Salmon River Water Quality Assessment Summary

Introduction

The Salmon River is in the Southern BC interior of the Thompson-Okanagan region. The headwaters of the river originate in Monte Hills Provincial Forest and flow 120 kms to Shuswap Lake. The Salmon River has significant ecological, economic, recreational and value. Traditionally, the river is an important fishery to the local Indigenous Nations. The Salmon River is a major source of water for agriculture activities in the region and has some minor domestic usage.

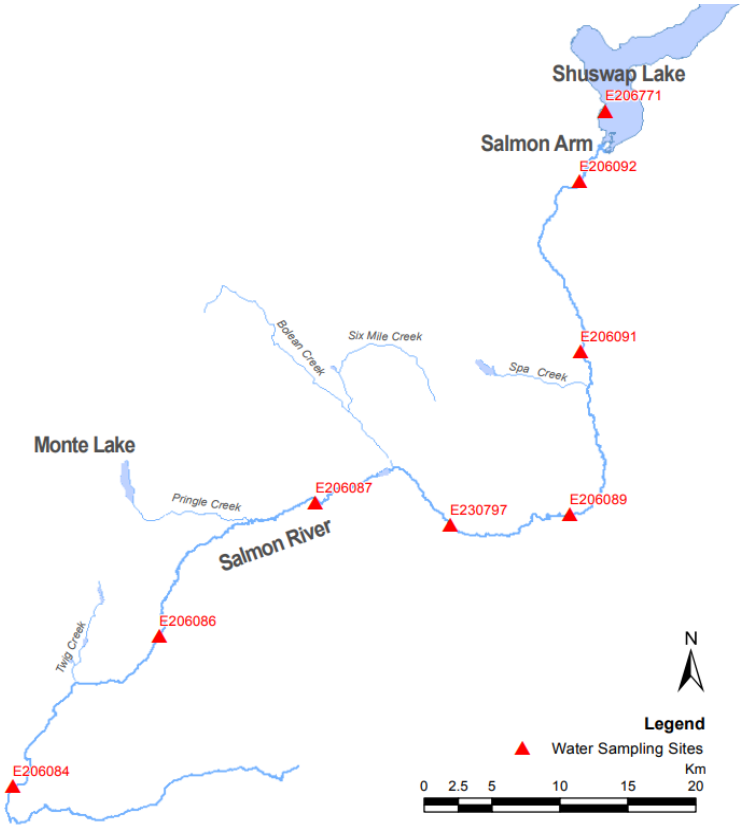

Figure 1. Map of the Salmon River showing water sampling sites.

What does each parameter tell us?

Temperature: influences other water quality parameters by adjusting the chemical and biological processes that can increase toxicity of chemicals or results in algae growth. Increases in temperature alone can be detrimental to fish and other aquatic life.

Dissolved Oxygen (DO): the amount of oxygen found in water. Cold water can hold more dissolved oxygen and turbulent water in flowing streams tends to be higher in oxygen from the air that gets mixed into the water. Adult fish prefer higher concentrations of dissolved oxygen, but it is critical to the success of developing fish eggs and alevin.

Total Phosphorus (TP): includes dissolved and particulate forms of phosphorus in water. Phosphorus is an essential nutrient for plant life and algae (phytoplankton) which feeds little organisms (zooplankton) and in turn, small fish. Too much phosphorus can negatively affect the nutrient balance in a body of water resulting in an algal bloom.

pH: is a measure of the acidity or alkalinity of water. Most water in the interior of BC is more basic with pH levels of > 7. Safe pH ranges for drinking water and aquatic organisms are from 6.5 to 8.5.

Water flows in the Salmon River greatly influence water quality as higher river levels pick up more nutrients from the surrounding land base and reduce the water quality. The highest flows in the Salmon River occur during the freshet from May to June and are heavily influenced by the melting snowpack. Flows continue to decrease until August and remain low throughout the fall months. Since monitoring began in 2005, the highest flows recorded were in May 2018 at 75.4 m^3/s, while the lowest flows recorded were in August 2009 at 0.344 m^3/s.

The river's proximity to expanding urban development, agricultural production, forest harvesting, and mineral extraction has contributed to water quality concerns over the years. To maintain water quality in the Salmon River, the BC Ministry of Environment and Climate Change Strategy (ENV) developed Water Quality Objectives (WQO) in 1998 to protect aquatic life and other sensitive users.

WQOs for the Salmon River are benchmarks for comparison to water quality measurements, both over time and along the length of the river. Water sampling sites, identified by red triangles in Figure 1 above, were established along the length of the Salmon River and measurements were taken from 2005-2010 and again from 2016-2019; with a total of 1190 samples collected. Sampling included temperature, dissolved oxygen, total phosphorus (TP), pH, turbidity, total suspended solids (TSS), total ammonia, fecal coliforms, *Escherichia coli (E. coli), Enterococcus* sp.

Water quality sampling results were compared to the 1998 WQOs to determine if water quality in the Salmon River had changed over time. Where WQOs were not available, parameters were compared to the British Columbia's Water Quality Guidelines (BC WQG) for drinking water or Health Canada's guidelines (HCG) for recreational use.

Temporal analysis

For some water quality parameters both long term and short term WQOs were developed for the Salmon River. Long term WQOs identify appropriate limits for ensuring protection of water quality from chronic or ongoing inputs of a parameter while short term WQOs provide guidance concentrations for acute or intermittent exposures. For example, the long term WQO for dissolved oxygen (DO) in the Salmon River is 11mg/L and the short term WQO is 9mg/L.

Total Ammonia: is a portion of nitrogen that can cause toxicity to fish with increasing water temperature and changes in pH.

Turbidity: is a measure of the clarity of water. Turbid water can lessen the ability of fish to find food and limit plant growth.

Total Suspended Sediments (TSS): is a measure of suspended particles in water. Nutrients and metals will bind themselves to sediment particles and settle on the bottom of a water body. Large volumes of sediments can damage fish gills, smother eggs, and limit food availability.

Total Organic Carbon (TOC): measures the amount of both particulate and dissolved organic compounds contained in water. Increased amounts of TOC can reduce the effectiveness of water treatments systems so low TOC (< 4 mg/L) is recommended. The breakdown of very high concentrations of TOC can deplete dissolved oxygen causing impacts to nearby aquatic life.

The graph below (Figure 2) illustrates the frequency that each listed parameter, DO, temperature, pH, ammonia, and TP exceeded its corresponding long term WQO during each sampling period (2005-2010 and 2016-2019) at all the sites along the length of the Salmon River. The short-term WQO for DO, not shown, was exceeded in only 11% and 9.5% of the readings in 2005-2010 and 2016-2019 respectively. Of the parameters listed in the figure, ammonia was the only parameter that always met the WQOs.

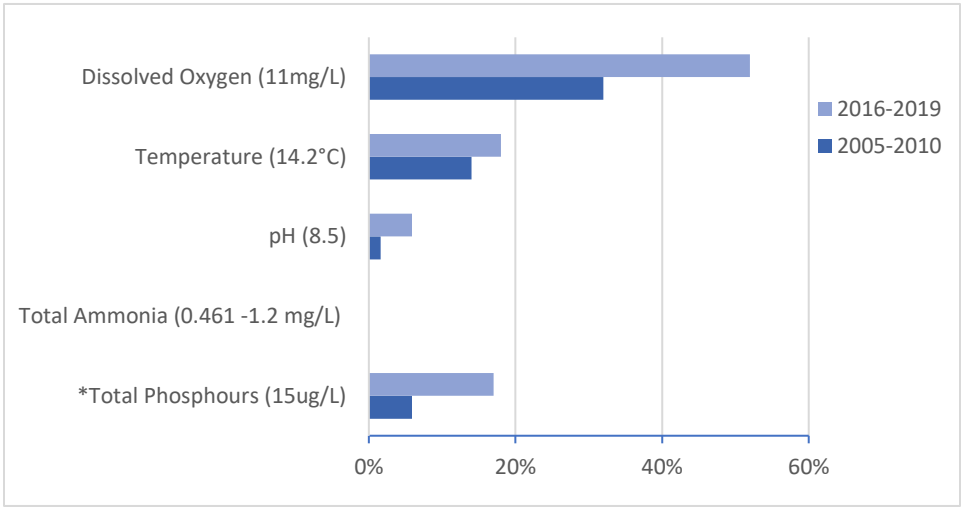

Figure 2. Frequency of exceeding Long-Term Water Quality Objectives in the Salmon River.
*Samples for total phosphorus were only collected with regularity at Tappen Bay.

It can be observed in Figure 2, that there were more exceedances of the WQOs during the 2016-2019 period than the 2005-2010 period indicating decreasing water quality. The biggest change was seen in DO with an increase in exceedances of 20% while TP had a smaller increase of 11% between the two sampling periods.

Turbidity and TSS were also measured, however background data was not available to do comparisons to the WQOs. The data indicate an over-all decrease of 33% in turbidity and Table 1 below shows the range of turbidity and TSS measured in the two sampling periods.

Table 1. Turbidity and total suspended solids (TSS) measured in the Salmon River during the 2005-2010 and 2016-2019 sampling.

Parameter	2005-2010	2016-2019
Turbidity NTU	0.2-26.4	0.285-23.2
TSS mg/L	<1 to 52	<1 to 47.3

Other parameters including nitrate, nitrite, and total organic carbon (TOC) were compared to the British Columbia Water Quality Guidelines (BC WQGs) as no WQOs exist. Of these three parameters, only TOC exceeded any of the relevant guidelines and that was by almost 59% for drinking water at 4 mg/L.

Short term WQO were developed for microbial indicators in the Salmon River for raw drinking water. In addition to the short term WQO for drinking water, single samples of microbial indicators were compared to the BC WQGs for livestock and the Health Canada Guidelines (HCG) for recreational water use (Table 2). BC now relies on the HCGs for recreational waters. The maximum allowable limit of microbial indicators is developed to reduce the potential for a bacterial waterborne illness and depends on the intended water use. In the future fecal coliforms will no longer be used as a microbial indicator of disease in favour of more accurate indicators such as *E. coli* and *Enterococcus* sp.

Table 2. Microbial indicator WQOs, BC WQGs and HCG

Microbial Indicator	WQOs raw drinking water CFU/100mL	BC WQG livestock watering CFU/100mL	HCG recreational use CFU/100mL
Fecal coliforms	10	200	---
E. coli	10	200	400
Enterococcus sp.	3	50	70

CFU= colony forming units.

Fecal coliforms: a group of bacteria that are often found in gut of warm-blooded animals but also found in plants, sand, soil, and sediments. They have historically been used as an indicator of sewage effluent.

***E. coli*:** a diverse group of fecal coliform bacteria with some strains that can cause serious digestive illness.

***Enterococcus sp.*:** a group of bacteria present in warm-blooded animals including humans that can indicate other potential disease-causing bacteria and protozoa found in sewage.

The graph below (Figures 3), shows that all the listed microbial indicators exceeded the Salmon River WQOs for drinking water in more than 70% of the samples during both sampling periods. However, there are very few water withdrawals from the Salmon River used for drinking today. Livestock watering is a more common use of water and there were few exceedances of this BC WQG guideline for *E. coli*. Exceedances of the BC WQG for livestock watering were 3.6% during the 2005-2010 sampling period and 3.9% during the 2016-2019 sampling period. Data for *Enterococcus* sp. was only available during the 2005-2010 sampling period and exceeded the BC WQG for livestock watering 25% of the time. There were no exceedances of the HCG for recreational water use from *E. coli* but *Enterococcus* sp. exceeded the HCG 14% of the time during 2005-2010.

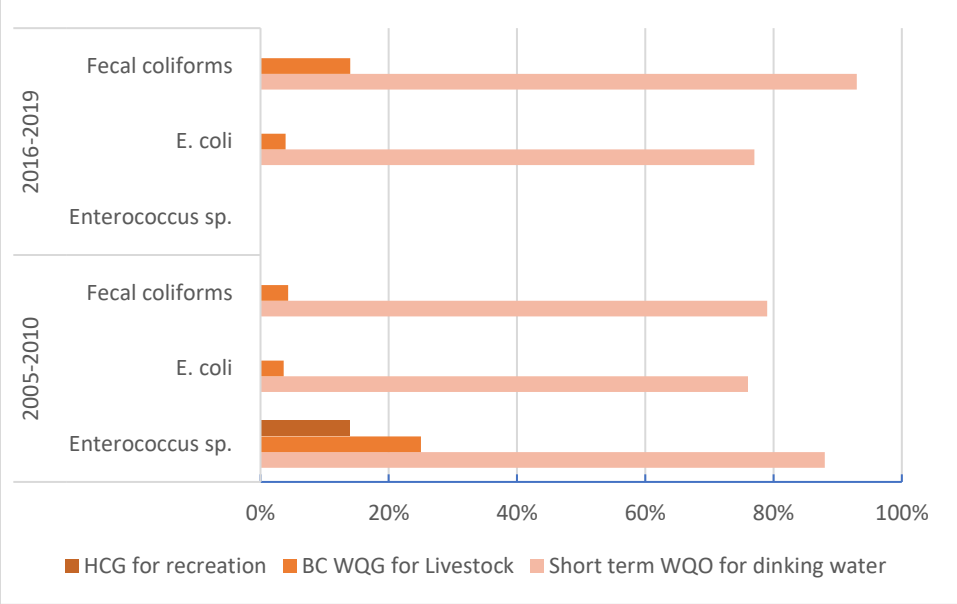

Figure 3. Frequency of microbial indicator exceedances of WQO and guidelines during the 2005-2010 and 2016-2019 sampling periods.

Spatial analysis

In addition to looking at how water quality had changed over time, water quality was also considered spatially along the length of the Salmon River to see if it was improving or degrading as it got closer to Shuswap Lake. The furthest site was located upstream of McInnis Creek and results from there were compared to the site near Salmon Arm. Table 3 below shows that TP and orthophosphate concentrations generally decreased as water moved downstream during clear flow times as in summer and early fall. During turbid flows such as during spring snowmelt, orthophosphate still decreased; however, total phosphorus concentrations increased at the downstream location. Total nitrogen and nitrate plus nitrite concentrations increased from upstream to downstream regardless of the season. *E. coli* concentrations also increased from upstream to downstream irrespective of the flow conditions.

Table 3. Mean concentrations upstream and downstream during clear and turbid flows.

	Clear flow		Turbid flow	
Parameter	**upstream**	**downstream**	**upstream**	**downstream**
Total Phosphorus (mg/L)	0.082	0.061	0.097	0.112
Orthophosphate (mg/L)	0.070	0.035	0.058	0.04
Total Nitrogen (mg/L)	0.169	0.218	0.328	0.349
Nitrate plus Nitrite (mg/L)	0.0091	0.0191	0.00731	0.0381
***E. coli* (CFU/100 mL)**	22.01	48.31	10.51	67.51

Upstream: E206084 Salmon River upstream of McInnis Creek
Downstream: E206092 near Salmon Arm

Orthophosphate: is the most biological readily available form of phosphorus.

Nitrate plus Nitrite: are two forms of nitrogen that can interchange under the right conditions though nitrate is very stable compared to nitrite. Nitrate is often an indicator of urine and found in many fertilizers.

Summary

Water quality in the Salmon River is heavily influenced by the flows but also by adjacent land use. Worsening water quality was observed in the later sampling period (2016-2019) for temperature, DO, pH, and TP as WQOs were exceeded more frequently. Phosphorus contributions from the Salmon River into Tappen Bay are of particular concern. Previous studies have noted that the Salmon River and its land use is the main contributor of phosphorus loading to Tappen Bay in Shuswap Lake. Increasing concentrations of phosphorus can trigger algae blooms and potentially shift the trophic status of Tappen Bay.

The short term WQOs developed for *E. coli*, Fecal Coliforms and *Enterococci sp.* in the Salmon River were initially designed to protect the most sensitive water use of raw drinking water at the time. The prevailing use of the Salmon River is for agricultural and recreational activities, as such the BC WQGs for livestock watering and the HCGs for recreational use were considered as part of this analysis. Exceedances of the short-term WQO for drinking water were higher then 70% for all microbial indicators and across both sampling periods; however, exceedances of the livestock watering BC WQGs and for recreational use under the HCGs were below 30% across both sampling periods.

Phosphorus concentrations where higher downstream than upstream during turbid flows indicating ties to particulate matter. Nitrate concentrations and *E. coli* numbers increased in the Salmon River regardless of the flow type suggesting continuous influences from nearby land uses such agriculture though the nitrate values remained below BC WQGs.

The Salmon River is a vital waterbody in the Thompson-Okanagan region and recurring water quality monitoring is needed to ensure protection of water uses and to make science-based resource management decisions.

This summary is based on the Salmon River Water Quality Assessment by LGL Limited Environmental Research Associates dated June 2022. The assessment should be referred to for more complete information as this summary does not include all the data, discussion, or recommendations of the full report. The full reference for the report is found below.

Reference:

Chalifour, A., A. Schein, and J. Sinclair. 2022. Salmon River Water Quality Assessment. Environmental Quality Series. Prov. B.C., Victoria B.C.