the restoration of wetlands, enhancement of riparian areas, different irrigation and livestock practices, and improved manure management,** to name a few.

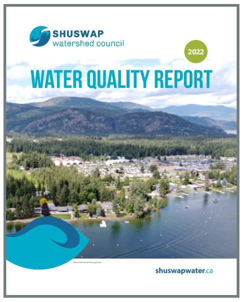
It is important to understand that even though nutrient management has been improving on some farms in the Shuswap in recent years, and from some point-sources such as waste water treatment plants, we may not see immediate changes to nutrient loadings or water quality. These are long term efforts, and their effectiveness may not be observed for years or decades. Nonetheless, it's never too early to take steps to protect water quality for the future.

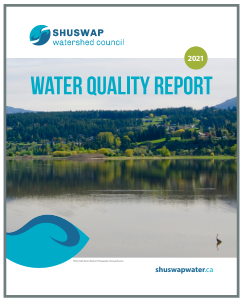
The Shuswap Watershed Council's Water Quality Grant Program

The Shuswap Watershed Council launched a Water Quality Grant Program in early 2020 as a direct response to the findings of the nutrient research project. The purpose of the grant program is **to provide financial assistance to farms and other large land holdings for projects to improve nutrient management,** and to ultimately reduce the amount of nutrients that wash off or leach out of soils into nearby creeks, rivers, and lakes within the Shuswap watershed. By retaining nutrients in soils, and preventing their movement to nearby watercourses, a win-win situation is created for farms and for water quality.

The grant program is administered through a process of applications, review, and approvals. The grant program is open for applications once annually. Contact the SWC staff for more information.

The Shuswap River. Photo credit: Megan Ludwig





For more information about this study, and water quality in the Shuswap

Full technical reports from the research team at UBC Okanagan are available on the Shuswap Watershed Council's website here: https://www.fraserbasin.bc.ca/Water_Quality_Reports.html#nutrient

For annual water quality reports produced by the Shuswap Watershed Council, visit https://www.fraserbasin.bc.ca/Water_Quality_Reports.html

Acknowledgments

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- The staff at the Columbia Shuswap Regional District for producing the maps in this summary.

WHO WE ARE

About the Shuswap Watershed Council

The SWC was established in 2014 as a watershed-based partnership of several organizations with an interest or responsibility for protecting water quality. There are up to 22 members that represent three regional districts, two municipalities, the Secwepemc Nation, three Provincial government agencies, and Shuswap communities. The SWC is a collaborative, non-regulatory group that focuses on strategic initiatives to protect, maintain, and enhance water quality and promote safe recreation in the Shuswap.

Staff

The Fraser Basin Council, a provincial non-government, non-profit organization, provides staff services to the Shuswap Watershed Council.

Our Vision

Enhanced water quality that supports human and ecosystem health and the local economy in the Shuswap watershed.

WHAT WE DO

Our Goals

The SWC's goals are that water quality is maintained and improved in the Shuswap for the benefits of a healthy ecosystem, a thriving tourism economy and a desirable lifestyle for residents; that the SWC is the trusted, go-to source for water quality information in the Shuswap; that people in the Shuswap practice safe water-based recreation; and that the SWC is a well-governed, transparent, collaborative organization.

The Work

The SWC's work on water quality, prevention of aquatic mussels, and safe water-based recreation is guided by its Strategic Plan for 2021–26.

SHUSWAP
watershed council

Contact: *For more information, please contact the SWC, care of the Fraser Basin Council in Kamloops:*
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Shuswap Watershed Council. Water Quality and Nutrients.
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