NOTE TO FILE

Date: January 31, 2017

File: PE-105809

Re: PE-105809 Upper Shawnigan Sediment Sampling Results, Fall 2016

In 2016 the Ministry of Environment (MOE) initiated an independent Water Quality Study to be undertaken by Associated Environmental Consultants Inc. in select tributaries and mainstem of South Shawnigan Creek. This study was conducted to address the concerns of residents, First Nations, local politicians, and other interested parties about the potential impacts of development to water quality within the upper watershed. In support of this study, the MOE conducted sediment sampling at six creek locations in the fall of 2016. The methods, results and initial comment are provided herein.

Methods

Sediment sampling was undertaken alongside Associated Environmental (AE) employee Ms. Nicole Basaraba during a previously scheduled water sampling event supplementary to AE's fall five-in-thirty sampling session. As part of the independent study, there are eight sites Ms. Basaraba routinely samples and on October 31st, four of the eight were found to have sediment. Sediment was also sampled from an additional site of interest to the MOE on Van Horn Creek. On November 3rd a repeat trip to one of the sites that was not sampled on the 31st, resulted in a sixth sample. See Figure 1 below for the map of sites sampled.

Samples were collected in accordance with the 2013 *BC Field Sampling Manual, Part D Soil and Sediment Sampling*. Each site was visually inspected for the presence of sediment, typically located in slower moving, depositional sections of the creek. If sediment was present, collection was limited to the surficial sediment layer (i.e., top 5 cm) with care exercised to avoid disturbance leading up to and during sampling.

Parameters for analysis included: total metals including mercury, Extractable Petroleum Hydrocarbons (EPH), Polycyclic aromatic hydrocarbons (PAH), Total Organic Carbon (TOC) and grain size. All samples destined for metals analysis were collected using a new plastic spoon and all samples destined for organics analysis were collected using a pre-rinsed, metal spoon.

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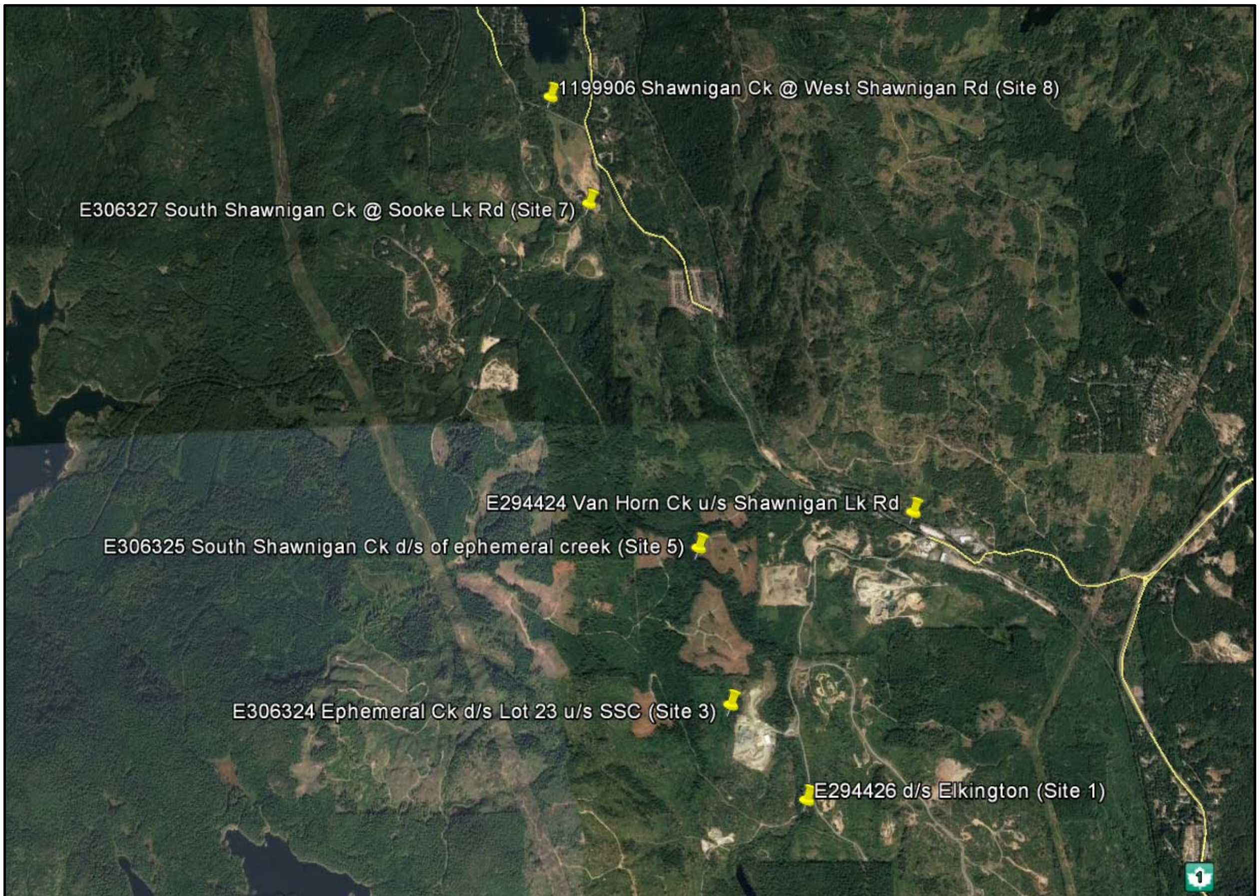

Figure 1. Sediment sampling sites October 31st and November 3rd, 2016

Results

The entirety of the results are tabulated with comparison to the Sediment Quality Guidelines (SQGs) on page seven. It is important to note that any comparison of sediment results should ideally be across sites with similar physical characteristics (e.g., grain size and organic content). The analysis indicates some differences in the size and organic content between sites and it is important to be aware of these differences when interpreting the results.

Particle Size

The variability in particle size analysis is important because fine-grained sediment is known to have a greater capacity to bind chemical contaminants. The site with the largest proportion of fines was the ephemeral creek downstream of Lot 23 at 5%, while South Shawnigan Creek at Sooke Road was found to be 60% fine sand. Other notable differences are South Shawnigan Creek downstream of the ephemeral creek which was found to be 65% gravel, whereas all other sites are notably lower.

Particle Size		D/s Elkington	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow
Cobbles (>3in.)	%	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Gravel (4.75mm-3in.)	%	26.8	16.1	65.8	4.5	<1.0	6.5
Coarse Sand (2.0mm-4.75mm)	%	30.8	33.9	20.0	26.7	<1.0	14.3
Medium Sand (0.425mm-2.0mm)	%	39.5	27.4	11.0	49.5	37.5	66.1
Fine Sand (0.075mm-0.425mm)	%	1.8	17.9	2.5	16.1	60.5	12.4
Fines (<0.075mm)	%	1.2	4.7	<1.0	3.1	2.0	<1.0

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Organic Content

The organic content analysis indicated minor variability in the percentage of total organic carbon across the six sites. All percentages were less than 2% TOC which may be negligible when considering differences in adsorption due to this parameter.

		D/s Elkington	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow
Total Organic Carbon	%	0.646	1.64	0.897	0.367	0.376	0.144

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Total Metals

There were exceedances of the Working Sediment Quality Guidelines for the following metals at one or more of the six sites sampled: total chromium, total copper, total iron, total manganese, and total nickel. The lower SWQG is the concentration that will protect aquatic life from adverse effects of a toxic substance in most situations. The upper SWQG is the concentration that if exceeded will likely cause severe effects on aquatic life.

Total Chromium

Total chromium exceeded the lower SQWG at the uppermost site downstream of Elkington Forest and at South Shawnigan Creek downstream of the ephemeral creek.

		D/s Elkington*	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow	**Lower SWQG**	**Upper SWQG**
Chromium	mg/kg	38.1	32.4	59.0	35.6	33.3	31.3	37.3	90

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Total Copper

Total copper marginally exceeded the lower SWQG at the ephemeral creek downstream of Lot 23.

		D/s Elkington*	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow	Lower SWQG	Upper SWQG
Copper	mg/kg	32.7	36.8	26.4	28.1	20.8	17.5	35.7	197

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Total Iron

Total iron marginally exceeded the lower SWQG at all six sites ranging from 21,700 to 32600 mg/kg.

		D/s Elkington*	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow	Lower SWQG	Upper SWQG
Iron	mg/kg	32600	29800	32600	31300	21700	23600	21,200 (about 2%)	43,766 (about 4%)

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Total Manganese

Total manganese exceeded lower SWQG at four of the six sites, ranging from 542 mg/kg to 1260 mg/kg. The ephemeral creek downstream of Lot 23 also slightly exceeded the Upper SWQG.

		D/s Elkington*	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow	Lower SWQG	Upper SWQG
Manganese	mg/kg	542	1260	557	976	346	334	460	1100

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Total Nickel

Total nickel exceeded the lower SWQG at all six sites ranging from 22.4 mg/kg to 56.4 mg/kg.

		D/s Elkington*	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow	Lower SWQG	Upper SWQG
Nickel	mg/kg	37.1	36.7	56.4	24.6	20.6	22.4	16	75

*Sites are listed left to right in order of upstream to downstream, see Figure 1

EPH

EPH analysis indicated all values were below the minimum detection level at all sites.

PAH

Exceedances of the lower SWQG for acenaphthylene, benzo(a)pyrene and dibenz(a,h)anthracene were observed at Van Horn Creek exclusively.

PAH		D/s Elkington*	Ephem. Ck d/s Lot 23	SSC d/s Ephem. Ck	Van Horn Ck	SSC @ Sooke Rd	Shawnigan Inflow	Lower SWQG	Upper SWQG
Acenaphthylene	mg/kg	<0.0050	<0.0050	<0.0050	0.0181	<0.0050	<0.0050	0.00587	0.128
Benzo(a)pyrene	mg/kg	<0.010	<0.010	<0.010	0.063	0.016	<0.010	0.0319	0.782
Dibenz(a,h)anthrac	mg/kg	<0.0050	<0.0050	<0.0050	0.0073	<0.0050	<0.0050	0.00622	0.135

*Sites are listed left to right in order of upstream to downstream, see Figure 1

Summary

Generally in water quality analysis, it is common to see increases in the concentration of parameters from upstream to downstream locations in rivers where water flows from a less developed to more developed land base, and where tributaries contribute water which has traveled through disturbed areas of the watershed. Sediment analysis is different in that factors that affect the adsorption of metals and organics (i.e., particle size and TOC) vary throughout the creek, and sediment tends to only settle out in slow moving depositional areas. None of the parameters which exceeded the SWQGs were found to be in higher concentration at the lowermost site when compared to the uppermost site; in every case they were found to be lower (18-47%). In addition, when comparing the parameters found to exceed guidelines in sediment to the results of the second quarter independent water study, none of the parameters that exceeded SWQGs were found to exceed WQGs (note: chromium results were not included in the quarter-two report so this parameter could not be compared).

Considering each site individually and moving from upstream to downstream, the uppermost site (downstream of Elkington Forest) had minor exceedances of the lower SWQG for chromium, iron, manganese and nickel. Chromium, iron and nickel were also found to marginally exceed guidelines during MOE sediment sampling in May of 2015. Since this site is considered to represent background conditions (owing to the fact that there are few land-based operations that disturb the water in the upper watershed), the exceedances detected at this location are thought to be indicative of naturally elevated levels of these parameters. The ephemeral creek downstream of Lot 23 also had minor exceedances of the lower SWQG for iron and nickel (similar to the background site), as well as a marginal exceedance of the lower SWQG for copper and of the upper SWQG for manganese. Ground water is known to surface throughout the watershed, and has been observed at this site in particular; this may account for the elevated levels of parameters including iron and manganese which once oxidized, form a precipitate that can settle out in slow moving sections of creek targeted as part of this sampling. While there were no exceedances of copper detected as part of the quarter-two independent water study, copper is known to exceed the chronic WQG at this site as recently as October to December 2016. South Shawnigan Creek downstream of the ephemeral creek had exceedances of the lower SWQG for chromium, iron, manganese and nickel; all of which are consistent with conditions at the background site. Van Horn Creek had exceedances of the lower SWQG for iron, manganese and nickel which may be naturally elevated in the watershed, as well as acenaphthylene, benzo(a)pyrene and dibenz(a,h)anthracene. Van Horn is the only site to have exceedances of PAHs and these are consistent with previous MOE sampling at this site. The two lowermost sites (South Shawnigan Creek at Sooke Road and Shawnigan Lake inflow) both showed slight exceedances of the lower SWQG for iron and nickel, which is consistent with the uppermost, background site indicating they may be naturally elevated parameters in the watershed.

All exceedances were of the lower SWQG, except for one. These guidelines are built with Uncertainty Factors (UF) that provide a margin of safety. In cases where results are close to or just above the guideline, the UF can help to buffer against potential harm to aquatic health. In addition, it is important to consider the elevated values throughout the sites are largely consistent with those detected at the uppermost site, indicating they may be reflective of background conditions that the biological community has acclimated to. Conversely, the manganese exceedance of the upper SWQG in the ephemeral creek downstream of Lot 23, although minimal, may indicate impacts to the benthic community.

Sincerely,

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Parameter	Units	E294426_REG	E306324_REG_0	E306325_REG_0	E294424_REG_0	E306327_REG_0	1199906_REG_0	Sediment Quality Guidelines		
ALS Samle ID		L1853583	L1851581	L1851558	L1851616	L1851524	L1851599-1	**Lower SWQG*** (µg/g dry weight)	**Upper SWQG*** (µg/g dry weight)	**Reference**
Sample Date		3-Nov-2016	31-Oct-16	31-Oct-16	31-Oct-16	31-Oct-16	31-Oct-16			
Depth / Duplicate		Upper Layer	Upper Layer	Upper Layer	Upper Layer	Upper Layer	Upper Layer			
Physical Tests (Soil)		D/s Elkington	Ephem, d/s Lot 23	SSC d/s Ephem.	Van Horn Ck	SSC @ Sooke Rd	SL Inflow			
Moisture	%	20.3	25.9	18.1	19.2	21.1	22.5			
Particle Size										
Cobbles (>3in.)	%	<1.0	<1.0	<1.0	<1.0	<1.0	<1			
Gravel (4.75mm-3in.)	%	26.8	16.1	65.8	4.5	<1.0	6.5			
Coarse Sand (2.0mm-4.75mm)	%	30.8	33.9	20.0	26.7	<1.0	14.3			
Medium Sand (0.425mm-2.0mm)	%	39.5	27.4	11.0	49.5	37.5	66.1			
Fine Sand (0.075mm-0.425mm)	%	1.8	17.9	2.5	16.1	60.5	12.4			
Fines (<0.075mm)	%	1.2	4.7	<1.0	3.1	2.0	<1.0			
Organic/Inorganic Carbon (soil)										
Total Organic Carbon	%	0.646	1.64	0.897	0.367	0.376	0.144			
Total Metals										
Aluminum	mg/kg	20600	19100	20000	19100	13800	14900			
Antimony	mg/kg	0.10	0.17	<0.10	<0.10	<0.10	<0.10			
Arsenic	mg/kg	2.91	2.56	1.90	2.66	1.79	1.38	5.9	17	CCME 1998
Barium	mg/kg	52.7	44.7	32.6	47.8	35.3	30.1			
Beryllium	mg/kg	0.46	0.36	0.32	0.34	0.20	0.21			
Boron	mg/kg	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0			
Cadmium	mg/kg	0.075	0.072	0.054	0.060	0.051	0.048	0.6	3.5	CCME 1997
Calcium	mg/kg	7180	6140	5810	6400	5020	5760			
Chromium	mg/kg	38.1	32.4	59.0	35.6	33.3	31.3	37.3	90	CCME 1998
Cobalt	mg/kg	19.7	21.2	17.2	14.5	9.06	9.95			
Copper	mg/kg	32.7	36.8	26.4	28.1	20.8	17.5	35.7	197	CCME 1998
Iron	mg/kg	32600	29800	32600	31300	21700	23600	21,200 (about 2%)	43,766 (about 4%)	Jaagumagi 1993b
Lead	mg/kg	4.45	3.61	2.34	3.34	3.17	1.77	35	91	CCME 1998
Magnesium	mg/kg	10100	8790	14500	9410	7100	8240			
Manganese	mg/kg	542	1260	557	976	346	334	460	1100	Jaagumagi 1993b
Mercury	mg/kg	0.0174	0.0199	0.0094	0.0142	0.0107	0.0088	0.17	0.486	CCME 1997
Molybdenum	mg/kg	0.42	1.79	0.19	0.39	0.17	0.13			
Nickel	mg/kg	37.1	36.7	56.4	24.6	20.6	22.4	16	75	Jaagumagi 1993b
Phosphorus	mg/kg	361	344	304	430	251	261			
Potassium	mg/kg	346	393	279	373	287	259			
Selenium	mg/kg	<0.20	0.22	<0.20	<0.20	<0.20	<0.20	2[1]		
Silver	mg/kg	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.5	N/A	Ontario MOEE 1993
Sodium	mg/kg	214	191	152	170	179	194			
Strontium	mg/kg	40.0	25.7	28.6	31.5	22.0	27.3			
Tin	mg/kg	0.54	0.31	0.25	0.30	0.22	0.23			
Titanium	mg/kg	1700	1450	1590	1660	1370	1530			
Vanadium	mg/kg	84.7	81.4	78.7	87.1	64.0	67.4			
Zinc	mg/kg	49.4	42.5	47.2	59.9	46.8	40.2	123	315	CCME 1998
Hydrocarbons (Soil)										
EPH 10-19	mg/kg	<200	<200	<200	<200	<200	<200			
EPH 19-32	mg/kg	<200	<200	<200	<200	<200	<200			
LEPH	mg/kg	<200	<200	<200	<200	<200	<200			
HEPH	mg/kg	<200	<200	<200	<200	<200	<200			
Polycyclic Aromatic Hydrocabons (soil)										
Acenaphthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.00671	0.0889	CCME 1998
Acenaphthylene	mg/kg	<0.0050	<0.0050	<0.0050	0.0181	<0.0050	<0.0050	0.00587	0.128	CCME 1998
Anthracene	mg/kg	<0.0040	<0.0040	<0.0040	0.0156	0.0049	<0.0040	0.0469	0.245	CCME 1998
Benz(a)anthracene	mg/kg	<0.010	<0.010	<0.010	0.021	<0.010	<0.010	0.0317	0.385	CCME 1998
Benzo(a)pyrene	mg/kg	<0.010	<0.010	<0.010	0.063	0.016	<0.010	0.0319	0.782	CCME 1998
Benzo(b)fluoranthene	mg/kg	<0.010	<0.010	<0.010	0.061	0.027	<0.010			
Benzo(b+j+k) fluoranthene	mg/kg	<0.015	<0.015	<0.015	0.091	0.039	<0.015			
Benzo(g,h,i)perylene	mg/kg	<0.010$^{(0.17,0.21)}$	<0.010$^{(0.17, 0.52)}$	<0.010$^{(0.17,0.29)}$	0.03$^{(0.17, 12)}$	<0.010$^{(0.17, 0.12)}$	<0.010$^{(0.17, 0.05)}$	0.17	0.32[2]	Ontario MOEE 1993
Benzo(k)fluroanthene	mg/kg	<0.010$^{(0.24, 8.7)}$	<0.010$^{(0.24, 22.0)}$	<0.010$^{(0.24, 12.0)}$	0.03$^{(0.24, 4.92)}$	0.012$^{(0.24, 5.04)}$	<0.010$^{(0.24, 1.93)}$	0.24	13.4[2]	Ontario MOEE 1993
Chrysene	mg/kg	<0.010	<0.010	<0.010	0.026	<0.020	<0.010	0.0571	0.862	CCME 1998
Dibenz(a,h)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	0.0073	<0.0050	<0.0050	0.00622	0.135	CCME 1998
Fluoranthene	mg/kg	<0.010	<0.010	<0.010	0.021	<0.010	<0.010	0.111	2.355	CCME 1998
Fluorene	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0212	0.144	CCME 1998
Ideno(1,2,3-c,d)pyrene	mg/kg	<0.010$^{(0.2, 2.07)}$	<0.010$^{(0.2, 5.2)}$	<0.010$^{(0.2, 2.9)}$	0.032$^{(0.2, 1.2)}$	<0.010$^{(0.2, 1.2)}$	<0.010$^{(0.2, 0.5)}$	0.2	3.2[2]	Ontario MOEE 1993
2-Methylnaphthalene	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0202	0.201	CCME 1998
Naphthalene	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0346	0.391	CCME 1998
Phenanthrene	mg/kg	<0.010	<0.010	<0.010	0.010	<0.010	<0.010	0.0419	0.515	CCME 1998
Pyrene	mg/kg	<0.010	<0.010	<0.010	0.053	<0.010	<0.010	0.053	0.875	CCME 1998
Acenaphthene d10	%	90.6	103.5	91.2	95.2	93.1	88.8			
Chrysene d12	%	107.3	100.7	93.6	96.5	96.4	114.2			
Napthalene d8	%	88.5	103.1	92.7	94.1	93.2	97			
Phenanthrene d10	%	100.8	104.4	96.4	103.7	96.2	93.1			
B(a)P Total Potency Equivalent	mg/kg	<0.020	<0.020	<0.020	0.086	0.023	<0.020			
IACR (CCME)	mg/kg	<0.15	<0.15	<0.15	0.87	0.32	<0.15			

*Lower SWQG - a concentration that will protect aquatic life from adverse effects of toxic substance in most situations (equivalent to CCME's Threshold Effect Level or Interim Sediment Quality Guidelines (TEL or ISQS; CCME 2001)); and Upper SWQGs - a concentration that if exceeded will likely cause severe effects on aquatic life (equivalent to CCME's Probable Effect Level (PEL; CCME (2001)).

[1]Sediment alert concentration, based on weight of evidence; lowest published toxcicity thresholds, no uncertainty factor applied; insufficient data for full guidelines at this time - Updated 2014 BC Se WQG

[2]Concentrations are expressed as ug/g sediment containing 1% organic carbon. A guideline expressed as ug/g is based on the sediment as a whole and does not require adjustment for organic carbon content. Adjustments to guidelines are required when they are expressed in terms of the sediment containing 1% organic carbon. For sediments with organic carbon other than 1%, an adjustment in guidelines should be made by multiplying the guideline by the % organic carbon content of the sediment.