Water Quality Assessment and Recommended Objectives for the Salmon River

Summary Report

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DISCLAIMER

This Report is part of the British Columbia Ministry of Environment, Lands and Parks' Water Quality Assessment and Objectives series. It has received formal review and approval from the Ministry. Environment Canada's Fraser River Action Plan provided funds for the production of this report. Its contents do not necessarily reflect the view and policies of Environment Canada.

SUMMARY

This document is one in a series that describes the ambient water quality objectives that have been developed for various waterbodies in British Columbia. The report has two parts, including the following overview and a technical appendix (Gwanikar *et al.* 1997), which is available separately. The overview is intended both for technical readers and for readers who may not be familiar with the process for establishing water quality objectives. The overview provides general information about water quality conditions in the Salmon River watershed. This document also provides a summary of the recommended water quality objectives and monitoring program for the watershed. The technical appendix presents more detailed information on water uses, aquatic ecosystem structure, contaminant sources, and ambient environmental conditions in the Salmon River watershed. In addition, the water quality objectives and the detailed monitoring recommendations for the river system are presented in the technical appendix.

The Salmon River is an important tributary of Shuswap Lake, which drains into the South Thompson River. In addition to supporting anadromous salmonids, resident fish species, and other aquatic organisms, the Salmon River and its tributaries provide important sources of raw water for domestic water supplies, irrigation, and livestock watering. Recreation and aesthetics also represent important uses of the aquatic environment, both of which generate social and economic benefits to area residents.

Concerns related to environmental quality conditions in the Salmon River are primarily associated with non-point source contaminant discharges. Such contaminants arise from a variety of land use activities, including forest management, agriculture, and urban development. Contaminants of concern in the watershed include suspended solids, turbidity, ammonia, phosphorus, nitrogen, metals, and fecal coliforms. In addition, water withdrawals from the river and nearby infiltration galleries have resulted in decreased streamflows and associated effects on water temperatures and other habitat features in the river.

This report describes the water quality objectives that have been recommended for the Salmon River watershed. These objectives specify the water quality conditions that are necessary to protect aquatic life, wildlife, livestock watering, irrigation, drinking water supplies, and aesthetic and recreational water uses in this river system. The objectives also represent targets which can be used to determine whether remediation efforts have been successful.

PREFACE

Purpose of Water Quality Objectives

Water quality objectives are tools that support the effective management of water resources. They describe conditions that water managers have agreed should be met in order to protect the most sensitive designated uses of freshwater, estuarine, and coastal marine ecosystems. They are used in conjunction with other management tools, such as effluent controls, best management practices, and best available or best practicable wastewater treatment technology (BAT/BPT), to achieve high standards of water quality.

Water quality objectives are being jointly prepared by Environment Canada and the Ministry of Environment, Lands, and Parks, as part of their respective mandates for responsible water resource management. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity, either now or in the future.

How Objectives are Determined

Water quality objectives are based on water quality guidelines and criteria. The Canadian water quality guidelines, which are developed by the Canadian Council of Ministers of the Environment (CCME), are numerical concentrations or narrative statements for chemical, physical, radiological, and biological variables that are recommended to support and maintain designated water uses. Like water quality guidelines, water quality criteria also relate the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment to their effects on water use, but differ in that they are developed by the Ministry of Environment, Lands and Parks.

Water quality objectives are numerical concentrations or narrative statements which have been established to support and protect the most sensitive designated use of water at a specified site (BCMOELP 1986; CCREM 1987). They are derived from the guidelines and criteria by considering local water quality, water uses, water movement, waste discharges, and other factors.

Water quality objectives are based on the best scientific information available at the time the objectives are developed. When insufficient information exists, provisional water quality objectives may be applied until the data required to develop permanent water quality objectives are available. Provisional objectives are deliberately conservative. To facilitate the establishment of permanent objectives, a monitoring or study program is usually recommended to fill any data gaps that are identified.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. Designated uses of water include the following:

- raw drinking water, public water supply, and food processing;
- fish, other aquatic life, and wildlife;
- agriculture (livestock watering and irrigation);
- recreation and aesthetics; and,
- industrial water supplies.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical, or biological characteristics affecting that waterbody.

How Objectives are Used

Water quality objectives have no legal standing at this time and, therefore, cannot be directly enforced. In British Columbia, water management objectives are achieved through the issuance of permits for effluent discharges, monitoring of the volumes and concentrations of contaminants discharged, inspection of farms, streambank restoration, erosion control, and enforcement of environmental legislation when violations occur. The limits on effluent discharges are generally based upon the best available technology for wastewater treatment; however, the objectives have also been used to support the permitting process in recent years.

Water quality objectives are important water management tools because they provide policy direction for resource managers with respect to the protection of water uses in specific waterbodies. Objectives provide benchmarks for evaluating water quality, issuing wastewater discharge permits, dispersing water withdrawal licences and orders, and managing fisheries and the province's land base. They also provide reference points against which the state of water quality can be checked and help to determine whether additional management actions are needed to protect and/or restore the designated water uses in a particular waterbody.

Objectives and Monitoring

Water quality objectives are established to protect all the uses which take place in a water body. To determine if the objectives are being met and if the water uses are being protected, monitoring programs are usually specified along with the objectives. Monitoring should take place at critical times when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at critical times, then they will also be protected at other times when the threat is less severe.

The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as average, conditions in the water. For some water bodies, the monitoring period and frequency will vary with the nature of the problem, the severity of threats to designated water uses, and the way the objectives are expressed (i.e., mean value, maximum value, etc.).

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1.0 INTRODUCTION

The Salmon River watershed is located within the Interior Plateau of south-central British Columbia. Its headwaters originate in the vicinity of Tahaetkun and Bouleau Mountains, south of Westwold and northeast of Merritt. The river's headwaters are located in Monte Hills Provincial Forest, some 15 km northeast from Salmon Lake. Some of the river's flow is diverted into Salmon Lake; much of that flow returns to the river via McInnis Creek, the outlet from Salmon Lake. From the confluence with McInnis Creek, the Salmon River flows northeast to Falkland, then southeast and east to Glenemma, and finally north to Salmon Arm of Shuswap Lake. The total length and drainage area of the Salmon River are approximately 120 km and 1510 km², respectively.

2.0 PROFILE OF THE SALMON RIVER WATERSHED

2.1 Hydrology

The Salmon River watershed has unique hydrological conditions, which are influenced by local climatic conditions and by the underlying geology of the area. Peak streamflows occur during periods of snowmelt and high precipitation, usually during April, May, and June. The tributaries to the Salmon River appear to follow this same general discharge pattern. Peak daily discharges in the Salmon River at Salmon Arm are typically in the order of 15 to 25 m^3/s each year.

Low flows in the Salmon River and its tributaries generally occur through the fall and winter months and are influenced significantly by linkages with groundwater. As such, inputs of groundwater maintain streamflows in many portions of the watershed during periods of low precipitation. This situation is reversed in the vicinity of Westwold. At this location, the Salmon River flows below the surface for most of the year, creating a dry reach for a distance of about 13 km. While year-round above ground flows have been observed in this reach, this section of the river usually represents a barrier to upstream fish passage.

Water withdrawals for irrigation and domestic water supplies have a pronounced influence on the hydrology of the Salmon River watershed. It has been estimated that 30 to 50% of the historic flow has been diverted from the Salmon River to support these uses. These water withdrawals have the potential to significantly influence both the quality and quantity of aquatic habitats in the river, with associated effects on fish and aquatic organisms. For this reason, water quantity objectives are also needed for the Salmon River and its tributaries.

2.2 Water Uses

There are both consumptive and non-consumptive water uses within the study area. Consumptive water uses include withdrawals of raw water for domestic water supplies, irrigation, and livestock watering. Non-consumptive water uses include instream uses by fish and aquatic life, and recreation and aesthetics. The Salmon River and its tributaries provide habitats for a number of important sportfish species, including chinook salmon, coho salmon, sockeye salmon, rainbow trout, and mountain whitefish. Aquatic habitats within the watershed also support a variety of resident fish species, aquatic invertebrates, amphibians, reptiles, birds, and mammals. The river is also becoming increasingly important for recreational water uses, including swimming, canoeing and bird watching.

2.3 Wastewater Discharges

There are no permitted wastewater discharges to the Salmon River or its tributaries. However, there are a number of indirect (i.e., non-point source) effluent discharges to tile fields, which have the potential to influence water quality conditions in the river. In addition, there are numerous other non-point or diffuse sources of environmental contaminants in the basin, including those originating from agricultural activities, forest management, urbanization, linear developments, and limited mineral extraction. Priority substances associated with these contaminant sources include suspended solids, turbidity, ammonia and other forms of nitrogen, phosphorus, metals, and fecal coliforms.

3.0 WATER QUALITY ASSESSMENT AND OBJECTIVES

3.1 Water Quality Assessment

Water quality data have been collected for more than 25 years in the Salmon River watershed. Of the locations that have been examined, the most complete information on water quality conditions is available for the Salmon River at Hwy #1 Bridge in the municipality of Salmon Arm. Examination of these data indicates that water quality is currently degraded in the Salmon River and, as such, does not fully support the designated water uses in the basin. For example, the concentrations of suspended solids and measurements of turbidity commonly exceed the levels needed to protect fish and aquatic life. While no information was located, it is likely that the high rates of erosion in the watershed are also affecting the quality of salmon spawning habitats.

Water quality concerns in the Salmon River are not limited to accelerated sediment transport and sedimentation. Elevated levels of nutrients (i.e., total phosphorus, total ammonia), certain metals (i.e., total arsenic, total cadmium, total chromium, total copper, total lead, total mercury, and total zinc) and microbial indicators (i.e., fecal coliforms) have also been observed at several locations in the basin. During the summer months, water temperatures approach or exceed the levels that are known to adversely affect salmonid fishes, particularly near the mouth of the river.

While water quality conditions are generally similar among the locations that have been sampled in the Salmon River watershed, some important trends are evident from the available data. For example, pH generally increases from the headwaters to the mouth of the river. This is not uncommon in B.C. since the headwaters of streams often have little buffering potential; however, both buffering potential and pH tend to increase along the lengths of B.C. streams.

Similarly, concentrations of suspended solids increase along the length of the river, presumably due to general erosion and inputs from non-point sources on the mainstem and in the tributaries. The levels of fecal coliforms also follow this same general pattern. However, the concentrations of ammonia and total phosphorus are highest in the vicinity of Bolean Creek, likely reflecting inputs from the cattle feed lots that are prevalent in this area.

Information on trends over time provide a basis for determining if water quality is improving, worsening, or remaining the same. Recently, two focussed studies were conducted to evaluate water quality conditions in the Salmon River. The results of both of these studies indicated that water quality conditions are not showing any environmentally significant long-term trends (Lilley and Webber 1997; Regnier and Shaw 1997).

Water quality conditions are also degraded in Tappen Bay, which is located near the mouth of the Salmon River. At this location, elevated levels of total and ortho-phosphorus have been observed, particularly during the spring and summer months. High phosphorus levels represent a significant environmental concern in lakes because they can stimulate algal growth, which can represent an aesthetic concern (i.e., due to reduced water clarity) and a threat to aquatic life (i.e., due to reduced dissolved oxygen levels). The phosphorus in the bay originates largely from the Salmon River and the Salmon Arm sewage treatment plant. High levels of fecal coliforms may also be adversely affecting certain water uses in the bay (e.g., swimming) during portions of the year. Together, these data show that improvements in water quality conditions are needed to maintain existing water uses and support fisheries restoration efforts in the watershed.

3.2 Water Quality Objectives

The designated water uses that need to be protected in the Salmon River watershed include raw water for drinking water supplies, freshwater aquatic life, wildlife, recreation and aesthetics, irrigation, and livestock watering. The priority variables with respect to the protection of these uses include water temperature, pH, dissolved oxygen, suspended sediments and turbidity, ammonia, phosphorus, microbial indicators, and trace metals. In addition, water quality objectives are needed for streambed substrate composition (which is associated with suspended sediments), algal growth and biomass (which is associated with phosphorus), and instream flow.

The water quality objectives for the Salmon River are presented in Tables 1 and 2. These objectives are based on the B.C. approved and working water quality criteria (Nagpal *et al.* 1995), the Canadian water quality guidelines (CCREM 1987), and the available data on ambient water quality conditions, water uses, and streamflows in the Salmon River watershed. The B.C. approved and working water quality criteria and/or the Canadian water quality guidelines are considered to apply to those variables for which site-specific water quality objectives have not been specified.

The water quality objectives for many of the priority substances identified are currently being met throughout much of the year in the Salmon River watershed. Where these objectives are not being met presently, they represent targets which should be used to identify priorities for future investigations, management actions, and remedial measures to improve water quality conditions.

3.3 Monitoring Recommendations

Monitoring programs should be designed and coordinated to determine the degree to which the water quality objectives are being met within the waterbody under investigation. Exceedances of the objectives indicate that one or more of the designated water uses may be threatened. Monitoring ecosystem responses to environmental disturbances provides a direct means of identifying situations where specific management actions or more restrictive water quality objectives are needed to meet water management goals. A recommended monitoring program design for the Salmon River and Tappen Bay is presented in Table 3. The recommended monitoring program specifies the locations, sampling timing, and sampling frequency needed to determine if the water quality objectives are currently being met. As there are various other monitoring programs being conducted in the watershed, it would be reasonable to integrate the recommended monitoring program into existing programs to achieve cost saving, prevent the perception of "duplication", and assure the comparability of the resultant data. Actual monitoring undertaken will depend upon resources available to B.C. Ministry of Environment, Lands, and Parks, Environment Canada, and local stewardship groups empowered to undertake such monitoring.

4.0 WATER QUALITY OBJECTIVES AND MONITORING TABLES

A summary of the recommended water quality objectives are provided in Tables 1 and 2. The recommended monitoring program for the Salmon River watershed is presented in Table 3. The objectives typically specify ranges of water quality conditions that are likely to protect the designated water uses in a waterbody. As such, the objectives often specify maximum, 90th percentile, or mean values that are not to be exceeded. In some cases, minimum values are also specified.

Some readers may be unfamiliar with terms such as: maximum concentration, 30-day average concentration, 90^{th} percentile, and not applicable (NA). A maximum concentration refers to the value for a specific variable that should never be exceeded. A 30-day average concentration defines the level that should not be exceeded by the average value calculated for five or more samples that are collected at approximately equal intervals during a period of 30 days. The term 90^{th} percentile indicates that 9 out of 10 values should be less than a particular value. Not applicable means that water uses are not threatened for that particular variable.

5.0 GLOSSARY

Ambient	Refers to conditions in the receiving environment.
Anthropogenic	Relates to, or involves, the impact of humans.
Biochemical Oxygen Demand (BOD)	A measure of the amount of oxygen used to decompose organic substances in water. The greater the quantities of organic substances in the water, the greater the BOD.
Chlorophyll *a*	The green pigment of plants that is directly involved in photosynthesis. It is used to indicate the abundance of algae (usually phytoplankton), higher levels of chlorophyll *a* indicating higher densities of algae.
Contaminant	A substance that is not naturally present in the environment or a substance that is present at concentrations above natural background levels.
Designated Water Use	A water use that is to be protected at a specific location (e.g., aquatic life, wildlife, drinking water, water for livestock, irrigation, recreation and aesthetics, or industry).
Disinfection	The process of destroying microorganisms in water usually through the application of a chemical agent (disinfectant), such as chlorine.
Effluent	Liquid waste material (e.g., sewage or liquid industrial wastes) discharged to the environment.
Enterococci	A group of bacteria which has the potential to cause gastrointestinal disease in humans.

Fecal Coliforms	A group of bacteria that are often used to assess the sanitary quality of water. Fecal coliforms are used as indicators of fecal contamination because they are present in virtually all warm-blooded animals at levels far exceeding those of more specific microbial pathogens.
Initial Dilution Zone	The initial portion of a larger effluent mixing zone adjacent to a wastewater discharge, wherein water quality may exceed water quality objectives for water or sediments, but not for fish or tissue. However, acutely toxic conditions should not occur within the initial dilution zone. Initial dilution zones are defined on a site-specific basis and should not impinge on areas such as water intakes, bathing beaches, shellfish beds, fish spawning and rearing areas, areas of sensitive aquatic vegetation, or other environmentally sensitive areas. Federal policy states that any effluents that are discharged into the initial dilution zone should not be acutely toxic to indicator species, such as rainbow trout and water fleas.
Nutrient	Substance (element or compound) necessary for the growth and development of plants and animals.
Periphyton	Organisms, such as algae and plants, that are attached to submerged plants, rocks and other objects.
pH	Value representing acidity or alkalinity of a solution. Expressed as the negative of the logarithm (base 10) of the hydrogen ion concentration of the solution. Scale ranges from 0 to 14: pH 7 is neutral; pH <7 is acid; pH >7 is alkaline.

Plankton	Plants (phytoplankton) and animals (zooplankton), usually microscopic, which are present in the water column of aquatic systems.
Primary Sewage Treatment	Denotes a level of effluent treatment in which suspended solids have been removed by skimming floating materials and gravity settling in sedimentation tanks.
Salmonid	Fish of the family Salmonidae, including trout, salmon, and char.
Secondary Sewage Treatment	Denotes a level of effluent treatment in which suspended solids and BOD are further reduced from the primary treated effluent by chemical and microbial biodegradation.
Tertiary Sewage Treatment	A level of effluent treatment above secondary treatment in which an advanced reduction in nutrients, suspended solids, BOD, and contaminants has been achieved.
(B.C. Approved and Working) Water Quality Criteria	Physical, chemical, and biological quality of water, sediment, and biota recommended by the B.C. Ministry of Environment, Lands and Parks to be protective of a designated water use.
(Canadian) Water Quality Guideline	Numerical concentration or narrative statement recommended by the Canadian Council of Ministers of the Environment to support and maintain a designated water use.
Water Quality Objective	A water quality criterion or guideline adapted to protect the most sensitive designated water use at a specified location, taking local circumstances into account.

6.0 LITERATURE CITED

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Tables 1 - 3

Table 1. Recommended water quality objectives for the Salmon River watershed.

Variable	Water Quality Objective	
	Maximum	**30-day Average**
Temperature	15.6 ^{o}C (December 1 - September 30) 12.8 ^{o}C (October 1 - November 30)	≤14.2 ^{o}C (year round)
Dissolved Oxygen	9.0 mg/L (minimum) 5.0 mg/L (short-term minimum)	≥11.0 mg/L ≥ 8.0 mg/L (short-term)
pH	6.5 - 8.5	6.5 - 8.5
Total Suspended Solids	NA	≤10 mg/L over background (long-term) ≤20 mg/L over background (short-term)
Streambed Substrate Composition		
% < 2.00 mm	10%	NA
% < 3.00 mm	19%	NA
% < 6.35 mm	25%	NA
Geometric Mean Diameter	12.0 mm	NA
Fredle Index	5.0 mm	NA
Intragraval Dissolved Oxygen	8.0 mg/L (minimum)	≥9.0 mg/L
Turbidity	NA	≤5 NTU over background ≤10 NTU over background (short-term)
Total Phosphorus	10 ug/L (Tappen Bay) 15 ug/L (Tappen Bay) (short-term)	NA
Total Ammonia	NA	See Table 2
Chlorophyll a	50 mg/m^2	NA
Microbial Indicators		
Total faecal coliforms	10 colonies/100 mL* (long-term) 100 colonies/100 mL* (short-term)	NA
Escherichia coli	10 colonies/100 mL*	NA
Enterococcus sp.	3 colonies/100 mL*	NA

NA = No water quality objective is recommended.

* = 90th percentile value (rather than maximum).

Table 2. Average 30-day concentrations of total ammonia nitrogen (mg/L) for protection of freshwater aquatic life (Nagpal *et al*. 1995).*

	Temperature Degrees Celsius																				
pH	**0.1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
6.5	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
7.0	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84	1.83	1.81	1.80	1.79	1.77	1.64	1.53	1.42	1.32	1.22
7.1	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84	1.83	1.81	1.80	1.79	1.77	1.65	1.53	1.42	1.32	1.23
7.2	2.08	2.05	2.02	1.99	1.96	1.95	1.92	1.90	1.88	1.86	1.85	1.83	1.81	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.3	2.08	2.05	2.02	1.99	1.97	1.95	1.92	1.90	1.88	1.86	1.85	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.4	2.08	2.05	2.02	2.00	1.97	1.95	1.92	1.90	1.88	1.87	1.85	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.5	2.08	2.05	2.02	2.00	1.97	1.95	1.93	1.91	1.88	1.87	1.85	1.83	1.82	1.81	1.80	1.78	1.66	1.54	1.43	1.33	1.23
7.6	2.09	2.05	2.03	2.00	1.97	1.95	1.93	1.91	1.89	1.87	1.85	1.84	1.82	1.81	1.80	1.79	1.66	1.54	1.43	1.33	1.24
7.7	2.09	2.05	2.03	2.00	1.98	1.95	1.93	1.91	1.89	1.87	1.86	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.60	1.59	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.50	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34	1.33	1.32	1.31	1.31	1.30	1.21	1.12	1.04	0.970	0.904
8.0	1.26	1.24	1.23	1.21	1.20	1.18	1.17	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	1.00	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.730	0.724	0.718	0.714	0.709	0.706	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380	0.377	0.375	0.372	0.370	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305	0.303	0.301	0.300	0.298	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241	0.241	0.240	0.240	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198	0.197	0.197	0.196	0.196	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.161	0.160	0.160	0.160	0.160	0.160	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.135	0.134	0.133	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

*The average of the measure values must be less than the average of the corresponding individual values in this table. Also each measured value is compared to the corresponding individual values in this table. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding criteria values in this table.

Table 3. Recommended water quality monitoring program in the Salmon River watershed.

Sampling Location	Site Number	Variables to be Measured	Sampling Date	Sampling Frequency	Number of Samples
Salmon River at first farm bridge (approximately 400m) upstream of confluence with McInnis Creek Latitude: 50.2844 Longitude: 119.9850	E206084	Water Temperature	Jan. - Dec.	Daily	Continuous
		Dissolved Oxygen	May - Oct.	Weekly	30
		Dissolved Oxygen	Nov. - Apr.	Monthly	6
		Total Suspended Solids, Turbidity, Water Hardness, pH, and Conductivity	Jan. - Dec.	Weekly	52
		Total Suspended Solids and Turbidity	Freshet	Every 3 days	20
		Total Ammonia	Mar., June, Sept., & Dec.	Weekly	20
		Microbial Indicators (total faecal coliforms, *Escherichia coli, Enterococcus spp.)*	May, July, & Sept.	Every 3 days	30
		Pesticides and Herbicides	TBD	Once	TBD
		Chlorophyll *a*	Aug., & Oct.	Once	TBD
		Streambed Substrate Composition	Sept.	Once	TBD
		Metals (arsenic, cadmium, copper, chromium, lead, mercury, and zinc), Water Hardness, and Conductivity	Mar. & Sept.	Weekly	10
Salmon River about 2 km east of Falkland Latitude: 50.4861 Longitude: 119.5381	E207855	Water Temperature	Jan. - Dec.	Daily	Continuous
		Dissolved Oxygen	May - Oct.	Weekly	30
		Dissolved Oxygen	Nov. - Apr.	Monthly	6
		Total Suspended Solids, Turbidity, Water Hardness, pH, and Conductivity	Jan. - Dec.	Weekly	52
		Total Suspended Solids and Turbidity	Freshet	Every 3 days	20
		Total Ammonia	Mar., June, Sept., & Dec.	Weekly	20
		Microbial Indicators (total faecal coliforms, *Escherichia coli, Enterococcus spp.)*	May, July, & Sept.	Every 3 days	30

Table 3. Recommended water quality monitoring program in the Salmon River watershed.

Sampling Location	Site Number	Variables to be Measured	Sampling Date	Sampling Frequency	Number of Samples
Salmon River about 2 km east of Falkland	E207855	Pesticides and Herbicides	TBD	Once	TBD
		Chlorophyll *a*	Aug., & Oct.	Once	TBD
		Streambed Substrate Composition	Sept.	Once	TBD
Salmon River 10 m upstream of highway 97 bridge above Glenemma Latitude: 50.4561 Longitude: 119.3728	E206089	Water Temperature	Jan. – Dec.	Daily	Continuous
		Dissolved Oxygen	May – Oct.	Weekly	30
		Dissolved Oxygen	Nov. – Apr.	Monthly	6
		Total Suspended Solids, Turbidity, Water Hardness, pH, and Conductivity	Jan. – Dec.	Weekly	52
		Total Ammonia	Mar., June, Sept., & Dec.	Weekly	20
		Chlorophyll *a*	Aug., & Oct.	Once	TBD
		Streambed Substrate Composition	Sept.	Once	TBD
Salmon River 10 m upstream of road bridge below the community of Silver Creek (approximately 1.7 km downstream of Silver Creek) Latitude: 50.6083 Longitude: 119.3642	E206091	Water Temperature	Jan. – Dec.	Daily	Continuous
		Dissolved Oxygen	May – Oct.	Weekly	30
		Dissolved Oxygen	Nov. – Apr.	Monthly	6
		Total Suspended Solids, Turbidity, Water Hardness, pH, and Conductivity	Jan. – Dec.	Weekly	52
		Total Ammonia	Mar., June, Sept., & Dec.	Weekly	20
		Chlorophyll *a*	Aug., & Oct.	Once	TBD
		Streambed Substrate Composition	Sept.	Once	TBD
Salmon River 5 m upstream of Salmon Valley Road bridge near Highway #1	BC08LE0004 E206092	Water Temperature	Jan. – Dec.	Daily	Continuous
		Dissolved Oxygen	May – Oct.	Weekly	30
		Dissolved Oxygen	Nov. – Apr.	Monthly	6

Table 3. Recommended water quality monitoring program in the Salmon River watershed.

Sampling Location	Site Number	Variables to be Measured	Sampling Date	Sampling Frequency	Number of Samples
Salmon River 5 m upstream of Salmon Valley Road bridge near Highway #1 Latitude: 50.6929 Longitude: 119.3298	BC08LE0004 E206092	Total Suspended Solids, Turbidity, Water Hardness, pH, and Conductivity	Jan. - Dec.	Weekly	52
		Total Suspended Solids and Turbidity	Freshet	Every 3 days	20
		Total Ammonia	Mar., June, Sept., & Dec.	Weekly	20
		Total and Ortho-Phosphorus	Jan. - Dec.	Bi-weekly	26
		Microbial Indicators (total faecal coliforms, *Escherichia coli, Enterococcus spp.)*	May, July, & Sept.	Every 3 days	30
		Pesticides and Herbicides	TBD	Once	TBD
		Metals (arsenic, cadmium, copper, chromium, lead, mercury, and zinc), Water Hardness, and Conductivity	Mar. & Sept.	Weekly	10
Shuswap Lake in southeast end of Tappen Bay shallows opposite downtown Salmon Arm Latitude: 50.7144 Longitude: 119.2789	E206770	Total and Ortho-Phosphorus	Open Water	Bi-Weekly	60
		Water Temperature, Hardness, and pH	Open Water	Bi-Weekly	60
		Dissolved Oxygen	Open Water	Bi-Weekly	60
		Chlorophyll *a*	Open Water	Monthly	30
		Microbial Indicators (total faecal coliforms, *Escherichia coli, Enterococcus spp.)*	Open Water	Every 3 days	50
Shuswap Lake in southwest end of Tappen Bay in deep hole opposite Sandy Point, in 30 m of water Latitude: 50.7239 Longitude: 119.3014	E206771	Total and Ortho-Phosphorus	Open Water	Bi-Weekly	60
		Water Temperature, Hardness, and pH	Open Water	Bi-Weekly	60
		Dissolved Oxygen	Open Water	Bi-Weekly	60
		Chlorophyll *a*	Open Water	Monthly	30
		Microbial Indicators (total faecal coliforms, *Escherichia coli, Enterococcus spp.)*	Open Water	Every 3 days	50

TBD = to be determined.