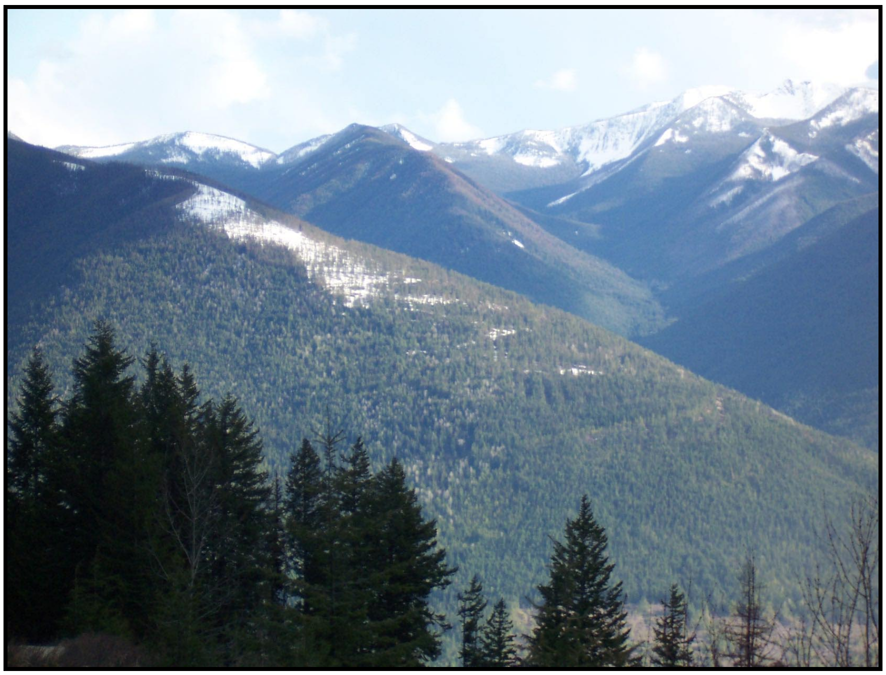
Water Quality Update for Harrop (Mill) and Narrows creeks for 2009



View of East Harrop Creek photo provided by E. Leslie

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ACKNOWLEDGEMENTS

Leeza Trione, a local resident, conducted the recent water quality sampling and water level measurements. Jennifer and Tony Yeow of Passmore Laboratory Ltd. designed the sampling program, conducted laboratory analyses of turbidity, total suspended-sediment, conductivity, fecal coliforms and sampled macroinvertebrates. Tony Yeow of Passmore Laboratory Ltd. installed and maintained the stream gauge. He also carried out the stream metering, and completed stage-discharge curve calculations and corrections.

Darcie Quamme of Integrated Ecological Research conducted project management, data analysis and reporting. Special thanks are extended to Erik Leslie for contract monitoring and his support of the program. Contact information is provided in Appendice 5.1.

1 INTRODUCTION

The Harrop-Procter Community Co-operative (HPCC) manages a Community Forest License in the Kootenay Lake Forest District of the Southern Interior Forest Region. A community-based water-monitoring program was initiated in 1999 in order to assess drinking water quality within the Harrop and Narrows watersheds. These creeks are important because they supply domestic and irrigation water to numerous local water licensees. Narrows Creek was established as a control for water quality monitoring because originally timber harvest had not occurred within this watershed. Monitoring of Harrop Creek (also known as Mill Creek) was added to the program in 2002 because half of the planned forest development was to occur within the Harrop watershed (Carver 2006).

The goal of the program was to monitor the baseline watershed condition, and assess trends in water quality parameters and hydrometrics related to forest development. The project evaluated trends in water quality variables with respect to the frequency at which BC Ministry of Environment (MoE 2010a) Water Quality guidelines (WQG) were exceeded. Hydrometric data was gathered mainly to aid the interpretation of the water quality data and to document the timing of seasonal flows.

The monitoring program included parameters influenced by forest harvesting practices and road building such as turbidity, total suspended solids (TSS), water temperature, and conductivity (Cavanagh et al. 1998, MacDonald et al. 1991, Jordan and Fanjoy 1999). Stratified collection of bacteriological samples (total and fecal coliforms) at low flow conditions was also carried out to further assess drinking water quality.

The water-monitoring program is part of a more comprehensive evaluation of trends within the Harrop-Procter community forest watersheds and operating areas. The water quality-monitoring project alone does not attempt to deduce effects of logging or road building. High natural variations in suspended-sediment (over time and location) and the complex interactions between development and peak flows (Toews and Gluns 2003) make it difficult to determine the effects of forest management on water quality. However, observations from this project may lead to further inspections of fish habitat and stream channel in years of exceptional peak flow. The program also serves as a community-based educational tool and most importantly provides evidence as to the state of drinking water quality following logging operations and high water events.

This report is an update of water quality monitoring that took place in 2009 at Harrop and Narrows creeks. In addition, a preliminary assessment of the macroinvertebrate community collected in 2008 at Harrop Creek was made relative to Environment Canada reference sites at Tam O'Shanter and Lockhart creeks.

The objectives of the 2009 program were to:

1. **Collect baseline water quality and flow data using a systematic sampling strategy.**
2. **Determine the number of days per year that parameters exceeded provincial drinking water quality guidelines.**
3. **Examine trends in drinking water quality in Harrop and Narrows creeks as forest and road development increases within the watershed.**
4. **Evaluate macroinvertebrate data collected from Harrop Creek relative to reference sites at Tam O'Shanter and Lockhart creeks.**

2 BACKGROUND INFORMATION

2.1 Watershed Characteristics

Harrop and Narrows creeks are located on the south side of the West Arm of Kootenay Lake east of the city of Nelson, B.C in the community of Harrop-Procter (Table 1, Figure 1, Appendix 5.2). The headwaters of the creeks are situated in the Nelson Range of the Selkirk Mountains and drain high gradient north-facing slopes reaching elevations of just over 2,300 m down to Kootenay Lake at 530 m.

Possible human influences on water quality include developments from private land, road building, agriculture, and forestry. Historical impacts include a sawmill located near the mouth of Harrop Creek in the 1920's (Carver 2005). Water from these creeks is presently used for domestic use, drinking, irrigation, aquatic and wildlife conservation and recreational purposes. Diversions along the lower 2 km of Harrop Creek provide 149 dam^3/day of water to 48 water licensees. As well, there are 46 licensees on Narrows Creek that divert 415.6 dam^3/day of water on the lower 1 km segment of the creek (MoE 2010b).

The lower reaches of Harrop and Narrows creeks, comprised of riffle-pool sequences, provide spawning habitat for West Arm kokanee populations (*Onchorhynchus nerka*) (FISS 2010). The spawning population for Harrop Creek has been estimated at 1,000-1,500 (Masse 2002). In addition, bull trout (blue listed) (*Salvelinus confluentus*) and rainbow trout (*Onchorhynchus mykiss*) utilize these lower reaches (Masse 2002) with up stream migration limited by steep gradients and step-pool morphology. Mill Lake provides recreational fishing of rainbow trout and eastern brook trout (*Salvelinus fontinalis*) (FISS 2010). Downstream migration of rainbow trout from Mill Lake (elevation 1,926) occurs in the upper reaches of Harrop Creek (Masse 2002).

A summary of the hydrogeomorphic conditions for Harrop watershed (from Carver 2006) is given in Appendix 5.3. This study found extensive unstable terrain and natural historic landslides that could contribute to suspended sediment in high water years. The study also found that levels of forest development (at that time 7.8% weighted ECA) were unlikely to result in higher in peak flows in the Harrop watershed.

The water collection sites on Harrop and Narrows creeks were located upstream of residential/agricultural developments (2 km and 1 km upstream of the fan, respectively) to determine possible effects from logging. This report focuses on the water quality at these two sites with coordinates given in Table 1.

The Harrop-Procter Community Co-operative oversees 10,900 ha of Crown land with an Allowable Annual Cut (AAC) of 2,603 m^3 timber/year (Silva 1999). At present HPCC is operating under a temporary AAC uplift of up to 12,000 m^3/year as part of the 2008-2012 cut control period to address mountain pine beetle and road development requirements in Harrop Creek.

Work in 2007-08 included 9 km of road on the face between Harrop and Slater creeks (East Harrop Creek) and four cutblocks. The 9-km of road was designed with narrow machine clearance to minimize visual and ecological impacts. In addition, no logging occurred within 100 meters of any streams. Retention in the cut blocks was; (1) 60% in all north aspects, (2) 40% in transitional areas with significant proportions of pine, (3) less than 15% in western ridge-top aspects that are primarily pine, and (4) close to zero retention in small patches of pure beetle-infested pine. Stands with small riparian areas, sensitive soils, old growth and wildlife habitats were also preserved in small within-stand reserves (Silva 1999).

Trail deactivation and clean up in East Harrop was carried out in the fall of 2009. A 40-hectare cutblock on the West Narrows face is currently being developed. Partial cutting in 4 ha of the Narrows Creek watershed may increase the Narrows Creek ECA by 0.1%. The Narrows Creek ECA remains <3%. Development of lower gradient slopes on the east side of Narrows Creek will be considered in the future. However, most of the watershed will remain undeveloped because of steep, sensitive slopes (Carver 2006) and the presence of mapped caribou habitat at higher elevations.

Table 1. Watershed characteristics and location of water collection sites

	Harrop	**Narrows**
Watershed Code	340-188100	340-200100
Stream order	4th	3rd
Gross drainage area (km^2)	42.2	12.2
Stream length (km)	12.2	10.58
Maximum elevation (m)	2,330	2,360
Coordinates of mouth at Kootenay Lake	11U 500494, 5496052	11U 496507, 5495101
Coordinates of water collection site & gauge	11U 495653, 5493641	11U 501036, 5496052
Access to water collection site via	McConnell Rd.	McMullin Rd.
Distance of water collection site from mouth	2 km	1 km
Biogeoclimatic zones[1]	ICHdw1, ICHmw2, ESSFwc1, ESSFwc4, ESSFwcp	

[1]See Appendix 5.4 for elevation bands of each zone specific to the watersheds

Figure 1. Map of Kootenay Lake with HPCC water monitoring sites on Harrop Creek and Narrows creeks and Environment Canada macroinvertebrate reference sites at Tam O'Shanter and Lockhart creeks.

Photo 1. Harrop Creek view of burn that occurred in 2003. View from Redfish Creek, submitted by E. Leslie, 2009.

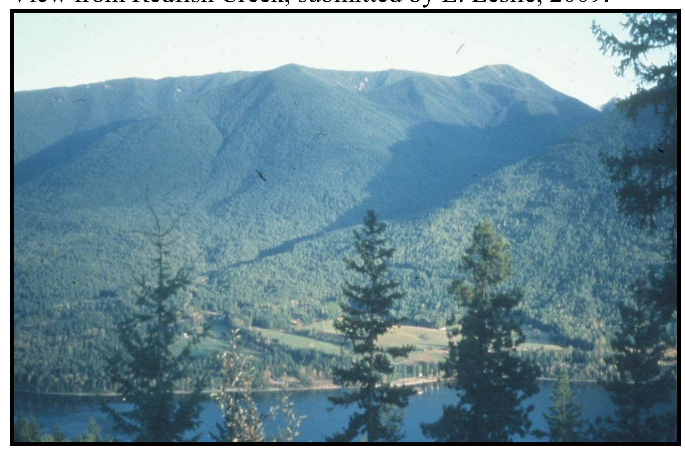


Photo 2. Narrows Creek watershed draining to Kootenay Lake, 2009. Photo by E. Leslie.

3 METHODS

3.1 Hydrometric Measurements

Water level measurements were recorded for Harrop and Narrows creeks by manual readings of a staff gauge at the water monitoring stations. A Price Type AA Current Meter was used to measure stream velocity. Stream discharge measurements followed Resource Inventory Committee (RIC) (1998) standard procedures, and involved stretching an Eslon tape across the channel and metering the water velocity at intervals of no more than 0.15 m. Starting at the water's edge, the recorder stood at the gauge site and measured the distance from the bank, water depth and water velocity at each interval. For each reading, the rod of the current meter was held in a vertical position with the meter completely submerged and pointing directly into the flow. Readings were taken at 0.6 of the total water depth at each interval. Each velocity measurement was taken over at least a 40 second period. Readings were recorded across the entire wetted width of the creek and the stage level was recorded.

Width-velocity data, coupled with manual stage readings, were used to create two stage-discharge rating tables (Appendices 5.5-5.6). The 2009 hydrograph was then calculated from these tables. The stage-discharge relationship was based on five flow measurements at Harrop Creek and seven at Narrows. The stage-discharge curves for the creeks were first developed manually. Regression formulas (discharge= a*stage^b) that were consistent with the manual method were then used to calculate the stage-discharge tables to three decimal places. Deviations for each calculated discharge ranged from 1.7-26.9% on both creeks (see Appendices Section 5.5).

3.2 Water Quality

A grab sampling program (Table 2) was implemented to collect seasonal conductivity, turbidity, and total suspended solids data. Leeza Trione collected samples at the beginning, during, and after rain events especially during spring freshet.

Samples were collected using a standard 1 L bottle supplied by the analytical laboratory. Prior to being filled, all sample bottles were labelled with the date and time of sampling. For each sample, a bottle was tilted upright and moved through the water column until filled, taking care to avoid human/environmental contamination and air pockets (Cavanagh et al. 1997). Air and water temperature measurements and staff gauge readings were taken at the same time as water samples. Weather reports and any other pertinent information were also recorded at that time. After collection, water samples were placed in a refrigerator and shipped immediately to Silverking Soya Foods where they were stored in a refrigerator until picked up by Passmore Laboratory Ltd. staff.

Leeza Trione, a local resident, collected samples for fecal and total coliforms at baseline flows following protocols for asceptic water sampling by Cavanagh et al. (1997). A sterile plastic bag was filled with stream water. The samples were placed on ice and brought to Nelson where Passmore Laboratory picked them up within 24 hours of collection.

Table 2. Water sampling regime in 2009

Sampling Method	Parameters Tested	Sampling Schedule
Manual water level Measurements and climate	Stage level, manual air, water temperatures, weather	Harrop Creek n=24 Narrows Creek n=23
Flow Measurements	Discharge metering	Over a range of stream flows Harrop Creek n=5 Narrows Creek n=7
Grab Sampling	Specific conductance, turbidity, TSS	Harrop Creek n=21 Narrows Creek n=19
Bacterial samples	Total and fecal coliforms	5 samples/ month August 12-September
Temperature	Peak summer temperatures, continuous meter	May 27 to December 31

3.3 Macroinvertebrates

Macroinvertebrate data was collected from Harrop Creek in 2008 following methods from the Canadian Aquatic Biomonitoring Network (CABIN) protocol (RIC 2009). The CABIN database uses a Reference Condition approach (RCA) in which an area specific multivariate model explains variability among reference sites using environmental variables to group types of reference sites. Test sites are then compared to reference site groups to determine if the test site is in reference condition. The advantage of RCA is that it integrates habitat data with biological data to determine stream condition and makes use of the suite of organisms monitored to assess the entire community. A Kootenay-Okanagan model within CABIN is in development and will not be available until later 2010 (pers com. Leon Gaber, MoE).

As a result, a simple assessment and preliminary screening of the macroinvertebrate data was carried out using the US EPA's Rapid Bioassessment II (Plafkin et al. 1989, Table 3). Rapid bioassessment protocols (RBP) use multi-metric indices to screen for large impacts to the macroinvertebrate community (Borisko et al. 2007). Harrop Creek was compared to reference sites (Tam O'Shanter and Lockhart creeks) selected by Environment Canada to meet criteria for the CABIN model reference sites.

In addition, macroinvertebrate data from Harrop Creek was compared to metrics used in the Okanagan Benthic Index of Biological Integrity (B-IBI). This large study surveyed twenty-three streams from low to high impacts and developed an in depth scoring system of biological condition specific to the Okanagan (Jensen 2006). B-IBI studies are typically calibrated exclusively to each geographic area (Karr and Chu 1999). However, there is no B-IBI for the Kootenay area because efforts by MoE and Environment Canada have largely focussed on developing the RCA model for this region. As a result, Harrop Creek was compared to Okanagan streams, as CABIN will soon be combining these areas in their upcoming RCA model. Multi-metric assessments are complementary to the RCA approach and can result in an assessment that is easy to communicate (Jensen 2006). However, an RCA approach incorporating multiple reference sites from the Kootenays will be more comprehensive when available.

Table 3. Biometrics used in analysis of Rapid bioassessment II.

Metric[1]	Measure	Indicator	Biological Scoring Criteria Comparability to reference site	Score
Taxa richness	Total number of taxa	Indicates health of the community, reflects increasing water quality, habitat diversity and suitability	>80% 60-80% 40-60% <40%	6 4 2 0
Family Biotic Index (FBI)	Tolerance	Specifies tolerance to organic pollution. $FBI=\Sigma x_i t_i/n$, x_i = number of individuals within a species, t_i = tolerance value of a species, n= total number of organisms in the sample	>85% 70-85% 50-70% <40%	6 4 2 0
Scrapers/collectorfilterers	Functional feeding group measure (FFG)	Examines prevalence of the periphyton community versus the availability of Fine Particulate Organic Material (FPOM). It may indicate organic enrichment or toxicants bound to FPOM.	>50% 35-50% 20-35% <20%	6 4 2 0
EPT/(EPT+ chironomid)	Tolerance	Measure of community balance, should have even distribution of all four groups, mayflies (E), stoneflies (P) and caddisflies (T) to chironmid or midge numbers	>75% 50-75% 24-50% <25%	6 4 2 0
% Dominant taxon	Composition	Indicates community balance, a community with only a few taxa indicates community stress	<20% 20-30% 30-40% >40%	6 4 2 0
EPT/total taxa	Taxonomic richness	Ratio of sensitive taxa (including mayflies (E), stoneflies (P) and caddisflies (T)) to total number of taxa	>90% 80-90% 70-80% <70%	6 4 2 0
Community Loss Index	Index of dissimilarity	Community loss = (total #species in sample A - # species common to both samples) /total # species in sample B – Measures the loss of benthic species between a reference and test sites	<0.5 0.5-1.5 1.5-4.0 >4.0	6 4 2 0
Shredders/Total	Functional feeding group measure	Allows potential impairment as indicated by the Coarse particulate organic matter-based Shredder community and toxicants of a terrestrial source such as pesticides and herbicides	>50% 35-50% 20-35% <20%	6 4 2 0

from Plafkin *et al*. 1989, EPT=Ephemeroptera, Plecoptera and Tricophtera

4 RESULTS AND DISCUSSION

4.1 Summary of Hydrometric and Suspended-Sediment Monitoring

In 2009, the peak flow occurred on May 31 at both Harrop (3.24 m^3/s) and Narrows (3.58 m^3/s) creeks (Figure 2). These flows were associated with warm temperatures and were well below the highest peak flows on record for Harrop Creek (11.807 m^3/s, May 18, 2006) and Narrows Creek (5.333 m^3/s, May 20, 2006, Figure 3, Appendix 5.7-5.8). The timing of these high water events was similar to nearby Water Survey of Canada sites (WSC 2010) at Duhamel (station 08NJ026) and Redfish Creeks (station 08NJ061, Figure 3). However, peak discharge at Harrop Creek when prorated by drainage area (0.08 $m^3/s/km^2$) was slightly lower than at Duhamel Creek (0.17 $m^3/s/km^2$ on May 30, 52.9 km^2). In addition, the peak discharge (0.16 $m^3/s/km^2$) for Narrows Creek was also lower than nearby Redfish Creek (0.22 $m^3/s/km^2$ on May 31, 26.2 km^2) when compared on a per drainage area basis.

The annual maximum TSS levels (5.5 mg/L, May 17) occurred on the rising limb of the hydrograph at Harrop Creek and coincided with peak flow on Narrows Creek (8.8 mg/L, May 31). Turbidity levels remained low on these dates, below provincial MoE guidelines of 5 NTU and 1 NTU. These suspended sediment levels were much lower than the peak levels of suspended-sediment on record (149 mg/L, turbidity 13 NTU for Harrop Creek and 76 mg/L, turbidity 7 NTU for Narrows Creek in 2006) (Figure 4).

Previous monitoring (Figure 4) on Harrop Creek has shown that MoE guidelines of 1 NTU and 5 NTU were exceeded at discharges of greater than 1 m^3/s on Harrop Creek and 0.57 m^3/s on Narrows Creek. However, two samples on record (Harrop Creek) had elevated suspended sediment at low discharges (December 14, 2006, 0.29 m^3/s, 1.1 NTU and October 31, 2003, 0.28 m^3/s, 32 mg/L).

4.2 Specific Conductance

Peak specific conductance levels in both creeks were well below the maximum BC MoE guideline of 700 µS/cm for drinking water in 2009. The specific conductance in Harrop Creek varied from 58.2-110 µS/cm (n=21) and ranged from 55.5-166 µS/cm (n=19) for Narrows Creek (Figures 2 and 4). Specific conductance levels declined with increasing dilution of groundwater during freshet. The annual minimum for Narrows Creek (55.5 µS/cm) coincided with the peak flow (May 31). While the lowest specific conductance levels on Harrop Creek occurred on the declining limb of the hydrograph (June 16, 58.2 µS/cm) (Appendice 5.7). The specific conductance levels of these streams at low flow conditions (82.2-154 µS/cm for Harrop Creek, n=8 and 101-156 µS/cm for Narrows Creek, n=8) were mid-range of other streams in the Kootenay Region (26-495 µS/cm, n=14 streams, from Ptolemy et al. 1991).

4.3 Temperature

Continuous temperature meters were secured in place from May 27 to December 31, 2009 in Harrop and Narrows creeks (Figure 5). Peak water temperatures in both creeks occurred from July 28 to September 3 with temperatures ranging from close to 9°C to just over 13°C. The maximum temperature of the year reached 12.8°C in Harrop Creek and 13.2°C in Narrows Creek on August 1, 2009. Summer temperatures did not exceed the BC water quality aesthetic guideline for drinking water of 15°C. Nor were guidelines for the maximum temperatures for rearing of bull trout (15°C), rainbow trout (18°C), and streams with unknown fish distributions (18°C) and spawning sockeye (13.8°C) exceeded. There are no guidelines specific for spawning kokanee. Minimum water temperatures dropped below 1°C at the beginning of December and remained low most of the month.

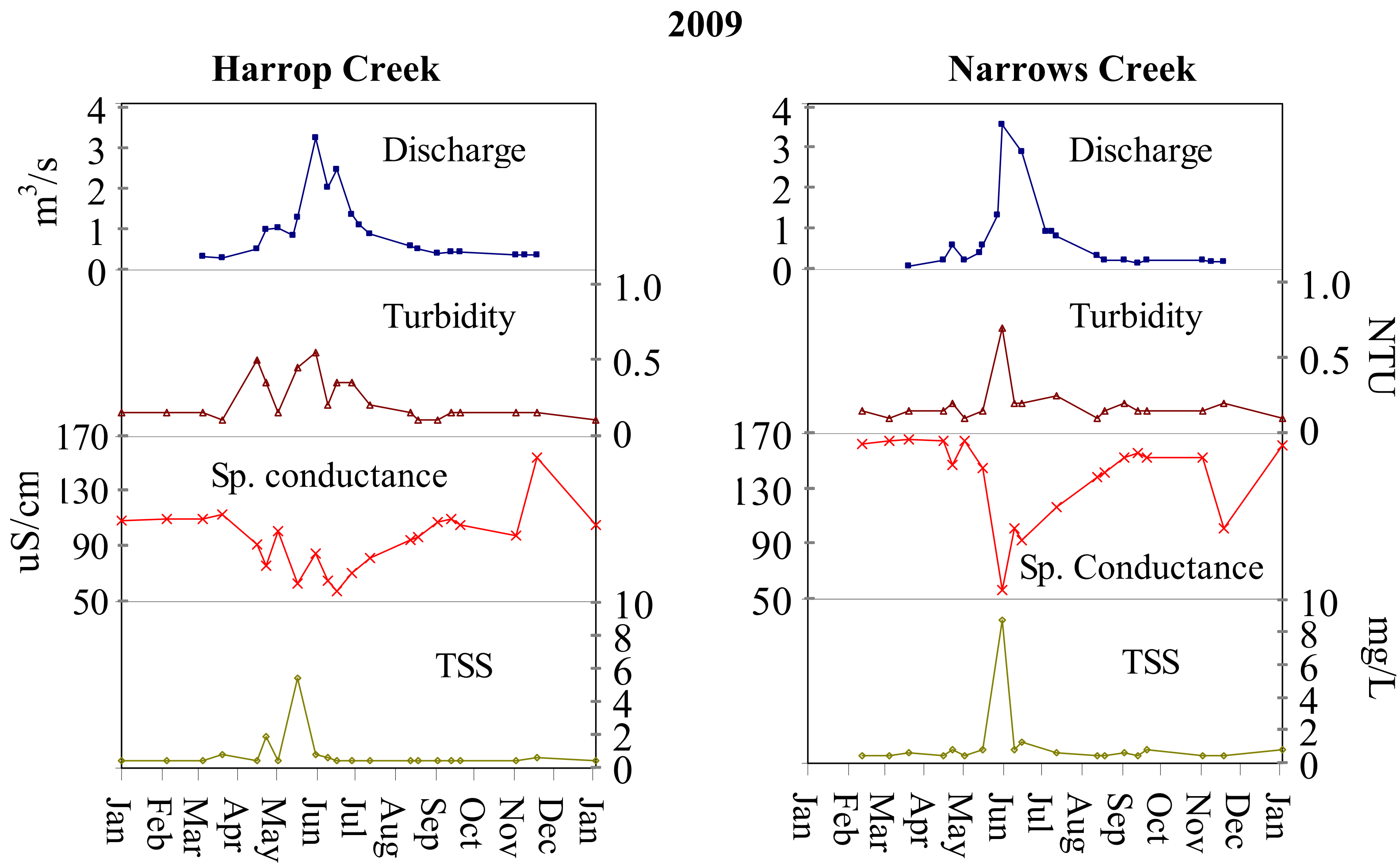
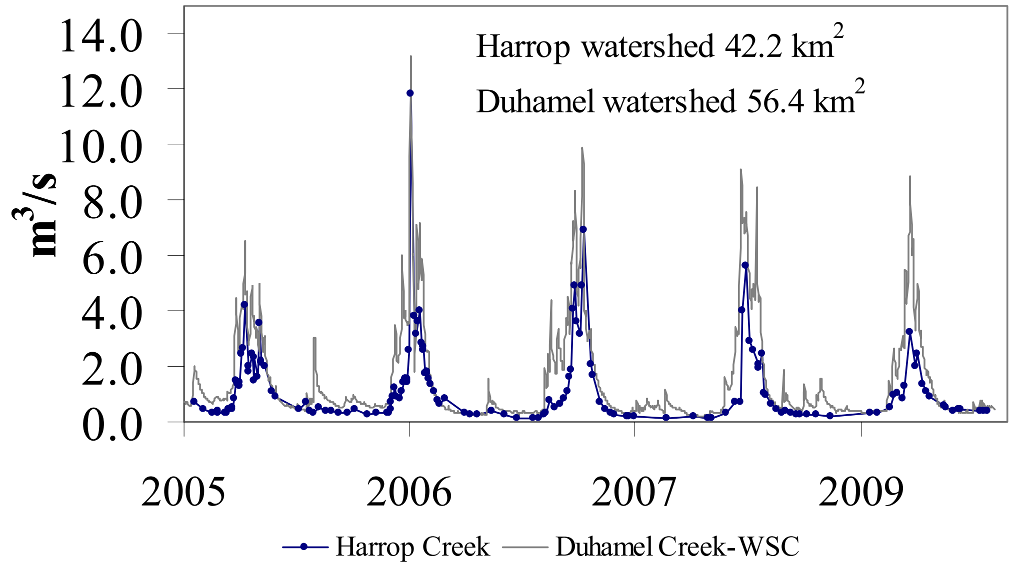


Figure 2. Discharge, TSS, turbidity and specific conductance from Harrop and Narrows creeks in 2009.

a.



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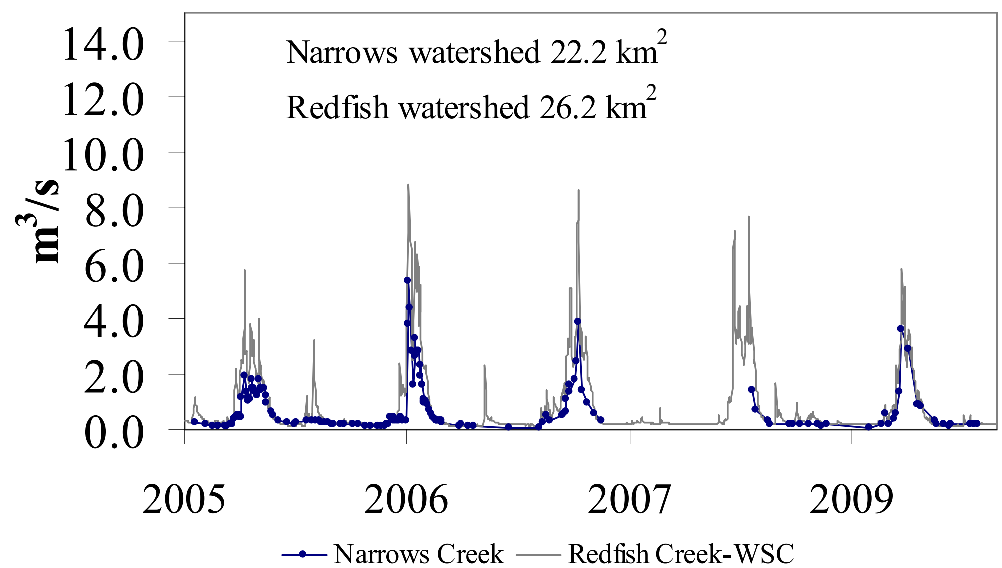

Figure 3. **a**. Comparison of discharge at Harrop Creek and WSC station at Duhamel creek. **b**. Discharge at Narrows Creeks and WSC station at Redfish Creek.

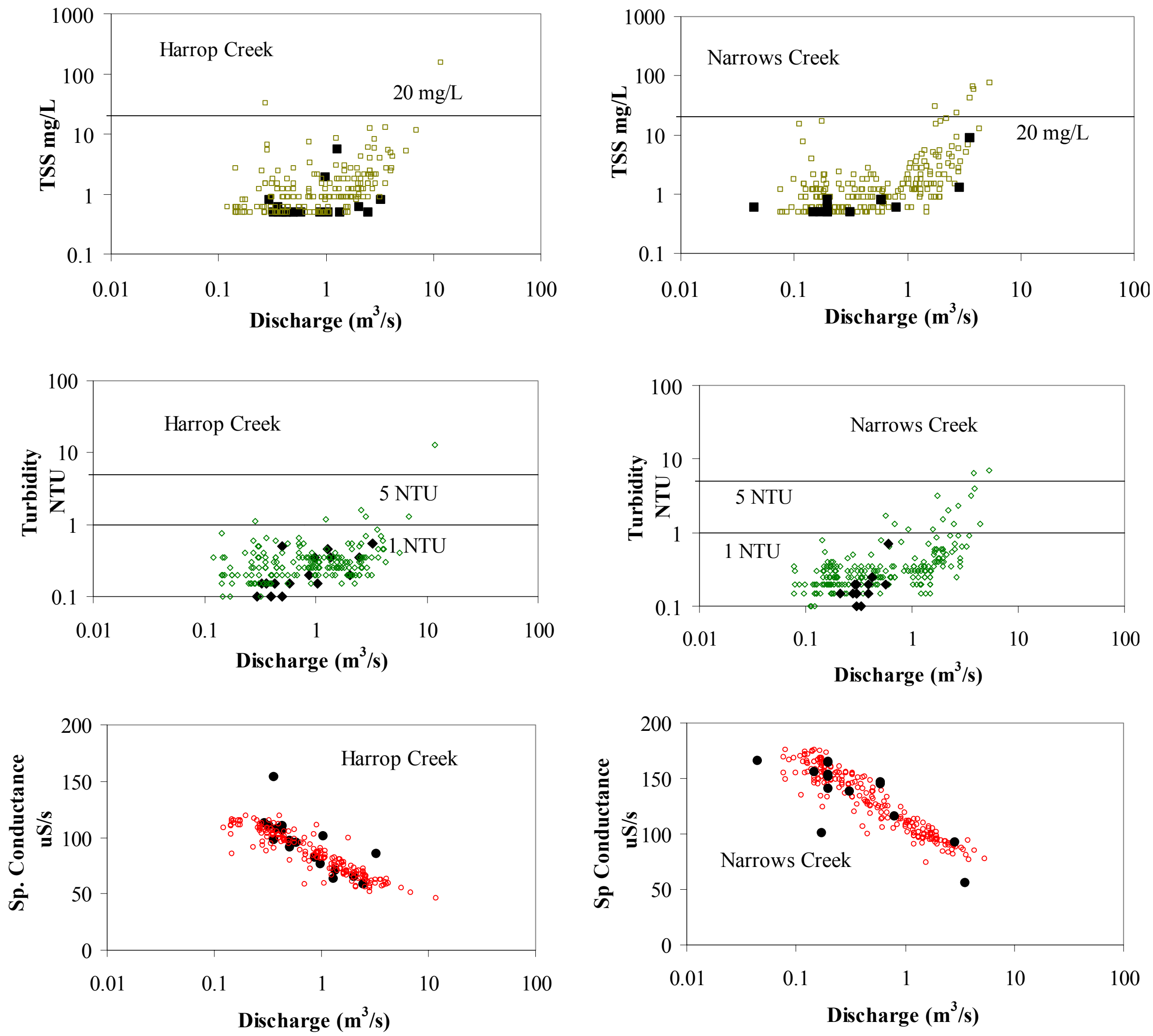

Figure 4. Log turbidity, Log TSS and specific conductance vs.log discharge. Black points indicate 2009 data. Open points designate previous data for Harrop (2002-08) and for Narrows (1999-08) creeks. Black lines specify MoE guidelines for turbidity with 20 mg/L as an approximation of the 5 NTU guideline for TSS.

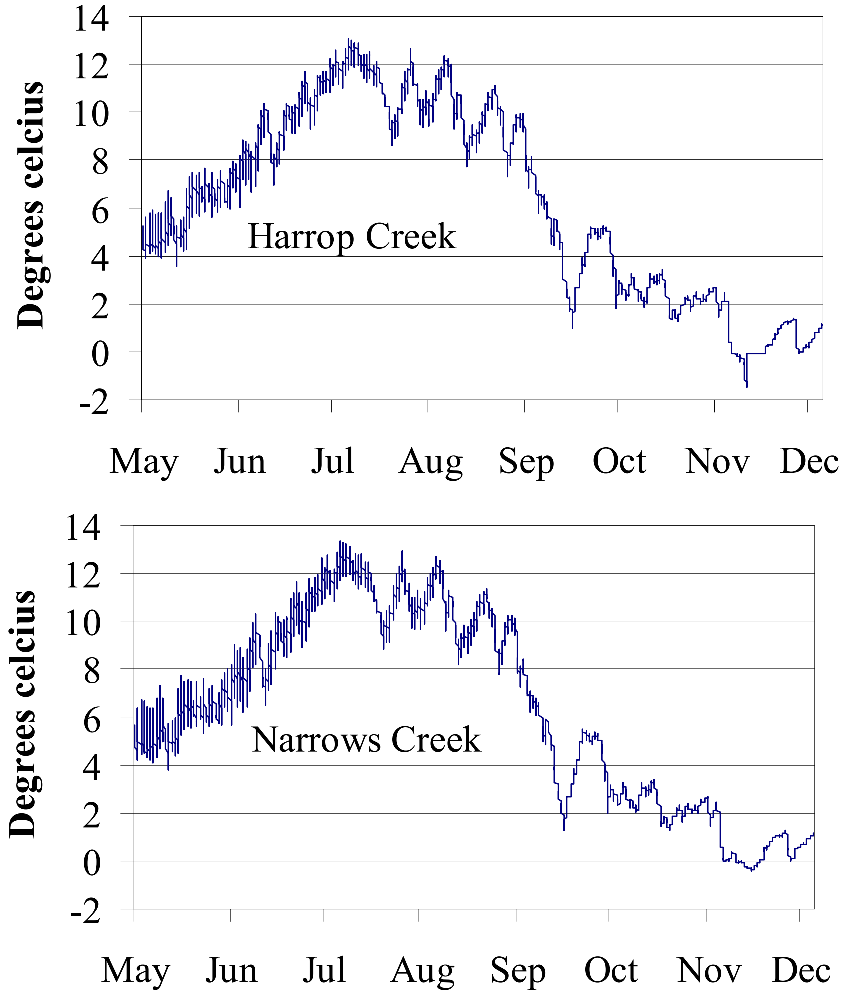

Figure 5. Continuous temperature recordings from Harrop and Narrows creeks.

4.4 Fecal and total coliforms

In 2009, fecal and total coliform levels (n=5) were monitored in late summer when stream temperatures typically increase and coliform levels are expected to peak. Some residents drawing water from the creeks do not disinfect their drinking water. For these residences, the provincial MoE guidelines for drinking water (undergoing no treatment) recommend no fecal coliforms for any date in the raw water. The drinking water guideline for residents disinfecting fecal coliforms is a 90^{th} percentile of not more than 10 CFU/100 mL (based on a minimum of five samples collected within a 30-day period).

During the summer of 2009, fecal coliform levels were below (<1 CFU/100 mL) the acceptable level for drinking water undergoing no treatment on August 18, 24 in Harrop Creek and August 18 in Narrows Creek. The 90th percentile for Harrop Creek (8 CFU/100 mL) met the drinking water guideline for water undergoing disinfection (10 CFU/100 mL) but the 90th percentile for Narrows Creek was slightly over this guideline (11 CFU/100 mL) (Table 4). Total coliforms counts in Harrop Creek ranged from 7 – 41 CFU/100 mL and from 14-34 CFU/100 mL at Narrows Creek. The calculated 90th percentile was similar for both Harrop Creek (35 CFU/100 mL) and Narrows Creek (34 CFU/100 mL). No BC MoE guidelines exist for total coliforms in drinking water. The sources of contamination are largely due to natural wildlife populations with possible effects from upstream recreational activities or forest operations, particularly on Harrop Creek because the water monitoring sites are upstream of residential development.

Table 4. Summary of fecal and total coliform values (CFU/100 mL) from 2009.

	Harrop Creek		**Narrows Creek**	
	Date	**CFU/100 mL**	**Date**	**CFU/100 mL**
Fecal coliforms	August 12	12	August 12	8
	August 18	1	August 18	1
	August 24	1	August 24	13
	August 27	<1	August 27	4
	September 2	<1	September 2	<1
Total coliforms	August 12	27	August 12	34
	August 18	7	August 18	34
	August 24	9	August 24	29
	August 27	8	August 27	14
	September 2	41	September 2	26

4.5 Quality Assurance/Quality Control of water sampling

Duplicate water samples collected on February 26, 2010 for total suspended solids, specific conductivity, and turbidity demonstrated that field and laboratory sampling were accurate and repeatable. The percent difference between duplicates was 0% for TSS and turbidity for both streams and 1% for specific conductance (Table 5). This was below the recommended <25% difference for duplicates (Cavanagh et al. 1998). All values for all parameters were less than five times the detection level. When values are close to detection, a higher percent difference is acceptable but despite this duplicate samples were very close or identical.

Table 5. Duplicate sample results from Passmore Laboratory Ltd. collected February 26, 2010

	TSS (mg/L)	**Sp. conductance (µS/sec)**	**Turbidity (NTU)**	**Precision Criteria**
Harrop Creek				
	Below detection[1]	112	0.20[1]	
	Below detection[1]	111	0.20[1]	
% Difference	**0%**[2]	**1%**	**0%**[2]	**25%**
Narrows Creek				
	Below detection[1]	168	0.20[1]	
	Below detection[1]	170	0.20[1]	
% Difference	**0%**[2]	**1%**	**0%**[2]	**25%**
Detection limits (DL)	0.2	10	0.1	
5 x DL	1.0	50	0.5	

[1]Less than five times detection limit, [2]Comparisons to % difference only valid if greater than five times detection limit

Trip blanks collected on the same date verified that there was no contamination of sample jars prior to or during transport (Table 6). TSS levels were below analytical detection limits, specific conductance levels were 1.2 µS/cm and turbidity was 0.20 NTU for both blanks (distilled water) carried to each of the streams in typical sampling containers. Measurements of distilled water before transport to site are below detection for TSS (0.2 mg/L), 1-6 µS/cm for specific conductance, and 0.10-0.25 NTU for turbidity (Tony Yeow, pers. com.). The trip blanks were within these ranges and well below natural environmental levels.

Table 6. Trip blank results from Passmore Laboratory Ltd. February 26, 2010

Creek	TSS (mg/L)	Specific Conductance (µS/sec)	Turbidity (NTU)
Harrop	Below detection	1.2	0.20
Narrows	Below detection	1.2	0.20

4.6 Macroinvertebrates

Macroinvertebrate data from Harrop Creek (Appendix 5.9) was compared to data from Environment Canada reference sites at Lockhart and Tam O'Shanter creeks using the EPA Rapid Bioassessment Protocol II. Lockhart Creek is located within Lockhart Provincial Park and flows west to the south arm of Kootenay Lake 40 km north of Creston (Figure 1). Tam O'Shanter is located north of Riondell and also flows west to north arm of Kootenay Lake. A comparison of habitat characteristics of each macroinvertebrate site is given in Table 7.

Impairment rating scores for Harrop Creek from the RBP II indicated a slight impairment at the water quality-monitoring site relative to reference sites. Harrop Creek rated the highest scores possible (6 out of 6) for taxa richness, scrapers/collector-filterers, EPT/(EPT+chironomids), EPT index and the community loss index (Table 8). However the % Dominant taxa (0/6) and the FBI (3/6) and the ratio of shredders/total (3/6) rated lower bioassessment scores accounting for the overall rating of slight impairment.

Rapid Bioassessments are best used to detect large impacts to the macroinvertebrate community (Borisko et al. 2007). For instance, high levels of deposited sediment (from natural or forest-related sources) that result in a loss in sensitive EPT organisms and an increase in Chironomidae, Oligochaeta and Spaeridae (Waters 1995) may be picked up using this protocol. Harrop Creek showed a high EPT index, EPT/(EPT+chironomids) ratio and %EPT (93%) indicating good biological condition (Table 8). The dominant taxa in the sample were baetid and heptagenid mayflies and taeniopterygid stoneflies. In addition, the sample contained few sediment tolerant organisms including; Oligochaeta, (0.3%), and chironomids (1.9%) and an absence of Spaeridae.

High gradient streams and flushing flows typical of the Kootenays often result in low to moderate levels of deposited sediment at baseline flow corresponding to the time at which benthic macroinvertebrates are also sampled (Quamme and Sundberg 2000). The EPA RBP II may not detect subtle or transitional effects on the biological community from deposited sediment. In general, the effects of low to moderate levels of deposited sediment are difficult to detect without rigorous methods and costly studies (Anigradi 1999).

Table 7. Selected habitat characteristics of reference and test sites

Name	Reference site Lockhart Creek	Reference site Tam O'Shanter Creek	Test site Mill Creek
Year	2007	2007	2008
Streamorder	3	3	4
Stream length (km)	10.86	9.52	12.2
Canopy - % coverage	2	1	2
Channel Depth – avg (cm)	24	22	61
Channel Depth – max (cm)	28	38	68
Habitats – pools	Present	Present	Absent
Habitats – riffles	Present	Present	Present
Habitats – straight run	Present	Absent	Absent
Macrophyte (PercentRange)	Absent	Absent	Present
Nitrogen – total (mg/L)	0.05	0.09	0.02
Ortho-phosphorus (mg/L)	Below detection	Below detection	0.005
Hardness (mg/L)	77.6	57.9	54.7
Riparian – coniferous trees	Present	Present	Present
Riparian – deciduous trees	Present	Absent	Present
Riparian – grasses/fern	Present	Present	Present
Riparian – shrubs (Binary)	Present	Absent	Present
Substrate – 2nd dominant size	Boulder	Bedrock	Pebble
Substrate – dominant size category	Bedrock	Boulder	Cobble
Substrate – embeddedness % covered	25	25	25
Velocity (Avg) (m/s)	0.52	0.56	0.41
Velocity (Max) (m/s)	1.2	0.8	0.68
Width – Bankfull (m)	5.9	8	9.2
Width – Wetted (m)	5.8	7	5.3

Table 8. Impairment rating score for Harrop Creek[1]

	Expected response to increasing human influence[2]	Metrics			% Comparison to reference		Bioassessment Score	
Metric		**Harrop**	**Lockhart**	**Tam O'Shanter**	**Harrop**	**Reference**	**Harrop**	**Ref comp**
		Test	**Reference**	**Reference**			**Test**	**Reference**
Taxa richness	Decrease	23	19	25	105	100	6	6
Family Biotic Index	Increase	3.5	3.2	2.7	84	100	3	6
Scrapers/ collector-filterers	Decrease	98	98	96	101	100	6	6
EPT/(EPT+chironomid #)	Decrease	0.83	0.61	0.59	138	100	6	6
% Contrib. Dom. Taxon	Increase	52	38	56	111	47	0	6
EPT index	Decrease	15	13	16	103	100	6	6
Community Loss Index	Decrease	0.38	0	0	0.38	0	6	6
Ratio of Shredders/Total	Decrease	10	23	46	29	100	3	6
Sum of Bioassessment scores							**36**	**48**
Percent of ref. Site							**75%**	
Impairment rating							**Slightly impaired**	

[1]Calculated at a Family level of identification, [2]From Karr and Chu (1999), EPT=mayflies, stoneflies and caddisflies

Harrop Creek was also compared to an Okanagan calibrated B-IBI (Jensen 2006), in which five metrics were used to rate stream condition into low, medium and high impact categories. Harrop Creek had better ratings for four of these metrics than the median of the low impact Okanagan streams including; the number Plecoptera taxa (4), Ephemeroptera taxa (4), intolerant taxa (11) and clinger taxa (14). The fifth metric used in the assessment, the total number of taxa, was better (higher) for Harrop Creek (9) than most moderately impacted streams in the Okanagan. The total Harrop Creek score based on these metrics was 23/25 resulting in a rating of "excellent" for Harrop Creek (see Appendix 5.10 for calculations).

Secondary metrics that were not used in the rating system because of higher variation over the range of impacted streams were also calculated for Harrop Creek and compared to Okanagan streams. These included percent % Dominance (56.2), number of trichoptera taxa (7), HBI index (3.6), percent tolerant taxa (8.7), which rated similarly or better than the median of low impact Okanagan streams. While the % predators (2.96) in Harrop Creek was better than the median of moderately impacted streams in the Okanagan.

Harrop Creek performed well against most Okanagan streams included in the Okanagan B-IBI. High levels of urbanization and pollutants such as polycyclic aromatic hydrocarbons, nickel, manganese in sediment and water alkalinity were associated with impacted streams in the Okanagan study (Jensen 2006). The Harrop Creek macroinvertebrate site was located upstream of most residential developments and sources of pollution likely accounting for the creek's similarity to Okanagan reference streams.

5 CONCLUSIONS AND RECOMMENDATIONS

MoE drinking water guidelines for conductivity (700 µS/cm), turbidity (1NTU, 5 NTU turbidity) and TSS (20 mg/L approximation of 5 NTU) were not exceeded in 2009. Suspended-sediment levels (TSS and turbidity) in Harrop Creek were also within the range of natural variability observed on Harrop Creek and at the control site on Narrows Creek. Both Harrop and Narrows Creeks met MoE guidelines for maximum summer temperatures for drinking water (15°C) and spawning (13.3°C) and rearing fish (18°C).

In 2009, spot checks of fecal coliform counts were below guidelines for drinking water undergoing no treatment (<1 CFU/100 mL) on three out of five days on Harrop Creek and four out of five days on Narrows Creek. Fecal coliforms counts were below guidelines for disinfection of < 10 CFU on Harrop Creek and just above guideline on Narrows Creek (11 CFU/100 mL) when monitored five times over 30 days.

The Harrop Creek macroinvertebrate community rated well compared to reference streams in the Kootenays and the Okanagan and indicated good biological condition. However, use of area specific CABIN tools when available will provide more comprehensive information on the ecosystem health of Harrop Creek.

Recommendations include:

1. **Continue to monitor water quality in Harrop and Narrows Creeks to ensure clean drinking water within the watershed.**
2. **Use field observations to initiate ground inspection of the watershed if required.**
3. **Continue to collect duplicate samples and trip blanks in order to ensure that are no contamination problems associated with sampling procedures.**
4. **Consider increasing the number of water level readings particularly during peak flows.**
5. **Review macroinvertebrate data using the Canadian Aquatic Biomonitoring Network (CABIN) model for the Kootenays when available in 2010.**

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5 APPENDICES

5.1 Table of Contacts

Name	Organization	Contact Number/Address
Gaber, Leon	Ministry of Environment, Victoria	250-387-6481
Leslie, Erik	Harrop-Procter Community Forest	250-229-2271
Quamme, Darcie	Integrated Ecological Research, Nelson	250-352-2603
Trione, Leeza	Local resident, Harrop-Procter	250-229-4424
Yeow, Jennifer and Tony	Passmore Laboratory Ltd., Slocan Valley	250-226-7339

5.2 Map of Harrop (Mill) and Narrows creeks

5.3 Hydrogeomorphic characteristics of Harrop Creek watershed for 2006

Measure	Harrop Creek [1]
Stream discharge	Low hydrological hazard rating. Present level of forest development (7.8% weighted ECA) unlikely to result in increases in peak flows.
Sediment delivery	Low to moderate hazard index for sediment sources. Extensive naturally unstable terrain with historic landslides and potential delivery to main channel. Sediment resulting from roads and trails is limited due to almost no development at present.
Riparian function	Riparian areas are intact everywhere except the lower 2 km on private land where riparian function has been highly impacted.
Channel instability	Low to moderate instability with a high hazard index on the naturally unstable alluvial fan exacerbated by rural development.

[1] Text and data taken from Carver (2006).

5.4 Elevations of biogeoclimatic sub-zones

Biogeoclimatic sub-zone		Elevation Bands (m) [1]	
		Northern slopes	Southern slopes
dry, warm, Interior Cedar-Hemlock	ICHdw1	530 m to 1000-1100 m	1000-1100 m to 1200-1250 m
moist, warm, Interior Cedar-Hemlock	ICHmw2	1000-1100 m to 1450-1550 m	1200-1250 m to 1550-1650 m
wet, cold, Engelmann Spruce – Subalpine Fir,	ESSFwc1	1450-1550 m to 1675-1725 m	1550-1650 m to 1725-1775 m
wet, cold, Engelmann Spruce – Subalpine Fir,	ESSFwc4	1675-1725 m to 2050-2150 m	1725-1775 m to 2250-2275 m
wet,cold, Engelmann Spruce Sub-alpine Fir parkland,	ESSFwcp	2050-2150 m to ridge tops	2250-2275 m to ridge tops

[1] HPCF 1999

5.5 Stream metering and discharge rating accuracy for 2009

Harrop/Mill Creek

Date	Measurement		Temp / °C		Width	Area	Velocity	Gauge Ht.	Metered Discharge	Discharge from stage-discharge table	Discharge rating accuracy	Stage-discharge Table
	By:	Type	Air	Water	M	m²	m/s	m	m³/s	m³/s	% Deviation	#
12/3/08	TY JY	Wade	3.0	0.0	6.584	0.676	0.265	0.215	0.233	0.2187	**-6.3**	1
5/13/09	TY&JY	Wade	14.0	3.5	7.254	1.286	0.508	0.348	0.800	0.8580	**-6.8%**	1
7/3/09	TY&JY	Wade	27.0	7.0	7.468	1.959	0.540	0.392	1.188	1.1110	**6.9%**	1
8/12/09	TY&JY	Wade	14.0	9.0	7.376	1.250	0.364	0.290	0.568	0.5870	**-3.2%**	1
11/9/09	TY&AY	Wade	9.0	2.5	7.315	0.976	0.324	0.235	0.386	0.3730	**3.6%**	1

Narrows Creek

Date	Measurement		Temp / °C		Width	Area	Velocity	Gauge Ht.	Metered Discharge	Discharge from stage-discharge table	Discharge rating accuracy	Stage-discharge Table
	By	Type	Air	Water	M	m²	m/s	m	m³/s	m³/s	% Deviation	#
12/3/08	TY/JY	Wade	-2.0	0.0	3.200	0.346	0.250	0.265	0.1009	0.1140	**13.0**	2
05/13/09	TY&JY	Wade	12.0	3.5	4.267	0.690	0.581	0.350	0.3490	0.3760	**-7.1%**	2
05/27/09	TY&JY	Wade	16.0	4.0	4.237	1.392	0.819	0.475	1.3700	1.3470	**1.7%**	2
07/03/09	TY&JY	Wade	25.0	8.0	Meter	broken						2
07/08/09	TY&AY	Wade	17.0	6.5	4.176	1.010	0.747	0.435	0.7360	0.9320	**-21.0%**	2
07/08/09	TY&AY	Wade	17.0	6.5	4.234	1.179	0.764	0.435	0.8660	0.9320	**-7.1%**	2
08/12/09	TY&JY	Wade	16.0	10.0	4.115	0.677	0.589	0.335	0.3970	0.3130	**26.9%**	2

5.6 Stage-discharge tables for 2009

Stage-discharge Table #1 Harrop Creek

Gauge Height (m)	0	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.25	0.429	0.432	0.436	0.439	0.443	0.447	0.451	0.454	0.458	0.462
0.26	0.466	0.469	0.473	0.477	0.481	0.485	0.489	0.493	0.496	0.500
0.27	0.504	0.508	0.512	0.516	0.520	0.524	0.528	0.532	0.537	0.541
0.28	0.545	0.549	0.553	0.557	0.561	0.566	0.570	0.574	0.578	0.583
0.29	0.587	0.591	0.595	0.600	0.604	0.608	0.613	0.617	0.622	0.626
0.3	0.630	0.635	0.639	0.644	0.648	0.653	0.657	0.662	0.667	0.671
0.31	0.676	0.680	0.685	0.690	0.694	0.699	0.704	0.709	0.713	0.718
0.32	0.723	0.728	0.732	0.737	0.742	0.747	0.752	0.757	0.762	0.767
0.33	0.771	0.776	0.781	0.786	0.791	0.796	0.801	0.807	0.812	0.817
0.34	0.822	0.827	0.832	0.837	0.842	0.848	0.853	0.858	0.863	0.869
0.35	0.874	0.879	0.884	0.890	0.895	0.901	0.906	0.911	0.917	0.922
0.36	0.928	0.933	0.939	0.944	0.950	0.955	0.961	0.966	0.972	0.977
0.37	0.983	0.989	0.994	1.000	1.006	1.011	1.017	1.023	1.029	1.034
0.38	1.040	1.046	1.052	1.058	1.063	1.069	1.075	1.081	1.087	1.093
0.39	1.099	1.105	1.111	1.117	1.123	1.129	1.135	1.141	1.147	1.153
0.4	1.159	1.166	1.172	1.178	1.184	1.190	1.197	1.203	1.209	1.215
0.41	1.222	1.228	1.234	1.241	1.247	1.254	1.260	1.266	1.273	1.279
0.42	1.286	1.292	1.299	1.305	1.312	1.318	1.325	1.332	1.338	1.345
0.43	1.351	1.358	1.365	1.371	1.378	1.385	1.392	1.398	1.405	1.412
0.44	1.419	1.426	1.433	1.439	1.446	1.453	1.460	1.467	1.474	1.481
0.45	1.488	1.495	1.502	1.509	1.516	1.523	1.530	1.537	1.545	1.552
0.46	1.559	1.566	1.573	1.581	1.588	1.595	1.602	1.610	1.617	1.624
0.47	1.632	1.639	1.646	1.654	1.661	1.669	1.676	1.683	1.691	1.698
0.48	1.706	1.713	1.721	1.729	1.736	1.744	1.751	1.759	1.767	1.774
0.49	1.782	1.790	1.798	1.805	1.813	1.821	1.829	1.836	1.844	1.852
0.5	1.860	1.868	1.876	1.884	1.892	1.900	1.908	1.916	1.924	1.932
0.51	1.940	1.948	1.956	1.964	1.972	1.980	1.988	1.996	2.005	2.013
0.52	2.021	2.029	2.038	2.046	2.054	2.062	2.071	2.079	2.088	2.096
0.53	2.104	2.113	2.121	2.130	2.138	2.147	2.155	2.164	2.172	2.181
0.54	2.189	2.198	2.206	2.215	2.224	2.232	2.241	2.250	2.259	2.267
0.55	2.276	2.285	2.294	2.302	2.311	2.320	2.329	2.338	2.347	2.356
0.56	2.365	2.374	2.382	2.391	2.400	2.409	2.419	2.428	2.437	2.446
0.57	2.455	2.464	2.473	2.482	2.492	2.501	2.510	2.519	2.528	2.538
0.58	2.547	2.556	2.566	2.575	2.584	2.594	2.603	2.613	2.622	2.631
0.59	2.641	2.650	2.660	2.669	2.679	2.689	2.698	2.708	2.717	2.727
0.6	2.737	2.746	2.756	2.766	2.775	2.785	2.795	2.805	2.814	2.824
0.61	2.834	2.844	2.854	2.864	2.874	2.884	2.893	2.903	2.913	2.923
0.62	2.933	2.943	2.953	2.964	2.974	2.984	2.994	3.004	3.014	3.024
0.63	3.034	3.045	3.055	3.065	3.075	3.086	3.096	3.106	3.117	3.127
0.64	3.137	3.148	3.158	3.169	3.179	3.190	3.200	3.211	3.221	3.232
0.65	3.242	3.253	3.263	3.274	3.285	3.295	3.306	3.317	3.327	3.338
0.66	3.349	3.359	3.370	3.381	3.392	3.403	3.413	3.424	3.435	3.446
0.67	3.457	3.468	3.479	3.490	3.501	3.512	3.523	3.534	3.545	3.556
0.68	3.567	3.578	3.589	3.601	3.612	3.623	3.634	3.645	3.657	3.668
0.69	3.679	3.691	3.702	3.713	3.725	3.736	3.747	3.759	3.770	3.782
0.7	3.793	3.805	3.816	3.828	3.839	3.851	3.862	3.874	3.886	3.897
0.71	3.909	3.920	3.932	3.944	3.956	3.967	3.979	3.991	4.003	4.014
0.72	4.026	4.038	4.050	4.062	4.074	4.086	4.098	4.110	4.122	4.134

Stage-discharge Table #2 Narrows Creek

Gauge Height (m	0	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.25	0.092	0.093	0.095	0.097	0.098	0.100	0.102	0.103	0.105	0.107
0.26	0.108	0.110	0.112	0.114	0.115	0.117	0.119	0.121	0.123	0.125
0.27	0.127	0.129	0.131	0.133	0.135	0.137	0.139	0.141	0.143	0.145
0.28	0.148	0.150	0.152	0.154	0.157	0.159	0.161	0.164	0.166	0.169
0.29	0.171	0.174	0.176	0.179	0.181	0.184	0.186	0.189	0.192	0.194
0.3	0.197	0.200	0.203	0.205	0.208	0.211	0.214	0.217	0.220	0.223
0.31	0.226	0.229	0.232	0.235	0.239	0.242	0.245	0.248	0.251	0.255
0.32	0.258	0.262	0.265	0.268	0.272	0.275	0.279	0.283	0.286	0.290
0.33	0.294	0.297	0.301	0.305	0.309	0.313	0.317	0.321	0.325	0.329
0.34	0.333	0.337	0.341	0.345	0.349	0.354	0.358	0.362	0.367	0.371
0.35	0.376	0.380	0.385	0.389	0.394	0.398	0.403	0.408	0.413	0.418
0.36	0.422	0.427	0.432	0.437	0.442	0.448	0.453	0.458	0.463	0.468
0.37	0.474	0.479	0.485	0.490	0.496	0.501	0.507	0.512	0.518	0.524
0.38	0.530	0.536	0.541	0.547	0.553	0.559	0.566	0.572	0.578	0.584
0.39	0.590	0.597	0.603	0.610	0.616	0.623	0.629	0.636	0.643	0.650
0.4	0.656	0.663	0.670	0.677	0.684	0.691	0.699	0.706	0.713	0.720
0.41	0.728	0.735	0.743	0.750	0.758	0.766	0.773	0.781	0.789	0.797
0.42	0.805	0.813	0.821	0.829	0.838	0.846	0.854	0.863	0.871	0.880
0.43	0.888	0.897	0.906	0.914	0.923	0.932	0.941	0.950	0.959	0.969
0.44	0.978	0.987	0.997	1.006	1.016	1.025	1.035	1.045	1.054	1.064
0.45	1.074	1.084	1.094	1.104	1.115	1.125	1.135	1.146	1.156	1.167
0.46	1.178	1.188	1.199	1.210	1.221	1.232	1.243	1.254	1.266	1.277
0.47	1.288	1.300	1.312	1.323	1.335	1.347	1.359	1.371	1.383	1.395
0.48	1.407	1.419	1.432	1.444	1.457	1.469	1.482	1.495	1.508	1.521
0.49	1.534	1.547	1.560	1.573	1.587	1.600	1.614	1.627	1.641	1.655
0.5	1.669	1.683	1.697	1.711	1.726	1.740	1.754	1.769	1.784	1.798
0.51	1.813	1.828	1.843	1.858	1.873	1.889	1.904	1.919	1.935	1.951
0.52	1.966	1.982	1.998	2.014	2.030	2.047	2.063	2.080	2.096	2.113
0.53	2.130	2.146	2.163	2.180	2.198	2.215	2.232	2.250	2.267	2.285
0.54	2.303	2.321	2.339	2.357	2.375	2.393	2.412	2.430	2.449	2.467
0.55	2.486	2.505	2.524	2.544	2.563	2.582	2.602	2.621	2.641	2.661
0.56	2.681	2.701	2.721	2.741	2.762	2.782	2.803	2.824	2.845	2.866
0.57	2.887	2.908	2.929	2.951	2.973	2.994	3.016	3.038	3.060	3.082
0.58	3.105	3.127	3.150	3.172	3.195	3.218	3.241	3.264	3.288	3.311
0.59	3.335	3.358	3.382	3.406	3.430	3.455	3.479	3.503	3.528	3.553
0.6	3.578	3.603	3.628	3.653	3.678	3.704	3.730	3.755	3.781	3.807
0.61	3.834	3.860	3.886	3.913	3.940	3.967	3.994	4.021	4.048	4.076
0.62	4.103	4.131	4.159	4.187	4.215	4.244	4.272	4.301	4.329	4.358
0.63	4.387	4.417	4.446	4.475	4.505	4.535	4.565	4.595	4.625	4.656
0.64	4.686	4.717	4.748	4.779	4.810	4.841	4.873	4.904	4.936	4.968
0.65	5.000	5.032	5.065	5.097	5.130	5.163	5.196	5.229	5.262	5.296
0.66	5.330	5.363	5.397	5.432	5.466	5.501	5.535	5.570	5.605	5.640
0.67	5.676	5.711	5.747	5.783	5.819	5.855	5.891	5.928	5.964	6.001
0.68	6.038	6.076	6.113	6.151	6.188	6.226	6.264	6.303	6.341	6.380
0.69	6.418	6.457	6.497	6.536	6.576	6.615	6.655	6.695	6.735	6.776
0.7	6.817	6.857	6.898	6.940	6.981	7.022	7.064	7.106	7.148	7.191
0.71	7.233	7.276	7.319	7.362	7.405	7.449	7.492	7.536	7.580	7.624
0.72	7.669	7.713	7.758	7.803	7.849	7.894	7.940	7.986	8.032	8.078

5.7 Raw Water quality Data

Harrop Creek

Date M/D/Y	Time	Weather	Air °C	Water °C	TSS mg/L	SpCond uS/cm	Turb NTU	Total Coli CFU	Fecal Coli CFU	Gauge m	Flow m^3/s
01/01/2009	2:00PM				<0.5	109	0.15			snow	
02/04/2009	3:30PM	Overcast			<0.5	110	0.15			snow	
03/04/2009	9:30AM	Overcast			<0.5	110.0	0.15			0.220	0.327
03/20/2009	11:50AM	Overcast			0.8	113.0	0.10			0.210	0.296
04/15/2009	3:30PM	Sunny			<0.5	91.3	0.50			0.270	0.504
04/22/2009	2:45PM	Overcast/rain			1.9	76.2	0.35			0.370	0.983
05/02/2009	1:50PM	Sunny			<0.5	101.0	0.15			0.380	1.040
05/13/2009										0.347	0.858
05/17/2009	4:30PM	Sunny			5.5	63.5	0.45			0.420	1.286
05/31/2009	1:50PM	Sunny/hot			0.8	85.2	0.55			0.650	3.242
06/09/2009	3:20PM	overcast			0.6	65.1	0.20			0.520	2.021
06/16/2009	8:40PM	Overcast			<0.5	58.2	0.35			0.570	2.455
06/28/2009	11:00AM	Sunny			<0.5	71.1	0.35			0.430	1.351
07/03/2009										0.392	1.111
07/12/2009	4:45PM	Overcast			<0.5	82.2	0.20			0.350	0.874
08/12/2009		Rain			<0.5	95.1	0.15	27	12	0.290	0.587
08/18/2009	5:48PM	Sunny/overcast			<0.5	97.1	0.10	7	1	0.270	0.504
08/24/2009								9	1		
08/27/2009								8	<1		
09/02/2009	11:43AM	Sunny			<0.5	108.0	0.10	41	<1	0.240	0.393
09/13/2009	11:30AM	Overcast			<0.5	110.0	0.15			0.250	0.429
09/20/2009	5:40PM	Sunny			<0.5	106.0	0.15			0.250	0.429
11/02/2009	11:30AM				<0.5	97.9	0.15			0.230	0.359
11/09/2009										0.234	0.372
11/18/2009	12:10PM	Overcast			0.6	154.0	0.15			0.230	0.359
01/02/2010	2:00PM	Overcast			<0.5	106.0	0.10			snow	

Narrows Creek

Date M/D/Y	Time	Weather	Air °C	Water °C	TSS mg/L	SpCond uS/cm	Turb NTU	Total Coli CFU	Fecal Coli CFU	Gauge m	Flow m^3/s
12/02/2009	11:40AM	Overcast			< 0.5	162	0.15			iced	
04/03/2009	8:50AM	Overcast			<0.5	165	0.1			iced	
20/03/2009	10:45AM	Overcast			0.6	166	0.15			0.210	0.044
15/04/2009	2:25PM	Sunny			<0.5	164	0.15			0.300	0.197
22/04/2009	2:10PM	Overcast/rain			0.8	147	0.2			0.390	0.590
02/05/2009	4:15PM	Sunny			<0.5	165	0.1			0.300	0.197
13/05/2009			12.0	3.5						0.350	0.376
16/05/2009	1:30PM	Sunny			0.8	145	0.15			0.390	0.590
27/05/2009			16.0	4.0						0.475	1.347
31/05/2009	7:10PM	Sunny/hot			8.8	55.5	0.7			0.600	3.578
09/06/2009	3:20PM	Overcast			0.8	101	0.2				
15/06/2009	5:00PM	Overcast			1.3	92.3	0.2			0.570	2.887
03/07/2009			25.0	8.0						0.435	0.932
08/07/2009			17.0	6.5						0.435	0.932
12/07/2009	3:50PM	Overcast			0.6	116	0.25			0.420	0.805
12/08/2009			16.0	10.0	<0.5	138	0.1	34	8	0.335	0.313
18/08/2009	5:07PM	Sunny/overcast			<0.5	141	0.15	34	0	0.300	0.197
24/08/2009								29	13		
27/08/2009								14	4		
02/09/2009	3:40PM	Sunny			0.6	152	0.2	26	0	0.300	0.197
13/09/2009	2:30PM	Overcast			<0.5	156	0.15			0.280	0.148
20/09/2009	4:30PM	Sunny			0.8	152	0.15			0.300	0.197
02/11/2009	1:45PM				<0.5	153	0.15			0.300	0.197
09/11/2009			6.0	2.0						0.288	0.166
18/11/2009	11:30AM	Overcast			<0.5	101	0.2			0.290	0.171
02/01/2010	1:55PM	Overcast			0.8	161	0.1			snow	

5.8 Causes of peaks in discharge and suspended sediment

Year	Date of peak discharge	Discharge m^3/s	TSS mg/L	Cause/comment
Harrop Creek				
2002	May 29	-	12.6	No discharge data available during freshet
2003	May 28, June 10, 16	2.832	8.4	-13.4 mm rain[1] in 4 days prior to May 28, warm temp in June
2004	May 28	2.572	2.4	-7.8 mm rain May 28[1]
2005	May 17	4.218	12.64-June 17	-Rain[2]and warm temp, TSS peak on second largest discharge event
2006	May 18	11.807	149	-13.3 mm rain from May 16-18[1]
2007	June 6	6.896	11.4	-24.4 mm rain from June 2-6[1]
2008	June1	5.631	7.4-May 19	-June 1 rain[2] and warm temperatures, peak TSS on rising limb of hydrograph, no rain
2009	May 31	3.242	5.50 -May 17	-Warm temperatures (peak discharge missed) , TSS on rising limb
Narrows Creek				
1999	June 26	3.425	9.0-June 24	-33 mm rain[1] on June 24, TSS peak on rising limb of hydrograph
2000	June 7	2.300	3.3	-Warm temperatures
2001	May 25	2.474	4.2	-Warm temperatures and melting snow
2002	June 16	3.529	-	-Warm temperatures
2003	June 9	3.595	42	-Warm temperatures, 5.2 mm rain June 9[1]
2004	June 8, 14, 28	1.319	2.1-June 28	-Rain[2] on June 28, 14, warm temp. June 28
2005	May 17	1.953	15-June 17	-Rain[2], Peak TSS on second largest discharge event
2006	May 20	5.333	76	-26.6 mm rain[1] May 20
2007	June 5	3.876	58.5	-23.4 mm rain June 2-5[1]
2009	May 31	3.578	8.8	-Warm temperatures

Peak TSS included with date if different than date of peak discharge. Any discharges greater than 4 m^3/s are estimates due to difficulties in metering at high flows. [1]Rain data was from Castlegar Airport when not available from monitoring stations, [2]Rain reported at water monitoring station

5.9 Macroinvertebrate raw data

Study name Site (Date)	EC-Columbia Basin LOC01 (Sep 26, 2007)	EC-Columbia Basin TAM01 (Sep 26, 2007)	CBWN-Slocan River NJMIL01 (Sep 29, 2008)
Latitude	49.50749969	49.79249954	
Longitude	-116.7822189	-116.8477783	
Name	Lockhart Creek	Tam O'Shanter Creek	Harrop (Mill) Creek
Basin	Kootenay Lake	Kootenay Lake	Columbia Basin
JulianDay	269	269	273
Year	2007	2007	2008
Device	Kick Net	Kick Net	Kick Net
Samplenumber	1	1	1
Site_Status	Pot. Ref.	Pot. Ref.	Test
Subsample	45	41	100
Totalsample	100	100	100
Ameletidae	2	2	1
Baetidae	398	219	209
Brachycentridae			2
Capniidae	2	12	
Ceratopogonidae	4	2	
Chironomidae	18	29	7
Chloroperlidae	24	2	1
Elmidae	29	34	9
Empididae		7	
Enchytraeidae			1
Ephemerellidae	18	10	14
Glossosomatidae		10	1
Heptageniidae	64	51	67
Hydropsychidae	9	5	1
Lebertiidae		2	1
Leptophlebiidae			1
Leuctridae	4	10	
Limnephilidae	2	2	1
Lumbriculidae	2		
Nemouridae	67	34	2
Perlidae	2	10	
Perlodidae		5	3
Perlodidae		5	3
Psychodidae			3
Rhyacophilidae	13	17	5
Simuliidae		2	
Sperchonidae		5	1
Stygothrombidiidae	2		
Taeniopterygidae	98	305	29
Tipulidae	4	7	4
Torrenticolidae		5	
Uenoidae		15	8

5.10 Okanagan Biological Index of Biotic Integrity Metrics and Scores

Okanagan B-IBI scoring for primary metrics

	High impacts	Moderate impacts	Low impacts
Metric Scores	**1**	**3**	**5**
Total Number of taxa	≤14.9	15.2-24.9	≥25
# of Plecoptera taxa	≤1	1.1-3.9	≥4
# of Ephemeroptera taxa	≤2	2.1-4.9	≥5
Mean # clinger taxa	≤5.9	6-9.9	≥10
# of intolerant taxa	≤0.49	0.5-2.9	>3.0

Table from Jensen (2006), Calculated at a lowest level of identification, typically to genus

The Okanagan (OK) stream condition rating system

Total B-IBI Score from adding metric score from 5 indices	Stream Condition
23-25	Excellent
19-22	Good
14-18	Fair
9-13	Poor
3-8	Very Poor

Table from Jenson (2006)

Harrop Creek Stream Condition

	Harrop Creek test site	
	Metric	Metric Score from OK B-IBI
Total Number of taxa	23	3
# of Plecoptera taxa	4	5
# of Ephemeroptera taxa	5	5
Mean # clinger taxa	14	5
# of intolerant taxa	11	5
Sum OK IBI Score	-	**23**
Stream Condition		***Excellent***