Coldstream Creek
Water Quality Monitoring: 2008-2009

Final Report – July 06, 2009

Ministry of Environment, Environmental Protection Division, Penticton

Introduction

Coldstream Creek is located within the Thompson-Okanagan Plateau east of the city of Vernon, BC, and has a total watershed area of approximately 20,600 hectares. Coldstream Creek originates in Silver Star Provincial Park and flows south through Noble Canyon to Lavington and then west where it drains into the north end of Kalamalka Lake (Figure 1). Downstream of Noble Canyon, the creek flows west along a broad valley flood plain with an average stream gradient of approximately 1% (Chapman Geoscience Ltd., 1999). Coldstream Creek is the main tributary (supplying 80% of the input) to Kalamalka Lake, which is used extensively for recreational activities and as a source of drinking water. The creek also provides habitat for a variety of aquatic life (including kokanee spawning habitat within the lower 6 km), community drinking water, and irrigation water.

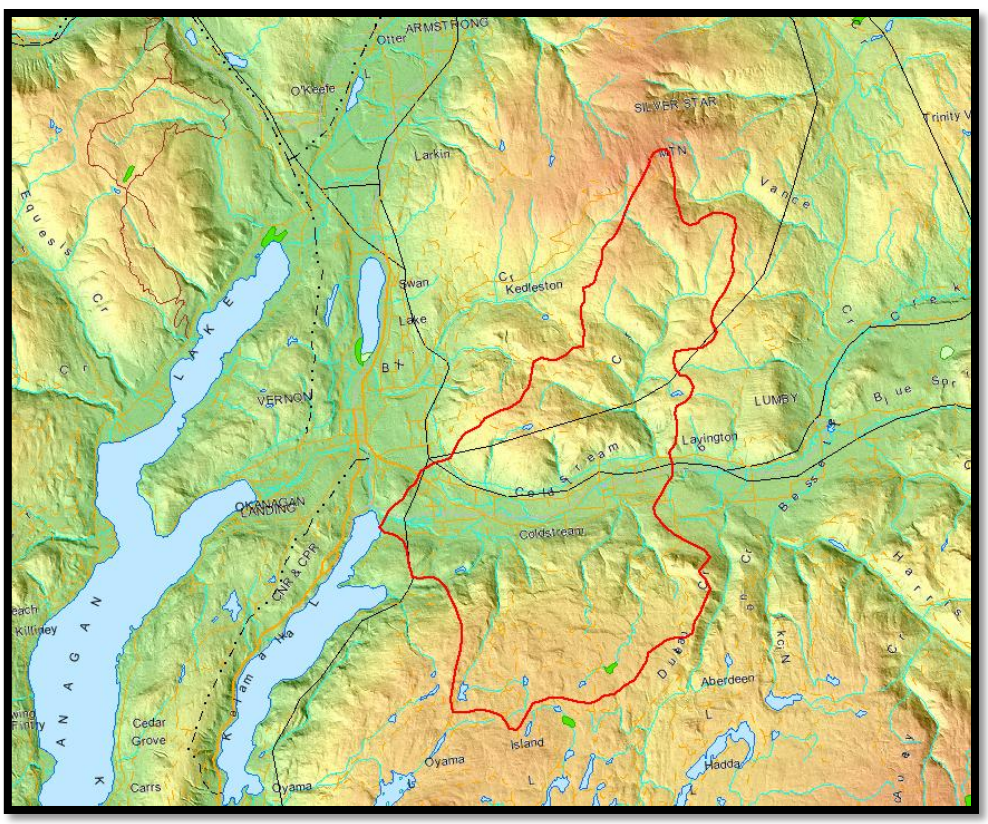

Figure 1. Location of Coldstream Creek watershed

Typical of many southern interior watersheds, Coldstream Creek peak stream flows occur from late-April to early-May as the snowpack at upper elevations begin to melt, however, valley bottom snow melt typically occurs earlier from early-March to mid-April. Maximum daily discharges recorded over the past 30 years at the municipal intake ranged from 0.54 m^3/s to 7.5 m^3/s (Water Survey of Canada, 2008). Annual precipitation ranges from 450 mm at low elevations to approximately 1,100 mm at high elevations. Snow accounts for about 28 percent of the precipitation typically occurring from November to April (Chapman Geoscience Ltd., 1999).

Land use in the valley bottom is largely agricultural and residential development, with some logging activities in the upper watershed. Approximately 10% of the entire watershed is characterized by agricultural use, and is almost entirely confined to the valley bottom (Figure 2). For example, total forage area is 1775 Ha (Horse – 196 Ha; Cattle – 117 Ha), feedlot area is 13 Ha, and fruit orchards comprise 112 Ha. Refer to Appendix 1 for a complete list of the primary agricultural uses around Coldstream Creek (CORD Land Use Inventory 2006).

A number of water quality studies have been conducted on Coldstream Creek over the past 30+ years (e.g. Water Investigations Branch, 1974; Ministry of Agriculture & Ministry of Environment, 1977; Warrington, 1990). Many of these have indicated impaired water quality, particularly with regards to nitrate concentrations and fecal coliform bacteria which are elevated well above the regional average. While a number of improvements have been made to community sewage collection and agricultural practices in the Coldstream Creek valley over the years, downstream water quality is still degraded. In this study, the objective is to provide additional spatial and temporal definition to the water quality issues in Coldstream Creek. Understanding how agricultural and urban development impact stream water quality can aid in identifying where further monitoring, assessment or compliance efforts may be necessary.

Methods

A total of six monitoring sites were selected along the length of Coldstream Creek (Figure 2). Five sites were selected to obtain spatial coverage of agricultural activity in the valley bottom and one site selected as a reference site in Noble Canyon, which is above the influence of agricultural activity (Table 1). Between Noble Canyon and School Rd, rural settlement and agricultural land use increase. Between School Rd and Howe Dr, land use is largely agricultural. Below Vimy Rd and particularly between McClounie Rd and Kirkland Dr, residential land use dominates.

Monitoring sites were sampled once in the late fall of 2008 (November 20) to capture low flow water quality conditions and once a week for five consecutive weeks in the early-spring of 2009 (March 18, 25, 31, April 7 and 14) to capture inputs from valley bottom snow melt. Sites that could not be sampled due to logistical and timing constraints, safety or ice conditions included McClounie Rd. (site 0500518), on November 20, 2008 and the three most upstream sites (Vimy Road [E216452], School Road [E216451], and Noble Canyon [E274383]) on March 18th and 25th, 2009. All samples were taken under approximately the same conditions, including time of day and with no major weather anomalies such as precipitation, however, the timing and rate of spring snowmelt was quite variable over the five week sampling period.

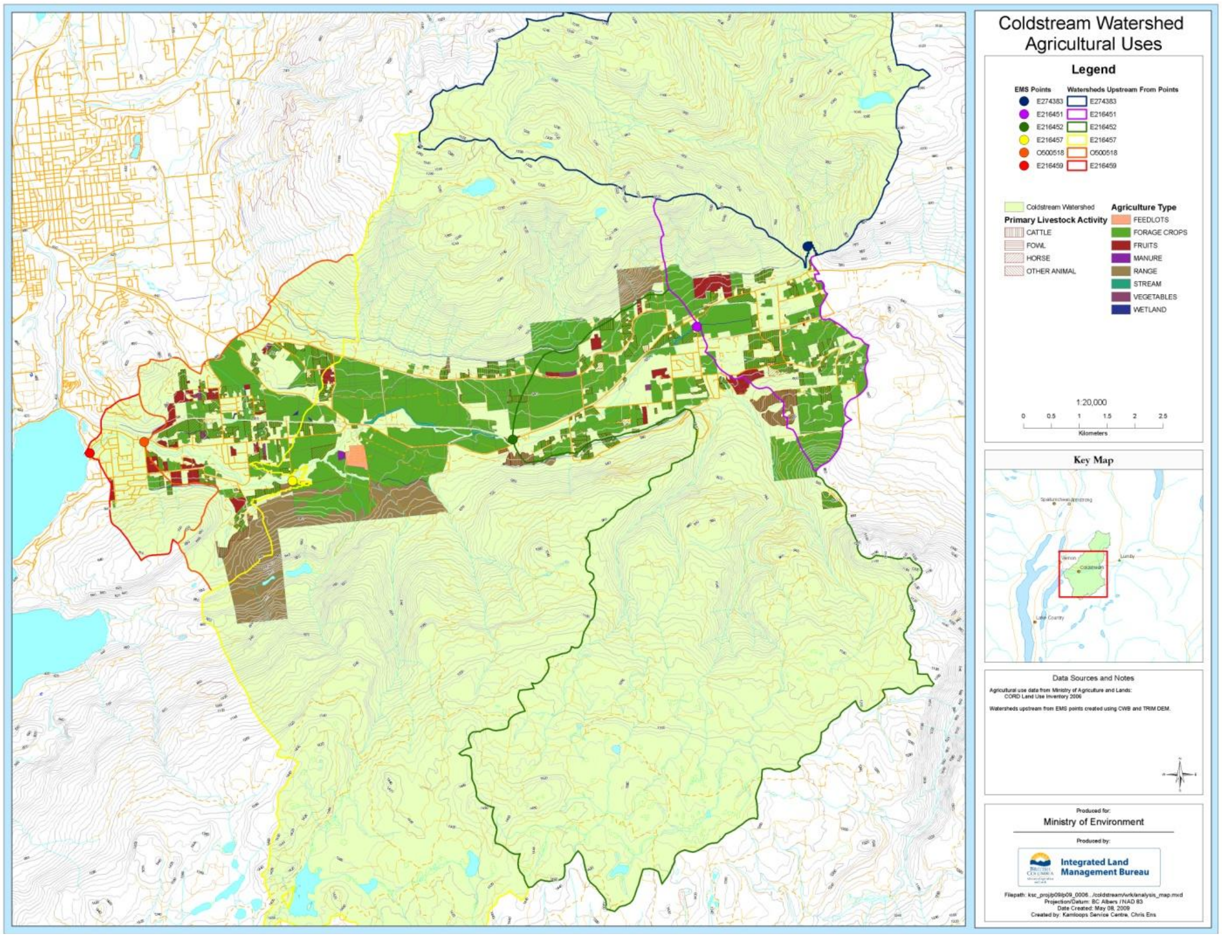

Figure 2. Location of Coldstream Creek sampling sites, site sub-watersheds and agricultural land use

Grab water samples were collected on each sampling date from the mid-point of the stream at depths varying from 0.2 m to 0.5 m. Grab samples were taken upstream above culverts, when safety and access permitted. Four different high-density polyethylene bottles were used to collect water samples: one 1 L bottle for turbidity, one 120 mL bottle for total phosphorus, dissolved phosphorus and dissolved ortho-phosphate; one 120mL bottle for chloride, total nitrogen, nitrate+nitrite, ammonia and total Kjeldahl nitrogen (TKN); and one 500 mL bottle with preservative for bacteriology.

Three bacteriological parameters were used to determine fecal contamination in Coldstream Creek: Fecal coliforms, *E. coli*, and *Enterococcus*. Fecal coliform bacteria are useful indicators of the presence of pathogens and naturally occur in the digestive tract of animals. Pathogenic organisms are found along with fecal coliform bacteria, and since pathogens are relatively scarce in water, fecal coliform levels are monitored to indicate the likelihood of contamination of the water by pathogenic organisms. *E. coli* is a pathogenic member of the fecal coliform group and is found exclusively in the intestines of warm blooded animals. Elevated levels of *E. coli* density primarily provide evidence of fecal pollution and secondarily reflect the possible presence of bacterial, viral and parasitic enteric pathogens. *Enterococcus* is an efficient bacterial indicator of water quality as it is found in both human and ruminant intestines and generally survives longer than *E. coli*. Its presence in water indicates fecal contamination.

Additional 1 L water samples were also collected on March 31, April 7 and April 14 for Bacteria Source Tracking (BST) analysis to identify the possible source(s) of fecal pollution in Coldstream Creek. BST is a relatively new monitoring tool useful for assessing the degree of risk posed to public health and for ensuring a more targeted approach to reduce the environmental loading of pathogens associated with waterborne disease transmission (Mohapatra, 2007). The BST method identifies the probable source(s) of fecal pollution by comparing the "fingerprints" (phenotypic or genotypic profiles) of the environmental *E. coli* isolate with a reference library consisting of the profiles of *E. coli* obtained from known sources of fecal pollution.

All water samples were packed on ice in coolers and shipped the same day to the various analytical laboratories (Can-Test, Maxxam Analytics, and Water & Watershed Research Laboratory, Department of Biology, University of Victoria) for analysis. At each site, after water collection, a YSI 650 multi-parameter water quality meter was used to take readings for dissolved oxygen (DO), conductivity, temperature and pH.

Table 1. Site Description of Coldstream Creek monitoring locations

EMS ID	Site Name	Location Description	Lat/Long
E216459	Kirkland Dr.	Upstream of Kirkland Dr. bridge, about 50m upstream of mouth	50° 13' 27" N, 119° 15' 43" W
0500518	McClounie Rd.	Upstream of McClounie Rd. bridge	50° 13' 30" N, 119° 14' 53" W
E216457	Howe Dr.	Downstream of Howe Dr. bridge	50° 13' 1" N, 119° 12' 44" W
E216452	Vimy Rd.	Upstream of culvert under Hwy. 6, east of Vimy Rd.	50° 13' 11" N, 119° 9' 22" W
E216451	School Rd.	Downstream of School Rd. bridge	50° 14' 6" N, 119° 6' 27" W
E274383	Noble Canyon	Northwest of first bend in Noble Canyon Rd., about 1km north of Hwy. 6	50° 14' 46" N, 119° 4' 40" W

Results

Physical and Chemical Parameters

- Water samples collected from Coldstream Creek sampling sites revealed various spatial and temporal trends. Generally, concentrations of most parameters were very low at the upstream monitoring site in Noble Canyon, and substantially increased in the valley bottom. Some parameters (e.g. conductivity & chloride) increased incrementally downstream with intensified agricultural, urban and rural development. Conversely, other parameters (e.g. nutrients) showed a more noticeable temporal trend and increased during higher stream flows (increased valley bottom snow melt). For detailed physical and chemical parameter monitoring data, refer to Appendix 2.

- Nitrate levels at Nobel Canyon were very low, but increased sharply between Noble Canyon and School Rd (Figure 3). Nitrate also peaked at School Rd on March 31 and was above the BCWQG for drinking water (10 mg/L), but this appeared to be an isolated event. For sites below Noble Canyon, nitrate levels were generally high and many were near or above the BCWQG for aquatic life (2.9 mg/L). This included both Vimy Rd and School Rd on March 31 and April 7, and Howe Dr on four consecutive sampling dates (March 18 to April 7). Although highest concentrations of nitrate were found at School Rd and Vimy Road during periods of higher flow, nitrate levels were also near or above the aquatic life guideline during low flow conditions in the fall.

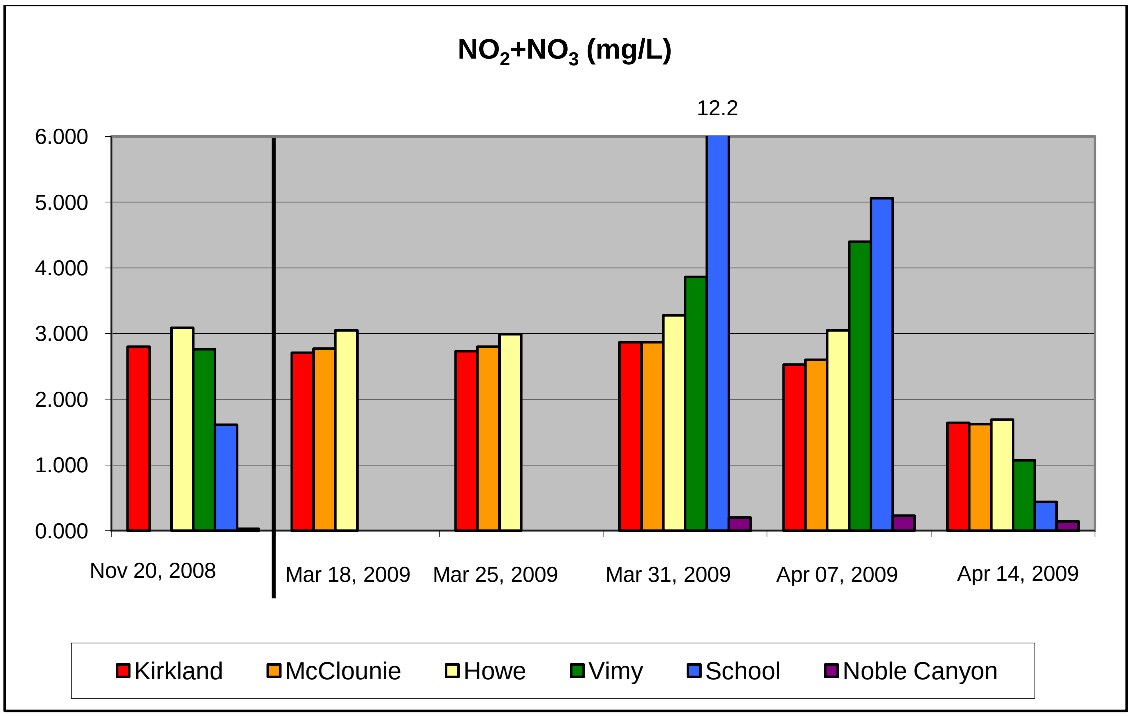

Figure 3. NO_2+NO_3 monitoring results from Coldstream Creek.

Fecal Bacteria Counts

- Overall, bacteria levels tended to increase downstream particularly under spring low flow conditions. The bacteria data collected in this study confirms monitoring data from numerous other studies indicating a chronic issue with high coliform bacteria in Coldstream Creek.
- Bacteria levels were low at Nobel Canyon through to School Rd, and then increased between School Rd and Howe Dr. Levels subsequently decreased at McClounie Rd, and then increased again at Kirkland Dr (Figure 4).
- While fecal contamination in the late fall was relatively low (with the exception of enterococci), early spring levels were found to be quite high. Bacteria counts were also

generally higher during weeks of lower flow and appear to be diluted during higher water levels and increased valley bottom melt (Figure 4).

- Average values at monitoring sites below School Rd were greater than BCWQG for drinking water (partial treatment) and primary contact recreation (Table 3).
- Three out of fifteen samples (only enterococci) were above BCWQG for drinking water and recreation in the fall. However, thirty out of seventy-two samples (15 enterococci, 8 *E. coli*, and 7 fecal coliforms) were above guideline levels in the spring. Refer to Table 3 for guideline levels and complete bacteriological results.
- The sampling in this study further supports the results of Ministry of Environment long-term monitoring at Kirkland Dr showing fecal contamination continues to be a chronic problem in Coldstream Creek. Throughout the year, fecal coliforms, *E. coli* and enterococci bacteria at Kirkland Dr consistently exceed BCWQG for drinking water and recreation (Figure 5).

Table 3. Coldstream Creek bacteriological results (CFU/100mL); Highlighted values indicate occurrences that were above the BCWQG.

Date	Bacteriological Indicator	*BCWQG for Drinking Water (partial treatment)*	*BCWQG for Recreation (primary contact)*	Kirkland Dr.	McClounie Rd.	Howe Dr.	Vimy Rd.	School Rd.	NobleCanyon
2008-11-20	Fecal Coliforms	*100*	*200*	55	N/A	71	31	27	8
	E. coli	*100*	*77*	34	N/A	63	24	27	8
	Entercocci	*25*	*20*	40	N/A	40	1000	7	2
2009-03-18	Fecal Coliforms	*100*	*200*	430	94	360	N/A	N/A	N/A
	E. coli	*100*	*77*	400	93	350	N/A	N/A	N/A
	Entercocci	*25*	*20*	310	82	45	N/A	N/A	N/A
2009-03-25	Fecal Coliforms	*100*	*200*	62	41	110	N/A	N/A	N/A
	E. coli	*100*	*77*	36	35	110	N/A	N/A	N/A
	Entercocci	*25*	*20*	18	17	78	N/A	N/A	N/A
2009-03-31	Fecal Coliforms	*100*	*200*	52	20	23	160	65	1
	E. coli	*100*	*77*	51	20	21	160	3	1
	Entercocci	*25*	*20*	32	21	19	510	86	1
2009-04-07	Fecal Coliforms	*100*	*200*	300	70	59	470	5	1
	E. coli	*100*	*77*	120	64	40	450	5	1
	Entercocci	*25*	*20*	32	38	12	47	84	3
2009-04-14	Fecal Coliforms	*100*	*200*	1300	72	36	32	18	70
	E. coli	*100*	*77*	1300	71	36	26	18	70
	Entercocci	*25*	*20*	270	120	68	29	14	2

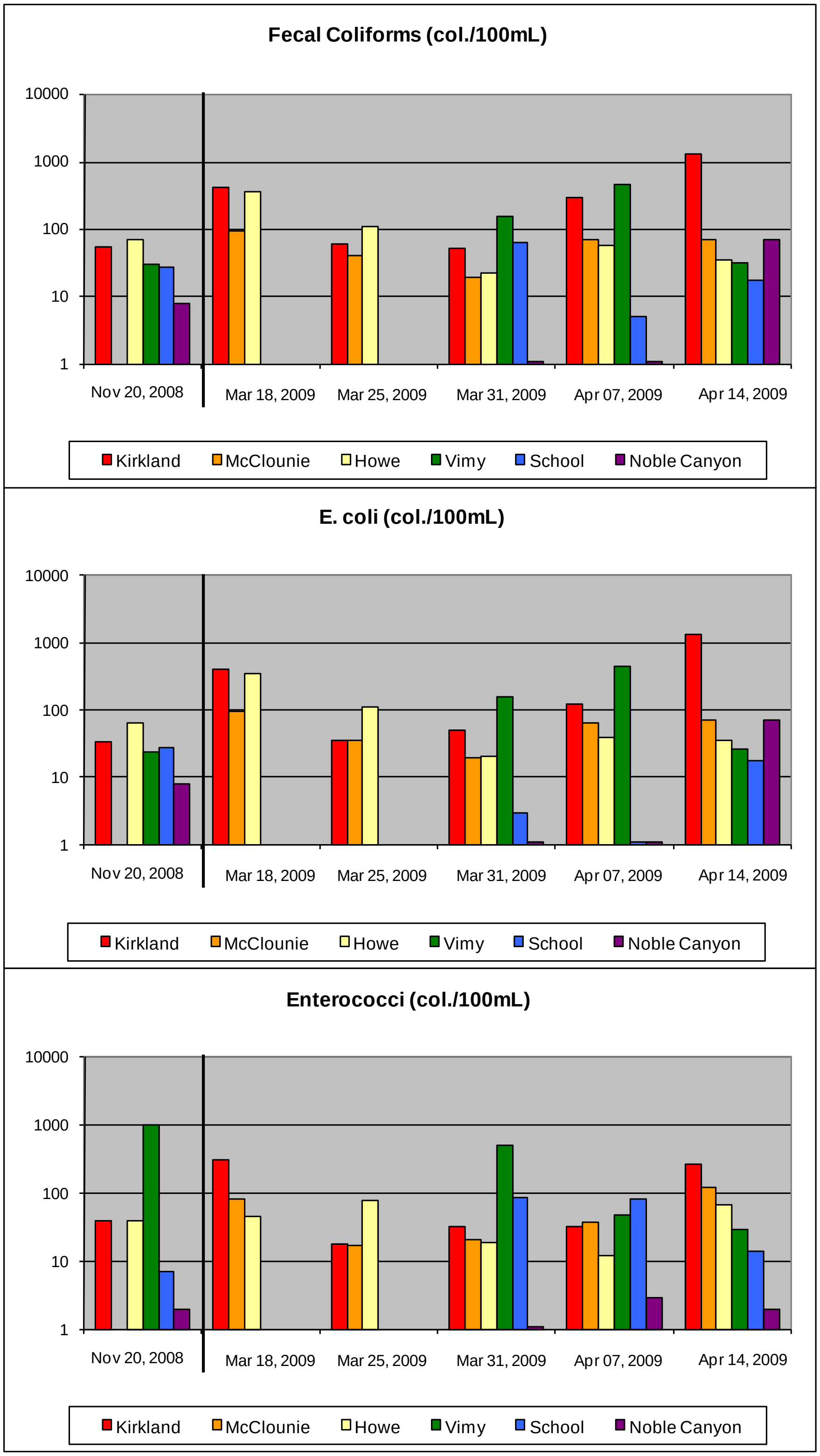

Figure 4. Bacteriological results for Coldstream Creek.

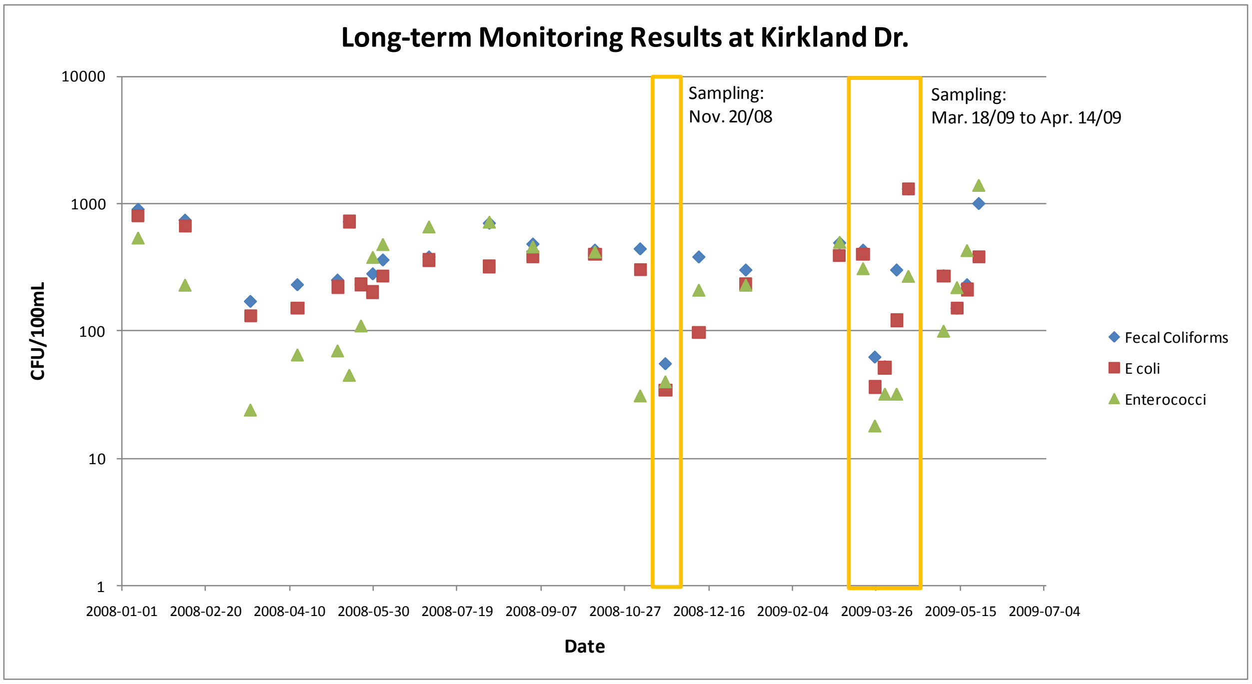

Figure 5. Ministry of Environment long-term bacteriological monitoring of Coldstream Creek at Kirkland Dr (January 2008 to June 2009). Yellow boxed areas indicate study sampling periods.

Bacteria Source Tracking (BST)

- Along with total numbers of fecal contamination, BST was also conducted at all monitoring sites on three consecutive dates (March 31, April 7, and April 14).
- Overall, BST results indicated multiple sources of fecal contamination in Coldstream Creek (Figure 6). *E. coli* bacteria were categorized primarily into four categories: Human, Livestock (including cow and horse), Dog and Avian (including waterfowl, gulls and songbirds).
    - The human component was very small, ranging from only 0.3% to 7.8% relative abundance.
    - Livestock bacteria were more abundant during higher creek flows on March 31 and April 7 (26.9% and 32.6%, respectively), but decreased considerably during lower flows on April 14 (2.6%).
    - The dog component was found to be moderately high and remained relatively stable on all three sampling dates (18.3%, 18.4%, and 21.1%, respectively).
    - The avian component was the largest source of fecal contamination. Birds contributed nearly half of the total bacteria during higher flows (47.1% and 48.7%), and 75.4% during lower flows.
- Bacteria sources were quite variable along the length of Coldstream Creek (Figure 7). *E. coli* bacteria were very low in Noble Canyon, representing background conditions. As the creek flows through the valley bottom, impacts from agricultural and urban development increased the level of fecal contamination downstream.
    - Human bacteria were very low and variable along the length of the creek.

- Livestock bacteria were found at each site in low to moderate abundances, with one larger peak at Kirkland Dr on April 7.
- Dog bacteria were found at all sites except in Noble Canyon and Vimy Rd, with the highest numbers consistently found at Kirkland Dr.
- Avian bacteria were consistently found at all sampling sites and were frequently the most abundant type identified.

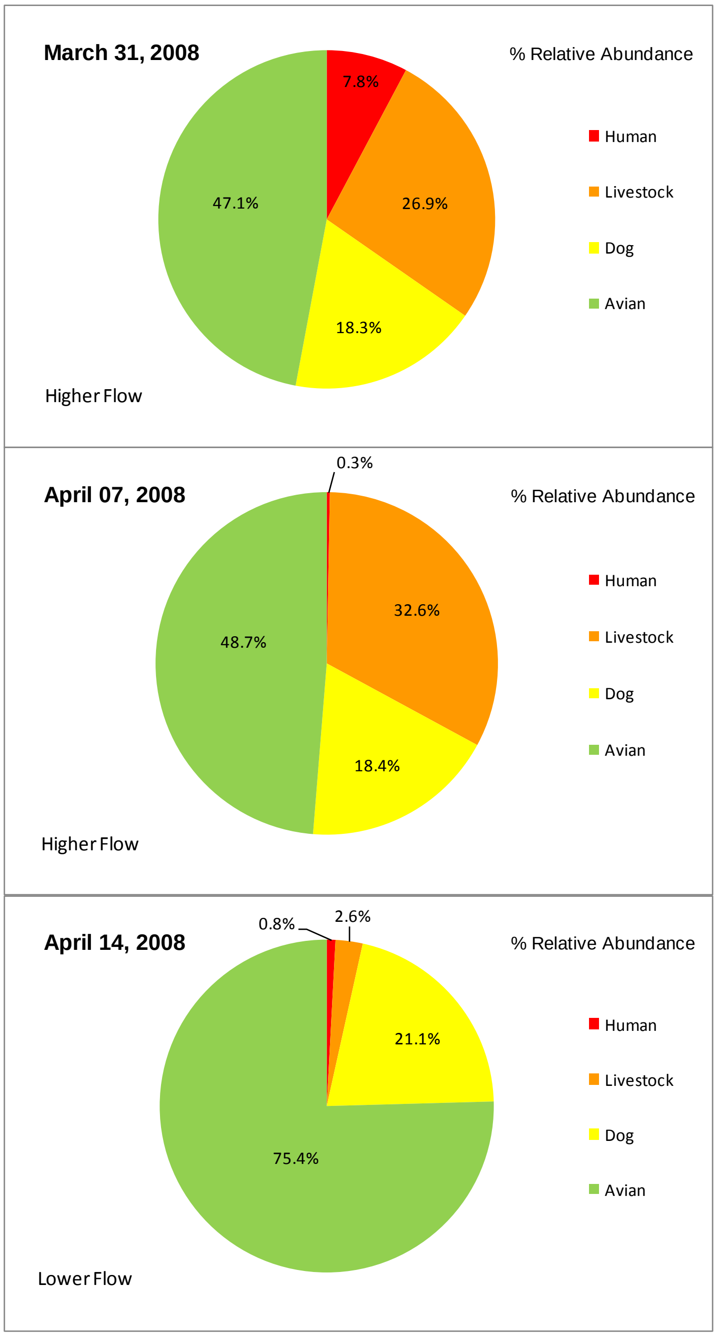

Figure 6. Overall Bacteria Source Tracking results for Coldstream Creek (all 6 sites).

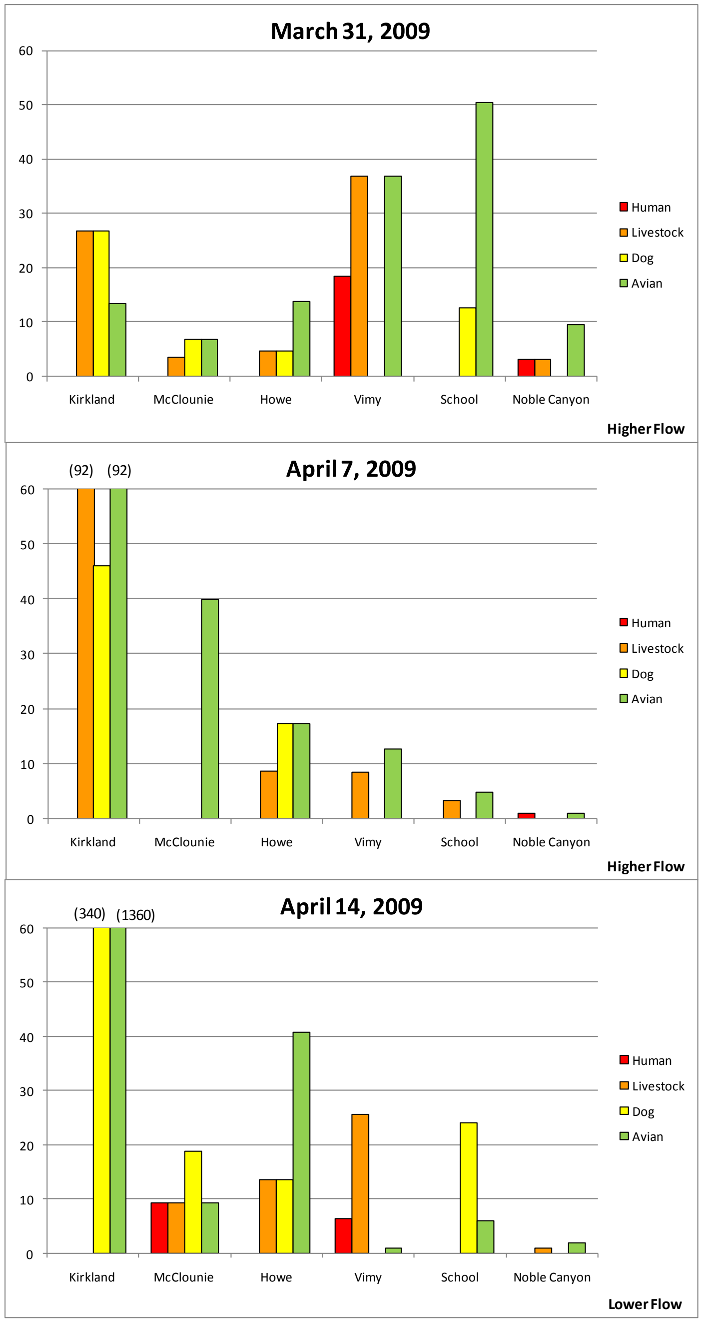

Figure 7. Site specific Bacteria Source Tracking results for Coldstream Creek.

Discussion

Both agricultural and urban development in the valley bottom appear to be negatively impacting water quality in Coldstream Creek. While water quality in Noble Canyon is excellent, it quickly deteriorates once it flows through the valley bottom. Multiple non-point sources of pollution along the length of Coldstream Creek are likely the main cause of this decreased water quality.

While a number of parameters do not appear to be problematic (temperature, dissolved oxygen, pH, conductivity and chloride), there are both seasonal and chronic problems associated with nitrate and bacteria. Ministry of Environment trend monitoring of Coldstream Creek at Kirkland Drive (site E216459), also indicate elevated levels of nitrate and high levels of fecal, E. Coli, and Enterococci bacteria that are frequently above the BC Approved Water Quality Guidelines (BC Ministry of Environment, 2009) for drinking water. Sources of elevated nitrate include fertilizer, manure, or sewage; similarly fecal coliform bacteria could be from animal, manure application, sewage or septic systems and roadway run-off.

Surface run-off from agricultural fields and ditches in the spring can lead to increased turbidity and nutrient enrichment of nearby water bodies. Fertilizers and manure contain nitrogen and phosphorus compounds which are readily utilized by aquatic plants such as algae. This enhanced plant growth can reduce dissolved oxygen in the water when dead plant material decomposes and can lead be problems to a variety of aquatic organisms. High enough concentrations can also be toxic to both aquatic organisms and humans. In Coldstream Creek, valley bottom snow melt results in over-land flow and considerably increases nutrient levels downstream. While there are no BCWQG for total phosphorus and total nitrogen in streams, the high concentrations recorded during this study have implications for downstream environments such as Kalamalka Lake. Since Coldstream Creek is the major tributary to Kalamalka Lake, increased turbidity and nutrient concentrations in the creek can have negative impacts on lake water quality.

Other forms of nitrogen, including ammonia and nitrate, were also found to be elevated in Coldstream Creek. Ammonia is most often very low in the creek, but increased concentrations were measured at Howe Dr, McClounie Rd. and Kirkland Dr during weeks of higher flows. Even though ammonia concentrations were not above guideline levels, they were elevated on March 25, 2008, coinciding with elevated phosphorus levels, indicating high overall nutrient loading to the creek during this early snow melt period. On this date, many agricultural fields in the vicinity of Howe Drive were flooded and increased run-off from fields and ditches was observed flowing into the creek. More importantly, nitrate concentrations were elevated throughout the duration of the study, and were consistently high at many sites. The Noble Canyon sampling site is above the influence of valley bottom agricultural inputs and as such, has very low concentrations of nitrate. The other sites, however, are all near or above the BCWQG for aquatic life (2.9 mg/L). In fact, Howe Dr is above this guideline level in the fall and on four consecutive dates in the spring. The highest concentrations of nitrate were found at School Rd and Vimy Road during periods of higher flow in the spring. However, nitrate levels were near or above the aquatic life guideline during low flow conditions in the fall, suggesting groundwater is likely a large contributor of nitrate to Coldstream Creek downstream of Noble Canyon. Long-term Ministry of Environment monitoring of the creek also indicates that nitrate levels have been steadily increasing over the past ~30 years, and appears to be a chronic water quality issue.

Bacteriological results from this study indicate elevated levels of bacteria, confirming long-term Ministry of Environment monitoring results of a chronic water quality problem in Coldstream Creek. Potential sources of these bacteria include wild and domestic animal feces, agricultural field and storm drain runoff, and seepage from septic and sewage systems. It is also important to note that although large numbers of animals occur on commercial farms, smaller numbers of animals on hobby farms could have equal or greater impact if improperly managed. Fecal coliforms often enter surface waters via non-point sources. Since there does not appear to be any single large point source, several smaller sources are likely present along the length of Coldstream Creek and their cumulative impacts are seen as high values downstream. There appears to be a marked increase in bacteria numbers on multiple occasions between McClounie Rd and Kirkland Dr, however, it is uncertain at this time why this occurs. Possibilities include; a storm-drain point source, multiple non-point sources from residential properties, or a re-mobilization of bacteria from sediments in a low-gradient section of the stream. The temporal trend in bacteria data follows an inverse relationship with nutrient concentrations. When Coldstream Creek has higher water flow, nutrient levels are generally higher and bacteria levels are lower. This is likely a function of increased over-land transport of nutrients during periods of higher snow melt and a simultaneous dilution of bacteria levels. Meays et al. 2006 found that *E. coli* are able to survive the winter in the environment. This relatively long-term survival of a micro-organism used for water quality monitoring can complicate the interpretation of data collected, since it would not be known if the fecal pollution was recent or not. There is still a need for more research in this area to better understand the environmental dynamics of *E. coli*.

BST results from this study do not indicate a primary source of bacteria, but rather reveal a more complex situation typical of non-point source pollution, with multiple sources which will require a more diverse approach to resolving the problem. It is important to note, that the human bacterial component is very minor and is likely not an issue. The majority of bacteria were from wild sources (birds), and as such, may be difficult if not impossible to reduce. Conversely, the other two large components of the BST analysis (livestock and dog) are more manageable. Over-land transport of cow and horse manure to the creek is a concern. Limiting this type of run-off through various methods including, riparian habitat protection, stream bank stabilization, ensuring requirements of the Agricultural Waste Control Regulation are met, restricted or off site watering provided for livestock, may largely reduce these inputs. The dog component remained relatively stable over the three week BST sampling period, but is largely concentrated between McClounie Rd and Kirkland Dr. Domestic dog waste runoff in this urbanized portion of the creek is likely contributing to the observed high fecal counts.

Recommendations

This report indicates water quality is likely being compromised from a variety of land use practices. Although further inspection and monitoring activities may aid source control opportunities, the following recommendations are provided:

- Provide appropriate outreach to specific groups such as large-scale farming, hobby farming or horse communities through peer groups or other local support and stakeholders with respect to manure and water management in the Coldstream Creek drainage.
- Increasing riparian zone to decrease the levels of nutrients and bacteria entering Coldstream Creek during the period of early valley bottom snow melt.
- Increase dog waste pickup (through education and/or enforcement programs).

- Storm water management, storm water retention or diversion in urban areas (downstream of Howe Dr).
- Groundwater inputs and their effects on the creek are currently unknown. Conduct a study to determine if groundwater is a significant pathway for nutrients and/or bacteria to enter the creek.
- Continue long-term seasonal monitoring of Coldstream Creek water quality at Kirkland Dr.
- Establish water quality objectives as remediation targets for Coldstream Creek.
- Conduct follow-up monitoring to determine if actions have been effective in protecting creek water quality.

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Appendix 1

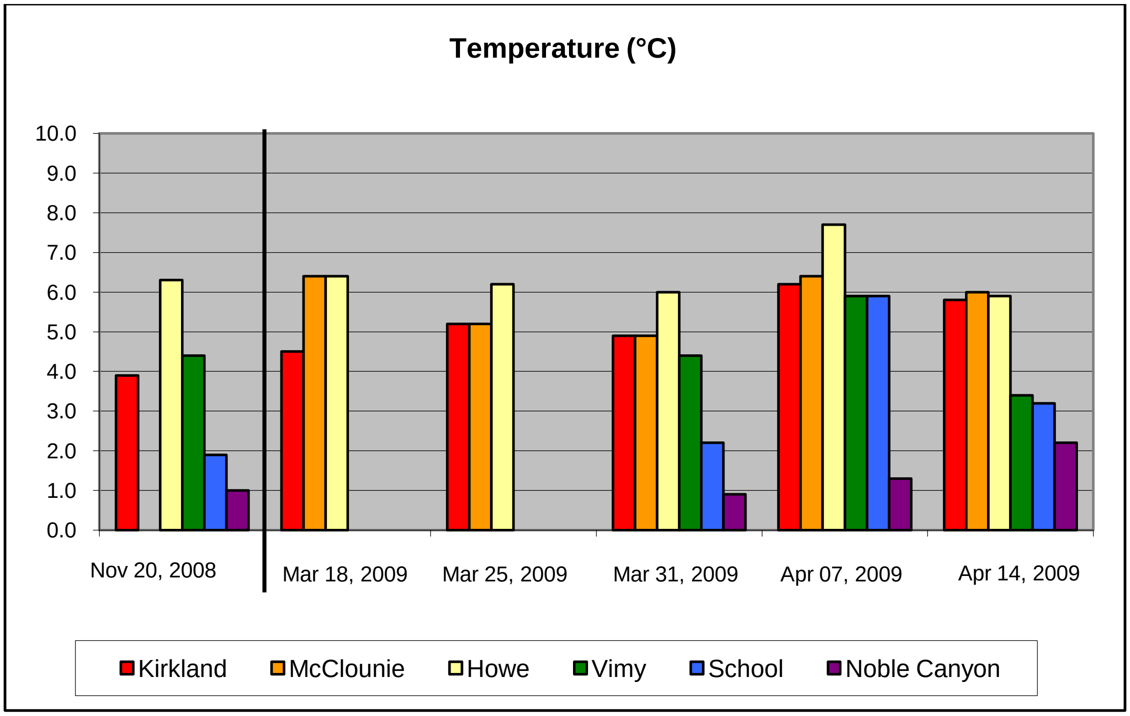
Primary agricultural land use activities: a) upstream of each monitoring site, and b) totals for each monitoring site sub-watershed. Highlighted values are totals for entire watershed.

	Site Name	EMS ID	Upstream Watershed Area (Ha)	ALR Area (Ha)	Total Forage Area (Ha)	Cattle Forage Area (Ha)	Horse Forage Area (Ha)	Other Animals Forage Area (Ha)	Fowl Forage Area (Ha)	Total Range Area (Ha)	Cattle Range Area (Ha)
a)	Kirkland Dr.	E216459	20600.86	3434.88	1774.9	117.1	196.06	14.2	1.79	391.32	50.44
	McClounie Rd.	O500518	20274.01	3401.18	1764.87	116.74	191.59	14.2	1.79	391.32	50.44
	Howe Dr.	E216457	19167.41	2765.24	1485	84.82	111.33	14.2	1.79	325.7	41.95
	Vimy Rd.	E216452	12201.47	1297.94	794.74	63.94	79.34	12.07	1.79	34.72	34.72
	School Rd.	E216451	7497.48	586.5	359.7	50.31	30.11	0	1.79	13	13
	Noble Canyon	E274383	6567.52	0.8	0	0	0	0	0	0	0
b)	Kirkland	E216459	326.85	33.7	10.03	0.36	4.47	0	0	0	0
	McClounie	O500518	1106.6	635.94	279.87	31.92	80.26	0	0	65.62	8.49
	Howe	E216457	6965.94	1467.3	690.26	20.88	31.99	2.13	0	290.98	7.23
	Vimy	E216452	4703.99	711.44	435.04	13.63	49.23	12.07	0	21.72	21.72
	School	E216451	929.96	585.7	359.7	50.31	30.11	0	1.79	13	13
	Noble Canyon	E274383	6567.52	0.8	0	0	0	0	0	0	0

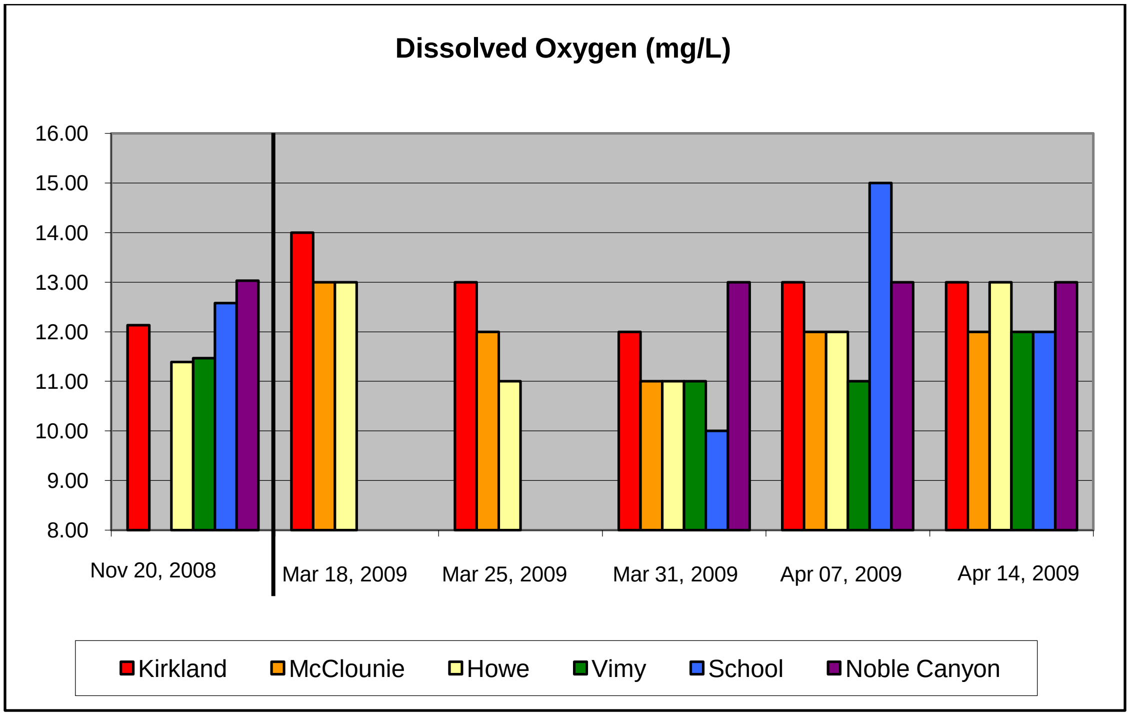
	Site Name	EMS ID	Fruits (Ha)	Vegetables (Ha)	Feedlots (Ha)	Manure (Ha)	Other Agriculture Survey Classification or no classification (Ha)	Other land classification - with Cattle Use (Ha)	Other land classification - with Horse Use (Ha)	Other land classification - with Fowl Use (Ha)
a)	Kirkland Dr.	E216459	111.92	8.53	13.21	1.94	18289.34	1.84	8.16	0.05
	McClounie Rd.	O500518	103	8.53	13.21	1.94	17981.44	1.84	8.16	0.05
	Howe Dr.	E216457	57.21	4.04	13.21	1.94	17271.64	1.84	7.14	0.05
	Vimy Rd.	E216452	52.39	4.04	0	0	11313.81	1.84	7.14	0.05
	School Rd.	E216451	29.28	0.45	0	0	7095.05	0.55	3	0.05
	Noble Canyon	E274383	0	0	0	0	6567.52	0	0	0
b)	Kirkland Dr.	E216459	8.92	0	0	0	307.9	0	0	0
	McClounie Rd.	O500518	45.79	4.49	0	0	709.8	0	1.02	0
	Howe Dr.	E216457	4.82	0	13.21	1.94	5957.83	0	0	0
	Vimy Rd.	E216452	23.11	3.59	0	0	4218.76	1.29	4.14	0
	School Rd.	E216451	29.28	0.45	0	0	527.53	0.55	3	0.05
	Noble Canyon	E274383	0	0	0	0	6567.52	0	0	0

Appendix 2

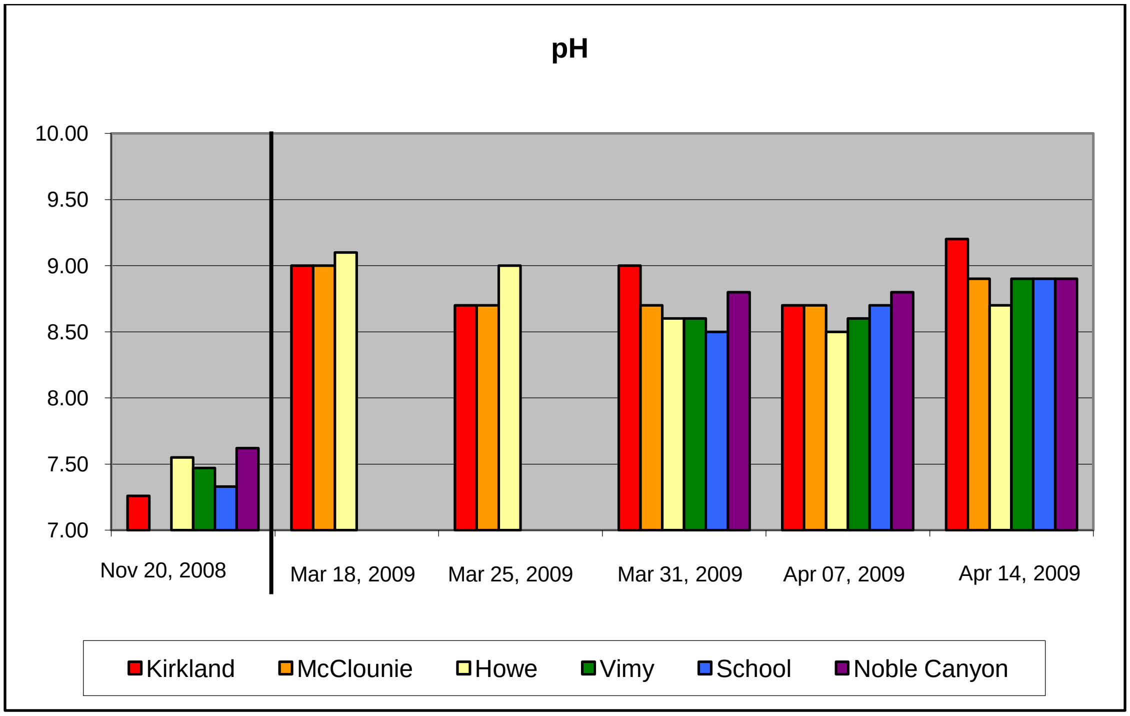
Results of physical and chemical parameters for Coldstream Creek monitoring sites.



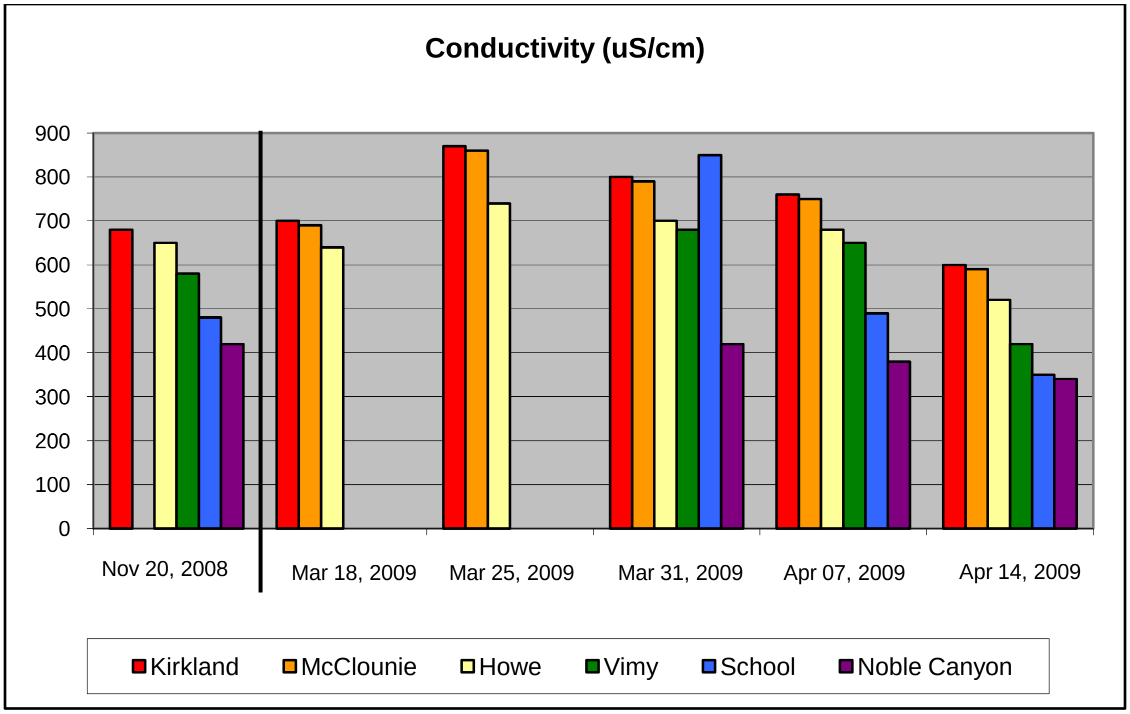
- The ambient temperature of all the samples ranged from 0.9 °C to 7.7 °C, with only slight variations over time. Temperatures generally increased downstream to Howe Dr, and then decreased slightly at both McClounie Rd and Kirkland Dr sites. Samples consistently met BC Water Quality Guideline (BCWQG) for drinking water and aquatic life.



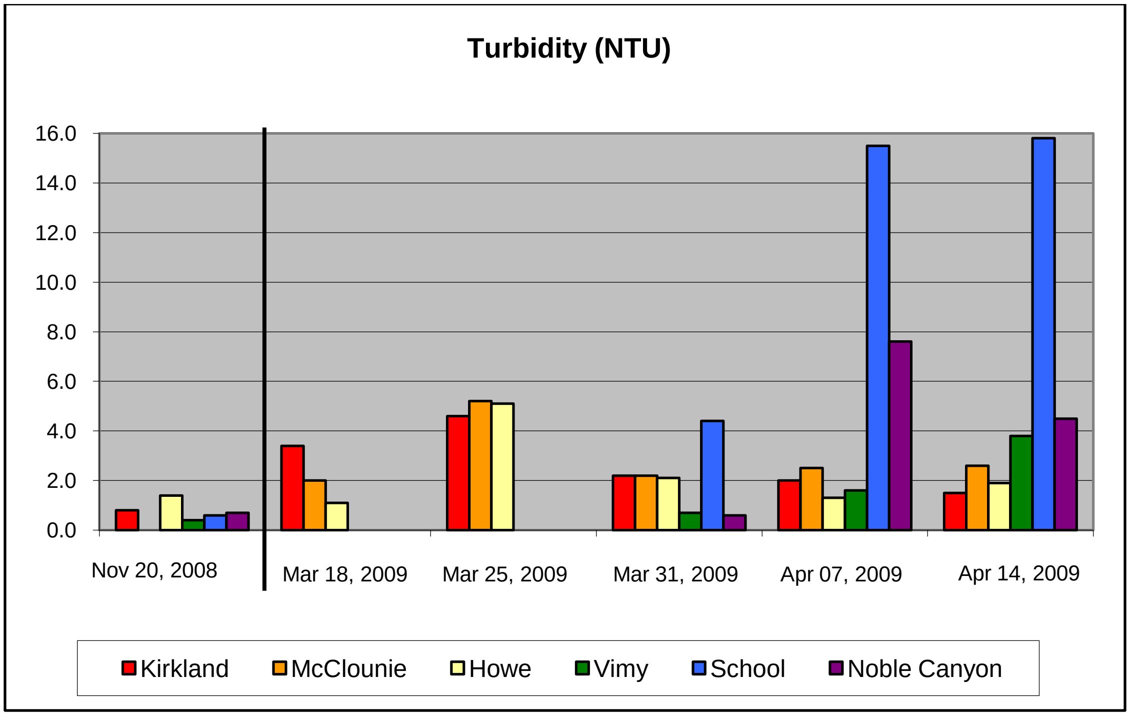
- Dissolved oxygen values ranged from 10 mg/L to 15 mg/L, and did not follow any significant spatial or temporal trends. Samples consistently met BCWQG for drinking water and aquatic life.



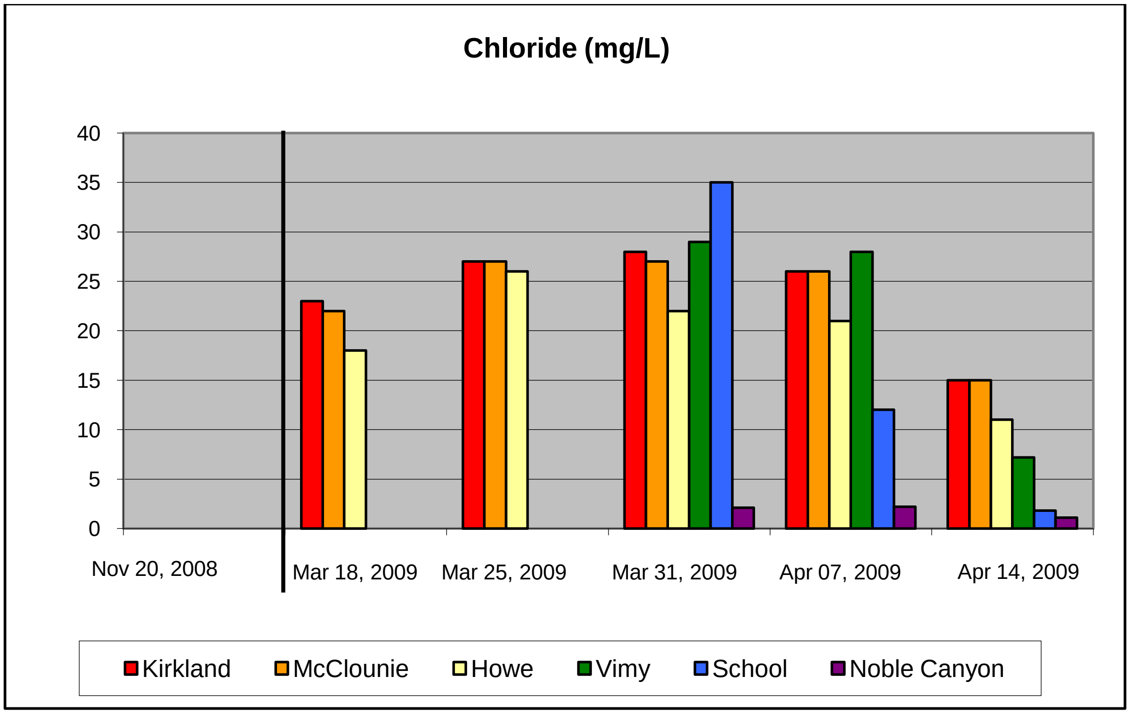
- The pH of all sites was slightly alkaline to moderately alkaline, ranging from 7.3 to 9.2. Values of pH did not appear to follow any spatial trends, however, the range of fall pH was lower than in the spring (7.3 to 7.6 and 8.5 to 9.2, respectively). Samples consistently met BCWQG for drinking water and aquatic life.



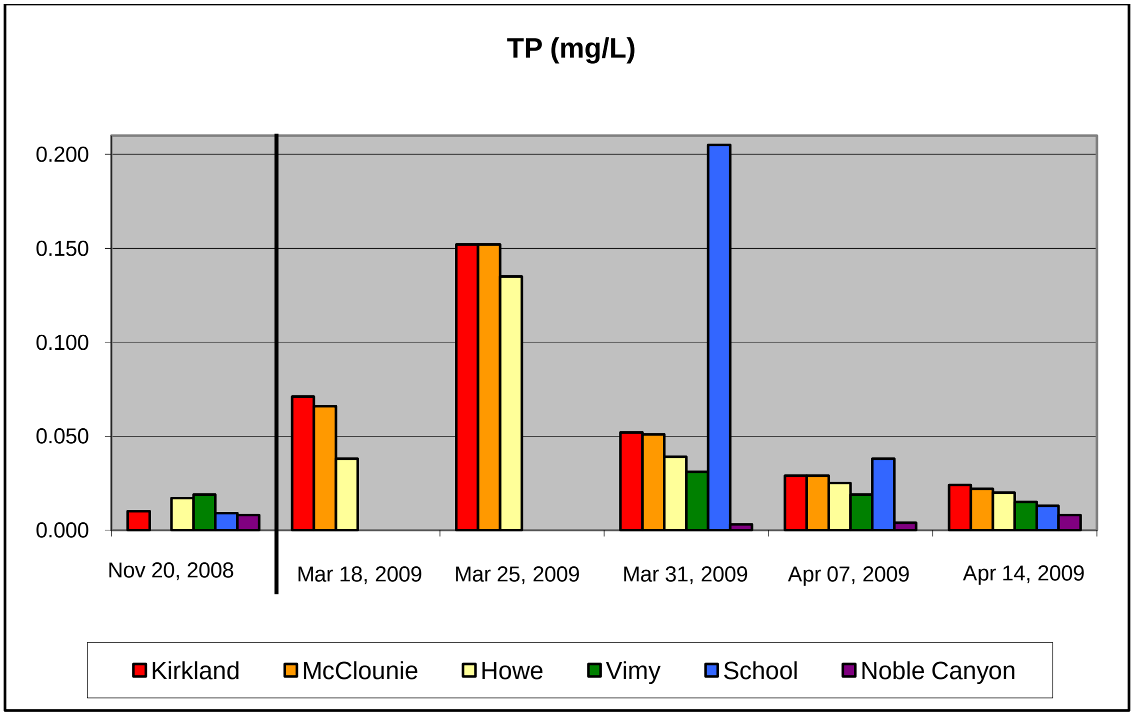
- Conductivity values ranged from 340 µS/cm to 870 µS/cm. Conductivity consistently increased downstream, except for one peak at School Rd on March 31. Temporally, conductivity was higher during periods of increased water flow (increased valley bottom), and slightly lower during periods of decreased flow. Samples consistently met BCWQG for aquatic life, but some were slightly above the aesthetic guideline for drinking water (700 µS/cm) during periods of higher flow (Kirkland Dr – March 25, March 31, April 7; McClounie Dr - March 25, March 31, April 7; Howe Dr – March 25; and School Rd – March 31).

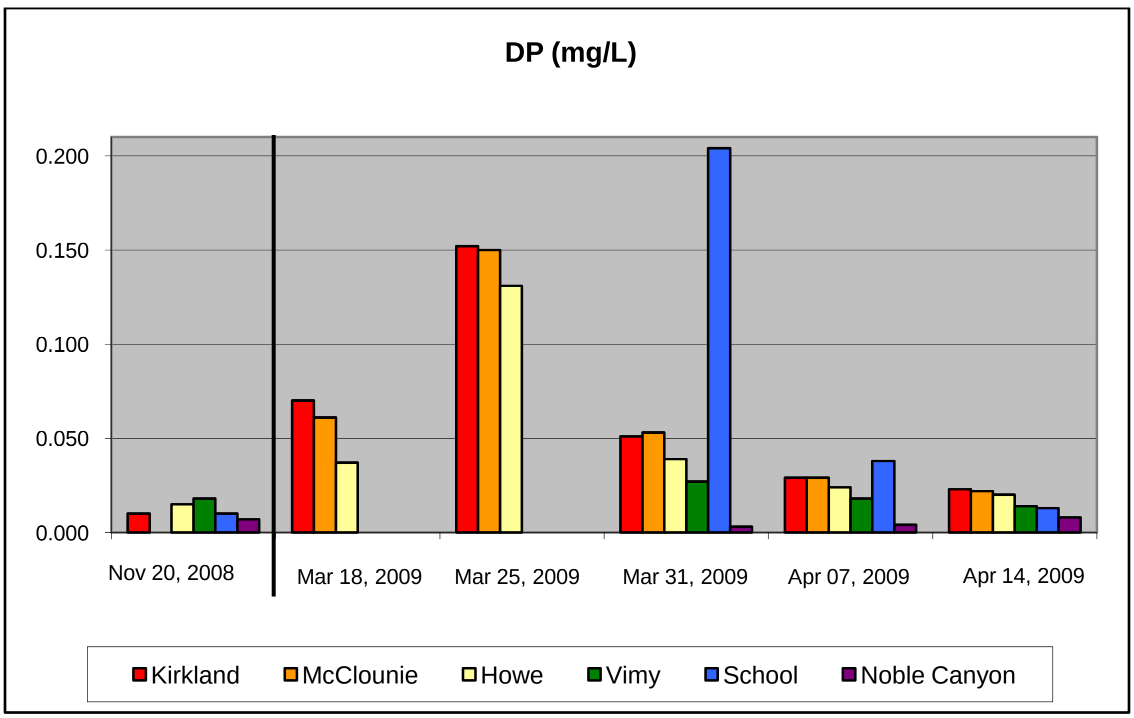


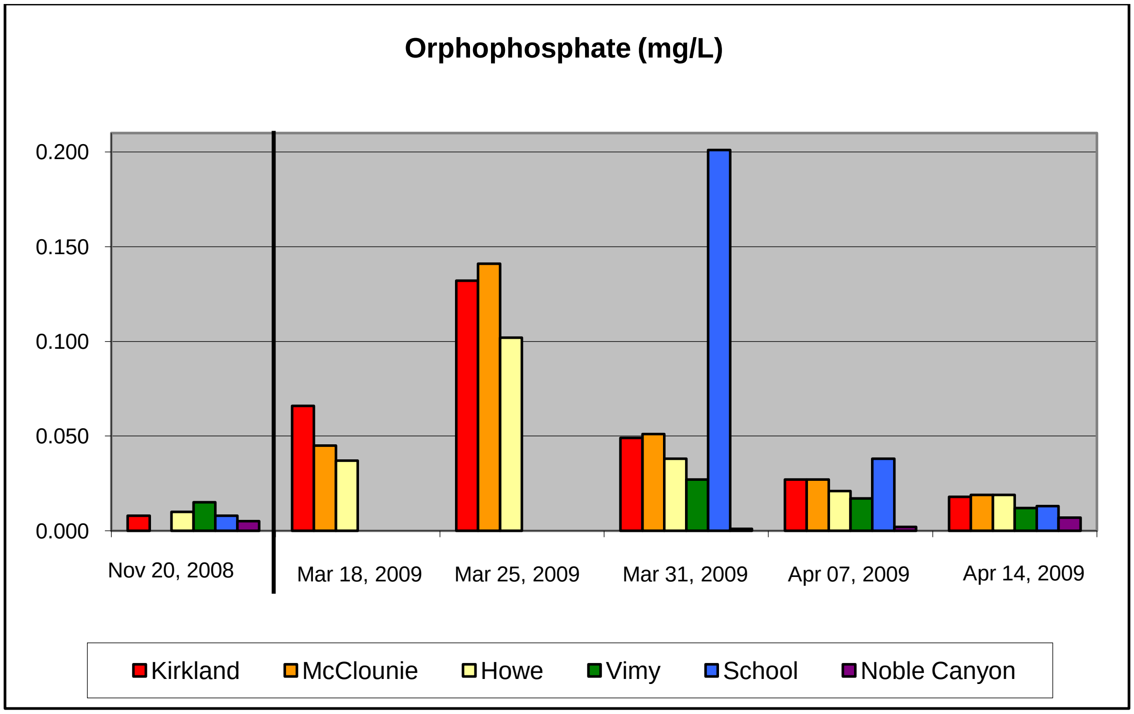
- Turbidity values were quite variable over time and space, and ranged from 0.4 NTU to 15.8 NTU. In the fall, turbidity was quite low, but was much higher during the period of valley bottom melt in the spring. Samples consistently met BC Water Quality Guideline (BCWQG) for aquatic life, but the majority of sites were above the drinking water guideline (1.0 NTU) for the entire five week spring monitoring period.



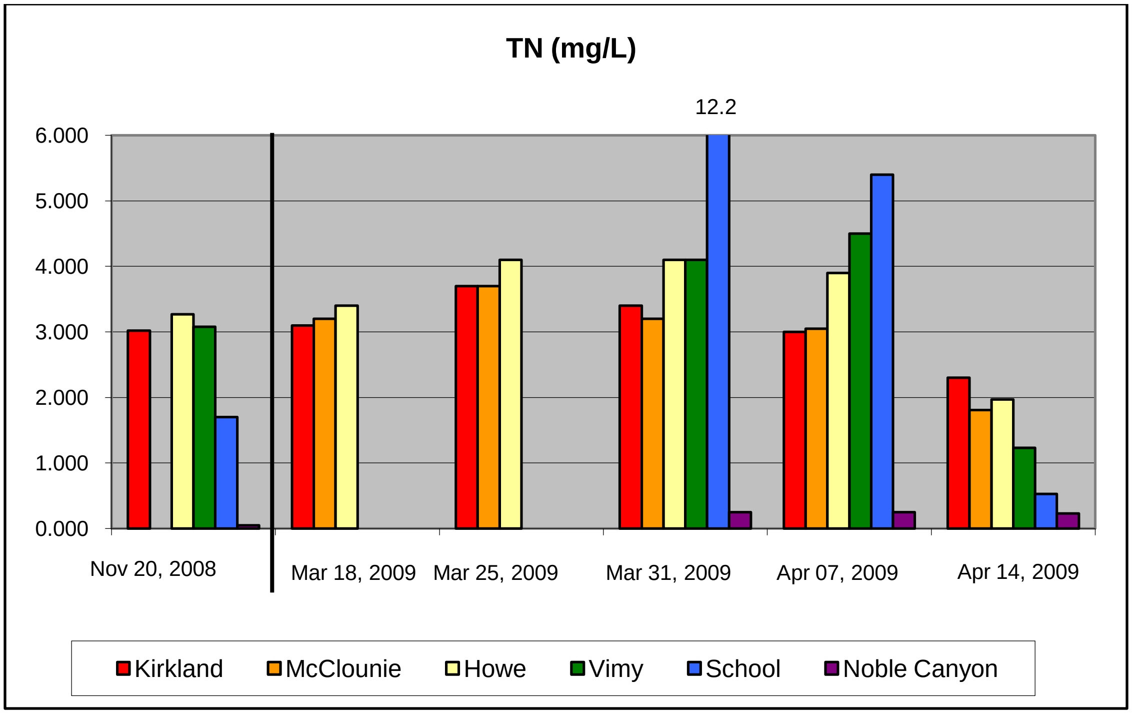
- Chloride concentrations ranged from 1.1 mg/L to 35.0 mg/L. Chloride levels increased downstream and were slightly elevated during periods of higher flow. Samples consistently met BC Water Quality Guideline (BCWQG) for drinking water and aquatic life.

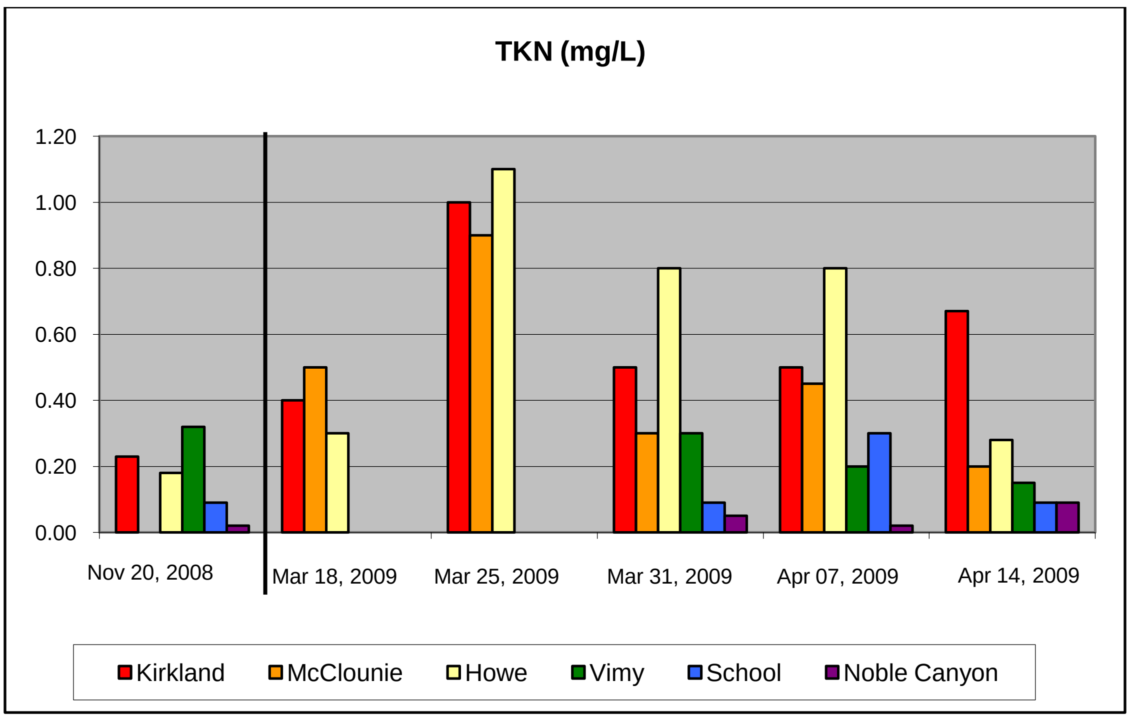

TP (mg/L)
0.200
0.150
0.100
0.050
0.000
Nov 20, 2008
Mar 18, 2009
Mar 25, 2009
Mar 31, 2009
Apr 07, 2009
Apr 14, 2009
Kirkland
McClounie
Howe
Vimy
School
Noble Canyon


DP (mg/L)
0.200
0.150
0.100
0.050
0.000
Nov 20, 2008
Mar 18, 2009
Mar 25, 2009
Mar 31, 2009
Apr 07, 2009
Apr 14, 2009
Kirkland
McClounie
Howe
Vimy
School
Noble Canyon

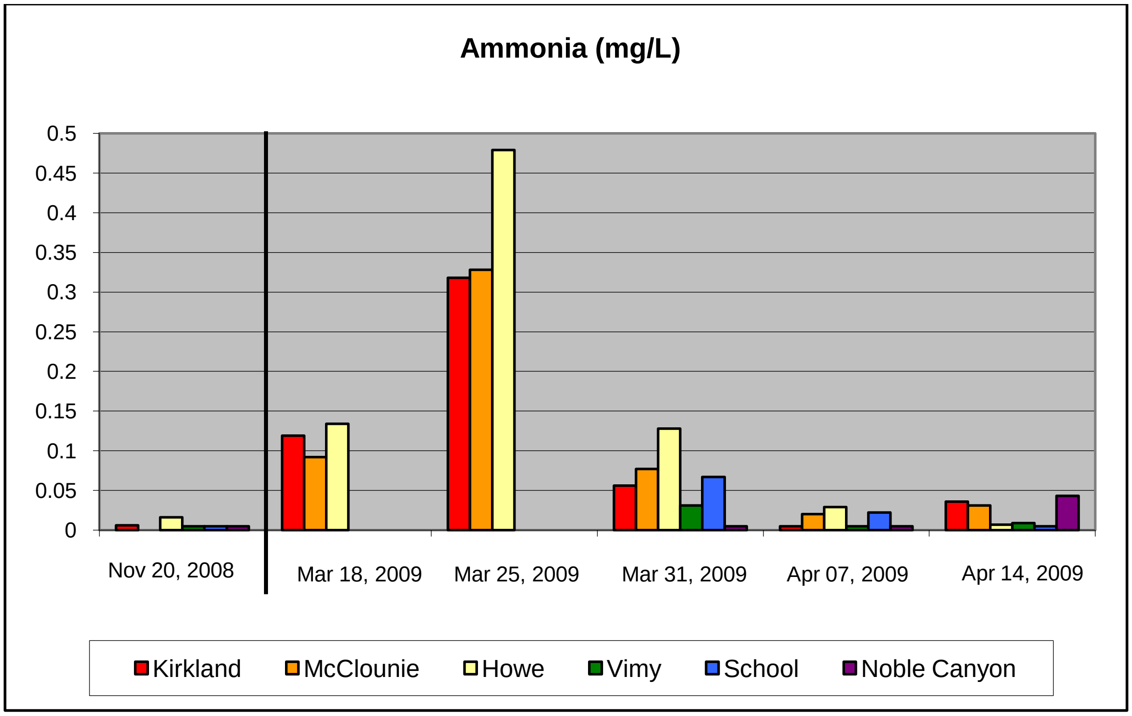


- Phosphorus concentrations (total, dissolved and orthophosphate) generally increased from upstream to downstream sites (with the exception of a very large peak at School Rd on March 31 and a small peak on April 7). However, over the five week monitoring period phosphorus loads increased dramatically at the three most downstream sites during early valley bottom snow melt, and subsequently decreased in a relatively short period of time (~2 weeks). While there are no BCWQG for phosphorus in streams, the very high loads in the spring and moderate loads throughout the rest of the year are a large source of phosphorus to downstream environments (e.g. Kalamalka Lake).





- Total nitrogen and TKN concentrations were somewhat variable over time and space, and do not appear to follow any major trends. Levels were moderately low, however, there was an anomalously large peak of total nitrogen at School Rd on March 31 which coincides with a large peak in phosphorus at the same time.



- Concentrations of ammonia were low at most sites and on most dates, but were elevated at the three most downstream sites on March 25, coinciding with increases in phosphorus and other forms of nitrogen.