Ministry of Environment
Kootenay Region

Environmental Protection

EFFECTIVENESS EVALUATION

CRESTON VALLEY, BC

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EFFECTIVENESS EVALUATION

Creston Valley, BC

ABSTRACT

Creston Valley is the Central Kootenay region's most significant agricultural area, producing mixed crops, fruit trees, hay, oats, canola, turf, nurseries, and livestock. Creston Valley Flats, within the Kootenay River floodplain, is a heavily diked and ditched area now used primarily for agriculture. This network of dikes and drainage ditches, along with two major tributaries, connects to the Kootenay River, which runs through the Flats from the United States, to Duck Lake and into the south end of Kootenay Lake. A previous study, intended to review impacts of runoff following a rain event on water quality in Wynndel, BC, demonstrated some non-point source pollution was occurring in the Wynndel area of Creston. From that data, a reconnaissance was planned and conducted on the Creston Valley, including the Wynndel area, to identify other potential areas of non-compliance throughout the valley. From this, detailed water analyses were conducted with the intention that the information gathered would guide administrative decisions on compliance, enforcement, and authorizations under the Environmental Management Act and determine where further monitoring, assessment and compliance efforts should be focused in the future.

Information about potential impact sites in Creston Valley was gathered locally and regionally. Twenty sites ranging from Canyon-Lister to Creston Flats, including both agricultural drainage ditches as well as streams, were chosen based on the reconnaissance. Shortly after the reconnaissance water samples were obtained for testing. Parameters included standard field measurements and lab analysis for nutrients, metals, anions and bacteriology. Some select sites were also tested for pesticide residue.

Field and laboratory results indicated that some non-compliance is occurring throughout the valley and water quality is being compromised by non-point source pollution, particularly in areas within close proximity to dairy farms. Bacteriology revealed enterococcus levels were above acceptable guidelines for most of the twenty sites tested. Rykerts Creek in the Canyon-Lister area, the Old Goat River Channel, and the Old Kootenay River Channel in the Flats were of particular concern for bacteriology.

From this reconnaissance, it was recommended that focused monitoring efforts be regularly conducted on those sites affected by non-point source pollution and that partnership with stakeholders, community stewardship groups, and environmental organizations be encouraged to enhance monitoring and data collection efforts.

1. INTRODUCTION

The Creston Valley is the most significant area agriculturally within the Central Kootenay Region, boasting mixed crops and livestock, fruit trees, hay, oats, and canola. Turf, sod farms, and nurseries are also prevalent. The long growing season, April to October, contributes to the valley's agricultural success. At the valley bottom is 2,000 acres of rich alluvial soil known as the Creston Valley Flats, which is well-suited to grain production, forage seeds, hay, and canola. This area was once the Kootenay River floodplain until it was heavily diked to support agriculture around the 1880's. In the 1920's, the Creston Diking District (CDD) was formed and is one of four diking authorities within the Creston Flats which maintains the ditch and diking system to ensure adequate drainage of water from the area. This water flows north to an area called the Pump House which is then pumped into a slough to Duck Lake (Beatty 2006). In the Canyon-Lister area, dairy and cattle farms dominate while in the Flats, there is an emphasis on crops. This, however, appears to be gradually shifting as Lower Mainland dairy farmers, wishing to expand their business, move their practices to more affordable locations such as the Creston Valley.

Also nestled within the Creston Valley, adjacent to the much of the agricultural areas on the Flats, are 17,000 acres of wetland that is protected and managed by the Creston Valley Wildlife Management Area (CVWMA). Recorded within the CVWMA, there are 354 species of terrestrial vertebrates, including six amphibian, six reptile, 286 bird species and 56 mammal species. Aquatic vertebrates include 16 fish species (Wilson *et al* 2004). One amphibian, the Northern Leopard Frog, was once relatively abundant in the Columbia Basin and B.C. in general. Now, however, this species exists only as a single population within the Creston Valley. The reason for its decline is not entirely known although changing climate, loss of habitat, introduction of new species, and chemicals, including pesticides and fertilizers, are suspect. This species is listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and is on the provincial Red List (Waye 2000).

The CVWMA is also intersected by a network of dikes and ditches which are regularly maintained. The dikes and ditches within the Creston Valley are typically vegetated by perennial grass mixes and some invasive plant species, requiring some chemical maintenance. There is growing concern, both regionally and nationally, about the spread of invasive plant species. Purple loosestrife (*Lythrum salicaria*) and knapweed (*Centaurea spp.*) are both highly invasive species that pose a significant threat to native plant communities. Both plants have been identified in the Kootenay region although purple loosestrife has not yet established within the Creston Valley wetlands (Rubec 1994).

A previous study on water quality in Wynndel, BC, was intended to review water quality from dikes and ditches immediately following a rain event to get an estimate of "worst case" runoff impacts to drainage ditches. This study indicated that fecal, enterococci and *E. coli* bacteria levels were above the B.C. Approved Water Quality Guidelines (2001) for irrigation and general livestock watering at some locations. It concluded that while the diking and ditch system in the Creston Valley is effective in removing surface water during a rain event, there is some negative impact to the water quality and further investigation was recommended (Beatty 2006). The guidelines have since been updated (2006), requiring that water used for irrigation have no greater than 1000 colony forming units (CFU) per 100ml of *E. coli* and no greater than 50 CFU/100ml enterococci bacteria. However, the results obtained from that study still exceed the updated guidelines.

The general objective of this effectiveness evaluation was to conduct a preliminary assessment of water quality within the Creston Valley and identify agricultural areas of potential non-compliance with the *Agricultural Waste Control Regulation* (AWCR). Effectiveness evaluation is a key component of the adaptive management process which helps guide Environmental Protection Division decisions that will improve environmental quality. The information gained through reconnaissance can guide administrative decisions on compliance, enforcement and authorizations under the *Environmental Management Act* and also determine where further monitoring, assessment and compliance efforts should be focused in the future. It should be noted that the scope and timing of this program had some logistical and funding limitations, therefore the study design was also limited to collecting only single samples at all sites between July 25 and August 13, 2008, reflecting a very short "snap-shot" in time. This kind of sampling program ideally should be conducted just following a severe rain event to capture worst case conditions. As well, at least 5 samples per site, over a 30-day period should be collected to compare with many of the established water quality guidelines. These study limitations somewhat restrict the interpretation but still fulfill the objectives of this reconnaissance-level investigation and evaluation.

2. METHODOLOGY

Information about potential impact sites was gathered from knowledgeable residents, Ministry of Environment Conservation Officers, Ministry of Agriculture and Lands staff, and Creston Valley Wildlife Management Area staff. From the information gathered, a reconnaissance mission was conducted to select the most appropriate sites for water quality testing.

Twenty grab water samples were taken over the course of several days in July 2008 from dikes, channels and streams in the Creston Flats and Canyon-Lister areas. Grab samples were taken upstream above culverts, when present. Samples taken from drainage ditches, which lacked water movement, were taken as deep into the ditch as possible with minimal disturbance to bed. Five different high-density polyethylene bottles were used to collect water samples: one 1L bottle for general chemistry, one 120mL bottle for phosphates, one 500mL bottle with preservative for bacteriology, one 120mL bottle for metals, and one 120mL bottle for nitrogen. These water samples were packed on ice in coolers and shipped the same day to the analytical laboratories (Can-Test and Maxxam Analytics) for analysis. Samples for pesticide testing were also taken at seven locations, using one 1L glass amber bottle for general pesticides, and one 1L plastic bottle for surfactants.

At each site after the grab sample of water was collected, a YSI multi-parameter water quality meter was used to take readings for dissolved oxygen (DO), specific conductivity, temperature and pH. Site conditions were also noted. Field blanks were also prepared for field quality control, reflecting 10% of the sampling effort. All samples were taken under approximately the same conditions, including time of day and with no weather anomalies such as precipitation.

Ten of the twenty sites were considered to be drainage ditches that control runoff from agricultural lands. Two of these sites, 6 and 9 were previously sampled for bacteriology count following a rainfall event at Pumphouse and Uri roads in Wynndel as part of a water quality investigation (Beatty 2006). Agricultural sites were evaluated according to the B.C. Water Quality Guidelines (BCWQG) for irrigation and livestock watering. These sites are listed in Table 1:

Table 1. Site description of sampled agricultural drainage ditches.

Site #	EMS ID	Location Description	Site Description	Location[a]
6	E272333	Drainage ditch below pumphouse	*Eutrophic, murky*	49.17217N 116.56011W
7	E272334	Sluice above pumphouse	*Clear; no movement*	49.17218N 116.56046W
9	E272336	Drainage ditch at Uri and Lower Wynndel roads	*Eutrophic; clear; no movement*	49.16068N 116.54347W
10	E272337	Old Goat River Channel at Wayleen Farms on Hwy 3	*Very eutrophic with lots of algae and plants*	49.11703N 116.55260W
12	E272339	Drainage ditch downstream from Hanson Farms (dairy)	*Moderately eutrophic; no movement*	49.03491N 116.56834W
13	E272340	Drainage ditch downstream from Creston Valley Farms (dairy)	*Moderately eutrophic; no movement*	49.07587N 116.57933W
14	E272341	Drainage ditch at Reclamation and Christenson roads	*Moderately eutrophic; snails; slow moving; confluence of 2 ditches*	49.04451N 116.56818W
17	E272344	Old Goat River Channel culvert on Kootenay River Road	*Extremely eutrophic; foul odour (decay); no movement; fine, grey sediment easily stirred up*	49.10266N 116.55992W
19	E272346	Drainage ditch on Lower Wynndel Road near Hwy 3 overpass	*Extremely eutrophic; no movement*	49.11777N 116.54000W
20	E272347	Drainage ditch on Duck Lake Road between Abbott and Channel roads.	*Extremely eutrophic; silty bottom; no movement; nursery and tree farm nearby; foul smelling*	49.17835N 116.53944W

The remaining ten sites were considered streams due to the confluence of multiple tributaries, including natural streams and man-made ditches, their visible water movement, and proximity to aquatic life-bearing water bodies.

These streams were evaluated according to BCWQG and Canadian Council of Ministers for the Environment (CCME) for aquatic life. The confluence of some of these sites included drainage ditches and sluices, which are part of the agricultural drainage system, which discharge directly into the Kootenay River or Duck Lake.

Site 8 and site 11 were sampled directly from the Kootenay River, with site 11 being regularly monitored both provincially by the Ministry of Environment and regionally. Site 11 was noted to be windy with rapidly moving, silty water. In contrast, site 8 was sampled at the pool section of a riffle-pool sequence of the river, and was eutrophic and slow-moving. Sites 5, 16, and 18 were also quite eutrophic. These sites are surrounded by numerous field crops. Sampled streams sites are listed below in Table 2.

Table 2. Site description of sampled aquatic streams.

Site #	EMS ID	Location Description	Site Description	Location
1	E272328	Rykerts Creek at culvert on Hagey Road	*Cloudy water, sample taken just above culvert upstream of road*	49.00873N 116.48264W
2	E272329	Edge of Rykerts Lake	*Clear water, sample taken along eastern shoreline*	49.00556N 116.49604W
3	E272330	Rykerts Creek culvert on Porthill Road	*Silty, grayish; rocks stained black; small creek runs under highway*	49.00618N 116.49554W
4	E272331	Rykert Creek culvert on Sinclair Road north of 7th Street	*Located close to log house; steep ravine, deep mud base, foul smelling; slow-moving*	49.01619N 116.46913W
5	E272683	West Creston and Nicks Island South roads confluence to Kootenay River	*Eutrophic; moderate water movement; adjacent to cattle farm*	49.08303N 116.59396W
8	E272335	Kootenay River at Duck Lake and Farmin roads	*Eutrophic; slow moving, silty; wide and deep channel*	49.19041N 116.61694W
11	E272338	Kootenay River at Creston/Prov. site	*Very windy; silty, fast-moving water*	49.11679N 116.58203W
15	E272342	Goat River at Hwy 21	*Clear, fast running*	49.08148N 116.52222W
16	E272343	Old Goat River Channel at culvert to unknown creek on Channel Road	*Moderately eutrophic; some movement*	49.20245N 116.59210W
18	E272345	Old Kootenay River Channel under Hwy 3 overpass	*Eutrophic, slow moving*	49.12686N 116.62563W

Distribution of sites was intended to most accurately assess impacts on stream and drainage systems by agricultural practices within the Creston Valley. All twenty sites are presented in Figures 1 and 2. See also Appendix 1 for photos taken during sampling.

3. RESULTS

3.1 General Parameters

The ambient temperature of all the samples ranged from 16 ºC to 22 ºC, with only slightly higher temperatures seen in the drainage ditches. pH of all of the sites was slightly alkaline to alkaline, ranging from 7.8 to 8.8. The highest pH of 8.8 was from site 18, a stream, putting it just slightly below the BCWQG of 9.0 for aquatic life.

Dissolved oxygen, as expected, was much lower in the agricultural drainage ditches than in the streams. There are no proposed water quality guidelines for general livestock use or irrigation. Table 3 list the specific parameters for agricultural drainage ditches.

Figure 1. Location of sampling sites in lower Creston Valley

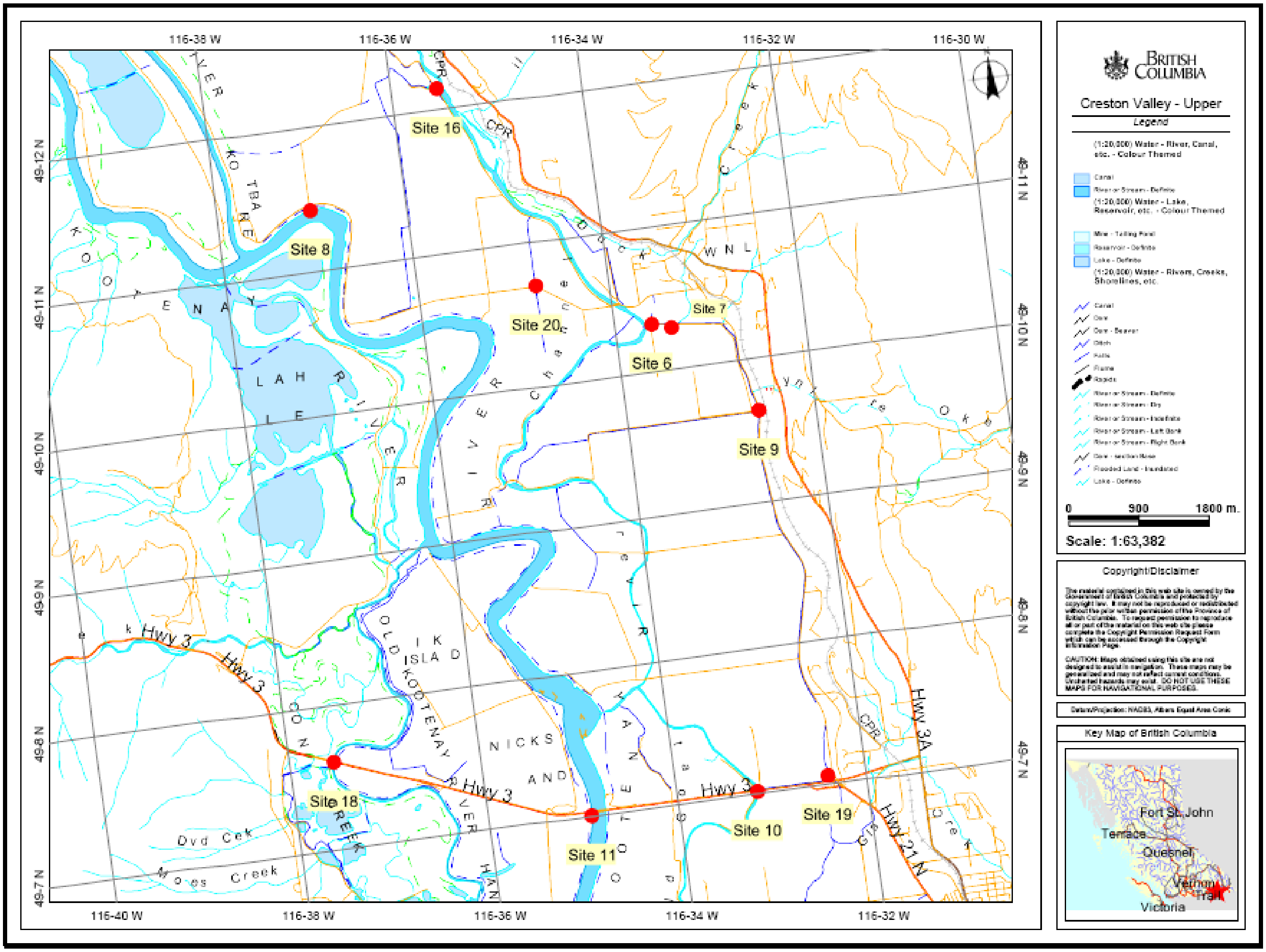

Figure 2. Location of sampling sites in upper Creston Valley.

Table 3. General parameters of agricultural drainage ditches.

		LOCATION									
PARAMETER	**UNITS**	**Site 6**	**Site 7**	**Site 9**	**Site 10**	**Site 12**	**Site 13**	**Site 14**	**Site 17**	**Site 19**	**Site 20**
Temperature	**(°C)**	20	22	17	19	22	20	20	17	16	16
pH	**(pH units)**	8.4	8.2	8.0	8.0	7.9	7.8	7.8	7.8	7.9	8.6
Dissolved Oxygen	**(mg/L)**	3	5	6.1	0.4	4.7	1.6	2.5	2.4	1.4	1.1

Dissolved oxygen of sampled streams fell within the parameters of BCWQG for the protection of aquatic life. However, site 18, which is located beneath the Highway 3 overpass in the Creston Valley Wildlife Management Area (CVWMA), expressed relatively low dissolved oxygen levels. While it met the instantaneous minimum dissolved oxygen of 5.0mg/L, it would be well under the minimum guidelines for aquatic life of 8.0mg/L if this level were sustained over 30 days. The pH levels at this site also indicated levels that barely meet the minimum BCWQG of 9.0. This site fed into the Kootenay River several kilometers upstream

Table 4. General parameters of sampled streams.

			LOCATION									
PARAMETER	**UNITS**	**BC WQG[a]**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 8**	**Site 11**	**Site 15**	**Site 16**	**Site 18**
Temperature	**(°C)**		n/a	22	16	17	22	17	18	18	18	22
pH	**(pH units)**	**9.0**	8.1	8.7	8.3	8.2	8.2	8.4	8.1	7.7	8.3	8.8
Dissolved Oxygen	**(mg/L)**	**5-9 min**	n/a	10	8.2	8.7	9.6	9.1	9.2	8.1	9.8	6.9

[a] *British Columbia Approved Water Quality Guideline (2006) maximum acceptable concentration for aquatic life.*

3.2 BACTERIOLOGY

Agricultural practices such as allowing livestock to graze near waterbodies, spreading manure as fertilizer on fields, and allowing livestock watering in streams can all contribute to fecal coliform contamination of the water. Three parameters were used to determine fecal contamination of water sources: Fecal coliform, *E. coli*, and enterococcus.

Fecal coliform counts are used [as a surrogate] to indicate the presence of pathogens. Fecal coliform bacteria naturally occur in the human digestive tract. Pathogenic organisms are found along with fecal coliform bacteria. Because pathogens are relatively scarce in water, fecal coliform levels are monitored to indicate the likelihood of fecal contamination of the water.

E. coli is a pathogenic member of the fecal coliform group and is found exclusively in the intestines of humans and other animals. Its presence in drinking water is an effective confirmation of fecal contamination.

Enterococcus is considered the most efficient bacterial indicator of water quality as it is bacteria found in both human and ruminant intestines and survives longer than *E. coli*. Its presence in water indicates fecal contamination. It is also believed to provide a higher correlation than fecal coliform with many of the human pathogens often found in sewage. Vancomycin-resistant enterococcus is becoming a concern since it is increasingly contributing to hospital-related nosocomial infections. Farming practices of daily administering low-dose antibiotics to enhance livestock growth is believed to cause antibiotic-resistant bacteria to be formed (Conly 2002).

Agricultural drainage ditches were evaluated according to guidelines for livestock watering and irrigation since drainage ditches are not considered appropriate sources of drinking water. Streams were evaluated according to the guidelines for primary contact recreation since direct contact with this water can be expected. Where guidelines were not met, table cells were highlighted in light blue.

Seven of ten sites were above the guidelines for general livestock use for enterococcus. Site 13, located directly downstream from a dairy farm and surrounded by predominantly canola and crop fields, was also above the threshold for fecal coliforms. Additionally, although site 13 demonstrated *E. coli* levels slightly below the guidelines, it still appeared as an anomaly in comparison to the other sites. Irrigation pumps were observed in operation on Reclamation Road close to site 13 at the time of sampling. These results are outlined in Table 5.

Table 5. Bacteriological results of sampled agricultural drainage ditches.

			LOCATION									
MICROBIAL INDICATORS (CFU/mL)	**BC WQG[a]**	**BC WQG[b]**	**Site 6**	**Site 7**	**Site 9**	**Site 10**	**Site 12**	**Site 13**	**Site 14**	**Site 17**	**Site 19**	**Site 20**
Fecal Coliform	**200**	**1000**	50	8	9	44	50	550	44	100	77	17
E. coli	**200**	**1000**	43	8	8	24	44	140	44	85	39	15
Enterococcus	**50**	**50**	28	20	79	340	30	390	110	120	270	110

[a] *British Columbia Approved Water Quality Guidelines (2006) maximum acceptable concentration for general livestock use.*
[b] *British Columbia Approved Water Quality Guideline (2006) maximum acceptable concentration for irrigation use.*

Stream samples yielded nine out of ten sites which far exceeded the guidelines for enterococcus for primary contact recreation. The sites with the highest readings, sites 1, 3 and 4, were located directly downstream from dairy farms. Sites 3 and 4 were also above the threshold for both fecal coliforms and *E. coli* whereas site 1 was elevated for *E. coli* only. Sites 1, 3, and 4 all fed into Rykerts Creek and eventually into Rykerts Lake (Site 2).

Bacterial counts decreased substantially within Rykerts Lake however, given that primary contact recreation would most likely occur in this location rather than in the streams that feed it, an elevated enterococcus reading indicated possible reason for concern. At the time of sampling at Site 5, a family was observed canoeing in the waters. These results are outlined in Table 6.

Table 6. Bacteriological results of streams.

		LOCATION									
MICROBIAL INDICATORS (CFU/mL)	**BC WQG[c]**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 8**	**Site 11**	**Site 15**	**Site 16**	**Site 18**
Fecal Coliform	**200**	100	5	220	200	30	7	13	12	6	8
E. coli	**77**	92	3	220	200	5	5	12	10	4	7
Enterococcus	**20**	220	33	220	200	45	100	17	93	32	140

[c] *British Columbia Approved Water Quality Guidelines (2006) for primary contact recreation.*

3.3 NUTRIENTS

In agricultural areas, drainage ditches are designed to remove surface run-off, which [often entrains] dissolved materials such as fertilizer and manure, to a network of larger streams and waterbodies. Fertilizers and manure contain nitrogen and phosphorus compounds which are readily utilized by aquatic plants such as algae. This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die.

Turbidity and total suspended solids are used to indicate suspended and dissolved solids in the water. Elevations in these parameters can be the result of excess algae growth, sediment influx, or other contamination which can block light from reaching submerged vegetation, causing vegetation reliant on sunlight penetration to die. Deposition of excess amounts of suspended sediment can smother eggs and aquatic insects, decrease resistance to disease and reduce visibility of aquatic organisms.

Specific conductance is a measure of the waters ability to conduct an electrical current. It is highly dependent on the amount of dissolved solids, such as salts, in the water and is an important water quality measurement since dissolved solids can affects the suitability of water for domestic, industrial, and agricultural purposes. When crops are irrigated, much water is lost to evaporation or used by plants, leaving behind highly soluble ions in the soil. These ions easily dissolve during precipitation events, becoming dissolved solids which are then transported into the waterbodies during runoff.

Agricultural drainage ditches within the Creston Valley demonstrated higher levels of both nitrogen and phosphorus. CCME trigger ranges for phosphorus indicate most of the sampled agricultural sites were eutrophic. Sites 10, 17, 19, and 20 were hyper-eutrophic. Lower dissolved oxygen levels at these sites, as seen previously in Table 3, confirm hypoxic conditions and a high oxygen demand likely related to increased primary production associated with elevated nutrient levels. Site 17 turbidity and total suspended solids far exceed the guidelines for general livestock use and irrigation. This site was extremely difficult to sample due to quicksand-like conditions of the ditch bed and, despite careful sampling techniques, some bottom sediment was present on the outside of the sampling bottles. Sites 19 and 20 also exceed the parameters for total suspended solids. Elevated phosphorus levels were present in sites 10, 17, 19, and 20. These results are outlined in Table 7.

Table 7. Nutrients of sampled agricultural drainage ditches.

			LOCATION									
Parameter	**CCME**	**BC WQG[a]**	**Site 6**	**Site 7**	**Site 9**	**Site 10**	**Site 12**	**Site 13**	**Site 14**	**Site 17**	**Site 19**	**Site 20**
Ammonia Nitrogen (mg/L)			0.012	<0.005	0.008	0.007	<0.005	<0.005	0.063	0.03	<0.005	<0.005
Total Phosphorus (µg/L)	**<4-100[b]**		33	35	30	302	80	82	89	207	590	122
Orthophosphate(mg/L)			0.018	0.014	0.011	0.093	0.044	0.048	0.028	0.045	0.002	0.035
Nitrate plus nitrite (mg/L)			0.007	<0.002	<0.002	0.01	0.015	0.014	0.008	0.041	0.034	<0.002
Turbidity (NTU)		**10[c]**	2	1.7	2.4	4.3	2.5	1.3	3.4	50.9	6.6	4.3
Total Suspended Solids (mg/L)		**20[d]**	<4	<4	<4	21	4	<4	8	270	47	89
Specific Conductivity (µS/cm)		**700-5000**	380	300	260	390	100	130	120	680	470	290

[a] *British Columbia Approved Water Quality Guideline (2006) maximum acceptable concentration for irrigation use.*
[b] *Ultra-oligotrophic <4µg/L;oligotrophic .4-10 µg/L; mesotrophic 10-20 µg/L; meso-eutrophic 20-35 µg/L; eutrophic 35-100 µg/L; hyper-trophic >100 µg/L*
[c] *When background is ≤50.*
[d] *When background is ≤100.*

Streams 1, 3, 4, and 18 tested high for total phosphorus, making them eutrophic according to CCME standards. There are no national standards for orthophosphates, which are more readily available for uptake by plants. As mentioned earlier, sites 1, 3 and 4 were located directly downstream from dairy farms. Site 4 demonstrated increased turbidity without corresponding increased total suspended solids, suggesting the increase in turbidity could be from higher levels of the finer solids suspended in water (i.e. bacteria and colloids), rather than larger soil particles measured in the total suspended fraction. Sites 3, 8, and 11 turbidity results were below guidelines but these sites exceeded guidelines for total suspended solids, suggesting higher levels of the larger solids fraction. Site 18 turbidity results exceeded the guidelines. High turbidity and high total phosphorus, along with corresponding high pH, low dissolved oxygen and high temperature (Table 4) suggest the presence of cyanobacteria (blue-green algae), which are potentially toxic to aquatic organisms and result in surface scum. Results for nutrients in streams are outlined in Table 8 on the following page.

Table 8. Nutrients for sampled streams.

			LOCATION									
Parameter	**CCME[a]**	**BC WQG[b]**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 8**	**Site 11**	**Site 15**	**Site 16**	**Site 18**
Ammonia Nitrogen (mg/L)		**0.692max, ≤0.133avg**	<0.005	0.047	<0.005	<0.005	0.01	0.008	<0.005	<0.005	0.005	0.022
Total Phosphorus (µg/L)	**<4-100[c]**		55	29	79	40	20	7	12	5	21	42
Orthophosphate(mg/L)			0.009	0.008	0.066	0.036	0.004	0.002	0.008	0.001	0.004	0.009
Nitrate plus nitrite (mg/L)		**0.06[d]**	0.020	0.003	0.29	0.068	0.013	0.068	0.058	0.027	<0.002	0.005
Turbidity (NTU)		**5[e]**	3.2	0.8	3.7	6	2.1	1.6	2.8	0.5	1.6	5.8
Total Suspended Solids (mg/L)		**25[f]**	7	<4	28	9	<4	55	160	8	<4	<4
Specific Conductivity (µS/cm)			220	240	250	200	110	210	220	69	190	120

[a] Canadian Council of Ministers of the Environment
[b] British Columbia Water Quality Guidelines (2006) for freshwater aquatic life.
[c] Ultra-oligotrophic <4µg/L;oligotrophic .4-10 µg/L; mesotrophic 10-20 µg/L; meso-eutrophic 20-35 µg/L; eutrophic 35-100 µg/L; hyper-trophic >100 µg/L.
[d] Nitrite value.
[e] When background is between 8 and 50.
[f] When background is 25-250.

3.4 METALS

Hardness is a measurement of the amount of dissolved ions, primarily calcium and magnesium, in water. This reading is largely dependent on naturally-occurring processes of water action within rocks and soil which release common compounds such as magnesium, sodium, calcium, potassium, manganese, iron and chloride, to name a few. The most important impact of hardness on aquatic life is its ability to cause harmful metals to form insoluble precipitates which drop out of solution, making them biologically unavailable to organisms. Generally, the harder the water, the less toxic metals become.

Turbidity is assessed along with hardness because metals are often attached to, or embedded in, sediment particles. Turbid water samples often contain higher proportions of metals and can be representative of naturally-occurring metal concentrations or introduced contaminants.

The hardness of sampled agricultural drainage ditches were between soft (below 60mg/L) at Site 12 to very hard (above 180mg/L) at Site 17, according to Guidelines for Canadian Drinking Water Quality, published by Health Canada. Metals for these sites fell within BCWQG with Site 17 approaching guideline limits for iron. Values for metals in agricultural drainage ditches are listed in Appendix 2. Hardness is displayed in Table 9 on the following page.

Table 9. Specific conductivity and hardness in agricultural drainage ditches.

		LOCATION									
PARAMETER	**GCDWQ[a]**	**Site 6**	**Site 7**	**Site 9**	**Site 10**	**Site 12**	**Site 13**	**Site 14**	**Site 17**	**Site 19**	**Site 20**
Hardness (CaCO2) (mg/L)	0 to ≥160	167	124	115	136	47.3	61.4	57.9	287	193	167

[a] Guidelines for Canadian Drinking Water Quality (Health Canada)
[b] Soft: 0 to <60 mg/L; medium hard: 60 to <120 mg/L; hard: 120 to <180 mg/L; very hard: ≥180 mg/L

Sampled stream hardness varied between soft and medium hard (60 to <120mg/L). Sites 5 and 11 tested above the limits for aluminum, iron, and lead. Site 5 drains directly into the Kootenay River, not far upstream from Site 11, which is the Creston-Provincial monitoring location of the Kootenay River. Site 11 also demonstrated elevated cadmium levels. Site 8 also demonstrated elevated lead levels. Values for metals in streams are listed in Appendix 3. Hardness is displayed in Table 10 below.

Table 10. Specific conductivity and hardness in streams.

		LOCATION									
PARAMETER	**GCDWQ[a]**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 8**	**Site 11**	**Site 15**	**Site 16**	**Site 18**
Hardness (CaCO3) (mg/L)	0 to ≥160	86.7	108	100	74.5	50.1	100	99.4	29.8	93.5	56

[a] Guidelines for Canadian Drinking Water Quality (Health Canada)
[b] Soft: 0 to <60 mg/L; medium hard: 60 to <120 mg/L; hard: 120 to <180 mg/L; very hard: ≥180 mg/L

3.5 PESTICIDES

All seven sites demonstrated that pesticides were below the reportable detection limits for all sites. A summary of these results can be found in Appendix 4.

4. SUMMARY

It should be noted that this study presents the results of a single sample at all sampling locations, reflecting merely a short snap-shot in time. Ideally, this kind of sampling program would be conducted just following a severe rain event, to capture worst case conditions, and would have incorporated at least 5 samples per site over a 30-day period. Since funds and staff were limited, this was not possible; however, the objectives of the reconnaissance–level study were met.

At the time of sampling, the weather was warm and dry, with no precipitation occurring prior to sampling. All sampled sites were found to have an ambient temperature between 16 ºC to 22 ºC, with only slightly higher temperatures in agricultural drainage ditches. All sites were slightly alkaline, with pH ranging from 7.8 to 8.8. Site 18 was close to the minimum aquatic BCWQG for pH.

Agricultural drainage ditches were found to be visibly eutrophic, with murky, plant-infested water. As expected, these sites had much lower dissolved oxygen and higher levels of both nitrogen and phosphorous than those found in streams. Sites 10, 17, 19, and 20 were hyper-eutrophic, with phosphorus levels exceeding CCME guidelines for irrigation. Nitrites were combined with nitrates, making it impossible to determine definitively whether either parameter for aquatic life had been exceeded in the sampled streams. Nitrites are a measure of a form of unstable nitrogen that is either quickly oxidized to nitrate which is a source of nutrients for plants. Nitrite is toxic to aquatic life at low concentrations. Nitrates are a measure of the most stable and oxidized form of nitrogen. It is less toxic to aquatic life and is the primary form utilized by plants. Site 17 had sediment that was grey, thick and sticky with a persistent foul odour, likely due to anaerobic decomposition of organic matter. Results for turbidity and total suspended solids at this site indicated those two variables also exceeded BCWQG for general livestock use and irrigation. Sites 19 and 20 also exceeded the BCWQG for total suspended solids.

Enterococcus counts in the agricultural drainage ditches were higher than guidelines in seven out of ten sites. Site 13 also exceeded guidelines for fecal coliforms and demonstrated elevated *E. coli* counts. This site was located directly downstream from a dairy farm.

Hardness and metals levels varied widely among agricultural sampling sites although most were within parameters. Pesticides in agricultural drainage ditches also all reported below reportable detection limits.

Streams were found to have higher dissolved oxygen levels and were generally less eutrophic than agricultural drainage ditches. Streams 1, 3, 4, and 18 tested high for total phosphorus, making them eutrophic by CCME standards. Although there are no national standards for orthophosphates, the form of phosphate most easily utilized by plants, site 3 levels were considerably higher for this compound than other streams. Site 1, 3, and 4 are located downstream from dairy farms. Site 4 demonstrated increased turbidity without corresponding increased total suspended solids. Sites 3, 8, and 11 turbidity results were below limits but these sites exceeded guidelines for total suspended solids. Typically, a high TSS will yield high turbidity; however, some circumstances (such as a stream current or wave action) can produce higher TSS values which aren't necessarily accompanied by a corresponding increase in turbidity because particles larger than silt typically settle out before a reading is taken but do contribute to the TSS value. Site 11, the Kootenay River Creston/Provincial testing site, had high TSS readings without corresponding high turbidity. This could be due to particles settling out before a reading is taken.

Stream samples yielded nine out of ten sites which far exceeded the guidelines for enterococcus for primary contact recreation, with sites 1, 3, and 4 yielding the highest counts. Sites 3 and 4 were also above the threshold for both fecal coliforms and *E. coli* whereas site 1 was elevated for *E. coli* only. Sites 1, 3, and 4 all feed into Rykerts Creek and eventually into Site 2, Rykerts Lake. While

E. coli and fecal coliform counts were low at this site, it should be noted that it exceeded guidelines for enterococcus, which is an indicator of fecal contamination.

Sampled stream hardness varied between soft and medium hard (60 to <120mg/L). Sites 5 and 11 tested above the limits for aluminum, iron, and lead. Site 11 also demonstrated elevated cadmium levels. Long-term monitoring of site 11 has indicated fluctuating metals levels is not abnormal for this site. Site 5 drains directly into the Kootenay River, not far upstream from Site 11, which is the Creston-Provincial monitoring location of the Kootenay River. Site 8 also demonstrates elevated lead levels.

The combination of high pH, increased nutrients, increased turbidity, decreased dissolved oxygen, and relatively high temperature indicate the presence of cyanobacteria (blue-green algae), which is potentially toxic to aquatic organisms, decreases water quality and forms surface scum. Streams are generally low in cyanobacteria populations (McKean 1991). Site 18, a very slow-moving stream with wide banks and deep pools which fed into the Kootenay River several kilometres upstream, did not meet aquatic BCWQG for turbidity and was close to not meeting guidelines for nutrients, pH and dissolved oxygen. These results suggest the presence of cyanobacteria at this site.

Pesticides were shown to be below the reportable detection limits for all sites. However, given that pesticides in small amounts can have impacts on the biological activity within waterbodies, there is no way to ascertain whether aquatic life is negatively affected given the limited sampling effort. Glyphosate, also called Round-Up, is a commonly used herbicide which is generally considered non-toxic. However, surfactants used to increase permeability of plant leaves have been found to cause a major reduction in populations of amphibians (Relyea 2005). Recent research has found that pesticides in low quantities are capable of injuring salmonid olfactory tissue (Tierney 2008).

5. RECOMMENDATIONS

The general objective of this effectiveness evaluation was to assess water quality within the Creston Valley and identify agricultural areas of potential non-compliance with the *Agricultural Waste Control Regulation* (AWCR). This report indicated water quality is being compromised from land use practices and more efforts should be made to review whether non-compliance with the AWCR is occurring. Several recommendations have been identified as a result of this reconnaissance mission for consideration.

- Focus monitoring efforts on areas affected by non-point source pollution. Key areas identified in this study include Rykerts Creek, Rykerts Lake, the Old Goat River Channel, and the old Kootenay River Channel. Monitoring should be done regularly to establish environmental conditions and more easily trace non-point sources of pollution in the Creston Valley.

- Conduct future investigations during the spring, winter, and fall when runoff is occurring and non-point source pollution is most evident. Attempt to conduct monitoring programs at the same time that pesticides are typically applied to crops.

- Analyze nitrite and nitrate separately to ensure values of each form of nitrogen are documented and can be properly assessed.

- Incorporate the ability to monitor short-term transient events, such as heavy rainfall, as part of the monitoring program to ensure these events and their impacts on aquatic life are understood more clearly. If possible, establish automated monitoring equipment in selected streams to capture data during these transient weather-driven pollution events.

- Use lower reportable detection limits in future pesticide monitoring programs. Ensure surfactant analyses are included in any pesticide monitoring program.

- Encourage partnerships with stakeholders, community stewardship groups (e.g. agricultural producer groups, Creston Valley Wildlife Management Area), and environmental groups to assist in carrying out an effective monitoring and assessment program to evaluate water quality in the Creston Valley. Ministry of Environment should provide technical support to the community-based volunteer water quality monitoring efforts to ensure data collection methods are reliable and acceptable.

- Engage stakeholders, community stewardship and environmental groups to take the necessary actions to reduce the amount of pollutants reaching surface water and conduct follow-up monitoring to understand if those actions have been effective.

REFERENCES

Beatty, J. 2006. Water quality investigations in the vicinity of Wynndel, BC. B.C. Ministry of Environment. Water Stewardship Division.

Conly, J. 2002. Antimicrobial resistance in Canada. CMAJ. 167 (8): pp.885-891.

Masse & Miller Consulting Ltd., Morrow Environmental Consultants Inc. 2008. Duck Lake environmental assessment. B.C. Ministry of Environment. Kootenay Region Environmental Quality.

McKean, C., Nagpal, N. 1991. Ambient water quality criteria for pH: technical appendix. B.C. Ministry of Environment.

Relyea, R.A. 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications. 1(2): April 1,2005.

Rubec, CDA. 1994. Management of Canadian Ramsar sites. Water and Habitat Conservation Branch. Canadian Wildlife Service. Environment Canada.

Tierney, K. 2008. Salmon olfaction is impaired by an environmentally realistic pesticide mixture. Environmental Science & Technology. 42 (13):pp.4996-5001

Waye, H.L. 2000. Status of the northern leopard frog in the Creston Valley Wildlife Management Area, BC. *In* Proc. Conf. on the Biology and Management of Species and Habitats at Risk, Kamloops, BC. Feb. 15–19, 1999.

Wilson, S.F., Steeger, C., Machmer, M., Morley, R. and C. Morley. 2004. Habitat management plan for the Creston Valley Wildlife Management Area. EcoLogic Research Report. 18.

Personal Communications

Beaucher, Marc-Andre. 2008. Wetland Management and Research, Creston Valley Wildlife Management Area. Creston, B.C.

Heal, Tom. 2008. Sunset Seed Company. Creston, B.C.

Low, Don. 2008. Ministry Agriculture and Lands. Creston, B.C.

Vakenti, Jerry. 2008. Ministry of Environment. Penticton, B.C.

APPENDIX 1

Photo Documentation

Appendix 1. Photo Documentation

Site 1. Rykerts Creek at culvert on Hagey Road

Site 2. Edge of Rykerts Lake

Site 3. Rykerts Creek culvert on Porthill Road

Site 4. Rykert Creek at culvert on Sinclair Road

Site 5. West Creston and Nicks Island South roads

Site 6. Drainage ditch below pumphouse

Site 7. Sluice above pumphouse

Site 8. Kootenay River at Duck Lake and Farmin roads.

Site 10. Old Goat River Channel at Wayleen Farms on Hwy 3

Site 11. Kootenay River at Creston/Prov. site

Site 12. Drainage ditch downstream from Hanson Farms

Site 13. Drainage ditch downstream from Creston Valley Farms

Site 14. Drainage ditch at Reclamation and Christenson roads

Site 16. Old Goat River Channel at Channel Road

Site 18. Old Kootenay River Channel under Hwy 3 overpass

Site 20. Drainage ditch on Duck Lake Road

APPENDIX 2

Summary of analytical results for metals in agricultural drainage ditches in the Creston Valley

Appendix 2. Analytical results for metals in agricultural drainage ditches.

				SITE LOCATION									
Total Metals	**Units**	**BC WQG[a]**	**BC WQG[b]**	**Site 6**	**Site 7**	**Site 9**	**Site 10**	**Site 12**	**Site 13**	**Site 14**	**Site 17**	**Site 19**	**Site 20**
Aluminum (Al)	ug/L	5000	5000	5.0	4.0	50.4	22.0	40.0	18.0	29.0	188	66.3	104
Antimony (Sb)	ug/L			0.07	0.09	0.08	0.06	0.05	0.06	0.05	0.09	0.06	0.19
Arsenic (As)	ug/L	25	100	1.41	1.34	1.08	1.83	3.10	3.09	3.29	4.32	3.32	9.40
Barium (Ba)	ug/L			86.5	46.3	23.5	43.7	16.8	20.4	14.1	91.5	74.1	34.8
Beryllium (Be)	ug/L	100	500	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.01	0.01
Bismuth (Bi)	ug/L			<0.005	<0.005	<0.005	<0.005	0.008	0.008	0.006	0.019	0.009	<0.005
Boron (B)	ug/L	5000	500-6000[c]	<50	<50	<50	<50	<50	<50	<50	81	110	<50
Cadmium (Cd)	ug/L	80	5.1	0.006	0.010	0.010	0.027	<0.005	0.010	0.017	0.181	0.028	0.015
Chromium (Cr)	ug/L	50(Cr[VI])	8(Cr[VI])	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.2	0.1
Cobalt (Co)	ug/L	1000		0.149	0.091	0.101	0.277	0.117	0.112	0.162	2.78	0.545	0.550
Copper (Cu)	ug/L	300	200	0.35	0.72	0.62	0.83	0.86	1.64	1.57	6.41	1.93	0.83
Iron (Fe)	ug/L		5000	287	180	242	400	666	651	399	3980	4060	2550
Lead (Pb)	ug/L	100	400	0.098	0.193	0.255	0.238	0.338	0.338	0.296	0.968	0.780	0.416
Lithium (Li)	ug/L			1.4	1.4	0.8	3.7	1.7	1.3	1.3	6.8	3.9	3.0
Manganese (Mn)	ug/L			403	49.2	22.1	458	29.7	101	117	1210	2140	401
Molybdenum (Mo)	ug/L	50-80	50	0.18	0.19	0.27	0.47	0.35	0.34	0.33	0.43	0.26	0.95
Nickel (Ni)	ug/L	1000	200	0.34	0.39	0.32	0.87	0.40	0.50	0.48	2.24	0.93	1.41
Selenium (Se)	ug/L	30	10	0.09	0.14	0.06	0.14	0.10	0.13	0.18	0.20	0.11	1.33
Silicon (Si)	ug/L			4150	1910	6260	3070	2240	3250	3050	7010	5670	656
Silver (Ag)	ug/L			0.034	0.081	0.061	0.058	0.187	0.533	0.193	0.058	0.112	0.043
Strontium (Sr)	ug/L			122	102	90.8	148	38.2	46.0	46.2	239	222	96.3
Thallium (Tl)	ug/L			<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	0.007	0.004	0.002
Tin (Sn)	ug/L			<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.03	0.07	0.02
Titanium (Ti)	ug/L			<0.5	<0.5	1.1	1.0	2.0	0.9	0.9	4.7	3.6	2.7
Uranium (U)	ug/L	200	10	0.680	1.03	1.33	0.666	0.174	0.051	0.162	2.52	0.527	1.60
Vanadium (V)	ug/L			<0.2	<0.2	0.4	<0.2	0.2	<0.2	<0.2	1.0	0.7	0.5
Zinc (Zn)	ug/L	2000	1000	2.9	1.8	1.3	13.1	2.3	3.4	3.1	22.7	23.4	4.9
Calcium (Ca)	mg/L			36.8	26.5	29.0	27.4	14.9	19.5	17.6	67.6	47.2	35.5
Magnesium (Mg)	mg/L			18.2	14.1	10.2	16.3	2.46	3.07	3.38	28.7	18.3	19.0
Potassium (K)	mg/L			1.69	0.98	0.93	1.06	1.25	0.95	1.24	4.19	4.36	0.29
Sodium (Na)	mg/L			11.1	8.52	5.58	19.3	1.99	1.82	1.99	40.6	23.8	3.86
Sulphur (S)	mg/L			<3	3	4	4	<3	<3	<3	<3	<3	<3

[a] *British Columbia Approved Water Quality Guidelines (2006) maximum acceptable concentration for general livestock use.*
[b] *British Columbia Approved Water Quality Guideline (2006) maximum acceptable concentration for irrigation use.*
[c] *Crop dependent: wheat, barley = 0.5-1.0 µg/L; oat, corn, clover = 2.0-4.0 µg/L.*

APPENDIX 3

Summary of analytical results for metals in streams of the Creston Valley

Appendix 3. Analytical results for metals in streams.

			SITE LOCATION									
Total Metals	**Units**	**BC WQG[a]**	**1**	**2**	**3**	**4**	**5**	**8**	**11**	**15**	**16**	**18**
Aluminum (Al)	ug/L	100[b]	54.3	8.1	71.4	50.6	181	52.0	248	17.1	18.8	9.2
Antimony (Sb)	ug/L		0.07	0.08	0.07	0.07	0.04	0.06	0.09	0.05	0.06	0.06
Arsenic (As)	ug/L	5	2.50	4.47	2.72	2.65	1.48	0.51	1.06	0.56	0.49	1.27
Barium (Ba)	ug/L	5000	19.0	21.2	24.0	14.5	17.4	34.3	40.3	13.0	81.0	20.9
Beryllium (Be)	ug/L	5.3	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.03	<0.01	<0.01	<0.01
Bismuth (Bi)	ug/L		<0.005	<0.005	0.009	<0.005	0.012	<0.005	0.019	<0.005	<0.005	<0.005
Boron (B)	ug/L	1200	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium (Cd)	ug/L	.01-.06[c]	0.005	<0.005	0.009	<0.005	0.014	0.017	0.078	0.010	<0.005	0.008
Chromium (Cr)	ug/L	1 (Cr[VI])	0.2	<0.1	0.4	0.2	0.3	0.1	0.3	<0.1	<0.1	<0.1
Cobalt (Co)	ug/L	110	0.089	0.115	0.129	0.089	0.244	0.077	0.403	0.155	0.055	0.123
Copper (Cu)	ug/L	4.8-29.0[d]	0.58	10.3	1.39	0.41	1.06	0.57	1.78	0.86	0.28	0.68
Iron (Fe)	ug/L	300	113	50	158	109	658	93	520	118	228	360
Lead (Pb)	ug/L	0.0007-0.4[e]	0.165	0.077	0.338	0.173	0.530	0.489	4.46	0.120	0.129	0.184
Lithium (Li)	ug/L	5000	2.1	3.0	2.8	1.8	1.4	1.4	1.9	<0.5	0.9	0.5
Manganese (Mn)	ug/L	868-3700[f]	5.12	22.0	14.9	7.11	33.9	7.42	43.1	54.9	33.7	22.7
Molybdenum (Mo)	ug/L	2000	1.02	1.08	1.05	0.94	0.30	0.51	0.51	0.36	0.31	0.18
Nickel (Ni)	ug/L	25000-150000[g]	0.39	0.39	0.60	0.33	0.46	0.28	0.71	0.26	0.09	0.31
Selenium (Se)	ug/L	2	0.06	0.08	0.09	0.08	0.19	0.61	0.63	<0.04	<0.04	<0.04
Silicon (Si)	ug/L		5320	4960	5570	5230	2990	2180	2570	3840	3880	1200
Silver (Ag)	ug/L	0.1-3.0[h]	0.006	0.009	0.483	0.006	0.029	0.044	0.034	0.077	0.031	0.038
Strontium (Sr)	ug/L		81.8	117	109	71.9	46.2	86.6	86.3	31.2	38.7	41.4
Thallium (Tl)	ug/L	0.3	<0.002	<0.002	0.003	<0.002	0.011	0.005	0.015	0.002	<0.002	<0.002
Tin (Sn)	ug/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01
Titanium (Ti)	ug/L		2.2	<0.5	3.1	2.1	12.6	1.4	9.2	<0.5	<0.5	0.8
Uranium (U)	ug/L	300	1.79	2.71	2.82	1.66	0.333	0.530	0.640	0.172	0.448	0.309
Vanadium (V)	ug/L		1.0	0.9	1.1	0.9	0.4	0.3	0.7	<0.2	0.2	<0.2
Zinc (Zn)	ug/L	12.2-180.8[i]	0.7	3.1	1.5	1.1	2.8	1.1	6.9	2.5	0.8	1.3
Calcium (Ca)	mg/L		24.7	28.4	26.7	21.6	14.5	27.8	27.5	8.01	21.5	18.6
Magnesium (Mg)	mg/L		6.09	9.00	8.16	5.01	3.38	7.51	7.44	2.38	9.71	2.34
Potassium (K)	mg/L		3.31	2.82	4.28	2.09	0.78	0.51	0.60	0.57	1.01	0.39
Sodium (Na)	mg/L		3.99	5.79	4.52	3.43	1.81	2.38	2.33	1.43	1.41	1.03
Sulphur (S)	mg/L		4	4	4	4	<3	6	7	<3	<3	<3

[a] British Columbia Approved Water Quality Guidelines (2006) maximum acceptable for aquatic life.
[b] When pH>6.5.
[c] Criterion for cadmium is determined using the following formula:: 10 exp (0.86[log{hardness}]-3.2).
[d] Criterion for copper is determined using the following formula: (0.094(hardness)+2) µg/L.
[e] Tetra-ethyl lead: 0.0007µg/L; tri-ethyl lead: 0.4µg/L; tetra-methyl lead: 0.006µg/L
[f] Calculated using formula 0.01102(hardness)=0.54*
[g] Hardness 0-60ug/L value is 25,000; hardness 60-120ug/L value is 65,000; hardness 120-180ug/L value is 110,000; hardness >180ug/L value is 150,000
[h] For total hardness ≤100mg/L value is 0.1; for total hardness >100mg/L value is 3.0
[i] Criterion for zinc determined using the following formula: 33 + 0.75(hardness-90)

APPENDIX 4

Summary of analytical results for pesticides in agricultural drainage ditches and streams of the Creston Valley

Appendix 4. Pesticide results for sampled sites in Creston Valley.

					LOCATION						
Base Neutrals	**BC WQG[a]**	**BC WQG[b]**	**BC WQG[c]**	**Units**	**Site 5**	**Site 9**	**Site 11**	**Site 12**	**Site 15**	**Site 16**	**Site 20**
Diphenylamine				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pentachloronitrobenzene				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pronamide				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorobenzenes											
Hexachlorobenzene				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
FOOD GROUP PARAMETERS											
Bromophos				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorothalonil (Daconil)	170	5.8	.18	ug/L	<1	<1	<1	<1	<1	<1	<1
Dichlobenil				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Dicofol				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Malaoxon				ug/L	<1	<1	<1	<1	<1	<1	<1
Phosalone				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Parameter											
4,4'-DDE				ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4,4'-DDT				ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4,4'-methoxychlor				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
a-Chlordane				ug/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Azinophos methyl (Guthion)				ug/L	<1	<1	<1	<1	<1	<1	<1
Bromacil				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyrifos	24		.002	ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Disulfoton (Di-Syston)				ug/L	<1	<1	<1	<1	<1	<1	<1
Endosulfan I				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan II				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
g-Chlordane				ug/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Mevinphos (Phosdrin)				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion methyl				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phorate (Thimet)				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Stirophos				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Organophosphorus Pest.											
Alachlor				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Atrazine	5	10		ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Butylate				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Captan	1.3		1.3	ug/L	<1	<1	<1	<1	<1	<1	<1
Chlorpropham				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanazine (Bladex)	10	0.5	2	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Desethyl-atrazine				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Diazinon			.043	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dichloran				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dimethoate	3			ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethion				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fenthion				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Folpet				ug/L	<1	<1	<1	<1	<1	<1	<1
Fonofos				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Malathion			0.1	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methidathion				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Metolachlor	50	29	7.8	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metribuzin (Sencor)	80	0.5	1	ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Parathion				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phosmet				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Phosphamidon				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Prometryn				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Propazine				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Simazine	10	0.5	10	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Terbufos				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Trifluralin	45		0.2	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Vinclozolin				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

					LOCATION						
Organochlorine Pesticides	BC WQG[a]	BC WQG[b]	BC WQG[c]	Units	Site 5	Site 9	Site 11	Site 12	Site 15	Site 16	Site 20
2,4'-DDT + 4,4'-DDD				ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
a-BHC				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin				ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Aspon				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Azinphos ethyl				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
b-BHC				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benfluralin				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bromophos-ethyl				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Carbophenothion				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chlorbenside				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorfenson(ovex)				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorfenvinphos(e/z)				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlormephos				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyriphos-methy				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorthiophos				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Cyanophos				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Dacthal				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
d-BHC				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Demeton				ug/L	<1	<1	<1	<1	<1	<1	<1
Desmetryn				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Diallate(e/z)				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichlofenthion				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Dichlofluanid				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichlorvox + Naled				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dicrotophos				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin				ug/L	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Dioxathion				ug/L	<1	<1	<1	<1	<1	<1	<1
Endosulfan Sulfate			0.02	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Endrin				ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Endrin Aldehyde				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin ketone				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EPN				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Eptam				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethalfluralin				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fensulfothion				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor epoxide				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Hexazinone				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Iodofenphos				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Isofenphos				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Lindane (BHC), gamma	4		0.01	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Metalaxyl				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Mirex				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Nitrofen				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
o,p'-DDD				ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p'-DDE				ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Omethoate				ug/L	<1	<1	<1	<1	<1	<1	<1
Permethrin				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pirimicarb				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pirimiphos-ethyl				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pirimiphos-methyl				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Procymidone				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Profenophos				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Profluralin				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pyrazophos				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Quinalophos				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Ronnel				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Organochlorine Pesticides	BC WQG[a]	BC WQG[b]	BC WQG[c]	Units	LOCATION Site 5	Site 9	Site 11	Site 12	Site 15	Site 16	Site 20
Sulfotepp				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tecnazene				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Terbuthylazine				ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Terbutryne				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tetradifon				ug/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tolylfluanid				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Triadimefon				ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Triallate	230		2000	ug/L	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PESTICIDE RESIDUE											
Iprodione				ug/L	<1	<1	<1	<1	<1	<1	<1
Propiconazole				ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Surrogate Recovery (%)											
2-FLUOROBIPHENYL (sur.)				%	71	78	80	80	70	77	75
D5-NITROBENZENE (sur.)				%	69	79	85	81	67	79	79
p,p'-DDE13C12 (sur.)				%	74	78	76	80	75	77	75
TERPHENYL-D14 (sur.)				%	78	85	83	83	80	82	80
Triphenyl phosphate (sur.)				%	77	82	81	81	80	79	79
SURFACTANTS											
Non-Ionic Surfactants (CTAS) (mg/L)				ug/L	<1	<0.5	n/a	<1	<1	<1	<1
Anionic Surfactants (MBAS) (mg/L)				ug/L	<0.05	<0.1	n/a	<0.1	<0.1	<0.1	<0.1

[a] British Columbia Approved Water Quality Guidelines (2006) maximum acceptable concentration for general livestock use.
[b] British Columbia Approved Water Quality Guideline (2006) maximum acceptable concentration for irrigation use.
[c] *British Columbia Water Quality Guidelines (2006) for fresh water aquatic life.*