Nose Creek Watershed

2012 Water Quality Monitoring Report

For the Nose Creek Watershed Partnership

Palliser Environmental Services Ltd.
March 2013

Nose Creek Watershed Partnership

Palliser Environmental Services Ltd.

Acknowledgements

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Executive Summary

In 2012, the Nose Creek Watershed Partnership (NCWP) completed the fourth year of a surface water quality monitoring program for the Nose Creek watershed as recommended in the Nose Creek Watershed Water Management Plan. Six sites in the watershed were sampled twice monthly during April, May and June and once per month from July to October. In addition, the City of Calgary collected water samples monthly at four sites from January to December. Water monitoring results were compared to the Bow River Basin Council Water Quality Objectives established for the Nose Creek watershed (BRBC 2008).

In 2012, and similar to previous years, water temperature in Nose and West Nose creeks were below the acute objective of 29^{o}C and the chronic objective of 24^{o}C (see table below). The pH compliance rate was also high at Nose Creek (95%) and West Nose Creek (96%) and was the same as or comparable to pH in previous years. Temperature and pH do not appear to be a concern at Nose or West Nose creeks based on established objectives. However, the temperature objectives do not consider cooler temperatures required for trout species which are known to inhabit the lower reach (within the Calgary City Limits) of Nose Creek and West Nose Creek. A lower temperature objective may be more suitable to meet the requirements of coldwater fish species. Cooler water temperatures can be obtained by establishing and maintaining riparian vegetation, particularly trees and shrubs to provide shade.

At Nose Creek, eight samples did not meet the acute dissolved oxygen guideline of 5 mg/L and the chronic seven day guideline of 6.5 mg/L. The compliance rate for acute dissolved oxygen in 2012 (88%) was similar to 2009 and 2011, lower than 2010 but higher compared to 1999-2001. At West Nose Creek, one sample was below the acute 5 mg/L guideline and one sample was below the 6.5 mg/L chronic guideline for dissolved oxygen. Compliance with the acute and chronic dissolved oxygen guidelines has always been greater at West Nose Creek compared to Nose Creek. The diurnal fluctuation of dissolved oxygen at Nose Creek and West Nose Creek is not well understood. However, it is likely that low dissolved oxygen concentrations prevail during the night and on days with heavy cloud cover due to the large amount of instream vegetation (i.e., algae and rooted aquatic macrophytes) that consume oxygen.

Electrical conductivity at Nose Creek ranged from 673 to 2134 uS/cm and 32% of samples met the water quality objective of less than 1000 uS/cm. Compliance rates were higher at West Nose Creek (81%) compared to Nose Creek in 2012 and in previous years. High electrical conductivity within the City of Calgary, particularly during the winter months is a concern. Sources contributing to high conductivity probably include road salt. Ten percent (10%) of samples met the water quality objectives of less than 500 mg/L at Nose Creek and West Nose Creek, which was a compliance rate similar to previous years, with the exception of 2011 which had a higher compliance rate at both creeks. Total dissolved solids followed a trend similar to electrical conductivity.

Total phosphorus ranged from 0.039 to 0.644 mg/L at Nose Creek and 5% of samples complied with the water quality objective of less than 0.05 mg/L. At West Nose Creek concentrations ranged from 0.016 to 1.890 mg/L and 41% of samples complied with the water quality objective. Much of the phosphorus in the creeks is in the dissolved form and is readily available to plants. Phosphorus concentrations are a concern at both creeks since it enriches freshwater (a process known as eutrophication), contributing to the growth of aquatic plants. Although aquatic plants produce oxygen through photosynthesis during the day; however, on cloudy days or during the night, the plants consume oxygen for respiration and can deteriorate fish habitat conditions. In addition, oxygen is used during the decomposition of plant material, again decreasing oxygen resources for fish and other aquatic life. Sources of phosphorus include organic and inorganic fertilizers that are used for agricultural crop production and urban lawn maintenance, livestock manure, pet feces, poorly designed or failing septic systems, and treated municipal effluent. Application of phosphorus at the appropriate rates will limit the amount of excess phosphorus that can be transported to Nose or West Nose creeks.

For nitrate-nitrite nitrogen, 83% of samples met the water quality objective of less than 1.5 mg/L at Nose Creek and West Nose Creek. Nitrate-nitrite nitrogen concentrations are not a concern at Nose and West Nose creeks as compliance was high in 2012 and in previous years. For total ammonia, 98% and 96% of samples met the water quality objective at Nose Creek and West Nose Creek, respectively. Total ammonia concentrations are not a concern at Nose and West Nose creeks as compliance was high in 2012 and in previous years.

Fifty-eight percent (58%) and 44% of samples analysed for fecal and *E. coli* bacteria counts at Nose Creek and West Nose Creek, respectively, met the water quality objective of less than 100 CFU/100 mL (irrigation). Seventy percent (70%) and 67% of samples analysed for fecal and *E. coli* bacteria counts at Nose Creek and West Nose Creek, respectively, met the water quality objective of less than 400 CFU/100 mL (contact recreation). Data from 2009 to 2012 indicates consistently elevated concentrations of *E. coli* at **NC at Mouth** during winter months (October to March). Monitoring of outfalls in the vicinity of the mouth of Nose Creek should be completed to determine the source(s) of elevated bacteria. Elevated fecal coliform counts are a concern at Nose Creek and West Nose Creek. In rural areas, bacteria sources are generally linked to wildlife (e.g., beaver, deer), waterfowl (e.g., ducks and geese) and livestock (e.g., horses and cattle). In addition to waterfowl, large number of dogs and dog parks concentrated in urban centres can contribute bacteria to Nose Creek either directly or via stormwater runoff.

Water quality improvements for Nose Creek and West Nose Creek may be obtained by implementing best management practices in rural and urban areas, including off-stream watering for livestock, streamside fencing, stormwater management in urban areas (reductions in volumes generated, treatment of water in storm ponds), stoop and scoop at dog parks and private yards, reductions in lawn fertilizer and effective street cleaning prior to spring runoff and rainfall. In addition, maintaining and improving riparian area condition will reduce water temperatures via shade from trees and shrubs and aid in the filtration of runoff water prior to flowing into the creeks.

Parameter	Nose Creek					West Nose Creek				
	1999-2001	2009	2010	2011	2012	1999-2001	2009	2010	2011	2012
Temperature	100	100	100	100	100	100	100	100	100	100
pH	95	97	79	99	95	100	100	100	100	96
Dissolved Oxygen-acute	84	91	97	90	88	86	100	100	100	96
Dissolved Oxygen-chronic	69	79	92	79	76	76	95	100	96	93
Electrical Conductivity	38	29	27	63	32	91	90	76	86	81
Total Dissolved Solids	15	0	9	36	10	6	0	0	80	10
Total Phosphorus	2	0	12	4	5	15	52	33	25	41
Dissolved Phosphorus	24	32	37	9	23	19	62	43	32	41
Nitrate-Nitrite Nitrogen	89	83	94	93	83	85	88	93	82	83
Total Ammonia	91	83	88	100	98	97	100	100	100	96
Fecal Coliform - irrigation	42	38	56	67	58	45	38	53	64	44
Fecal Coliform - recreation	76	65	84	90	70	83	71	87	89	67

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1.0 INTRODUCTION

The Nose Creek Watershed Partnership completed the Nose Creek Watershed Water Management Plan (Plan) in 2007. On completion, the City of Airdrie, City of Calgary, Rocky View County, Town of Crossfield and Alberta Environment agreed to implement the recommendations within the Plan to the best of their ability. One of the recommendations in the plan was to integrate the current water quality monitoring that is conducted by various agencies, municipalities and organizations into a comprehensive program that avoids duplication of effort and promotes sharing of information. Palliser Environmental Services Ltd. was retained to develop a comprehensive long-term water monitoring strategy for the Nose Creek watershed that is consistent with the recommendations and implementation actions of the Nose Creek Watershed Water Management Plan (2007) and the water quality objectives set for Nose Creek by the Bow River Basin Council (BRBC) (2008). The 2008 BRBC water quality guidelines for dissolved phosphorus, total phosphorus and pathogens (as indicated by *E. coli*), dissolved oxygen and total suspended solids were revised in 2010/2011 for Nose Creek.

Effective watershed management includes monitoring the state of air, land and water resources. Monitoring water resources in terms of its physical, chemical and biological character allows managers to determine if the water quality meets requirements for various uses, including human, livestock and ecological (aquatic) needs. Water monitoring can also provide insight into land management practices as runoff quality is reflected in surface water bodies (e.g., stormwater from urban and rural landscapes). Flow volumes may increase or decrease according to changes in land cover. Water monitoring is a critical decision-support system for any water management program. With appropriate water quality data, land managers can make decisions that will help protect the integrity of water bodies for future generations.

The Bow River Basin Council has identified reach-specific desired outcomes for the Bow River watershed (BRBC). For the Nose Creek watershed the desired outcomes are:

- Surface water quality that is appropriate for irrigation of crops.
- Surface water quality that is appropriate for livestock watering.
- Surface water quality where water withdrawal systems are protected from high levels of algae and/or macrophytes.
- Surface water quality that maintains the existing cool-water aquatic ecosystem fauna structure and abundance (e.g., healthy pike populations and benthic invertebrates) (BRBC 2008).

Short- to long-term performance monitoring and management recommendations for the Nose Creek as identified by the BRBC (2008) are summarized in Appendix A.

Palliser Environmental Services Ltd. (PESL) was contracted in 2012 to monitor six sites identified in the Long-Term Water Monitoring Strategy. The City of Calgary monitored four sites in the watershed as part of their monitoring program.

2.0 BACKGROUND

2.1 Water Quality Parameters

The Nose Creek watershed water monitoring program monitors 11 parameters that describe the physical and chemical state of stream quality: temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, total phosphorus, dissolved phosphorus, nitrate+nitrite nitrogen, total ammonia, fecal coliform bacteria, and total suspended solids. A short description (sources, concerns) of each water quality variable is presented below. In addition, the water monitoring program measures discharge (water volume) at water quality sites.

Temperature

Water temperature has direct and indirect effects on nearly all aspects of aquatic ecology. The amount of oxygen that can be dissolved in water is partly governed by temperature. Cold water can hold more oxygen than warm water. Temperature also influences the rate of photosynthesis by algae and aquatic plants (BRBC 2008) and is an important determinant of total ammonia (NH_3) concentrations. Fish species also have specific preference and tolerances for water temperatures. Cold water species (trout and whitefish) select summer water temperatures from 10 to 18^{o}C whereas cool water species (e.g., pike, fathead minnow, brook stickleback) select summer water temperatures from 18 to 26^{o}C (Nelson and Paetz 1992).

pH

This is a logarithmic scale based on the Hydrogen Ion concentration by which water and other substances are measured to determine if they are acidic, neutral or alkaline. The midpoint of the scale is pH 7.0 and is neutral. Readings from 0 to <7.0 are acidic and the lower the number the more strongly acid the solution. Battery acid has a pH value of approximately 0. Readings from >7.0 to 14 are alkaline, with the higher numbers indicating a strongly basic or alkaline solution. Chlorine bleach has a pH of approximately 13. pH is an important determinant of total ammonia (NH_3) concentration as increasing the acidity of a solution by one pH unit can cause the total ammonia to increase tenfold. The provincial pH guideline for the protection of freshwater aquatic life is 6.5 to 8.5. The federal pH guideline for the protection of freshwater aquatic life is 6.5 to 9.0 (Alberta Environment 1999).

Dissolved Oxygen

Oxygen is vital to freshwater organisms. Oxygen is soluble in water and the solubility increases with decreasing water temperature (i.e., cold water holds more oxygen). Oxygen enters the water directly from the atmosphere or by aquatic plant/algae photosynthesis. Oxygen is removed by the respiration of animals and plants and by organic decomposition. The provincial oxygen guideline for the protection of freshwater aquatic life is 5 mg/L (acute: 1 day minimum) and 6.5 mg/L (chronic: 7 day mean). The federal cold water biota oxygen guideline for the protection of freshwater aquatic life is 6.5 mg/L (other life stages) to 9.5 mg/L (early life stages) (Alberta Environment 1999).

Electrical Conductivity

Electrical Conductivity (EC) is the measure of minerals (e.g., sodium, chloride, magnesium, potassium) dissolved in the water (total dissolved solids), or the salinity. EC is measured as the resistance of a solution to electrical flow; therefore, the purer the water is (i.e., the lower its salinity) the greater its resistance to electrical flow will be. EC, when applied to water, refers to the electrical charge of a given water sample and is expressed as micro Seimens per centimeter (μS/cm) (USEPA 1978; Cole 1994). Sources can include soil and mineral weathering, surface runoff from saline soils, groundwater discharge, municipal and industrial effluents, agricultural runoff and aerosol fallout. Excessive salts applied to soils may interfere with extraction of water by plants. High total dissolved solids may also affect taste and palatability of drinking water and at high concentrations may have a laxative effect. High conductivity water is also undesirable in most industrial process waters. The irrigation guideline for electrical conductivity is 1000 µS /cm (Alberta Agriculture 1983); however, this does not provide adequate protection for crops sensitive to salinity such as strawberries, raspberries, beans and carrots. To protect these crops a guideline limit of 700 µS/cm is recommended (CCREM 1987).

Total Dissolved Solids

Total dissolved solids (TDS) comprise inorganic salts and small amounts of organic matter that are dissolved in water. TDS refers to the total amount of substances in the water other than the pure water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulphate and, particularly in groundwater, nitrate (from agricultural use). Conductivity measurements are converted to TDS values by a factor that varies with the type of water, typically 0.55 to 0.75. For irrigation water, the TDS should not exceed 500 to 3500 mg/L, depending on the crop. For livestock water, the TDS should not exceed 3000 mg/L (AENV 1999).

Total and Dissolved Phosphorus

Phosphorus is an essential nutrient required for plant growth. Sources of phosphorus can include animal manures (e.g., cattle, waterfowl), commercial inorganic fertilizers, sewage treatment plants, phosphate-containing detergents, food processing plants, urban runoff, atmospheric deposition, and natural levels found in soils and bottom sediments. Total phosphorus (TP) measures the nutrient in all forms whether particulate or dissolved, organic or inorganic. Dissolved phosphorus (DP) indicates the phosphorus not associated with sediment particles. Dissolved phosphorus is a closer measure of the nutrient more readily available for plant growth, though the phosphorus in particulate form is potentially available for plant growth through time. The particulate phosphorus concentration gives an indication of the sediments suspended in the water column.

Excessive nutrients in water can cause eutrophic conditions with increased algae and weed growth. In some circumstances, increased plant abundance can change the chemistry of the water, affect oxygen concentrations (through photosynthesis /respiration and decay of organic matter), affect aesthetics and affect the physical movement of water. Dense growths of filamentous algae and aquatic plants can physically block culverts and clog water intakes. Certain strains of algae can impart an off-taste to drinking water and in some instances blue-green algae produce a toxin that can cause health issues for humans and is toxic to livestock and waterfowl. Phosphorus concentrations are expressed as milligrams per litre (mg/L) of water (USEPA 1978; Cole 1994). Total phosphorus concentration guidelines for rivers (Environment Canada 2004) range from 0.025 to 0.050 mg/L, with Alberta and Manitoba guidelines at 0.050 mg/L, Ontario and Quebec at 0.030 mg/L and Australia and New Zealand at 0.035 to 0.037mg/L. These are typically for the protection of aquatic life.

Nitrate+Nitrite Nitrogen

Nitrate is the principal and most stable form of inorganic nitrogen in aquatic environments. Nitrite is an intermediate form in the nitrification/denitrification pathway and can be toxic; however, it is usually found in low concentrations because of its instability in the presence of oxygen. Nitrate and nitrite are typically reported as a combined concentration due to the instability of nitrite. Natural sources of nitrogen to surface water bodies can include atmospheric deposition. Human sources of nitrogen include municipal and industrial wastewater, septic tanks and runoff from agricultural practices. Nitrate is necessary for plant growth; however, elevated concentrations can also result in the excessive growth of algae and aquatic plants. High concentrations of nitrate can pose a toxic risk for infants and livestock watering. The nitrate-nitrite water quality objective for Nose Creek is <1.5 mg/L chosen from the City of Calgary Total Loading Management Target that corresponds to 5 mg/L oxygen for the period April 1 to September 30 (BRBC 2008). The nitrate+nitrite guideline for the protection of livestock water is <100 mg/L and the nitrite guideline for the protection of livestock water is <10 mg/L (AENV 1999).

Total Ammonia

Total ammonia is the most reduced form of inorganic nitrogen in water and includes both the ionized (NH_4) and un-ionized forms (NH_3). Un-ionized ammonia (NH3) is the toxic form and its concentration depends on a combination of pH and water temperature. In most well-oxygenated waters, ammonia is quickly converted to nitrate. Ammonia is produced by the decomposition of organic matter. Ammonia can be found in municipal and industrial wastewater effluent and in runoff downstream of fields with intensive manure or fertilizer applications (BRBC 2008). Measurements of total ammonia in the aquatic environment are often expressed as `total ammonia-nitrogen` and is the sum of ammonia (NH_3) and ammonium (NH_4). The total ammonia target for Nose Creek is the CCME guideline which varies depending on water temperature and pH.

Fecal Coliform Bacteria

Fecal coliform bacteria (FCB) are specific to the intestinal tracts of warm-blooded animals (cattle, birds, pets etc.) and humans and are thus a more specific test for animal waste or sewage contamination. FCB can enter surface waters through fecal contamination by wildlife, domestic animals and through wastewater discharges or surface water runoff. Fecal coliform bacteria are not necessarily harmful to human health, but they indicate fecal contamination and the possible presence of other pathogenic organisms including *Escherichia coli* (*E. coli*), *Salmonella*, *Giardia* and *Cryptosporidium* which can have serious health implications affecting drinking water, irrigation, livestock watering and recreation (BRBC 2008). FCB can be a concern for fresh garden produce particularly leafy crops such as lettuce. Fecal coliform bacteria levels are expressed as the number of bacteria colonies per 100 mL of water. The irrigation guideline for fecal coliform bacteria is 100 colonies per 100 mL (Alberta Environment 1999).

Total Suspended Solids

Total suspended solids (TSS) are a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms which are held in suspension in water. Total suspended solids concentrations are expressed as milligrams per litre (mg/L) of water (USEPA 1978). Suspended solids can transport nutrients and contaminants downstream and may be aesthetically undesirable. Excessively high TSS in irrigation water can cause the formation of crusts on top of the soil which can inhibit water infiltration, and plant emergence and impedes soil aeration. The formation of films on plant leaves can reduce sunlight and impede photosynthesis. TSS residues can reduce the marketability of some leafy crops such as lettuce. High TSS can interfere with the treatment of drinking and industrial process water. High concentrations of suspended and deposited sediment can reduce benthic invertebrate abundance and species richness. Deposited sediment can fill in deep pools and bury spawning gravels leading to reduced survival of fry fish. Sub-lethal effects on fish can include avoidance/re-distribution, reduced feeding/growth, respiratory impairment, reduced tolerance to disease and increased physiological stress. In very high concentrations, suspended sediment can result in direct mortality of fish (Waters 1995). For the protection of aquatic life, the AENV (1999) chronic guideline indicates TSS should not be increased by more than 10 mg/L above background.

2.2 Bow River Basin Water Quality Objectives for Nose Creek

Table 1 summarizes the water quality objectives or targets identified for the Nose Creek watershed by the Bow River Basin Council (BRBC).

Table 1 - Summary of indicators identified in the BRBC Watershed Management Plan (2008). Dissolved phosphorus and pathogen water quality targets/objectives were updated in 2011 by BRBC.

Indicator	WQO/Target
Water Temperature	WQO: should not exceed 29°C at any time or a 7 day mean of 24°C.
Dissolved Oxygen	Provisional WQO: ≥5.0 mg/L (acute daily minimum); ≥6.5 mg/L (7-day average)
Total Phosphorus	Provisional WQO: 0.05 mg/L (AENV 1999).
Total Dissolved Phosphorus	Provisional WQO: 0.02 mg/L.
Nitrate + Nitrite Nitrogen	WQO: <1.5 mg/L. Target: eliminate levels that cause nuisance aquatic plant growth.
Total Ammonia	Target: Should not exceed CCME guidelines for aquatic life. Guideline is variable depending on temperature and pH (table available in CCME fact sheet).
Pathogens as indicated by *E. coli*	Provisional WQO: Meet recreational guideline - no single value to exceed 400 *E. coli* per 100 mL or <200 *E. coli*/100 mL (geometric mean 5 samples/30 day)[a]
Total Suspended Solids	A severity-of-ill-effects (SEV) guideline was developed in 2011; however, the SEV guideline is only suitable for monitoring instream disturbances and is not intended for long-term water quality monitoring. Calculation of a compliance rate was therefore not possible.
Attached Algae (Periphyton biomass defined as chlorophyll *a*)	WQO: No periphytic algal biomass that adversely affects users. Target: 150 mg/m^2 maximum value during open water season.
Pesticides and degradation products	WQO: not recommended at this time. Target: should not exceed CCME guidelines for aquatic life in the river.
Riparian Condition	Target for Nose Creek: a 'Healthy with Problems' rating. Target for West Nose Creek: a 'Healthy' rating
Runoff, soil erosion and impervious areas	Target: impervious and runoff recommendations as detailed in the Nose Creek Watershed Water Management Plan.

[a]: Due to sampling frequency, only the 400 CFU/100 mL. objective can be evaluated within the NCWP monitoring program

3.0 METHODS

Ten sites within the Nose Creek watershed were sampled twice monthly during April, May and June and once per month from June to October 2012 (Figure 1). More frequent sampling during April to June was completed to account for the spring runoff and the higher rainfall during these months. The number of samples collected at each site in 2012 ranged from 6 (some sites were dry in late summer) to 10. Five sites were located on Nose Creek and one site was on West Nose Creek (Table 2). Grab samples were collected at each site with bottles supplied by ALS Laboratories (Calgary) and using standard protocols (e.g., triple rinsing and preservation, where required). Water samples were kept on ice in coolers and transported to ALS Laboratories. ALS

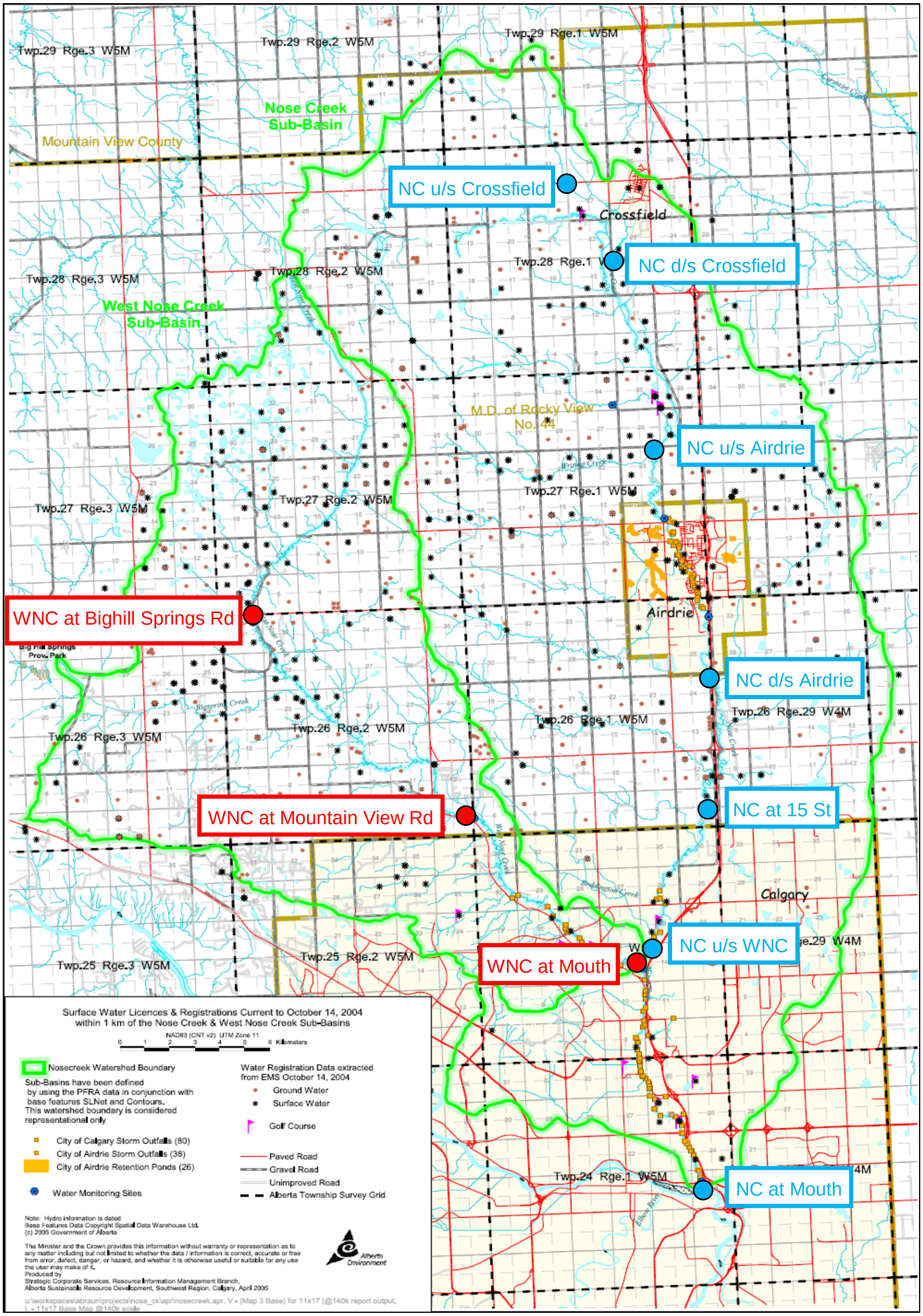

Figure 1 - Map of water quality monitoring sample locations for Nose Creek (blue) and West Nose Creek (red). Note sample locations are approximate.

Laboratories is a CALA[1] accredited lab for criteria and standards established by the Association under their Certificate of Laboratory Proficiency. Samples were analysed using APHA[2] approved methods for total ammonia-N (NH_4 + NH_3), total phosphorus (TP), dissolved phosphorus (DP), total suspended solids (TSS) and fecal coliform bacteria (FCB). At each site *in situ* water quality was completed by measuring dissolved oxygen, percent oxygen saturation, water temperature, pH, total dissolved solids and electrical conductivity using a Hanna (Model HI 9828) multi-parameter water quality meter. Water samples from Nose Creek were collected between 11:00 am and 11:20 am (**NC u/s Crossfield**), 11:30 am and 12:10 pm (**NC d/s Crossfield**), 12:30 pm and 1:00 pm (**NC u/s Airdrie**), 1:25 pm and 3:00 pm (**NC d/s Airdrie**), 9:40 am and 10:15 am (**NC u/s WNC**), 9:20 am and 10:51 am (**NC at 15 St**) and 9:01 am and 10:18 am (**NC at Mouth**). Water samples from West Nose Creek were collected between 12:35 pm and 2:00 pm (**WNC at Bighill Springs Rd**), 9:57 am and 11:26 am (**WNC at Mountain View Rd**) and 9:20 am and 10:25 am (**WNC at Mouth**).

Discharge at the sites monitored by PESL was calculated using a Swoffer water velocity meter (Model 2100). The discharge was calculated as a function of width, depth and water velocity (i.e., the velocity-area method). The mean number of panels (width x depth x velocity) completed at each discharge transect was 17 (range: 8 to 31) for Nose Creek and 17 (range 12 to 21) for West Nose Creek. Staff gauges were installed at five locations: **NC u/s Crossfield**, **NC d/s Crossfield**, **NC u/s Airdrie**, **NC d/s Airdrie** and **NC u/s WNC**. The water level on the staff gauge was recorded each time a discharge measurement was calculated.

The City of Calgary Water Quality Services (WQS) collected water samples from Nose Creek at two sites (**Nose Creek at Mouth** and **Nose Creek at 15 St**) from January to December, collecting a sample once per month. At West Nose Creek, **West Nose Creek at Mountain View Rd** was sampled from March to December (once per month) and **West Nose Creek at Mouth** was sampled from April to October (once per month) (Table 2). The samples were analysed for total phosphorus, total dissolved phosphorus, total suspended solids, nitrate+nitrite nitrogen (NO_3+NO_2 –N), total ammonia and E*. coli* at the City's WQS Laboratory using APHA approved methods. The City of Calgary is a CALA accredited laboratory. The City of Calgary staff used a YSI 556 MPS (Multi-Probe System) meter to measure *in situ* pH, conductivity, water temperature and dissolved oxygen at the four sites.

All water chemistry data was summarized into tables by site and sampling date and values exceeding the guideline were shown as a bold font. Sample data for total phosphorus, dissolved phosphorus, fecal coliform and total suspended solids were divided into three groups according to season and expected water quality/quantity conditions:

Winter: November to March (low flow, low biological activity, ice-covered conditions),
Spring: April to June (higher flow, spring runoff),
Summer: July to October (moderate flow, high biological activity).

These data were summarized by median values on an annual basis (2012) and by season and presented in graph format (annual data). The data for each site were compared to water quality objectives established by the Bow River Basin Council (BRBC WQOs) to determine compliance. Overall, the data were summarized in a percent compliance format.

[1] CALA – Canadian Association for Laboratory Accreditation Inc.
[2] APHA – American Public Health Association

Table 2 – Site descriptions and locations for the Nose Creek Watershed Partnership water quality monitoring program. Sites marked with an * (asterisk) were sampled by the City of Calgary.

Site Name	UTM Coordinates		Staff Gauge Location
Nose Creek (NC)			
NC u/s Crossfield	11U703543	5701784	Installed along right downstream bank, mounted on T-post, snug to bank. Staff gauge destroyed in late 2012 after re-fencing allowed cattle access to the gauge.
NC d/s Crossfield	11U705270	5698762	Staff gauge installed on south side of post in the east side of the culvert (upstream end). Installed in 2010.
NC u/s Airdrie	11U707182	5690627	Installed on wood piling, along right downstream bank, underneath bridge. Installed in 2010.
NC d/s Airdrie	11U709175	5682704	Installed along right downstream bank and mounted on T-post, snug to bank. May move with ice. Staff gauge was washed away during high flows in 2011 and site back flooded by a beaver dam.
NC at 15 St*	11U708027	5673032	No staff gauge or discharge monitoring at this site.
NC u/s WNC	11U706614	5668605	Installed along left downstream bank on T-post, snug to bank. May move with ice.
NC at Mouth*	11U708859	5659391	No staff gauge or discharge monitoring at this site.
West Nose Creek (WNC)			
WNC at Bighill Springs Rd	11U690928	5683285	No staff gauge at this site.
WNC at Mountain View Rd*	11U699702	5674845	No staff gauge or discharge monitoring at this site.
WNC at Mouth*	11U706601	5668415	No staff gauge or discharge monitoring at this site.

4.0 RESULTS

4.1 Compliance with Water Quality Objectives

Table 3 summarizes the 2012 water quality percent compliance with the recommended water quality guidelines and compares historical compliance rates from 2011, 2010, 2009 and 1999-2001. Table 3 also provides the total precipitation data for the study years. The driest summer and winter was in 2012 which surprisingly had the wettest spring. Overall precipitation in 2012 was lower at 368 mm. The year 2011 was the wettest year (519 mm) with the second wettest spring (223 mm). One of the driest years was 2009 (328 mm) with the driest spring (68 mm). The year 2010 was also a wet year (455 mm), particularly the summer (226 mm). The combined years 1999-2001 had average precipitation; although, the year 2000 was the driest (318 mm) and had the second driest summer (104 mm). The year 1999 had the driest winter (32 mm).

Some trends with water quality compliance and total precipitation are apparent. Fecal coliform bacteria and dissolved oxygen generally had higher compliance rates in wet years (2010 and 2011) compared to drier years (1999-2001, 2009, 2012). No other trends were apparent with compliance rates and total precipitation. Analysis of median parameter concentrations by season/year with total precipitation may reveal stronger trends; however, such analysis is beyond the scope of this baseline water quality monitoring report.

Higher fecal coliform compliance during wet years may seem counterintuitive as runoff from rural agricultural pastures and impervious surfaces in urban areas typically carries high bacteria numbers (Young and Thackston 1999); however, a large amount of runoff could serve to dilute (lower) bacteria numbers; whereas, in dry years discharge from point sources of runoff (outfalls, sediment ponds) can contribute high numbers of bacteria to the base flow of streams (Gregory and Frick 2000). The higher compliance of oxygen during wet years is probably due to increased stream flows (less stagnation) and cooler water temperatures (cooler water can hold more dissolved oxygen).

Table 3 – Summary of historical (1999-2001, 2009, 2010, 2011) water quality compliance rates (%) in comparison with 2012 for Nose Creek and West Nose Creek.

Parameter	Nose Creek					West Nose Creek					BRBC WQOs
	1999-2001	2009	2010	2011	2012	1999-2001	2009	2010	2011	2012	
Temperature	100	100	100	100	100	100	100	100	100	100	WQO: Should not exceed 29°C at any time or 7-day mean of 24°C.
pH	95	97	79	99	95	100	100	100	100	96	6.5 – 9.0[b]
Dissolved Oxygen	84	91	97	90	88	86	100	100	100	96	≥5.0 mg/L (1-day acute)
	69	79	92	79	76	76	95	100	96	93	≥6.5 mg/L (mean 7-day chronic)
Electrical Conductivity	38	29	27	63	32	91	90	76	86	81	<1000 µS/cm[c]
Total Dissolved Solids	15	0	9	36	10	6	0	0	80	10	<500 mg/L[d]
Total Phosphorus	2	0	12	4	5	15	52	33	25	41	<0.05 mg/L
Dissolved Phosphorus	24	32	37	9	23	19	62	43	32	41	<0.02 mg/L
Nitrate-Nitrite Nitrogen	89	83	94	93	83	85	88	93	82	83	<1.5 mg/L
Total Ammonia	91	83	88	100	98	97	100	100	100	96	Guideline depends on pH and temperature: CCME table
Fecal Coliform Bacteria (*E. coli*)	42	38	56	67	58	45	38	53	64	44	Not to exceed 100 CFU/100 mL: irrigation guideline
	76	65	84	90	70	83	71	87	89	67	No single value to exceed 400 CFU/100 mL: contact recreation

PRECIPITATION DATA

Time Period	1999-2001	2009	2010	2011	2012[f]	Comments
Total Precipitation (mm):Jan-Dec	318 – 459, mean: 397	328	455	519	368	Majority of precipitation during winter falls as snow. Converted to water equivalent for 'total precipitation'.
Total Precipitation (mm):spring	156 – 221, mean: 183	68	180	223	235	
Total Precipitation (mm):summer	104 – 206, mean: 165	166	226	216	99	
Total Precipitation (mm):winter	32 – 71, mean: 49	94	49	80	33	

[a] Madawaska Consulting 2002
[b] pH guideline is from CCREM (1987)
[c] conductivity guideline is for irrigation (Alberta Agriculture 1983)
[d] AENV (1999) guideline for irrigation
[e] Precipitation data is from Calgary International Airport (www.climate.weatheroffice.gc.ca: National Climate Data and Information Archive). Total Precipitation: the sum of the total rainfall and the water equivalent of the total snowfall.
[f] Total Precipitation (mm) by Month: January 1.3, February 7.8, March 10.5, April 47.2, May 54.9, June 132.9, July 36.9, August 28.4, September 3.7, October 30.4, November 5.6, December 8.1

4.2 Water Quantity (Discharge)

The five discharge sites at Nose Creek had varied stream widths due to a range of flows in 2011: **NC u/s Crossfield** (0.75 to 1.35 m: mean 1.03 m), **NC d/s Crossfield** (0.86 to 2.40 m: mean 1.40 m), **NC u/s Airdrie** (4.9 to 10.60 m: mean 8.00 m), **NC d/s Airdrie** (3.00 to 7.10 m: mean 5.15 m) and **NC u/s WNC** (4.25 to 5.60 m: mean 4.78 m). In 2012, the discharge within Nose Creek varied substantially by location and date ranging from 0.0 to 2.259 m^3/s (Table 4). Three of the highest flows at the five Nose Creek sites occurred in early June. On June 6 the water level was too high to safely obtain a discharge at **NC u/s WNC**. There was discharge at **NC u/s Crossfield** and **NC d/s Crossfield** during early-April to late-June but from July to October these two sites contained only minor flow, no flow or were dry. **Nose Creek u/s Airdrie** had flows from April to late-June, but only minor flow or no flow was observed from July to October (Table 4). **Nose Creek d/s Airdrie** and **NC u/s WNC** showed similar discharge patterns with lower flows in April, higher flow from early-May to late June (0.187 to 2.080 m^3/s), lower flow during July, and higher flows in August followed by a sharp decline in flow during September and October (minor flow to 0.062 m^3/s). Although the two sites **Nose Creek u/s Airdrie** and **Nose Creek d/s Airdrie** are relatively close to each other, discharge at **Nose Creek d/s Airdrie** ranged from 1.1 to 8.0 times higher than the corresponding flow at **NC u/s Airdrie**. During July to October when minor to no flow was recorded at **NC u/s Airdrie** there was a recorded flow at **Nose Creek d/s Airdrie** (0.015 to 0.690 m^3/s). This indicates that precipitation runoff and discharge from stormwater ponds and outfalls in Airdrie can contribute a substantial amount of flow to Nose Creek. The highest measured discharge in Nose Creek was 2.259 m^3/s on August 15th at **NC u/s WNC** (Table 4); although, a higher flow would have occurred on June 6th at this site when a measurement could not be obtained due to high flow.

Of the four monitoring years (2009 to 2012) at Nose Creek, 2009 had the lowest discharge (low spring precipitation) and 2011 had the highest discharge (higher spring and summer precipitation). Discharge in 2010 and 2012 (moderate spring and summer precipitation) was intermediate compared to 2009 and 2011.

Table 4 - Water discharge (m^3/s) at sites within Nose Creek and West Nose Creek, from April to October 2012. Shaded cell indicates maximum discharge for site.

Date	Nose Creek					West Nose Creek
	NC u/s Crossfield	NC d/s Crossfield	NC u/s Airdrie	NC d/s Airdrie	NC u/s WNC	WNC at Big Hill Springs Rd
Apr-5	minor flow	0.013	0.138	0.153	0.157	0.076
Apr-25	0.008	0.049	0.186	0.205	0.283	0.116
May-9	0.073	0.187	0.480	0.809	1.137	0.198
May-23	0.001	0.004	0.056	0.187	0.632	0.097
Jun-6	0.007	0.478	0.261	2.080	flood	0.599
Jun-20	0.055	0.100	0.851	1.159	1.333	0.129
Jul-18	no flow	minor flow	minor flow	0.158	0.357	0.033
Aug-15	no flow	minor flow	no flow	0.690	2.259	0.032
Sep-20	dry	dry	no flow	0.015	minor flow	0.014
Oct-18	no flow	no flow	minor flow	0.041	0.062	0.030

flood: water levels very high and unsafe
minor flow: water movement visible but too slow to register on velocity meter, discharge probably <0.001 m^3/s
no flow: no visible water movement, but standing water may be present
dry: no moving or standing water, substrate is exposed and dry

The discharge site at West Nose Creek ranged in width from 1.75 to 2.80 m with a mean width of 2.08 m. The discharge at the West Nose Creek site ranged between 0.014 and 0.599 m^3/s with the highest flow in early June (during numerous precipitation events) and the lowest flow in late-September, a month which had only 3.7 mm of precipitation (Table 4). Of the four monitoring years (2009 to 2012) at **WNC at Big Hill Springs Rd**, 2009 had the lowest discharge (low spring precipitation) and 2011 had the highest discharge (higher spring and summer precipitation). Discharge in 2010 and 2012 (moderate spring and summer precipitation) was intermediate between 2009 and 2011. The consistent discharge from July to September 2012 during a low-precipitation summer suggests a base flow from groundwater sources at **WNC at Big Hill Springs Rd.** A similar observation was made in 2009.

4.3 Water Quality Parameters

Temperature

Water temperature in 2012 at Nose Creek ranged from -0.1 to 22.9°C (N=66) at the seven sites (Table 5). The lowest temperature (-0.1°C) occurred in November, December and January at **NC at 15 St** and the warmest water temperature (22.9°C) occurred July 18th at **NC d/s Airdrie** (Table 5) which was a similar result to 2011. All of the water sample temperatures at Nose Creek were below the water quality objective of 29°C (acute) and 24°C (7-day chronic). The water temperature compliance rate at Nose Creek in 2012 (100%) was the same as historical compliance data in 2011, 2010, 2009 and 1999-2001 (Table 3).

Water temperature in 2012 at West Nose Creek ranged from -0.1 to 19.7°C (N=27) (January through December (Table 5) at the three sites (Table 5). The lowest temperature (-0.1°C) occurred in November and December during the freeze-up period and the warmest water temperature (19.7°C) occurred July 18th at **WNC at Big Hill Springs Rd** (Table 5). All of the water temperatures at West Nose Creek were below the water quality objective of 29°C (acute) and 24°C (7-day chronic). The water temperature compliance rate in 2012 (100%) at West Nose Creek was the same as historical compliance data in 2011, 2010, 2009 and 1999-2001 (Table 3).

Water temperatures in streams and rivers undergo a diurnal[3] cycle with the maxima usually occurring in the afternoon and the minima occurring during the latter half of the night. In small streams in the summer the diurnal fluctuations in temperature are not usually greater than 6°C (Hynes 1970; Hauer and Hill 1996). The water temperatures collected from June to August during this study would represent maximum or near maximum temperature for those collected in the afternoon (i.e., **NC u/s Airdrie**, **NC d/s Airdrie** and **WNC at Big Hill Springs Rd**) while those collected in the morning would represent temperatures somewhere between the minimum and maximum. In all likelihood, the compliance rate would remain the same (100%) if the maximum temperature had been collected at each site. In 2009, Morris (2009) continuously monitored water temperature every 30 minutes at **NC u/s Airdrie** and **NC at Mouth** from June 23 to September 4, a low-flow, low-precipitation year. The maximum (acute) temperature of 29°C was never exceeded at either site and the chronic 7-day temperature of 24°C was not reached at **NC at Mouth** and water temperatures only briefly exceeded 24°C for 1 and 2 days in July (Morris 2009).

Since 2007, brown trout (*Salmo trutta*) and mountain whitefish (*Prosopium williamsoni*) have been captured in Nose Creek from the confluence with the Bow River, upstream to the

[3] Diurnal: Having a daily cycle or pattern that re-occurs every 24 hours, synonymous with the term 'diel.'

confluence with West Nose Creek. At West Nose Creek, brown trout, brook trout (*Salvelinus fontinalis*) and mountain whitefish have been captured in the lowermost portion within Confluence Park. The current water temperature objective for Nose Creek (Objective: should not exceed 29^{o}C at any time or a 7-day mean of 24^{o}C) is too warm if trout populations are to remain and expand their range within Nose and West Nose creeks. It is recommended that the water temperature objective that the Bow River Basin council has adopted for the Bow River Central (Objective: should not exceed 22^{o}C at any time or a 7-day mean of >18^{o}C) is more appropriate for the lower reaches of Nose Creek and West Nose Creek. A review of water temperature data from 2009 to 2012 indicates both creeks are almost always in compliance with the more stringent water temperature objective.

pH

In 2012, the pH of water samples from Nose Creek ranged from 7.11 to 10.07 (N=66). At Nose Creek, 95% of the samples were within the pH target compliance objective (6.5 to 9.0), with the three non-compliances occurring April 5th at **NC u/s Crossfield**, **NC d/s Crossfield** and **NC d/s Airdrie**. No samples at Nose Creek were below the lower limit of the target compliance objective (i.e., <6.5) (Table 6). The pH compliance rate at Nose Creek in 2012 (95%) was similar to 2011 (99%), 2009 (97%) and 1999-2001 (95%) and higher when compared to 2010 (79%) (Table 3).

In 2012, the pH of water samples from West Nose Creek ranged from 8.2 to 9.10 (N=27). At West Nose Creek, 96% of the samples met the target compliance objective for pH. No samples at West Nose Creek were below the lower limit of the target compliance objective (i.e., <6.5) (Table 6). The single non-compliance occurred on April 5th at **WNC at Big Hill Springs Rd** when the pH was 9.10. The pH compliance rate at West Nose Creek in 2012 (96%) was similar when compared to historical data in 2011 (100%) 2010 (100%), 2009 (100%) and 1999-2001 (100%) (Table 3).

pH tends to undergo a diurnal fluctuation during the active growing season that is mediated by plant photosynthesis. The highest pH values occur during peak photosynthesis (afternoon) and the lowest pH values occur during plant respiration (late evening/early morning). During photosynthesis plants absorb carbon dioxide (CO_2), eliminate bicarbonates, precipitate carbonates and form hydroxyl ions which lead to an increase in pH. Conversely, at night plants undergo a process of respiration which releases CO_2 and lowers the pH. In 2009, Morris (2009) continuously monitored pH every 30 minutes at **NC u/s Airdrie** and **NC at Mouth** from June 23 to September 4, a low-flow, low-precipitation year. The pH never fell below 6.5 at either site, and the pH never exceeded 9.0 at the **NC at Mouth** site. At **NC u/s Airdrie**, the pH was generally above 9.0 from late-June to late-July and was below 9.0 from late-July to early-September (Morris 2009). The continuously high pH in 2009 at **NC u/s Airdrie** may have been due to the fact that the site had no flow (i.e., site was stagnant) and was subject to intensified photosynthesis for much of the study whereas in 2010 and 2011 the site was continuously flowing. In this study, **NC u/s Airdrie**, **NC d/s Airdrie** and **WNC at Big Hill Springs Rd** samples were collected between 12:30 pm to 3:00 pm and probably represent the maximum or near maximum pH. At the other sites in this study the maximum pH may not have been reached at the time of sampling and the compliance rate may be overestimated if the late-day pH maximum was greater than 9.0.

Table 5 - Water temperature (^{o}C) data from Nose Creek and West Nose Creek, January to December 2012. A yellow value indicates the temperature may have exceeded the chronic 7-day water temperature objective for that site and date. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

Temperature (°C)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																						
NC u/s Crossfield				0.8		8.8	9.6		9.6	13.6		14.2		nf	nf			dry	nf			
NC d/s Crossfield				1.2		11.1	10.5		12.1	14.2		15.7		19.1	13.4			dry	nf			
NC u/s Airdrie				0.8		10.2	11.4		13.9	15.2		16.1		20.5	15.0			nf	nf			
NC d/s Airdrie				4.6		13.6	12.9		14.9	15.4		16.4		22.9	17.8			15.0	6.7			
NC at 15 St	-0.1	0.0	0.0		0.2			13.5			15.1		18.3			18.6	9.8			0.9	-0.1	-0.1
NC u/s WNC				1.1		11.3	11.7		12.3	13.9		14.6		15.3	15.9			11.4	2.7			
NC at Mouth	0.0	0.0	0.0		4.0			13.9			15.1		18.2			18.3	11.1			2.9	0.0	0.0
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				1.3		10.6	10.1		12.9	12.5		14.4		19.7	15.6			11.0	2.1			
WNC at Mountain View Rd			0.0		2.2			11.3			13.2		15.9			16.7	8.5			0.8	-0.1	-0.1
WNC at Mouth					2.9			11.3			13.4		16.9			15.7	9.8			2.5		

Table 6 - pH data from Nose Creek and West Nose Creek, January to December 2012. A red value indicates the pH exceeded the pH water quality objective for that site and date. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

pH	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																						
NC u/s Crossfield				**9.13**		8.22	8.45		7.40	7.91		7.98		nf	nf			dry	nf			
NC d/s Crossfield				**10.07**		8.96	8.74		8.45	8.26		8.33		8.59	8.20			dry	nf			
NC u/s Airdrie				8.93		8.40	8.26		8.36	8.29		7.98		7.91	8.18			nf	nf			
NC d/s Airdrie				**9.83**		8.72	8.53		8.71	8.52		8.06		8.31	8.65			8.62	8.66			
NC at 15 St	7.9	7.6	8.2		8.5			8.6			8.4		8.5			8.9	8.7			8.6	8.2	7.9
NC u/s WNC				7.11		8.78	8.29		8.20	8.02		8.32		8.06	8.34			8.04	8.42			
NC at Mouth	8.1	8.2	8.2		8.5			8.7			8.3		8.2			8.4	8.3			8.4	8.3	8.2
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				**9.10**		8.35	8.35		8.30	8.41		8.22		8.32	8.35			8.31	8.46			
WNC at Mountain View Rd			8.3		8.4			8.4			8.5		8.4			8.5	8.5			8.5	8.2	8.2
WNC at Mouth					8.4			8.5			8.5		8.3			8.4	8.4			8.4		

Dissolved Oxygen

Dissolved oxygen in Nose Creek ranged from 1.84 to 13.26 mg/L (N=66) in 2012 (Table 7). At Nose Creek, eight samples were less than the 1-day 5.0 mg/L acute dissolved oxygen objective, resulting in an 88% compliance rate. Five of the lowest dissolved oxygen concentrations (1-day 5.0 mg/L acute) at Nose Creek occurred on June 6th. Overcast conditions on June 5th and 6th during two days of rain as well as an increase in suspended sediment likely resulted in a reduction of dissolved oxygen through reduced photosynthesis. Eight samples were less than the 7-day 6.5 mg/L chronic dissolved oxygen objective[4], resulting in a 76% compliance rate. At Nose Creek, the acute oxygen compliance rate in 2012 (88%) was similar to 2011 (90%) and 2009 (91%), lower than 2010 (97%) but higher than 1999-2001 (84%) (Table 3). The chronic oxygen compliance rate in 2012 (76%) was similar to 2011 (79%) and 2009 (79%) but was lower than 2010 (100%) and higher than 1999-2001 (69%) (Table 3).

Dissolved oxygen in West Nose Creek ranged from 2.21 to 13.46 mg/L (N=27) in 2012 (Table 7). At the three West Nose Creek sites, one sample was less than the 1-day 5.0 mg/L acute dissolved oxygen objective at **WNC at Big Hill Springs Rd** on June 6 (2.21 mg/L). A sample from April 5th at **WNC at Big Hill Springs Rd** had an oxygen concentration of 5.76 mg/L which was less than the 6.5 mg/L chronic dissolved oxygen objective; however, it is not known if the sample was less than 6.5 mg/L for more than 7 days. The maximum dissolved oxygen concentration at West Nose Creek (13.46 mg/L) occurred on October 22nd at **WNC at Mountain View Rd**. At West Nose Creek, the acute oxygen compliance rate in 2012 (96%) was similar to 2011 (100%), 2010 (100%) and 2009 (100%) and higher than 1999-2001 (86%) (Table 3). The chronic oxygen compliance rate in 2012 (93%) was similar to 2011 (96%), 2010 (100%) and 2009 (95%) and higher than 1999-2001 (76%) (Table 3).

In 2009, Morris (2009) recorded fluctuations in oxygen concentration at **NC u/s Airdrie** from June 23 to September 4 and observed that oxygen concentrations often fell below 5 mg/L during the night. At **NC at Mouth**, oxygen concentrations were always above 5 mg/L from June 23 to July 3 (no data collected after July 3) (Morris 2009). A highly variable dissolved oxygen regime at sites within Nose Creek is probably due to aquatic macrophytes and filamentous algae. In aquatic systems, algae and aquatic plants are the primary sources and consumers of oxygen. Extensive diurnal variation in oxygen concentrations is often observed in creeks and rivers with dense growths of aquatic plants. Sunlight promotes intense photosynthesis (oxygen production) during daylight hours, particularly in late afternoon, with lower oxygen concentrations often observed at night, just before dawn, as a result of plant respiration (oxygen consumption) (Hynes 1970; Hauer and Hill 1996). The large diurnal fluctuations in dissolved oxygen in 2009 at **NC u/s Airdrie** may have been exacerbated due to the fact that the site had no flow (i.e., site was stagnant) and may have been subject to intensified photosynthesis for much of the study whereas in 2010 and 2011 the site was flowing when oxygen samples were taken. Nonetheless, it is likely that most of the sites within this study undergo diurnal oxygen fluctuations during the active growing season (June to September) with oxygen concentrations often falling below 5 mg/L during late evening/early morning.

Electrical Conductivity

In 2012, electrical conductivity (EC) ranged from 673 to 2134 µS/cm (N=66) in Nose Creek (Table 8). The highest EC in Nose Creek (2134 µS/cm) occurred at **NC at 15 St** February 13th,

[4] The 6.5 mg/L chronic dissolved oxygen objective is a 7-day running average. Samples in this study were taken approximately from one to three times monthly; therefore, it was assumed oxygen values less than 6.5 mg/L did not meet the chronic guideline for one week but in most cases the mean 7-day oxygen concentration was likely greater than 6.5 mg/L. Therefore, chronic compliance rates in this report are likely underestimated.

while the lowest EC (673 µS/cm) occurred at **NC d/s Airdrie** on June 6th. In 2012, 32% of the samples from Nose Creek met the compliance target of less 1000 µS/cm. The Town of Crossfield released treated effluent into Nose Creek from August 9th to August 30th. The release of treated effluent did not appear to influence conductivity on August 15th as the specific conductivity was 1212 µS/cm above the release point (**NC d/s Crossfield**) and 1186 µS/cm below the release point (**NC u/s Airdrie**).

The sites within the City of Calgary (**NC at 15 St**, **NC u/s WNC** and **NC at Mouth)** had a low compliance rate of 15% (N=34) compared to the compliance rate of 53% for the sites upstream of Calgary (N=32). The electrical conductivity compliance rate at Nose Creek in 2012 (32%) was similar to 2010 (27%), 2009 (29%) and 1999-2001(38%) but lower than 2011 (63%) (Table 3).

In 2012, electrical conductivity at West Nose Creek ranged from 656 to 1676 µS/cm (N=27), with the lowest electrical conductivity at **WNC at Big Hill Springs Rd** on April 5th and the highest on October 22nd at **WNC at Mouth**. A total of 81% of the samples from West Nose Creek were in compliance with the water quality objective of less than 1000 µS/cm. The site **WNC at Mouth** had the lowest compliance rate at 43% while the site **WNC at Big Hill Springs Rd** had the highest compliance rate at 100%. The electrical conductivity compliance rate at West Nose Creek in 2012 (81%) was similar to 2011 (86%) and 2010 (76%) but lower when compared to 2009 (90%) and 1999-2001 (91%) (Table 3).

Table 7 - Dissolved oxygen from Nose Creek and West Nose Creek, January to December 2012. A red value indicates the oxygen did not meet the applicable acute oxygen water quality objective. A yellow value indicates the oxygen did not meet the chronic 7-day oxygen water quality objective. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

Dissolved Oxygen (mg/L)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																						
NC u/s Crossfield				**2.54**		5.46	7.18		7.12	**1.84**		6.27		nf	nf			dry	nf			
NC d/s Crossfield				8.77		12.04	9.43		10.24	**3.85**		8.11		11.43	7.88			dry	nf			
NC u/s Airdrie				5.76		9.86	9.42		10.62	**4.76**		6.76		6.21	7.90			nf	nf			
NC d/s Airdrie				8.67		11.49	9.80		11.72	**4.84**		6.61		8.06	6.02			10.69	11.07			
NC at 15 St	10.15	5.14	11.60		11.07			9.44			7.40		7.07			8.36	9.30			12.89	10.15	8.33
NC u/s WNC				8.51		7.68	8.55		7.94	**4.05**		6.44		5.74	**3.79**			**3.56**	6.65			
NC at Mouth	13.21	13.26	12.58		12.89			8.79			7.82		6.87			7.12	8.31			11.39	13.00	12.45
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				5.76		10.31	11.84		13.07	**2.21**		9.11		12.04	11.36			9.92	11.38			
WNC at Mountain View Rd			11.45		11.83			10.76			8.66		8.77			10.50	11.79			13.46	10.18	11.09
WNC at Mouth					12.91			11.14			9.11		7.74			8.81	10.60			12.46		

Table 8 - Electrical conductivity data from Nose Creek and West Nose Creek, January to December 2012. A red value indicates the electrical conductivity exceeds the applicable electrical conductivity water quality objective. Blank cells indicate no sample was taken (nf: indicates 'no flow', standing water may have been present).

Electrical Conductivity (µS/cm)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																						
NC u/s Crossfield				700		860	838		**1066**	837		850		nf	nf			dry	nf			
NC d/s Crossfield				734		991	888		**1072**	**1023**		941		**1104**	**1212**			dry	nf			
NC u/s Airdrie				731		874	**1154**		**1109**	963		876		**1078**	**1186**			nf	nf			
NC d/s Airdrie				860		**1054**	**1142**		**1078**	673		910		**1091**	890			**1125**	**1150**			
NC at 15 St	**2001**	**2134**	**1744**		**1176**			**1209**			**1018**		**1308**			780	**1216**			**1223**	**1029**	801
NC u/s WNC				**1256**		**1302**	**1362**		**1429**	**1127**		**1017**		**1189**	**1083**			**1038**	**1544**			
NC at Mouth	**1641**	**1417**	**1098**		**1294**			**1227**			**1092**		771			**1149**	770			**2031**	**1581**	713
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				656		781	834		931	861		825		913	978			914	976			
WNC at Mountain View Rd			781		788			944			943		799			827	836			876	**1527**	874
WNC at Mouth					995			**1036**			**1025**		708			**1040**	941			**1676**		

Total Dissolved Solids

Total dissolved solids (TDS) ranged from 437 to 1038 mg/L (N=42) in Nose Creek (Table 9). The maximum TDS concentration in Nose Creek (1038 mg/L) at **NC u/s WNC** occurred on September 20th while the lowest TDS concentration (437 mg/L) occurred on June 6th at **NC d/s Airdrie**. Nose Creek on average had higher TDS concentrations in comparison to West Nose Creek. At Nose Creek, the TDS compliance rate in 2012 (10%) was similar to 1999-2001, 2009 and 2010 (0 to 15%) but lower than 2011 (36%) (Table 3).

Total dissolved solids (TDS) at West Nose Creek (**WNC at Big Hill Springs Rd**) ranged from 427 to 636 mg/L (N=10) (Table 9). At West Nose Creek, the TDS compliance rate in 2012 (10%) was similar to 1999-2001, 2009 and 2010 (0 to 6%) but considerably lower than 2011 (80%) (Table 3).

Grasby *et al.* (1997) determined that Nose Creek has a TDS load, particularly sulphate, which is significantly higher than the Bow River or its other tributaries. Using chemical and stable isotope analysis to determine sources of TDS in Nose Creek they determined that substantial amounts of water are added to Nose Creek by leaking municipal pipes via groundwater from Airdrie and Calgary. They identified three clusters of sulphate in Nose Creek in the fall that suggested different sources. Upstream of Airdrie, the source of sulphate was identified as being consistent with SO_2 emissions during processing of sour gas near Crossfield. The oxidation of organic matter in soils was identified as the primary source of increased sulphate concentrations between Airdrie and Calgary. The third source of sulphates within the City of Calgary was identified as a large flux of water added by the City of Calgary (via leaking pipes) that is oxidizing reduced forms of sulphur in the till, which is then mobilized as SO_4 and transported into Nose Creek via groundwater flow (Grasby *et al.* 1997).

Table 9 - Total dissolved solids (TDS) data from Nose Creek and West Nose Creek, April to October 2012. A red value indicates the TDS exceeds the water quality objective.

Total Dissolved Solids (mg/L)	5-Apr	25-Apr	9-May	23-May	06-Jun	20-Jun	18-Jul	15-Aug	20-Sep	18-Oct
Nose Creek										
NC u/s Crossfield	454	**558**	**545**	**693**	**543**	**552**	nf	nf	dry	nf
NC d/s Crossfield	477	**644**	**577**	**696**	**667**	**612**	**717**	**788**	dry	nf
NC u/s Airdrie	476	**568**	**750**	**720**	**626**	**569**	**700**	**771**	nf	nf
NC d/s Airdrie	**559**	**685**	**743**	**700**	437	**591**	**709**	**544**	**731**	**747**
NC u/s WNC	**816**	**846**	**887**	**928**	**732**	**661**	**774**	**581**	**1038**	**1010**
West Nose Creek										
WNC at Big Hill Springs Rd	427	**507**	**542**	**605**	**560**	**535**	**594**	**636**	**594**	**635**

Total Phosphorus

Total phosphorus, ranging from 0.039 to 0.644 mg/L (N=66), usually exceeded the target compliance objective (0.05 mg/L) at Nose Creek throughout the year and had a compliance rate of 5% (Table 10). At Nose Creek, the total phosphorus compliance rate in 2012 (5%) was similar to 2011 (4%), 2009 (0%) and 1999-2001 (2%) but lower than 2010 (12%) (Table 3). The highest TP concentration (0.644 mg/L) occurred on July 18th at **NC u/s Airdrie** and the lowest (0.039 mg/L) occurred on January 18th at **NC at Mouth**. The Town of Crossfield released treated effluent into Nose Creek from August 9th to August 30th. In 2012, the effect of the treated wastewater release on downstream total phosphorus concentrations was unclear. In previous years, the treated wastewater release increased total phosphorus concentrations at **NC u/s Airdrie**, particularly when the site **NC d/s Crossfield** had minor to no flow. In 2012, the TP concentration was 0.320 mg/L upstream of the release point (**NC d/s Crossfield**) and 0.576 mg/L downstream of the release point (**NC u/s Airdrie**). The downstream increase in TP was similar to that observed on other sampling dates from April 5th to July 18th. The ongoing trend of increased total phosphorus concentrations at **NC u/s Airdrie**, even during periods outside of designated release periods may be due to the Town of Crossfield lagoon. On two separate occasions, two different landowners approached Palliser Environmental staff to inform them that the lagoon frequently overflows in the spring and after rain events as they observed flow in the channel that conveys effluent from the lagoon to Nose Creek. The channel does however drain a watershed area upstream of the lagoon; therefore, it is not known if these flows are from the lagoon or from spring runoff and/or precipitation events draining the watershed. Further monitoring of the lagoon channel and the channel upstream of the lagoon may be warranted.

The seasonal median TP concentration was above 0.05 mg/L for winter, spring and summer at the Nose Creek sites (Figure 2). The lowest median total phosphorus concentration occurred during the winter at **NC at Mouth** (0.055 mg/L) and **NC at 15 St** (0.066 mg/L). The highest median TP concentrations occurred at **NC u/s Airdrie** in the spring and summer and may have been due to effluent releases from the Town of Crossfield. Generally, the seasonal median concentration of total phosphorus was higher in spring and summer at the upper watershed sites compared to the lower watershed sites (Figure 2). The higher concentration of TP at the upper sites (**NC u/s Crossfield** and **NC u/s Airdrie**) was probably due to agricultural runoff and releases from the lagoon. The lower TP concentration at the lower sites was probably a result of phosphorus uptake by filamentous algae and aquatic plants at the lower sites which was observed to be dense.

Forty-one percent of the West Nose Creek samples had TP concentrations below the target compliance objective of 0.05 mg/L, and ranged from 0.016 to 1.890 mg/L (N=27) (Table 10). At West Nose Creek, the total phosphorus compliance rate in 2012 (41%) was higher than 2011 (25%), 2010 (33%) and 1999-2001 (15%) but lower than 2009 (52%) (Table 3). The lowest TP concentration was 0.016 mg/L on September 17th at **WNC at Mountain View Rd** and the highest was 1.890 mg/L on June 6th at **WNC at Big Hill Springs Rd**. Forty-three percent of the total June rainfall fell on June 5th and 6th. The increased watershed runoff and increased suspended sediment (142 mg/L) would have resulted in the increased total phosphorus on June 6th as phosphorus will adsorb onto suspended sediment. By site, the highest compliance rate was at **WNC at Mouth** (71%) and the lowest compliance rate was at **WNC at Big Hill Springs Rd** (10%). At **WNC at Big Hill Springs Rd**, the seasonal median TP concentration was above the 0.05 mg/L guideline for spring (0.125 mg/L) and summer (0.085 mg/L). At **WNC at Mountain View Rd** the winter (0.067 mg/L) and spring (0.073 mg/L) seasonal median TP concentration was above the guideline; however, the summer median TP concentration (0.045 mg/L) was below the guideline. The spring (0.05 mg/L) and summer (0.038 mg/L) median TP concentration was below the guideline at **WNC at Mouth** (Figure 2). Overall, the median TP concentrations at West Nose Creek were lower when compared to Nose Creek.

Phosphorus concentrations are a concern at both creeks since it enriches freshwater (a process known as eutrophication), contributing to the growth of aquatic plants. Aquatic plants produce oxygen through photosynthesis during the day; however, on cloudy days or during the night, the plants consume oxygen for respiration and can deteriorate fish habitat conditions. In addition, oxygen is used during the decomposition of plant material, again decreasing oxygen resources for fish and other aquatic life.

Sources of phosphorus include organic and inorganic fertilizers that are used for agricultural crop production and urban lawn maintenance, livestock manure, pet feces, poorly designed or failing septic systems, and treated municipal effluent. In urban areas, Waschbusch *et al.* (1999) found lawns and streets were the largest sources of phosphorus in urban stormwater. Rast and Lee (1983) examined nearly 100 watersheds in the United States and found urban area phosphorus nutrient export coefficients were about two times higher than the export coefficients from agricultural (row crops) areas. This difference was due in part to the greater amount of runoff in urban areas than in agricultural areas due to the greater amount of impervious surface. Urban areas contributed about 10 times more phosphorus per unit area than forested areas. Similarly, both urban and agricultural areas contributed much greater amounts of phosphorus per unit area than forested areas (Rast and Lee 1983).

Table 10 - Total phosphorus data from Nose Creek and West Nose Creek, January to December 2012. A red value indicates total phosphorus exceeds the water quality objective for site and date. Blank cells indicate no sample was taken.

Phosphorus, Total (mg/L)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
Nose Creek																						
NC u/s Crossfield				**0.459**		**0.278**	**0.254**		**0.448**	**0.489**		**0.601**		nf	nf			dry	nf			
NC d/s Crossfield				**0.347**		**0.161**	**0.145**		**0.112**	**0.168**		**0.331**		**0.192**	**0.320**			dry	nf			
NC u/s Airdrie				**0.526**		**0.550**	**0.335**		**0.597**	**0.511**		**0.325**		**0.644**	**0.576**			nf	nf			
NC d/s Airdrie				**0.251**		**0.256**	**0.218**		**0.236**	**0.204**		**0.327**		**0.345**	**0.290**			**0.143**	**0.109**			
NC at 15 St	**0.088**	**0.066**	**0.190**		**0.226**			**0.183**			**0.291**		**0.264**			**0.209**	**0.138**			**0.067**	0.051	**0.063**
NC u/s WNC				**0.124**		**0.176**	**0.142**		**0.130**	**0.184**		**0.300**		**0.136**	**0.382**			**0.129**	**0.103**			
NC at Mouth	0.039	0.043	**0.275**		**0.077**			**0.116**			**0.224**		**0.166**			**0.128**	**0.071**			**0.074**	**0.055**	**0.061**
West Nose Creek																						
WNC at Big Hill Springs Rd				**0.128**		**0.121**	**0.098**		**0.100**	**1.890**		**0.155**		**0.116**	**0.098**			**0.072**	0.035			
WNC at Mountain View Rd			**0.239**		**0.073**			0.052			**0.204**		**0.130**			0.045	0.016			0.025	0.038	**0.067**
WNC at Mouth					0.050			0.039			**0.172**		**0.144**			0.038	0.026			0.028		

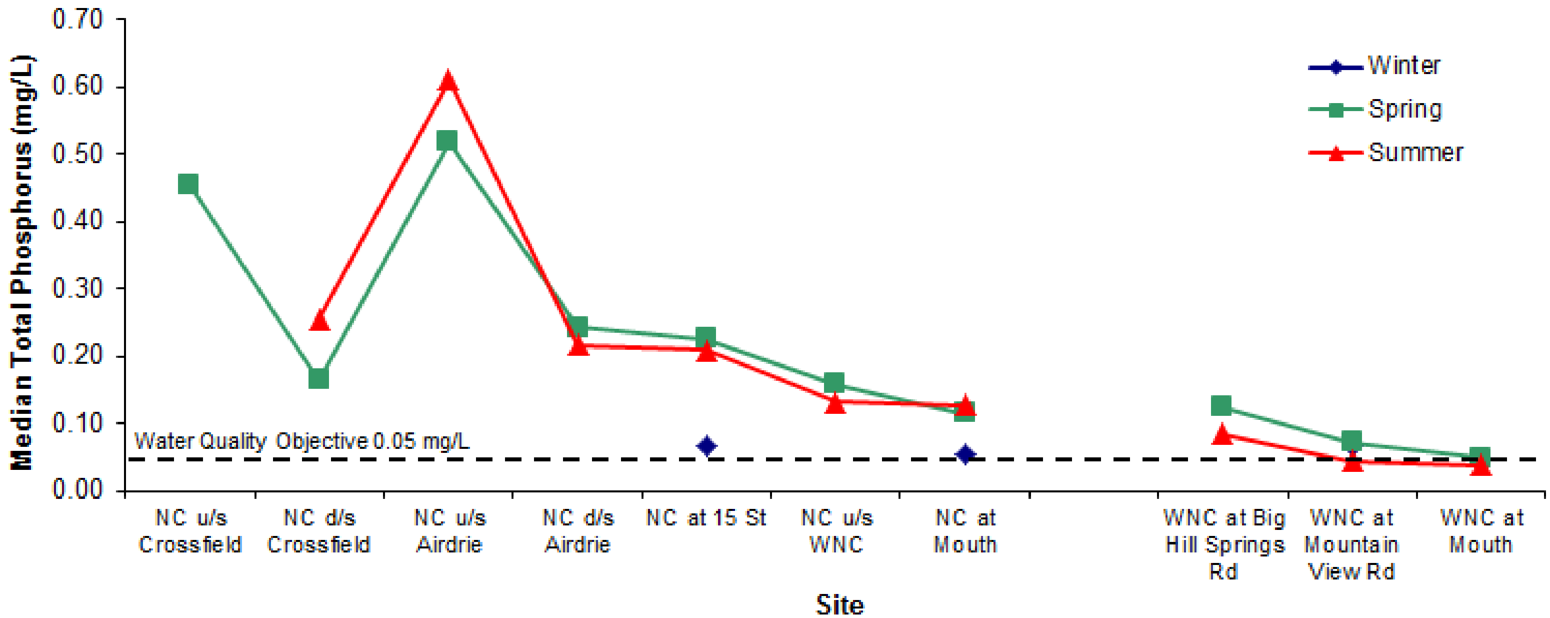

Figure 2 - Seasonal median total phosphorus in Nose Creek and West Nose Creek (upstream to downstream) in 2012.

Dissolved Phosphorus

Dissolved phosphorus (DP) in Nose Creek ranged from 0.012 to 0.604 mg/L (N=66), and often exceeded the target compliance objective (0.02 mg/L) throughout the year with a compliance rate of 23% (Table 11). At Nose Creek, the dissolved phosphorus compliance rate in 2012 (23%) was similar to 1999-2001 (24%), higher than 2011 (9%) but lower than 2009 (32%) and 2010 (37%) (Table 3). The highest DP concentration (0.604 mg/L) occurred on July 18th at **NC u/s Airdrie** and the lowest (0.004 mg/L) occurred on September 20th at **NC d/s Airdrie** and at **NC u/s WNC**. The Town of Crossfield released treated effluent into Nose Creek from August 9th to August 30th. In 2012, the effect of the treated wastewater release on downstream dissolved phosphorus concentrations was unclear. In previous years, the treated wastewater release increased total phosphorus concentrations at **NC u/s Airdrie**, particularly when the site **NC d/s Crossfield** had minor to no flow. In 2012, the DP concentration was 0.177 mg/L upstream of the release point (**NC d/s Crossfield**) and 0.604 mg/L below the release point (**NC u/s Airdrie**). However, the downstream increase in DP was consistent with the downstream increase at this site on other sampling dates from April 5th to July 18th. The downstream increases of DP at **NC u/s Airdrie** from April 5th to July 18th (prior to treated effluent release) may have been influenced by the Town of Crossfield lagoon. Two separate landowners on two separate occasions approached Palliser Environmental staff to inform them that the lagoon frequently overflows in the spring and after rain events.

All of the seasonal median DP concentrations were above the 0.02 mg/L objective with the exception of the winter and summer concentrations at **NC at Mouth** (Figure 3). The higher spring and summer median concentration of DP at **NC u/s Airdrie** was likely due to the release of effluent from the Town of Crossfield. Generally, the seasonal median DP concentration was higher in spring and summer at the upper watershed sites compared to the lower watershed sites (Figure 3). The higher concentration of DP at the upper sites (**NC u/s Crossfield** and **NC u/s Airdrie**) was probably due to agricultural runoff and releases from the lagoon. The lower DP concentration at the lower sites was probably a result of phosphorus uptake by filamentous algae and aquatic plants at the lower sites which was observed to be dense.

Dissolved phosphorus (DP) in West Nose Creek ranged from <0.010 to 0.966 mg/L (N=27) (Table 11). Forty-one percent of the West Nose Creek samples had DP concentrations below the target compliance objective of 0.02 mg/L (Table 10). At West Nose Creek, the dissolved phosphorus compliance rate in 2012 (41%) was similar to 2010 (43%), higher than 2011 (32%) and 1999-2001 (19%) but lower than 2009 (62%) (Table 3). The lowest DP concentration was <0.01 mg/L on September 17th at **WNC at Mountain View Rd** and the highest was 0.966 mg/L on June 6th at **WNC at Big Hill Springs Rd**. Forty-three percent of the total June rainfall fell on June 5th and 6th. The increased watershed runoff and would have resulted in the increased dissolved phosphorus on June 6th. By site, the highest compliance rate was at **WNC at Mouth** (71%) and the lowest compliance rate was at **WNC at Big Hill Springs Rd** (20%). At West Nose Creek, the highest spring and summer median concentrations of dissolved phosphorus occurred at the most upstream site (**WNC at Big Hill Springs Rd**), and the lowest concentrations occurred at the most downstream site (**WNC at Mouth**) (Figure 3). At **WNC at Mountain View Rd** the winter and summer median DP concentration met the 0.02 mg/L guideline and at **WNC at Mouth** both the spring and summer DP concentration met the guideline. Overall, the median DP concentrations at West Nose Creek were lower when compared to Nose Creek.

Table 11 - Dissolved phosphorus data from Nose Creek and West Nose Creek, January to December 2012. Blank cells indicate no sample was taken.

Phosphorus, Dissolved (mg/L)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
Nose Creek																						
NC u/s Crossfield				**0.386**		**0.166**	**0.226**		**0.379**	**0.368**		**0.563**		nf	nf			dry	nf			
NC d/s Crossfield				**0.139**		**0.041**	**0.075**		**0.055**	**0.114**		**0.260**		**0.177**	**0.286**			dry	nf			
NC u/s Airdrie				**0.386**		**0.412**	**0.284**		**0.436**	**0.365**		**0.278**		**0.604**	**0.542**			nf	nf			
NC d/s Airdrie				**0.114**		**0.045**	**0.122**		**0.079**	**0.042**		**0.170**		**0.278**	**0.120**			0.004	0.016			
NC at 15 St	**0.060**	**0.043**	**0.109**		**0.064**			**0.090**			**0.180**		**0.173**			0.024	**0.031**			0.021	0.016	**0.047**
NC u/s WNC				**0.045**		**0.027**	**0.075**		0.020	**0.053**		**0.138**		**0.068**	**0.134**			0.004	0.008			
NC at Mouth	0.017	0.017	**0.109**		0.020			**0.028**			**0.124**		**0.046**			0.012	0.012			0.015	0.013	**0.046**
West Nose Creek																						
WNC at Big Hill Springs Rd				**0.031**		**0.035**	**0.035**		**0.025**	**0.966**		**0.058**		**0.061**	**0.065**			0.009	0.012			
WNC at Mountain View Rd			**0.145**		**0.027**			**0.031**			**0.113**		**0.063**			0.018	<0.01			0.017	0.017	**0.023**
WNC at Mouth					0.013			0.011			**0.079**		**0.033**			0.011	0.010			0.012		

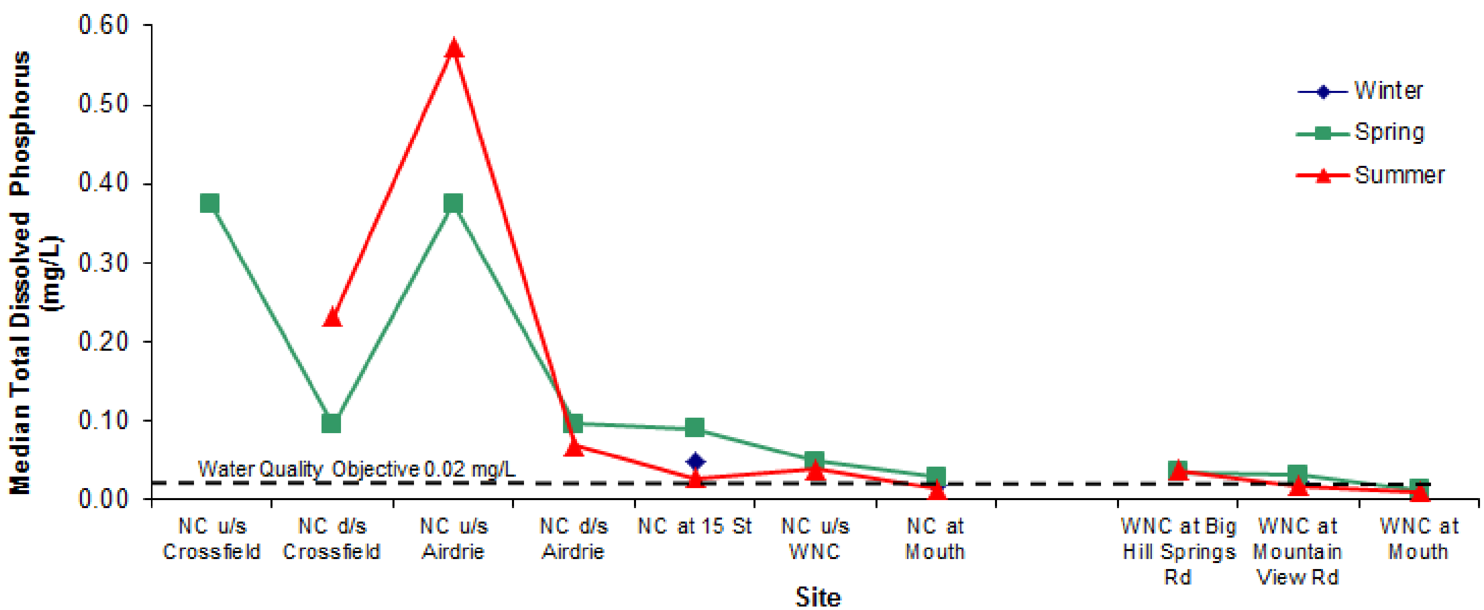

Figure 3 - Seasonal median total dissolved phosphorus in Nose Creek and West Nose Creek in 2012.

Nitrate-Nitrite

At Nose Creek, nitrate-nitrite (<0.071 to 2.94 mg/L) was usually below the guideline of 1.5 mg/L with an overall compliance rate of 83% in 2012 (N=29) (Table 12). Four of the five samples exceeding the guideline all occurred at **NC at Mouth** from November to February. Forty-one percent of the samples were below the detection limit for nitrate-nitrite. The higher concentrations of nitrate-nitrite during the colder months are probably due to reduced utilization by plants/algae and increased inputs from groundwater. At Nose Creek, the nitrate-nitrite compliance rate in 2012 (83%) was the same as 2009 (83%) but lower the 2011 (93%), 2010 (94%) and 1999-2001 (89%) (Table 3).

At West Nose Creek, nitrate-nitrite was also usually below the guideline of 1.5 mg/L with an overall compliance rate of 83% in 2012 (N=18) (Table 12). The three samples exceeding the guideline occurred in late-summer from August to October, two of the exceedances were at **WNC at Mouth**. Twenty-eight percent of the samples were below the detection limit for nitrate-nitrite. At West Nose Creek, the nitrate-nitrite compliance rate in 2012 (83%) was similar to 2011 (82%) and 1999-2001 (85%) but slightly lower than 2010 (93%) and 2009 (88%) (Table 3).

Total Ammonia-N

At Nose Creek, total ammonia-N was often below the detection limit and was considered to have an overall compliance rate of 98% in 2012 (N=61) (Table 13). A single sample slightly exceeded the guideline on August 15 at **NC d/s Airdrie** when the total ammonia-N was 0.146 mg/L and the guideline was 0.141 mg/L. Although 98% of the samples were in compliance for the total ammonia-N guideline; 30% of the sample detection limits were greater than the total ammonia-N guideline[5], thus, there is some uncertainty as to whether these samples met the guideline. At Nose Creek, the total ammonia-N compliance rate in 2012 (98%) was similar to 2011 (100%) and both 2012 and 2011 compliance rates were slightly higher than 2010 (88%), 2009 (83%) and 1999-2001 (91%) (Table 3).

At West Nose Creek, total ammonia-N was often below the detection limit and was considered to have an overall compliance rate of 96% in 2012 (N=26) (Table 13). The single sample above the guideline occurred on June 6th when the total ammonia-N was 2.57 mg/L and the guideline was 0.282 mg/L (approximately nine times the guideline). Although 96% of the samples were in compliance for the total ammonia-N guideline; 58% of the sample detection limits were greater than the total ammonia-N guideline; thus, there is some uncertainty as to whether these samples met the guideline. At West Nose Creek, the total ammonia-N compliance rate in 2012 (96%) was similar to the historical compliance rates of 2011 (100%), 2010 (100%), 2009 (100%) and 1999-2001 (97%) (Table 3).

[5] Total ammonia guidelines vary and are dependent on pH and water temperature.

Table 12 - Nitrate-nitrite nitrogen data for Nose Creek and West Nose Creek, January to December 2012. A red value indicates the nitrate-nitrite nitrogen exceeds the water quality objective for that site and date. Blank cells indicate no sample was taken.

Nitrate-nitrite nitrogen (mg/L)	18-Jan	13-Feb	12-Mar	10-Apr	14-May	18-Jun	20-Jun	16-Jul	21-Aug	17-Sep	22-Oct	12-Nov	17-Dec
NOSE CREEK													
NC u/s Crossfield							<0.071						
NC d/s Crossfield							0.156						
NC u/s Airdrie							<0.071						
NC d/s Airdrie							0.237						
NC at 15 St	1.1	<0.60	<0.60	<0.60	<0.60	<0.60		<0.60	<0.60	<0.60	**2.94**	0.65	1.08
NC u/s WNC							0.420						
NC at Mouth	**2.76**	**2.49**	1.03	0.80	<0.60	<0.60		0.82	0.85	1.33	1.22	**1.96**	**2.48**
WEST NOSE CREEK													
WNC at Big Hill Springs Rd							0.301						
WNC at Mountain View Rd			0.95	0.85	<0.60	1.03		<0.60	<0.60	**1.69**	0.99	1.17	1.40
WNC at Mouth				1.03	<0.60	<0.60		0.86	**1.56**	0.62	**1.73**		

Table 13 - Total ammonia-N data for Nose Creek and West Nose Creek, January to December 2012. A yellow value indicates the detection limit of the total ammonia-N analysis was greater than the total ammonia-N guideline for that site and date; therefore, it is uncertain if the sample meets the guideline. Blank cells indicate no sample was taken.

Total Ammonia-N (mg/L)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																					
NC u/s Crossfield				<0.25		<0.05	<0.05		0.072	0.175											
NC d/s Crossfield				<0.05		<0.05	0.051		<0.05	0.105			<0.05	<0.05							
NC u/s Airdrie				0.127		<0.05	<0.05		<0.05	0.051			<0.05	<0.05							
NC d/s Airdrie				<0.50		<0.05	<0.05		<0.05	0.179			0.099	**0.146**			<0.05	<0.05			
NC at 15 St	<0.9	<0.9	<0.9		<0.9			<0.9			<0.9	<0.9			<0.9	<0.9			<0.9	<0.9	<0.9
NC u/s WNC				0.072		<0.05	<0.05		<0.05	0.230			<0.05	<0.05			<0.05	<0.05			
NC at Mouth	<0.9	<0.9	<0.9		<0.9			<0.9			<0.9	<0.9			<0.9	<0.9			<0.9	<0.9	<0.9
WEST NOSE CREEK																					
WNC at Big Hill Springs Rd				0.192		0.133	<0.05		<0.05	**2.57**			<0.05	<0.05			<0.05	<0.05			
WNC at Mountain View Rd			<0.9		<0.9			<0.9			<0.9	<0.9			<0.9	<0.9			<0.9	<0.9	<0.9
WNC at Mouth					<0.9			<0.9			<0.9	<0.9			<0.9	<0.9			<0.9		

Fecal Coliform

Bacteria concentrations ranged from <1 to >20,000,000 CFU/100 mL in Nose Creek (N=66) (Table 14) in 2012. The highest concentration of fecal coliform (>20,000,000 CFU/100 mL) occurred on June 20th at **NC d/s Airdrie**. Eight samples with fecal coliform ranging from 3,300 to >20,000,000 CFU/100 mL were collected on June 6th or June 20th. Approximately 74% of the total June rainfall (132.9 mm) had fallen by June 18th; therefore, runoff from rural pastures and urban areas (outfalls) probably accounted for the very high bacteria counts. Although 2012 was generally considered a dry year, the spring period was the wettest of the seven monitoring years (Table 3). Seventy percent of the Nose Creek samples had fecal coliform concentrations below the *contact recreation objective* of 400 CFU/100 mL. The sites **NC u/s Airdrie** and **NC at Mouth** had the lowest compliance rate at 50%, whereas, the site **NC at 15 St** had a 100% highest compliance. At Nose Creek, the 400 CFU/100 mL fecal coliform compliance rate in 2012 (70%) was similar to 2009 (65%) and 1999-2001 (76%) but lower than 2011 (90%) and 2010 (84%) (Table 3). Fifty-eight percent of the Nose Creek samples had fecal coliform concentrations below the *irrigation guideline* of 100 CFU/100 mL. The site **NC at Mouth** had the lowest compliance rate at 17%, whereas, the site **NC at 15 St** had the highest compliance rate at 83%. At Nose Creek, the 100 CFU/100 mL fecal coliform compliance rate in 2012 (58%) was similar to 2011 (64%) and 2010 (53%) but higher than 2009 (38%) and 1999-2001 (45%) (Table 3).

All of the median spring concentrations of bacteria were below both the 100 and 400 CFU/100 mL guidelines (irrigation and contact recreation) with the exception of the **NC at Mouth** site which slightly exceeded the irrigation guideline (105 CFU/100 mL). Most of the median summer concentrations of bacteria were above the 100 CFU/100 mL guideline for irrigation (four of six sites exceeded the irrigation guideline); however, for the contact recreation guideline, only two of six sites exceeded the 400 CFU/100 mL guideline (**NC u/s Airdrie** and **NC at Mouth**). Seasonally, the highest median concentration of bacteria occurred at **NC u/s Airdrie** (Figure 4) during the summer (2650 CFU/100 mL). High bacteria counts at this site was probably due to livestock and wildlife (e.g., waterfowl) as the area upstream of NC u/s Airdrie is dominated by pasture lands, and contains large wetland areas. Although the site **NC u/s Airdrie** is influenced by the Town of Crossfield effluent release, the fecal bacteria count during the effluent release was relatively low (4800 CFU/100 mL) compared to the maximum count from this site on June 20th (4,400,000 CFU/100 mL). Similarly, a water sample was obtained in 2011 from the channel draining the Town of Crossfield sewage lagoon during the effluent release and fecal coliform bacteria were low at 4 CFU/100 mL. The median winter bacteria count at **NC at Mouth** were elevated in 2012 (461 CFU/100 mL) compared to the upstream **NC at 15 St** site. This result is similar to higher counts in 2011 (687 CFU/100 mL), 2010 (649 CFU/100 mL) and 2009 (2076 CFU/100 mL) at **NC at Mouth** (Palliser Environmental 2010, 2011, 2012). The cause of elevated bacteria counts at **NC at Mouth** is not known but the data suggests a nearby, point source (i.e., an outfall influenced by the Calgary Zoo). Median winter bacteria counts at **NC at 15 St** have been consistently low from 2009 to 2012, ranging from 3.5 to 34 CFU/100 mL.

Bacteria concentrations ranged from <1 to 9,700,000 CFU/100 mL in West Nose Creek (N=27) in 2012 (Table 14). The highest bacteria count was at **WNC at Big Hill Springs Rd** on June 20th with the second highest count (540,000 CFU/100 mL) occurring at **the same site** on June 6th. Approximately 74% of the total June rainfall (132.9 mm) had fallen by June 18th; therefore, runoff from rural pastures probably accounted for the very high bacteria counts. Sixty-seven percent of the West Nose Creek samples had fecal coliform concentrations below the *contact recreation objective* of 400 CFU/100 mL. The sites **WNC at Big Hill Springs Rd** and **WNC at Mountain View Rd** had the lowest compliance rate at 70%, whereas, the site **WNC at Mouth** had the highest compliance rate at 86%. At West Nose Creek, the 400 CFU/100 mL fecal coliform compliance rate in 2012 (67%) was similar to 2009 (71%) and lower than 2011 (89%), 2010 (87%) and 1999-2001 (83%) (Table 3). Forty-four percent of the West Nose Creek samples had fecal coliform concentrations below the *irrigation guideline* of 100 CFU/100 mL. The site **WNC at Big Hill Springs Rd** had the highest compliance rate at 60%, whereas, the site **WNC at Mountain View Rd** had the lowest compliance rate at 20%. At West Nose Creek, the 100 CFU/100 mL fecal coliform compliance rate in 2012 (44%) was similar to 2009 (38%) and 1999-2001 (45%) but lower than 2011 (64%) and 2010 (53%) (Table 3).

Seasonally, all of the spring, summer and winter median concentrations of bacteria at West Nose Creek were below the 400 CFU/100 mL guideline for contact recreation. All of the median summer concentrations of bacteria at West Nose Creek were above the 100 CFU/100 mL guideline for irrigation. The median spring concentration of bacteria at **WNC at Mountain View Rd** (161 CFU/100 mL) was above the irrigation guideline (Figure 4).

Elevated fecal coliform counts are a concern at Nose Creek and West Nose Creek. In rural areas, bacteria sources are generally linked to wildlife (e.g., beaver, deer, muskrat), waterfowl (e.g., ducks and geese), birds, livestock (e.g., cattle, horses and poultry) and humans (Hagedorn *et al.* 1999; Hyer and Moyer 2003). In urban areas, dogs (including dog parks), cats, waterfowl (particularly geese), birds and humans are sources of fecal coliform (Whitlock *et al.* 2002; Sercu *et al.* 2009). Runoff from nonpoint sources such as parking lots, lawns and pastures are a major source of bacteria particularly after storm events in areas with high watershed development and large areas of impervious surfaces (Gregory and Frick 2000). Recent studies on the Milk River suggest the presence of 'environmental bacteria' or those that can be attributed to growth in the environment rather than originating directly from a host source (L. Tymenson, AARD, unpublished).

Table 14 - Bacteria data (fecal and *E. coli*) for Nose Creek and West Nose Creek, January to December 2012. A red value indicates the bacteria count exceeds the water quality objective (400 CFU/100 mL). Blank cells indicate no sample was taken.

Bacteria (CFU/100mL)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																						
NC u/s Crossfield				<1		14	56		36	**12,700**		**20,000**		nf	nf			dry	nf			
NC d/s Crossfield				<1		12	4		28	**500**		**2,600,000**		**500**	43			dry	nf			
NC u/s Airdrie				<1		11	6		22	**27,000**		**4,400,000**		**500**	**4,800**			nf	nf			
NC d/s Airdrie				4		4	12		30	**3,300**		**>20,000,000**		149	**900**			58	17			
NC at 15 St	9	14	8		2			15			101		238			93	38			6	4	<1
NC u/s WNC				<1		<1	15		28	400		**30,000**		116	**2,500**			78	32			
NC at Mouth	**770**	**>2,420**	**461**		26			105			261		**1,986**			121	109			**1,300**	**435**	59
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				<1		2	14		40	**540,000**		**9,700,000**		**700**	**1,100**			48	42			
WNC at Mountain View Rd			29		9.7			161			**437**		**1,733**			**461**	121			206	**613**	28
WNC at Mouth					25			24			185		**1,553**			214	57			62		

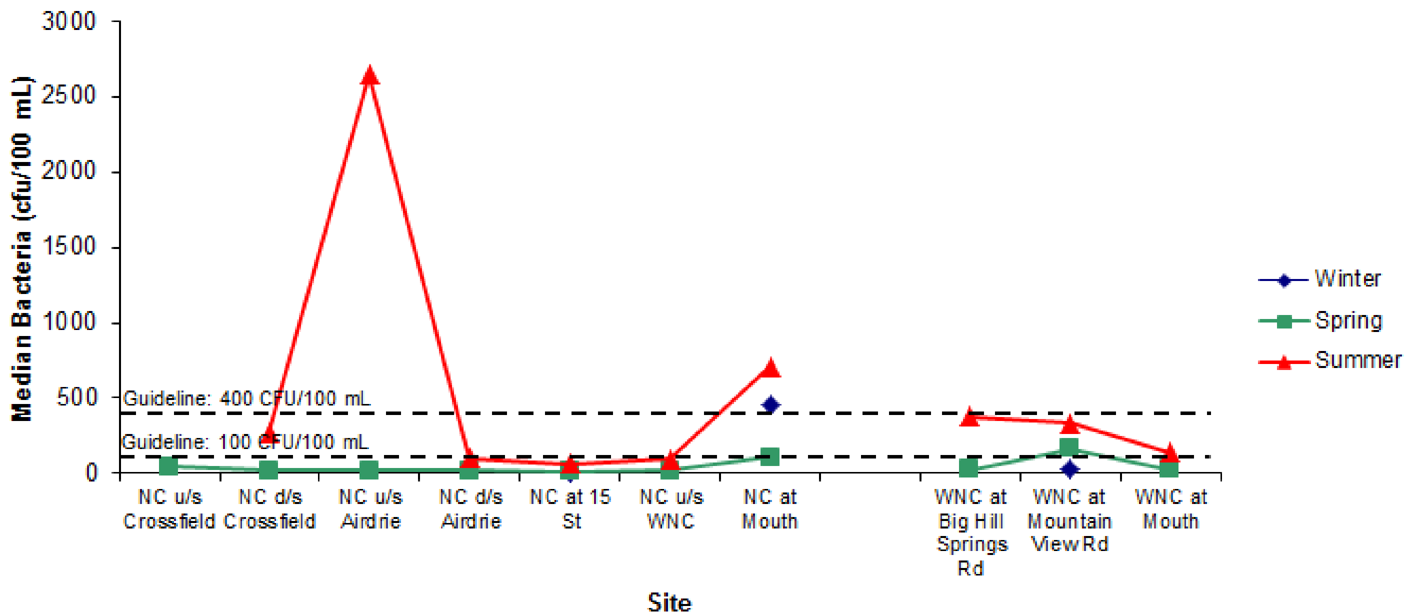

Figure 4 - Seasonal median bacteria concentration in Nose Creek and West Nose Creek in 2012. Data points for **NC d/s Airdrie**, **NC u/s WNC** and **WNC at Big Hill Springs Rd** represent fecal coliform bacteria. Other data points represent *E. coli.*

Total Suspended Solids

In 2012, total suspended solids (TSS) ranged from 2.6 to 116 mg/L in Nose Creek (N=66) (Table 15). The range of TSS concentrations in 2012 was similar to 2010 (<3 to 138 mg/L), higher than 2011 (<3 to 86) but lower than 2009 (4 to 221 mg/L) and 2000-2001 (0.6 to 1620 mg/L) at Nose Creek. The lowest concentrations of suspended sediment (2.6 mg/L) at Nose Creek occurred on February 13th at **NC at 15th St**, and the highest concentration occurred at **NC u/s WNC** (116.0 mg/L) on August 15th during high flow (2.26 m^3/s). The Town of Crossfield released treated effluent into Nose Creek from August 9th to August 30th. The release of treated effluent did not appear to influence total suspended solids on August 15th as the TSS was 8 mg/L above the release point (**NC d/s Crossfield**) and 5 mg/L below the release point (**NC u/s Airdrie**). Seasonally, the spring, summer and winter median TSS concentration increased from upstream to downstream which is probably the result of the increase in watershed area at each downstream site in conjunction with TSS contributions from stormwater outfalls in Airdrie and Calgary (Figure 5). Generally, the median spring concentration of TSS was higher than the summer concentrations (due to spring runoff) and the median winter TSS concentration was substantially lower than the spring or summer concentrations (Figure 5).

In 2012, total suspended solids (TSS) ranged from 2.4 to 142.0 mg/L in West Nose Creek (N=27) (Table 15). The 2012 range of TSS was similar to 2011 (<3 to 108.7 mg/L), lower than 2010 (3 to 249 mg/L) and 2009 (4 to 262 mg/L), but higher than 2000-2001 (1.6 to 72.3 mg/L). The lowest concentrations of suspended sediment (2.4 mg/L) at West Nose Creek occurred at **WNC at Mountain View Rd** (September 17th) and the highest concentration of suspended solids occurred at **WNC at Big Hill Springs Rd** (142.0 mg/L) on June 6th. Generally, the median spring TSS concentrations at West Nose Creek were higher than winter or summer concentrations. The highest median summer concentration of TSS (14.8 mg/L) occurred at **WNC at Mouth** (Figure 5); and the highest median spring concentration of TSS (43.9 mg/L) occurred at **WNC at Mountain View Rd**. In 2012, there was not a TSS trend with lower concentrations in the upper watershed and higher concentrations in the lower watershed as occurred in 2011.

Table 15 - Total suspended solids data from Nose Creek and West Nose Creek, January to December 2012. Blank cells indicate no sample was taken.

Total Suspended Solids (mg/L)	18-Jan	13-Feb	12-Mar	05-Apr	10-Apr	25-Apr	09-May	14-May	23-May	06-Jun	18-Jun	20-Jun	16-Jul	18-Jul	15-Aug	21-Aug	17-Sep	20-Sep	18-Oct	22-Oct	12-Nov	17-Dec
NOSE CREEK																						
NC u/s Crossfield				6.0		7.0	<3.0		4.0	8.6		<3.0		nf	nf			dry	nf			
NC d/s Crossfield				27.0		26.0	19.0		12.5	10.0		<3.0		<3.0	8.0			dry	nf			
NC u/s Airdrie				29.0		31.0	25.0		14.4	23.0		6.3		5.0	5.0			nf	nf			
NC d/s Airdrie				23.0		45.0	37.0		28.0	57.0		32.5		28.0	75.0			30.0	11.0			
NC at 15 St	8.7	2.6	9.3		24.6			19.0			61.3		44.8			42.2	30.3			6.4	7.2	3.5
NC u/s WNC				18.0		43.0	33.0		35.6	57.0		40.0		40.0	116.0			34.0	26.0			
NC at Mouth	11.5	10.9	61.8		28.3			23.0			49.3		75.5			40.0	24.0			21.2	18.5	9.9
WEST NOSE CREEK																						
WNC at Big Hill Springs Rd				48.0		32.0	29.0		15.0	142		37.5		9.0	6.0			28.0	<4.0			
WNC at Mountain View Rd			22.7		43.9			10.8			62.3		29.9			4.7	2.4			6.6	23.5	47.2
WNC at Mouth					9.1			10.5			65.4		80.6			21.9	7.7			7.4		

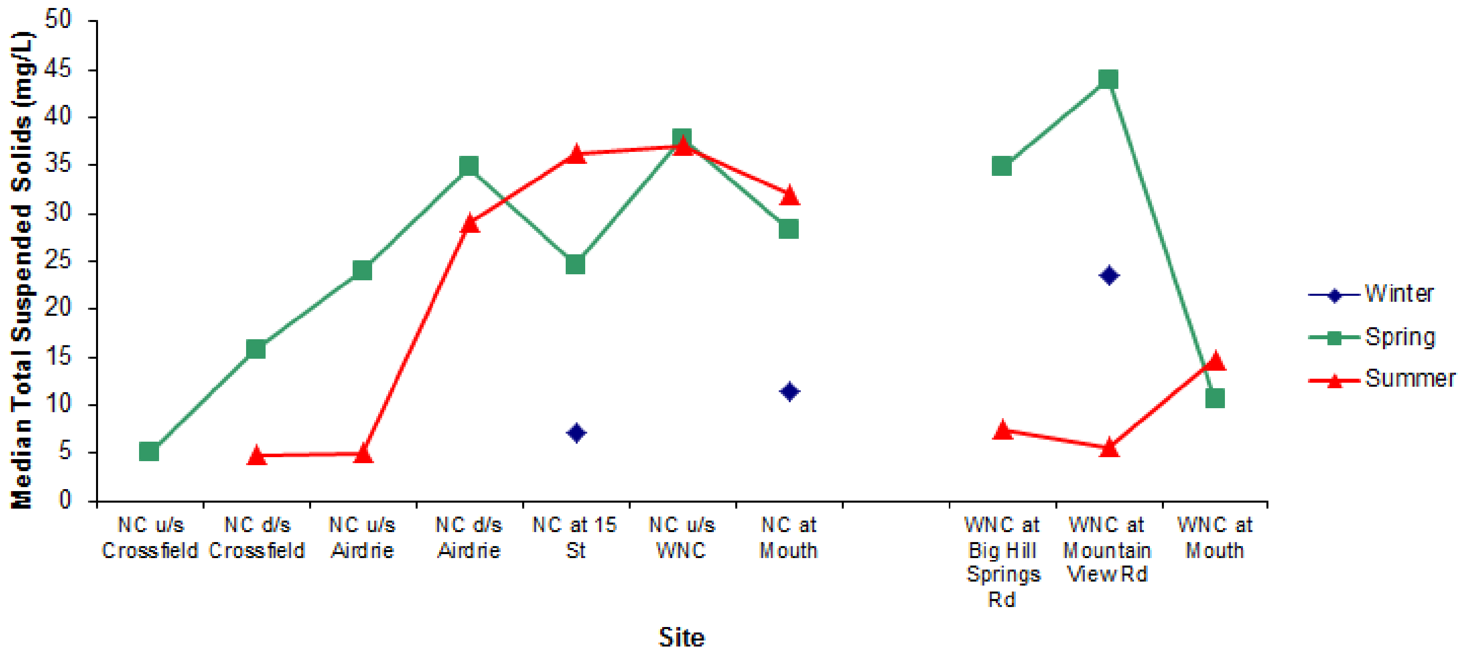

Figure 5 - Seasonal median total suspended solids in Nose Creek and West Nose Creek (upstream to downstream) in 2012.

5.0 SUMMARY AND RECOMMENDATIONS

The following summarizes the results of the water quality parameters monitored at Nose Creek and West Nose Creek in 2012:

- All temperatures in Nose Creek and West Nose Creek in 2012 were below the acute water temperature objective of 29°C and the chronic water temperature objective of 24°C, which was the same compliance rate as 2011, 2010, 2009 and 1999 to 2001.
- The pH compliance rate at Nose Creek in 2012 (95%) was higher than 2010 (79%) and similar to 1999-2001, 2009 and 2011 (95 to 99%). The pH compliance rate at West Nose Creek in 2012 (96%) was similar to 1999-2001, 2009, 2010 and 2011 (100%).
- At Nose Creek in 2012, eight oxygen samples were less than the acute guideline of 5 mg/L and at West Nose Creek one sample was less than 5 mg/L. The compliance rate for acute oxygen at Nose Creek in 2012 (88%) was similar to 2009 and 2011 (90 to 91%), lower than 2010 (97%) but higher than 1999-2001 (84%). The acute compliance rate at West Nose Creek in 2012 was 96% which was similar to 2009-2011 (100%) but higher than 1999-2001(86%).
- Electrical conductivity at Nose Creek in 2012 ranged from 673 to 2134 µS/cm and 32% of samples met the water quality objective of less than 1000 µS/cm which was similar to 1999-2001, 2009 and 2010 (27 to 38% compliance) but lower than 2011 (63%). Electrical conductivity at West Nose Creek in 2012 ranged from 656 to 1676 µS/cm and 81% of samples met the water quality objective of less than 1000 µS/cm compared which was similar to 2011 (86%) and 2010 (76%) but lower when compared to 2009 (90%) and 1999-2001 (91%).
- Total dissolved solids at Nose Creek in 2012 ranged from 437 to 1038 mg/L and 10% of samples met the water quality objective of less than 500 mg/L which was similar to 1999-2001, 2009 and 2010 (0 to 15%) but lower than 2011 (36%). Total dissolved solids at West Nose Creek in 2012 ranged from 427 to 636 mg/L and 10% of samples met the water quality objective of less than 500 mg/L which was similar to 1999-2001, 2009 and 2010 (0 to 6%) but considerably lower than 2011 (80%).
- Total phosphorus at Nose Creek in 2012 ranged from 0.039 to 0.644 mg/L and only 5% of the samples met the water quality objective of less than 0.05 mg/L which was similar to 2011 (4%), 2009 (0%) and 1999-2001 (2%) but lower than 2010 (12%). Total phosphorus at West Nose Creek in 2012 ranged from 0.016 to 1.890 mg/L and 41% of samples met the water quality objective of less than 0.05 mg/L which was higher than 2011 (25%), 2010 (33%) and 1999-2001 (15%) but lower than 2009 (52%).
- Nitrate-nitrite at Nose Creek in 2012 ranged from <0.071 to 2.94 mg/L and 83% of the samples met the water quality objective of less than 1.5 mg/L which was the same as 2009 (83%) but lower the 2011 (93%), 2010 (94%) and 1999-2001 (89%). Nitrate-nitrite at West Nose Creek in 2012 ranged from <0.60 to 1.73 mg/L and 83% of samples met the water quality objective of less than 1.5 mg/L which was similar to 2011 (82%) and 1999-2001 (85%) but slightly lower than 2010 (93%) and 2009 (88%).
- Total ammonia at Nose Creek in 2012 was often below the detection limit and 98% of the samples met the water quality objective which was similar to 2011 (100%) and both 2012 and 2011 compliance rates were slightly higher than 2010 (88%), 2009 (83%) and 1999-2001 (91%). Total ammonia at West Nose Creek in 2012 was often below the detection limit and 96% of samples met the water quality objective which was similar to 1999-2001, 2009, 2010 and 2011 (97 to 100%).
- Bacteria (fecal and *E. coli*) at Nose Creek in 2012 ranged from <1 to >20,000,000 CFU/100 mL and 58% of samples met the *irrigation* guideline of less than 100 CFU/100

mL which was similar to 2011 (64%) and 2010 (53%) but higher than 2009 (38%) and 1999-2001 (45%). Seventy percent of the Nose Creek samples had fecal coliform concentrations below the *contact recreation* guideline of 400 CFU/100 mL which was similar to 2009 (65%) and 1999-2001 (76%) but lower than 2011 (90%) and 2010 (84%) (Table 3). Bacteria at West Nose Creek in 2012 ranged from <1 to 9,700,000 CFU/100 mL and 44% of samples met the irrigation water quality objective of less than 100 CFU/100 mL which was similar to 2009 (38%) and 1999-2001 (45%) but lower than 2011 (64%) and 2010 (53%). Sixty-seven percent of the West Nose Creek samples had fecal coliform concentrations below the *contact recreation* guideline of 400 CFU/100 mL which was similar to 2009 (71%) and lower than 2011 (89%), 2010 (87%) and 1999-2001 (83%)

- Total suspended solids (TSS) at Nose Creek in 2012 ranged from 2.6 to 116 mg/L which was similar to 2010 (<3 to 138 mg/L), higher than 2011 (<3 to 86) but lower than 2009 (4 to 221 mg/L) and 2000-2001 (0.6 to 1620 mg/L). Total suspended solids at West Nose Creek in 2012 ranged from 2.4 to 142 mg/L which was similar to 2011 (<3 to 108.7 mg/L), lower than 2010 (3 to 249 mg/L) and 2009 (4 to 262 mg/L), but higher than 2000-2001 (1.6 to 72.3 mg/L).

The following recommendations are provided for the Nose Creek watershed monitoring program:

- The results of the water monitoring program in 2012 should be disseminated to the Nose Creek Watershed Partnership membership. The report could be posted on the NCWP website, or the results could be summarized in a simple 4-page factsheet. Monitoring results could also be communicated to all stakeholders at an annual meeting or other community meeting.
- Reasonably detailed (spatially and temporally) water quality data exists for the Nose Creek watershed for the years 1980 and 1999-2001. It is recommended that the current monitoring program continue for at least 5 years (with review at this time) to account for years with varying precipitation (2009 was a low precipitation year and 2011 was a higher precipitation year) but to also allow for a historical comparison.
- In order to obtain a more comprehensive water quality dataset for the watershed, it is recommended monitoring begin in April and extend to October. During the months of April, May and June sampling should occur twice monthly to better characterize the influence of spring runoff and rainfall. Samplng should occur once monthly from July to October.
- The monitoring data from 1999 to 2012 indicates a high compliance rate for total ammonia (~95%) and nitrate-nitrite nitrogen (~80%). Palliser Environmental recommends that the NCWP remove nitrate-nitrite nitrogen and total ammonia from the parameters analysed due to the high compliance rate which should reduce the analytical budget by $1,000 to $2,000.
- Stormwater monitoring at select locations should be undertaken to begin to address point sources of phosphorus and fecal coliform bacteria to Nose Creek. Priority sites should include 1) the channel upstream and downstream of the Town of Crossfield lagoon and 2) outfalls in the vicinity of the mouth of Nose Creek to determine the source(s) of elevated bacteria (October to March)

6.0 CLOSURE

We trust the information provided is sufficient to describe the water quality of the Nose Creek watershed in 2012. If you have any questions, please do not hesitate to contact Palliser Environmental Services Ltd. at 403-684-3117.

Yours truly,

Palliser Environmental Services Ltd.

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APPENDIX A

Bow River Basin Council: Summary of Monitoring and Management Requirements for Nose Creek

Total Suspended Solids WQO and research: A total suspended solids WQO should be developed for Nose Creek. Research is required to identify the anthropogenic causes of total suspended solids in Nose Creek and how it compares in quantity to natural causes (NCWP; Long-Term: 2013-2014).

Dissolved Oxygen Monitoring: Enhanced monitoring of DO is required to better characterize and understand low nocturnal DO concentrations (AENV/City of Calgary; Short-Term Goal: 2008-10).

Periphyton Biomass: Future water quality monitoring should include the collection of periphyton biomass (as chlorophyll *a*). (AENV; Short-Term: 2008-10)

Peak and Base Flows: Further research is needed to compare the frequency and magnitude of base and peak flows. Storm events should remain within the range of pre-development conditions (pre-1970s) (NCWP; Short-Term: 2008-10).

Total Phosphorus Reductions: Responsible for working to reduce total phosphorus and total dissolved phosphorus. Conduct research into the primary productivity of Nose Creek (NCWP; Medium-Term: 2011-2012).

Enhanced stream and stormwater flow monitoring at various points throughout the system is needed to assist in the identification of the impervious and runoff targets (City of Calgary; Short-Term Goal: 2008-10)