Water Quality Update for Harrop (Mill) and Narrows creeks: 2005-08

Photo of L. Trione at Harrop Creek provided by J. and T. Yeow

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ACKNOWLEDGEMENTS

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Tony Yeow of Passmore Laboratory Ltd. installed and maintained the stream gauge and carried out the stream metering, and completed stage-discharge curve calculations and corrections. Jennifer and Tony Yeow of Passmore Laboratory Ltd. designed the monitoring program, and conducted laboratory analyses of turbidity, total suspended-sediment, conductivity, and fecal coliforms.

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1 INTRODUCTION

This project is an update of water quality monitoring carried out from 2005-2008 for Harrop (also known as Mill) Creek and Narrows Creek. The Harrop-Procter Community Co-operative holds a Community Forest License in the Kootenay Lake Forest District of the Southern Interior Forest Region. The community forest initiated the water-monitoring program in 1999 in order to examine the possible effects of forest harvest activities on watershed condition and integrity of local creeks in their operating area. These creeks are also important because they supply domestic and irrigation water to numerous local water licensees. Narrows Creek was established as a control in the present study because timber harvest has not occurred to date within this watershed and it has been monitored since 1999. Monitoring of Harrop Creek was added to the program in 2002 because half of the planned forest development will occur within the Harrop watershed (Carver 2006).

The purpose of the study was to monitor the baseline watershed condition, and assess trends in water quality parameters and hydrometrics related to forest development. The project evaluated water quality variables with respect to the BC Ministry of Environment (MoE) Water Quality guidelines (WQG). Trends in drinking water quality were assessed by analyzing the frequency with which parameters exceeded these guidelines. Hydrometric data was collected secondarily as an aid to the interpretation of water quality information and to monitor the annual variations and timing of peak flows. The community-based monitoring program, designed by Passmore Laboratories, included water quality indicators that are susceptible to forest harvesting practices such as turbidity, total suspended solids (TSS), water temperature, and conductivity (Cavanagh et al. 1998 and MacDonald et al. 1991). In 2008, they also added stratified collection of bacteriological samples (total and fecal coliforms) at low flow conditions to address community concerns over drinking water quality. This project encourages community awareness of water quantity and water quality issues that exist within the watershed in order to protect these resources for future years.

The objectives of the 2005-2008 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, and examine any relationship between exceedances and discharge.**
3. **Examine trends in drinking water quality in Harrop (Mill) Creek as forest and road development increases within the watershed.**
4. **Continue to monitor Narrows Creek as a control site.**

2 BACKGROUND INFORMATION

Watershed Characteristics

The Harrop Creek and Narrows Creek watersheds drain steep north-facing slopes of the Nelson Range of the Selkirk Mountains into Kootenay Lake. The creeks are situated 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). The watersheds are characterized by high gradients with steep sidewalls. Harrop Creek is a fourth order stream with a watershed area of 42.2 km^2 - the creek itself is 12.2 km in length. Narrows Creek is a third order stream, and smaller than Harrop Creek (10.58 km in length, with a total watershed area of 22.2 km^2).

Private land, road building and diversion of water (for domestic, irrigation and conservation purposes) have affected the lower portions of the study area. In addition, in the 1920's a sawmill was located near the mouth of Harrop Creek (Carver 2005). 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. The water quality monitoring sites are located upstream of residential impacts to isolate trends resulting from forest development.

Table 1. Coordinates of various locations.

Watershed	Watershed Code	Site	Zone	Easting	Northing
Narrows	340-200100	Mouth	11U	500494	5496052
		Gauge	11U	501036	5494630
Harrop/Mill	340-188100	Mouth	11U	496507	5495101
		Gauge	11U	495653	5493641
		Mill Lake	11U	498656	5484711

Maximum elevations are 2,330 m in the Harrop watershed and 2,360 m for Narrows Creek, while the minimum elevation at Kootenay Lake is 530 m. The biogeoclimatic sub-zones vary with elevation and slope orientation. Aspects that face southeast to west are slightly warmer, and those facing northwest to east-northeast which are cooler (HPWPS 1999). The Interior Cedar – Hemlock dry, warm sub-zone (**ICHdw1**) occurs from the valley bottom to 1,000-1,100 m on northern slopes and at slightly higher elevations (1,200-1,250 m) on southern aspects. This zone gives way to the moist warm Interior Cedar-Hemlock variant (**ICHmw2**) of the Columbia – Shuswap zone in a band up to 1,450-1,550 m on north-facing aspects and 1,550-1,650 m on south slopes. The ICHmw2 zone transitions to the wet cold Engelmann Spruce – Subalpine Fir subzone Columbia variant (**ESSFwc1**) subzone at elevations of 1675-1725 m on cool slopes and 1725-1775 m on warm aspects. The wet cold Engelmann Spruce – Subalpine Fir subzone Selkirk variant (**ESSFwc4**) is found at elevations of 2050-2150 m on north slopes and 2250-2275 m on south-facing slopes. The wet cold Engelmann

Spruce Sub-alpine Fir parkland (**ESSFwcp**) occupies the uppermost elevations to the ridge tops.

Maximum rainfall occurs in May and June while air temperatures peak in July and August (Figure 1). The snow pack accumulates between October and early May with peak snowfall in December and January. Snow-melt begins at the valley bottom in late March and continues at progressively higher elevations through early April to June. Peak snow depths at nearby Redfish Creek (2,104 m, MoE site 2D14P) occur near the beginning of May (1035-1706 mm, 2002-08). Mean monthly flows peak in June on both Harrop and Narrows creeks (Carver 2005).

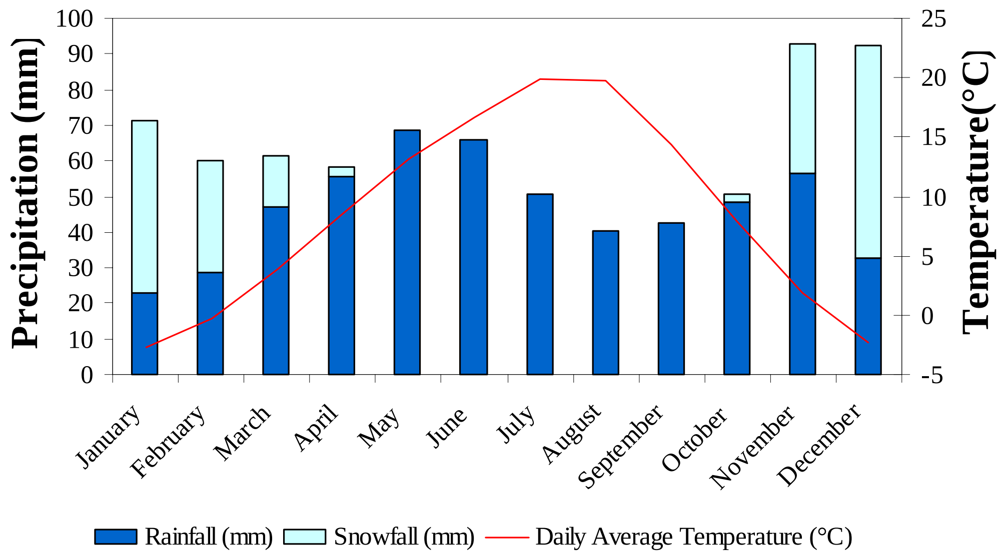

Figure 1. Environment Canada climate normals from 1979-2000 for Castlegar Airport. Snowfall is in water equivalent

The lower reaches of both Harrop and Narrows creeks have riffle-pool morphology (Masse 2002) with step-pool morphology at higher gradients. A summary of the hydrogeomorphic conditions for Harrop watershed (from Carver 2006) is given in Table 3. Carver (2005) reported debris flow hazards at the alluvial fan on both Harrop and Narrows creeks. The riffle-pool sequences of Harrop Creek (found in the lower 1.34 km, Tredger and Taylor 1977) and Narrows Creek (FISS 2008) provide spawning habitat for West Arm kokanee populations (*Onchorhynchus nerka*). Masse (2002) reported that the annual spawning run on Harrop Creek is 1,000-1,500 spawners maintained in part by gravel replacements. Resident populations of bull trout (blue listed) (*Salvelinus confluentus*) and rainbow trout also rear in Harrop Creek and Narrows Creek (Masse 2002).

Mill Lake is found at an elevation of 1,926 m in the headwaters of Harrop Creek. The lake was stocked in 1916 with rainbow trout (*Onchorhynchus mykiss*) and in 1961 with eastern brook trout (*Salvelinus fontinalis*) (FISS 2008). Mill Lake provides recreational fishing and is accessed by the Mill Lake Trail. Downstream migration of rainbow trout from Mill Lake occurs in the upper reaches of Harrop Creek (Masse 2002). However, upstream migration of rainbow trout and bull trout is limited by steep gradients in both creeks.

The Harrop-Procter Community Co-operative manages 10,900 ha of Crown land. Their community ecosystem-based plan includes an Allowable Annual Cut of 2,603 m^3 timber/year (Silva 1999), approximately one-third to one-half the maximum volume recommended by the Ministry of Forests. In 2006, prior to development, the weighted equivalent area clearcut (ECA) for Harrop watershed was 7.8%. The ECA calculation included impacts from fires and a few small helipads (Carver 2006). Work in 2007 and 2008 has included 8 km of road on the face between Harrop and Slater creeks and three cutblocks developed in January 2008 by Porcupine Wood Products. Retention of the developments ranged from (1) 60% in all north aspects to (2) 40% in transitional areas with significant proportions of pine, to (3) less than 15% in western ridge-top aspects that are primarily pine, and (4) zero retention in areas of beetle-infested pine. Development at present is not planned for Narrows Creek because of the steep topography in most of the watershed (Carver 2006). However, development of lower gradient slopes on the east side of Narrows Creek will likely be considered in the future. As a result the Narrows Creek water-monitoring site can serve as a control in the present study but also as background monitoring in the event of future harvest.

Table 2. Summary of 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).

Photo 1. Harrop Creek water monitoring station. Photo submitted by J. and T. Yeow.

The Harrop Creek water quality-monitoring site (Photo 1) is situated approximately 2 km from the mouth of Harrop Creek and is accessed from McConnell Road near the trailhead to Lasca Creek.

Photo 2. Narrows Creek view downstream of water monitoring station, 2008. Photo by J. and T. Yeow.

The Narrows Creek water quality-monitoring site is approximately one kilometre upstream from the alluvial fan. The water monitoring station is accessed from McMullen Rd through private land. Water collections locations on both creeks are upstream of most residential development.

3 METHODS

Hydrometric Measurements

Water level measurements were recorded for Harrop and Narrows creeks by manual readings of a staff gauge at the water monitoring stations (see raw data in companion CD). The staff gauge was read two to sixteen times per month according to the sampling schedule (Table 3). Channel metering was undertaken over a range of flows (see Appendices, Section 7). 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. The 2007 hydrograph was then calculated from these tables. The stage-discharge relationship was based on sixteen flow measurements at Harrop Creek and twenty-five 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 0.2-32% on both creeks (see Appendices Section 7).

Table 3. Sampling schedule of water level readings and grab samples.

Month	# water level readings/month	# grab samples/month
January	4	2
February	8	2
March	12	4
April	12	8
May	16	12
June	16	12
July	12	4
August	8	2
September	8	2
October	2	2
November	2	2
December	2	2
Total	102	54

Water Quality

Grab Sampling

A strategic grab sampling water quality program (Tables 3 and 4) was implemented to collect seasonal conductivity, turbidity, and total suspended solids data. The monthly sampling schedule is outlined in Table 3. Leeza Trione collected samples at the beginning, during, and after rain events especially during spring freshet. If turbidity in Harrop Creek increased for any reason, water samples were collected. However, if there was no sediment in the water sample it was not analyzed (Carver 2005).

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 being collected, water samples were placed in a refrigerator and shipped immediately to Slocan Park, where they were stored in a refrigerator until Passmore Laboratory Ltd picked them up later that day.

Passmore Laboratory Ltd collected samples for fecal and total coliforms at baseline flows following protocols for water sampling by Cavanagh et al. (1997). A sterile plastic bag was filled with stream water. The sample was placed on ice immediately and brought to the laboratory within two hours of collection.

Table 4. Water sampling regime in 2005-2008

Sampling Method	Parameters Tested	Sampling Schedule	Sampling period
Manual water level Measurements	Stage level, manual air, water temperatures, weather	Peak flow monitoring	2005-2008
Flow Measurements	Discharge metering	Multiple times per year across a range of stream flows	2005-2008
Grab Sampling Program	Specific conductivity, turbidity, total suspended solids	Peak suspended-sediment monitoring	2005-2008
Bacterial sample collection	Total and fecal coliforms	Low flow stratified sampling 5 samples per month in 2008 only	August 29-October 10, 2008
Continuous temperature	Temperature	Meter put in place July 3, 2008	July 3-December 3, 2008

4 RESULTS AND DISCUSSION

Summary of Hydrometric and Suspended-Sediment Monitoring

Monitoring of suspended sediments and turbidity shows that MoE guidelines were often exceeded and levels were dependent on the natural flow regime (Figures 2 and 3). The largest 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 2, Table 5). High discharges in 2006 were associated with an extended rainfall event (Table 5) and the highest 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). Peak flows on Harrop Creek in other years were 4.218 m^3/s (2005), 6.896 m^3/s (2007) and 5.631 m^3/s (2008). Turbidity and suspended sediment were very low in these years and were below guidelines of 5 NTU, 1 NTU and 20 mg/L TSS on most days. Except in 2007 when peak turbidity was 1.3 NTU, slightly above the 1 NTU guideline for drinking water. Peak flow in Narrows Creek was 1.955 m^3/s in 2005 and 3.876 m^3/s in 2007, but was not monitored in 2008 due to funding constraints. Levels of TSS peaked at 58.5 mg/L on June 5, 2007 with a turbidity of 4 NTU and but otherwise TSS and turbidity were below MoE guidelines in these years. Low flows occurred between December and March each year.

The peak discharge of 2006 for Harrop Creek (11.807 m^3/s) may be slightly overestimated due to difficulties in metering at high flows. Documented historical peak flows varied from 2.55-10.9 m^3/s on Harrop Creek were lower than the 2006 estimate (1925-30, 1968-70, 1973-94 monitoring at the WSC station). However, Carver (2005) interviewed local residents and found that some remembered large floods in 1948, 1972, and 1974 that may have exceeded the 2006 peak flow. In addition, peak discharge in May 2006 for Harrop Creek (0.280 $m^3/s/km^2$) was similar to Duhamel Creek (0.250 $m^3/s/km^2$ WSC station 08NJ026, 52.9 km^2) when compared by drainage area.

The estimate of peak flow in 2006 (5.333 m^3/s) for Narrows Creek was lower than historical peak flows monitored on Narrows Creek (WSC 1.42-7.16 m^3/s, 1947-1950). The peak in May 2006 (0.240 $m^3/s/km^2$) was slightly lower than nearby Redfish Creek (0.338 $m^3/s/km^2$ WSC station 08NJ061, 26.2 km^2) when compared on a per drainage area basis.

Prior to forest development in the Harrop watershed (2002-September 2007), the guideline of 1 NTU was exceeded at discharges of greater than 1 m^3/s (14 days out of 202 when samples were collected) while the thresholds of 5 NTU and 20 mg/L for TSS were exceeded only on one day (May 18, 2006 described above, Figure 3). The control site on Narrows Creek followed a similar pattern from 1999-2008, but the guideline of 1 NTU was exceeded at slightly lower discharges (0.8 m^3/s on 15 days out of 250) while thresholds of 5 NTU and 20 mg/L were surpassed when flows increased to greater than 10 m^3/s (Figure 3). This included two days out of 250 in which the 5 NTU guideline was exceeded and six days during which the 20 mg/L threshold was exceeded (see Table 5 for peak events). Year-to-year comparisons in suspended-sediment were made as a function of discharge because sampling intensity varied each year (Figure 3).

Monitoring from October 2007 - December 2008 during development activities and post-harvest) showed that turbidity levels ranged from 0.1-0.65 NTU and TSS values ranged from below detecton to 7.4 mg/L. All values were below MoE water quality guidelines.

Specific Conductance

The specific conductance in Harrop Creek (45.7-119 µS/cm, n=203, 2002-2008) was lower than for Narrows Creek (74-210 µS/cm, n=251, 1999-2008). Peak conductivity levels in both creeks were well below the maximum BC MoE guideline of 700 µS/cm for drinking water each year.

The yearly minimum conductivity level corresponded to increases in surface runoff and dilution of high conductivity groundwater during freshet (May 17-July 12, Table 5). Annual minima for Harrop Creek (45.7-63.5 µS/cm) were lower than for Narrows Creek (74-97.7 µS/cm, Table 5).

The median value at low flow (August to April) was 105 µS/cm for Harrop Creek (72.3-119 µS/cm, n=58, 2002-2008) and 155 µS/cm for Narrows Creek (108-210 µS/cm, n=70, 1999-2008). These values are midrange of other streams in the Kootenay Regions (median 131 µS/cm for 14 streams, range 26-495 µS/cm, from Ptolemy et al. 1991).

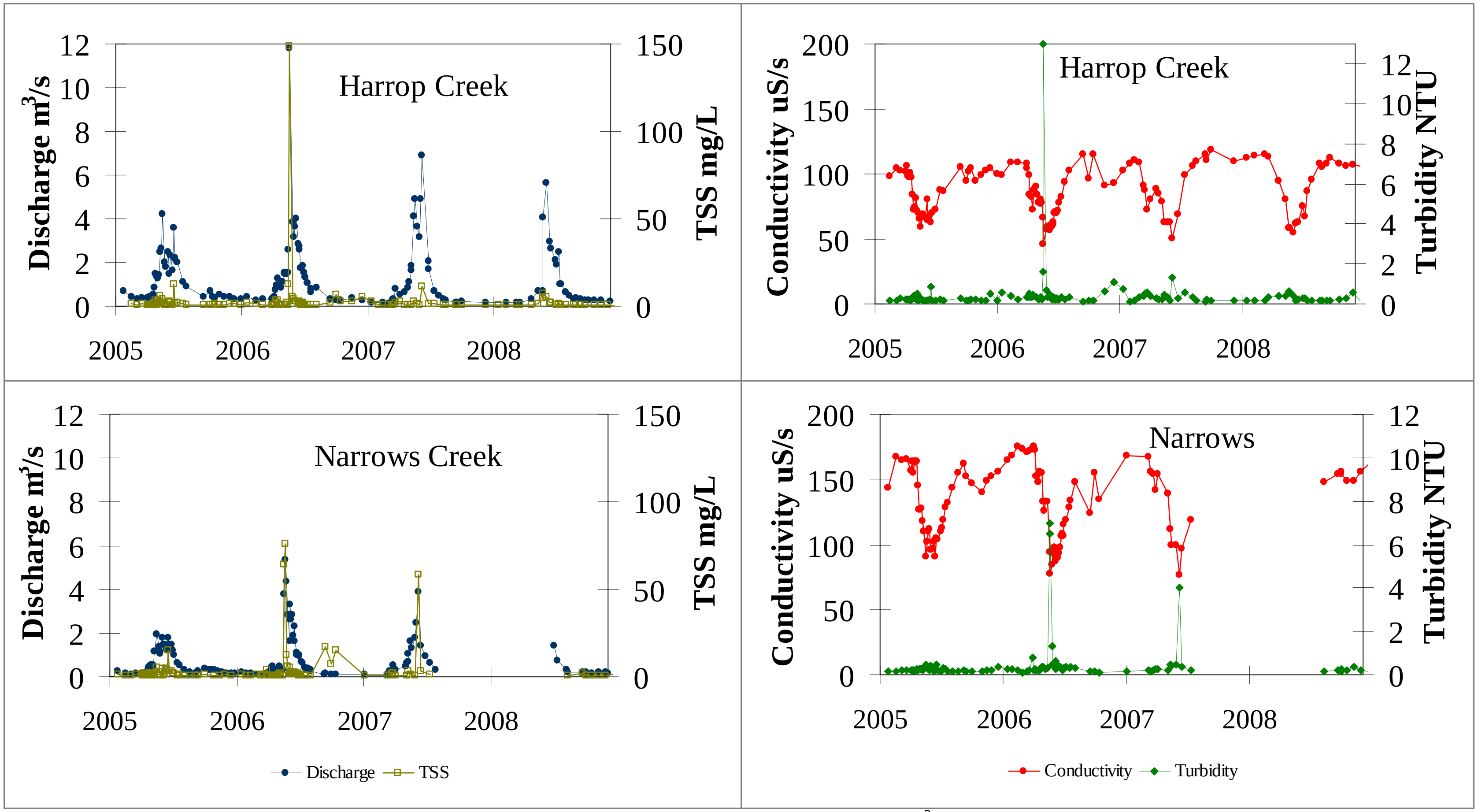

Figure 2. Discharge, TSS, turbidity and conductivity from 2005-2008. Discharge above 4 m^3/s m is estimated due to difficulties of metering in the stream.

Table 5. Causes of peaks in discharge, TSS, turbidity, and minimum specific conductance (peaks in bold).

Year	Date	Discharge m^3/s	TSS mg/L	Turbidity NTU	Specific Conductance	Cause/comment
Harrop Creek						
2002	May 29	-	**12.6**	1.8	56.3	No discharge data available during freshet
	June 17	-	8.1	**1.9**	51.4	Rain[1]
	June 18	-	**6.6**	1.2	**49.6**	Rain[1]
2003	May 4	-	2.1	**2.5**	91.1	-On rising limb of hydrograph
	May 28	**2.832**	**8.4**	1.2	66.3	-13.4 mm rain in 4 days prior to May 28[1]
	June 10	**2.832**	5.7	0.7	**52.2**	-Warm temperatures, possibly missed peak due to lack of sampling
	June 16	**2.832**	2.1	0.35	57	-Warm temperatures
2004	May 28	**2.572**	**2.4**	0.25	64.8	-7.8 mm rain May 28[1]
	June 14	2.229	0.9	0.25	**63.5**	-Descending limb of hydrograph, trace rain[1]
2005	May 17	**4.218**	4.2	0.3	**59.6**	-Rain[2]and melting snow
	June 17	3.567	**12.6**	**0.85**	62.5	-Max. TSS occurred on second largest discharge event, rain[2]
2006	May 18	**11.807**	**149**	**13**	**45.7**	-13.3 mm rain from May 16-18[1]
2007	June 6	**6.896**	**11.4**	**1.3**	**50.8**	-24.4 mm rain from June 2-6[1]
2008	May 19	0.320	**7.4**	**0.65**	58.3	-Warm temperatures
	June1	**5.631**	5.1	0.4	**55.3**	-Rain[2] and warm temperatures
Narrows Creek						
1999	June 24	**2.713**	**9.0**	0.9	86.2	-33 mm rain on June 24[1]
	June 26	**3.425**	6.8	**0.9**	86.2	-Rain[1]
	July 12	-	6.6	0.45	**85.2**	-No discharge data, warm temperatures
2000	June 7	**2.300**	**3.3**	0.9	93.7	-Warm temperatures
	June 8	**1.579**	<0.5	**1.1**	**74**	-15.8 mm rain on June 8[1]
2001	May 25	**2.474**	**4.2**	**1.3**	**83.2**	-Warm temperatures and melting snow
2002	June 16	**3.529**	-	-	**-**	-Water quality not monitored during freshet, warm temperatures
2003	June 9	**3.595**	**42**	**3.2**	**80.7**	-Warm temperatures, 5.2 mm rain June 9[1]
2004	June 8	**1.319**	1	**0.3**	97.1	-Peak discharge possibly missed because of lack of sampling, rain[2]
	June 14	**1.319**	1.8	0.25	96.6	-Rain[2]
	June 28	**1.319**	**2.1**	0.25	**97.6**	-Warm temperatures
2005	May 17	**1.953**	5.4	**0.45**	**90.5**	-Rain[2]
	June 17	1.783	**15**	**0.45**	105	-Rain[2]
2006	May 20	**5.333**	**76**	**7**	**77.9**	-26.6 mm rain[1] May 20
2007	June 5	**3.876**	**58.5**	**4**	**76.7**	-23.4 mm rain June 2-5[1]

Peak values for discharge, TSS and turbidity and minimum values for conductivity are in **bold.** Any discharges greater than 4 m^3/s are estimates due to difficulties in metering at high flows. [1]Rain data from Castlegar Airport when not available from monitoring stations, [2]Rain reported at water monitoring station

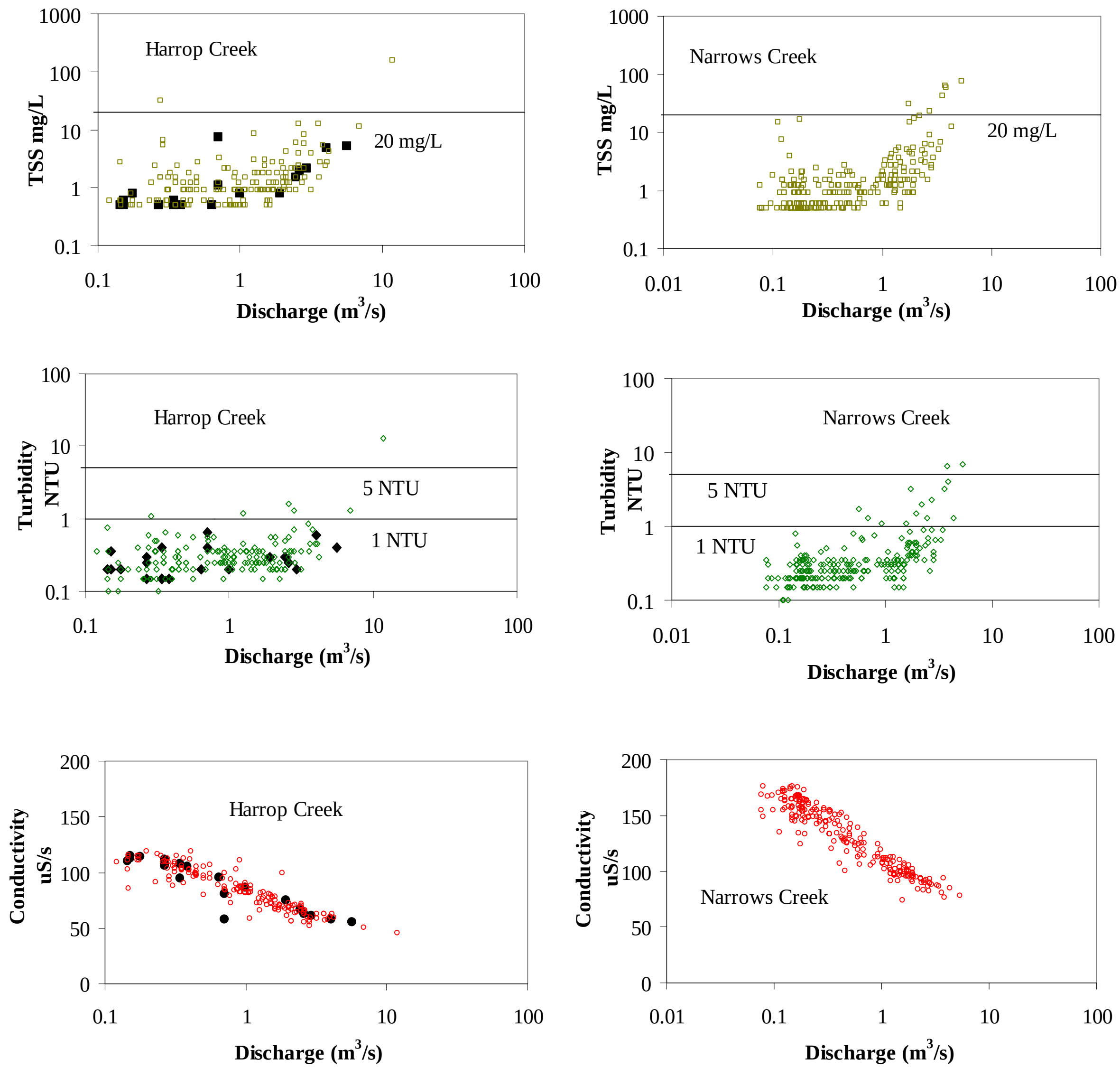

Figure 3. Log turbidity, Log TSS and conductivity versus log discharge. Black points on Harrop Creek indicate the levels during and after forest development (October 2007-December 2008). Open points for Harrop Creek indicate the period prior to development (2002-2008). The Narrows Creek control site serves as a comparison (1999-2007, August-December 2008). Black lines indicate MoE drinking water guidelines for turbidity (1 NTU and 5 NTU) with 20 mg/L as an approximation of the 5 NTU guideline for TSS (Toews and Glun 2003).

Temperature

A continuous temperature meter was secured in place from July 3 to December 5, 2008 in both Harrop and Narrows creeks (Figure 4). Peak water temperatures at Harrop and Narrows creeks were very similar and occurred from August 16-20 with temperatures ranging from 12°C to just over 13°C. In neither case did temperatures exceed the BC water quality aesthetic guideline for drinking water of 15°C. Summer temperatures on both creeks were also below maximum temperatures recommended for rearing of bull trout (15°C), rainbow trout (18°C), and streams with unknown fish distributions (18°C). Although there are no provincial guidelines specifically for spawning kokanee, the maximum temperature threshold for spawning sockeye is 13.8°C, again above the peak temperature observed on both Harrop and Narrows creeks. Minimum water temperatures ranging from 1.3-2°C occurred from November 23 – December 3.

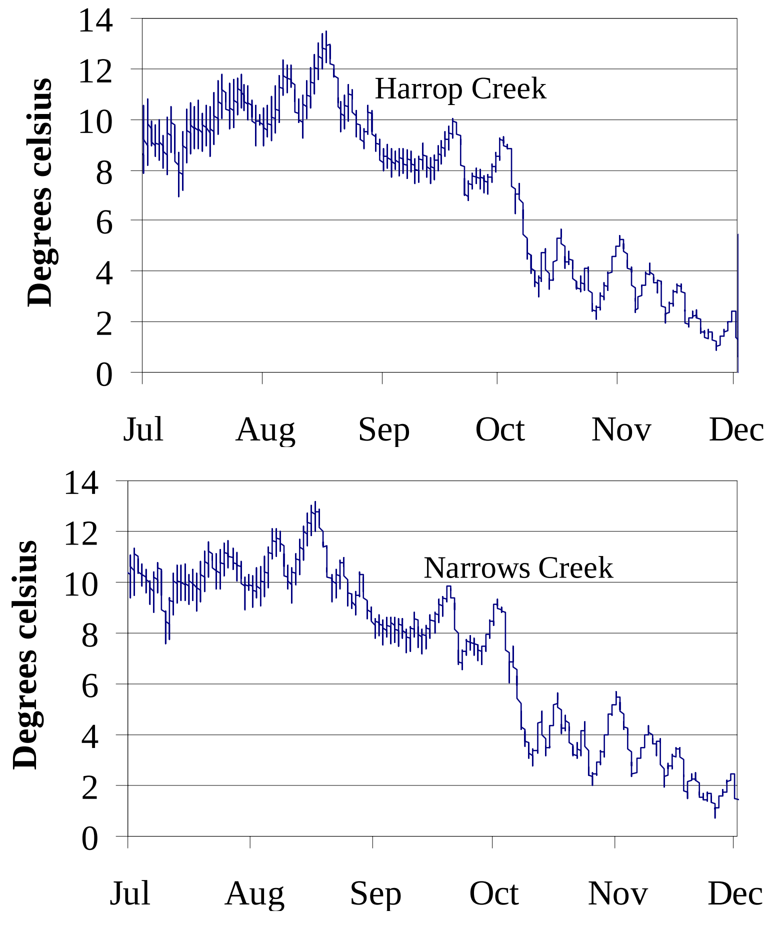

Figure 4. Continuous temperature recording from Harrop Creek and Narrows Creek water monitoring stations for summer 2008.

Fecal and total coliforms

For drinking water undergoing no treatment (as occurs in Harrop and Narrows creeks), no fecal coliforms for any date are permitted in the raw water. The drinking water guideline for fecal coliforms in drinking water receiving disinfection only is a 90th percentile of not more than 10 CFU/100 mL (based on a minimum of five samples collected within a 30-day period).

In 2003 all samples analyzed for fecal coliforms (n=3 for Narrows and n=2 for Harrop creeks) were at or near detection levels (Table 6). While total coliforms (n=2 on both creeks) were below detection except for one sample collected from Harrop Creek on October 7, 2003 that was 2 CFU/100 mL. In 2005 one water sample collected October 9 on Narrows Creek was below detection for fecal coliforms and measured 6 CFU/100 mL for total coliforms (Table 6).

In 2008 fecal and total coliform levels (n=5) were monitored from August 29 to October 10 during low flow at Harrop and Narrows creeks. Fecal coliform levels were below the acceptable level for drinking water undergoing no treatment (<1 CFU/100 mL) on just one out of the five dates monitored (September 29, Table 7) in Harrop Creek but met guidelines on all dates at Narrows Creek. The 90th percentile for both Harrop Creek (4 CFU/100 mL) and Narrows Creek (<1 CFU/100 mL) met the drinking water guideline for water undergoing disinfection (10 CFU/100 mL) (Table 6). Total coliforms counts in Harrop Creek ranged from 12 - 66 CFU/100 mL and from <1-59 CFU/100 mL at Narrows Creek. The calculated 90th percentile was higher for Harrop Creek (70 CFU/100 mL) than for Narrows Creek (48 CFU/100 mL). No BC MoE guidelines exist for total coliforms in drinking water.

Contamination from wildlife is thought to be primary source of coliforms at the monitoring sites because residential development occurs downstream from the sampling location. However, upstream activities related to recreation at Mill Lake or forest operations within the Harrop watershed could also be sources of contamination.

Table 6. Summary of fecal and total coliform values (CFU/100 mL) from 2003-2008.

		Harrop Creek		Narrows Creek	
	Year	**Date**	**CFU/100 mL**	**Date**	**CFU/100 mL**
Fecal coliforms	**2003**	--		August 22	1
		September 3	<1	September 3	<1
		September 7	<1	September 7	<1
	2005	--		October 9	<1
	2008	August 29	5	September 14	<1
		September 14	2	September 21	<1
		September 21	1	September 28	<1
		September 29	<1	September 29	<1
		October 10	2	October 10	<1
Total coliforms	**2003**	September 3	<1	September 3	<1
		September 7	2	September 7	<1
	2005	--		October 9	6
	2008	August 29	39	September 14	17
		September 14	27	September 21	59
		September 21	84	September 28	32
		September 29	50	September 29	10
		October 10	2	October 10	<1

5 CONCLUSIONS AND RECOMMENDATIONS

Development activities conducted in the Harrop Creek watershed between October 2007 and December 2008 do not appear to have significantly impacted drinking water quality. 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 during this period. Suspended-sediment levels (TSS and turbidity) in Harrop Creek were also within the range of natural variability observed prior to development 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 2003 and 2005 spot checks of fecal coliform counts were below guidelines for drinking water undergoing no treatment (<1 CFU/100 mL). In 2008 fecal coliforms counts were below guidelines for disinfection of < 10 CFU on both creeks when monitored five times over 30 days. However, fecal coliform levels above the acceptable level for drinking water undergoing no treatment (<1 CFU/100 mL) on four out of the five dates monitored (August 29, September 14, 21 and October 10).

This study does not attempt to infer effects of logging or road building. Road building in particular is thought to have the largest impact on suspended-sediment levels (Jordan and Fanjoy 1999). Instead, the primary goal of our study is to determine if drinking water quality remains similar during both background conditions and development. This is because interannual, site-to-site and instantaneous sample variation in suspended-sediment can often make it difficult to isolate effects of forest management on water quality (Toews and Gluns 2003). For example, peak suspended-sediment events are primarily correlated with flow events that happen in years where there is a cool spring, delayed snow-melt preceding rapid warming and heavy rains (Apex 2006). The impacts of logging can also be delayed resulting in a complex interaction between development and peak flows that is difficult to separate.

Toews and Gluns (2003) comment that water users often demand evidence that logging is not affecting drinking water quality. We propose that water quality monitoring can be used as one indicator in a multi-faceted evaluation to follow trends within the Harrop-Procter community forest watersheds. In addition, observations by the water-monitoring program can be used to trigger further ground assessments of fish habitat, and channel and landslide evaluations in years of peak flow or exceptional suspended-sediment levels.

Recommendations include:

1. **Continue to monitor water quality in Harrop Creek to determine whether protective measures ensure ongoing clean drinking water within the watershed.**
2. **Continue to monitor water quality in Narrows Creek as a control site until further harvest occurs in the watershed.**
3. **Use field observations from the gauge site during unusual suspended-sediment events to initiate site investigations or corrective measures within the watershed.**
4. **Collect duplicate samples and trip blanks in order to ensure that are no contamination problems associated with sampling procedures. Establish hydrometric benchmarks at each site.**
5. **Record air and water temperature with each gauge reading in logbook of monitoring activities. Also record length of rain events if possible in days/hours.**
6. **Consider increasing the number of water level readings during “flashy” events on the rising and declining limbs of the hydrograph as well as during the peak.**
7. **Summarize benthic macroinvertebrate data from Harrop Creek relative to regional reference sites in the Canadian Aquatic Biomonitoring Network (CABIN 2009) database.**

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7 APPENDICES

Table of Contacts

Name	**Organization**	**Contact Number**
Leslie, Erik	Harrop-Proctor Community Forest	250-229-2271
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Trione, Leeza	Local resident	250-229-4424
Yeow, Jennifer and Tony	Passmore Laboratory Ltd.	250-226-7339

Map of Harrop (Mill) and Narrows creeks

Stream metering and discharge rating accuracy for 2005-2008

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**	**#**
01/25/05	TY	Wade	-1.0	1.0	7.010	1.486	0.498	0.310	0.7090	0.2060	**-3.5**	1
03/17/05	TY	Wade	3.0	1.0	6.858	0.940	0.328	0.252	0.3639	2.5132	**-0.6**	1
04/20/05	TY	Wade	8.5	1.5	6.828	1.110	0.346	0.275	0.4652	2.0124	**1.7**	1
05/5/05	TY	Wade	11.5	2.5	7.468	1.982	0.612	0.391	1.3127	1.6548	**6.4**	1
05/25/05	TY	Wade	17.5	3.5	7.468	2.303	0.766	0.425	1.8324	0.9564	**-1.5**	1
06/20/05	TY	Wade	21.0	7.0	7.468	2.534	0.873	0.453	2.2498	2.1972	**-2.3**	1
06/20/05	TY	Wade	21.0	7.0	7.468	2.534	0.873	0.453	2.250	2.1972	**3.6**	2
05/10/06	TY	Wade	15.0	5.0	7.315	1.686	0.825	0.393	1.492	1.480	**0.8**	2/3
06/23/06	TY	Wade	20.0	5.5	7.163	2.184	0.793	0.425	1.784	1.826	**-2.4**	2/3
07/07/06	TY	Wade	24.0	9.0	7.163	1.933	0.631	0.372	1.226	1.276	**-4.1**	2/3
07/21/06	TY	Wade	31.0	12.0	7.163	1.387	0.433	0.288	0.653	0.641	**1.8**	2/3
05/01/07	TY	Wade	10.0	3.5	7.010	1.607	0.669	0.375	1.111	1.1990	**7.9**	4
05/08/07	TY	Wade	20.0	4.5	7.772	1.937	0.876	0.420	1.847	1.757	**-4.9**	4
05/17/07	TY	Toohigh	19.0	3.5				0.570				4
06/01/07	TY/JY	Toohigh	26.0	5.5				0.570				4
06/25/07	TY/JY	Wade	16.0	5.0	7.467	1.849	0.783	0.415	1.695	1.687	**-0.5**	4
07/26/07	TY/JY	Wade	32.0	12.0	7.193	1.013	0.396	0.280	0.457	0.447	**-2.2**	4
06/27/08	TY JY	Wade	23.5	7.0	7.468	2.442	0.739	0.463	2.301	2.0796	**-9.6**	5
07/9/08	TY JY	Wade	24.0	10.0	7.437	1.683	0.502	0.362	0.886	1.0097	**13.9**	5
08/5/08	TY	Wade	26.0		7.315	0.990	0.400	0.279	0.453	0.4700	**3.8**	5
09/29/08	TY JY	Wade	9.0	8.0	6.736	0.758	0.258	0.229	0.264	0.2632	**-0.2**	5
12/3/08	TY JY	Wade	3.0	0.0	6.584	0.676	0.265	0.215	0.233	0.2187	**-6.3**	5

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**	**#**
03/17/05	TY	Wade	na	na	3.810	0.420	0.349	0.308	0.159	0.138	**13.2**	1
04/20/05	TY	Wade	11.5	2.0	3.962	0.451	0.368	0.325	0.161	0.179	**-11.2**	1
05/05/05	TY	Wade	13.0	4.0	4.298	0.889	0.615	0.400	0.555	0.478	**13.9**	1
05/25/05	TY	Wade	18.5	5.5	4.267	1.165	0.776	0.465	0.953	0.975	**-2.3**	1
06/20/05	TY	Wade	24.5	8.5	4.267	1.471	0.988	0.498	1.510	1.349	**10.7**	1
05/10/06	TY	Wade	22.0	5.0	4.267	0.844	0.484	0.410	0.408	0.537	**-31.6**	1
06/02/06	TY	Wade	20.0	6.0	4.267	1.907	1.206	0.561	2.645	2.640	**0.2**	2
06/23/06	TY	Wade	27.0	8.0	4.267	1.225	0.841	0.445	0.961	0.969	**-0.8**	2
07/07/06	TY	Wade	21.0	10.0	4.206	0.833	0.767	0.400	0.617	0.611	**1.0**	2
07/21/06	TY	Wade	28.0	12.0	4.084	0.516	0.606	0.340	0.302	0.303	**-0.3**	2
05/01/07	TY	Wade	10.0	4.0	4.267	0.755	0.587	0.375	0.494	0.495	**0.2**	3
05/08/07	TY	Wade	25.0	5.5	4.206	0.906	0.698	0.405	0.616	0.665	**8.0**	3
05/17/07	TY	Toohigh	20.0	4.0				0.485				3
06/01/07	TY/JY	Wade	27.0	7.0	4.389	1.844	1.143	0.570	2.357	2.459	**2.6**	3
06/25/07	TY/JY	Wade	n/a	n/a	4.206	1.278	0.764	0.445	1.053	0.953	**-9.5**	3
07/26/07	TY	Wade	29.0	12.0	3.962	0.642	0.554	0.335	0.323	0.322	**-0.3**	3
7/1/08	TYJY	Wade	15.0	8.0	4.145	1.465	0.999	0.495	1.4579	1.3572	**-6.9**	4
7/9/08	TYJY	Wade	25.0	10.0	4.237	1.154	0.473	0.415	0.5335	0.6747	**26.5**	4
8/5/08	TY	Wade	23.0	n/a	3.902	0.634	0.558	0.326	0.3493	0.2591	**-25.9**	4
9/29/08	TY/JY	Wade	15.0	7.0	3.627	0.410	0.380	0.290	0.1608	0.1630	**1.3**	4
12/3/08	TY/JY	Wade	-2.0	0.0	3.200	0.346	0.250	0.265	0.1009	0.1140	**13.0**	4