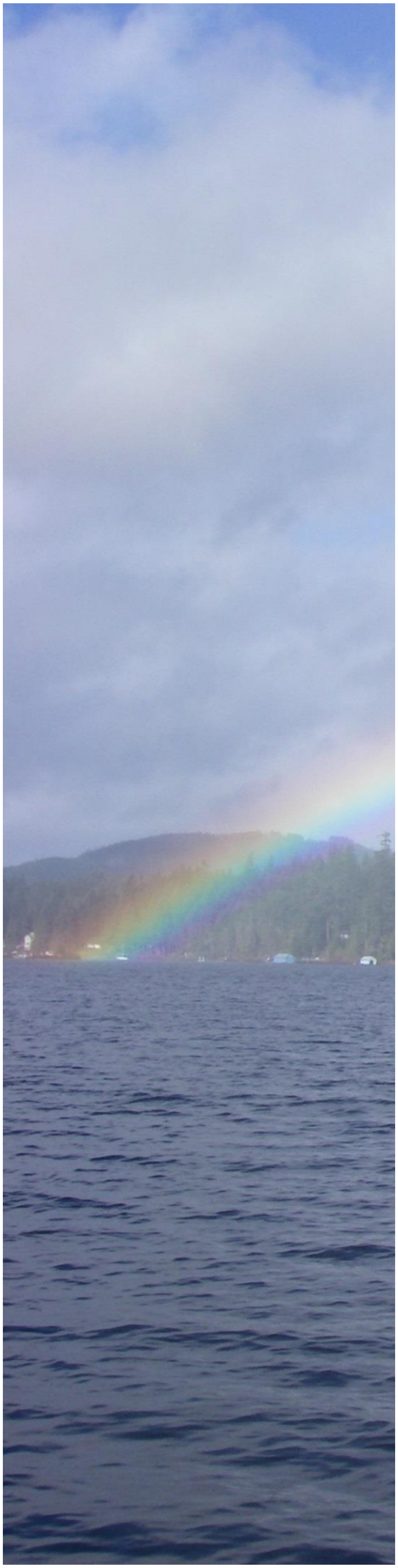

Ministry of Environment and Climate Change Strategy

Water Quality Assessment of the Upper Shawnigan Lake Watershed (2013)

February 2019

Environmental Protection Division
Regional Operations Branch

Acknowledgments

The authors would like to thank the following individuals for their assistance in the preparation of this report: Todd Davis (Ministry of Forests, Lands and Natural Resource Operations and Rural Development (FLNRO)), Emily Doyle-Yamaguchi (Cowichan Valley Regional District (CVRD)), Barry Gates (Elkington Forest Professional Land Manager), Bruce Fraser (CVRD Area Director for Shawnigan Lake), and Ken Gray (Mill Bay Conservation Society). Supportive funding for this program has been provided by the CVRD. We would also like to those who reviewed and provided comments, including individuals from the CVRD, Island Health, TimberWest Forest Corporation, Island Timberlands LP, Shawnigan Residents Association, Ministry of Environment and Climate Change Strategy (ENV) and FLNRO. Final edits were completed by Burke Phippen (BWP Consulting Inc.) and Rosie Barlak, EIA Biologist, Ministry of Environment and Climate Change Strategy (Nanaimo).

Prepared by:

Martina Kopat
Deborah Epps
Environmental Protection Division, Nanaimo, BC

Michael Sokal
Environmental Protection Division, Penticton, BC

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Executive Summary

This report summarizes water and sediment quality data collected in 2013 for tributaries to Shawnigan Lake, as well as at various sites within the lake itself, to determine if local activities are impacting water uses within the watershed. Generally, non-point sources of pollution derived from urban runoff, industry, land development, on-site sewage systems, agriculture, and forestry activities are the major input of pollutants to Shawnigan Lake. In addition, there was also some concern from local citizens with respect to waste dumping facilities in the upper Shawnigan watershed that could be impacting both Upper Shawnigan Creek and ultimately Shawnigan Lake water quality. Overall the findings from this study indicate that water and sediment quality in the watershed were generally good. Some tributary streams showed occasional elevated total phosphorus, *E. coli* and high summer water temperatures. Microbial source tracking identified some of the *E.coli* results were from anthropogenic sources. One stream, Van Horne Creek, had some elevated metals concentrations. Further investigation should occur to better identify specific sources of water quality contaminants. With regards to sediment data, a few metals were slightly above Sediment Quality Guidelines and extractable petroleum hydrocarbon concentrations were occasionally found at measurable concentrations. Overall sediment quality results were generally low and additional sediment sampling was not recommended at this time.

Introduction

In 2013 the Cowichan Valley Regional District (CVRD) and the British Columbia (BC) Ministry of Environment and Climate Change Strategy (ENV) partnered to expand on the Shawnigan Lake Water Quality Objective (WQO) attainment monitoring program (Rieberger, 2007), which only included lake sites. This was done with a view to a more integrated approach to watershed monitoring, and to assess potential impacts to water and sediment quality from anthropogenic activities around the lake and in the upper watershed. Additional sampling occurred in several tributaries to Shawnigan Lake (upper watershed) as well as at additional sites in the lake itself (Figure 1). The results are summarized in this report. The recommended WQO attainment data for Shawnigan Lake from 2006-2014 are summarized in a separate document; the lake attainment data showed few WQO exceedances and no indication of overall lake deterioration (Kopat *et al.*, 2019).

Land uses in the upper Shawnigan Lake watershed include residential development, agriculture, forestry activities, industrial sites (CVRD, 2015), three active permits for authorized wastewater effluent discharge, and recreational activities (HB Lanarc Consultants Ltd, 2010). Illegal dumping also occurs (Doyle-Yamaguchi pers. comm., 2014). Potential sources of contamination associated with households and agriculture (such as runoff, septic fields, fecal matter from domestic animals, fertilizers and pesticides), as well as increased sediment loadings from land disturbance and roads, may impact water quality in the watershed. There are domestic drinking water licences on McGee Creek, Shawnigan Creek and Shawnigan Lake (into which all the tributaries flow) (BC MFLNRO, 2015). Local knowledge suggests that there are many additional unlicensed water users withdrawing from the lake for drinking water purposes. It is worth noting that there is also some karst topography in the watershed (DataBC, 2015), which may affect natural filtration and drainage. Concerns were raised by local government, First Nations, health officials and members of the general community about potential impacts to water quality in Shawnigan Creek and Shawnigan Lake resulting from discharged effluent and seepage from the Cobble Hill Holdings Ltd. (South Island Aggregate) site, where contaminated soil was permitted to be treated between 2013 and the permit cancellation in 2017 (BC ENV, 2017). These concerns were considered in selection of monitoring sites for this assessment.

Water Quality Assessment

Methodology

Water samples were collected from several tributaries to Shawnigan Lake, from numerous perimeter sites in the lake itself, and in the outflow from the lake in 2013, with a few additional samples collected in 2007 and 2012. When possible, water samples were collected with a sampling frequency of a minimum of five samples within a 30-day period (required for comparison to specific water quality standards) during both the summer low-flow period and the fall high-flow period (to best capture extremes in water quality). The locations of the sampling sites are shown in Figure 1, site coordinates are in Table 1, while monitoring parameters and schedule are outlined in Table 2. All samples were collected by ENV personnel or stewardship groups trained by ENV staff (except for a few bacteriological samples collected by Island Health staff), as per standard ENV sampling protocols (BC ENV, 2013).

In order to identify potential sources of microbiological contamination, Shawnigan Lake tributary samples with the highest *E. coli* results were shipped to the University of Victoria Water Research lab where microbial source tracking (MST) was completed (Mazumder, 2015). The lab has a DNA library for the Shawnigan watershed, collected from various sources of scat found in the area. The test samples were compared to this reference library to determine the source of contamination. One sample from each of Van Horn Creek u/s Shawnigan Road (E294424), West Arm inflow (1199911), McGee Creek (1199909), Shawnigan Creek outflow (1199912), South Shawnigan Creek d/s Elkington Forest (E294426), and Unnamed Creek @ Worthington Rd d/s PE4320 lagoons (E295309) were submitted.

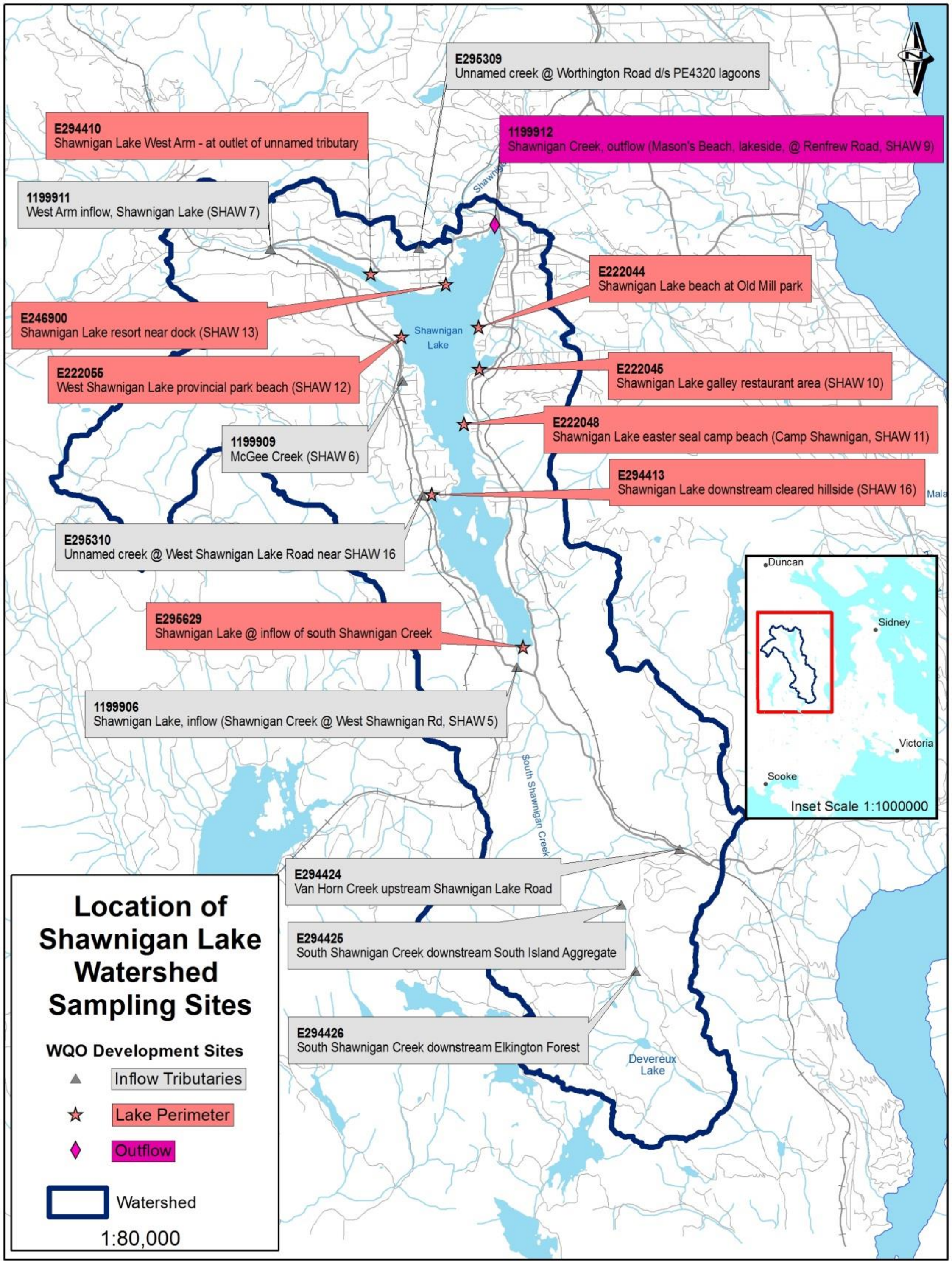

Figure 1. Location of 2013 water quality sampling sites within the Upper Shawnigan Lake watershed.

Table 1 Shawnigan Lake watershed 2013 sample site coordinates

Site Name	EMS ID	Latitude	Longitude	Description
Shawnigan Lake perimeter sites				
Shawnigan Lake beach at Old Mill park	E222044	48.64244	-123.63234	--
Shawnigan Lake galley restaurant area	E222045	48.63629	-123.63247	SHAW 10
Shawnigan Lake easter seal camp beach (Camp Shawnigan)	E222048	48.62835	-123.63625	SHAW 11
West Shawnigan Lake provincial park beach	E222055	48.64142	-123.64952	SHAW 12
Shawnigan Lake resort near dock	E246900	48.64893	-123.63932	SHAW 13
Shawnigan Lake West Arm - at outlet of unnamed tributary	E294410	48.65082	-123.65582	--
Shawnigan Lake downstream cleared hillside	E294413	48.61811	-123.64396	SHAW 16
Shawnigan Lake at inflow of south Shawnigan Creek	E295629	48.59528	-123.62488	Sediment sampling only at this site.
Tributary to Shawnigan Lake (inflow)				
Shawnigan Lake, inflow (Shawnigan Creek at West Shawnigan Rd)	1199906	48.59235	-123.62641	SHAW 5
Mcgee Creek	1199909	48.63502	-123.64966	SHAW 6
West Arm inflow, Shawnigan Lake	1199911	48.65503	-123.67787	SHAW 7
Van Horn Creek upstream Shawnigan Lake Road	E294424	48.56482	-123.59185	--
South Shawnigan Creek downstream South Island Aggregate	E294425	48.55698	-123.60517	--
South Shawnigan Creek downstream Elkington Forest	E294426	48.54714	-123.6025	--
Unnamed creek at Worthington Road d/s PE4320 lagoons	E295309	48.65443	-123.645	--
Unnamed creek at West Shawnigan Lake Road near SHAW 16	E295310	48.61806	-123.64608	Near SHAW 16
Shawnigan Lake outflow				
Shawnigan Creek, outflow (Mason's Beach, lakeside, at Renfrew Road)	1199912	48.65738	-123.62802	SHAW 9

Table 2. Summary of parameters measured in the Shawnigan Lake watershed – lake perimeter and tributaries. "X" indicates five weekly samples were collected in a 30 day period.

Site Name	EMS ID	Sample Year	Biological			Conventionals	Metals		Nutrients
			E. coli	Chlorophyll a	Fecal coliforms[1]	DO, pH, temp, hardness, TSS, turbidity, specific conductivity	Dissolved	Total	Total phosphorus (TP)
Shawnigan Lake perimeter sites									
Shawnigan Lake beach at Old Mill park	E222044	2013	--	--	6 monthly samples	--	--	--	--
Shawnigan Lake galley restaurant area	E222045	2012	--	--	--	Aug 13 only	--	--	--
		2013	X	--	---	X (summer; temp only; n = 4)	--	--	--
Shawnigan Lake easter seal camp beach (Camp Shawnigan)	E222048	2013	--	--	6 monthly samples	--	--	--	--
Shawnigan Lake resort near dock	E246900	2012	--	--	--	Aug 13 only	--	--	--
		2013	X	--	--	X (summer; temp only; n = 4)	--	--	--
Shawnigan Lake West Arm - at outlet of unnamed tributary	E294410	2013	X (summer)	--	--	--	--	--	X (summer)
Shawnigan Lake downstream cleared hillside	E294413	2012		--	--	Aug 13 only	--	--	--
		2013	X (summer)	--	--	X (summer; temp; n = 4)	--	--	X (summer)
Tributary to Shawnigan Lake (inflow)									
Shawnigan Lake, inflow (Shawnigan Creek at West Shawnigan Rd)	1199906	2007	--	Aug 23 only	--	--	--	--	--
		2012	X	--	--	X	Cl and F (n=2)	--	X (ammonia, dissolved nitrate, TP)
		2013	X	Sept 10 only	--	X	--	X	X (summer)
McGee Creek	1199909	2012	--	--	--	Aug 13 only	--	--	
		2013	X	--	--	X	--	--	X (summer)
West Arm inflow, Shawnigan Lake	1199911	2012	--	--	--	Aug 13 only	--	--	
		2013	X	--	--	X	--	X (fall)	X (summer)
Van Horn Creek upstream Shawnigan Lake Road	E294424	2012	--	--	--	Aug 13 only	--	--	
		2013	X	--	--	X	--	X	X (summer)
South Shawnigan Creek downstream South Island Aggregate	E294425	2012	--	--	--	Aug 13 only	--	--	
		2013	X	--	--	X	--	X	X (summer)
South Shawnigan Creek downstream Elkington Forest	E294426	2012	--	--	--	Aug 13 only	--	--	
		2013	X	--	--	X	--	X	X (summer)
Unnamed creek at Worthington Road d/s PE4320 lagoons	E295309	2012	--	--	--	Aug 13 only	--	--	
		2013	X (fall)	--	--	X	--	--	X (fall)
Unnamed creek at West Shawnigan Lake Road near SHAW 16	E295310	2013	X (fall)	--	--	Nov 5 only	--	--	X (fall)
Shawnigan Lake outflow									
Shawnigan Creek, outflow (Mason's Beach, lakeside, at Renfrew Road)	1199912	2012	--	--	--	Aug 13 only	--	--	--
		2013	X	--	6 monthly samples	X	--	X	X (summer)

[1] collected by Island Health

Temperature

Water temperatures were measured on a few occasions in 2012 and 2013 by CVRD staff during the summer months in the tributary streams (Table 3). Temperatures observed in Shawnigan Creek (both inflow (1199906) and outflow (1199912) sites) as well as Unnamed Creek at Worthington Road (E295309) were higher than those seen in the other tributaries. Lake outflow temperatures were generally higher due to the heating of the lake's surface as observed during the 2013 Shawnigan Lake attainment sampling (Kopat *et al.,* 2019). The maximum summer temperatures exceeded the aquatic life rearing guidelines for coho salmon (17°C), cutthroat trout (17°C), and steelhead trout (19°C) (Oliver and Fidler, 2001) in the Shawnigan Creek outflow (1199912) and Unnamed Creek at Worthington (E295309) sites. However, there are likely refuge areas within the creeks with cooler temperatures, minimizing summer stress on these species. Further investigation into the riparian areas of the creeks could be conducted by local government or stewardship groups if warranted. If water temperatures in the tributaries are a concern, continuous monitoring using an in-situ probe is recommended to accurately measure maximum summer temperatures, as these are not likely to be captured during random site visits.

It is possible that activities such as forest harvesting, agriculture or urban development, that have the potential to decrease stream shading if removal of vegetation occurs in riparian areas, and climate change, could exacerbate peak summer water temperature further. Therefore, efforts should be made to protect riparian areas to retain vegetative cover over streams and keep stream temperatures from increasing where land clearing from development occurs.

Table 3. Water temperatures (°C) for tributaries within the Shawnigan Lake watershed - CVRD sampling (2012-2013).

		Minimum	Maximum	Average	No. of samples
Shawnigan Creek					
1199912	Shawnigan Creek outflow	18.8	21.3	20.3	5
1199906	Shawnigan Creek inflow	11.1	17.0	14.7	10
E294425	South Shawnigan Creek D/S SIA	13.8	15.6	14.9	5
E294426	South Shawnigan Creek D/S Elkington Forest	12.4	14.5	13.2	5
Other Tributaries to Shawnigan Lake					
1199909	McGee Creek	14.9	15.5	15.3	5
1199911	West Arm inflow, Shawnigan Lake	11.8	13.0	12.4	5
E294424	Van Horn Creek	12.7	13.8	13.3	5
E295309	Unnamed Creek at Worthington Rd	17.0	23.0	21.0	5

Turbidity

Turbidity (a measure of the clarity or cloudiness of water) events can result from non-point sources such as runoff from roads, ditches, and farmland, as well as from landslides (both natural and those resulting from anthropogenic impacts such as timber harvesting or road construction). Turbidity is often correlated with other potential issues such elevated microbiological parameters, nutrients and metals. Elevated turbidity levels can decrease the efficiency of disinfection, allowing microbiological contaminants to enter the water system.

Turbidity was measured at eight sites in tributaries to Shawnigan Lake, as well as at the outflow to Shawnigan Lake (1199912) (Table 2, Figure 2). The McGee Creek site (1199909) is most representative of ambient conditions in the watershed, as it has the least amount of anthropogenic disturbances. Turbidity here remained low (< 1 NTU) for all samples collected in 2013. Turbidity levels greater than 2 NTU were observed at the West Arm inflow site (1199911) (3.18 NTU) and Van Horn Creek site (E294424) (4.2 NTU) during November and December 2013, respectively. These spikes in turbidity tended to be associated with precipitation events. The lake outflow site (1199912) had one value above 2 NTU, occurring in July 2013 (2.78 NTU), likely due to the presence of organic matter (i.e., algae) flowing out of the surface waters of Shawnigan Lake.

While turbidity data are fairly limited, occasional turbidity spikes and turbidity over background levels in most tributaries suggests anthropogenic turbidity inputs and/or riparian area degradation. The turbidity values are not of concern at this time but can help identify areas within the watersheds where improvements could be made to reduce erosion or run off in riparian areas. For a better understanding of seasonal turbidity patterns relative to streams where there are domestic water intakes (and turbidity spikes could comprise effectiveness of disinfection) and to capture maximum turbidity during storm events, continuous water quality monitoring sondes could be installed in tributaries of interest.

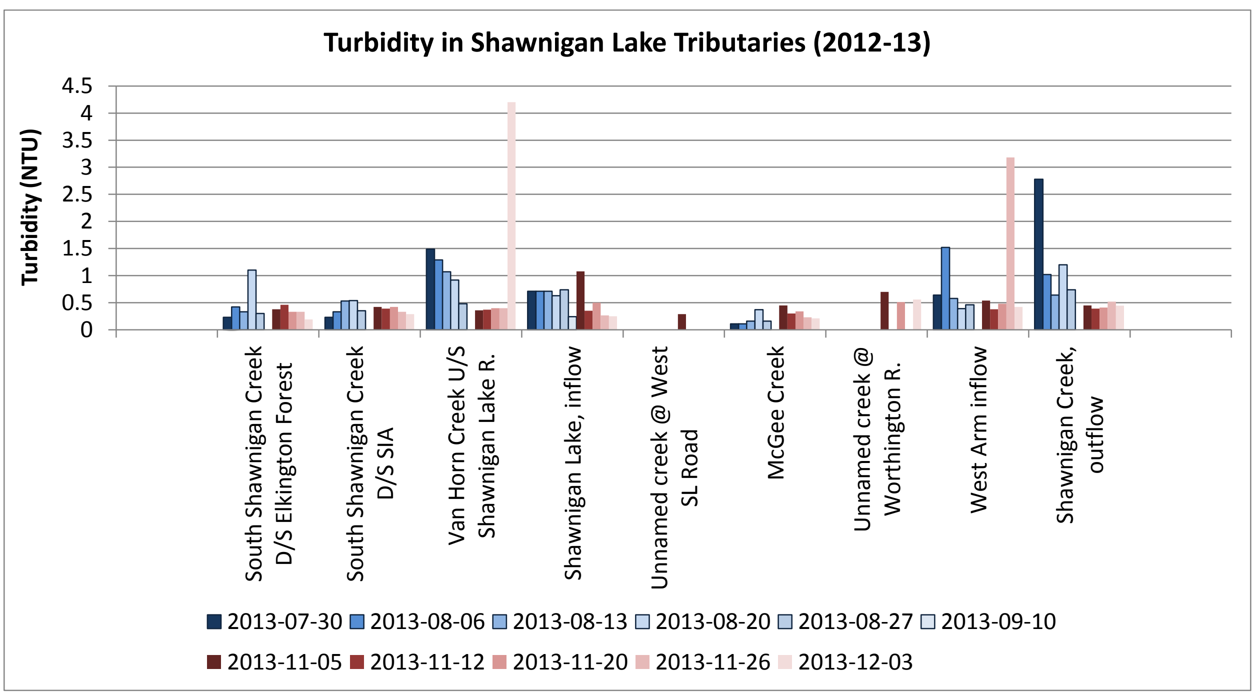

Figure 2. Individual turbidity measurements in Shawnigan Lake tributaries (2013).

Total Phosphorus

The ENV Nanaimo regional office has developed a Vancouver Island phosphorus objective using area-specific data to protect Vancouver Island streams from phosphorus pollution (BC ENV, 2015). The objective for total phosphorus in streams is a maximum concentration of 10 µg/L and an average concentration of 5 µg/L, based on samples collected monthly over the growing season (May- September) (BC ENV, 2015). This proposed objective takes into consideration the fact that elevated phosphorus is primarily a concern during the summer low flow period, when elevated nutrient levels are most likely to lead to aesthetic problems and a deterioration of habitat for aquatic life (e.g. decreased dissolved oxygen).

A summer (Aug-Sept) and fall (Oct-Nov) set of five weekly samples in 30 days were collected at the Shawnigan Lake inflow site (1199906) in 2012, at seven tributary sites (Table 2) in summer (July-Aug) 2013 and at two tributary sites in fall (Nov-Dec) 2013. These were analyzed for total phosphorus to determine potential nutrient sources to the lake (Figure 3). Individual measurements were compared to the proposed objectives. There were several exceedances of the objective (the maximum and/or the average), primarily during the summer sampling periods when excess nutrients can lead to increases in algal production.

The sampling frequency did not support the calculation of an average growing season concentration, as samples were collected weekly, not monthly. Instead, averages of the summer measured values were calculated for comparison purposes. Nutrients are not primarily of concern during the winter, but can provide information on sources, so comparisons to the proposed objectives were not conducted for fall/winter sample dates.

Mean values were higher than the proposed total phosphorus WQO of 5 µg/L in most tributaries during the summer months (Figure 4), except the South Shawnigan Creek downstream of South Island Aggregates site (E294425), where the concentration was quite low (3.2 µg/L). The West Arm inflow (1199911) site had an average that was higher than both the proposed average WQO but also the 10 µg/L maximum objective limit (10.4 µg/L). Likely sources of total phosphorus in the watershed are on-site septic systems, urban runoff, and agriculture. Further investigation is warranted to better identify specific sources.

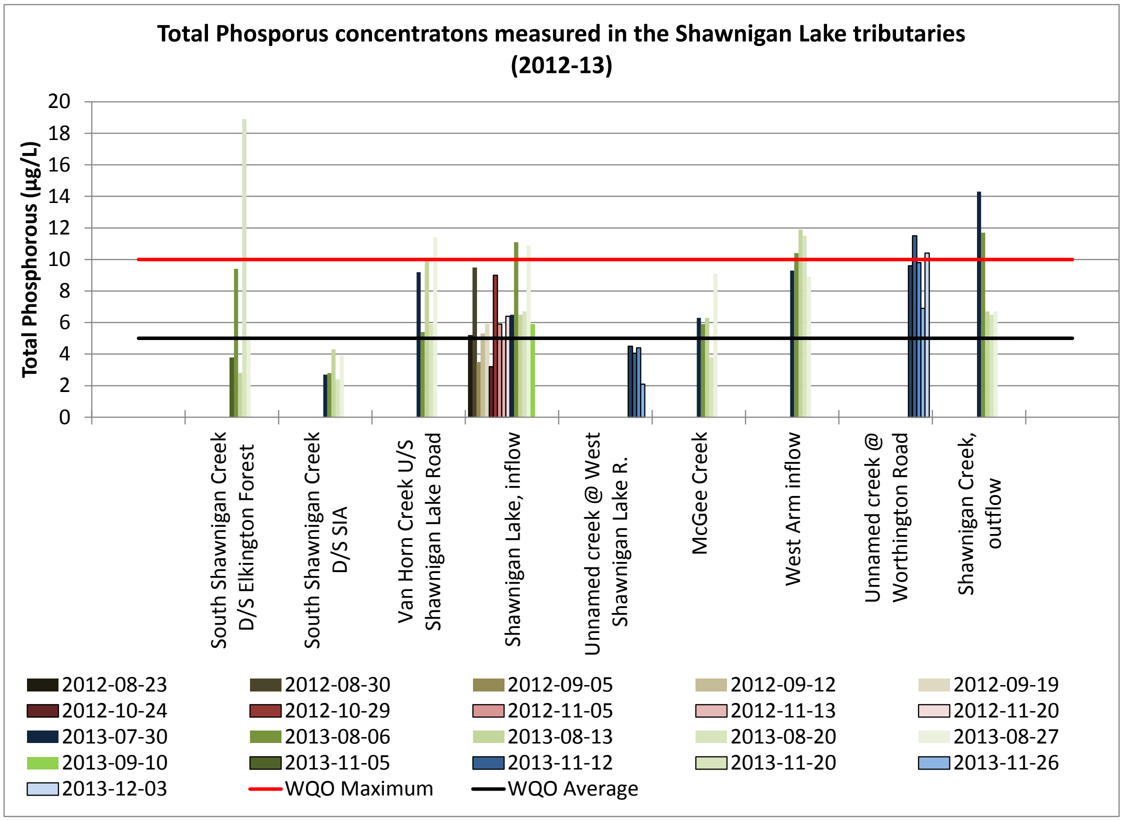

Figure 3. Total phosphorus concentrations in Shawnigan Lake tributaries (2012-13).

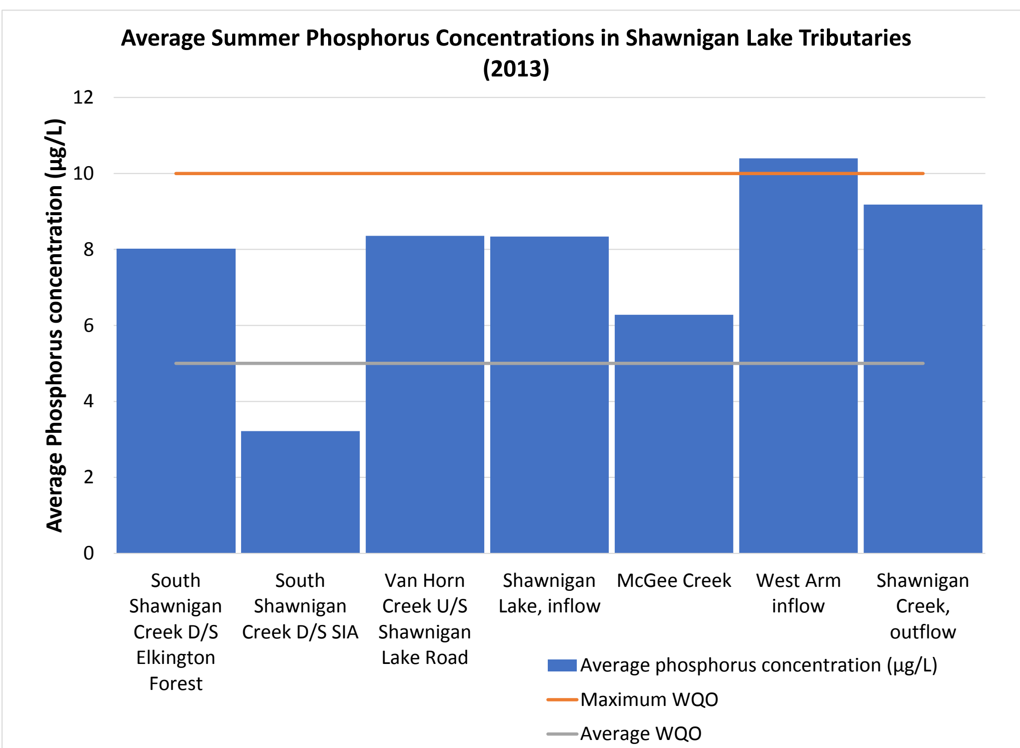

Figure 4. Average summer phosphorus concentrations in Shawnigan Lake tributaries (2013).

Bacteriological Indicators - *E. coli*

Bacteria often enter surface waters via non-point sources, including wild and domestic animal feces, as well as seepage from leaking or failing septic systems. Microbiological indicators are monitored to evaluate of the risk of disease from these various pathogens (Warrington, 1988). Studies have shown that *Escherichia coli* is the main thermo-tolerant coliform species present in fecal samples (94%) of humans and other endotherms such as birds and mammals, (Tallon *et al*., 2005), and at contaminated bathing beaches (80%) (Davis *et al.*, 2005).

Samples collected from the tributary stream sites (Table 2) in the Shawnigan Lake watershed had elevated levels of *E. coli* that tended to be higher in the summer than the fall (Table 4, Figure 5). *E. coli* 90th percentiles (based on five weekly samples collected over 30 days) in tributary streams ranged from 16.8 CFU/100 mL at the inflow site (1199906) to 118 CFU/100 mL at the outflow site (1199912) during the summer sampling. This pattern was reversed in the fall samples, where the lowest 90th percentile value was observed at the outflow site (3.8 CFU/mL) and the highest value was observed at the inflow site (34 CFU/100 mL). While the stream data did not show exceedances of the BC water quality guidelines (WQG) for primary contact recreation (200 CFU/100mL, based on geometric mean of at least five weekly samples in 30 days), tributary stream values were regularly above the WQO established for Shawnigan Lake to protect drinking water sources with disinfection (90th percentile of 10 CFU/mL, based on at least five weekly samples in 30 days) (Rieberger, 2007). Samples collected from four lake perimeter sites in 2013 had very low levels of *E. coli* and there were no exceedances of the objective at these sites (Table 4).

These *E. coli* levels are of concern, as values were consistently high regardless of time of year or water level. For the creeks where there are authorized drinking water licences (Shawnigan and McGee Creeks), disinfection of drinking water in critical, and property owners using raw water do so at their own risk. Tributary streams appear to be contributing to *E.coli* levels in the lake, which upon entering the lake are then diluted to levels meeting WQO for drinking water in the lake. The source of these microbiological inputs is likely anthropogenic (possibly associated with faulty septic fields or domestic animals), although wildlife undoubtedly contributes somewhat as well.

Island Health collected samples at the beach sites in 2013 to monitor fecal coliforms, to protect public health at recreational locations (Table 5). Samples were not collected with the required frequency to compare against guidelines, but results indicate that fecal coliforms were generally low, with some elevated results consistently at the West Shawnigan Lake Provincial Park site, and at the Shawnigan Creek outflow site.

Table 4. *E. coli* sampling results within the Shawnigan Lake watershed (2013). Highlighted values exceed the WQO or WQG.

Area/ Station	Sample Year	Summer Sampling (CFU/100 mL)							Fall Sampling (CFU/100 mL)						
		Count	Min	Max	Avg	SD	Geomean	90th percentile	Count	Min	Max	Avg	SD	Geomean	90th percentile
SL Perimeter															
E222045	2013	5	<1	3	1.4	0.89	1.25	2.2	5	<1	4	1.7	1.3	1.43	3
E246900	2013	5	<1	1	1	0	1	0.6	5	1	3	1.6	0.89	1.43	2.6
E294410	2013	4	<1	3	1.5	1	1.32	2.4	--	--	--	--	--	--	--
E294413	2013	5	<1	<1	1	0	1	1	--	--	--	--	--	--	--
Tributary to SL															
1199906*	2012	5	5	33	14.2	11.03	11.52	25.4	5	10	42	20.6	12.76	18.06	34
1199906	2013	5	2	20	9.8	7.16	7.33	16.8	5	1.5	8	4	3.22	3.02	7.6
1199909	2013	5	17	130	50	46.9	37.1	99.2	5	2	30	11	11	7.59	22
1199911	2013	5	18	120	43.6	43.48	32.36	87.2	5	1	9	3.2	3.35	2.22	6.6
E294424	2013	5	6	48	27.8	19.9	19.81	45.6	5	3	13	6.6	4.04	5.74	11
E294425	2013	5	<1	21	11.2	8.29	7.43	19.8	5	2.5	10	4.9	3.01	4.32	8
E294426	2013	5	24	64	39.4	17.99	36.35	59.6	5	2	9	5.2	2.77	4.55	7.8
E295309	2013	--	--	--	--	--	--	--	4	<1	35	10	16.67	3.44	25.1
E295310	2013	--	--	--	--	--	--	--	5	<1	20	6.6	8.2	3.25	15.6
SL outflow															
1199912	2013	5	13	130	58.6	53.03	39.6	118	5	<1	5	2	1.73	1.58	3.8

**CVRD sampling*

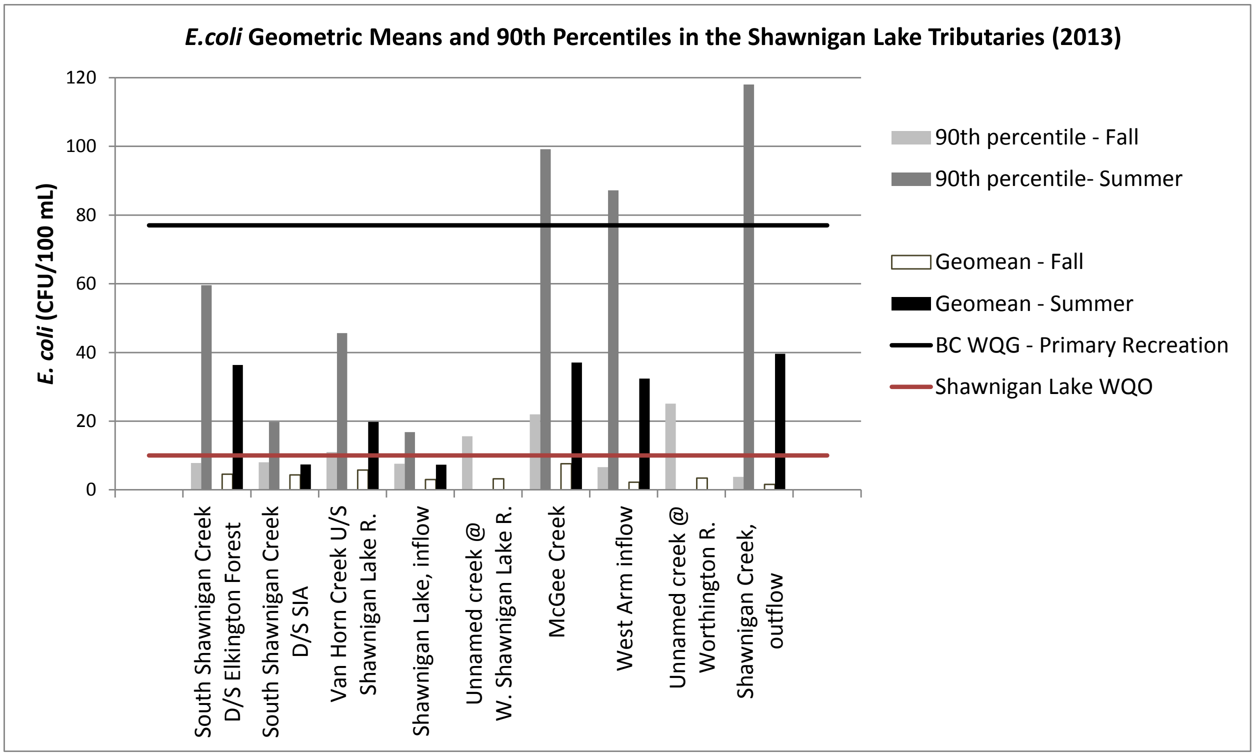

Figure 5. Summary of 2013 results of *E. coli* analyses within the Shawnigan Lake tributaries.

Table 5. Summary of fecal coliform count at Shawnigan Lake beach sites* (2013).

Season	Sample Year	Fecal Coliform (CFU/100mL)			
		SL Outflow	SL Perimeter		
		1199912	E222044	E222048	E222055
Fall	20131006	<5	<5	<5	5
Fall	20131007	50	14	40	105
Fall	20131208	<5	<5	<5	9
Summer	20130529	<5	5	--	--
Summer	20130530	--	--	--	10
Summer	20130625	<5	5	5	45
Summer	20130724	20	5	<5	5

**Collected by Island Health*

Microbial Source Tracking

The Shawnigan Creek outflow (1199912) and Van Horn Creek upstream Shawnigan Road (E294424) sites did not have sufficient *E. coli* markers present to identify any sources. The other four samples had sufficient quantities of *E. coli* to identify one or more sources of bacteria, including black bear (39%), human (26%), unknown (22%), coyote (8.7%), and elk (4.3%) (Table

6). Note that coyotes are not present on Vancouver Island, so the likely source is from domestic dogs. *E. coli* samples that did not have a minimum 80% match to the markers in the DNA library were categorized as `unidentified` or ‘unknown`. Two sites were identified as having only wildlife sources (West Arm inflow (1199911) and McGee Creek (1199909)), while two other sites were identified as having both human and wildlife sources (South Shawnigan Creek downstream Elkington Forest (E294426) and Unnamed Creek @ Worthington Road downstream PE4320 lagoons (E295309)).

These results are consistent with the results obtained by the study conducted by the Water and Aquatic Sciences Research Program at the University of Victoria (Mazumder, 2015). This program was initiated in 2010 to characterize, quantify and model the impacts of climate and land use variability on water quality in Shawnigan Lake, with a focus on the types and sources of waterborne pathogens. In the report, water samples collected in the lake identified *E. coli* contributing sources as: black bear (22.9%), human (14.9%), unknown (14.5%), elk (10.9%) horse (10.2%.), cow (~6%), dog (~4.5%) and mule deer (~3.5%). About one third of markers identified were associated with human activity in the watershed (humans, horses and dogs). In addition, the same study found evidence of three types of pathogenic *E. coli* in the raw water, as well as an enriched stable isotope of nitrogen, caffeine, and health care products, all of which are indicative of septic loading. Concentrations of caffeine and health care products were much higher during summer months when the local population increases (Mazumder, 2015).

Table 6. Shawnigan Lake watershed microbial source tracking results (December 4, 2013).

EMS ID	Sampling Location	*E. coli* (CFU/100ml)			Non- *E. coli* Coliforms (CFU/100ml)			Probable Sources
		Plate 1	Plate 2	Avg	Plate 1	Plate 2	Avg	
1199911	West Arm inflow, Shawnigan Lake	2	1	**2**	21	13	**17**	Coyote, elk
1199909	McGee Creek	2	2	**2**	34	28	**31**	Black bear
E294426	S. Shawnigan Creek d/s Elkington	13	4	**9**	68	58	**63**	Black bear, Human, NI*
E295309	Unnamed Creek @ Worthington Rd d/s PE4320 lagoons	7	13	**10**	16	15	**16**	Black bear, coyote, human, NI

*NI = not identified, used when a sample presented a group membership probability less than 0.80

Metals

Metals results for the five Shawnigan Lake tributaries in 2013 (Table 2Table 1) were compared to the BC WQGs. Five weekly samples collected over 30-day period occurred at all of these sites except for South Shawnigan Creek downstream Elkington Forest (E294426), where during the fall, the sampling frequency was four samples in 30 days (Appendix I Table 8).

For those samples where concentrations were above detection limits, metals values were generally below the BC approved or working guidelines, or alternatively, no guidelines were available. The only exceptions were exceedances of iron and arsenic at the Van Horn Creek upstream of Shawnigan Lake Road (E294424) site (Appendix I, Table 8). In samples from Van Horn Creek collected on August 13th, 2013, the iron concentration was 1.32 mg/L (BC WQG maximum is 1 mg/L). On November 26th, 2013, the concentration of iron was 5.35 mg/L, and the concentration of arsenic was 0.0066 mg/L (BC WQG maximum is 0.005 mg/L). On December 3rd, 2013, the iron concentration was 1.32 mg/L. Though these exceedances may be natural and associated with groundwater interactions, exceedances at a single site in the watershed suggest a site-specific condition that is likely not representative of metal concentrations in the entire watershed. This was supported by a sediment study conducted in South Shawnigan Creek and tributaries which showed levels of iron, manganese, nickel and polycyclic aromatic hydrocarbons (PAHs) above the lower interim BC sediment quality guidelines (SQG) in Van Horne Creek (BC ENV, 2017). There is an old and inactive recycling depot site upstream of the Van Horn Creek sampling site, and runoff from this site may be impacting the downstream water quality, as well as anecdotal evidence of an area close by with abandoned vehicles on site. More investigation is recommended to ascertain the source of the elevated metals concentrations at the Van Horn Creek site.

Sediment Quality Assessment

Methodology

Contaminants can enter water bodies from a variety of sources (e.g., industrial and municipal discharges, urban and agricultural runoff, and atmospheric deposition), and due to the physical and chemical properties of these contaminants, many tend to accumulate in sediments. Sediment sampling was conducted in 2013 as part of the monitoring program to determine potential impacts from the Cobble Hill Holdings facility. Sampling protocols followed the 2013 BC Field Sampling Manual (BC ENV, 2013). It was decided to sample within the lake at the locations where the creeks entered, rather than in the creeks themselves, as these were expected to be the best depositional sites. Thus, the sampling was conducted near the inflow of Shawnigan Creek at the south end of Shawnigan Lake (E295629), and at the West Arm (1199903) lake site. These sites are fairly similar, as both have significant creek inflows near them. The south end samples were taken near the inlet of Shawnigan Creek at three locations (0, 50, and 100 m from the creek mouth). Sampling included conventional parameters, hydrocarbons, metals, polychlorinated biphenyls (PCBs) and volatiles.

Conventional Parameters

Conventional parameters such as grain size distribution and organic matter content assists in the interpretation of contaminant chemistry results in sediments. Results obtained from test sites should be compared with the results obtained from reference sites with similar physical (e.g., grain size, organic matter content) characteristics (MacDonald and Ingersoll, 2003). Sediments with a higher proportion of organic matter generally have a greater capacity to bind organic chemicals, and the concentrations of organic contaminants have been observed to correlate well with the organic carbon content of sediments (DiToro *et al*., 1991). In addition, the concentrations of trace metals in sediments are influenced by a variety of factors, such as grain size, sediment mineralogy, and organic content (Schropp and Windom, 1988). Fine-grained sediments have a greater capacity to bind chemical contaminants.

The sediments collected from the inflow sites (E295629) contained 46-53% fines, whereas the West Arm site (1199903) contained 37% fines. Organic matter content in samples collected at the mouth of the inlet site (11–18%) was lower than that of the West Arm site (33%).

Metals

Metal concentrations in the sediment at all four sampling sites revealed only minor exceedances for a few parameters (Table 7). The West Arm site exceeded the BC SQG for cadmium, lead, and zinc. However, none of these concentrations exceed the Probable Effects Limits (PEL). Cadmium marginally exceeded the guideline (0.807 mg/kg), lead was twice the guideline (70.7 mg/kg) and zinc was measured at the guideline limit (123 mg/kg) (BC ENV, 2006). At all three distances from the inflow of Shawnigan Creek, the BC SQG for nickel (16 µg/g) was exceeded (0m=21.1 µg/g, 50m=18.9 µg/g and 100m=18.1 µg/g), but the PEL was not exceeded. These were relatively minor exceedances, and likely did not influence the aquatic community (i.e., benthic invertebrates). Additional sediment sampling done in South Shawnigan Creek in 2016 suggests that some metals may be naturally elevated in the creek sediments based on the local site geology (BC ENV, 2016). Metals results in water (see Water Quality results) suggest that there could be site specific metals inputs into Van Horne Creek. Additional lake sediment sampling is not recommended at this time.

Table 7. Concentrations of selected metals in sediments at the West Arm site (1199903) and South Shawnigan Creek inflow site (E295629) (2013). Highlighted values are above interim BC SQG.

Chemical	Shawnigan Lake, West Arm (1199903) Comparison Site (mg/kg)*	Shawnigan Lake @ inflow of south Shawnigan Creek (E295629) - Test site			BC Working Sediment Quality Guidelines	
		0m from mouth (mg/kg)*	50m from mouth (mg/kg)*	100m from mouth (mg/kg)*	Interim SQG (µg/g dry weight)*	Probable Effect Limit (µg/g dry weight)*
Total Aluminum (Al)	9790	17000	15500	14000	--	--
Total Antimony (Sb)	0.34	0.18	0.19	0.33	--	--
Total Arsenic (As)	2.27	1.32	1.6	1.9	5.9	17
Total Barium (Ba)	61.3	73.6	62.9	61.2	--	--
Total Beryllium (Be)	<0.4	<0.4	<0.4	<0.4	--	--
Total Bismuth (Bi)	0.12	<0.1	<0.1	<0.1	--	--
Total Cadmium (Cd)	0.807	0.218	0.237	0.218	0.6	3.5
Total Calcium (Ca)	5250	6340	5390	5080	--	--
Total Chromium (Cr)	14.6	35.5	30.5	28.8	37.3	90
Total Cobalt (Co)	5.68	9.12	8.25	7.81	--	--
Total Copper (Cu)	34	25.5	23	22.7	35.7	197
Total Iron (Fe)	9970	18300	18400	15700	21,200 (about 2%)	43,766 (about 4%)
Total Lead (Pb)	70.7	6.1	11.6	6	35	91
Total Magnesium (Mg)	3010	5630	5280	4840	--	--
Total Manganese (Mn)	186	264	217	198	460	1100
Total Molybdenum (Mo)	0.63	0.53	0.47	0.47	--	--
Total Nickel (Ni)	11.3	21.1	18.9	18.1	16	75
Total Potassium (K)	298	448	315	269	--	--
Total Selenium (Se)	0.87	<0.5	<0.5	<0.5	2	N/A
Total Silicon (Si)	193	175	120	110	--	--
Total Silver (Ag)	0.135	<0.05	<0.05	<0.05	0.5	N/A
Total Sodium (Na)	123	207	182	135	--	--
Total Strontium (Sr)	25.5	33.8	31.6	32.6	--	--
Total Thallium (Tl)	<0.05	<0.05	<0.05	<0.05	--	--
Total Tin (Sn)	1.9	0.45	0.52	0.42	--	--
Total Titanium (Ti)	195	1080	1050	852	--	--
Total Vanadium (V)	34.2	58.5	54.5	52.6	--	--
Total Zinc (Zn)	123	60.6	55.4	53.8	123	305
Total Zirconium (Zr)	1.23	1.54	1.46	1.67	--	--

** 1mg/kg = 1µg/g = 1ppm*

Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) along with benzene, toluene, ethyl benzene, and xylenes (BTEX) are light hydrocarbons associated with gasoline or fuel oil, and are typical pollutants from atmospheric deposition and urban runoff in a system like Shawnigan Lake. However, results for PAHs and BTEX (Appendix I,Table 9) were all below detection limits at both sites. A 2016 sediment study in South Shawnigan Creek (BC ENV, 2017) had similar results.

Extractable petroleum hydrocarbons (EPH) are a group of heavy, non-volatile toxic compounds. There are no regulatory criteria in BC for assessing EPH, but data are often used as a screening tool to identify and define areas where petroleum products may have been released into the environment (BC ENV, 2003). EPH are not a direct indicator of risk to humans or to the environment, as the category represents a mixture with similar substances being grouped together into carbon fractions. Each fraction is considered to have its own health risk.

EPH were not detected in the samples analyzed from the West Arm site, but samples collected at the other three sites contained EPH concentrations for the C16-C34 and C34-C50 fractions, which ranged from below laboratory detection to 440 mg/kg. The highest concentration of the C16-C34 fraction occurred at the site 100 m from the inlet of South Shawnigan Creek. Notably, in the separate 2016 sediment study in South Shawnigan Creek (BC ENV, 2017), EPH values were below detection limits at all sites sampled. The C16-C34 fraction range includes, but is not limited to, hydrocarbons such as: #2 Diesel, fuel oil #2, kerosene, motor oil, hydraulic fluids and power steering fluid (State of Washington, 2016).

The source of the EPH is unknown but potential sources include runoff from Shawnigan Lake Road and West Shawnigan Lake Road, boats within the lake, or the moorage areas. These EPH are heavy and have likely been accumulating over many years. Source identification is difficult since any petroleum products released into the environment are subject to weathering processes, such as chemical oxidation, evaporation, microbial degradation and leaching through solution and entrainment (Christensen and Larsen, 1993). Further investigation may be warranted; if this is pursued, a separate comprehensive sampling program would be required to confidently identify sources.

Summary

Overall, the state of water quality in the tributaries to Shawnigan Lake, as well as at perimeter sites within the lake, is good. Water quality monitoring conducted in 2013 showed occasional elevated summer water temperatures in tributaries, as well as elevated total phosphorus concentrations. These factors can result in increased algal production, as well as stress to aquatic organisms, although there are likely refuge areas within the tributaries where fish and other species can retreat to reduce stresses. *E. coli* in the tributary streams was elevated above the WQO established for drinking water in Shawnigan Lake (into which they flow), including sites where there are authorized drinking water licences. Microbial source tracking within the watershed showed that approximately one-third of the bacteriological contamination originated from anthropogenic sources (i.e., humans and domestic animals). Further investigation should occur at Van Horne Creek as it showed elevated metals concentrations. All of the above suggest that the likeliest sources impacting water quality in the watershed are related to urban and rural residential development (e.g., urban runoff, on-site septic systems, recreational use, agriculture), and that there may be a benefit in providing water stewardship educational materials to the community and maintaining or restoring riparian zones. Further investigation is warranted to better identify specific sources.

While PAH and BTEX concentrations in sediments were below detectable limits at the various sampling sites, measurable levels of EPH were found at some sites. Further investigation may be warranted but the likely sources are the roadways in the area. Occasional elevated levels of a few metals in sediments are likely associated with runoff and/or the natural geology of the area, and are therefore not a concern.

References

BC ENV (British Columbia Ministry of Environment). 2003. Update on contaminated sites, clarification on hydrocarbon analytical methods and standards. Ministry of Environment. Victoria, BC. http://www.env.gov.bc.ca/epd/remediation/updates/pdf/hydro_analy_meth_update030523.pdf

BC ENV (British Columbia Ministry of Environment). 2006. Compendium of working water quality guidelines for British Columbia - Working Guidelines for the Sediments. Ministry of Environment. Victoria, BC. https://www.for.gov.bc.ca/hfd/library/ffip/Nagpal_NK2001.pdf

BC ENV (British Columbia Ministry of Environment). 2013. British Columbia Field Sampling Manual – For continuous monitoring plus the collection of air, air-emission, water, wastewater, soil, sediment, and biological samples. Ministry of Environment. Victoria, BC. http://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/monitoring/emre/field_sample_man2013.pdf

BC ENV. 2015. Phosphorous management in Vancouver Island streams. Environmental Protection Division. Ministry of Environment. Nanaimo, BC.

BC ENV. 2017. Permitting and Compliance Sites of Interest: South Island Aggregates – Cobble Hill Holdings. Victoria, British Columbia, Canada. https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-permitting-compliance/sia

BCMFLNRO (Ministry of Forests, Lands and Natural Resource Operations British Columbia), Water Licenses Query [web application]. August 2015. Victoria, British Columbia, Canada. Available online at: http://a100.gov.bc.ca/pub/wtrwhse/water_licences.input

Christensen, L.B., and Larsen, T.H., "Method for Determining the Age of Diesel Oil Spills in the Soil," *Groundwater Monitoring Report*, Fall 1993, pp. 142-149.

Cowichan Valley Regional District (CVRD). 2015. Shawnigan Lake Electoral Area B Activities. Available online at: http://www.cvrd.bc.ca/index.aspx?nid=271

DataBC: Map Layer "Karst Potential - outlined" [web application]. 2015. Geographic Services, Government of British Columbia. Victoria, British Columbia, Canada. Available online at: http://www.data.gov.bc.ca/dbc/geographic/view_and_analyze/imapbc/index.page?

Davis, K., M.A. Anderson, and M.V. Yates. 2005. Distribution of indicator bacteria in Canyon Lake, California. Water Res., 39:1277-1288.

DiToro, D.M., C.S. Zarba, D.J. Hansen, W.J. Berry, R.C. Swartz, C.E. Cowan, S.P. Pavlou, H.E. Allen, N.A. Thomas, and P.R. Paquin. 1991. Technical basis for establishing sediment quality criteria for nonionic organic chemicals using equilibrium partitioning. Environmental Toxicology and Chemistry 10: 1541-1583.

Doyle-Yamaguchi, E. 2014. Personal communication. Environmental Analyst. Water Management Division, Engineering Services, CVRD. Duncan, BC.

HB Lanarc Consultants Ltd. 2010. Shawnigan Lake Parks and Trails Master Plan. Prepared for the Cowichan Valley Regional District Parks and Trails Division.

Kopat, M., D. Epps and M. Sokal. 2019. Water Quality Objectives Attainment for Shawnigan Lake. Environmental Protection Division. Ministry of Environment. Nanaimo, BC.

MacDonald, D.D. and Ingersoll, C.G. 2003. A guidance manual to support the assessment of contaminated sediments in freshwater, estuarine, and marine ecosystems in British Columbia. Industrial Wastes and Hazardous Contaminants Branch, Ministry of Environment, Lands, and Parks. Victoria, British Columbia.

Mazumder, A. 2015. *Characterizing and modeling impacts of climate and land-use variability on water quality - Shawnigan Lake community water system and watershed*. Report on results from September 2010 to September 2015. Water and Aquatic Sciences Research Program, Department of Biology, University of Victoria. Victoria, British Columbia.

Oliver, G.G. and L.E. Fidler. 2001. Towards a water quality guideline for temperature in BC. Prepared for Water Quality Section, Ministry of Environment, Lands and Parks. Victoria BC. http://www.env.gov.bc.ca/wat/wq/BCguidelines/temptech/index.html

Rieberger, K. 2007. Water quality assessment and objectives for Shawnigan Lake: technical appendix. Science and Information Branch. Ministry of Environment. Victoria, BC.

Schropp, S.J. and H.L. Windom. 1988. A guide to the interpretation of metal concentrations in estuarine sediments. Coastal Zone Management Section. Florida Department of Environmental Regulation. Tallahassee, Florida. 44 pp. + app.

State of Washington, Department of Ecology. Accessed on July 13, 2016. http://www.ecy.wa.gov/eim/helpDocs/EIMHelp_EnteringPetroleumHydrocarbonData.pdf

Tallon, P., B. Magajna, C. Lofranco, and K.T. Leung. 2005. Microbial indicators of faecal contamination in water: A current perspective. Water Air Soil Pollut., 166:139-166.

Warrington, P. D. 1988. Water Quality Criteria for Microbiological Indicators - Overview Report. Ministry of Environment and Parks, Resource Quality Section, Water Management Branch. Victoria, BC. March, 1988 (updated August 2001). http://www.env.gov.bc.ca/wat/wq/BCguidelines/microbiology/microbiology.html

APPENDIX I Objectives Attainment Water Quality Results

Table 8. Water metal analysis results for five Shawnigan Lake tributary sites (2013)

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Aluminum	mg/L	20130730	Summer			0.0473		0.0371	0.016	0.0178
Total Aluminum	mg/L	20130806	Summer			0.0291		0.0352	0.0193	0.0173
Total Aluminum	mg/L	20130813	Summer			0.0327		0.182	0.028	0.0177
Total Aluminum	mg/L	20130820	Summer			0.0292		0.0345	0.0231	0.311
Total Aluminum	mg/L	20130827	Summer			0.0716		0.0809	0.0235	0.0344
Total Aluminum	mg/L	20130910	Summer	0.5	0.5	0.0273				
Total Aluminum	mg/L	20131105	Fall			0.0542	0.0359	0.137	0.0421	0.0393
Total Aluminum	mg/L	20131112	Fall			0.055	0.0366	0.105	0.0416	0.0421
Total Aluminum	mg/L	20131120	Fall			0.0494	0.085	0.115	0.0685	0.0593
Total Aluminum	mg/L	20131126	Fall			0.0478	0.253	0.0277	0.044	0.0437
Total Aluminum	mg/L	20131203	Fall			0.0472	0.0304	0.366	0.0469	
Total Antimony	mg/L	20130730	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20130806	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20130813	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20130820	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20130827	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20130910	Summer	0.5	0.5	0.000026				
Total Antimony	mg/L	20131105	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20131112	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20131120	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20131126	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Antimony	mg/L	20131203	Fall			<0.0005	<0.0005	<0.0005	<0.0005	
Total Arsenic	mg/L	20130730	Summer			0.0002		0.00015	0.00012	<0.0001
Total Arsenic	mg/L	20130806	Summer			0.00015		0.00017	<0.0001	0.00012
Total Arsenic	mg/L	20130813	Summer			0.00014		0.00031	0.00014	<0.0001
Total Arsenic	mg/L	20130820	Summer			0.00018		0.0002	0.00011	0.00015
Total Arsenic	mg/L	20130827	Summer			0.0002		0.00023	<0.0001	<0.0001
Total Arsenic	mg/L	20130910	Summer	0.5	0.5	0.0001				
Total Arsenic	mg/L	20131105	Fall			0.00012	0.00018	0.00015	<0.0001	<0.0001
Total Arsenic	mg/L	20131112	Fall			0.0001	0.00014	0.00015	<0.0001	<0.0001
Total Arsenic	mg/L	20131120	Fall			0.00016	0.00017	0.00014	0.0001	0.00011
Total Arsenic	mg/L	20131126	Fall			<0.0001	0.00015	0.0066	<0.0001	<0.0001
Total Arsenic	mg/L	20131203	Fall			<0.0001	0.00014	0.00026	<0.0001	
Total Barium	mg/L	20130730	Summer			0.007		0.0119	0.0057	0.0041
Total Barium	mg/L	20130806	Summer			0.0071		0.0129	0.0058	0.0042
Total Barium	mg/L	20130813	Summer			0.0075		0.0191	0.0066	0.0042
Total Barium	mg/L	20130820	Summer			0.0077		0.0153	0.0064	0.0071
Total Barium	mg/L	20130827	Summer			0.0074		0.0176	0.0058	0.004
Total Barium	mg/L	20130910	Summer	0.5	0.5	0.00617				
Total Barium	mg/L	20131105	Fall			0.0038	0.008	0.005	0.0036	0.0034
Total Barium	mg/L	20131112	Fall			0.0038	0.0078	0.0053	0.0036	0.0032
Total Barium	mg/L	20131120	Fall			0.0073	0.0082	0.0043	0.0035	0.0031
Total Barium	mg/L	20131126	Fall			0.0036	0.0092	0.0967	0.003	0.0028
Total Barium	mg/L	20131203	Fall			0.0036	0.0079	0.0085	0.0035	
Total Beryllium	mg/L	20130730	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20130806	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20130813	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20130820	Summer			<0.0001		<0.0001	<0.0001	<0.0001

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Beryllium	mg/L	20130827	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20130910	Summer	0.5	0.5	<0.00001				
Total Beryllium	mg/L	20131105	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20131112	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20131120	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20131126	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Beryllium	mg/L	20131203	Fall			<0.0001	<0.0001	<0.0001	<0.0001	
Total Bismuth	mg/L	20130730	Summer			<0.001		<0.001	<0.001	<0.001
Total Bismuth	mg/L	20130806	Summer			<0.001		<0.001	<0.001	<0.001
Total Bismuth	mg/L	20130813	Summer			<0.001		<0.001	<0.001	<0.001
Total Bismuth	mg/L	20130820	Summer			<0.001		<0.001	<0.001	<0.001
Total Bismuth	mg/L	20130827	Summer			<0.001		<0.001	<0.001	<0.001
Total Bismuth	mg/L	20130910	Summer	0.5	0.5	<0.000005				
Total Bismuth	mg/L	20131105	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Bismuth	mg/L	20131112	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Bismuth	mg/L	20131126	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Bismuth	mg/L	20131203	Fall			<0.001	<0.001	<0.001	<0.001	
Total Bismuth	mg/L	20131120	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Boron	mg/L	20130730	Summer			<0.05		<0.05	<0.05	<0.05
Total Boron	mg/L	20130806	Summer			<0.05		<0.05	<0.05	<0.05
Total Boron	mg/L	20130813	Summer			<0.05		<0.05	<0.05	<0.05
Total Boron	mg/L	20130820	Summer			<0.05		<0.05	<0.05	<0.05
Total Boron	mg/L	20130827	Summer			<0.05		<0.05	<0.05	<0.05
Total Boron	mg/L	20130910	Summer	0.5	0.5	<0.05				
Total Boron	mg/L	20131105	Fall			<0.05	<0.05	<0.05	<0.05	<0.05
Total Boron	mg/L	20131112	Fall			<0.05	<0.05	<0.05	<0.05	<0.05
Total Boron	mg/L	20131120	Fall			<0.05	<0.05	<0.05	<0.05	<0.05
Total Boron	mg/L	20131126	Fall			<0.05	<0.05	0.603	<0.05	<0.05
Total Boron	mg/L	20131203	Fall			<0.05	<0.05	<0.05	<0.05	
Total Cadmium	mg/L	20130730	Summer			<0.00001		<0.00001	<0.00001	<0.00001
Total Cadmium	mg/L	20130806	Summer			<0.00001		<0.00001	<0.00001	<0.00001
Total Cadmium	mg/L	20130813	Summer			<0.00001		0.000013	<0.00001	<0.00001
Total Cadmium	mg/L	20130820	Summer			<0.00001		0.000014	<0.00001	0.000013
Total Cadmium	mg/L	20130827	Summer			<0.00001		0.000011	<0.00001	<0.00001
Total Cadmium	mg/L	20130910	Summer	0.5	0.5	0.00001				
Total Cadmium	mg/L	20131105	Fall			<0.00001	<0.00001	<0.00001	<0.00001	0.000013
Total Cadmium	mg/L	20131112	Fall			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Cadmium	mg/L	20131120	Fall			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Cadmium	mg/L	20131126	Fall			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Cadmium	mg/L	20131203	Fall			<0.00001	<0.00001	<0.00001	<0.00001	
Total Calcium (Ca)	mg/L	20130730	Summer			9.01		13.7	10.1	5.75
Total Calcium (Ca)	mg/L	20130806	Summer			8.81		13.9	8.75	5.83
Total Calcium (Ca)	mg/L	20130813	Summer			9.11		15.1	10.4	6.22
Total Calcium (Ca)	mg/L	20130820	Summer			10.1		15.8	11.9	6.85
Total Calcium (Ca)	mg/L	20130827	Summer			9.95		15.4	9.93	6.18
Total Calcium (Ca)	mg/L	20130910	Summer	0.5	0.5	8.57				
Total Calcium (Ca)	mg/L	20131105	Fall			6.03	18.8	5.92	5.66	5.22
Total Calcium (Ca)	mg/L	20131112	Fall			6.11	17.7	6.15	5.65	5.24

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Calcium (Ca)	mg/L	20131120	Fall			19	19.6	5.7	5.79	5.3
Total Calcium (Ca)	mg/L	20131126	Fall			5.98	17.6	191	5.17	4.67
Total Calcium (Ca)	mg/L	20131203	Fall			6.45	20.5	6.81	6.02	
Total Chromium	mg/L	20130730	Summer			<0.001		<0.001	<0.001	<0.001
Total Chromium	mg/L	20130806	Summer			<0.001		<0.001	<0.001	<0.001
Total Chromium	mg/L	20130813	Summer			<0.001		<0.001	<0.001	<0.001
Total Chromium	mg/L	20130820	Summer			<0.001		<0.001	<0.001	<0.001
Total Chromium	mg/L	20130827	Summer			<0.001		<0.001	<0.001	<0.001
Total Chromium	mg/L	20130910	Summer	0.5	0.5	0.00012				
Total Chromium	mg/L	20131105	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Chromium	mg/L	20131112	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Chromium	mg/L	20131120	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Chromium	mg/L	20131126	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Chromium	mg/L	20131203	Fall			<0.001	<0.001	<0.001	<0.001	
Total Cobalt	mg/L	20130730	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Cobalt	mg/L	20130806	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Cobalt	mg/L	20130813	Summer			<0.0005		0.00109	<0.0005	<0.0005
Total Cobalt	mg/L	20130820	Summer			<0.0005		<0.0005	<0.0005	0.00114
Total Cobalt	mg/L	20130827	Summer			<0.0005		0.00064	<0.0005	<0.0005
Total Cobalt	mg/L	20130910	Summer	0.5	0.5	0.000089				
Total Cobalt	mg/L	20131105	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Cobalt	mg/L	20131112	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Cobalt	mg/L	20131120	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Cobalt	mg/L	20131126	Fall			<0.0005	<0.0005	0.00156	<0.0005	<0.0005
Total Cobalt	mg/L	20131203	Fall			<0.0005	<0.0005	0.00062	<0.0005	
Total Copper	mg/L	20130730	Summer			0.00067		0.00043	0.00038	0.00056
Total Copper	mg/L	20130806	Summer			0.00062		0.00059	0.00032	0.00032
Total Copper	mg/L	20130813	Summer			0.00052		0.00081	0.00044	0.00059
Total Copper	mg/L	20130820	Summer			0.00066		0.00045	0.00037	0.00105
Total Copper	mg/L	20130827	Summer			0.00303		0.00055	0.00044	0.00043
Total Copper	mg/L	20130910	Summer	0.5	0.5	0.000639				
Total Copper	mg/L	20131105	Fall			0.00075	0.00061	0.00097	0.00068	0.00083
Total Copper	mg/L	20131112	Fall			0.00069	0.00073	0.00081	0.00058	0.00074
Total Copper	mg/L	20131120	Fall			0.00055	0.00056	0.0008	0.00063	0.00063
Total Copper	mg/L	20131126	Fall			0.00068	0.00108	0.00184	0.00069	0.00077
Total Copper	mg/L	20131203	Fall			0.00066	0.00041	0.00119	0.00061	
Total Iron	mg/L	20130730	Summer			0.244		0.386	0.0424	0.0958
Total Iron	mg/L	20130806	Summer			0.279		0.34	0.0463	0.122
Total Iron	mg/L	20130813	Summer			0.212		1.32	0.0693	0.111
Total Iron	mg/L	20130820	Summer			0.305		0.249	0.0519	0.559
Total Iron	mg/L	20130827	Summer			0.351		0.524	0.0581	0.131
Total Iron	mg/L	20130910	Summer	0.5	0.5	0.11				
Total Iron	mg/L	20131105	Fall			0.103	0.125	0.211	0.1	0.102
Total Iron	mg/L	20131112	Fall			0.086	0.1	0.169	0.0841	0.0813
Total Iron	mg/L	20131120	Fall			0.125	0.151	0.15	0.0997	0.0891
Total Iron	mg/L	20131126	Fall			0.0654	0.352	5.35	0.0635	0.0543
Total Iron	mg/L	20131203	Fall			0.0773	0.108	1.32	0.0698	
Total Lead	mg/L	20130730	Summer			<0.0002		<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20130806	Summer			<0.0002		<0.0002	<0.0002	<0.0002

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Lead	mg/L	20130813	Summer			<0.0002		<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20130820	Summer			<0.0002		<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20130827	Summer			<0.0002		<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20130910	Summer	0.5	0.5	0.000059				
Total Lead	mg/L	20131105	Fall			<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20131112	Fall			<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20131120	Fall			<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20131126	Fall			<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total Lead	mg/L	20131203	Fall			<0.0002	<0.0002	0.00025	<0.0002	
Total Lithium	mg/L	20130730	Summer			<0.005		<0.005	<0.005	<0.005
Total Lithium	mg/L	20130806	Summer			<0.005		<0.005	<0.005	<0.005
Total Lithium	mg/L	20130813	Summer			<0.005		<0.005	<0.005	<0.005
Total Lithium	mg/L	20130820	Summer			<0.005		<0.005	<0.005	<0.005
Total Lithium	mg/L	20130827	Summer			<0.005		<0.005	<0.005	<0.005
Total Lithium	mg/L	20130910	Summer	0.5	0.5	<0.0005				
Total Lithium	mg/L	20131105	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Lithium	mg/L	20131112	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Lithium	mg/L	20131120	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Lithium	mg/L	20131126	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Lithium	mg/L	20131203	Fall			<0.005	<0.005	<0.005	<0.005	
Total Magnesium (Mg)	mg/L	20130730	Summer			2.11		2.92	2.25	0.924
Total Magnesium (Mg)	mg/L	20130806	Summer			2.19		3.13	2.03	0.862
Total Magnesium (Mg)	mg/L	20130813	Summer			2.26		3.11	2.63	0.97
Total Magnesium (Mg)	mg/L	20130820	Summer			2.42		3.34	2.92	1.01
Total Magnesium (Mg)	mg/L	20130827	Summer			2.36		3.26	2.51	0.92
Total Magnesium (Mg)	mg/L	20130910	Summer	0.5	0.5	2.28				
Total Magnesium (Mg)	mg/L	20131105	Fall			1.42	2.62	1.22	1.15	0.899
Total Magnesium (Mg)	mg/L	20131112	Fall			1.45	2.65	1.33	1.09	0.9
Total Magnesium (Mg)	mg/L	20131120	Fall			2.6	2.64	1.17	1.06	0.875
Total Magnesium (Mg)	mg/L	20131126	Fall			1.4	2.48	14.5	1.02	0.817
Total Magnesium (Mg)	mg/L	20131203	Fall			1.46	2.83	1.44	1.1	
Total Manganese	mg/L	20130730	Summer			0.0394		0.332	0.016	0.0193
Total Manganese	mg/L	20130806	Summer			0.0359		0.371	0.0179	0.0226
Total Manganese	mg/L	20130813	Summer			0.0392		0.941	0.0294	0.0231
Total Manganese	mg/L	20130820	Summer			0.042		0.441	0.0457	0.201
Total Manganese	mg/L	20130827	Summer			0.06		0.701	0.0373	0.0241
Total Manganese	mg/L	20130910	Summer	0.5	0.5	0.0202				
Total Manganese	mg/L	20131105	Fall			0.0029	0.0059	0.0471	0.0062	0.0063
Total Manganese	mg/L	20131112	Fall			0.0031	0.0073	0.0407	0.0061	0.0051
Total Manganese	mg/L	20131120	Fall			0.0075	0.0118	0.0261	0.0085	0.0042
Total Manganese	mg/L	20131126	Fall			0.003	0.0508	1.04	0.0072	0.0039
Total Manganese	mg/L	20131203	Fall			0.0027	0.008	0.296	0.0049	
Total Mercury (Hg)	mg/L	20130730	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Mercury (Hg)	mg/L	20130806	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Mercury (Hg)	mg/L	20130813	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Mercury (Hg)	mg/L	20130820	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Mercury (Hg)	mg/L	20130827	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Mercury (Hg)	mg/L	20131105	Fall			<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Mercury (Hg)	mg/L	20131112	Fall			<0.00005	<0.00005	<0.00005	<0.00005	<0.00005

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Mercury (Hg)	mg/L	20131120	Fall			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Mercury (Hg)	mg/L	20131126	Fall			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total Mercury (Hg)	mg/L	20131203	Fall			<0.00001	<0.00001	<0.00001		
Total Molybdenum	mg/L	20130730	Summer			<0.001		<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20130806	Summer			<0.001		<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20130813	Summer			<0.001		<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20130820	Summer			<0.001		<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20130827	Summer			<0.001		<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20130910	Summer	0.5	0.5	0.000103				
Total Molybdenum	mg/L	20131105	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20131112	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20131120	Fall			<0.001	<0.001	<0.001	<0.001	<0.001
Total Molybdenum	mg/L	20131126	Fall			<0.001	<0.001	0.0012	<0.001	<0.001
Total Molybdenum	mg/L	20131203	Fall			<0.001	<0.001	<0.001	<0.001	
Total Nickel	mg/L	20130730	Summer			<0.001		<0.001	<0.001	<0.001
Total Nickel	mg/L	20130806	Summer			<0.001		<0.001	<0.001	<0.001
Total Nickel	mg/L	20130813	Summer			<0.001		<0.001	<0.001	<0.001
Total Nickel	mg/L	20130820	Summer			<0.001		<0.001	<0.001	<0.001
Total Nickel	mg/L	20130827	Summer			<0.001		<0.001	<0.001	<0.001
Total Nickel	mg/L	20130910	Summer	0.5	0.5	0.000299				
Total Nickel	mg/L	20131105	Fall			<0.001	<0.001	<0.001	0.0037	<0.001
Total Nickel	mg/L	20131112	Fall			0.0013	<0.001	<0.001	<0.001	0.0015
Total Nickel	mg/L	20131120	Fall			<0.001	<0.001	<0.001	0.0027	<0.001
Total Nickel	mg/L	20131126	Fall			<0.001	<0.001	0.0013	<0.001	<0.001
Total Nickel	mg/L	20131203	Fall			<0.001	<0.001	<0.001	<0.001	
Total Potassium (K)	mg/L	20130730	Summer			0.294		1.05	0.162	0.106
Total Potassium (K)	mg/L	20130806	Summer			0.326		1.06	0.158	0.122
Total Potassium (K)	mg/L	20130813	Summer			0.331		1.13	0.178	0.155
Total Potassium (K)	mg/L	20130820	Summer			0.342		1.26	0.148	0.15
Total Potassium (K)	mg/L	20130827	Summer			0.389		1.29	0.115	0.103
Total Potassium (K)	mg/L	20131105	Fall			0.316	0.479	0.483	0.208	0.172
Total Potassium (K)	mg/L	20131112	Fall			0.207	0.349	0.51	0.148	0.103
Total Potassium (K)	mg/L	20131120	Fall			0.406	0.443	0.396	0.139	0.125
Total Potassium (K)	mg/L	20131126	Fall			0.243	0.316	3.93	0.147	0.16
Total Potassium (K)	mg/L	20131203	Fall			0.202	0.324	0.487	0.127	
Total Selenium	mg/L	20130730	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20130806	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20130813	Summer			<0.0001		<0.0001	0.00011	<0.0001
Total Selenium	mg/L	20130820	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20130827	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20130910	Summer	0.5	0.5	<0.00004				
Total Selenium	mg/L	20131105	Fall			<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20131112	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20131120	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20131126	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Selenium	mg/L	20131203	Fall			<0.0001	<0.0001	<0.0001	<0.0001	
Total Silicon (Si)	mg/L	20130730	Summer			5.58		5.04	3.96	2.75
Total Silicon (Si)	mg/L	20130806	Summer			6.07		5.07	3.41	2.69
Total Silicon (Si)	mg/L	20130813	Summer			5.6		5.41	3.66	2.8

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Silicon (Si)	mg/L	20130820	Summer			6.11		5.49	3.86	3.21
Total Silicon (Si)	mg/L	20130827	Summer			5.53		4.85	3.24	2.46
Total Silicon (Si)	mg/L	20131105	Fall			3.77	5.27	4.37	2.74	2.72
Total Silicon (Si)	mg/L	20131112	Fall			3.53	4.8	3.84	2.66	2.49
Total Silicon (Si)	mg/L	20131120	Fall			5.48	5.72	3.9	3.13	2.91
Total Silicon (Si)	mg/L	20131126	Fall			4.14	5.7	8.6	2.97	2.82
Total Silicon (Si)	mg/L	20131203	Fall			4.18	5.97	4.68	3.29	
Total Silver	mg/L	20130730	Summer			<0.00002		<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20130806	Summer			<0.00002		<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20130813	Summer			<0.00002		<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20130820	Summer			<0.00002		<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20130827	Summer			<0.00002		<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20130910	Summer	0.5	0.5	<0.000005				
Total Silver	mg/L	20131105	Fall			<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20131112	Fall			<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20131120	Fall			<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20131126	Fall			<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Total Silver	mg/L	20131203	Fall			<0.00002	<0.00002	<0.00002	<0.00002	
Total Sodium (Na)	mg/L	20130730	Summer			4.62		9.41	3.18	2.12
Total Sodium (Na)	mg/L	20130806	Summer			4.63		11	2.82	2.11
Total Sodium (Na)	mg/L	20130813	Summer			5.29		10.7	3.59	2.69
Total Sodium (Na)	mg/L	20130820	Summer			5.48		11.6	3.98	2.65
Total Sodium (Na)	mg/L	20130827	Summer			5.44		11.4	3.39	2.19
Total Sodium (Na)	mg/L	20131105	Fall			3.11	4.07	3.35	2.34	2.22
Total Sodium (Na)	mg/L	20131112	Fall			3.37	3.99	3.61	2.41	2.35
Total Sodium (Na)	mg/L	20131120	Fall			4.11	4.29	2.95	2.46	2.19
Total Sodium (Na)	mg/L	20131126	Fall			3.11	3.55	122	2.22	2.08
Total Sodium (Na)	mg/L	20131203	Fall			3.36	4.3	3.55	2.49	
Total Strontium	mg/L	20130730	Summer			0.0427		0.0574	0.042	0.0291
Total Strontium	mg/L	20130806	Summer			0.0444		0.0582	0.0392	0.0289
Total Strontium	mg/L	20130813	Summer			0.0453		0.0648	0.0459	0.031
Total Strontium	mg/L	20130820	Summer			0.0476		0.0688	0.0508	0.0332
Total Strontium	mg/L	20130827	Summer			0.0494		0.0688	0.0432	0.031
Total Strontium	mg/L	20130910	Summer	0.5	0.5	0.0444				
Total Strontium	mg/L	20131105	Fall			0.0266	0.065	0.0222	0.0247	0.0242
Total Strontium	mg/L	20131112	Fall			0.0258	0.0607	0.0243	0.0249	0.0246
Total Strontium	mg/L	20131120	Fall			0.0591	0.0599	0.0189	0.0235	0.021
Total Strontium	mg/L	20131126	Fall			0.0245	0.0583	1.67	0.0212	0.0202
Total Strontium	mg/L	20131203	Fall			0.025	0.0645	0.0245	0.0243	
Total Sulphur (S)	mg/L	20130730	Summer			<3		4.5	<3	<3
Total Sulphur (S)	mg/L	20130806	Summer			<3		<3	<3	<3
Total Sulphur (S)	mg/L	20130813	Summer			<3		<3	<3	<3
Total Sulphur (S)	mg/L	20130820	Summer			<3		<3	<3	<3
Total Sulphur (S)	mg/L	20130827	Summer			<3		3.1	<3	<3
Total Sulphur (S)	mg/L	20131105	Fall			<3	<3	<3	3.3	<3
Total Sulphur (S)	mg/L	20131112	Fall			<3	<3	<3	<3	<3
Total Sulphur (S)	mg/L	20131120	Fall			<3	<3	<3	<3	<3
Total Sulphur (S)	mg/L	20131126	Fall			6.3	4.6	107	7	4.9
Total Sulphur (S)	mg/L	20131203	Fall			<3	<3	<3	<3	

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Thallium	mg/L	20130730	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20130806	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20130813	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20130820	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20130827	Summer			<0.00005		<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20130910	Summer	0.5	0.5	<0.000002				
Total Thallium	mg/L	20131105	Fall			<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20131112	Fall			<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20131120	Fall			<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20131126	Fall			<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Total Thallium	mg/L	20131203	Fall			<0.00005	<0.00005	<0.00005	<0.00005	
Total Tin	mg/L	20130730	Summer			<0.005		<0.005	<0.005	<0.005
Total Tin	mg/L	20130806	Summer			<0.005		<0.005	<0.005	<0.005
Total Tin	mg/L	20130813	Summer			<0.005		<0.005	<0.005	<0.005
Total Tin	mg/L	20130820	Summer			<0.005		<0.005	<0.005	<0.005
Total Tin	mg/L	20130827	Summer			<0.005		<0.005	<0.005	<0.005
Total Tin	mg/L	20130910	Summer	0.5	0.5	<0.0002				
Total Tin	mg/L	20131105	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Tin	mg/L	20131112	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Tin	mg/L	20131120	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Tin	mg/L	20131126	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Tin	mg/L	20131203	Fall			<0.005	<0.005	<0.005	<0.005	
Total Titanium (Ti)	mg/L	20130730	Summer			<0.005		<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20130806	Summer			<0.005		<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20130813	Summer			<0.005		0.0052	<0.005	<0.005
Total Titanium (Ti)	mg/L	20130820	Summer			<0.005		<0.005	<0.005	0.0108
Total Titanium (Ti)	mg/L	20130827	Summer			<0.005		<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20131105	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20131112	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20131120	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20131126	Fall			<0.005	0.0082	<0.005	<0.005	<0.005
Total Titanium (Ti)	mg/L	20131203	Fall			<0.005	<0.005	0.0125	<0.005	
Total Uranium	mg/L	20130730	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20130806	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20130813	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20130820	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20130827	Summer			<0.0001		<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20130910	Summer	0.5	0.5	0.000003				
Total Uranium	mg/L	20131105	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20131112	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20131120	Fall			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Uranium	mg/L	20131126	Fall			<0.0001	<0.0001	0.00017	<0.0001	<0.0001
Total Uranium	mg/L	20131203	Fall			<0.0001	<0.0001	<0.0001	<0.0001	
Total Vanadium	mg/L	20130730	Summer			<0.005		<0.005	<0.005	<0.005
Total Vanadium	mg/L	20130806	Summer			<0.005		<0.005	<0.005	<0.005
Total Vanadium	mg/L	20130813	Summer			<0.005		<0.005	<0.005	<0.005
Total Vanadium	mg/L	20130820	Summer			<0.005		<0.005	<0.005	<0.005
Total Vanadium	mg/L	20130827	Summer			<0.005		<0.005	<0.005	<0.005
Total Vanadium	mg/L	20130910	Summer	0.5	0.5	0.0006				

Chemical	Units	Sample Collection Date (YYYYMMDD)	Collection Season	Collection Depth		EMS ID - Tributaries to Shawnigan Lake				
				Upper	Lower	1199906	1199911	E294424	E294425	E294426
Total Vanadium	mg/L	20131105	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Vanadium	mg/L	20131112	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Vanadium	mg/L	20131120	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Vanadium	mg/L	20131126	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Vanadium	mg/L	20131203	Fall			<0.005	<0.005	<0.005	<0.005	
Total Zinc	mg/L	20130730	Summer			<0.005		<0.005	<0.005	<0.005
Total Zinc	mg/L	20130806	Summer			<0.005		<0.005	<0.005	<0.005
Total Zinc	mg/L	20130813	Summer			<0.005		0.0051	<0.005	<0.005
Total Zinc	mg/L	20130820	Summer			<0.005		<0.005	<0.005	<0.005
Total Zinc	mg/L	20130827	Summer			<0.005		<0.005	<0.005	<0.005
Total Zinc	mg/L	20130910	Summer	0.5	0.5	0.00067				
Total Zinc	mg/L	20131105	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Zinc	mg/L	20131112	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Zinc	mg/L	20131120	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Zinc	mg/L	20131126	Fall			<0.005	<0.005	<0.005	<0.005	<0.005
Total Zinc	mg/L	20131203	Fall			<0.005	<0.005	<0.005	<0.005	
Total Zirconium (Zr)	mg/L	20130730	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20130806	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20130813	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20130820	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20130827	Summer			<0.0005		<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20131105	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20131112	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20131120	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20131126	Fall			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Total Zirconium (Zr)	mg/L	20131203	Fall			<0.0005	<0.0005	<0.0005	<0.0005	

Table 9. Sediment analysis data (2013).

Chemical	Units	Sample Collection Date (YYYYMMDD)	Shawnigan Lake, West Arm	Shawnigan Lake @ inflow of south Shawnigan Creek		
				0m from mouth	50m from mouth	100m from mouth
Base Neutrals						
2,4-dinitrotoluene	mg/kg	20131120	<5	<1	<1	<1
2,6-dinitrotoluene	mg/kg	20131120	<5	<1	<1	<1
2-chloronaphthalene	mg/kg	20131120	<8	<1.6	<1.6	<1.6
3,3'-Dichlorobenzidine	mg/kg	20131120	<50	<10	<10	<10
4-bromophenyl phenyl ether	mg/kg	20131120	<6	<1.2	<1.2	<1.2
4-chlorophenyl phenyl ether	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Bis(2-chloroethoxy)methane	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Bis(2-chloroethyl)ether	mg/kg	20131120	<6	<1.2	<1.2	<1.2
Bis(2-chloroisopropyl)ether	mg/kg	20131120	<20	<4	<4	<4
Dibenzofuran	mg/kg	20131120	<10	<2	<2	<2
Hexachlorobutadiene	mg/kg	20131120	<5	<1	<1	<1
Hexachlorocyclopentadiene	mg/kg	20131120	<20	<4	<4	<4
Hexachloroethane	mg/kg	20131120	<6	<1.2	<1.2	<1.2
Isophorone	mg/kg	20131120	<6	<1.2	<1.2	<1.2
Nitrobenzene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
N-nitroso-di-n-propylamine	mg/kg	20131120	<6	<1.2	<1.2	<1.2
N-nitrosodiphenylamine	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Chlorobenzenes						
1,2,4-trichlorobenzene	mg/kg	20131120	<6	<1.2	<1.2	<1.2
1,2-dichlorobenzene	mg/kg	20131120	<10	<2	<2	<2
1,3-dichlorobenzene	mg/kg	20131120	<10	<2	<2	<2
1,4-dichlorobenzene	mg/kg	20131120	<10	<2	<2	<2
Hexachlorobenzene	mg/kg	20131120	<6	<1.2	<1.2	<1.2
Conventional						
Loss on Ignition	%	20131120	33.1	18	10.5	14.4
Moisture	%	20131120	92	76	75	72
Ext. Pet. Hydrocarbon						
C10-C16	mg/kg	20131120	<120	<40	<40	<40
C16-C34	mg/kg	20131120	<120	230	200	440
C34-C50	mg/kg	20131120	<120	<40	73	130
Nutrient						
Total Phosphorus (P)	mg/kg	20131120	741	514	539	499
PAH						
1-Methylnaphthalene	mg/kg	20131120	<3	<0.6	<0.6	<0.6
2-Methylnaphthalene	mg/kg	20131120	<3	<0.6	<0.6	<0.6
Acenaphthene	mg/kg	20131120	<9	<1.8	<1.8	<1.8
Acenaphthylene	mg/kg	20131120	<9	<1.8	<1.8	<1.8
Anthracene	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Benzo(a)anthracene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Benzo(a)pyrene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Benzo(b&j)fluoranthene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Benzo(g,h,i)perylene	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Benzo(k)fluoranthene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Chrysene	mg/kg	20131120	<9	<1.8	<1.8	<1.8
Dibenz(a,h)anthracene	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Fluoranthene	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Fluorene	mg/kg	20131120	<9	<1.8	<1.8	<1.8
Indeno(1,2,3-cd)pyrene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Naphthalene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Perylene	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Phenanthrene	mg/kg	20131120	<8	<1.6	<1.6	<1.6
Pyrene	mg/kg	20131120	<8	<1.6	<1.6	<1.6

Chemical	Units	Sample Collection Date (YYYYMMDD)	Shawnigan Lake, West Arm	Shawnigan Lake @ inflow of south Shawnigan Creek		
				0m from mouth	50m from mouth	100m from mouth
PCBs						
Aroclor 1242	mg/kg	20131120	<0.12	<0.03	--	--
Aroclor 1248	mg/kg	20131120	<0.12	<0.03	--	--
Aroclor 1254	mg/kg	20131120	<0.12	<0.03	--	--
Aroclor 1260	mg/kg	20131120	<0.12	<0.03	--	--
Total PCB	mg/kg	20131120	<0.12	<0.03	--	--
Phenols						
2,3,4,5-tetrachlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,3,4,6-tetrachlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,3,4-trichlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,3,5-trichlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,4 + 2,5-Dichlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,4,5-trichlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,4,6-trichlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2,4-dimethylphenol	mg/kg	20131120	<5	<1	<1	<1
2,4-dinitrophenol	mg/kg	20131120	<50	<10	<10	<10
2,6-dichlorophenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
2-chlorophenol	mg/kg	20131120	<8	<1.6	<1.6	<1.6
2-methylphenol	mg/kg	20131120	<5	<1	<1	<1
2-nitrophenol	mg/kg	20131120	<5	<1	<1	<1
4,6-dinitro-2-methylphenol	mg/kg	20131120	<50	<10	<10	<10
4-chloro-3-methylphenol	mg/kg	20131120	<7	<1.4	<1.4	<1.4
4-nitrophenol	mg/kg	20131120	<5	<1	<1	<1
m,p-Cresol	mg/kg	20131120	<5	4.2	<1	<1
Pentachlorophenol	mg/kg	20131120	<2	<0.4	<0.4	<0.4
Phenol	mg/kg	20131120	<6	<1.2	<1.2	<1.2
Phthalate Esters						
Bis(2-ethylhexyl)phthalate	mg/kg	20131120	<200	<40	<40	<40
Butyl benzyl phthalate	mg/kg	20131120	<10	<2	<2	<2
Diethyl phthalate	mg/kg	20131120	<9	<1.8	<1.8	<1.8
Dimethyl phthalate	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Di-n-butyl phthalate	mg/kg	20131120	<7	<1.4	<1.4	<1.4
Di-n-octyl phthalate	mg/kg	20131120	<10	<2	<2	<2
Volatiles						
Benzene	mg/kg	20131120	<0.091	<0.031	--	--
Ethylbenzene	mg/kg	20131120	<0.18	<0.063	--	--
m & p-Xylene	mg/kg	20131120	<0.73	<0.25	--	--
Methyl-tert-butylether (MTBE)	mg/kg	20131120	<1.8	<0.63	--	--
o-Xylene	mg/kg	20131120	<0.73	<0.25	--	--
Styrene	mg/kg	20131120	<0.55	<0.19	--	--
Toluene	mg/kg	20131120	<0.37	<0.13	--	--
VH C6-C10	mg/kg	20131120	<180	<63	--	--
VPH (VH6 to 10 - BTEX)	mg/kg	20131120	<180	<63	--	--
Xylenes (Total)	mg/kg	20131120	<0.73	<0.25	--	--