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MINISTRY OF ENVIRONMENT

Water Quality Assessment and Objectives for the Cowichan and Koksilah Rivers

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EXECUTIVE SUMMARY

This report summarizes the findings of the 2002, 2003 and 2008 water quality objectives attainment monitoring of the Cowichan and Koksilah Rivers, located near Duncan on Vancouver Island, British Columbia. The sampling program was based on the Cowichan-Koksilah Rivers Water Quality Assessment and Objectives report (McKean, 1989). At that time, forestry, agriculture, industrial operations and residential development were all occurring within the watershed, and there was a concern that these would influence water quality in the future. To date, these activities are still occurring and some are likely contributing to the water quality objectives exceedances observed in the Cowichan and Koksilah Rivers.

Less than half of the parameters sampled met the water quality objectives. Dissolved oxygen, non-filterable residue (NFR) and turbidity objectives were often exceeded in both rivers. A habitat improvement project in the Cowichan appears to have remedied the suspended sediment issue in this river, while the problem persists in the Koksilah River. Fecal coliform and *Escherichia coli* results exceeded the objectives on most occasions and at most sites, and have been attributed primarily to non-point sources. Chlorophyll *a* objectives were occasionally exceeded in the lower part of the Cowichan River.

The objectives for bacteriological parameters, NFR, turbidity and metals have been updated based on changes to the provincial guidelines. New temperature and total phosphorus objectives are also proposed. The objectives for total residual chlorine and copper-8-quinolinolate have been removed as they are no longer relevant.

Recommendations include identifying and addressing the sources of elevated turbidity and NFR in the Koksilah River, and using these parameters as a surrogate for other parameters of concern. In addition, a mitigation plan should be developed for bacteriological contamination and phosphorus inputs in both rivers. Finally, benthic invertebrate sampling should be incorporated into the Cowichan and Koksilah Rivers monitoring program.

The updated water quality objectives for the Cowichan and Koksilah Rivers are listed in the table on the following page.

Variable	Original Objectives (1989)		Revised Objectives (2011)	
	Site	Objective	Site	Objective
Fecal coliforms	All but C5	≤ 10 cells/100 mL*	none	
	C5	none		
Escherichia coli	All but C5	≤ 10 cells/100 mL*	All but C5	≤ 10 CFU/100 mL*
	C5	≤ 385 cells/100 mL*	C5	≤ 77 CFU/100 mL**
enterococci	All but C5	≤ 3 cells/100 mL*	none	
	C5	≤ 100 cells/100 mL*		
Dissolved Oxygen	All (Oct to May)	≥ 11.2 mg/L	All (Oct to May)	≥ 11.2 mg/L
	All (June to Sept)	≥ 8 mg/L	All (June to Sept)	≥ 8 mg/L
Non-filterable Residue (Total Suspended Solids)	All	≤ 10 mg/L increase (when background ≤ 100 mg/L) ≤ 10% increase (when background > 100 mg/L)	All	≤ 27 mg/L (max) ≤ 7 mg/L (mean)
Turbidity	All	≤ 5 NTU increase (when background ≤ 50 NTU) ≤ 10% increase (when background > 50 NTU)	All (Oct to Apr)	≤ 5 NTU (max)
			All (May to Sept)	≤ 2 NTU (max)
Ammonia	All	see ammonia tables	All (Oct to Apr)	≤ 1.31 mg/L (mean) ≤ 6.83 mg/L (max)
			All (May to Sept)	≤ 0.49 mg/L (mean) ≤ 3.61 mg/L (max)
Total Phosphorus	none		All (May to Sept)	≤ 5 µg/L (mean) ≤ 7 µg/L (max)
Chlorophyll *a*	d/s of PE-247 and PE-1497	≤ 5.0 µg/m^2	d/s of PE-247 and PE-1497	≤ 5.0 µg/m^2
Total Copper* **	All	≤ 2 µg/L (mean) ≤ 4 µg/L (max)	All	≤ 2 µg/L (mean) ≤ 4 µg/L (max)
Total Lead* **	All	≤ 3 µg/L (mean) ≤ 8 µg/L (max)	All	≤ 4 µg/L (mean) ≤ 11 µg/L (max)
Total Zinc* **	All	≤ 30 µg/L (mean) ≤ 180 µg/L (max)	All	≤ 7.5 µg/L (mean) ≤ 33 µg/L (max)
Temperature	none		All	≤ 17 °C (weekly mean)
total chlorine residual	All	≤ 0.002 mg/L (max)	none	
copper-8-quinolinolate	All	≤ 0.5 µg/L (max)	none	

*90th percentile
**geometric mean
***original objective was set for dissolved metal
note: all calculations are based on five samples in 30 days

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1.0 INTRODUCTION

As part of the Province of British Columbia (BC), Ministry of Environment's (MOE) mandate to manage water bodies, water quality objective reports have been created for a number of lakes, rivers and marine surface waters. These reports provide a list of objectives to protect water quality, tailored to the specific water body for which they have been created. These take into account natural local water quality, water uses, water movement and waste discharges. While water quality objectives are not directly enforceable, they do provide direction for resource managers and are used as a standard against which to measure the water quality of a particular lake or river. Once objectives have been developed, periodic monitoring (every three to five years) is undertaken to determine whether they are being met. While attainment monitoring has been ongoing in the Vancouver Island region, a need has been identified for more detailed attainment reporting.

The Vancouver Island region has adopted an ecoregion approach to developing water quality objectives. The Vancouver Island ecoregions are based on the ecosections developed by Demarchi (1996) (Deniseger *et al.* 2009). This approach operates under the premise that lakes and rivers within an ecoregion will be more similar to each other than to lakes and rivers in other ecoregions. As a result, water quality objectives for one watershed can be applied, on an interim basis, to another watershed within the same ecoregion. Both the Cowichan and Koksilah Rivers lie within the Nanaimo Lowlands Ecoregion (Figure 1).

The Cowichan and Koksilah Rivers support one of Vancouver Island's most valuable sport, commercial and First Nations fisheries. The Cowichan River is one of only three rivers in BC designated as a Canadian Heritage River, based on its outstanding natural, cultural and recreational values. This watershed is used extensively for contact recreation such as swimming and kayaking, and is also a source of water for drinking, irrigation and industrial purposes (McKean, 1989). The Town of Lake Cowichan has an authorized sewage treatment plant (STP) effluent discharge into the Cowichan River located in the upper watershed, approximately 3.5 km downstream of the weir at Cowichan Lake, and the City of Duncan/District of North Cowichan, referred to as the Joint Utilities Board (JUB), also has an authorized treated STP discharge into the river approximately 1.5 km downstream of the highway bridge in the lower watershed.

Figure 1. Location of Cowichan and Koksilah Rivers within the Vancouver Island Ecoregions.

Monitoring on the Cowichan and Koksilah Rivers began in 1988 and water quality objectives were developed in 1989 (McKean, 1989). Parameters for which objectives were proposed included fecal coliform, *Escherichia coli*, enterococci, dissolved oxygen, non-filterable residue (NFR), turbidity, ammonia, chlorophyll *a*, total chlorine residual, dissolved copper, dissolved lead, dissolved zinc, and copper-8-quinolinolate. Objectives for microbiological indicators were more restrictive upstream from the city of Duncan as they were set to protect drinking water use.

The objectives report stated that the source of bacterial contamination needed to be identified before the situation could be corrected.

Monitoring conducted up to 1993 found results consistent with earlier data and it was recommended that routine monitoring be discontinued until corrective action was taken to address the parameters of concern (BCMELP, 1994). Monitoring, from 1998 to the present, consistently showed elevated levels of bacteriological parameters and low dissolved oxygen levels. In addition, turbidity, suspended solids and chlorophyll *a* occasionally exceeded the objectives. A thorough water quality assessment was conducted in 1998-1999 and identified non-point sources of pollution as the cause of elevated bacteriological results (Rideout *et al.*, 2000). The assessment also found that excessive nutrient levels in both rivers were causing considerable algae growth.

Water quality objectives attainment sampling was conducted in 2002, 2003 and 2008 at five sites in each river, and the results were compared to the water quality objectives developed in 1989, shown in Table 1. This report provides a thorough assessment of the 2002, 2003 and 2008 attainment monitoring and makes recommendations for updated objectives where required.

Table 1. Original water quality objectives for the Cowichan and Koksilah Rivers (McKean, 1989).

Variable	Original Objectives (1989)	
	Site	**Objective**
Fecal coliforms	All but C5	≤ 10 cells/100 mL*
	C5	none
Escherichia coli	All but C5	≤ 10 cells/100 mL*
	C5	≤ 385 cells/100 mL*
enterococci	All but C5	≤ 3 cells/100 mL*
	C5	≤ 100 cells/100 mL*
Dissolved Oxygen	All (Oct to May)	≥ 11.2 mg/L
	All (June to Sept)	≥ 8 mg/L
Non-filterable Residue (Total Suspended Solids)	All	≤ 10 mg/L increase (when background ≤ 100 mg/L) ≤ 10% increase (when background > 100 mg/L)
Turbidity	All	≤ 5 NTU increase (when background ≤ 50 NTU) ≤ 10% increase (when background > 50 NTU)
Ammonia	All	see ammonia tables
Chlorophyll *a*	d/s of PE-247 and PE-1497	≤ 5.0 $\mu g/m^2$
Dissolved Copper	All	≤ 2 µg/L (mean) ≤ 4 µg/L (max)
Dissolved Lead	All	≤ 3 µg/L (mean) ≤ 8 µg/L (max)
Dissolved Zinc	All	≤ 30 µg/L (mean) ≤ 180 µg/L (max)
total chlorine residual	All	≤ 0.002 mg/L (max)
copper-8-quinolinolate	All	≤ 0.5 µg/L (max)

*90^{th} percentile

2.0 CHANGES IN THE WATERSHED

When the water quality objectives were developed in 1989, water uses within the watershed included domestic, industrial, irrigation, recreation and fisheries. These uses remain important today; however, there have been some changes in the watershed that are worth noting.

Overall sewage effluent volumes have increased due to population growth. The Duncan/North Cowichan JUB STP began using alum in 2003 as a chemical addition to significantly reduce phosphorus levels in the effluent. This represented a reduction in phosphorus loadings to the river of greater than 80%. The establishment of a loadings limit in the facility's Operational Certificate ensures that phosphorus levels will not increase as population and volume increase over time. The Town of Lake Cowichan STP continues to use chlorination and dechlorination as part of their effluent disinfection process.

The fish hatchery that discharges effluent into the Cowichan River upstream of the Duncan/North Cowichan JUB STP remains in operation, but is now run by the Freshwater Fisheries Society of British Columbia. It produces 30,000 to 32,000 kg of trout per year. The 2000 Water Quality Assessment (Rideout *et al.*, 2000) found that impacts from this hatchery were minimal.

The Youbou saw mill, which discharged into Cowichan Lake, was noted as a potential source of contaminants in the watershed. The mill closed in January 2001 and the possible contaminants, which would have been limited to localized areas in the lake only, are no longer a concern in the Cowichan River.

In the Cowichan River, high turbidity had been an ongoing problem due to erosion of natural material from a long exposed clay bank at Stoltz Bluff. This was addressed through an extensive habitat improvement project in 2006 which involved building a berm and terrace to catch and retain falling material, as well as installing bendway weirs to reduce the stream flow velocities and scour along the toe of the berm (Wightman *et al.*, 2008).

3.0 STUDY DETAILS

Five sites on each of the Cowichan and Koksilah Rivers were sampled for attainment monitoring (Table 2 and Figure 2).

Sampling was conducted during the summer low flow and fall high flow periods; five weekly samples were collected over 30 days (5-in-30 sampling) to calculate 30-day averages and 90th percentiles, as recommended in the water quality objectives report. Some variation from the monitoring recommendations in the water quality objectives report occurred, and these changes are noted in the discussions for each parameter.

Table 2. Cowichan and Koksilah Rivers site numbers, EMS numbers and descriptions.

Sampling Site No.	***EMS Number***	***Location Description***
C1	E206108	Cowichan River at weir
C2	0120808	Cowichan River upstream of PE 247
C3	E206107	Cowichan River downstream of PE 247
C4	0120802	Cowichan River at the Highway
C5	E206106	Cowichan River 1 km downstream of PE 1497
K1	E207425	Koksilah River at Port Renfrew Road
K2	E206976	Koksilah River at Koksilah Road
K3	E207427	Kelvin Creek at Koksilah Road
K4	E207433	Koksilah River downstream of Kelvin Road
K5	0123981	Koksilah River at the Highway

Fecal coliform samples were collected for the low and high flow 5 weekly samples in a 30 day period as recommended, but over 300 additional bacteriological samples were also collected from 2002 to 2008 as part of a separate federal/provincial trend monitoring program. Samples were taken monthly or biweekly in some years or in separate 5-in-30 day periods in the summer or fall. Where the sampling regime met the criteria of 5 weekly samples in 30 days, these data were compared to the objectives.

The BC water quality guidelines and the objectives established by McKean (1989) were used to assess water quality and to protect designated water uses such as drinking water, primary and secondary contact recreation, and habitat for aquatic life. Some of the BC water quality guidelines have been updated since the original Cowichan and Koksilah River water quality objectives were developed. As such, changes are recommended to some of the objectives.

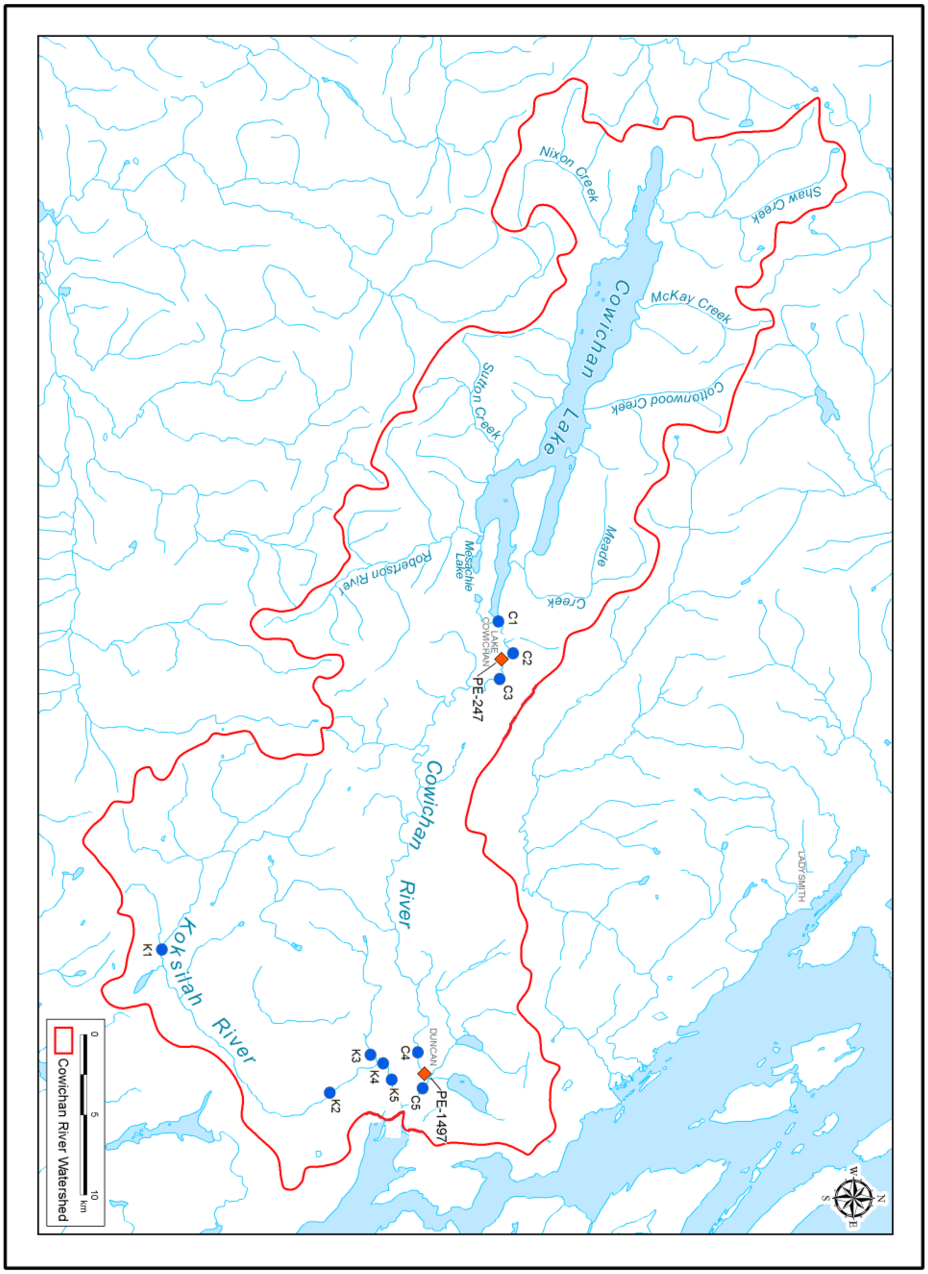

Figure 2. Map of the Cowichan and Koksilah River systems showing sampling site locations.

4.0 WATER QUALITY OBJECTIVES ATTAINMENT

All raw data and summary data are presented in Appendix I.

4.1 MICROBIOLOGY

Fecal contamination of surface waters used for drinking and recreating can result in high risks to human health from pathogenic microbiological organisms as well as significant economic losses due to closure of beaches (Scott *et al*., 2002). The direct measurement and monitoring of pathogens in water, however, is difficult due to their low numbers, intermittent and generally unpredictable occurrence, and specific growth requirements (Krewski *et al*., 2004; Ishii and Sadowsky, 2008). To assess risk of microbiological contamination from fecal matter, resource managers commonly measure fecal indicator bacteria levels (Field and Samadpour, 2007; Ishii and Sadowsky, 2008). The most commonly used indicator organisms for assessing the microbiological quality of water are the total coliforms, fecal coliforms (a subgroup of the total coliforms more appropriately termed thermotolerant coliforms as they can grow at elevated temperatures), and *E. coli* (a thermotolerant coliform considered to be specifically of fecal origin) (Yates, 2007).

There are a number of characteristics that suitable indicator organisms should possess. They should be present in the intestinal tracts of warm-blooded animals, not multiply outside the animal host, be nonpathogenic and have similar survival characteristics to the pathogens of concern. They should also be strongly associated with the presence of pathogenic microorganisms, be present only in contaminated samples and be detectable and quantifiable by easy, rapid, and inexpensive methods (Scott *et al*., 2002; Field and Samadpour, 2007; Ishii and Sadowsky, 2008).

Total and fecal coliforms have traditionally been used in the assessment of water for domestic and recreational uses. However, research in recent years has shown that there are many differences between the coliforms and the pathogenic microorganisms they are a surrogate for, which limits the use of coliforms as an indicator of fecal contamination (Scott *et al*., 2002). For example, many pathogens, such as enteric viruses and parasites, are not as easily inactivated by water and wastewater treatment processes as coliforms are. As a result, disease outbreaks do occur when indicator bacteria counts are at acceptable levels (Yates, 2007; Haack *et al*., 2009). Additionally, some members of the coliform group, such as *Klebsiella*, can originate from non-fecal sources (Ishii and Sadowsky, 2008) adding a level of uncertainty when analyzing data. Waters contaminated with human feces are generally regarded as a greater risk to human health, as they are more likely to contain human-specific enteric pathogens (Scott *et al*., 2002). Measurement of total and fecal coliforms does not indicate the source of contamination, which can make the actual risk to human health uncertain; thus it is not always clear where to direct management efforts.

The BC-approved water quality guidelines for microbiological indicators were developed in 1988 (Warrington, 1988) and include *E. coli*, enterococci, *Pseudomonas aeruginosa*, and fecal coliforms. The monitoring programs of the BC MOE have traditionally measured total coliforms, fecal coliforms, *E. coli* and enterococci, either alone or in combination, depending on the specific program. As small pieces of fecal matter in a sample can skew the overall results for a particular site, the 90^{th} percentiles (for drinking water) and geometric means (for recreation) are generally used to determine if the water quality guideline is exceeded, as extreme values would have less effect on the data.

The BC MOE drinking water guideline for raw waters receiving disinfection only is that the 90^{th} percentile of at least five weekly samples collected in a 30-day period should not exceed 10 colony forming units (CFU)/100 mL for either fecal coliforms or *E. coli*. The guideline for primary contact recreation is that the geometric mean should not exceed 200 CFU/100 mL for fecal coliforms or 77 CFU/100 mL for *E. coli* (Warrington, 2001).

For the Koksilah River, and the Cowichan River upstream of the highway bridge, where domestic water use and primary contact recreation were occurring, McKean (1989) recommended a fecal coliform and *E. coli* objective of 10 CFU/100 mL (90^{th} percentile) and an enterococci objective of 3 cells/100 mL (90^{th} percentile). Downstream of the highway bridge, where at that time only secondary contact recreation was occurring, McKean (1989) recommended an *E. coli* objective of 385 CFU/100 mL (geometric mean) and an enterococci objective of 100 cells/100 mL (geometric mean). This portion of the river is now used for primary contact recreation as well.

The microbiological results are presented in Table 3 and Table 4. It should be noted that *E. coli* was not measured at C5 and K5 in the summer of 2008 due to a sampling error, and enterococci was not measured at any sites. The bacteriological samples from October 19, 2003 were not analyzed due to a shipment error; therefore the statistics for the 2003 fall period are based on only four samples. This data set was included as it was apparent the fall flush event was captured and the data was indicative of trends in the watershed.

Table 3. Summary of 90th percentile values for fecal coliforms (CFU/100 mL) at Cowichan and Koksilah River sites, calculated when a minimum of five samples were collected within a 30-day period.

	2002		**2003**		**2008**	
Site	**summer**	**fall**	**summer**	**fall**	**summer**	**fall**
C1	144	31	374	250	28	5
C2	32	22	82	35	93	9
C3	26	66	184	154	73	10
C4	15	146	138	143	95	42
C5	28	158	148	46	198	107
K1	183	28	45	50	155	12
K2	430	20	72	66	1156	200
K3	55	14	1432	196	536	60
K4	47	9	213	473	216	61
K5	149	113	686	497	132	151

Table 4. Summary of 90th percentile values for *E. coli* (CFU/100 mL) at Cowichan and Koksilah River sites, calculated when a minimum of five samples were collected within a 30-day period. Note that the geometric mean is reported for C5.

	2002		**2003**		**2008**	
Site	**summer**	**fall**	**summer**	**fall**	**summer**	**fall**
C1	80	22	406	211	21	4
C2	32	10	59	14	51	6
C3	23	38	19	89	38	9
C4	6	60	50	26	83	38
C5	11	15	8	10	—	35
K1	140	8	8	16	142	12
K2	412	8	34	46	1096	191
K3	37	7	478	180	392	57
K4	31	8	155	370	192	51
K5	69	58	570	430	—	154

The provincial drinking water guidelines for fecal coliforms and *E. coli* were exceeded at all sites and in nearly all sampling periods. Sites C1, K2, K3, K4 and K5 had consistently higher results than other sites. As these sites are located upstream of any point-source discharges such as STPs, it suggests that the bacterial contamination is from non-point sources such as stormwater, aging septic systems, agriculture or wildlife. This is consistent with the 2000 Water Quality Assessment (Rideout *et al*., 2000), which found that elevated bacteriological levels were from non-point source pollution. The Koksilah River's elevated results may be related to agricultural activities occurring in the watershed. Site C1 may be affected by land and water uses which occur in Cowichan Lake, just upstream of the sampling location. Contributing factors may be the marinas, public beaches, houseboat activity and waterfront homes in the area.

Additional data were also collected as part of a federal/provincial agreement, and the sampling periods that met the 5 consecutive weekly samples collected in 30 days criteria are shown in Table 5. Although these samples were not collected at the same time as the MOE samples, results show that they also exceeded the provincial guidelines for drinking water.

Table 5. Summary of 90th percentile values for fecal coliforms (CFU/100 mL) collected as part of a federal/provincial sampling program.

	2003		**2004**	**2006**	**2007**
Site	**summer**	**fall**	**fall**	**summer**	**fall**
K5	139	17	138	49	184
C5	10	—	62	70	35

The data also show that results for fecal coliforms and *E. coli* have a similar general trend and in all but one sampling period, fecal coliforms are higher than *E. coli*. Studies have shown that *E. coli*, a component of the fecal coliforms group, is the main thermotolerant coliform species present in human and animal fecal samples (94%) (Tallon *et al*., 2005) and at contaminated bathing beaches (80%) (Davis *et al*., 2005). In cases where fecal coliform counts were greater than *E. coli*, we can assume a high likelihood of contributions from non-fecal sources. Thus, the value added benefit of measuring both groups is limited (Rieberger, 2010).

Given the uncertainty in linking thermotolerant (i.e. fecal) coliforms to human sources of sewage, it is recommended that *E. coli* be used as the microbiological indicator for the Cowichan and Koksilah Rivers.

The original objectives separated the lower Cowichan River from the rest of the Cowichan and Koksilah watersheds, based on the premise that water use below the highway bridge in the Cowichan River included only secondary contact recreation. Due to the uncertainty around possible surface water and groundwater interactions, and the fact that the Lower Cowichan River aquifers provide drinking water to the City of Duncan, and parts of the District of North Cowichan (Lapcevic, 2011), it is recommended that this portion of the river also be protected for drinking water use.

Therefore, it is recommended that the original objective for fecal coliforms be removed and that E. **coli** ***remain as the only microbiological objective. The objective for*** **E. coli** ***is that the 90th percentile of a minimum of five weekly samples collected within a 30-day period must not exceed 10 CFU/100 mL. This applies to all Cowichan River and Koksilah River sites.*** In addition to the protection of groundwater, this also provides a level of protection in the Cowichan estuary, which is an important priority area for future shellfish harvesting. While it is clear that this objective will be exceeded in the short term at many sites, it serves as a target for area-based watershed planning to address the sources of bacteriological contamination.

The original objectives included enterococci. This fecal indicator bacteria has a high presence in the environment (Tallon *et al.*, 2005) and as such, ***it is recommended that the original objective for*** **enterococci** ***be removed.***

4.2 DISSOLVED OXYGEN

Dissolved oxygen (DO) was measured at C5 and K5, as part of the federal/provincial trend monitoring program, during the summer and fall from 2002 to 2005, and weekly or bi-weekly from 2006 to 2008.

The DO objective is based on the minimum requirement for eyed or hatched fish eggs (October to May) or alevins and juvenile fish (June to September). As such, the objective was set at a minimum of 11.2 mg/L from October to May, and a minimum of 8.0 mg/L from June to September. At both site C5 and site K5, the DO levels were often lower than the objective in the winter months. At C5, the objective was usually met in the summer months. At K5, however, the DO levels in the summer were often well below the objective (Figures 3-6). This was likely due to low water levels and slow-moving water. Local land use, including stormwater, agricultural runoff and aging septic systems may also play a role by increasing the nutrient load in the river. The resulting plant and algal growth can deplete oxygen levels when it dies and begins to decompose, as well as during periods of low productivity when plants consume oxygen (i.e., at night and during the winter under ice cover).

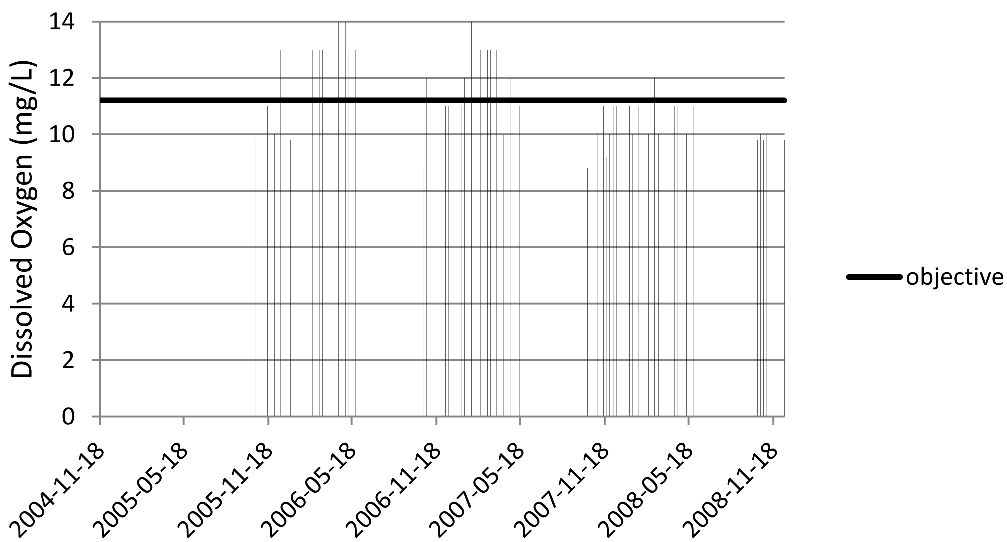

Figure 3. Dissolved oxygen levels during the winter months, 2004-2008, at site C5.

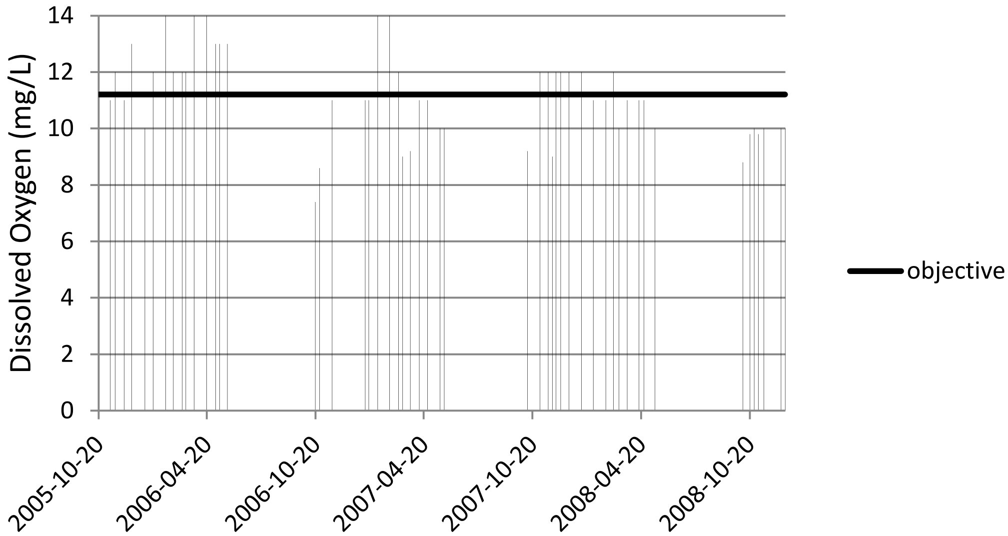

Figure 4. Dissolved oxygen levels during the winter months, 2005-2008, at site K5.

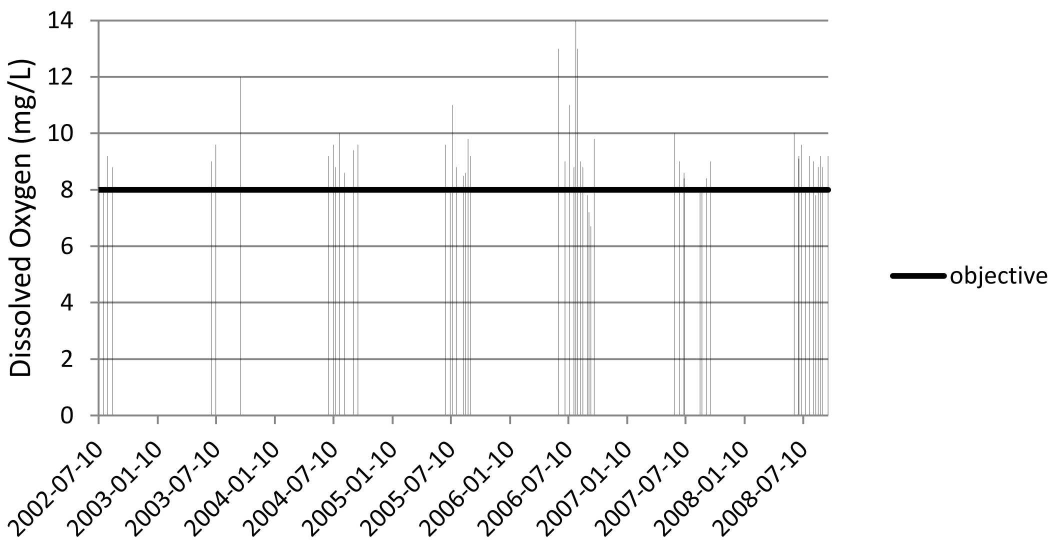

Figure 5. Dissolved oxygen levels during the summer months, 2002-2008, at site C5.

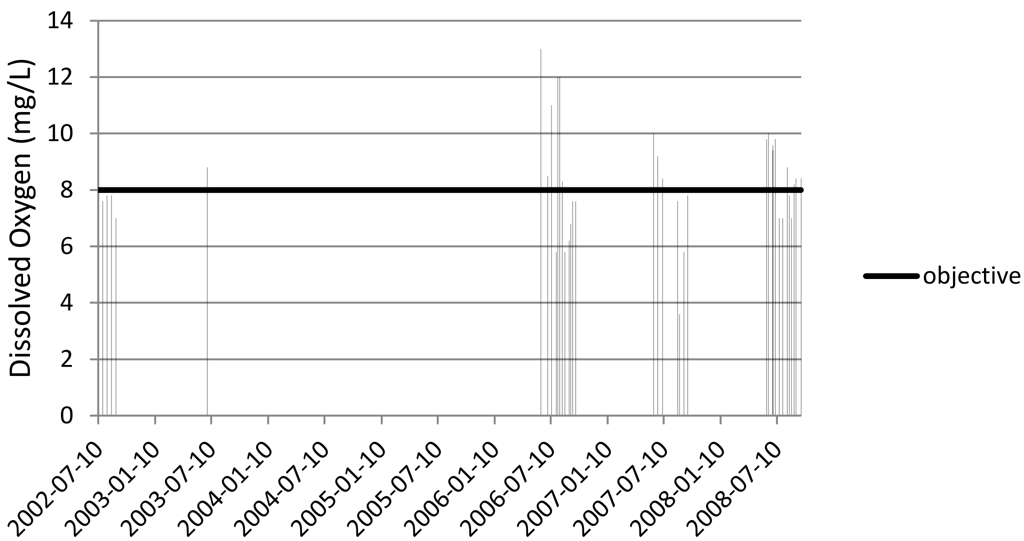

Figure 6. Dissolved oxygen levels during the summer months, 2002-2008, at site K5.

It is recommended that the water quality objective for DO remain unchanged for the Cowichan and Koksilah Rivers: a minimum of 11.2 mg/L from October to May, and a minimum of 8.0 mg/L from June to September.

4.3 NON-FILTERABLE RESIDUE

Total suspended solids (TSS), or non-filterable residue (NFR), include all of the undissolved particulate matter in a sample. This value should be closely correlated with the turbidity value, however, unlike turbidity, it is not measured by optics. Instead, a quantity of the sample is filtered, and the residue is dried and weighed so that a weight of residue per volume is determined. No guideline has been established for drinking water sources at this time. For the protection of aquatic life, the maximum concentration allowed is an induced TSS concentration over background of 25 mg/L at any one time in 24 hours when background is less than or equal to 25 mg/L (clear flows) and an induced TSS concentration of 5 mg/L over background concentrations at any one time for a duration of 30 days (clear flows). Initially, less frequent monitoring may be appropriate to determine the need for more extensive monitoring (Caux *et al*., 1997).

McKean (1989) recommended a TSS objective of 10 mg/L above background. This was based on provincial guidelines at that time, which were changed in 1997. Concentrations of TSS ranged from below detectable limits (<1 mg/L) to 166 mg/L (Table 6). Results were lowest at sites C1, C2, C3 and K1. Sites C4 and C5 had elevated TSS until the Stoltz Bluff remediation project was undertaken in 2006 (see Section 2). After this remediation, results were substantially lower, especially in summer months. In the Cowichan River, most of the elevated results occurred in the fall, suggesting that they were related to rainfall events.

Sites K2, K3, K4 and K5 had TSS results up to 41 mg/L, and elevated results did not show a seasonal pattern. Elevated TSS levels in the Koksilah River may be related to stormwater or agricultural runoff, particularly from tributaries, as mentioned in the objectives report (McKean, 1989). Containment of livestock to ensure cattle are kept out of the river, as well as managing the storage and spreading of manure, and ensuring the gravel operations are following correct protocols, may all be useful in reducing TSS levels.

Table 6. Total suspended solids concentrations (mg/L) for the Cowichan and Koksilah Rivers.

	2002				**2003**				**2008**			
	summer		**fall**		**summer**		**fall**		**summer**		**fall**	
Site	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean
C1	6	3	16	6	3	2	7	3	1	1	3	1
C2	4	2	2	1	2	1	6	3	2	1	2	1
C3	1	1	2	1	2	1	5	2	7	3	1	1
C4	3	2	80	25	9	3	166	60	8	4	12	5
C5	2	2	123	30	51	11	90	39	3	2	22	6
K1	2	1	4	2	8	2	12	3	1	1	2	1
K2	3	2	6	2	1	1	41	10	15	4	4	2
K3	8	3	18	6	36	11	13	5	4	3	3	1
K4	1	1	7	4	10	3	16	7	7	2	6	3
K5	4	2	18	7	7	2	34	13	23	9	11	5

Both the original objectives and the updated provincial guidelines for TSS are based on background concentrations. McKean (1989) reported background concentrations from sites C2 (1.5 mg/L) and K1 (2.5 mg/L). The average for C2 was based on only two data points, and it is unclear how many results were used to calculate the K1 average. As there have been forestry activities in the upper Koksilah River watershed, it is believed that K1 may no longer represent background conditions. Similarly, site C2 may be affected by runoff from human activities. Site C1 most accurately represents background TSS conditions in the watershed, and although it may be affected by activities in Cowichan Lake, it is believed that the lake provides an area for TSS to settle out of the water column before entering the river. As such, all available TSS data for C1 were analyzed to determine background conditions.

In some sampling events in 1993, 1998, 2000 and 2001, the detection limit was 4 or 5 mg/L, rather than 1 mg/L. In these cases, when results were below the detection limit they were discarded as they would have artificially raised the results. The remaining dataset included 70 samples from 1985 to 2008. Results ranged from <1 mg/L to 17 mg/L and the overall average was 2 mg/L. Provincial guidelines are based on five samples in 30 days. In cases where these criteria were met, the average was 3 mg/L. Recently, TSS objectives for some east coast Vancouver Island streams (e.g. Englishman River) have included a seasonal component (Barlak *et al.*, 2010). For the October to December period, the average TSS concentration at C1 was 3 mg/L. For the remainder of the year, it was 2 mg/L. Using these values, BC Water Quality Guidelines for aquatic life in the watershed specify a maximum of 27 mg/L in the summer and 28 mg/L in the fall (25 mg/L over background) at any one time in 24 hours, and a maximum of 7 mg/L in the summer and 8 mg/L in the fall (5 mg/L over background) at any one time for a duration 30 days. As the fall and summer values are so similar, a seasonal objective for the Cowichan and Koksilah Rivers is not required. The slightly lower summer values should be applied year-round as they are more protective.

It is evident that occasional high concentrations of TSS can occur, and for this reason a water quality objective for TSS is still needed. The objective is meant to apply to situations which are not natural but may have been triggered by human activities. It is recommended that the updated BC water quality guidelines be used to establish the objective. Thus, ***it is recommended that TSS measured in the Cowichan and Koksilah Rivers should not exceed 27.0 mg/L at any time and the mean of five weekly samples in 30-days in this period should not exceed 7.0 mg/L.*** Means of five weekly samples in 30 days were chosen (rather than maximum values of 30 samples in a 30 day period, as recommended in the guideline) considering the practicality of, and resources available for, monitoring, as well as local hydrology and the fact that Vancouver Island streams have clear flows for most of the year.

Water quality objectives for Cowichan Lake include objectives for tributaries (Epps & Phippen, 2011). The TSS objectives are a maximum of 26 mg/L and a mean of 6 mg/L. The slightly higher objectives for the Cowichan River reflect the fact that the river is subject to natural runoff inputs throughout its length.

4.4 TURBIDITY

Turbidity is a measure of the clarity or cloudiness of water, and is measured by the amount of light scattered by the particles in the water as nephelometric turbidity units (NTU). Elevated turbidity levels can decrease the efficiency of disinfection, allowing microbiological contaminants to enter the water system. As well, there are aesthetic concerns with cloudy water, and particulate matter can clog water filters and leave a film on plumbing fixtures. The guideline for drinking water that does not receive treatment to remove turbidity is an induced turbidity over background of 1 NTU when background is less than 5 NTU, and a maximum of 5 NTU (during turbid flow periods) (Caux *et al*., 1997).

McKean (1989) recommended a turbidity objective of 5 NTU above background when background is ≤ 50 NTU, and an increase of 10% above background when background is > 50 NTU. As with TSS, this was based on the provincial guidelines at the time, which were changed in 1997.

Turbidity values ranged from 0.1 NTU to 118.0 NTU. Results show that there was elevated turbidity in the lower Cowichan in the fall of 2002 and 2003, and in all Koksilah River sites in the fall of 2003 (Table 7). Results were also elevated at K2, K3 and K4 in the summers of 2003 and 2008. Other sites or sampling periods also occasionally had high values. As with TSS, turbidity appears to have decreased in the lower Cowichan between 2003 and 2008, likely in response to the Stoltz Bluff habitat improvement project. In the Koksilah River, the objective was frequently exceeded. As with TSS, turbidity levels in the lower Koksilah River may be related to stormwater, agriculture or other activities.

Table 7. Turbidity concentrations (NTU) for the Cowichan and Koksilah Rivers.

	2002				**2003**				**2008**			
	summer		**fall**		**summer**		**fall**		**summer**		**fall**	
Site	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean
C1	1.1	0.6	1.2	0.7	1.7	1.0	2.0	1.2	1.0	0.7	0.9	0.6
C2	0.6	0.5	2.0	1.1	1.4	0.9	5.2	2.1	1.0	0.7	1.0	0.6
C3	0.6	0.5	1.1	0.6	0.6	0.6	3.3	1.8	0.8	0.5	0.7	0.6
C4	0.9	0.7	25.9	8.1	0.8	0.6	118.0	41.0	1.1	0.8	2.4	1.2
C5	0.7	0.6	27.2	8.9	1.3	0.9	101.0	34.2	1.3	1.0	9.6	3.6
K1	0.7	0.4	1.8	0.7	0.4	0.3	7.4	2.2	0.5	0.4	1.2	0.7
K2	1.3	0.7	1.4	0.9	3.3	0.9	12.1	3.0	2.5	1.0	4.5	1.8
K3	4.4	1.5	2.7	1.5	3.5	2.1	8.8	3.5	3.1	1.8	3.4	1.9
K4	0.7	0.6	2.3	1.5	9.9	2.5	9.1	3.5	6.9	2.1	5.1	1.6
K5	0.8	0.7	3.1	1.5	1.2	0.8	25.0	6.4	1.9	1.4	5.8	2.1

Both the original objectives and the updated provincial guidelines for turbidity are based on background concentrations. However, background turbidity was not reported in McKean (1989). As with TSS, site C1 most accurately represents background turbidity conditions. All available data for this site were analyzed to determine the background turbidity level. There were 58 samples from 1985 to 2008, ranging from 0.2 NTU to 2.0 NTU. The overall average was 0.7 NTU. Provincial guidelines are based on five samples in 30 days. In cases where these criteria were met, the average turbidity was also 0.7 NTU. Recently, turbidity objectives for some east coast Vancouver Island streams (e.g. Englishman River) have included a seasonal component (Barlak *et al.*, 2010). For the October to December period, the average turbidity at C1 was 0.8 NTU. For the remainder of the year, it was 0.6 NTU.

Background turbidity levels for the Cowichan and Koksilah Rivers have been consistently low. It is apparent that turbidity can be elevated downstream, and as such an objective is still needed. It is recommended that the updated BC water quality guidelines be used. Thus, ***it is recommended that from October to April (when turbid flows can occur) turbidity measured in the Cowichan and Koksilah Rivers should not exceed a maximum of 5 NTU; during the remainder of the year (clear flow periods) turbidity should not exceed a maximum of 2 NTU (1 NTU above ambient levels, as measured at C1 from 1985 to 2008).***

When turbidity results are elevated, it is common to see other parameters follow the same pattern. Turbidity can therefore be used as a surrogate for parameters that are detrimental to human or aquatic health, such as bacteriological parameters and metals. Controlling turbidity will often also control the other parameters of concern.

4.5 NUTRIENTS

While ammonia was the only nutrient parameter with an objective in the Cowichan and Koksilah Rivers, other nitrogen and phosphorus samples were collected and results were compared with existing provincial guidelines.

4.5.1 Ammonia

The ammonia objective was set for total ammonia using the ammonia guideline tables, and temperature and pH data. The provincial guidelines for nitrogen have been updated (Meays, 2009), but the ammonia tables have not changed since they were first published (Nordin and Pommen, 1986). During attainment monitoring, the majority of samples collected were for dissolved ammonia, therefore dissolved ammonia was compared to the total ammonia objective.

The toxicity of ammonia increases with pH and temperature. To reflect the possible worst case scenario, maximum temperature and pH values for the 2002-2008 summer and fall periods were used to determine the appropriate objective level. The maximum temperature reported in the provincial guideline tables is 20°C (Meays, 2009). When receiving environment water temperature is higher than this, the 20°C data are used to determine the guideline due to limited data above this temperature (Meays, 2010).

In the summer sampling periods between 2002 and 2008, maximum temperature and pH in the Cowichan and Koksilah Rivers were 24°C and 8.20 pH units, and in the fall they were 13.0°C and 7.9 pH units. Thus, based on the summer sampling the mean ammonia objective is 0.49 mg/L and the maximum objective is 3.61 mg/L. Based on the fall sampling, the mean and maximum objectives are 1.31 mg/L and 6.83 mg/L, respectively. The summer numbers should be applied May to September and the fall numbers for the remainder of year.

The objective was met at all sites in both summer and fall. Many dissolved ammonia values were below the detection limit of 0.005 mg/L. The highest summer mean value for dissolved ammonia was 0.258 mg/L (C5 in 2008) and the maximum was 0.314 mg/L (C5 on August 18, 2008). The highest fall mean value was 0.120 mg/L (C5 in 2008) and the maximum was 0.197 mg/L (C5 on October 20, 2008). Site C5 is located downstream of the JUB effluent discharge, which may be a contributor to the higher ammonia concentrations observed in the lower watershed.

It is recommended that the water quality objective for ammonia remain unchanged; thus refer to the ammonia tables (Meays, 2009) for determination of the objective. Temperature and pH should be monitored as they are necessary to calculate the objective.

4.5.2 Nitrogen

There are no objectives set for nitrogen. All nitrate plus nitrite values met the provincial drinking water guideline of 10 mg/L (maximum) (Meays, 2009). The highest nitrate plus nitrite value was 1.14 mg/L (at K2 on November 11, 2003), and most other values were below 0.4 mg/L.

The highest mean nitrate plus nitrite value was 0.30 mg/L (at K2 in fall 2003), which is well below the nitrate guideline of 3.0 mg/L (mean) for the protection of aquatic life. Most of the average values were below 0.15 mg/L. Based on the attainment data, nitrogen does not appear to be an issue in the Cowichan or Koksilah Rivers at this time.

4.5.3 Phosphorus

In Vancouver Island streams, phosphorus is the nutrient which limits algal growth or biomass. Chlorophyll *a* is used as a measure of algal biomass and a proxy for phosphorus because no phosphorus guideline currently exists. The BC MOE is working towards a phosphorus objective for Vancouver Island. This proposed guideline takes into consideration the fact that elevated phosphorus is primarily a concern during the summer low flow period when elevated nutrient levels are most likely to lead to deterioration in aquatic life habitat and aesthetic problems. The proposed total phosphorus objective applies from May to September and is an average of 5 µg/L and a maximum of 7 µg/L (BCMOE, *in press*). As this objective is under development, the numbers and the way in which they are applied are subject to change.

Attainment monitoring results show that total phosphorus is elevated at all sites in nearly all sampling periods (Table 9 and 9). Sites C1 and C2 have the lowest values, and C4, C5 and K5 have the highest values.

Table 8. Average phosphorus values (µg/L) for the Cowichan and Koksilah Rivers, 2002, 2003 and 2008, in the summer and fall periods.

	2002		2003		2008	
Site	**summer**	**fall**	**summer**	**fall**	**summer**	**fall**
C1	4	10	3	13	4	4
C2	3	7	2	6	3	4
C3	10	9	12	8	11	6
C4	7	45	4	56	8	8
C5	45	42	17	39	19	38
K1	6	6	3	6	6	5
K2	7	9	9	16	13	9
K3	17	24	23	19	24	11
K4	7	19	10	19	13	10
K5	8	22	10	26	24	16

Table 9. Maximum total phosphorus values (µg/L) for the Cowichan and Koksilah Rivers, 2002, 2003 and 2008, in the summer and fall periods.

	2002		2003		2008	
Site	**summer**	**fall**	**summer**	**fall**	**summer**	**fall**
C1	5	22	8	35	5	6
C2	4	12	2	9	4	5
C3	12	12	18	16	19	10
C4	8	84	7	116	20	16
C5	52	69	25	59	29	44
K1	9	13	6	12	10	6
K2	9	16	20	26	24	13
K3	25	35	28	26	32	15
K4	10	23	18	35	27	14
K5	11	62	12	60	31	26

In the lower Cowichan, at Site C5, the summer phosphorus levels in 2003 and 2008 are lower than in 2002. This is due in part to the start of seasonal alum addition at the Duncan/North Cowichan JUB STP in 2003.

Phosphorus levels in the Cowichan and Koksilah Rivers may be having an impact on overall stream health. Possible sources include the two STP discharges, agricultural activity, and residential properties with aging or improperly maintained septic systems. In order to protect the rivers from the impacts of phosphorus, ***it is recommended that the Vancouver Island***

phosphorus objective be adopted for the Cowichan and Koksilah Rivers, and thus that total phosphorus measured from May to September should not exceed an average of 5 µg/L and a maximum of 7 µg/L. If the Vancouver Island phosphorus objective is changed before it is finalized, the Cowichan and Koksilah objectives should be updated accordingly. As with bacteriological parameters, it is clear that this objective may not be met in the short term at many sites in both rivers. However, it serves as a target for area-based watershed planning to address the sources of phosphorus.

4.6 CHLOROPHYLL *A*

Chlorophyll *a* was measured in several years, both upstream and downstream of the STPs, whereas McKean (1989) recommended sampling downstream only.

A chlorophyll a objective of 5.0 µg/cm^2 was set for locations downstream of both sewage treatment plants (PE-247 and PE-1497). This was met at C3 in the two years that it was sampled (2003 and 2004). There was a measureable increase in chlorophyll *a* concentrations downstream of the Town of Lake Cowichan STP (C3) discharge, compared with upstream (C2), as shown in Figure 7, but the values remained below the objective. The algal biomass was higher in September than in August in both years.

Samples were collected upstream and downstream of the Duncan/North Cowichan JUB STP discharge, and sample locations varied year to year. There was a measureable increase in chlorophyll *a* immediately downstream of the discharge, and then a decrease farther downstream (Figure 8). The objective was exceeded on two occasions, on August 22, 2002 at 200 m downstream of the discharge (30.9 µg/cm^2) and on August 26, 2004 at C5 (6.3 µg/cm^2). There appears to have been a substantial decrease in chlorophyll *a* 200 m downstream of the discharge after 2002. In 2003, the Duncan/North Cowichan JUB STP began adding alum to their effluent seasonally to reduce phosphorus levels; the lower chlorophyll *a* levels after this date suggest that the alum addition is successfully reducing chlorophyll *a* levels in the river.

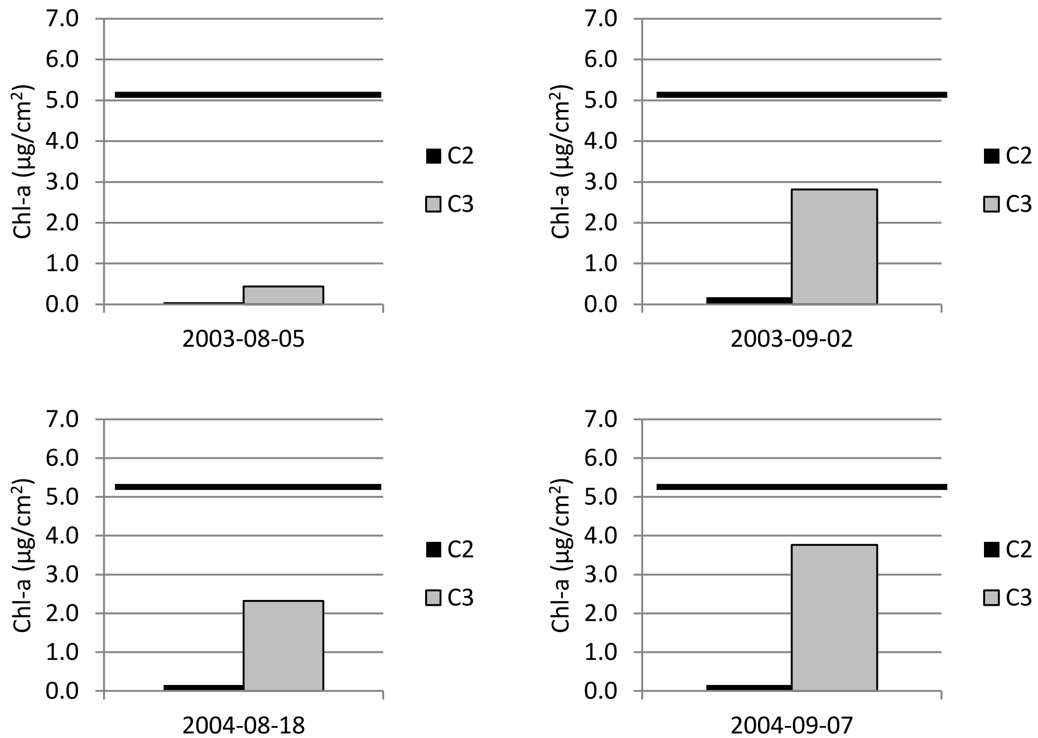

Figure 7. Mean chlorophyll *a* concentrations at C2 and C3 in August and September 2003 and 2004; — indicates objective of 5.0 µg/cm^2.

The Duncan/North Cowichan JUB STP operators conduct a chlorophyll *a* monitoring program in the summer months. Their annual monitoring reports have shown that chlorophyll *a* levels have exceeded the objective of 5.0 µg/cm^2 downstream of the discharge in some sampling events, even after the addition of alum began. However, the overall extent of the algal mats downstream of the discharge has decreased substantially since the alum addition started (Delcan, 2006; 2007). This observation was also noted by MOE biologists who have sampled the river both before and after the 2003 upgrade (Deniseger, 2010).

It is recommended that the chlorophyll* a *objective of 5.0 µg/cm^2 remain unchanged and continue to be applied downstream of both STPs.

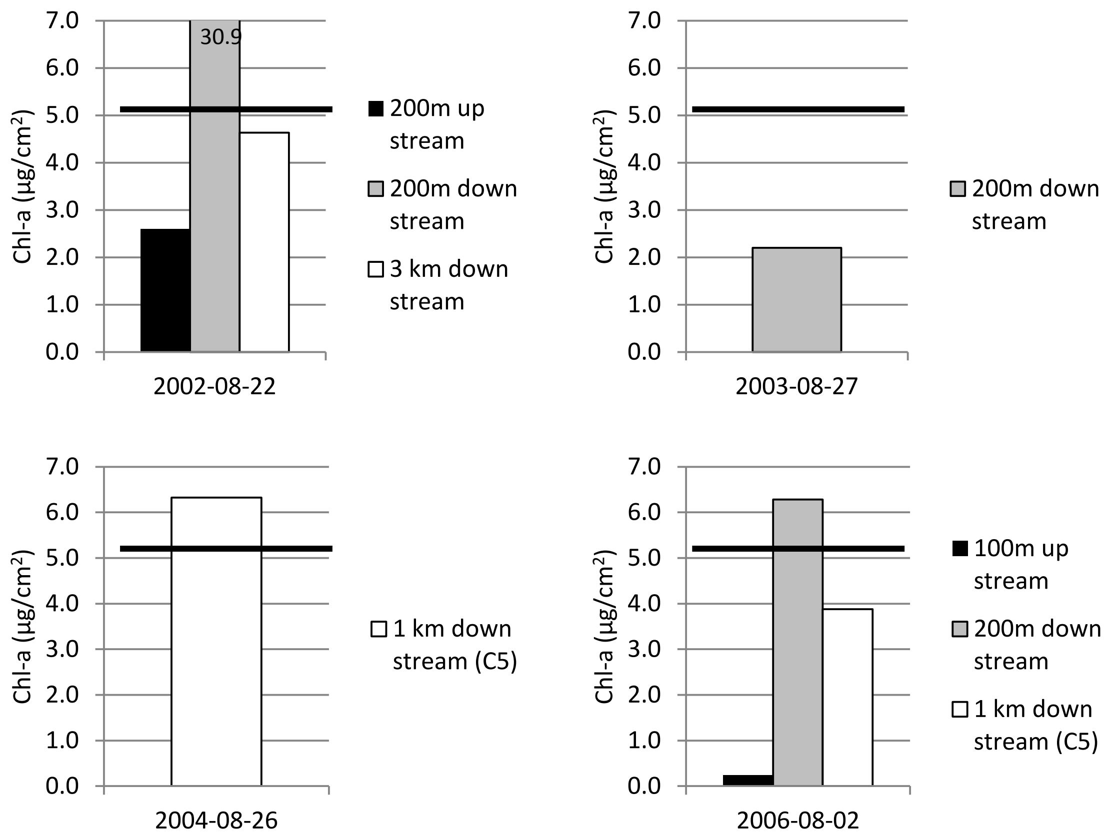

Figure 8. Mean chlorophyll *a* concentrations at sites upstream and downstream of the Duncan/North Cowichan JUB STP discharge in 2002, 2003, 2004 and 2006. Note that the concentration of the 200 m downstream site in 2002 was 30.9 µg/cm^2, but the axis of the graph was scaled down to show the detail at the other sites; ▬ indicates objective of 5.0 µg/cm^2.

4.7 TOTAL RESIDUAL CHLORINE

Total residual chlorine was not measured during attainment monitoring as it is no longer a parameter of concern. Therefore, ***it is recommended that the objective for total residual chlorine be removed.***

4.8 METALS

Objectives were developed for dissolved copper, dissolved lead and dissolved zinc. As stated in the original report, “objectives are set for dissolved rather than total metals to eliminate the effects of increased metal loading associated with increased suspended residue concentrations” (McKean, 1989). The provincial copper, zinc and lead guidelines have changed since the development of the Cowichan and Koksilah water quality objectives in 1989. As such, these parameters were compared to the updated guidelines. As the guideline for many metals depends on water hardness, this parameter was also measured. The lowest hardness observed was 20 mg/L. This lowest observed value was used in calculations for determining guidelines, because it represented the worst case scenario and thus resulted in the most protective guideline value.

The updated provincial copper guidelines are the same numbers as the original objectives (2 µg/L 30-day average and 4 µg/L maximum) but are instead applied to total copper. There was only one exceedance of the average guideline: site C4 in the fall of 2003, at 2.48 µg/L. The maximum guideline was also exceeded in three locations in the fall of 2003, during the same sampling week, at C4 (7.13 µg/L), C5 (4.92 µg/L) and K5 (4.37 µg/L). As the total copper values were much higher than the dissolved copper values in these instances, it is likely that they were related to elevated suspended solids. ***It is recommended that the updated provincial total copper guidelines of 2 µg/L 30-day average and 4 µg/L maximum be adopted as water quality objectives for the Cowichan and Koksilah Rivers***

The updated provincial lead guidelines are 4 µg/L (30-day average) and 11 µg/L (maximum), and are to be applied to total lead. These guidelines are higher than the original objectives. The average guideline was easily met; the only site that came close to this guideline was at C4, and only in the fall of 2004. The maximum guideline was exceeded at this same site, on October 19, 2003, measured at 13.5 µg/L. Similarly to copper, the total lead value was much higher than the dissolved value in this case, and it is likely that it was related to elevated suspended solids. Values were considerably lower in 2003 and 2008, as compared with 2002, a pattern observed at all sites. However, the pattern was not observed with copper, zinc, turbidity or NFR. It is possible that the decrease in dissolved lead coincided with a change in field or lab filtration procedures or the beginning of the use of lead-free filter paper, but this cannot be confirmed and the cause is therefore uncertain. ***It is recommended that the updated provincial total lead guidelines of 4 µg/L 30-day average and 11 µg/L maximum be adopted as water quality objectives for the Cowichan and Koksilah Rivers.***

The updated zinc guidelines are 7.5 µg/L (30-day average) and 33 µg/L (maximum) and are applied to total zinc. These guidelines are lower than the original objectives, but all values remained well below these guidelines. ***It is recommended that the updated provincial total zinc***

guidelines of 7.5 µg/L 30-day average and 33 µg/L maximum be adopted as water quality objectives for the Cowichan and Koksilah Rivers.

In addition to the metals listed above, results for aluminum, iron, cadmium and manganese were compared to the provincial guidelines. Of these, only cadmium had results above the guideline. The guideline was exceeded at several different sites, and eight times in total. However, the method detection limit for cadmium is the same as the guideline, 0.01 µg/L. Precision is influenced by how close the analytical value is to the method detection limit, and quality assurance and quality control calculations are limited to values that are at least five times the method detection limit (BCMELP, 1998). As such, results that are close to the method detection limit must be interpreted with caution. The total cadmium result in one case was very elevated, 0.16 µg/L. The dissolved cadmium was not elevated and thus the high result may have been related to elevated suspended solids, or more likely was an outlier. Based on this information, there does not appear to be a need for objectives for these metals in the Cowichan and Koksilah Rivers.

It is important to note that metal objectives are based on hardness; in future attainment monitoring, the objectives may need to be adjusted to reflect the hardness at that time.

4.9 COPPER-8-QUINOLINOLATE

Copper-8-quinolinolate is a wood preservative that was used at the sawmill in Youbou, on Cowichan Lake (McKean, 1989). Because of the potential for this chemical to enter the lake and thus the Cowichan River, an objective was proposed. However, the sawmill closed in January 2001, and this parameter is no longer believed to be a concern and was not measured during attainment monitoring. ***It is recommended that the objective for copper-8-quinolinolate be removed.***

4.10 TEMPERATURE

Temperature is considered in drinking water for aesthetic reasons. The aesthetic guideline is 15°C and temperatures above this level are considered to be too warm to be aesthetically pleasing (Oliver and Fidler, 2001). For the protection of aquatic life, the allowable change in temperature is +/-1°C from naturally occurring levels. The optimum temperature ranges for salmonids are based on specific life history stages such as incubation, rearing, migration and spawning. For steelhead, which are present in both the Cowichan and Koksilah River systems, the optimum temperature ranges are: 10 – 12°C for incubation; 16 – 18°C for rearing; and 10 – 15.5°C for spawning (Oliver and Fidler, 2001). Each salmon species also has its own optimum temperature range. Chum salmon, which are present as well, are the most sensitive salmonid to warmer temperatures (12-14°C for rearing); however, the juveniles are not present in the river during the summer months. Steelhead and coho, which have similar temperature thresholds, are the species in the watershed for the longest periods of time, including the summer.

No temperature objective was proposed in the original water quality objectives, but water temperature was measured at each site in all sampling periods except fall 2002. The minimum temperature was just over 4.5°C in the fall of 2003 and the maximum temperature was 24.0°C in the summer of 2003 (Figure 9).

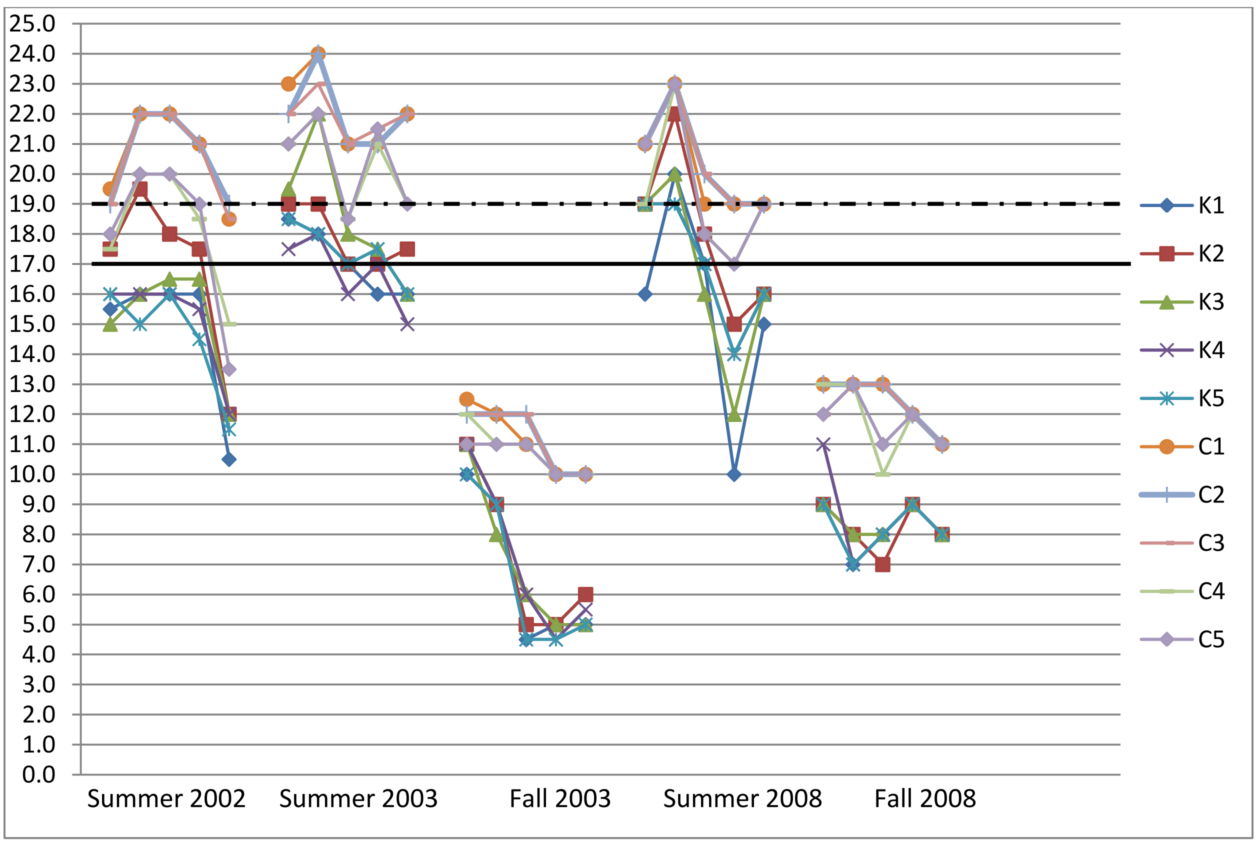

Figure 9. Temperature data for all sites, during 5-in-30 sampling periods; ▬▬ indicates the guideline for coho, Dolly Varden and cutthroat rearing; ‒ · ‒ indicates the guideline for steelhead rearing.

Maximum summer water temperatures exceed the guideline (optimum maximum temperature plus a change of 1°C) for coho (17°C), Dolly Varden (17°C), cutthroat (17°C) and steelhead (19°C) rearing. While adult steelhead typically return to the ocean after spawning, most juveniles spend one to two years in freshwater maturing into smolts before entering the ocean. Some salmon species, including coho, utilize freshwater for up to three years before entering the ocean, and cutthroat and Dolly Varden are resident year-round.

Cowichan River sites, especially C1 and C2, had higher summer maximum temperatures than the Koksilah River sites. This is likely due to their proximity to the outlet of Cowichan Lake. ***Due to the high summer temperatures and the high values of the Cowichan and Koksilah Rivers as fisheries habitat, a water quality objective is proposed to protect trout and juvenile salmonids, in particular coho. The average weekly temperature at any location in the river should not exceed 17°C at any time during the year.*** Ideally, temperature should be monitored continuously for a one-year period during the next attainment monitoring cycle. While maximum temperatures in the Cowichan River are likely to exceed the guideline, as long as refuges remain with average temperatures below the guideline, trout and salmonid juveniles should be able to retreat to these areas during periods of elevated temperatures.

The aesthetic drinking water guideline (a maximum of 15°C) was exceeded, often by a considerable margin, each summer at all sites. Many watersheds on the east coast of Vancouver Island, as well as throughout the Southern Interior, typically have elevated summer water temperatures. It is therefore likely that higher summer temperatures are, for the most part, a natural occurrence. However, it is possible that activities such as forest harvesting, agriculture or urban development, activities that have the potential to decrease stream shading if removal of vegetation occurs in riparian areas, and climate change, could exacerbate peak summer water temperature.

5.0 MONITORING RECOMMENDATIONS

5.1 WATER CHEMISTRY

Attainment monitoring should include all ten water quality monitoring stations. In order to capture the periods where water quality concerns are most likely to occur (i.e. summer low flows and initial fall rains) it is recommended that a minimum of five weekly samples be collected within a 30-day period between August and September, as well as between October and November. Samples collected during the fall months should coincide with rain events whenever possible. In this way, the two critical periods (minimum dilution and maximum turbidity) will be monitored. Samples should be analyzed for general water chemistry (including temperature, pH, hardness, NFR, turbidity), nutrients (ammonia, total phosphorus), total and dissolved metals (low level analysis), and *E. coli*. Field measurements of temperature and dissolved oxygen should be taken.

In addition to these general monitoring recommendations, several parameters should be monitored more specifically.

Chlorophyll *a* should be monitored downstream of both sewage treatment plant discharges (PE-247 and PE-1497) during summer low flows. One site (C3) is likely sufficient downstream of the Town of Lake Cowichan sewage treatment plant discharge, while additional sites may be required downstream of the Duncan/North Cowichan discharge, in addition to C5, to document the full impact of the discharge. Additional actions may be required to further reduce algal biomass if it appears to be a problem in the future in the lower reaches of the river.

With respect to bacteriological parameters, as sites C3 and C4 are quite far apart, sampling at additional locations between C3 and C4 may be required to more accurately map the inputs of bacteriological contamination. In addition, monitoring could be used to confirm that agriculture is the source of the high bacteriology results in the Koksilah River. In both cases, it would be beneficial to work with other relevant agencies, such as municipalities and the regional district, to develop a plan to address the sources of bacteriological contamination.

Similarly to bacteriological parameters, phosphorus inputs into both rivers should be addressed, potentially through area-based planning.

Metal objectives are based on the provincial water quality guidelines, and require a calculation using water hardness; therefore it is important that hardness be measured during future attainment monitoring. Although the objectives are applied to total metals, it is recommended that dissolved metals be measured as well. Increases in total suspended solids can cause elevated total metal concentrations, and the dissolved metal data may be useful in distinguishing between spikes caused by suspended sediments versus an increasing trend in metal concentrations.

Finally, it is recommended that turbidity and NFR be monitored in additional locations in the watershed. Identifying the sources of these parameters from C3 to the mouth of the Cowichan River, as well as throughout the Koksilah River, would identify priority areas for mitigation strategies. As stated above, controlling turbidity can also control other parameters of concern. If stormwater runoff and non-point sources are determined to be the primary sources of turbidity, area-based planning could be used to address these issues.

5.2 BENTHIC INVERTEBRATE MONITORING

Objectives development has traditionally focused on physical, chemical and bacteriological parameters. Biological data has been underutilized due to the highly specialized interpretation required and the difficulty in applying the data quantitatively. Notwithstanding this problem, with few exceptions, the most sensitive use of our water bodies is aquatic life. Therefore biological objectives need to be incorporated into the overall objectives development program.

In streams, benthic invertebrate bio-monitoring has been accepted as a very important assessment tool. Considerable progress has been made in the development of benthic invertebrate indices, which can be incorporated into impact assessments and water quality objectives. On Vancouver Island, regional staff have been collecting data at a broad range of both reference and test sites. Once all the data has been compiled and analyzed, biological objectives and/or indices will be developed for those watersheds where water quality objectives have already been developed.

6.0 SUMMARY OF UPDATED OBJECTIVES AND MONITORING SCHEDULE

In BC, water quality objectives are mainly based on approved or working water quality guidelines, and take into account background conditions, impacts from current land use and any known potential future impacts that may arise within the watershed. These objectives should be periodically reviewed and revised to reflect any future improvements or technological advancements in water quality assessment and analysis. The water quality objectives recommended here (Table 10) include updates to the original objectives (McKean, 1989) as well as the addition of new parameters.

The recommended water quality monitoring program for the Cowichan and Koksilah Rivers is summarized below (Table 11). It is recommended that future attainment monitoring occur every 3-5 years based on staff and funding availability, and whether additional activities which could affect water quality are happening within the watershed.

Table 10. Summary of proposed water quality objectives for Cowichan and Koksilah Rivers.

Variable	Revised Objectives (2011)	
	Site	**Objective**
Escherichia coli	All	≤ 10 CFU/100 mL*
Dissolved Oxygen	All (Oct to May)	≥ 11.2 mg/L
	All (June to Sept)	≥ 8 mg/L
Non-filterable Residue (Total Suspended Solids)	All	≤ 27 mg/L (max) ≤ 7 mg/L (mean)
Turbidity	All (Oct to Apr)	≤ 5 NTU (max)
	All (May to Sept)	≤ 2 NTU (max)
Ammonia	All (Oct to Apr)	≤ 1.31 mg/L (mean) ≤ 6.83 mg/L (max)
	All (May to Sept)	≤ 0.49 mg/L (mean) ≤ 3.61 mg/L (max)
Total Phosphorus	All (May to Sept)	≤ 5 µg/L (mean) ≤ 7 µg/L (max)
Chlorophyll *a*	d/s of PE-247 and PE-1497	≤ 5.0 µg/m^2
Total Copper* **	All	≤ 2 µg/L (mean) ≤ 4 µg/L (max)
Total Lead* **	All	≤ 4 µg/L (mean) ≤ 11 µg/L (max)
Total Zinc* **	All	≤ 7.5 µg/L (mean) ≤ 33 µg/L (max)
Temperature	All	≤ 17 °C (weekly mean)

*90th percentile
**geometric mean
***original objective was set for dissolved metal
note: unless otherwise specified, all calculations are based on five samples in 30 days

Table 11. Proposed schedule for future water quality and benthic invertebrate monitoring in the Cowichan and Koksilah Rivers.

Frequency and Timing	Characteristic to be Measured	Sites
August – September (low-flow season): once per week for five consecutive weeks	Hardness (once during 30 day period), temperature, pH, NFR, turbidity, ammonia, phosphorus, total and dissolved metals, *E. coli*, dissolved oxygen	All
October – November (high-flow season): once per week for five consecutive weeks	Hardness (once during 30 day period), temperature, pH, NFR, turbidity, ammonia, phosphorus, total and dissolved metals, *E. coli*, dissolved oxygen	All
Continuously	Temperature	At high-value rearing locations, and C5
Once during low-flow season	Chlorophyll *a*	Downstream of PE-247, PE-1497
Once every five years	Benthic invertebrate sampling	All sites

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APPENDIX I. WATER QUALITY DATA

Table 12. Temperature Data for the Cowichan and Koksilah Rivers.

	K1	K2	K3	K4	K5	C1	C2	C3	C4	C5
2002-08-07	15.5	17.5	15.0	16.0	16.0	19.5	19.0	19.0	17.5	18.0
2002-08-14	16.0	19.5	16.0	16.0	15.0	22.0	22.0	22.0	20.0	20.0
2002-08-25	16.0	18.0	16.5	16.0	16.0	22.0	22.0	22.0	20.0	20.0
2002-09-02	16.0	17.5	16.5	15.5	14.5	21.0	21.0	21.0	18.5	19.0
2002-09-08	10.5	12.0	12.0	12.0	11.5	18.5	19.0	18.5	15.0	13.5
2003-08-10	18.5	19.0	19.5	17.5	18.5	23.0	22.0	22.0	21.0	21.0
2003-08-17	18.0	19.0	22.0	18.0	18.0	24.0	24.0	23.0	22.0	22.0
2003-08-24	17.0	17.0	18.0	16.0	17.0	21.0	21.0	21.0	18.5	18.5
2003-09-01	16.0	17.0	17.5	17.0	17.5	21.0	21.0	21.5	21.0	21.5
2003-09-07	16.0	17.5	16.0	15.0	16.0	22.0	22.0	22.0	19.0	19.0
2003-10-19	10.0	11.0	11.0	11.0	10.0	12.5	12.0	12.0	12.0	11.0
2003-10-26	9.0	9.0	8.0	9.0	9.0	12.0	12.0	12.0	11.0	11.0
2003-11-02	4.5	5.0	6.0	6.0	4.5	11.0	12.0	12.0	11.0	11.0
2003-11-11	5.0	5.0	5.0	4.5	4.5	10.0	10.0	10.0	10.0	10.0
2003-11-16	5.0	6.0	5.0	5.5	5.0	10.0	10.0	10.0	10.0	10.0
2008-08-10	16.0	19.0	19.0	19.0	19.0	21.0	21.0	21.0	19.0	21.0
2008-08-17	20.0	22.0	20.0	19.0	19.0	23.0	23.0	23.0	23.0	23.0
2008-08-23	17.0	18.0	16.0	17.0	17.0	19.0	20.0	20.0	18.0	18.0
2008-08-31	10.0	15.0	12.0	14.0	14.0	19.0	19.0	19.0	17.0	17.0
2008-09-07	15.0	16.0	16.0	16.0	16.0	19.0	19.0	19.0	19.0	19.0
2008-10-14	9.0	9.0	9.0	11.0	9.0	13.0	13.0	12.0	13.0	12.0
2008-10-19	7.0	8.0	8.0	7.0	7.0	13.0	13.0	13.0	13.0	13.0
2008-10-26	8.0	7.0	8.0	8.0	8.0	13.0	13.0	13.0	10.0	11.0
2008-11-02	9.0	9.0	9.0	9.0	9.0	12.0	12.0	12.0	12.0	12.0
2008-11-11	8.0	8.0	8.0	8.0	8.0	11.0	11.0	11.0	11.0	11.0

Table 13. Chlorophyll *a* Data for the Cowichan River, 2003-2008.

Date	Site	Mean Chl-a (µg/cm^2), n=3
2002-08-22	200m up stream	2.6
2002-08-22	200m down stream	30.9
2002-08-27	3 km down stream	4.6
2003-08-05	C2	0.1
2003-08-05	C3	0.4
2003-08-27	200m down stream	2.2*
2003-09-02	C2	0.2
2003-09-02	C3	2.8
2004-08-10	C2	0.8
2004-08-18	C2	0.2
2004-08-18	C3	2.3
2004-08-26	1 km down stream (C5)	6.3
2004-09-07	C2	0.2
2004-09-07	C3	3.8
2006-08-02	100m up stream	0.2
2006-08-02	200m down stream	6.3
2006-08-02	1 km down stream (C5)	3.9
2006-08-22	down stream	1.4
2007-08-15	50m up stream	0.2

*n=2

Table 14. Dissolved Oxygen Data for Site K5, 2002-2008.

Site	Date	Dissolved Oxygen (mg/L)
K5	2002-07-10	4.9
K5	2002-07-24	7.6
K5	2002-08-07	7.8
K5	2002-08-21	7.8
K5	2002-08-21	7.8
K5	2002-08-21	7.8
K5	2002-09-05	7.0
K5	2003-06-26	8.8
K5	2005-10-20	8.4
K5	2005-11-08	11.0
K5	2005-11-16	12.0
K5	2005-12-01	11.0
K5	2005-12-14	13.0
K5	2006-01-05	10.0
K5	2006-01-19	12.0
K5	2006-02-09	14.0
K5	2006-02-09	14.0
K5	2006-02-09	14.0
K5	2006-02-22	12.0
K5	2006-03-09	12.0
K5	2006-03-15	12.0
K5	2006-03-29	14.0
K5	2006-04-19	14.0
K5	2006-05-04	13.0
K5	2006-05-11	13.0
K5	2006-05-24	13.0
K5	2006-06-08	13.0
K5	2006-06-08	13.0
K5	2006-06-29	8.5
K5	2006-07-12	11.0
K5	2006-07-27	5.8
K5	2006-08-02	12.0
K5	2006-08-08	12.0
K5	2006-08-16	8.3
K5	2006-08-24	5.8
K5	2006-09-07	6.2
K5	2006-09-12	6.8
K5	2006-09-18	7.6
K5	2006-09-28	7.6
K5	2006-10-19	7.4
K5	2006-10-26	8.6
K5	2006-11-16	11.0
K5	2006-11-16	11.0
K5	2006-11-16	11.0
K5	2007-01-11	11.0
K5	2007-01-17	11.0
K5	2007-02-01	14.0
K5	2007-02-21	14.0
K5	2007-02-21	14.0
K5	2007-02-21	14.0
K5	2007-03-08	12.0
K5	2007-03-15	9.0
K5	2007-03-28	9.2
K5	2007-04-12	11.0
K5	2007-04-26	11.0
K5	2007-05-17	10.0
K5	2007-05-24	10.0
K5	2007-06-06	10.0
K5	2007-06-20	9.2
K5	2007-07-05	8.4
K5	2007-07-05	8.4
K5	2007-08-23	7.6
K5	2007-08-29	3.6
K5	2007-09-13	5.8
K5	2007-09-25	7.8
K5	2007-10-11	9.2
K5	2007-11-01	12.0
K5	2007-11-01	12.0
K5	2007-11-15	12.0
K5	2007-11-22	9.0
K5	2007-11-28	12.0
K5	2007-12-06	12.0
K5	2007-12-20	12.0
K5	2008-01-10	12.0
K5	2008-01-30	11.0
K5	2008-02-20	11.0
K5	2008-03-04	12.0
K5	2008-03-13	10.0
K5	2008-03-27	11.0
K5	2008-04-16	11.0
K5	2008-04-24	11.0
K5	2008-05-13	10.0
K5	2008-06-05	9.8
K5	2008-06-11	10.0
K5	2008-06-26	9.6
K5	2008-06-26	9.4
K5	2008-07-03	9.8
K5	2008-07-17	7.0
K5	2008-07-28	7.0
K5	2008-08-11	8.8
K5	2008-08-18	7.8
K5	2008-08-25	7.0
K5	2008-09-02	8.2
K5	2008-09-08	8.4
K5	2008-09-25	8.4
K5	2008-10-08	8.8
K5	2008-10-20	9.8
K5	2008-10-27	10.0
K5	2008-11-03	9.8
K5	2008-11-12	10.0
K5	2008-11-12	10.0
K5	2008-12-11	10.0
K5	2008-12-18	10.0

Table 15. Dissolved Oxygen Data for Site C5, 2002-2008

Site	Date	Dissolved Oxygen (mg/L)
C5	2002-07-10	7.3
C5	2002-07-24	8.0
C5	2002-08-07	9.2
C5	2002-08-21	8.8
C5	2002-08-21	8.8
C5	2002-08-21	8.8
C5	2003-06-26	9.0
C5	2003-07-09	9.6
C5	2003-09-25	12.0
C5	2004-06-22	9.2
C5	2004-06-22	9.2
C5	2004-06-22	9.2
C5	2004-07-08	9.6
C5	2004-07-15	8.8
C5	2004-07-28	10.0
C5	2004-08-12	8.6
C5	2004-09-09	9.4
C5	2004-09-23	9.6
C5	2004-11-18	4.0
C5	2005-06-23	9.6
C5	2005-07-07	8.0
C5	2005-07-14	11.0
C5	2005-07-28	8.8
C5	2005-07-28	8.8
C5	2005-07-28	8.8
C5	2005-08-17	8.5
C5	2005-08-24	8.6
C5	2005-09-01	9.8
C5	2005-09-08	9.2
C5	2005-10-20	9.8
C5	2005-11-08	9.6
C5	2005-11-16	11.0
C5	2005-12-01	10.0
C5	2005-12-14	13.0
C5	2006-01-05	9.8
C5	2006-01-19	12.0
C5	2006-02-09	12.0
C5	2006-02-09	12.0
C5	2006-02-09	12.0
C5	2006-02-22	13.0
C5	2006-03-09	13.0
C5	2006-03-15	13.0
C5	2006-03-29	13.0
C5	2006-04-19	14.0
C5	2006-05-04	14.0
C5	2006-05-11	13.0
C5	2006-05-25	13.0
C5	2006-06-08	13.0
C5	2006-06-08	13.0
C5	2006-06-29	9.0
C5	2006-07-12	11.0
C5	2006-07-27	8.8
C5	2006-08-02	14.0
C5	2006-08-08	13.0
C5	2006-08-16	9.0
C5	2006-08-24	8.8
C5	2006-09-07	7.8
C5	2006-09-12	7.2
C5	2006-09-18	6.7
C5	2006-09-28	9.8
C5	2006-10-19	8.8
C5	2006-10-26	12.0
C5	2006-11-16	10.0
C5	2006-11-16	10.0
C5	2006-11-16	10.0
C5	2006-12-07	11.0
C5	2006-12-14	11.0
C5	2007-01-11	11.0
C5	2007-01-17	12.0
C5	2007-02-01	14.0
C5	2007-02-21	13.0
C5	2007-02-21	13.0
C5	2007-02-21	13.0
C5	2007-03-08	13.0
C5	2007-03-15	13.0
C5	2007-03-28	13.0
C5	2007-04-12	10.0
C5	2007-04-26	12.0
C5	2007-05-17	11.0
C5	2007-05-24	10.0
C5	2007-06-06	10.0
C5	2007-06-20	9.0
C5	2007-07-05	8.6
C5	2007-07-05	8.4
C5	2007-08-23	8.0
C5	2007-08-29	8.0
C5	2007-09-13	8.4
C5	2007-09-25	9.0
C5	2007-10-11	8.8
C5	2007-11-01	10.0
C5	2007-11-01	10.0
C5	2007-11-15	11.0
C5	2007-11-22	9.2
C5	2007-11-28	10.0
C5	2007-12-06	11.0
C5	2007-12-13	11.0
C5	2007-12-20	11.0
C5	2008-01-10	11.0
C5	2008-01-17	10.0
C5	2008-01-30	11.0
C5	2008-02-20	10.0
C5	2008-03-04	12.0
C5	2008-03-13	10.0
C5	2008-03-27	13.0
C5	2008-04-16	11.0
C5	2008-04-24	11.0
C5	2008-05-13	10.0
C5	2008-05-27	11.0
C5	2008-06-11	10.0
C5	2008-06-26	9.1
C5	2008-06-26	9.2
C5	2008-07-03	9.6
C5	2008-07-17	8.0
C5	2008-07-28	9.2
C5	2008-08-11	9.0
C5	2008-08-18	7.8
C5	2008-08-25	8.8
C5	2008-09-02	9.2
C5	2008-09-08	8.8
C5	2008-09-25	9.2
C5	2008-10-08	9.0
C5	2008-10-14	9.8
C5	2008-10-20	10.0
C5	2008-10-27	9.8
C5	2008-11-03	10.0
C5	2008-11-12	9.6
C5	2008-11-12	9.4
C5	2008-11-25	10.0
C5	2008-12-11	9.8

Table 16. Additional fecal coliform data collected as per the Federal Provincial agreement.

Site	Date	Coli:Fec (CFU/100mL)	Summary Statistics				
K5	2003-08-14	59	n	min	max	mean	90th
K5	2003-08-21	131	**5**	**48**	**145**	**86**	**139**
K5	2003-08-28	145					
K5	2003-09-04	48					
K5	2003-09-11	48					
K5	2003-10-27	9	n	min	max	mean	90th
K5	2003-11-03	12	**5**	**4**	**20**	**12**	**17**
K5	2003-11-12	13					
K5	2003-11-20	20					
K5	2003-11-27	4					
K5	2004-10-26	20	n	min	max	mean	90th
K5	2004-11-03	37	**5**	**2**	**205**	**56**	**138**
K5	2004-11-09	2					
K5	2004-11-18	14					
K5	2004-11-25	205					
K5	2006-07-27	64	n	min	max	mean	90th
K5	2006-08-02	24	**5**	**14**	**64**	**30**	**49**
K5	2006-08-08	27					
K5	2006-08-16	19					
K5	2006-08-24	14					
K5	2007-11-15	53	n	min	max	mean	90th
K5	2007-11-22	<1	**6**	**1**	**280**	**71**	**184**
K5	2007-11-28	3					
K5	2007-12-06	280					
K5	2007-12-13	<1					
K5	2007-12-20	87					
C5	2003-08-14	6	n	min	max	geo mean	90th
C5	2003-08-21	<1	**5**	**1**	**12**	**3**	**10**
C5	2003-08-28	<1					
C5	2003-09-04	7					
C5	2003-09-11	12					
C5	2004-10-26	55	n	min	max	geo mean	90th
C5	2004-11-03	36	**5**	**19**	**66**	**39**	**62**
C5	2004-11-09	19					
C5	2004-11-18	36					
C5	2004-11-25	66					
C5	2006-07-27	7	n	min	max	geo mean	90th
C5	2006-08-02	3	**5**	**3**	**91**	**17**	**70**
C5	2006-08-08	21					
C5	2006-08-16	91					
C5	2006-08-24	39					
C5	2007-11-15	34	n	min	max	geo mean	90th
C5	2007-11-22	35	**6**	**9**	**35**	**23**	**35**
C5	2007-11-28	26					
C5	2007-12-06	28					
C5	2007-12-13	18					
C5	2007-12-20	9					

Table 17. Raw Data for Site C1, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C-1	2002-08-07	2.6	21.2	<5		1	0.28	0.54	1			<2		0.07	1	4	0.23	2.18	<2	<1	49	0.54	7.6	0.9	0.5
C-1	2002-08-14	4.6	18	7		230	0.12	0.14	130			2		0.1	<1	5	0.16	0.18	2	3	53	0.5	7.7	1.3	0.3
C-1	2002-08-25	13	21.1	<5		4	0.45	0.59	4			3		0.06	<1	2	0.27	0.15	<2	5	69	1.13	7.7	1.4	1
C-1	2002-09-02	4.9	8.4	<5		14	0.76	0.34	5			3		0.08	1	5	0.13	0.1	3	6	52	0.46	7.7	0.7	<0.1
C-1	2002-09-08	4.4	15.5	<5		<1	0.38	0.86	<1			<2		0.16	<1	3	0.16	0.17	5	<1	52	0.49	7.7	0.9	0.9
C-1	2002-10-27	3.4	7	<5		6	0.56	0.5	4			<2		0.08	<1	8	0.11	0.06	3	<1	51	0.63	7.4	8.1	0.2
C-1	2002-11-03	0.9	3.9	<5		3	0.7	0.5	<1			<2		0.06	2	5	0.09	<0.01	3	1	50	0.56	7.3	<0.1	<0.1
C-1	2002-11-11	5.6	8.4	<5		44	0.58	0.24	31			37		0.18	<1	22	0.21	0.07	5	16	51	0.51	7.4	1.2	0.2
C-1	2002-11-17	4.8	19.3		<5	8	0.31	0.44	5			24	<0.1	0.1	1	5	0.14	0.13	3	1	47	1.2	7.5	0.2	0.8
C-1	2002-11-24	6.5	62.2		<5	12	0.09	0.26	8			59	<0.1	0.13	1	9	0.09	0.12	7	10	48	0.54	7.3	0.4	0.6
C-1	2003-08-10	2.6	26.6	<5		11	0.29	0.77	11			<2		0.08	1	2	<0.01	0.07	<2	1	51	0.8	7.7	0.2	0.6
C-1	2003-08-17	4.3	58	<5		610	0.31	0.64	670			2		0.06	3	<2	<0.01	0.04	<2	2	49	1.08	7.7	0.2	0.5
C-1	2003-08-24	2.7	12.2	<5		6	0.28	0.4	3			2		0.07	1	8	<0.01	<0.01	2	1	49	0.62	7.6	0.2	0.2
C-1	2003-09-01	3.8	32.2	<5		5	0.36	0.73	3			<2		0.06	2	3	<0.01	0.06	<2	3	53	1.7	7.7	0.4	1.4
C-1	2003-09-07	4.2	13.4	<5		19	0.32	0.57	1			3		0.07	2	2	<0.01	0.01	<2	1	51	0.7	7.6	0.4	0.7
C-1	2003-10-19	68.8	112	<5			0.9	1				280		0.5	2	16	0.06	0.12	7	3	32	1.71	6.9	3.4	3.6
C-1	2003-10-26	16.1	65.2	<5		353	0.88	1	299			24		0.2	13	35	0.03	0.12	17	2	46	2	7.3	3.3	4.4
C-1	2003-11-02	9.4	32.9	<5		1	0.38	1.19	2			24		0.09	2	6	0.01	0.02	7	1	48	0.76	7.3	0.2	0.3
C-1	2003-11-11	6.2	17	7		3	0.84	0.41	1			32		0.12	6	3	0.03	0.05	2	2	49	0.67	7.5	1	1.2
C-1	2003-11-16	8.3	19.3	<5		9	0.38	1.03	5			38		0.12	<1	7	<0.01	0.02	<2	7	48	0.95	7.5	<0.1	0.2
C-1	2008-08-10	4.1		<5	0	4	0.28	0.37	3	21.3	0.07	<2	0.07	0.07		4	0.005			<1		1	7.4	0.3	
C-1	2008-08-17	9.4		<5	0	4	0.96		1	21.7	0.15	4	0.15	0.16		3	0.043			1		0.6	7.6	2.1	
C-1	2008-08-24	6.2		19	20	42	0.68		31	21.6	0.11	7	0.09	0.12		3	0.015			<1		0.8	7.8	0.4	
C-1	2008-09-01	3.4		<5	0	4	0.37		2	20.7	0.03	3	0.03	0.04		5	0.02			1		0.6	7.4	0.2	
C-1	2008-09-07	3.3		<5	0	8	0.57		6	21.1	0.07	8	0.07	0.08		3	0.007			<1		0.5	7.8	1	
C-1	2008-10-13	3.3		<5		1	0.44		1	21.2	0.05	<2	0.05	0.05		6	0.011			1		0.7	7.6	0.3	
C-1	2008-10-19	6.2		<5	0	5	0.41		3	21.2	0.08	<2	0.08	0.08		5	0.007			<1		0.6	7.7	0.2	
C-1	2008-10-26	3.2		<5		<1	0.6		<1	21.1	<0.02	3	<0.02	0.02		4	<0.005			<1		0.4	7.7	0.4	
C-1	2008-11-02	2.7		<5	0	5	0.52		4	21.3	0.04	3	0.04	0.04		3	0.007			3		0.9	7.6	0.4	
C-1	2008-11-11		14.5	<5	0			1.66			0.06	11	0.06	0.07		4		0.019		1		0.5	7.5		1

Table 18. Raw Data for Site C2, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C-2	2002-08-07	8.3	12.1	<5		12	0.25	0.23	11			<2		0.06	2	<2	0.17	0.18	4	<1	49	0.43	7.6	1.6	<0.1
C-2	2002-08-14	4.2	10.7	<5		18	0.2	0.06	13			4		0.04	<1	4	0.13	0.11	2	1	53	0.48	7.7	0.5	<0.1
C-2	2002-08-25	6	10.9	<5		38	0.28	0.25	40			3		0.06	10	2	0.14	0.1	<2	1	66	0.63	7.7	0.8	0.2
C-2	2002-09-02	4.8	11.3	<5		23	0.35	0.24	18			3		0.05	1	4	0.16	0.15	3	4	52	0.4	7.6	0.6	0.2
C-2	2002-09-08	3.9	40.2	<5		21	0.31	0.3	19			<2		0.07	<1	3	0.12	0.09	3	<1	53	0.45	7.6	0.5	0.3
C-2	2002-10-27	2.9	6.9	<5		14	0.61	0.41	8			<2		0.12	2	12	0.1	0.09	4	2	52	1.04	7.4	0.8	0.2
C-2	2002-11-03	3.7	3.8	<5		2	1.13	0.37	2			3		0.06	1	3	0.12	<0.01	4	<1	50	0.36	7.3	<0.1	<0.1
C-2	2002-11-11	5.3	14.6	<5		27	0.36	0.34	11			27		0.1	<1	6	0.13	0.13	3	2	51	0.51	7.4	0.6	0.3
C-2	2002-11-17	5.2	22.5		<5	8	0.55	0.25	3			7	<0.1	0.09	2	5	0.16	0.13	6	1	47	1.41	7.5	0.4	0.2
C-2	2002-11-24	76.4	23.8		<5	2	0.05	0.05	2			24	<0.1	0.1	<1	10	0.08	0.08	5	1	49	1.97	7.4	0.2	<0.1
C-2	2003-08-10	2.8	15.1	<5		77	0.25	0.47	45			<2		0.07	1	2	<0.01	0.04	<2	1	51	1.12	7.7	0.1	0.4
C-2	2003-08-17	5.5	64.1	<5		2	0.3	0.64	2			6		0.06	1	2	<0.01	0.09	<2	1	48	1.39	7.7	0.4	1.1
C-2	2003-08-24	2.8	14.6	<5		70	0.23	0.35	68			<2		0.04	1	<2	<0.01	<0.01	3	<1	49	0.54	7.6	0.1	0.2
C-2	2003-09-01	4	25.7	<5		45	0.37	0.76	9			3		<0.02	2	<2	0.01	0.06	<2	2	52	0.81	7.7	0.3	0.6
C-2	2003-09-07	4.9	18.5	<5		85	0.28	0.45	23			3		0.06	2	2	<0.01	0.03	<2	1	51	0.69	7.6	0.2	0.3
C-2	2003-10-19	13.2	37.9	<5			0.43	0.46				31		0.1	2	9	0.02	0.03	3	6	47	5.18	7.4	<0.1	<0.1
C-2	2003-10-26	8.6	37.6	<5		20	0.48	0.64	5			27		0.1	2	4	0.01	0.03	2	3	48	2.11	7.5	0.5	0.8
C-2	2003-11-02	9.4	37.7	<5		4	0.34	0.43	3			28		0.08	2	7	<0.01	0.03	5	2	48	1.14	7.3	0.3	0.6
C-2	2003-11-11	6.1	16.1	6		10	0.27	0.56	3			31		0.1	3	4	<0.01	0.02	<2	<1	49	1.04	7.5	0.2	0.4
C-2	2003-11-16	9.2	29.9	<5		42	0.35	0.4	18			37		0.1	<1	4	<0.01	0.03	<2	<1	49	1.02	7.4	0.4	0.4
C-2	2008-08-10	3.4		<5	0	22	0.3		7	21.8	0.16	<2	0.16	0.16		4	<0.005			<1		1	7.4	0.2	
C-2	2008-08-17	10		8	10	5	3.32		4	21.7	0.14	29	0.13	0.17		4	0.026			2		0.8	7.8	1.7	
C-2	2008-08-24	7.9		6	10	140	0.59		80	22.2	0.07	6	0.06	0.07		2	0.015			1		0.9	7.7	0.5	
C-2	2008-09-01	66		<5		7	0.56		6	21.1	<0.02	<2	<0.02	<0.02		3	0.007			<1		0.5	7.3	0.1	
C-2	2008-09-07	3.7		<5	0	10	0.28		8	20.5	0.03	16	0.03	0.05		2	0.006			<1		0.4	7.8	<0.1	
C-2	2008-10-14	3.4		<5		5	0.32		4	21.6	<0.02	32	<0.02	0.05		4	0.005			<1		0.6	7.6	0.2	
C-2	2008-10-19	2.2		<5	0	3	0.54		2	21.2	0.02	4	0.02	0.03		5	<0.005			1		0.5	7.7	0.1	
C-2	2008-10-26	4.9		<5	0	2	0.26		1	21.1	0.03	<2	0.03	0.03		4	<0.005			<1		0.5	7.7	<0.1	
C-2	2008-11-02	3.1		<5	0	8	0.49		5	21.4	0.03	4	0.03	0.03		4	0.006			<1		1	7.6	0.3	
C-2	2008-11-11		10.8	<5	0	9		0.52	6		0.03	9	0.03	0.03		4		0.008		2		0.6	7.5		0.4

Table 19. Raw Data for Site C3, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C-3	2002-08-07	3.8	11.8	<5		23	0.17	0.16	16			<2		0.07	<1	8	0.15	0.16	3	<1	49	0.39	7.7	1	<0.1
C-3	2002-08-14	4.3	17.4	<5		7	0.05	0.09	3			8		0.06	<1	8	0.13	0.14	2	<1	54	0.58	7.7	0.9	<0.1
C-3	2002-08-25	8.6	10	<5		28	0.18	0.16	28			4		0.08	<1	9	0.15	0.11	2	<1	66	0.55	7.7	0.6	<0.1
C-3	2002-09-02	5.2	12.5	<5		20	0.28	0.31	14			<2		0.09	2	12	0.18	0.17	4	<1	53	0.55	7.6	0.3	<0.1
C-3	2002-09-08	14	8.5	<5		20	0.37	0.25	13			<2		0.1	<1	12	0.14	0.08	6	<1	53	0.46	7.6	0.6	<0.1
C-3	2002-10-27	3.5	7.7	<5		10	0.42	0.4	6			30		0.1	<1	8	0.09	0.08	<2	<1	52	0.45	7.3	0.4	<0.1
C-3	2002-11-03	1.7	4.1	<5		6	1.01	0.44	<1			33		0.13	1	11	0.06	<0.01	4	<1	51	0.4	7.2	<0.1	<0.1
C-3	2002-11-11	5.7	10.6	10		36	0.45	0.38	21			47		0.13	<1	12	0.13	0.09	4	2	53	0.42	7.5	0.8	0.3
C-3	2002-11-17	5.9	21.5		<5	86	0.5	0.37	49			23	<0.1	0.09	2	7	0.23	0.17	8	<1	47	1.08	7.5	0.6	0.9
C-3	2002-11-24	13.4	19.6		5	5	0.05	0.05	3			35	<0.1	0.1	<1	7	0.08	0.07	6	<1	49	0.51	7.3	0.8	<0.1
C-3	2003-08-10	3	13.4	<5		160	0.23	0.38	22			15		0.07	2	10	<0.01	0.02	4	2	52	0.4	7.7	<0.1	0.1
C-3	2003-08-17	4.4	23.1	<5		10	0.27	0.5	4			12		0.09	3	11	<0.01	0.02	5	1	49	0.61	7.7	0.3	0.9
C-3	2003-08-24	3.9	13.9	<5		200	0.26	0.37	15			15		0.07	2	10	<0.01	0.01	4	<1	50	0.61	7.7	0.2	0.2
C-3	2003-09-01	10.7	17.6	<5		12	0.3	0.46	7			26		0.03	6	9	<0.01	0.03	3	1	54	0.54	7.7	0.2	0.7
C-3	2003-09-07	5.8	18.6	<5		71	0.55	2.39	10			60		0.13	13	18	<0.01	0.1	13	1	52	0.59	7.6	0.6	2.2
C-3	2003-10-19	13.3	42.9	<5			0.49	0.46				32		0.1	3	9	0.02	0.05	4	2	46	2.22	7.4	<0.1	<0.1
C-3	2003-10-26	9.3	39.6	<5		43	0.35	0.47	25		0.08	29	<0.1	0.11	1	7	<0.01	0.02	2	5	49	1.83	7.5	0.3	0.5
C-3	2003-11-02	9.9	135	<5		179	0.42	1.07	116			28		0.14	2	16	0.01	0.22	17	2	49	3.25	7.3	0.3	1.2
C-3	2003-11-11	6.6	16.7	8		97	0.28	0.3	3			33		0.12	<1	5	<0.01	0.02	<2	<1	47	0.67	7.5	0.3	0.4
C-3	2003-11-16	9.4	27.4	<5		24	0.6	0.67	15			37		0.11	8	5	0.02	0.04	8	<1	49	0.82	7.4	0.4	0.5
C-3	2008-08-10	3.9		45	50	49	0.44		10	21.8	0.17	10	0.12	0.18		11	0.01			2		0.8	7.4	1.3	
C-3	2008-08-17	10		9	10	22	0.47		17	22	0.08	8	0.07	0.09		14	0.018			1		0.8	7.6	0.7	
C-3	2008-08-24	7.6		43	<30	77	0.52		29	22.4	0.05	15	<0.02	0.06		19	0.019			7		0.1	7.7	0.6	
C-3	2008-09-01	4.3		11	10	66	0.64		44	21.3	0.04	4	0.03	0.05		5	0.007			4		0.4	7.2	0.3	
C-3	2008-09-07	4.2		<5	0	10	0.47		6	21.2	0.03	12	0.03	0.05		7	0.019			1		0.4	7.8	0.3	
C-3	2008-10-13	3.1		7		7	0.54		5	21.6	0.06	2	0.05	0.06		6	0.008			1		0.7	7.6	0.4	
C-3	2008-10-19	2.4		12	20	7	1.86		2	20.3	0.05	3	0.03	0.05		10	0.04			1		0.5	7.8	2	
C-3	2008-10-26	5.5		<5	0	6	0.31		6	21.6	0.03	3	0.03	0.03		5	0.005			1		0.7	7.7	0.3	
C-3	2008-11-02	3.4		9	10	10	0.53		8	21.9	0.05	5	0.04	0.05		6	0.007			1		0.7	7.7	0.4	
C-3	2008-11-11		12.5	<5	0	10		0.59	10		0.04	17	0.04	0.06		4		0.012		<1		0.5	7.5		0.5

Table 20. Raw Data for Site C4, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C-4	2002-08-07	3.7	20.2	<5		4	0.2	0.25	4			2		0.05	1	7	0.18	0.13	4	1	57	0.47	7.7	0.6	<0.1
C-4	2002-08-14	5.3	28.5	<5		21	0.08	0.23	8			2		0.05	1	6	0.11	0.14	3	2	61	0.88	7.8	0.9	<0.1
C-4	2002-08-25	12.4	9.5	<5		4	0.21	0.53	3			3		0.06	<1	6	0.08	0.17	<2	1	73	0.58	7.7	0.1	1
C-4	2002-09-02	5.2	11.7	<5		5	0.32	0.38	4			3		0.09	2	8	0.11	0.14	2	3	59	0.88	7.7	0.3	<0.1
C-4	2002-09-08	4.2	15.7	11		4	0.68	0.43	2			<2		0.06	1	7	0.11	0.14	5	1	60	0.54	7.7	0.5	0.1
C-4	2002-10-28	4	8.9	<5		6	0.41	0.4	<1			<2		0.07	<1	4	0.09	0.03	<2	<1	58	0.44	7.4	<0.1	<0.1
C-4	2002-11-04	3.1	10.9	95		11	1.37	1	2			341		2	64	84	0.08	0.05	70	2	65	0.98	7.3	<0.1	<0.1
C-4	2002-11-11	11.4	66.3	113		110	0.59	0.85	47			88		0.4	6	38	0.14	0.19	13	16	64	1.81	7.5	0.5	0.3
C-4	2002-11-18	22.4	392		14	170	0.55	3.23	68			64	0.18	0.26	2	59	0.16	2	8	80	52	25.9	7.6	0.5	2
C-4	2002-11-25	17.9	253		14	4	0.05	1.21	<1			46	<0.1	0.16	<1	39	0.09	0.2	7	24	51	11.3	7.4	<0.1	0.7
C-4	2003-08-10	3.1	18	<5		160	0.24	0.46	15			3		0.05	1	4	<0.01	0.03	2	9	59	0.75	7.8	<0.1	0.2
C-4	2003-08-17	4.2	29.2	<5		6	0.29	0.49	2			4		0.08	2	7	<0.01	0.11	2	1	57	0.7	7.8	0.1	0.2
C-4	2003-08-24	3	14.1	<5		22	0.28	0.39	13			<2		0.05	1	6	<0.01	0.01	2	<1	58	0.5	7.8	0.2	0.2
C-4	2003-09-01	3.6	34.9	<5		104	0.32	0.66	73			<2		0.05	2	<2	0.01	0.1	5	1	58	0.69	7.7	0.1	0.5
C-4	2003-09-07	4.1	16.8	<5		6	0.3	0.48	5			<2		0.06	2	2	<0.01	0.03	<2	1	62	0.45	7.8	0.2	0.2
C-4	2003-10-19	85	899	<5			1.57	7.13				73		0.23	4	116	0.17	13.5	7	166	47	118	7.4	<0.1	5.1
C-4	2003-10-26	31.3	207	<5		171	0.57	1.5	18			29		0.12	2	91	0.02	0.17	<2	83	50	51.2	7.5	0.2	1
C-4	2003-11-02	22.1	414	9		29	0.51	2.18	6			33		0.13	<1	24	<0.01	0.55	29	21	50	14	7.4	<0.1	2
C-4	2003-11-11	11.9	103	22		27	0.42	0.64	7			41		0.14	2	21	0.02	0.06	4	13	53	7.84	7.6	0.2	0.5
C-4	2003-11-16	18.3	265	12		79	0.55	0.97	29			45		0.17	<1	28	<0.01	0.06	<2	19	53	14.2	7.5	<0.1	0.5
C-4	2008-08-10	2.5		<5	0	22	0.37		14	25.4	0.07	7	0.07	0.08		7	0.006			2		0.6	7.4	1.4	
C-4	2008-08-17	6.9		<5	0	57	0.41		57	26	0.12	4	0.12	0.12		6	0.01			3		0.9	7.7	0.3	
C-4	2008-08-24	5.5		<5	0	120	0.44		100	25.1	0.05	7	0.05	0.06		20	0.018			4		0.6	7.8	0.9	
C-4	2008-09-01	5.3		<5	0	11	0.36		7	23.4	0.02	4	0.02	0.03		5	0.01			4		1.1	7.2	0.2	
C-4	2008-09-07	4.5		<5	0	24	0.56		13	22.6	0.03	8	0.03	0.04		4	0.036			8		0.9	7.8	0.2	
C-4	2008-10-13	4		<5		27	0.55		23	22.6	0.04	<2	0.04	0.04		7	0.008			2		1.4	7.6	0.3	
C-4	2008-10-20	3.8		<5	0	7	0.59		4	23.1	0.09	<2	0.09	0.09		6	0.009			3		0.7	7.6	0.5	
C-4	2008-10-26	4.5		<5	0	7	0.41		7	23.8	0.03	5	0.03	0.04		7	0.008			2		0.4	7.7	0.2	
C-4	2008-11-02	5.1		13	20	43	0.53		35	22.9	0.04	16	0.02	0.05		6	0.009			5		0.9	7.7	0.6	
C-4	2008-11-11		36.5	22	20	40		0.48	40		0.11	24	0.09	0.14		16		0.017		12		2.4	7.5		0.4

Table 21. Raw Data for Site C5, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C-5	2002-08-07	4.5	15.1	<5		17	0.35	0.47	8			90		0.23	<1	49	0.16	0.16	24	2	61	0.6	7.7	0.7	<0.1
C-5	2002-08-14	7.1	18.1	<5		34	0.36	0.83	18			125		0.22	25	43	0.14	0.13	24	2	65	0.73	7.8	0.8	0.2
C-5	2002-08-26	7.1	19.9	<5		11	0.44	0.51	11			116		0.23	26	44	0.15	0.13	31	2	76	0.68	7.6	0.8	0.3
C-5	2002-09-02	3.5	2.8	<5		9	0.4	0.48	5			132		0.25	33	52	<0.01	0.04	39	1	64	0.51	7.7	0.5	1.2
C-5	2002-09-08	4.4	9.2	8		18	0.53	0.4	18			279		0.58	19	38	0.1	0.1	27	<1	72	0.44	7.7	1.1	0.6
C-5	2002-10-28	5.3	14.5	<5		44	0.72	0.64	26			174		0.48	33	44	0.13	0.12	34	<1	62	0.43	7.4	0.7	<0.1
C-5	2002-11-04	2.2	8.7		<5	15	0.62	0.46	9			7	<0.1	0.08	2	7	0.08	<0.01	3	<1	57	0.44	7.3	<0.1	<0.1
C-5	2002-11-11	40.4	84.9	12		140	1.29	1.8	79			222		0.59	11	51	0.2	0.18	30	4	66	2.57	7.4	1.4	3.5
C-5	2002-11-18	13.1	172		19	170	0.44	1.47	46			78	0.21	0.3	3	69	0.14	0.34	7	123	52	27.2	7.6	0.9	0.7
C-5	2002-11-25	13	107		14	6	0.08	0.96	<1			59	0.12	0.19	<1	40	0.09	0.16	5	22	52	14.1	7.4	0.2	0.7
C-5	2003-08-11	4.4	23.6	31		190	0.3	0.5	26			100		0.19	12	20	<0.01	0.02	14	51	62	1.03	7.8	<0.1	0.2
C-5	2003-08-18	17.4	39.1	20		50	0.53	0.63	7			246		0.39	13	25	<0.01	<0.01	20	1	64	0.76	7.7	0.1	0.3
C-5	2003-08-25	8.2	29	18		85	0.42	0.61	31			205		0.31	5	14	<0.01	<0.01	8	1	63	0.94	7.7	0.3	0.4
C-5	2003-09-02	11.6	26.1	<5		43	0.51	0.67	7			204		0.31	6	9	0.01	0.03	5	1	65	1.34	7.7	0.2	0.4
C-5	2003-09-08	12.1	24.8	<5		33	0.61	1.46	<1			212		0.35	13	18	<0.01	0.05	12	1	69	0.63	7.7	0.4	1.2
C-5	2003-10-20	80	837	<5			1.15	4.92				69		0.2	3	39	0.05	0.5	9	90	49	101	7.4	<0.1	2.8
C-5	2003-10-27	28.1	224	<5		40	0.63	1.48	15			34		0.14	2	59	0.02	0.13	6	57	51	42.8	7.5	0.2	1.2
C-5	2003-11-03	21.5	301	9		28	0.5	0.91	10			38		0.21	3	31	0.01	0.05	15	23	52	14.9	7.3	0.2	0.7
C-5	2003-11-12	10.2	76.6	78		28	0.44	0.6	22			53		0.24	11	28	0.02	0.06	14	8	56	5.93	7.5	0.3	1.1
C-5	2003-11-17	15.3	129	73		48	0.53	0.73	33			56		0.28	10	36	<0.01	0.04	10	15	57	6.45	7.5	<0.1	0.4
C-5	2008-08-11			244		25				26.5		87			10	21			17	1	70	0.6	7.7		
C-5	2008-08-18			314		18				26.7		97			17	29			24	1	71	0.8	7.6		
C-5	2008-08-25			292		310				27.3		93			13	25			19	2	71	1.2	7.6		
C-5	2008-09-02			245		30				24.8		56			4	18			5	2	65	0.9	7.6		
C-5	2008-09-08			196		28				23.4		27			4	1.6			7	3	60	1.3	7.4		
C-5	2008-10-14	5.1		139	<130	10	0.54		11	23.7	0.15	17	<0.02	0.16	17	42	0.061		30	3	60	1.1	7.7	0.1	
C-5	2008-10-20	8.8		197	<140	11	0.46		11	24.3	0.16	15	<0.02	0.17	19	33	0.017		30	2	58	1.3	7.6	0.2	
C-5	2008-10-27		3.7	106	100	66		0.38	66		0.19	17	0.09	0.21	18	30		<0.005	23	3	56	0.8	7.6		0.1
C-5	2008-11-03	8.6		94	<60	72	0.41		52	22.9	0.08	136	<0.02	0.21	15	41	0.013		25	2	58	5.2	7.7	0.3	
C-5	2008-11-12		88.6	65	50	130		0.73	130		0.1	49.5	0.05	0.175	9	44		0.0465	9	22	51	9.6	7.45		0.55

Table 22. Raw Data for Site K1, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K-1	2002-08-07	6.6	11.6	<5		285	0.12	0.38	221			6		0.11	<1	8	0.19	0.17	2	2	136	0.45	8	0.5	0.5
K-1	2002-08-14	8.4	7.6	<5		16	0.84	0.1	7			17		0.06	7	4	0.15	0.11	3	<1	149	0.27	8	0.7	<0.1
K-1	2002-08-25	3.4	14.9	28		9	0.45	0.43	9			163		0.29	5	9	0.15	0.15	7	<1	183	0.66	8.1	0.8	0.6
K-1	2002-09-02	2.7	2.4	<5		6	0.34	0.22	4			5		0.08	2	5	<0.01	<0.01	3	1	155	0.24	8.1	0.3	<0.1
K-1	2002-09-08	7.2	7.4	<5		29	0.79	0.19	18			5		0.07	3	5	0.19	0.07	4	<1	155	0.2	7.8	1.6	0.1
K-1	2002-10-27	3	3.3	<5		4	0.47	0.36	1			<2		0.05	3	3	0.09	0.02	4	<1	164	0.18	7.9	0.3	<0.1
K-1	2002-11-03	2	2		<5	1	0.5	0.4	<1			3	<0.1	0.04	3	3	0.05	<0.01	4	<1	165	0.14	7.7	<0.1	<0.1
K-1	2002-11-11	33.3	53.6	<5		43	0.93	0.88	12			375		0.57	2	13	0.14	0.14	9	4	89	1.17	7.5	0.5	0.5
K-1	2002-11-17	42.1	73.7		<5	6	0.7	0.76	2			42	0.16	0.2	2	7	0.17	0.14	5	2	52	1.77	7.4	0.4	0.1
K-1	2002-11-24	21.5	26.9		6	<1	0.14	0.12	<1			37	<0.1	0.13	<1	5	0.1	0.08	4	3	65	0.28	7.4	<0.1	<0.1
K-1	2003-08-10	3.4	6.9	<5		6	0.45	0.6	7			7		0.06	1	2	0.01	0.04	<2	<1	164	0.27	8.1	0.4	0.5
K-1	2003-08-17	3.5	7.3	14		16	0.3	0.45	2			7		0.06	3	2	<0.01	0.01	<2	<1	157	0.25	8.1	0.5	0.5
K-1	2003-08-24	3	5.4	<5		65	0.27	0.31	9			<2		0.1	1	4	<0.01	<0.01	<2	8	156	0.27	8.1	0.1	0.2
K-1	2003-09-01	2	5.3	14		5	0.25	0.32	3			9		0.08	1	<2	<0.01	0.01	<2	<1	173	0.28	8.1	0.1	0.2
K-1	2003-09-07	3.9	12.1	<5		9	0.39	0.56	<1			8		0.1	2	6	0.01	0.03	2	<1	161	0.37	8.1	0.4	1
K-1	2003-10-19	61.7	176	<5			0.88	0.97				30		0.15	2	12	0.02	0.07	9	12	47	7.35	7.4	<0.1	0.4
K-1	2003-10-26	23.2	32.3	<5		58	0.52	0.54	16			17		0.11	1	5	0.02	0.02	4	<1	67	0.45	7.6	0.3	0.3
K-1	2003-11-02	16	25.6	<5		12	0.5	0.6	5			11		0.07	2	6	0.02	0.05	6	<1	83	0.24	7.6	0.3	0.4
K-1	2003-11-11	12.9	17.1	13		1	0.33	0.36	1			6		0.13	<1	<2	0.03	0.04	<2	<1	93	0.17	7.8	0.5	0.6
K-1	2003-11-16	27.4	194	<5		32	0.61	0.84	15			<2		0.09	6	7	0.03	0.09	<2	2	88	2.93	7.7	<0.1	0.6
K-1	2008-08-10	8.9		<5	0	14	0.39		8	62.5	0.07	6	0.07	0.08		6	<0.005			<1		0.4	7.8	0.3	
K-1	2008-08-17	10.2		<5	0	14	0.95		9	69.3	0.04	12	0.04	0.05		8	0.028			<1		0.3	8.1	1.1	
K-1	2008-08-24	9.2		<5	0	240	0.54		220	64.4	0.05	14	0.05	0.07		10	0.023			<1		0.5	8.1	0.6	
K-1	2008-09-01	5.6		14	10	28	0.38		24	46.2	0.04	7	0.03	0.05		3	<0.005			<1		0.5	7.8	0.4	
K-1	2008-09-07	6.3		<5	0	12	0.37		7	62.5	0.03	14	0.03	0.04		3	<0.005			<1		0.4	8.1	0.1	
K-1	2008-10-13	9		<5		4	0.74		4	48.2	0.08	14	0.08	0.09		4	0.023			<1		0.5	7.9	0.3	
K-1	2008-10-19	16.9		<5	0	4	0.62		4	39.8	0.09	38	0.09	0.13		6	0.015			<1		0.3	7.8	0.2	
K-1	2008-10-26	9.1		<5	0	<1	0.43		<1	45.7	0.03	7	0.03	0.04		5	0.006			<1		0.2	7.9	0.2	
K-1	2008-11-02	21.5		<5		17	0.67		17	41	<0.02	27	<0.02	0.04		5	0.029			2		1.1	7.8	0.4	
K-1	2008-11-11		62.8	6	10	4		0.68	4		0.07	27	0.06	0.1		5		0.018		2		1.2	7.5		0.5

Table 23. Raw Data for Site K2, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K-2	2002-08-07	7.2	8.2	<5		23	0.36	0.4	18			<2		0.15	2	6	0.21	0.25	<2	3	159	1.26	8.1	0.9	<0.1
K-2	2002-08-14	6.6	10.6	<5		34	0.33	0.24	19			33		0.11	7	9	0.14	0.1	4	<1	165	0.51	8.1	2.2	<0.1
K-2	2002-08-25	5.4	10.4		<5	630	0.39	0.38	630			13	0.11	0.12	1	7	0.11	0.12	2	3	192	0.7	8.1	0.6	0.2
K-2	2002-09-02	8.6	26.5	<5		30	0.52	0.52	24			10		0.13	3	7	0.15	0.13	4	1	178	0.61	8.1	0.9	0.6
K-2	2002-09-08	7.7	13.9	<5		130	0.67	0.61	86			<2		0.11	3	6	0.13	0.13	4	<1	170	0.57	8.1	1.2	0.4
K-2	2002-10-27	2.9	3.3	<5		<1	0.53	0.77	<1			<2		0.38	3	6	0.09	0.05	2	1	180	1.04	7.9	0.4	0.2
K-2	2002-11-03	1.1	1.3		<5	3	0.84	0.63	<1			<2	0.13	0.13	3	8	0.06	0.02	3	6	187	0.31	7.8	<0.1	<0.1
K-2	2002-11-11	22.2	38.4	<5		32	1.05	0.66	13			74		0.22	2	16	0.17	0.08	5	1	115	1.43	7.6	1	0.2
K-2	2002-11-17	43.4	67.5		<5	3	0.81	0.74	1			72	0.17	0.24	3	8	0.15	0.14	8	2	56	1.44	7.5	0.4	<0.1
K-2	2002-11-24	19.9	26		6	2	0.19	0.15	<1			55	<0.1	0.15	<1	6	0.08	0.06	5	1	69	0.4	7.4	<0.1	<0.1
K-2	2003-08-10	0.7	9.7	<5		18	0.36	0.51	5			12		0.08	2	4	<0.01	<0.01	2	<1	185	0.34	8.1	0.1	0.2
K-2	2003-08-17	2.5	7.3	<5		68	0.39	0.47	17			11		0.12	3	8	<0.01	<0.01	3	1	183	0.35	8	0.4	0.4
K-2	2003-08-24	0.8	32.7	<5		74	0.37	0.59	41			6		0.09	1	20	<0.01	0.02	2	<1	183	3.32	8.2	0.2	0.7
K-2	2003-09-01	2.4	7.8	<5		69	0.5	0.56	23			11		0.1	4	3	0.01	0.05	3	1	200	0.36	8.1	0.5	0.6
K-2	2003-09-07	2.3	9.8	<5		43	0.8	1.71	24			27		0.13	3	10	<0.01	0.05	3	<1	193	0.33	8.1	0.3	1.8
K-2	2003-10-19	82.4	359	<5			1.74	3.2				28		0.53	3	26	0.06	0.37	8	41	67	12.1	7.4	0.2	2.1
K-2	2003-10-26	28.1	50	<5		32	0.89	3.2	26			100		0.34	3	18	0.02	0.04	12	2	83	0.99	7.6	0.8	1
K-2	2003-11-02	17.4	39.9	<5		7	0.66	1.07	4			101		0.23	2	14	0.01	0.04	8	3	98	0.38	7.6	0.4	0.6
K-2	2003-11-11	11.4	19	9		16	0.78	0.82	<1			1140		1.44	<1	8	0.03	0.04	6	<1	127	0.35	7.7	0.5	0.7
K-2	2003-11-16	24.9	77.6	<5		80	0.67	0.84	54			123		0.3	<1	12	0.03	0.06	6	<1	116	1.37	7.7	2.5	3.3
K-2	2008-08-10	7.4		9		73	0.53	0.82	64	69.7	<0.02	50	<0.02	0.06		10	0.005			<1		1.1	7.7	0.3	
K-2	2008-08-17	10.5		<5	0	340	0.62		190	72.6	0.06	36	0.06	0.09		11	0.011			1		0.5	7.9	0.8	
K-2	2008-08-24	7.9		13	10	1700	1.62		1700	67.2	0.15	29	0.14	0.18		24	0.018			15		2.5	7.9	0.8	
K-2	2008-09-01	6.3		5	10	38	0.63		38	63.1	0.05	13	0.04	0.06		9	0.023			<1		0.5	7.8	0.4	
K-2	2008-09-07	7.4		5	0	20	0.65		14	67.9	0.09	30	0.09	0.12		11	0.022			<1		0.5	8.1	0.3	
K-2	2008-10-13	7.9		<5		34	1.19		13	52.7	0.05	24	0.05	0.07		8	0.012			3		0.6	7.8	0.7	
K-2	2008-10-19	13.1		<5	0	310	0.98		300	46.3	0.09	5	0.09	0.1		8	0.016			<1		1.1	7.8	0.4	
K-2	2008-10-26	10.4		<5	0	2	0.89		<1	49	0.03	15	0.03	0.05		7	0.011			<1		1.1	7.9	0.3	
K-2	2008-11-02	10.4		20	30	8	1.51		6	51.6	0.08	5	0.05	0.08		9	0.03			4		4.5	7.8	0.8	
K-2	2008-11-11		57.4	8	10	33		1.76	27		0.11	85	0.1	0.19		13		0.036		1		1.5	7.6		1.5

Table 24. Raw Data for Site K3, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K-3	2002-08-07	6.5	16	<5		39	0.52	0.52	30			77		0.22	4	13	0.15	0.13	9	<1	153	0.54	7.7	0.8	<0.1
K-3	2002-08-14	4.1	7.3	<5		65	0.38	0.42	41			63		0.17	15	14	0.1	0.09	6	<1	154	0.61	8.1	1.2	<0.1
K-3	2002-08-25	7.8	95		<5	2	0.59	0.82	2			5	0.15	0.16	2	25	0.16	0.2	4	8	176	4.35	7.4	1.3	0.5
K-3	2002-09-02	6.5	22.7	5		13	0.53	0.61	9			<2		0.16	6	19	0.13	0.13	8	2	160	1.29	7.9	1.6	0.6
K-3	2002-09-08	6	13.1	<5		40	0.65	0.55	18			47		0.19	8	14	0.13	0.12	7	1	155	0.81	7.9	0.7	0.6
K-3	2002-10-27	4.5	6.5	<5		5	0.72	0.54	3			73		0.2	6	11	0.1	0.09	7	<1	180	0.43	7.4	1.1	<0.1
K-3	2002-11-03	3.6	5		<5	1	0.68	0.67	<1			36	0.1	0.14	6	11	0.05	0.05	10	<1	186	0.46	7.3	<0.1	<0.1
K-3	2002-11-11	15.5	51.2	<5		8	0.81	0.94	6			189		0.47	9	35	0.13	0.17	15	18	186	2.74	7.6	0.9	0.8
K-3	2002-11-17	35.7	60.4		24	10	0.8	1.12	5			452	0.27	0.75	11	33	0.21	0.15	32	8	86	2.54	7.4	0.3	0.8
K-3	2002-11-24	23.5	36		85	16	0.35	0.4	8			301	0.22	0.61	14	29	0.19	0.07	22	2	87	1.17	7.3	<0.1	1
K-3	2003-08-10	3.7	19.5	30		130	0.42	0.58	100			43		0.31	4	26	0.03	0.03	8	2	155	2.03	7.6	0.5	0.7
K-3	2003-08-17	9.2	19.6	<5		1800	0.48	0.61	23			62		0.23	5	17	<0.01	<0.01	7	12	153	1.43	7.7	0.2	0.4
K-3	2003-08-24	3.6	17.2	18		63	0.57	0.81	40			60		0.21	5	20	<0.01	0.03	9	36	147	1.7	7.6	0.5	0.9
K-3	2003-09-01	3.4	16.3	<5		70	0.47	0.67	19			31		0.2	4	23	0.01	0.04	4	2	160	3.48	7.7	0.4	1.8
K-3	2003-09-07	3.7	14.3	38		880	0.45	0.69	730			122		0.32	4	28	<0.01	0.03	4	1	176	1.8	7.7	0.3	0.7
K-3	2003-10-19	86.8	165	<5			1.62	1.86				379		0.69	8	26	0.03	0.07	15	5	54	3.83	7.2	0.7	1.4
K-3	2003-10-26	35.1	48.5	8		70	1.95	2.27	17			197		0.42	3	20	0.1	0.19	13	13	69	8.82	7.3	1.6	2.5
K-3	2003-11-02	22.8	26.1	<5		3	1.05	1.09	4			147		0.35	5	17	0.01	0.02	11	<1	88	0.48	7.3	0.2	0.3
K-3	2003-11-11	18.3	28.9	<5		25	0.66	0.74	7			141		0.31	4	14	0.04	0.04	6	<1	100	0.47	7.6	0.3	0.3
K-3	2003-11-16	33.8	71.1	<5		250	0.95	1.08	250			<2		0.32	2	19	0.03	0.05	6	7	100	3.87	7.5	0.4	0.6
K-3	2008-08-10		1.5	14	10	72		0.41	57		0.26	3	0.25	0.26		32		<0.005		4		3.1	7.5		<0.1
K-3	2008-08-17	8.8		25	20	14	0.64		12	66.8	0.23	20	0.21	0.25		31	0.006			3		2.1	7.6	0.3	
K-3	2008-08-24	10.5		5	0	820	1.23		580	63.4	0.1	261	0.1	0.36		29	0.083			4		2.2	7.8	0.6	
K-3	2008-09-01	7.4		<5	0	110	0.63		110	56.6	0.06	163	0.06	0.22		13	0.033			<1		0.7	7.5	0.3	
K-3	2008-09-07	7.5		21	20	58	0.63		30	61.1	0.06	181	0.04	0.24		15	0.02			<1		0.8	7.9	0.5	
K-3	2008-10-13	6.3		<5		77	0.61		73	61.2	0.07	69	0.07	0.14		10	0.017			1		1	7.9	0.2	
K-3	2008-10-19	7.5		60	60	35	0.65		33	53.7	0.1	118	0.04	0.21		13	<0.005			<1		0.6	7.7	0.1	
K-3	2008-10-26	6.4		<5	0	11	0.48		10	61.8	0.05	87	0.05	0.13		9	<0.005			<1		2.6	7.8	<0.1	
K-3	2008-11-02	7.7		<5	0	15	0.68		15	60.4	0.08	29	0.08	0.11		10	0.009			1		3.4	7.6	0.4	
K-3	2008-11-11		81.8	<5	0	31		1.02	28		0.17	214	0.17	0.39		15		0.038		3		1.9	7.4		0.4

Table 25. Raw Data for Site K4, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K-4	2002-08-07	14.8	14.1	<5		31	0.64	0.31	21			64		0.18	<1	3	0.16	<0.01	3	<1	154	0.57	8	0.1	<0.1
K-4	2002-08-14	3	15.6	<5		27	0.21	0.5	16			128		0.18	6	8	0.12	0.12	4	<1	155	0.62	8.1	0.5	0.5
K-4	2002-08-26	3.7	9.1		<5	22	0.42	0.35	22			143	<0.1	0.22	8	6	0.14	0.11	2	<1	181	0.61	7.9	1.5	0.2
K-4	2002-09-02	7	10.4	<5		49	0.7	0.54	36			158		0.28	4	10	0.15	0.06	6	<1	157	0.7	7.8	1.5	0.2
K-4	2002-09-08	5.9	11.5	<5		44	0.58	0.47	24			108		0.24	5	8	0.13	0.1	5	<1	162	0.65	8	0.9	0.5
K-4	2002-10-27	2.3	7.7	<5		5	0.49	0.67	4			91		0.19	3	8	0.08	0.02	4	2	184	1.49	7.6	0.6	<0.1
K-4	2002-11-03	1.2	6.7		<5	1	0.8	0.7	<1			88	<0.1	0.17	4	6	0.1	0.1	4	<1	181	0.3	7.2	<0.1	<0.1
K-4	2002-11-11	18.6	59.2	<5		7	0.86	1.22	<1			43		0.2	4	15	0.16	0.2	8	6	126	1.67	7.6	0.6	1.3
K-4	2002-11-17	44.5	66.2		<5	7	0.67	0.86	4			121	0.19	0.31	3	11	0.13	0.16	7	3	58	1.52	7.4	0.3	<0.1
K-4	2002-11-24	18.5	34.2		5	10	0.23	0.27	10			91	0.13	0.22	<1	23	0.1	0.09	7	7	75	2.3	7.4	0.6	0.1
K-4	2003-08-10	2	12.9	11		30	0.53	0.65	41			125		0.17	1	5	0.04	0.03	<2	1	160	0.49	7.8	0.5	0.6
K-4	2003-08-17	2.5	20.2	<5		24	0.5	0.96	13			130		0.23	4	13	<0.01	0.03	8	1	170	0.65	7.8	0.5	1
K-4	2003-08-24	3.8	191	<5		290	0.54	1.56	220			340		0.41	2	18	<0.01	0.17	5	10	171	9.9	7.7	0.4	1.4
K-4	2003-09-01	2.1	13.9	<5		27	0.51	0.64	17			213		0.19	3	4	0.01	0.03	<2	3	176	0.64	7.8	0.2	0.4
K-4	2003-09-07	2.4	13.9	8		97	0.41	0.69	57			211		0.33	2	11	<0.01	0.03	2	1	171	0.87	7.7	0.7	1.6
K-4	2003-10-19	78.7	181	<5			1.41	1.71				389		0.71	8	35	0.03	0.07	14	16	60	9.05	7.2	0.3	1.2
K-4	2003-10-26	34.6	54.4	<5		59	1.08	1.18	20			152		0.39	3	17	0.02	0.04	9	3	80	1.67	7.5	1	1.5
K-4	2003-11-02	19.4	31	<5		18	0.74	0.84	5			108		0.25	3	13	0.02	0.02	8	1	100	0.51	7.5	0.5	0.8
K-4	2003-11-11	11.8	17.2	<5		15	0.63	0.63	7			121		0.24	4	5	0.02	0.03	4	2	114	0.57	7.7	0.6	0.6
K-4	2003-11-16	25.2	114	<5		650	0.92	1.13	520			149		0.42	<1	24	0.03	0.05	4	12	114	5.89	7.6	0.6	0.8
K-4	2008-08-10	3.6		<5	0	36	0.45		30	67	0.05	204	0.05	0.25		10	<0.005			1		1.4	7.5	0.2	
K-4	2008-08-17	5		<5	0	45	0.91		29	68.4	0.05	146	0.05	0.19		17	0.022			<1		0.6	7.7	0.5	
K-4	2008-08-24	20.6		8	10	330	1.07		300	69.8	0.06	628	0.05	0.69		27	0.015			7		6.9	7.8	0.3	
K-4	2008-09-01	4.1		<5	0	20	0.52		17	62	0.02	94	0.02	0.12		9	<0.005			1		0.7	7.6	0.1	
K-4	2008-09-07	4.8		<5	0	16	0.84		13	64.4	0.08	87	0.08	0.17		4	0.044			<1		0.8	7.9	0.8	
K-4	2008-10-13	7.1		<5		82	0.6		67	55.5	0.08	36	0.08	0.11		9	0.009			6		5.1	7.9	0.3	
K-4	2008-10-19	8.2		<5	0	15	0.58		12	46.7	0.12	16	0.12	0.14		10	0.007			<1		0.5	7.8	0.2	
K-4	2008-10-26	10.9		<5		30	0.49		28	52	<0.02	47	<0.02	0.07		9	<0.005			<1		0.5	7.9	0.1	
K-4	2008-11-02	7.6		<5	0	23	0.69		16	53.5	0.04	15	0.04	0.06		6	0.012			1		0.6	7.8	0.3	
K-4	2008-11-11		64.7	<5	0	27		1.08	22		0.15	140	0.15	0.29		14		0.029		4		1.1	7.5		0.6

Table 26. Raw Data for Site K5, 2002, 2003 and 2008.

SITE	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	Hardness Tot. (D) (mg/L)	N.Kjel:T (mg/L)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K-5	2002-08-07	3.8	27.4	<5		147	0.39	0.38				92		0.19	2	5	0.15	0.13	3	<1	159	0.77	7.9	2.1	<0.1
K-5	2002-08-14	3.3	22.5	10		75	0.46	0.42	56			168		0.26	5	11	0.14	0.14	4	<1	167	0.78	8.1	0.9	0.2
K-5	2002-08-25	7.1	7.1		<5	58	0.13	0.13	58			6	<0.1	0.06	3	4	0.12	0.08	2	<4	172	0.26	8	0.7	0.2
K-5	2002-09-02	3.5	16.7	15		91	0.57	0.57	73			202		0.34	3	9	0.12	0.12	5	1	168	0.8	7.8	1.1	0.4
K-5	2002-09-08	5.1	12.2	<5		150	0.75	0.55	61			151		0.27	5	9	0.14	0.1	5	<1	170	0.81	8	1.7	0.6
K-5	2002-10-28	2	3.5	<5		4	0.54	0.34	2			89		0.17	4	9	0.1	0.01	4	<1	184	0.35	7.7	0.7	<0.1
K-5	2002-11-04	1.3	2.9		<5	6	0.69	0.59	5			94	<0.1	0.18	4	6	0.07	<0.01	5	2	185	1	7.5	<0.1	<0.1
K-5	2002-11-11	54.4	82.6	<5		180	1.86	1.63	92			611		0.89	3	62	0.43	0.31	11	12	112	3.12	7.5	2.7	1.6
K-5	2002-11-17	59.1	84.5		<5	12	0.67	0.83	6			119	0.19	0.31	2	13	0.17	0.14	7	4	58	1.85	7.4	0.3	<0.1
K-5	2002-11-25	18.4	30.5		<5	6	0.22	0.21	2			101	0.16	0.26	<1	20	0.09	0.09	7	18	79	1.09	7.4	0.1	<0.1
K-5	2003-08-10	1.1	8.7	49		110	0.37	0.55	81			122		0.21	6	8	<0.01	0.02	4	<1	173	0.54	7.8	0.2	0.3
K-5	2003-08-18	2.2	27.9	23		240	0.52	0.78	210			129		0.27	4	12	<0.01	0.04	6	7	175	0.72	7.7	0.5	0.7
K-5	2003-08-25	1.5	11.5	56		950	0.39	0.55	810			192		0.34	5	11	<0.01	0.01	8	1	176	0.77	7.6	0.4	0.4
K-5	2003-09-02	1.5	17.3	20		123	0.54	0.67	33			201		0.35	3	6	0.01	0.05	<2	1	187	1.18	7.7	0.2	0.6
K-5	2003-09-08	2.1	18.7	39		290	1.94	3.26	110			177		0.34	2	11	<0.01	0.04	2	1	174	0.8	7.7	0.8	1
K-5	2003-10-20	95.5	418	<5			1.8	4.37				290		0.66	11	60	0.08	0.67	22	34	62	25	7.3	1.4	4.9
K-5	2003-10-27	26.5	45.9	<5		5	1.32	1.55	1			112		0.34	3	24	0.05	0.1	10	1	88	1.13	7.6	1.4	1.9
K-5	2003-11-02	19.7	31.8	<5		14	0.96	0.98	10			105		0.28	4	16	0.02	0.04	7	1	103	0.72	7.5	1.2	1.4
K-5	2003-11-11	11.6	17	8		22	0.58	0.6	7			137		0.24	3	6	<0.01	0.02	3	<1	114	0.84	7.7	0.4	0.4
K-5	2003-11-16	25.9	117	<5		700	0.95	1.22	610			146		0.39	<1	22	0.05	0.1	4	27	117	4.13	7.6	0.8	1.3
K-5	2008-08-11			<5		24				66.8		118				15			11	23	170	1.1	7.7		
K-5	2008-08-18			28		22				69.5		56				19			12	1	170	1.6	7.7		
K-5	2008-08-25			10		140				67.4		312				26			21	4	160	1.9	7.6		
K-5	2008-09-02			5		30				65.8		90				31			11	6	160	1.1	7.6		
K-5	2008-09-08			6		120				64.3		97				28			3	12	160	1.3	7.5		
K-5	2008-10-08					27				68.2		18				15			10	2	160	1.3	7.8		
K-5	2008-10-20		14.7	<5	0	8		0.7	8		0.1	33	0.1	0.13		8.9		0.036	7	<1	120	0.9	7.8		0.5
K-5	2008-10-27	5.5		<5	0	8	0.96		7	51.4	0.07	36	0.07	0.11		11	0.069		9	<1	130	0.6	7.8	0.4	
K-5	2008-11-03		36.5	<5	0	190		1.77	180		0.12	31	0.12	0.15		19		0.256	20	11	120	1.8	7.7		1.7
K-5	2008-11-12	64.55		<5	0	92	0.975		92	27.65	0.1	147	0.1	0.25		26	0.0735		10	8	63	5.75	7.5	0.65	

Table 27. Summary Data for Site C1, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C1	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
20002	min	2.6	8.4	5		1	0.12	0.14	1	2		0.06	1	2	0.13	0.10	2	1	49	0.46	7.6	0.7	0.1
sum	max	13.0	21.2	7		230	0.76	0.86	130	3		0.16	1	5	0.27	2.18	5	6	69	1.13	7.7	1.4	1.0
	mean	5.9	16.8	5		50	0.40	0.49	28	2		0.09	1	4	0.19	0.56	3	3	55	0.62	7.7	1.0	0.6
	stdev	4.1	5.3	1		101	0.24	0.27	57	1		0.04	0	1	0.06	0.91	1	2	8	0.28	0.0	0.3	0.4
	90th	9.8	21.2	6		144	0.64	0.75	80	3		0.14	1	5	0.25	1.38	4	6	63	0.89	7.7	1.4	1.0
C1	N	5	5	3	2	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	0.9	3.9	5	5	3	0.09	0.24	1	2		0.06	1	5	0.09	0.01	3	1	47	0.51	7.3	0.1	0.1
fall	max	6.5	62.2	5	5	44	0.70	0.50	31	59		0.18	2	22	0.21	0.13	7	16	51	1.20	7.5	8.1	0.8
	mean	4.2	20.2	5	5	15	0.45	0.39	10	25		0.11	1	10	0.13	0.08	4	6	49	0.69	7.4	2.0	0.4
	stdev	2.2	24.2	0	0	17	0.25	0.13	12	24		0.05	0	7	0.05	0.05	2	7	2	0.29	0.1	3.4	0.3
	90th	6.1	45.0	5	5	31	0.65	0.50	22	50		0.16	2	17	0.18	0.13	6	14	51	0.97	7.5	5.3	0.7
C1	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	2.6	12.2	5		5	0.28	0.40	1	2		0.06	1	2	0.01	0.01	2	1	49	0.62	7.6	0.2	0.2
sum	max	4.3	58.0	5		610	0.36	0.77	670	3		0.08	3	8	0.01	0.07	2	3	53	1.70	7.7	0.4	1.4
	mean	3.5	28.5	5		130	0.31	0.62	138	2.2		0.07	2	3	0.01	0.04	2	2	51	0.98	7.7	0.3	0.7
	stdev	0.8	18.6	0		268	0.03	0.15	298	0		0.01	1	3	0.00	0.03	0	1	2	0.44	0.1	0.1	0.4
	90th	4.3	47.7	5		374	0.34	0.75	406	3		0.08	3	6	0.01	0.07	2	3	52	1.45	7.7	0.4	1.1
C1	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	6.2	17.0	5		1	0.38	0.41	1	24		0.09	1	3	0.01	0.02	2	1	32	0.67	6.9	0.1	0.2
fall	max	68.8	112.0	7		353	0.90	1.19	299	280		0.50	13	35	0.06	0.12	17	7	49	2.00	7.5	3.4	4.4
	mean	21.8	49.3	5		92	0.68	0.93	77	80		0.21	5	13	0.03	0.07	7	3	45	1.22	7.3	1.6	1.9
	stdev	26.6	40.0	1		174	0.27	0.30	148	112		0.17	5	13	0.02	0.05	6	2	7	0.60	0.2	1.6	1.9
	90th	47.7	93.3	6		250	0.89	1.13	211	183		0.38	10	27	0.05	0.12	13	5	49	1.88	7.5	3.4	4.1
C1	N	5		5	5	5	5	1	5	5		5		5	5			5		5	5	5	
2008	min	3.3		5	0	4	0.28	0.37	1	2		0.04		3	0.01			1		0.50	7.4	0.2	
sum	max	9.4		19	20	42	0.96	0.37	31	8		0.16		5	0.04			1		1.00	7.8	2.1	
	mean	5.3		8	4	12	0.57	0.37	9	5		0.09		4	0.02			1		0.70	7.6	0.8	
	stdev	2.6		6	9	17	0.27		13	3		0.05		1	0.02			0		0.20	0.2	0.8	
	90th	8.1		13	12	28	0.85	0.37	21	8		0.14		5	0.03			1		0.92	7.8	1.7	
C1	N	4	1	5	3	4	4	1	4	5		5		5	4	1		5		5	5	4	1
2008	min	2.7	14.5	5	0	1	0.41	1.66	1	2		0.02		3	0.01	0.02		1		0.40	7.5	0.2	1.0
fall	max	6.2	14.5	5	0	5	0.60	1.66	4	11		0.08		6	0.01	0.02		3		0.90	7.7	0.4	1.0
	mean	3.9	14.5	5	0	3	0.49	1.66	2	4		0.05		4	0.01	0.02		1		0.62	7.6	0.3	1.0
	stdev	1.6	n/a	0	0	2	0.09		2	4		0.02		1	0.00	n/a		1		0.19	0.1	0.1	n/a
	90th	5.3	14.5	5	0	5	0.58	1.66	4	8		0.08		6	0.01	0.02		2		0.82	7.7	0.4	1.0

Table 28. Summary Data for Site C2, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C2	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.9	10.7	5		12	0.20	0.06	11	2		0.04	1	2	0.12	0.09	2	1	49	0.40	7.6	0.5	0.1
summer	max	8.3	40.2	5		38	0.35	0.30	40	4		0.07	10	4	0.17	0.18	4	4	66	0.63	7.7	1.6	0.3
	mean	5.4	17.0	5		22	0.28	0.22	20	3		0.06	3	3	0.14	0.13	3	2	55	0.48	7.6	0.8	0.2
	stdev	1.8	13.0	0		10	0.06	0.09	12	1		0.01	4	1	0.02	0.04	1	1	7	0.09	0.1	0.5	0.1
	90th	7.4	29.0	5		32	0.33	0.28	32	4		0.07	7	4	0.17	0.17	4	3	61	0.57	7.7	1.3	0.3
C2	N	5	5	3	2	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	2.9	3.8	5	5	2	0.05	0.05	2	2		0.06	1	3	0.08	0.01	3	1	47	0.36	7.3	0.1	0.1
fall	max	76.4	23.8	5	5	27	1.13	0.41	11	27		0.12	2	12	0.16	0.13	6	2	52	1.97	7.5	0.8	0.3
	mean	18.7	14.3	5	5	11	0.54	0.28	5	13		0.09	1	7	0.12	0.09	4	1	50	1.06	7.4	0.4	0.2
	stdev	32.3	9.0	0	0	10	0.40	0.14	4	12		0.02	1	4	0.03	0.05	1	1	2	0.66	0.1	0.3	0.1
	90th	48.0	23.3	5	5	22	0.92	0.39	10	26		0.11	2	11	0.15	0.13	6	2	52	1.75	7.5	0.7	0.3
C2	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	2.8	14.6	5		2	0.23	0.35	2	2		0.02	1	2	0.01	0.01	2	1	48	0.54	7.6	0.1	0.2
summer	max	5.5	64.1	5		85	0.37	0.76	68	6		0.07	2	2	0.01	0.09	3	2	52	1.39	7.7	0.4	1.1
	mean	4.0	27.6	5		56	0.29	0.53	29	3		0.05	1	2	0.01	0.05	2	1	50	0.91	7.7	0.2	0.5
	stdev	1.2	20.9	0		34	0.05	0.16	27	2		0.02	1	0	0.00	0.03	0	0	2	0.34	0.1	0.1	0.4
	90th	5.3	48.7	5		82	0.34	0.71	59	5		0.07	2	2	0.01	0.08	3	2	52	1.28	7.7	0.4	0.9
C2	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	6.1	16.1	5		4	0.27	0.40	3	27		0.08	1	4	0.01	0.02	2	1	47	1.02	7.3	0.1	0.1
fall	max	13.2	37.9	6		42	0.48	0.64	18	37		0.10	3	9	0.02	0.03	5	6	49	5.18	7.5	0.5	0.8
	mean	9.3	31.8	5		19	0.37	0.50	7	31		0.10	2	6	0.01	0.03	3	3	48	2.10	7.4	0.3	0.5
	stdev	2.5	9.4	0		17	0.08	0.10	7	4		0.01	1	2	0.00	0.00	1	2	1	1.78	0.1	0.2	0.3
	90th	11.7	37.8	6		35	0.46	0.61	14	35		0.10	3	8	0.02	0.03	4	5	49	3.95	7.5	0.5	0.7
C2	N	5		5	4	5	5	0	5	5		5		5	5			5		5	5	5	
2008	min	3.4		5	0	5	0.28	0.00	4	2		0.02		2	0.01			1		0.40	7.3	0.1	
summer	max	66.0		8	10	140	3.32	0.00	80	29		0.17		4	0.03			2		1.00	7.8	1.7	
	mean	18.2		6	5	37	1.01		21	11		0.09		3	0.01			1		0.72	7.6	0.5	
	stdev	26.9		1	6	58	1.30		33	12		0.07		1	0.01			0		0.26	0.2	0.7	
	90th	43.6		7	10	93	2.23		51	24		0.17		4	0.02			2		0.96	7.8	1.2	
C2	N	4	1	5	4	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	2.2	10.8	5	0	2	0.26	0.52	1	2		0.03		4	0.01	0.01		1		0.50	7.5	0.1	0.4
fall	max	4.9	10.8	5	0	9	0.54	0.52	6	32		0.05		5	0.01	0.01		2		1.00	7.7	0.3	0.4
	mean	3.4	10.8	5	0	5	0.40	0.52	4	10		0.03		4	0.01	0.01		1		0.64	7.6	0.2	0.4
	stdev	1.1	n/a	0	0	3	0.13		2	12		0.01		0	0.00	n/a		0		0.21	0.1	0.1	n/a
	90th	4.5	10.8	5	0	9	0.53	0.52	6	23		0.04		5	0.01	0.01		2		0.84	7.7	0.3	0.4

Table 29. Summary Data for Site C3, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C3	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.8	8.5	5		7	0.05	0.09	3	2		0.06	1	8	0.13	0.08	2	1	49	0.39	7.6	0.3	0.1
summer	max	14.0	17.4	5		28	0.37	0.31	28	8		0.10	2	12	0.18	0.17	6	1	66	0.58	7.7	1.0	0.1
	mean	7.2	12.0	5		20	0.21	0.19	15	4		0.08	1	10	0.15	0.13	3	1	55	0.51	7.7	0.7	0.1
	stdev	4.2	3.4	0		8	0.12	0.09	9	3		0.02	0	2	0.02	0.04	2	0	6	0.08	0.1	0.3	0.0
	90th	11.8	15.4	5		26	0.33	0.29	23	6		0.10	2	12	0.17	0.17	5	1	61	0.57	7.7	1.0	0.1
C3	N	5	5	3	2	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	1.7	4.1	5	5	5	0.05	0.05	1	23		0.09	1	7	0.06	0.01	2	1	47	0.40	7.2	0.1	0.1
fall	max	13.4	21.5	10	5	86	1.01	0.44	49	47		0.13	2	12	0.23	0.17	8	2	53	1.08	7.5	0.8	0.9
	mean	6.0	12.7	7	5	29	0.49	0.33	16	34		0.11	1	9	0.12	0.08	5	1	50	0.57	7.4	0.5	0.3
	stdev	4.5	7.6	3	0	35	0.34	0.16	20	9		0.02	0	2	0.07	0.06	2	0	2	0.29	0.1	0.3	0.3
	90th	10.4	20.7	9	5	66	0.81	0.42	38	42		0.13	2	12	0.19	0.14	7	2	53	0.85	7.5	0.8	0.7
C3	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	3.0	13.4	5		10	0.23	0.37	4	12		0.03	2	9	0.01	0.01	3	1	49	0.40	7.6	0.1	0.1
summer	max	10.7	23.1	5		200	0.55	2.39	22	60		0.13	13	18	0.01	0.10	13	2	54	0.61	7.7	0.6	2.2
	mean	5.6	17.3	5		91	0.32	0.82	12	26		0.08	5	12	0.01	0.04	6	1	51	0.55	7.7	0.3	0.8
	stdev	3.0	3.9	0		86	0.13	0.88	7	20		0.04	5	4	0.00	0.04	4	0	2	0.09	0.0	0.2	0.8
	90th	8.7	21.3	5		184	0.45	1.63	19	46		0.11	10	15	0.01	0.07	10	2	53	0.61	7.7	0.5	1.7
C3	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	6.6	16.7	5		24	0.28	0.30	3	28		0.10	1	5	0.01	0.02	2	1	46	0.67	7.3	0.1	0.1
fall	max	13.3	135.0	8		179	0.60	1.07	116	37		0.14	8	16	0.02	0.22	17	5	49	3.25	7.5	0.4	1.2
	mean	9.7	52.3	6		86	0.43	0.59	40	32		0.12	3	8	0.01	0.07	7	2	48	1.76	7.4	0.3	0.5
	stdev	2.4	47.4	1		69	0.12	0.30	52	4		0.02	3	5	0.01	0.08	6	2	1	1.06	0.1	0.1	0.4
	90th	11.9	98.2	7		154	0.56	0.91	89	35		0.13	6	13	0.02	0.15	13	4	49	2.84	7.5	0.4	0.9
C3	N	5		5	5	5	5	0	5	5		5		5	5			5		5	5	5	
2008	min	3.9		5	0	10	0.44	0.00	6	4		0.05		5	0.01			1		0.10	7.2	0.3	
summer	max	10.0		45	50	77	0.64	0.00	44	15		0.18		19	0.02			7		0.80	7.8	1.3	
	mean	6.0		23	20	45	0.51		21	10		0.09		11	0.01			3		0.50	7.5	0.6	
	stdev	2.7		20	20	28	0.08		15	4		0.06		6	0.01			3		0.30	0.2	0.4	
	90th	9.0		44	42	73	0.59		38	14		0.14		17	0.02			6		0.80	7.8	1.1	
C3	N	4	1	5	4	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	2.4	12.5	5	0	6	0.31	0.59	2	2		0.03		4	0.01	0.01		1		0.50	7.5	0.3	0.5
fall	max	5.5	12.5	12	20	10	1.86	0.59	10	17		0.06		10	0.04	0.01		1		0.70	7.8	2.0	0.5
	mean	3.6	12.5	8	8	8	0.81	0.59	6	6		0.05		6	0.02	0.01		1		0.62	7.7	0.8	0.5
	stdev	1.3	n/a	3	10	2	0.71		3	6		0.01		2	0.02	n/a		0		0.11	0.1	0.8	n/a
	90th	4.9	12.5	11	17	10	1.46	0.59	9	12		0.06		8	0.03	0.01		1		0.70	7.8	1.5	0.5

Table 30. Summary Data for Site C4, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C4	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.7	9.5	5		4	0.08	0.23	2	2		0.05	1	6	0.08	0.13	2	1	57	0.47	7.7	0.1	0.1
summer	max	12.4	28.5	11		21	0.68	0.53	8	3		0.09	2	8	0.18	0.17	5	3	73	0.88	7.8	0.9	1.0
	mean	6.2	17.1	6		8	0.30	0.36	4	2		0.06	1	7	0.12	0.14	3	2	62	0.67	7.7	0.5	0.3
	stdev	3.6	7.6	3		8	0.23	0.13	2	1		0.02	0	1	0.04	0.02	1	1	6	0.20	0.0	0.3	0.4
	90th	9.6	25.2	9		15	0.54	0.49	6	3		0.08	2	8	0.15	0.16	5	3	68	0.88	7.8	0.8	0.6
C4	N	5	5	3	2	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.1	8.9	5	14	4	0.05	0.40	1	2		0.07	1	4	0.08	0.03	2	1	51	0.44	7.3	0.1	0.1
fall	max	22.4	392.0	113	14	170	1.37	3.23	68	341		2.00	64	84	0.16	2.00	70	80	65	25.90	7.6	0.5	2.0
	mean	11.8	146.2	71	14	60	0.59	1.34	24	108		0.58	15	45	0.11	0.49	20	25	58	8.09	7.4	0.3	0.6
	stdev	8.5	169.8	58	0	76	0.48	1.10	32	134		0.80	28	30	0.04	0.85	28	32	7	10.91	0.1	0.2	0.8
	90th	20.6	336.4	109	14	146	1.06	2.42	60	240		1.36	41	74	0.15	1.28	47	58	65	20.06	7.6	0.5	1.5
C4	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	3.0	14.1	5		6	0.24	0.39	2	2		0.05	1	2	0.01	0.01	2	1	57	0.45	7.7	0.1	0.2
summer	max	4.2	34.9	5		160	0.32	0.66	73	4		0.08	2	7	0.01	0.11	5	9	62	0.75	7.8	0.2	0.5
	mean	3.6	22.6	5		60	0.29	0.50	22	2.6		0.06	2	4	0.01	0.06	3	3	59	0.62	7.8	0.1	0.3
	stdev	0.6	9.0	0		69	0.03	0.10	29	1		0.01	1	2	0.00	0.05	1	4	2	0.13	0.0	0.1	0.1
	90th	4.2	32.6	5		138	0.31	0.59	50	4		0.07	2	7	0.01	0.11	4	6	61	0.73	7.8	0.2	0.4
C4	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	11.9	103.0	5		27	0.42	0.64	6	29		0.12	1	21	0.01	0.06	2	13	47	7.84	7.4	0.1	0.5
fall	max	85.0	899.0	22		171	1.57	7.13	29	73		0.23	4	116	0.17	13.50	29	166	53	118.00	7.6	0.2	5.1
	mean	33.7	377.6	11		77	0.72	2.48	15	44.2		0.16	2	56	0.05	2.87	9	60	51	41.05	7.5	0.1	1.8
	stdev	29.5	312.4	7		67	0.48	2.66	11	17		0.04	1	44	0.07	5.95	11	66	3	46.31	0.1	0.1	1.9
	90th	63.5	705.0	18		143	1.17	5.15	26	62		0.21	3	106	0.11	8.32	20	133	53	91.28	7.6	0.2	3.9
C4	N	5		5	5	5	5	0	5	5		5		5	5			5		5	5	5	
2008	min	2.5		5	0	11	0.36	0.00	7	4		0.03		4	0.01			2		0.60	7.2	0.2	
summer	max	6.9		5	0	120	0.56	0.00	100	8		0.12		20	0.04			8		1.10	7.8	1.4	
	mean	4.9		5	0	47	0.43		38	6		0.07		8	0.02			4		0.82	7.6	0.6	
	stdev	1.6		0	0	44	0.08		40	2		0.04		7	0.01			2		0.22	0.3	0.5	
	90th	6.3		5	0	95	0.51		83	8		0.10		15	0.03			6		1.02	7.8	1.2	
C4	N	4	1	5	4	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	3.8	36.5	5	0	7	0.41	0.48	4	2		0.04		6	0.01	0.02		2		0.40	7.5	0.2	0.4
fall	max	5.1	36.5	22	20	43	0.59	0.48	40	24		0.14		16	0.01	0.02		12		2.40	7.7	0.6	0.4
	mean	4.4	36.5	10	10	25	0.52	0.48	22	10		0.07		8	0.01	0.02		5		1.16	7.6	0.4	0.4
	stdev	0.6	n/a	8	12	17	0.08		16	10		0.04		4	0.00	n/a		4		0.78	0.1	0.2	n/a
	90th	4.9	36.5	18	20	42	0.58	0.48	38	21		0.12		12	0.01	0.02		9		2.00	7.7	0.6	0.4

Table 31. Summary Data for Site C5, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
C5	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.5	2.8	5		9	0.35	0.40	5	90		0.22	1	38	0.01	0.04	24	1	61	0.44	7.6	0.5	0.1
summer	max	7.1	19.9	8		34	0.53	0.83	18	279		0.58	33	52	0.16	0.16	39	2	76	0.73	7.8	1.1	1.2
	mean	5.3	13.0	6		16	0.42	0.54	11	148		0.30	21	45	0.11	0.11	29	2	68	0.59	7.7	0.8	0.5
	stdev	1.7	7.0	1		10	0.07	0.17	6	75		0.16	12	5	0.06	0.05	6	1	6	0.12	0.1	0.2	0.4
	90th	7.1	19.2	7		28	0.49	0.70	18	220		0.45	30	51	0.16	0.15	36	2	74	0.71	7.8	1.0	1.0
C5	N	5	5	2	3	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	2.2	8.7	5	5	6	0.08	0.46	1	7		0.08	1	7	0.08	0.01	3	1	52	0.43	7.3	0.1	0.1
fall	max	40.4	172.0	12	19	170	1.29	1.80	79	222		0.59	33	69	0.20	0.34	34	123	66	27.20	7.6	1.4	3.5
	mean	14.8	77.4	9	13	39	0.63	1.07	15	108		0.33	10	42	0.13	0.16	16	30	58	8.95	7.4	0.7	1.0
	stdev	15.1	68.1	5	7	75	0.44	0.56	31	88		0.21	13	23	0.05	0.12	15	53	6	11.68	0.1	0.5	1.4
	90th	29.5	146.0	11	18	158	1.06	1.67	66	203		0.55	24	62	0.18	0.28	32	83	64	21.96	7.5	1.2	2.4
C5	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	4.4	23.6	5		33	0.30	0.50	1	100		0.19	5	9	0.01	0.01	5	1	62	0.63	7.7	0.1	0.2
summer	max	17.4	39.1	31		190	0.61	1.46	31	246		0.39	13	25	0.01	0.05	20	51	69	1.34	7.8	0.4	1.2
	mean	10.7	28.5	16		65	0.47	0.77	8	193		0.31	10	17	0.01	0.02	12	11	65	0.94	7.7	0.2	0.5
	stdev	4.8	6.2	11		64	0.12	0.39	13	55		0.07	4	6	0.00	0.02	6	22	3	0.27	0.0	0.1	0.4
	90th	15.3	35.1	27		148	0.58	1.14	29	232		0.37	13	23	0.01	0.04	18	31	67	1.22	7.8	0.4	0.9
C5	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	10.2	76.6	5		28	0.44	0.60	10	34		0.14	2	28	0.01	0.04	6	8	49	5.93	7.3	0.1	0.4
fall	max	80.0	837.0	78		48	1.15	4.92	33	69		0.28	11	59	0.05	0.50	15	90	57	101.00	7.5	0.3	2.8
	mean	31.0	313.5	34		17	0.65	1.73	10	50		0.21	6	39	0.02	0.16	11	39	53	34.22	7.4	0.2	1.2
	stdev	28.2	305.1	38		10	0.29	1.82	10	14		0.05	4	12	0.02	0.20	4	34	3	40.24	0.1	0.1	0.9
	90th	59.2	622.6	76		46	0.94	3.54	30	64		0.26	11	51	0.04	0.35	15	77	57	77.72	7.5	0.3	2.2
C5	N			5		5	0	0		5			5	5			5	5	5	5	5		
2008	min			196		18	0.00	0.00		27			4	28			5	1	60	0.60	7.4		
summer	max			314		310	0.00	0.00		97			17	59			24	3	71	1.30	7.7		
	mean			258.2		41				72			10	39			14	2	67	0.96	7.6		
	stdev			46		127				30			6	12			8	1	5	0.29	0.1		
	90th			305		198				95			15	51			22	3	71	1.26	7.7		
C5	N	3	2	5		5	3	2	5	5		5	5	5	3	2	5	5	5	5	5	3	2
2008	min	5.1	3.7	65	50	10	0.41	0.38	11	15		0.16	9	2	0.01	0.01	9	2	51	0.8	7.5	0.1	0.1
fall	max	8.8	88.6	197	140	130	0.54	0.73	130	136		0.21	19	29	0.06	0.05	30	22	60	9.6	7.7	0.3	0.6
	mean	7.5	46.2	120	96	37	0.47	0.56	35	47		0.19	16	19	0.03	0.03	23	6	57	3.6	7.6	0.2	0.3
	stdev	2.1	60.0	50	40	50	0.07	0.25	49	52		0.02	4	10	0.03	0.03	9	9	3	3.8	0.1	0.1	0.3
	90th	8.8	80.1	174	136	107	0.52	0.70	104	101		0.21	19	27	0.05	0.04	30	14	59	7.8	7.7	0.3	0.5

Table 32. Summary Data for Site K1, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K1	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	2.7	2.4	5		6	0.12	0.10	4	5		0.06	1	4	0.01	0.01	2	1	136	0.20	7.8	0.3	0.1
summer	max	8.4	14.9	28		285	0.84	0.43	221	163		0.29	7	9	0.19	0.17	7	2	183	0.66	8.1	1.6	0.6
	mean	5.7	8.8	10		69	0.51	0.26	52	39		0.12	4	6	0.14	0.10	4	1	156	0.36	8.0	0.8	0.3
	stdev	2.5	4.7	10		121	0.30	0.14	95	69		0.10	2	2	0.07	0.06	2	0	17	0.19	0.1	0.5	0.2
	90th	7.9	13.6	19		183	0.82	0.41	140	105		0.22	6	9	0.19	0.16	6	2	172	0.58	8.1	1.3	0.6
K1	N	5	5	2	3	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	2.0	2.0	5	5	1	0.14	0.12	1	2		0.04	1	3	0.05	0.01	4	1	52	0.14	7.4	0.1	0.1
fall	max	42.1	73.7	5	6	43	0.93	0.88	12	375		0.57	3	13	0.17	0.14	9	4	165	1.77	7.9	0.5	0.5
	mean	20.4	31.9	5	5	11	0.55	0.50	3	92		0.20	2	6	0.11	0.08	5	2	107	0.71	7.6	0.3	0.2
	stdev	17.9	31.4	0	1	18	0.29	0.31	5	159		0.22	1	4	0.05	0.06	2	1	54	0.73	0.2	0.2	0.2
	90th	38.6	65.7	5	6	28	0.84	0.83	8	242		0.42	3	11	0.16	0.14	7	4	165	1.53	7.8	0.5	0.3
K1	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	2.0	5.3	5		5	0.25	0.31	1	2		0.06	1	2	0.01	0.01	2	1	156	0.25	8.1	0.1	0.2
summer	max	3.9	12.1	14		65	0.45	0.60	9	9		0.10	3	6	0.01	0.04	2	8	173	0.37	8.1	0.5	1.0
	mean	3.2	7.4	9		20	0.33	0.45	4	7		0.08	2	3	0.01	0.02	2	2	162	0.29	8.1	0.3	0.5
	stdev	0.7	2.8	5		25	0.08	0.13	3	3		0.02	1	2	0.00	0.01	0	3	7	0.05	0.0	0.2	0.3
	90th	3.7	10.2	14		45	0.43	0.58	8	9		0.10	3	5	0.01	0.04	2	5	169	0.33	8.1	0.5	0.8
K1	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	12.9	17.1	5		1	0.33	0.36	1	2		0.07	1	2	0.02	0.02	2	1	47	0.17	7.4	0.1	0.3
fall	max	61.7	194.0	13		58	0.88	0.97	16	30		0.15	6	12	0.03	0.09	9	12	93	7.35	7.8	0.5	0.6
	mean	28.2	89.0	7		26	0.57	0.66	9	13		0.11	2	6	0.02	0.05	5	3	76	2.23	7.6	0.3	0.5
	stdev	19.6	88.0	4		25	0.20	0.24	7	11		0.03	2	4	0.01	0.03	3	5	19	3.09	0.1	0.2	0.1
	90th	48.0	186.8	10		50	0.77	0.92	16	25		0.14	4	10	0.03	0.08	8	8	91	5.58	7.8	0.4	0.6
K1	N	5		5	5	5	5	0	5	5		5		5	5			5		5	5	5	
2008	min	5.6		5	0	12	0.37	0.00	7	6		0.04		3	0.01			1		0.30	7.8	0.1	
summer	max	10.2		14	10	240	0.95	0.00	220	14		0.08		10	0.03			1		0.50	8.1	1.1	
	mean	8.0		7	2	62	0.53		54	11		0.06		6	0.01			1		0.42	8.0	0.5	
	stdev	2.0		4	4	100	0.25		93	4		0.02		3	0.01			0		0.08	0.2	0.4	
	90th	9.8		10	6	155	0.79		142	14		0.08		9	0.03			1		0.50	8.1	0.9	
K1	N	4	1	5	3	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	9.0	62.8	5	0	1	0.43	0.68	1	7		0.04		4	0.01	0.02		1		0.20	7.5	0.2	0.5
fall	max	21.5	62.8	6	10	17	0.74	0.68	17	38		0.13		6	0.03	0.02		2		1.20	7.9	0.4	0.5
	mean	14.1	62.8	5	3	6	0.62	0.68	6	23		0.08		5	0.02	0.02		1		0.66	7.8	0.3	0.5
	stdev	6.2	n/a	0	6	6	0.13		6	12		0.04		1	0.01	n/a		1		0.46	0.2	0.1	n/a
	90th	20.1	62.8	6	8	12	0.72	0.68	12	34		0.12		6	0.03	0.02		2		1.16	7.9	0.4	0.5

Table 33. Summary Data for Site K2, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K2	N	5	5	4	1	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	5.4	8.2	5	5	23	0.33	0.24	18	2		0.11	1	6	0.11	0.10	2	1	159	0.51	8.1	0.6	0.1
summer	max	8.6	26.5	5	5	630	0.67	0.61	630	33		0.15	7	9	0.21	0.25	4	3	192	1.26	8.1	2.2	0.6
	mean	7.1	13.9	5	5	169	0.45	0.43	155	12		0.12	3	7	0.15	0.15	3	2	173	0.73	8.1	1.2	0.3
	stdev	1.2	7.3	0	n/a	261	0.14	0.14	267	13		0.02	2	1	0.04	0.06	1	1	13	0.30	0.0	0.6	0.2
	90th	8.2	21.5	5	5	430	0.61	0.57	412	25		0.14	5	8	0.19	0.20	4	3	186	1.04	8.1	1.8	0.5
K2	N	5	5	2	3	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	1.1	1.3	5	5	1	0.19	0.15	1	2		0.13	1	6	0.06	0.02	2	1	56	0.31	7.4	0.1	0.1
fall	max	43.4	67.5	5	6	32	1.05	0.77	13	74		0.38	3	16	0.17	0.14	8	6	187	1.44	7.9	1.0	0.2
	mean	17.9	27.3	5	5	8	0.68	0.59	3	41		0.22	2	9	0.11	0.07	5	2	121	0.92	7.6	0.4	0.1
	stdev	17.2	27.4	0	1	13	0.33	0.25	5	36		0.10	1	4	0.05	0.04	2	2	61	0.54	0.2	0.4	0.1
	90th	34.9	55.9	5	6	20	0.97	0.76	8	73		0.32	3	13	0.16	0.12	7	4	184	1.44	7.9	0.8	0.2
K2	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	0.7	7.3	5		18	0.36	0.47	5	6		0.08	1	3	0.01	0.01	2	1	183	0.33	8.0	0.1	0.2
summer	max	2.5	32.7	5		74	0.80	1.71	41	27		0.13	4	20	0.01	0.05	3	1	200	3.32	8.2	0.5	1.8
	mean	1.7	13.5	5		54	0.48	0.77	22	13		0.10	3	9	0.01	0.03	3	1	189	0.94	8.1	0.3	0.7
	stdev	0.9	10.8	0		24	0.19	0.53	13	8		0.02	1	7	0.00	0.02	1	0	7	1.33	0.1	0.2	0.6
	90th	2.5	23.5	5		72	0.68	1.26	34	21		0.13	4	16	0.01	0.05	3	1	197	2.14	8.2	0.5	1.4
K2	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	11.4	19.0	5		7	0.66	0.82	1	28		0.23	1	8	0.01	0.04	6	1	67	0.35	7.4	0.2	0.6
fall	max	82.4	359.0	9		80	1.74	3.20	54	1140		1.44	3	26	0.06	0.37	12	41	127	12.10	7.7	2.5	3.3
	mean	32.8	109.1	6		34	0.95	1.83	21	298		0.57	2	16	0.03	0.11	8	10	98	3.04	7.6	0.9	1.5
	stdev	28.5	141.3	2		33	0.45	1.26	25	472		0.50	1	7	0.02	0.15	2	18	24	5.08	0.1	0.9	1.2
	90th	60.7	246.4	7		66	1.40	3.20	46	733		1.08	3	23	0.05	0.25	10	26	123	7.81	7.7	1.8	2.8
K2	N	5		5	4	5	5	1	5	5		5		5	5			5		5	5	5	
2008	min	6.3		5	0	20	0.53	0.82	14	13		0.06		9	0.01			1		0.50	7.7	0.3	
summer	max	10.5		13	10	1700	1.62	0.82	1700	50		0.18		24	0.02			15		2.50	8.1	0.8	
	mean	7.9		7	5	434	0.81	0.82	401	32		0.10		13	0.02			4		1.02	7.9	0.5	
	stdev	1.6		4	6	719	0.46		729	13		0.05		6	0.01			6		0.87	0.1	0.3	
	90th	9.5		11	10	1156	1.23	0.82	1096	44		0.16		19	0.02			9		1.94	8.0	0.8	
K2	N	4	1	5	4	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	7.9	57.4	5	0	2	0.89	1.76	1	5		0.05		7	0.01	0.04		1		0.60	7.6	0.3	1.5
fall	max	13.1	57.4	20	30	310	1.51	1.76	300	85		0.19		13	0.03	0.04		4		4.50	7.9	0.8	1.5
	mean	10.5	57.4	9	10	77	1.14	1.76	69	27		0.10		9	0.02	0.04		2		1.76	7.8	0.6	1.5
	stdev	2.1	n/a	7	14	131	0.28		129	33		0.05		2	0.01	n/a		1		1.56	0.1	0.2	n/a
	90th	12.3	57.4	15	24	200	1.41	1.76	191	61		0.15		11	0.03	0.04		4		3.30	7.9	0.8	1.5

Table 34. Summary Data for Site K3, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K3	N	5	5	4	1	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	4.1	7.3	5	5	2	0.38	0.42	2	2		0.16	2	13	0.10	0.09	4	1	153	0.54	7.4	0.7	0.1
summer	max	7.8	95.0	5	5	65	0.65	0.82	41	77		0.22	15	25	0.16	0.20	9	8	176	4.35	8.1	1.6	0.6
	mean	6.2	30.8	5	5	32	0.53	0.58	20	39		0.18	7	17	0.13	0.13	7	3	160	1.52	7.8	1.1	0.4
	stdev	1.3	36.3	0	n/a	25	0.10	0.15	16	34		0.03	5	5	0.02	0.04	2	3	10	1.61	0.3	0.4	0.3
	90th	7.3	66.1	5	5	55	0.63	0.74	37	71		0.21	12	23	0.16	0.17	9	6	170	3.13	8.0	1.5	0.6
K3	N	5	5	2	3	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.6	5.0	5	5	1	0.35	0.40	1	36		0.14	6	11	0.05	0.05	7	1	86	0.43	7.3	0.1	0.1
fall	max	35.7	60.4	5	85	16	0.81	1.12	8	452		0.75	14	35	0.21	0.17	32	18	186	2.74	7.6	1.1	1.0
	mean	16.6	31.8	5	38	8	0.67	0.73	5	210		0.43	9	24	0.14	0.11	17	6	145	1.47	7.4	0.5	0.6
	stdev	13.5	25.3	0	42	6	0.19	0.29	3	171		0.26	3	12	0.07	0.05	10	7	53	1.11	0.1	0.5	0.4
	90th	30.8	56.7	5	73	14	0.81	1.05	7	392		0.69	13	34	0.20	0.16	28	14	186	2.66	7.5	1.0	0.9
K3	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	3.4	14.3	5		63	0.42	0.58	19	31		0.20	4	17	0.01	0.01	4	1	147	1.43	7.6	0.2	0.4
summer	max	9.2	19.6	38		1800	0.57	0.81	730	122		0.32	5	28	0.03	0.04	9	36	176	3.48	7.7	0.5	1.8
	mean	4.7	17.4	19		589	0.48	0.67	182	64		0.25	4	23	0.01	0.03	6	11	158	2.09	7.7	0.4	0.9
	stdev	2.5	2.2	15		760	0.06	0.09	308	35		0.06	1	4	0.01	0.01	2	15	11	0.81	0.1	0.1	0.5
	90th	7.0	19.6	35		1432	0.53	0.76	478	98		0.32	5	27	0.02	0.04	9	26	170	2.90	7.7	0.5	1.4
K3	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	18.3	26.1	5		3	0.66	0.74	4	2		0.31	2	14	0.01	0.02	6	1	54	0.47	7.2	0.2	0.3
fall	max	86.8	165.0	8		250	1.95	2.27	250	379		0.69	8	26	0.10	0.19	15	13	100	8.82	7.6	1.6	2.5
	mean	39.4	67.9	6		87	1.25	1.41	70	173		0.42	4	19	0.04	0.07	10	5	82	3.49	7.4	0.6	1.0
	stdev	27.5	57.2	1		112	0.53	0.63	120	136		0.16	2	4	0.03	0.07	4	5	20	3.42	0.2	0.6	0.9
	90th	66.1	127.4	7		196	1.82	2.11	180	306		0.58	7	24	0.08	0.14	14	11	100	6.84	7.6	1.2	2.1
K3	N	4	1	5	5	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	7.4	1.5	5	0	14	0.63	0.41	12	3		0.22		13	0.01	0.01		1		0.70	7.5	0.3	0.1
summer	max	10.5	1.5	25	20	820	1.23	0.41	580	261		0.36		32	0.08	0.01		4		3.10	7.9	0.6	0.1
	mean	8.6	1.5	14	10	215	0.78	0.41	158	126		0.27		24	0.04	0.01		3		1.78	7.7	0.4	0.1
	stdev	1.4	n/a	9	10	340	0.30		239	111		0.05		9	0.03	n/a		2		1.02	0.2	0.2	n/a
	90th	10.0	1.5	23	20	536	1.05	0.41	392	229		0.32		32	0.07	0.01		4		2.74	7.9	0.6	0.1
K3	N	4	1	5	4	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	6.3	81.8	5	0	11	0.48	1.02	10	29		0.11		9	0.01	0.04		1		0.60	7.4	0.1	0.4
fall	max	7.7	81.8	60	60	77	0.68	1.02	73	214		0.39		15	0.02	0.04		3		3.40	7.9	0.4	0.4
	mean	7.0	81.8	16	15	34	0.61	1.02	32	103		0.20		11	0.01	0.04		1		1.90	7.7	0.2	0.4
	stdev	0.7	n/a	25	30	26	0.09		25	70		0.11		3	0.01	n/a		1		1.14	0.2	0.1	n/a
	90th	7.6	81.8	38	42	60	0.67	1.02	57	176		0.32		14	0.01	0.04		2		3.08	7.9	0.3	0.4

Table 35. Summary Data for Site K4, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K4	N	5	5	4	1	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.0	9.1	5	5	22	0.21	0.31	16	64		0.18	1	3	0.12	0.01	2	1	154	0.57	7.8	0.1	0.1
summer	max	14.8	15.6	5	5	49	0.70	0.54	36	158		0.28	8	10	0.16	0.12	6	1	181	0.70	8.1	1.5	0.5
	mean	6.9	12.1	5	5	35	0.51	0.43	24	120		0.22	5	7	0.14	0.08	4	1	162	0.63	8.0	0.9	0.3
	stdev	4.7	2.7	0	n/a	11	0.20	0.10	7	36		0.04	3	3	0.02	0.05	2	0	11	0.05	0.1	0.6	0.2
	90th	11.7	15.0	5	5	47	0.68	0.52	31	152		0.26	7	9	0.16	0.12	6	1	173	0.68	8.1	1.5	0.5
K4	N	5	5	2	3	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	1.2	6.7	5	5	1	0.23	0.27	1	43		0.17	1	6	0.08	0.02	4	1	58	0.30	7.2	0.1	0.1
fall	max	44.5	66.2	5	5	10	0.86	1.22	10	121		0.31	4	23	0.16	0.20	8	7	184	2.30	7.6	0.6	1.3
	mean	17.0	34.8	5	5	6	0.61	0.74	4	87		0.22	3	13	0.11	0.11	6	4	125	1.46	7.4	0.4	0.3
	stdev	17.5	27.9	0	0	3	0.26	0.34	4	28		0.05	1	7	0.03	0.07	2	3	58	0.72	0.2	0.2	0.5
	90th	34.1	63.4	5	5	9	0.84	1.08	8	109		0.27	4	20	0.15	0.18	8	7	183	2.05	7.6	0.6	0.8
K4	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	2.0	12.9	5		24	0.41	0.64	13	125		0.17	1	4	0.01	0.03	2	1	160	0.49	7.7	0.2	0.4
summer	max	3.8	191.0	11		290	0.54	1.56	220	340		0.41	4	18	0.04	0.17	8	10	176	9.90	7.8	0.7	1.6
	mean	2.6	50.4	7		94	0.50	0.90	70	204		0.27	2	10	0.02	0.06	4	3	170	2.51	7.8	0.5	1.0
	stdev	0.7	78.7	3		114	0.05	0.39	86	87		0.10	1	6	0.01	0.06	3	4	6	4.13	0.1	0.2	0.5
	90th	3.3	122.7	10		213	0.54	1.32	155	289		0.38	4	16	0.03	0.11	7	7	174	6.29	7.8	0.6	1.5
K4	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	11.8	17.2	5		15	0.63	0.63	5	108		0.24	1	5	0.02	0.02	4	1	60	0.51	7.2	0.3	0.6
fall	max	78.7	181.0	5		650	1.41	1.71	520	389		0.71	8	35	0.03	0.07	14	16	114	9.05	7.7	1.0	1.5
	mean	33.9	79.5	5		186	0.96	1.10	138	184		0.40	4	19	0.02	0.04	8	7	94	3.54	7.5	0.6	1.0
	stdev	26.4	67.7	0		310	0.31	0.41	255	116		0.19	3	11	0.01	0.02	4	7	23	3.79	0.2	0.3	0.4
	90th	61.1	154.2	5		473	1.28	1.50	370	294		0.59	6	31	0.03	0.06	12	14	114	7.79	7.7	0.8	1.4
K4	N	5		5	5	5	5	0	5	5		5		5	5			5		5	5	5	
2008	min	3.6		5	0	16	0.45	0.00	13	87		0.12		4	0.01			1		0.60	7.5	0.1	
summer	max	20.6		8	10	330	1.07	0.00	300	628		0.69		27	0.04			7		6.90	7.9	0.8	
	mean	7.6		6	2	89	0.76		78	232		0.28		13	0.02			2		2.08	7.7	0.4	
	stdev	7.3		1	4	135	0.26		124	226		0.23		9	0.02			3		2.71	0.2	0.3	
	90th	14.4		7	6	216	1.01		192	458		0.51		23	0.04			5		4.70	7.9	0.7	
K4	N	4	1	5	3	5	4	1	5	5		5		5	4	1		5		5	5	4	1
2008	min	7.1	64.7	5	0	15	0.49	1.08	12	15		0.06		6	0.01	0.03		1		0.50	7.5	0.1	0.6
fall	max	10.9	64.7	5	0	82	0.69	1.08	67	140		0.29		14	0.01	0.03		6		5.10	7.9	0.3	0.6
	mean	8.5	64.7	5	0	35	0.59	1.08	29	51		0.13		10	0.01	0.03		3		1.56	7.8	0.2	0.6
	stdev	1.7	n/a	0	0	27	0.08		22	52		0.09		3	0.00	n/a		2		1.99	0.2	0.1	n/a
	90th	10.1	64.7	5	0	61	0.66	1.08	51	103		0.23		12	0.01	0.03		5		3.50	7.9	0.3	0.6

Table 36. Summary Data for Site K5, 2002, 2003 and 2008.

SITE, YEAR, SEASON	START DATE	Al-D (µg/L)	Al-T (µg/L)	Amonia Diss. (µg/L)	Amonia:T (µg/L)	Coli:Fec (CFU/100mL)	Cu-D (µg/L)	Cu-T (µg/L)	E Coli (CFU/100mL)	NO2+NO3 Diss. (µg/L)	N Organic-Total (mg/L)	N Total (mg/L)	Ortho-P Diss. (µg/L)	P--T (µg/L)	Pb-D (µg/L)	Pb-T (µg/L)	P Tot. Diss. (µg/L)	NFR (mg/L)	Spec. Conduct. (uS/cm)	Turbidit (NTU)	pH (pH units)	Zn-D (µg/L)	Zn-T (µg/L)
K5	N	5	5	4	1	5	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	3.3	7.1	5	5	58	0.13	0.13	56	6		0.06	2	4	0.12	0.08	2	1	159	0.26	7.8	0.7	0.1
summer	max	7.1	27.4	15	5	150	0.75	0.57	73	202		0.34	5	11	0.15	0.14	5	4	172	0.81	8.1	2.1	0.6
	mean	4.6	17.2	9	5	104	0.46	0.41	62	124		0.22	4	8	0.13	0.11	4	2	167	0.68	8.0	1.3	0.3
	stdev	1.6	8.1	5	n/a	42	0.23	0.18	8	77		0.11	1	3	0.01	0.02	1	1	5	0.24	0.1	0.6	0.2
	90th	6.3	25.4	14	5	149	0.68	0.56	69	188		0.31	5	10	0.15	0.14	5	3	171	0.81	8.1	1.9	0.5
K5	N	5	5	2	3	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2002	min	1.3	2.9	5	5	4	0.22	0.21	2	89		0.17	1	6	0.07	0.01	4	1	58	0.35	7.4	0.1	0.1
fall	max	59.1	84.5	5	5	180	1.86	1.63	92	611		0.89	4	62	0.43	0.31	11	18	185	3.12	7.7	2.7	1.6
	mean	27.0	40.8	5	5	42	0.80	0.72	21	203		0.36	3	22	0.17	0.11	7	7	124	1.48	7.5	0.8	0.4
	stdev	28.0	40.6	0	0	77	0.62	0.56	40	228		0.30	1	23	0.15	0.12	3	7	59	1.06	0.1	1.1	0.7
	90th	57.2	83.7	5	5	113	1.39	1.31	58	414		0.66	4	45	0.33	0.24	9	16	185	2.61	7.6	1.9	1.0
K5	N	5	5	5		5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	1.1	8.7	20		110	0.37	0.55	33	122		0.21	2	6	0.01	0.01	2	1	173	0.54	7.6	0.2	0.3
summer	max	2.2	27.9	56		950	1.94	3.26	810	201		0.35	6	12	0.01	0.05	8	7	187	1.18	7.8	0.8	1.0
	mean	1.7	16.8	37		343	0.75	1.16	249	164		0.30	4	10	0.01	0.03	4	2	177	0.80	7.7	0.4	0.6
	stdev	0.5	7.4	16		348	0.67	1.18	320	36		0.06	2	3	0.00	0.02	3	3	6	0.23	0.1	0.2	0.3
	90th	2.2	24.2	53		686	1.38	2.27	570	197		0.35	6	12	0.01	0.05	7	5	183	1.03	7.8	0.7	0.9
K5	N	5	5	5		4	5	5	4	5		5	5	5	5	5	5	5	5	5	5	5	5
2003	min	11.6	17.0	5		5	0.58	0.60	1	105		0.24	1	6	0.01	0.02	3	1	62	0.72	7.3	0.4	0.4
fall	max	95.5	418.0	8		700	1.80	4.37	610	290		0.66	11	60	0.08	0.67	22	34	117	25.00	7.7	1.4	4.9
	mean	35.8	125.9	6		185	1.12	1.74	157	158		0.38	4	26	0.04	0.19	9	13	97	6.36	7.5	1.0	2.0
	stdev	33.9	167.7	1		343	0.46	1.51	302	76		0.17	4	20	0.03	0.27	8	16	23	10.51	0.2	0.4	1.7
	90th	67.9	297.6	7		497	1.61	3.24	430	232		0.55	8	46	0.07	0.44	17	31	116	16.65	7.7	1.4	3.7
K5	N			5		5	0.00	0.00		5				5			5	5	5	5	5		
2008	min			5		22	0.00	0.00		56				15			3	1	160	1.10	7.5		
summer	max			28		140	0.00	0.00		312				31			21	23	170	1.90	7.7		
	mean			11		67				135				24			12	9	164	1.40	7.6		
	stdev			10		58				102				7			6	9	5	0.35	0.1		
	90th			21		132				234				30			17	19	170	1.78	7.7		
K5	N	2	2	4	4	5	2	2	4	5		4		5	2	2	5	5	5	5	5	2	2
2008	min	5.5	14.7	5	0	8	0.96	0.70	7	18		0.11		9	0.07	0.04	7	1	63	0.6	7.5	0.4	0.5
fall	max	64.6	36.5	5	0	190	0.98	1.77	180	147		0.25		26	0.07	0.26	20	11	160	5.8	7.8	0.7	1.7
	mean	35.0	25.6	5	0	65	0.97	1.24	72	53		0.16		16	0.07	0.15	11	5	119	2.1	7.7	0.5	1.1
	stdev	41.8	15.4	0	0	78	0.01	0.76	82	53		0.06		7	0.00	0.16	5	5	35	2.1	0.1	0.2	0.8
	90th	58.6	34.3	5	0	151	0.97	1.66	154	103		0.22		23	0.07	0.23	16	10	148	4.2	7.8	0.6	1.6