Carson Land Resources Management Ltd.
1861 Lower Road, Roberts Creek, B.C. V0N 2W6
Ph 604 886 3282 Email: brian_carson@dccnet.com

Haslam Lake Lang Creek Water Quality and Quantity Monitoring Program for 2009

Prepared for

Powell River Salmonid Enhancement Society.
Funded by Forest Investment Accounts (FIA)

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Report prepared by
Brian Carson, P.Geo.

Summary

The Forest Investment Accounts (FIA) has funded the Haslam –Lang Water Quality monitoring program since late summer of 2008. This report presents 2009 data and discusses progress of the water quality monitoring program to date.

As a result of late startup, only sporadic laboratory sampling was conducted from grab samples towards the end of 2008 sampling year and some water temperature data from automated data loggers. All data collection systems were operable and collection schedules working in 2009. The automated monitoring station located at the Salmon Enhancement Society Counting Station at the mouth of Lang Creek of Lang Creek has recorded stage, rainfall, turbidity, and water and air temperature on a continuous basis. The stage, water and air temperature data is reliable whereas the turbidity data demonstrated inconsistencies so as to prevent acceptance of the whole data set.

Bi-weekly on-site sampling has been carried out by the Powell River Salmonid Enhancement Society at six strategic locations within the watershed throughout the 2009 season. This data has been collected from 1997 to present with a two year gap between 2006 and 2008. The results proved useful as support data for a water quality assessment being conducted by the Powell River Community Watershed, one of the main licensees harvesting timber within the watershed.

Water temperature recorders, (TIDBITS) have been in place over the previous year including one on Anderson Creek, Duck Lake and at the sorting station at the mouth of Lang Creek. This continuous temperature data was of high quality and provided important insights into temperature fluctuations during the critical maximum high water temperatures of summer.

All water quality laboratory analysis collected representing six strategic locations within the Haslam Lang Watershed since the start of the program is presented here.

All digital data, well beyond what can be presented here, is archived with the Powell River Salmonid Enhancement Society.

Recommendations are provided to fine tune the frequency and location of sampling. Some work will be required to recalibrate the continuous turbidity meter at the mouth of Lang Creek, as it is not producing reliable data. Fine tuning of the low flow portion of the stage discharge rating curve for lower Lang Creek should be considered given its overall importance to fisheries and the Brew Bay Water Users' Group.

I. INTRODUCTION

Forest Investment Accounts (FIA) has provided funding to The Powell River Salmon Enhancement Society in 2009 to monitor water quality within the Haslam Lang Watershed. The purpose of this monitoring is to

- provide information for resource management planning and decision making at the community and regional level;
- establish baseline levels in support of specific criteria/objective development and attainment reporting;
- provide information on the status, health, trends and uses of water resources;
- employ and train persons from local communities to foster interest and involvement in community watersheds.

This report reviews the data collected during the 2009 monitoring program within the Haslam Lake and Lang Creek Community Watershed.

II. BACKGROUND

The Study Area lies immediately east of Powell River. It is confined to the drainages flowing into Haslam Lake and Lang Creek, comprising a total area of around 12,800 ha. Elevations range from sea level at the mouth of Lang Creek to 1103 meters on Tin Hat Mountain. Most of the area falls within the Coastal Western Hemlock Biogeoclimatic zone. Douglas fir, red cedar, western hemlock and alder are the most common tree species found. Along the highest ridges on the north east portion of the watershed, one encounters the Mountain Hemlock Biogeoclimatic Zone. Most of the watershed has either been logged or burned in the last 80 years although small isolated patches of old growth remain. A network of forest roads is maintained within the watershed. An even more extensive network of old skid trails occurs at lower elevations throughout the watersheds and these are now used extensively for recreation activities.

Most of the watershed (excepting land immediately adjacent to Lang Creek) is comprised of crown land. Forestry for timber extraction is likely to be the major industrial use of the watersheds for the foreseeable future. Forest Development Plans have been drawn up, indicating future cutblocks and required access roads. The Ministry of Environment, Lands and Parks, (MoELP) completed the first Coastal Watershed Assessment Procedure (CWAP) in 1997. The results from this study indicated that the forest harvesting activities planned was conservative, and unlikely to influence hydrological characteristics of the watershed. Mining does not play much of a role on the area. Small rock quarries are used for the extraction of road ballast. The interest in a large kaolin deposit along the south bank of Lang Creek appears to have lessened as preliminary results showed that the deposit was of low quality. Agriculture is restricted to a few small hobby farms along lower Lang Creek. Settlement (low density) is likewise confined to the southern strip adjacent to Lang Creek and even less so along the southern slopes of Haslam Lake. Being close to the population center of Powell River, the Haslam Lang area is popular with recreationists for hiking, mountain bike riding and non-motorized boating. Fisheries resources are substantial, particularly in the lower watershed. A large salmon population is supported along the course of Lang Creek within the lower 8 km of channel and adjacent tributaries. Major investment has been made in a fish hatchery, a counting station and an artificial spawning channel on Lang Creek. In 2000, Lang Creek was classified as a sensitive stream because of its high fisheries values. In the summer of 2000, a second Coastal Watershed Assessment Procedure (CWAP) was carried out which supported the conclusions of the first CWAP. It also stressed that good management would be more important to the continued health of the watershed than the actual amount of watershed logged or roaded.   With the recently established Community Forest positioned within the watershed area, there is renewed interest in water quality monitoring.

III. METHODOLOGY

This project was instigated to provide a continuation for a monitoring program than ran between 1997 and 2001 and restarted in 2008 within the Haslam Lang Community Watershed. Between 2001 and 2006, the Powell River Salmonid Enhancement Society maintained a small water quality data collection program on their own. The water quality data that has been collected to date provides a reliable base line documenting water quality at strategic locations within the Haslam Lang Watershed. The sites chosen for water sampling were almost the same as those developed in the original program and are located on the map on Figure 1 and the sampling schedule is presented in Table 1.

Figure 1. Location of Monitoring Stations within Haslam Lang Community Watershed

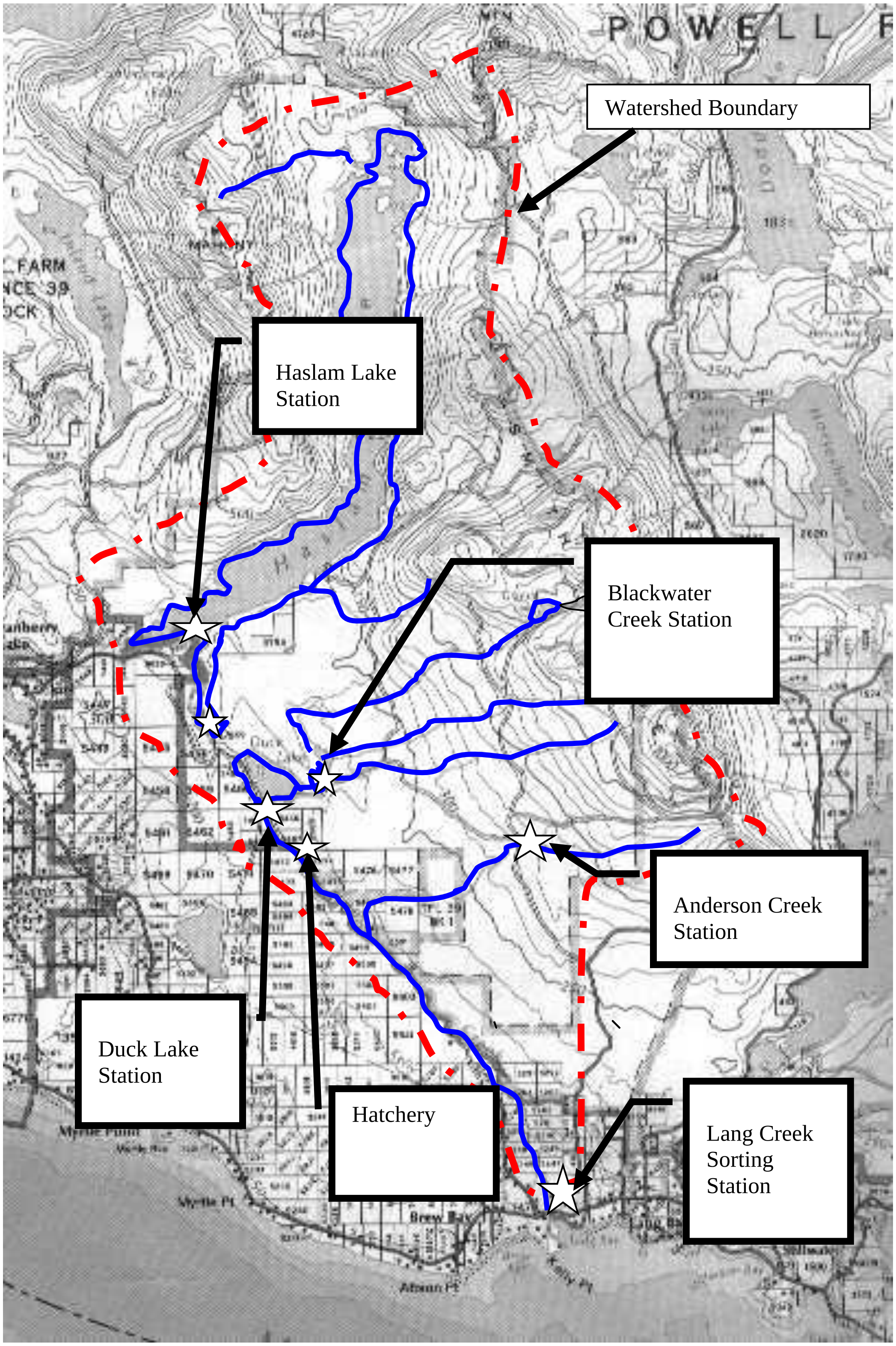


Table 1. Schedule for Monitoring Sites

Station	Sampling Interval	Sampling For
Station 1 Lang Creek Sorting Station Provincial Identification Number E220912	Continuous Biweekly Random	Water temperature, stage, air temp, rainfall Turbidity Portable meter to check on continuous recorders Complete chemical analysis (random checks)
Station 2 Anderson Creek Provincial Identification Number (4 km upstream of E220913)	Continuous Biweekly Seasonal	temperature by tidbit) Portable meter for turbidity, pH, specific conductivity, temp and discharge Complete chemical analysis
Station 3 Black Water Creek Provincial Identification Number E220914	Biweekly Random	Portable meter for turbidity, pH, specific conductivity, temp and discharge Complete chemical analysis
Station 4 Outlet of Duck Lake Provincial Identification Number E220915	Bi weekly Seasonal	Portable meter for turbidity, pH, specific conductivity, temp, and discharge Complete chemical analysis
Station 5 Upper Lang Creek Hatchery	Biweekly Seasonal	Portable meter for turbidity, pH, specific conductivity , temp, and stage Complete chemical analysis
Station 6 Haslam Lake (moved from intake to 1 km north)	Bi weekly Seasonal	Portable meter for turbidity, pH, specific conductivity ,temp Complete chemical analysis

IV. SAMPLING PROCEDURES

1. Water sampling for laboratory analyses

All grab samples used for laboratory analyses were to be taken by sampling midstream using laboratory cleaned plastic 1000 ml bottles, as long as safety permitted this. The samples taken for total metal analysis were preserved immediately by addition of 1 ml of 1 molar nitric acid into the 250-ml bottle. Other bottles were cleaned and acid washed at the lab. After collection, samples were packed in ice and air freighted to the laboratory. Six strategic sites within the watershed were sampled 10 times over 2009, five collections during various stages of winter flows and five collections during relatively low summer flow.

2. Analysis using portable meters

Biweekly analysis was measured using portable meters. Before sampling, the meters were calibrated with standard solutions following directions supplied by the meter manufacturers. Problems were encountered with calibrating both the pH readings and the salinity readings and data only became reliable towards the end of 2008.

3. Automated samplers At the Sorting Station at the mount of Lang Creek an automated stage, rainfall and turbidity recorder has been installed. Small data loggers (Tidbits $_{TM}$) were used at a number of locations throughout the watershed to record water temperature on an hourly schedule throughout the year.

V. RESULTS AND DISCUSSION

Below is a discussion of water quality parameters that were collected during the course of the monitoring program. Not all data is presented here because of the amount of detail. Some parameters were collected on a 15 minute interval, others hourly over the whole year. All of the original digital information used to develop these figures and tables is available at the Powell River Salmon Enhancement Society office.

A. Laboratory Results: Water Chemistry and Biology

1. Standard Water Quality

On Tables 2 and 3 water quality data is presented from laboratory analysis of grab samples taken 10 times at 6 locations throughout the watershed in 2009. It was noted that no sampling was conducted while Lang Creek was undergoing turbidity events. This is unfortunate because a number of other water quality characteristics vary with turbidity and these are of primary interest to water purveyors.

Most of the routine chemistry samples fell within the range that has been established with past monitoring. Blackwater Creek has the highest organic carbon and colour throughout the year. Blackwater Creek also showed consistently the highest levels of calcium, while of no concern to water quality, reflects that the Duck Lake Main FRS running alongside of Blackwater Creek was surfaced with limestone and has been treated with a dust- reducing compound.

Table 2. Water Chemistry Winter 2009

		Lang Creek Lower E230912	Anderson Creek E230913	Blackwater Creek E230914	Duck Lake Outlet E230915	Lang Creek Upper E230916	Haslam Lake E230917
4-Feb-09							
Total Organic Carbon (C)	mg/L	2.0	3.6	3.4	2.2	1.9	1.8
True Colour	Col. Unit	5	10	15	10	5	<5
pH	pH Units	7.0	6.8	7.0	6.9	7.1	7.0
Turbidity	NTU	0.4	0.2	0.3	0.3	0.2	0.3
10-Feb-09							
Total Hardness (CaCO3)	mg/L	7.8	5.7	8.2	7.3	7.8	8.3
Total Organic Carbon (C)	mg/L	2.8	3.8	3.9	3.1	1.9	2.5
True Colour	Col. Unit	5	15	15	10	5	5
pH	pH Units	7.1	6.9	7.1	7.0	7.1	7.0
Turbidity	NTU	0.3	0.2	0.3	0.4	0.2	11.4
17-Feb-09							
Total Hardness (CaCO3)	mg/L	8.0	6.5	9.4	7.4	8.0	8.0
Total Organic Carbon (C)	mg/L	2.0	3.6	3.9	4.0	3.0	<0.5
True Colour	Col. Unit	5	5	10	10	5	<5
pH	pH Units	7.1	7.0	7.1	7.0	7.0	7.1
Turbidity	NTU	0.2	0.2	0.3	0.4	0.4	0.4
24-Feb-09							
Total Hardness (CaCO3)	mg/L	7.8	5.5	1190	6.6	7.5	7.2
Total Organic Carbon (C)	mg/L	3.4	5.5	6.6	2.4	2.1	1.5
True Colour	Col. Unit	<5	5	15	<5	<5	<5
pH	pH Units	7.1	6.7	6.8	7.0	7.0	7.2
Turbidity	NTU	0.4	0.3	0.3	0.3	0.2	0.5
3-Mar-09							
Total Organic Carbon (C)	mg/L	3.2	5.9	6.2	3.1	2.7	1.4
True Colour	Col. Unit	10	15	15	<5	<5	<5
pH	pH Units	7.1	6.7	6.8	7.0	7.0	7.1
Turbidity	NTU	0.8	0.3	0.3	0.4	0.4	0.4

Table 3. Water Chemistry Summer 2009

		Lang Creek Lower E230912	Anderson Creek E230913	Blackwater Creek E230914	Duck Lake Outlet E230915	Lang Creek Upper E230916	Haslam Lake E230917
27-Aug-09							
Total Hardness (CaCO3)	mg/L	9.8	10.5	12.4	7.3	6.6	7.0
Total Organic Carbon (C)	mg/L	1.7	2.2	3.2	3.8	2.5	1.8
True Colour	Col. Unit	10	10	30	10	10	5
pH	pH Units	7.2	7.2	7.3	7.1	7.1	7.2
Turbidity	NTU	0.4	0.4	1.4	0.6	0.3	0.5
2-Sep-09							
Total Hardness (CaCO3)	mg/L	NA	11.6	14.1	7.3	7.4	7.5
Total Organic Carbon (C)	mg/L	NA	1.9	3.1	3.2	2	0.8
True Colour	Col. Unit	NA	5	30	5	5	<5
pH	pH Units	NA	7.3	7.4	7.2	7.2	7.3
Turbidity	NTU	NA	0.3	1.1	0.8	0.6	0.3
10-Sep-09							
Total Hardness (CaCO3)	mg/L	9.2	7.4	9.8	7.7	7.8	7.9
Total Organic Carbon (C)	mg/L	3.3	5.5	5.9	2.3	3.5	1.8
True Colour	Col. Unit	20 (1)	20 (1)	30 (1)	15 (1)	15 (1)	<5 (1)
pH	pH Units	7.2	6.9	6.9	7.2	7.2	7.2
Turbidity	NTU	1.5	0.3	0.4	0.5	0.5	0.3
14-Sep-09							
Total Hardness (CaCO3)	mg/L	9.8	8.3	12.8	8	8.1	7.7
Total Organic Carbon (C)	mg/L	3	3.2	3.6	3.2	3	1.6
True Colour	Col. Unit	5	10	15	10	5	<5
pH	pH Units	7.1	7	7.4	7.2	7.2	7.2
Turbidity	NTU	0.4	<0.1	0.3	0.4	0.4	0.3
17-Sep-09							
Total Hardness (CaCO3)	mg/L	10.7	9	17	15.9	8.6	8.5
Total Organic Carbon (C)	mg/L	2.9	2.4	3.6	3	2.9	1.6
True Colour	Col. Unit	15	<5	30	10	5	<5
pH	pH Units	7.3	7.1	6.9	7.2	7.1	7.6
Turbidity	NTU	0.4	0.1	0.4	0.5	0.3	0.3

2. Laboratory Results: Total Metals

Total metal data is presented in the Annex. No significant anomalies are noted in this data set. Phosphorous levels are below the detectable limit (10ppb) for most winter samples and just above the detectable limit for summer samples.

3. Laboratory Results: Fecal Coliform

Fecal coliform data collected in 2009 is presented below on Table 4 and 5. Past records show the lower Lang Creek with consistently the highest fecal coliform readings taken at the sampling sites throughout the watershed. The Lower Lang Creek samples are still consistent with historic relatively high values. Two important anomalies were noted. The sample site on Haslam Lake, one km north of the intake, had the highest fecal coliform rating of any site though out the whole winter sampling period (with a minimum fecal count of 37 and maximum of 550. (Summer levels were reassuringly 2 orders of magnitude lower) While there is not likely any means for transport between this site and the Powell River Intake on Haslam Lake, this high rate of contamination of Haslam Lake is disturbing none the less. Whether the contamination source originates with wildlife or recreationist should be determined.

Blackwater Creek also showed very high fecal contamination throughout the summer of 2009. Again the reason why this was so was not discovered but would have to be related, as in the last case, to wildlife and or recreationist activity.

Table 4 Fecal Coliform within Haslam Lang Watershed (Winter 2009)

	Lang Creek Lower E230912	Anderson Creek E230913	Blackwater Creek E230914	Duck Lake Outlet E230915	Lang Creek Upper E230916	Haslam Lake E230917
Date of sampling	Fecal Coliform (Col/100mL)	Fecal Coliform (Col/100mL)	Fecal Coliform (Col/100mL)	Fecal Coliform (Col/100mL)	Fecal Coliform (Col/100mL)	Fecal Coliform (Col/100mL)
4-Feb-09	10	< 1	< 1	< 1	< 1	57
10-Feb-09	2	< 1	1	< 1	1	550
17-Feb-09	1	< 1	< 1	< 1	< 1	67
24-Feb-09	25	1	2	1	2	37
3-Mar-09	4	1	3	4	1	77

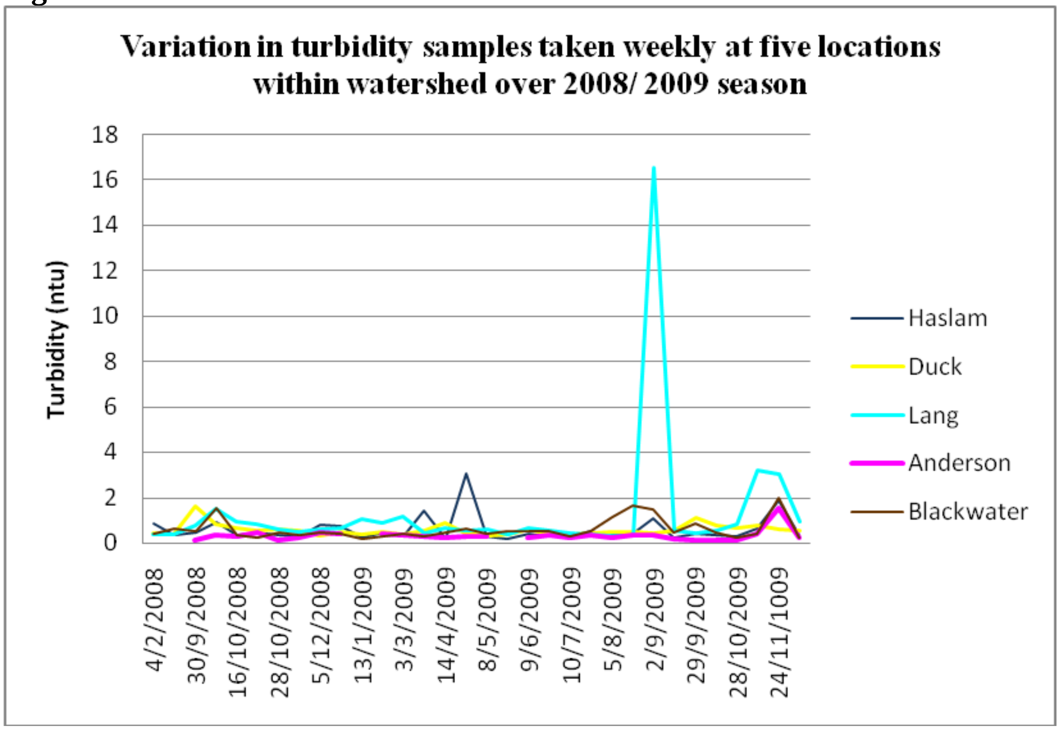
Table 5. Fecal Coliform within Haslam Lake Watershed (Summer 2009)

	Lower Lang	Anderson	Blackwater	Duck Lake	Upper Lang	Haslam Lake
Date of Sampling	Fecal Col./100 mL	Fecal Col./100 mL	Fecal Col./100 mL	Fecal Col./100 mL	Fecal Col./100 mL	Fecal Col./100 mL
08/27/2009	15	2	140	1	1	2
09/02/2009	100	2	800	< 1	12	<1
09/10/2009	280	22	150	11	8	5
09/14/2009	95	4	270	8	9	1
09/17/2009	200	3	620	3	35	2

B. Field Sample Results measured with Portable Meter

On Figure 2 all weekly turbidity samples collected are presented for 2009. Generally, turbidities at all stations are less than 1 NTU although occasional turbidity peaks are on Lang Creek. This general absence of turbidity events, in part, may be a result of lower intensity of sampling during storm events. The small but apparent turbidity events recorded on Haslam Lake were the result of wave action on the beach during a north wind.

Figure 2



On Figure 3 only the head waters and mouth of Lang Creek are presented. It is apparent that the turbidity events occuring at the mouth of Lang Creek were generated along the channel of the Lang Creek and its tibutaries and not upstream of Duck lake which acts as an effective buffer. Although Black water Creek generated some turbid water, it was not transported as far as the Duck Lake outlet. It was learned that the sampling location forHaslam Lake itself was changed from the pier at the Powell River to an area used informally as a public boat launch more than 1 km away from the intake. Because of the distance and lack of any current that might move turbidity plumes, this site cannot be used as representative of the Powell River intake. It does give a reasonable assessment of a lake shore area with moderate use by recreationists.

Figure 3

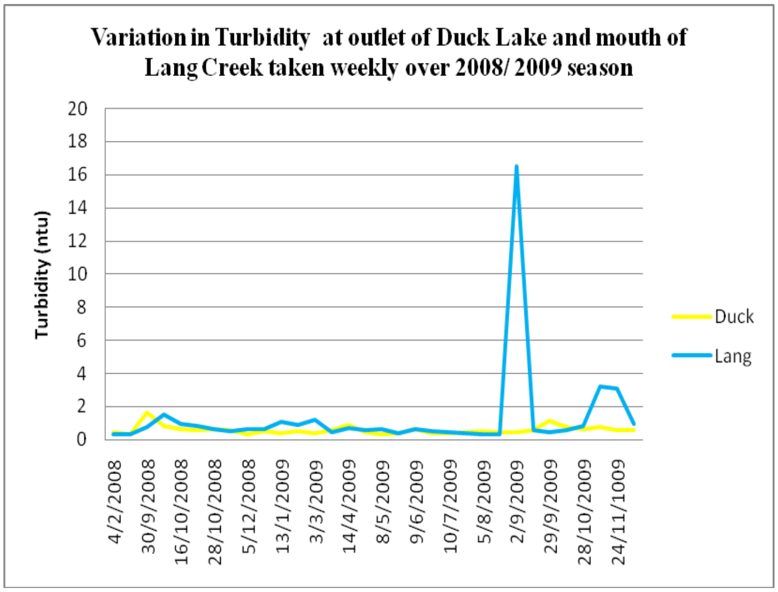


Figure 4 and 5 are of interest also becausethey show that Anderson Creek usually has a lower turbidity that the main stem of Lang Creek but occasionally has a a turbidity spike that may be felt at the mouth of Lang Creek. For these reasons , all streams in direct connection with Lang Creek are considered to be highly sensitive . As in the other sampling areas, there was no observable differences noted in water quality at the sampling locations between 1997-2001 and 2008-2009.

Figure 4

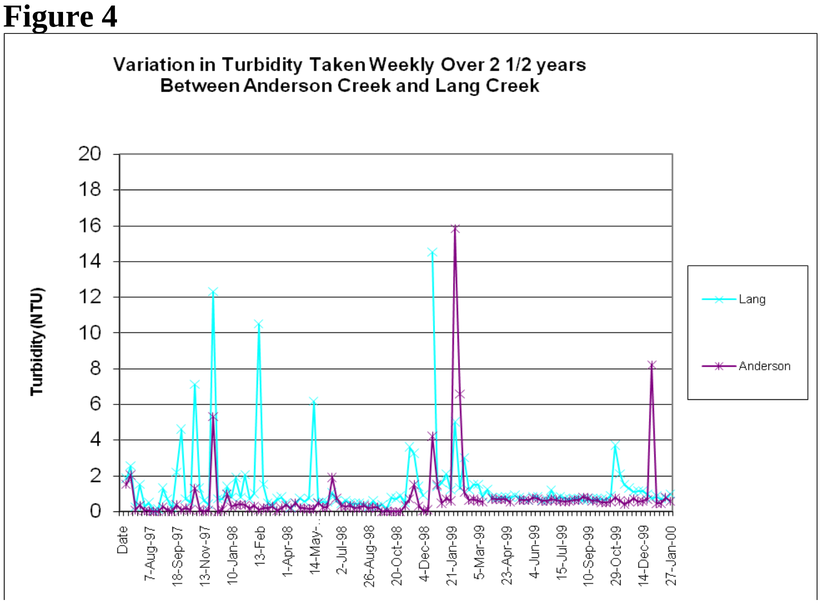
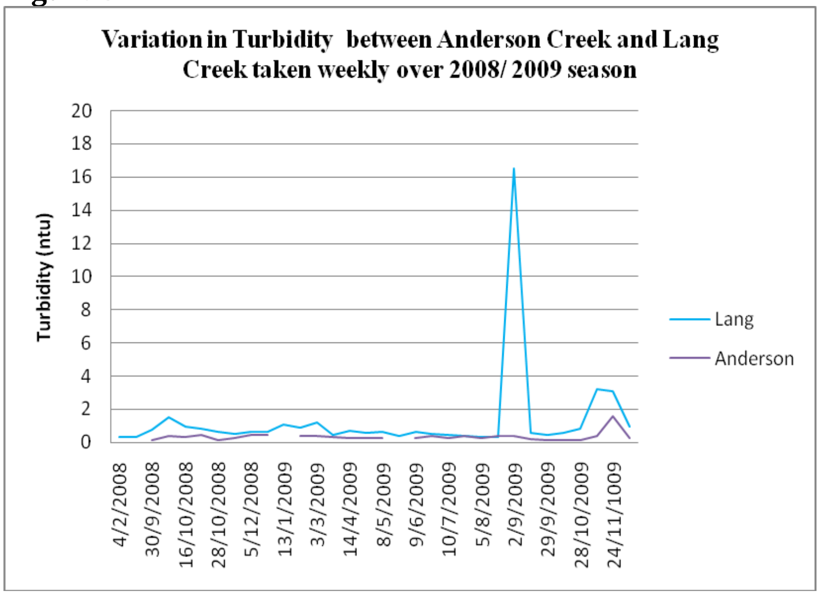


Figure 5



C. Water Temperature Monitoring Results

Figure 6 provides daily mean temperatures from air and water collected from the Sorting Station on lower Lang Creek over 2009.

Figure 6

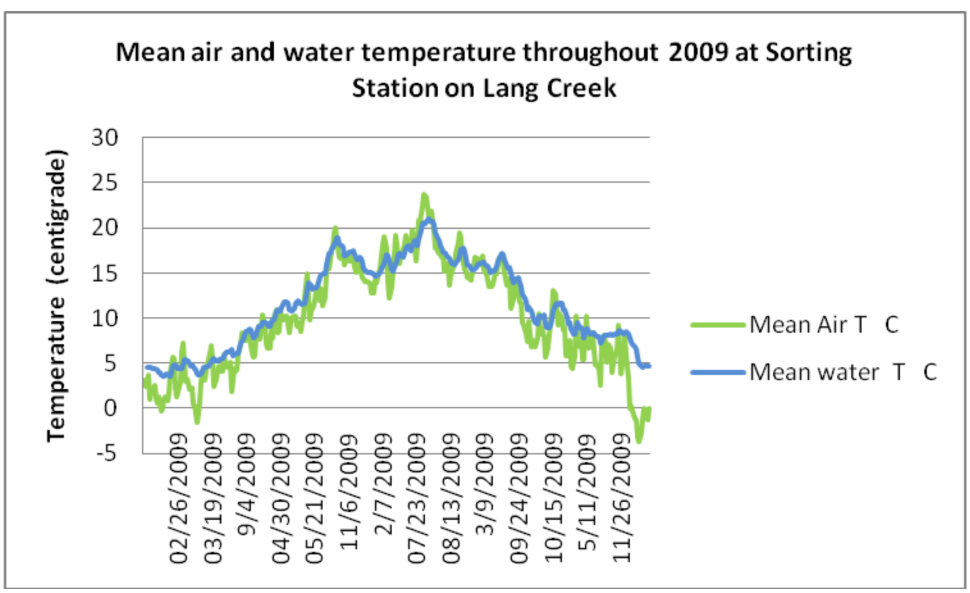


Figure 7 presents hourly temperature data from Sorting Station at the mouth of Lang Creek over the warmest period of the summer (July 24 through August 5 2009. Note the diurnal flux of 3 degrees and a peaking out at 23 º C on July 28-30.

Figure 7

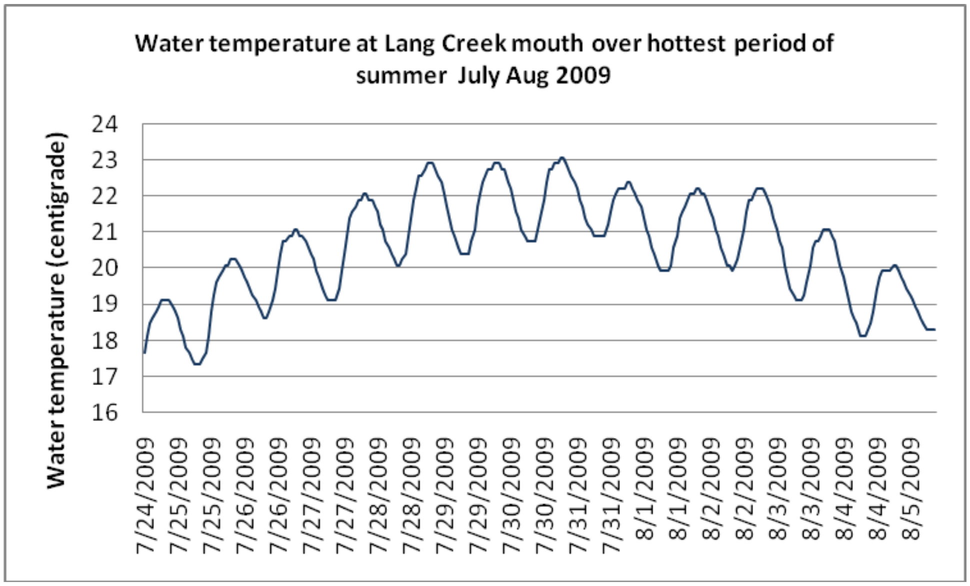
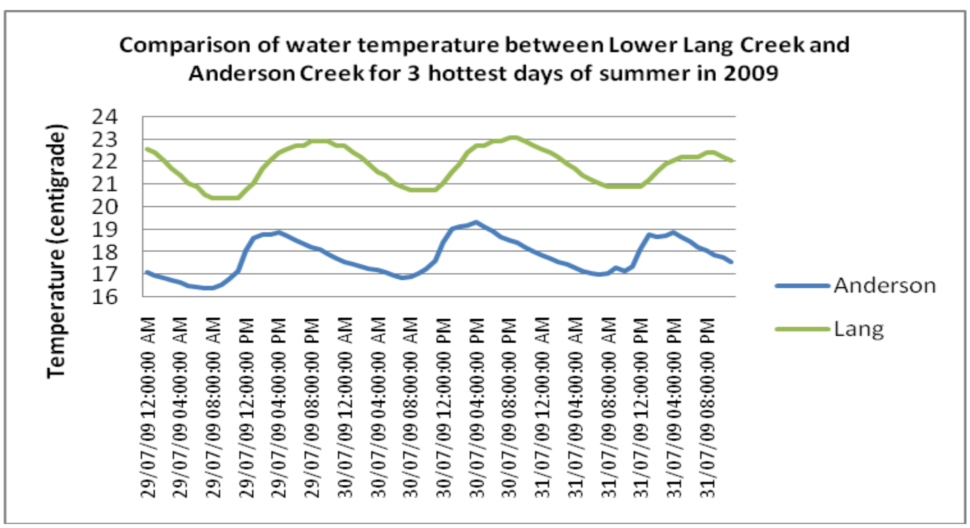


Figure 8 is of interest because it confirms the importance of Anderson Creek as a refuge for resident fish Coho during the time when temperatures might otherwise be lethal along the main channel of Lang Creek. Temperatures of Anderson Creek are consistently 4 degrees centigrade lower during these critical warm periods. The difference in shape of the two curves is also of interest. Anderson Creek warms up more quickly and reaches its peak temperature long before the Lang Creek Channel . A careful review of this sort of data can help when designing riparian leave strips for shade.

Figure 8

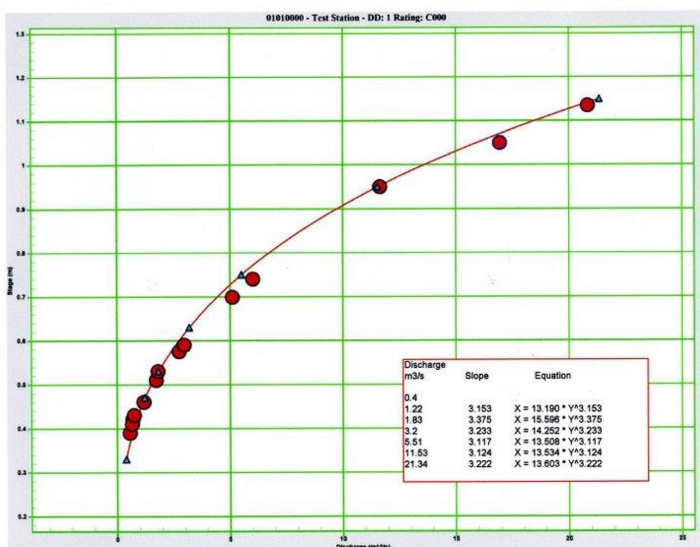


Digital data logger information is also available for a number of other smaller streams with the Haslam Lang Watershed and can be processed and presented as charts if required.

D. Discharge of Lang Creek over 2009 Season

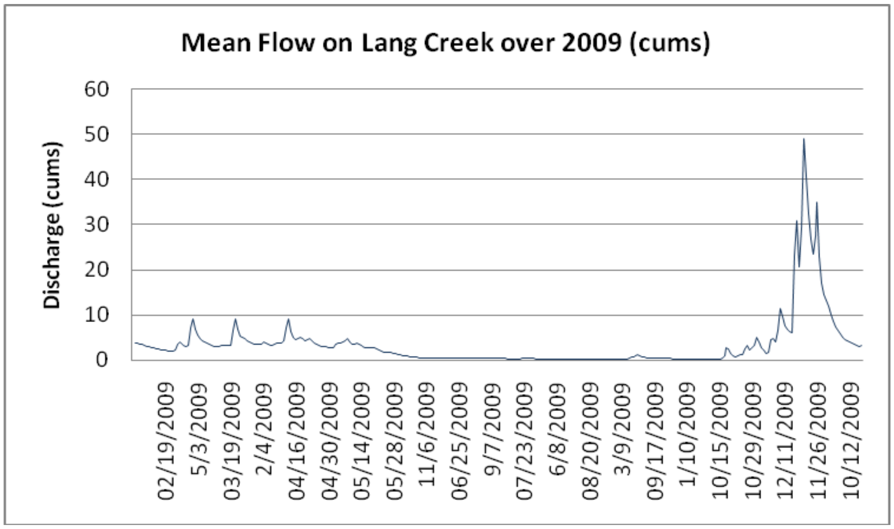
The original stage discharge curve developed for Lang Creek is presented on Figure 9. It is assumed that the configuration of the channel bed has not changed drastically when this original curve was constructed and higher flows should be relatively good. However, there may need to be some fine tuning at the low flow stages where small changes in the channel configuration resulting from winter storm flow can result in proportionally larger changes in the stage-discharge curve.

Figure 9. Stage Discharge Curve for Lower Lang Creek



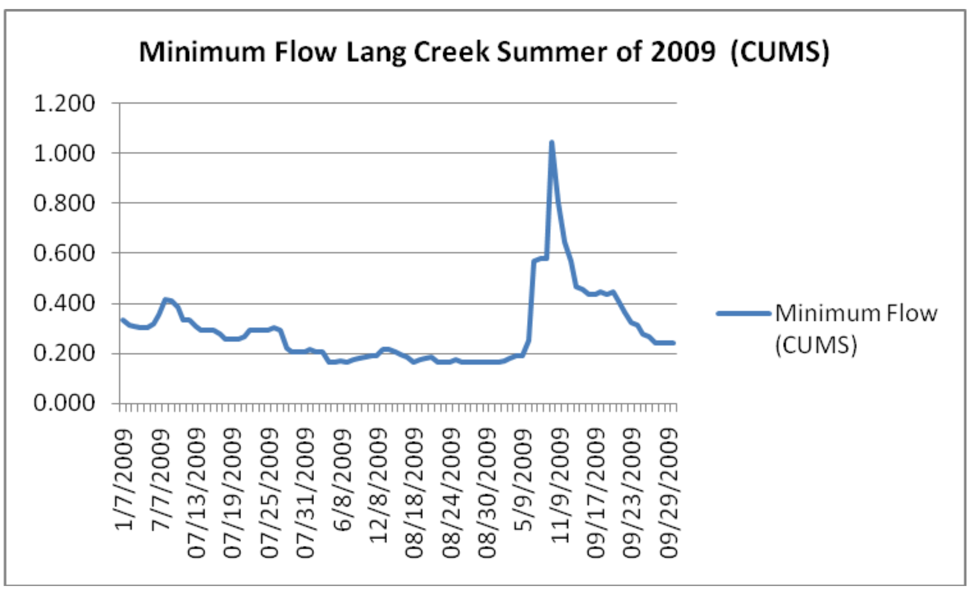
On Figure 10 the hydrograph showing mean daily flow over (Feb 6 through Dec 15, 2009. This hydrograph is similar to previous years with a mean daily average flow of 3.4 m^3/sec and a peak of 48 m^3/sec and a minimum of 0.2 m^3 /sec. This minimum is considerably below the value set by Department of Fisheries and Oceans when the original weir was installed. Spring runoff out of Haslam Lake was complete by early June and did not begin to flow over the weir until mid November. As has been stated in other studies on water quantity on Lang Creek, the importance of management of discharge through the sluice gate and over the weir itself cannot be overstated.

Figure10



On Figure 11 the critical low flow period July 1 through September 10, 2009 on lower Lang Creek is presented. Because this has a profound effect on returning salmon and survival of resident fish within Lang Creek it is important that this data is a precise as possible when managing summer discharge from the Haslam weir.

Figure 11



VI. RECOMMENDATONS FOR 2010 SAMPLING YEAR

The 2009 season was successful at collecting high quality data and the Powell River Salmon Enhancement Society should be commended for a job well done as a volunteer organization. There are opportunities for improvement that could be considered. These include:

1. Re-build stage discharge flow for low flows at the Lang Creek Sorting Station (i.e. with flows less than 1 m^3/sec). This is a relatively easy process and can be done by a non specialist. Once properly calibrated, it would be useful and interesting to compare discharge measured at the Powell River Weir on Haslam Lake with that measured at the Sorting Station at the mouth of Lang Creek. Precise data will be very important when discussing management of the weir with Powell River District.

2. Repair and recalibrate the continuous turbidity probe at the Sorting Station on Lang Creek. If budgets are not available to do so, the turbidity probe should be decommissioned.

3. When conducting biweekly sampling at strategically located stations throughout the watershed ensure that a portion are collected during storm conditions so that more turbid events can be recorded. Using only fair weather recordings are not as useful for calibrating human effects on watersheds. This is particularly so for portioning the relative importance of road generated sediment.

4. When collecting laboratory samples select specifically for special hydrologic events within the watershed as was done in the 1997 to 2001 data series. This would permit a better understanding of the reasons for variation of individual water quality parameters. At a minimum the samples should include 5 stations- Lang Sorting Station, headwaters of Lang Creek (Duck Lake outlet), Anderson Creek, Blackwater Creek and Haslam Lake. Either the hatchery sample or the Duck Lake sample could be discontinued as both reflect water quality at the head of Lang Creek. If there are budget constraints, the future collection of only one sample per specific event would reduce laboratory costs by more than 50 % while providing better information than from the present sampling regime. Events to be targeted for sampling include:

- Summer low flow. (late August)
- Summer flow after major rain storm
- First major autumn storms exhibiting substantial increases in discharge on Lang Creek (flushing of organics) with turbidity event on Lang Creek
- Winter peak flow on Lang Creek (turbid with discharge of >10 m^3/sec)
- Winter low flow (after period of extended cold temperatures)
- Spring runoff (with discharge of Lang Creek around 5 m^3)

5. Change location of Haslam Lake Sampling site as it does not represent normal conditions on the lake itself. The localized turbidity events appear to be the result of local wind generated wave action on a beach that is disturbed by boaters. The very high fecal coliform count observed in the winter season of 2009 is probably a result of heavy local use by residents and domestic animals and also does not reflect conditions over the lake as a whole.

ANNEX

Table A. Total Metals. Lower Lang Creek for winter and summer season 2009

Lower Lang Creek

Total Metals by ICPMS		27-Feb-09	17-Feb-09	10-Feb-09	27-Aug-09	2-Sep-09	10-Sep-09	14-Sep-09	17-Sep-09
Total Aluminum (Al)	ug/L	109	51	77	33	21	24	20	22
Total Antimony (Sb)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Barium (Ba)	ug/L	3	3	3	2	2	2	2	2
Total Beryllium (Be)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Boron (B)	ug/L	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.04	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01
Total Chromium (Cr)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Cobalt (Co)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	ug/L	0.9	0.4	0.5	0.4	0.6	0.4	0.5	0.5
Total Iron (Fe)	ug/L	83	53	55	30	19	16	16	22
Total Lead (Pb)	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Manganese (Mn)	ug/L	3	2	2	1	<1	<1	<1	<1
Total Molybdenum (Mo)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	ug/L	<1	<1	<1	<1	<1	9	<1	<1
Total Phosphorus (P)	ug/L	<10	<10	<10	13	16	14	18	<10
Total Selenium (Se)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Silicon (Si)	ug/L	3130	3320	3530	2590	2560	2770	2460	2620
Total Silver (Ag)	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Strontium (Sr)	ug/L	13	12	11	11	11	11	11	11
Total Tin (Sn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Titanium (Ti)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Vanadium (V)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Zinc (Zn)	ug/L	<5	<5	<5	<5	<5	<5	14	<5
Total Calcium (Ca)	ug/L	2.35	2.38	2.36	2.13	2.28	2.34	2.35	2.63
Total Magnesium (Mg)	ug/L	0.47	0.49	0.46	0.41	0.45	0.49	0.45	0.47
Total Potassium (K)	ug/L	0.21	0.22	0.21	0.22	0.24	0.25	0.24	0.25
Total Sodium (Na)	ug/L	1.66	1.68	1.61	1.32	1.50	1.63	1.43	1.44
Total Sulphur (S)	mg/L	<3	<3	4	<3	<3	<3	<3	<3

Table B. Total Metals. Anderson Creek for winter and summer season 2009

Anderson Creek

Total Metals by ICPMS		27-Feb-09	17-Feb-09	10-Feb-09	27-Aug-09	2-Sep-09	10-Sep-09	14-Sep-09	17-Sep-09
Total Aluminum (Al)	ug/L	275	126	172	49	49	244	102	87
Total Antimony (Sb)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.1	0.1
Total Barium (Ba)	ug/L	3	2	2	4	5	3	3	3
Total Beryllium (Be)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Boron (B)	ug/L	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.03	0.04	0.04	0.12	0.04	<0.01	<0.01	<0.01
Total Chromium (Cr)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Cobalt (Co)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	ug/L	0.9	0.6	0.5	0.6	0.6	0.9	0.7	0.5
Total Iron (Fe)	ug/L	64	18	25	9	13	45	14	12
Total Lead (Pb)	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3
Total Manganese (Mn)	ug/L	1	<1	<1	<1	<1	1	<1	<1
Total Molybdenum (Mo)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Phosphorus (P)	ug/L	<10	<10	<10	13	18	24	15	<10
Total Selenium (Se)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Silicon (Si)	ug/L	2380	3590	3400	5100	5360	3320	4480	4040
Total Silver (Ag)	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Strontium (Sr)	ug/L	8	8	7	17	17	10	11	13
Total Tin (Sn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Titanium (Ti)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Vanadium (V)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Zinc (Zn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Calcium (Ca)	ug/L	1.60	1.98	1.73	3.25	3.55	2.21	2.55	2.79
Total Magnesium (Mg)	ug/L	0.37	0.37	0.34	0.58	0.65	0.45	0.48	0.50
Total Potassium (K)	ug/L	0.07	0.08	0.07	0.23	0.28	0.10	0.13	0.17
Total Sodium (Na)	ug/L	1.47	1.31	1.19	2.38	2.79	1.52	1.78	1.83
Total Sulphur (S)	mg/L	<3	<3	4	<3	<3	<3	<3	<3

Table C. Total Metals. Blackwater Creek for winter and summer season 2009

Blackwater Creek

Total Metals by ICPMS		17-Feb-09	10-Feb-09	27-Aug-09	2-Sep-09	10-Sep-09	14-Sep-09	17-Sep-09
Total Aluminum (Al)	ug/L	111	155	94	90	235	100	107
Total Antimony (Sb)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	<0.1	<0.1	0.3	0.3	0.1	0.2	0.2
Total Barium (Ba)	ug/L	3	3	6	7	5	5	8
Total Beryllium (Be)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Boron (B)	ug/L	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.05	0.03	0.07	0.03	<0.01	<0.01	<0.01
Total Chromium (Cr)	ug/L	<1	<1	<1	<1	<1	<1	<1
Total Cobalt (Co)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	ug/L	0.5	2.5	0.4	0.5	0.8	0.5	0.8
Total Iron (Fe)	ug/L	92	91	580	626	130	218	331
Total Lead (Pb)	ug/L	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2
Total Manganese (Mn)	ug/L	3	3	9	10	6	6	12
Total Molybdenum (Mo)	ug/L	1	1	4	4	<1	2	4
Total Nickel (Ni)	ug/L	<1	<1	<1	<1	<1	<1	<1
Total Phosphorus (P)	ug/L	<10	<10	12	16	18	15	<10
Total Selenium (Se)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Silicon (Si)	ug/L	4470	4390	4650	4800	3630	4800	5020
Total Silver (Ag)	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Strontium (Sr)	ug/L	12	10	19	20	13	17	23
Total Tin (Sn)	ug/L	<5	<5	<5	<5	<5	<5	<5
Total Titanium (Ti)	ug/L	<5	<5	<5	<5	<5	<5	<5
Total Vanadium (V)	ug/L	<5	<5	<5	<5	<5	<5	<5
Total Zinc (Zn)	ug/L	<5	<5	<5	<5	<5	<5	<5
Total Calcium (Ca)	ug/L	2.95	2.60	3.94	4.51	3.05	4.10	5.51
Total Magnesium (Mg)	ug/L	0.48	0.42	0.61	0.68	0.52	0.62	0.78
Total Potassium (K)	ug/L	0.16	0.16	0.32	0.36	0.19	0.26	0.34
Total Sodium (Na)	ug/L	1.74	1.56	2.58	2.83	1.70	2.21	2.56
Total Sulphur (S)	mg/L	3	4	<3	<3	<3	<3	<3

Table D. Total Metals. Duck Lake for winter and summer season 2009

Duck Lake									
Total Metals by ICPMS		24-Feb-09	17-Feb-09	10-Feb-09	27-Aug-09	2-Sep-09	10-Sep-09	14-Sep-09	17-Sep-09
Total Aluminum (Al)	ug/L	63	83	101	37	34	35	43	83
Total Antimony (Sb)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.1	0.1
Total Barium (Ba)	ug/L	3	3	3	2	2	3	3	14
Total Beryllium (Be)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Boron (B)	ug/L	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.07	0.09	0.16	<0.01	<0.01	<0.01	<0.01	0.03
Total Chromium (Cr)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Cobalt (Co)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	ug/L	0.6	0.6	0.6	0.7	0.5	0.4	0.6	0.8
Total Iron (Fe)	ug/L	51	62	78	141	108	132	168	235
Total Lead (Pb)	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Manganese (Mn)	ug/L	2	2	3	6	5	7	7	44
Total Molybdenum (Mo)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Phosphorus (P)	ug/L	<10	<10	<10	13	16	16	12	54
Total Selenium (Se)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Silicon (Si)	ug/L	2630	3160	3480	1770	1620	1780	2010	1760
Total Silver (Ag)	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Strontium (Sr)	ug/L	10	10	9	12	12	12	12	29
Total Tin (Sn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Titanium (Ti)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Vanadium (V)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Zinc (Zn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Calcium (Ca)	ug/L	2.00	2.24	2.23	2.20	2.14	2.24	2.39	5.28
Total Magnesium (Mg)	ug/L	0.40	0.43	0.43	0.45	0.46	0.52	0.49	0.65
Total Potassium (K)	ug/L	0.17	0.18	0.20	0.20	0.21	0.22	0.21	3.24
Total Sodium (Na)	ug/L	1.31	1.43	1.46	1.53	1.64	1.76	1.70	2.09
Total Sulphur (S)	mg/L	<3	<3	4	<3	<3	<3	<3	<3

Table E. Total Metals. Upper Lang Creek for winter and summer season 2009

Upper Lang Creek										
Total Metals by ICPMS		24-Feb-09	17-Feb-09	10-Feb-09	27-Aug-09	2-Sep-09	10-Sep-09	14-Sep-09	17-Sep-09
Total Aluminum (Al)	ug/L	29	34	54	28	24	29	31	29
Total Antimony (Sb)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1
Total Barium (Ba)	ug/L	3	3	3	2	2	3	2	3
Total Beryllium (Be)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Boron (B)	ug/L	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	<0.01	0.02	0.38	0.04	<0.01	<0.01	<0.01	<0.01
Total Chromium (Cr)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Cobalt (Co)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	ug/L	0.7	0.6	0.7	0.5	0.4	0.4	1.0	0.5
Total Iron (Fe)	ug/L	31	32	40	96	84	110	164	122
Total Lead (Pb)	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Manganese (Mn)	ug/L	2	2	2	2	2	2	3	3
Total Molybdenum (Mo)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Phosphorus (P)	ug/L	<10	12	<10	13	15	21	17	<10
Total Selenium (Se)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Silicon (Si)	ug/L	2840	3280	3420	2520	2490	2780	2800	2610
Total Silver (Ag)	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Strontium (Sr)	ug/L	11	11	11	11	12	12	13	13
Total Tin (Sn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Titanium (Ti)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Vanadium (V)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Zinc (Zn)	ug/L	<5	<5	5	<5	<5	<5	<5	<5
Total Calcium (Ca)	ug/L	2.24	2.41	2.34	1.95	2.19	2.26	2.38	2.61
Total Magnesium (Mg)	ug/L	0.45	0.48	0.47	0.42	0.47	0.53	0.53	0.50
Total Potassium (K)	ug/L	0.22	0.24	0.25	0.19	0.22	0.23	0.24	0.24
Total Sodium (Na)	ug/L	1.47	1.58	1.57	1.39	1.54	1.68	1.69	1.51
Total Sulphur (S)	mg/L	<3	<3	5	<3	<3	<3	<3	<3

Table F. Total Metals. Haslam Lake for winter and summer season 2009

Haslam Lake

Total Metals by ICPMS		**24-Feb-09**	**17-Feb-09**	**10-Feb-09**	27-Aug-09	2-Sep-09	10-Sep-09	14-Sep-09	17-Sep-09
Total Aluminum (Al)	ug/L	24	28	918	33	21	24	20	22
Total Antimony (Sb)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Barium (Ba)	ug/L	2	3	5	2	2	2	2	2
Total Beryllium (Be)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Boron (B)	ug/L	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	<0.01	0.02	0.33	0.02	0.02	<0.01	<0.01	<0.01
Total Chromium (Cr)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Cobalt (Co)	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	ug/L	0.4	0.7	2.4	0.4	0.6	0.4	0.5	0.5
Total Iron (Fe)	ug/L	21	18	1050	30	19	16	16	22
Total Lead (Pb)	ug/L	<0.2	<0.2	1.4	<0.2	<0.2	<0.2	<0.2	<0.2
Total Manganese (Mn)	ug/L	<1	1	5	1	<1	<1	<1	<1
Total Molybdenum (Mo)	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	ug/L	<1	<1	<1	<1	<1	9	<1	<1
Total Phosphorus (P)	ug/L	<10	17	20	13	16	14	18	<10
Total Selenium (Se)	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Silicon (Si)	ug/L	2610	3150	3910	2590	2560	2770	2460	2620
Total Silver (Ag)	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Strontium (Sr)	ug/L	11	11	12	11	11	11	11	11
Total Tin (Sn)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Titanium (Ti)	ug/L	<5	<5	19	<5	<5	<5	<5	<5
Total Vanadium (V)	ug/L	<5	<5	<5	<5	<5	<5	<5	<5
Total Zinc (Zn)	ug/L	<5	<5	<5	<5	<5	<5	14	<5
Total Calcium (Ca)	ug/L	2.18	2.44	2.48	2.13	2.28	2.34	2.35	2.63
Total Magnesium (Mg)	ug/L	0.42	0.47	0.50	0.41	0.45	0.49	0.45	0.47
Total Potassium (K)	ug/L	0.21	0.26	0.29	0.22	0.24	0.25	0.24	0.25
Total Sodium (Na)	ug/L	1.35	1.51	1.58	1.32	1.50	1.63	1.43	1.44
Total Sulphur (S)	mg/L	<3	<3	4	<3	<3	<3	<3	<3