NOSE CREEK
SURFACE WATER QUALITY DATA
FINAL REPORT 2001

Prepared for:

CITY OF CALGARY
CITY OF AIRDRIE
MD OF ROCKY VIEW

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EXECUTIVE SUMMARY

The City of Calgary, City of Airdrie and Municipal District of Rocky View have undertaken a cooperative approach in addressing the water quality issues in the Nose Creek watershed. In 1999, a coordinated surface water quality monitoring program was undertaken by the partners, with the added assistance of Alberta Environment. This report documents the results of the third year of the program and summarizes the database since 1999. Water quality issues and trends are identified.

Water quality samples were taken at five sites in the watershed; at Nose Creek above and below Airdrie, at the Calgary City Limits and at the Bow River, and at West Nose Creek at the City Limits. The water quality issues investigated included temperature, oxygen and sediments, salinity and major ions, nutrients, bacteria, metals, pesticides and priority pollutants. Water quality trends, compliance with water quality guidelines and identification of site and reach specific issues were examined.

SITE SPECIFIC ISSUES

The most common site specific issues in terms of not complying with water quality guidelines were nutrients and total dissolved solids, followed closely by fecal coliform bacteria, other measures of salinity and dissolved oxygen. Iron, aluminum, cadmium, chromium, manganese and selenium were frequently identified as significant issues except above Airdrie. Dicamba and MCPA were issues at most sites except at West Nose Creek for dicamba and above Calgary for MCPA. Mercury was an issue at West Nose Creek, above Calgary and at the Bow River.

REACH SPECIFIC ISSUES

In the reach from above to below Airdrie concentration changes indicate sources of suspended solids, nitrate, lead and dicamba. These water quality changes reflect inputs from Airdrie and local drainage. Many concentrations decreased in this reach including nutrients and bacteria. This reflects a reduction from the high nutrient and bacteria contaminants measured above Airdrie through biological processing or dilution.

Changes along Nose Creek from below Airdrie to above Calgary included increasing total Kjeldahl nitrogen, ammonia and seven metals. One factor which may be contributing to the increase in metals concentrations is the analytical switch from measurement of extractable forms below Airdrie to total forms above Calgary.

A comparison of data between West Nose Creek and Nose Creek above Calgary showed many higher values in Nose Creek including measures of salinity, total phosphorus, total Kjeldahl nitrogen, biochemical oxygen demand, thirteen metals and five pesticides. In contrast, concentrations were higher in West Nose Creek for calcium and strontium. This comparison

reflects the largely agricultural inputs from West Nose Creek as compared to the more urban Nose Creek.

Changes from Nose Creek above Calgary to the Bow River incorporated the inputs (dilution) from West Nose Creek as well as local inputs through Calgary. Concentrations decreased for sodium adsorption ratio, sodium, potassium, dissolved phosphorus, total Kjeldahl nitrogen, boron, copper and molybdenum. Concentrations increased for nitrate, bacteria, lead, zinc and 2,4-D.

COMPARISON WITH 1980 STUDY

Water quality data collected from 1999 to 2001 were compared with data collected in 1980 to determine significant differences in the two data sets. Results reflect differences in precipitation, flow, sources, land use and in-stream biological processing.

Dissolved oxygen increases above and below Airdrie may reflect differences in the time of day when samples were taken, because oxygen is variable over a single day, depending on water temperature and biological community photosynthesis and respiration. The general increase in pH along Nose Creek indicates an increase in hydrogen ions. This can also be affected by the biological community in a daily variability.

Total suspended solids have increased in West Nose Creek since 1980, indicating more sediments in the water. There is a more general increase in total dissolved solids at all sites except above Airdrie, indicating an increase in the amount of dissolved material being carried in the creek.

While total phosphorus has increased above Airdrie, decreases were measured at the Bow River. Dissolved phosphorus also decreased at the Bow River as well as above Calgary. Concentrations of all three nitrogen forms increased at West Nose Creek, with increases in nitrate and total nitrogen below Airdrie and above Calgary. There were no increases in nitrogen above Airdrie and at the Bow River.

The only trends for bacteria were decreases of fecal coliform bacteria below Airdrie and fecal streptococci above Calgary.

Copper increased above Calgary, at the Bow River and at West Nose Creek, while there was a general decrease in lead concentration at all sites except above Calgary.

TRENDS OVER TIME

Water quality trends were determined for Nose Creek at the Bow River using the database since 1980 and for Nose Creek above Calgary since 1995. Data were divided into four seasons (March/April, May to July, August to October and November to February) for statistical analyses.

The data at Nose Creek at the Bow River represent the longer term trends since 1980, however the data were collected sporadically between 1980 and 1999 and were less than ideal. Results indicate that water quality at Nose Creek at the Bow River is increasing for pH, total dissolved solids and copper. Decreasing concentrations were dissolved phosphorus and lead.

While the data at Nose Creek above Calgary are ideal for trend analysis, the trends are short term (seven years). At Nose Creek above Calgary, concentrations which are increasing are biochemical oxygen demand, total suspended solids, sulphate, aluminum and iron. Concentrations which are decreasing are potassium, nitrate and total coliform bacteria.

CONCLUSION

The identification of issues and trends can help to focus efforts in the watershed to implement beneficial management practices. The site specific issues identify the water quality parameters which exceed guideline values, restricting water quality uses. The reach specific issues identify increases within the reach of the creek, which may help in source identification.

The comparison with the 1980 study indicates the differences in water quality between the twenty years of activity in the watershed. Results reflect differences in precipitation, flow, sources, land use and in-stream biological processing. The trend analysis above Calgary and at the Bow River indicates some of the changes over time, however the definition of temporal trends is limited by the database available.

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1.0 INTRODUCTION

Nose Creek is a tributary to the Bow River, arising just north of Crossfield and flowing into the Bow River just downstream of the Calgary Zoo (Figure 1, pg 33). The eastern watershed boundary is just to the east of Deerfoot Trail and Highway 2. West Nose Creek is a major tributary which extends the western watershed boundary almost as far as Cochrane.

Water quality in this watershed is influenced by urban and rural land use practices. Nose Creek flows into the Bow River upstream of an important fishery in the Bow River and water withdrawals for the Western Irrigation District at the Western Headworks canal.

The City of Calgary, City of Airdrie and Municipal District of Rocky View have undertaken a cooperative approach in addressing the water quality issues in the Nose Creek watershed. As a first step in this water quality management, they commissioned a study of historical surface water quality in the watershed (Madawaska Consulting 1999). The study identified the water quality issues in the watershed as suspended solids, bacteria, nutrients, organic matter, metals, salinity and pesticides.

The historical data indicated that Airdrie was contributing suspended solids, bacteria and zinc. Upstream water quality was better in West Nose Creek than in Nose Creek in terms of suspended solids, nutrients, organic matter, chromium and zinc. However concentration increases along West Nose Creek included suspended solids, nutrients, organic matter and bacteria. Before the two creeks join, their differences were apparent. Nose Creek had generally higher concentrations of phosphorus and organic carbon, while West Nose Creek had higher concentrations of suspended solids and bacteria. Apart from reflecting the water quality at the upstream sites, within the City of Calgary in the downstream reach there were increases in biochemical oxygen demand, nitrogen, bacteria and lead.

In 1999, a coordinated surface water quality monitoring program was undertaken by the partners, with the added assistance of Alberta Environment. The Nose Creek water quality monitoring project objectives are:

1) To improve water quality in the Nose Creek watershed through awareness and education of watershed residents.
2) Monitoring program will characterize changes in water quality within the watershed currently and as compared to the historical data.
3) It will determine whether water quality is adequate for the uses within the watershed by comparing results with Canadian Water Quality Guidelines.
4) It will provide the watershed community with water quality data to implement practice change.

This report documents the results of the third year of the program and summarizes the database since 1999. Water quality issues and trends are identified.

2.0 METHODS

2.1 SAMPLING AND DATA

The sampling program depended on the coordination of the partners in their monitoring efforts. Water quality samples in the Nose Creek watershed were collected by Alberta Environment and the City of Calgary at five major sites (Table 1, Figure 1, pg 33). The City of Calgary sampled Nose Creek and West Nose Creek at the Calgary City Limits and Nose Creek at the Bow River. Alberta Environment (AENV) sampled above and below Airdrie with some additional samples at McPherson Coulee upstream of Airdrie (Tp Rd 275, Rg Rd 12). AENV also took samples at all five sites for pesticides (monthly from May to September).

AENV took monthly discharge (flow) measurements. Precipitation data were provided by the City of Calgary at four sites in the watershed; at Crossfield, Airdrie, Country Hills and Spyhill from May to September. A more complete record from March to September was available at the Calgary Airport (Environment Canada).

Table 1 Water Quality Sampling Locations and Data

NUMBER	SITE	LOCATION	DATA
5 - us Airdrie	Nose Creek above Airdrie	upstream of 8th Street, north of Hwy 567	monthly
4 - ds Airdrie	Nose Creek below Airdrie	just west of Hwy 2, downstream of Big Springs Road	monthly
3 - West Nose	West Nose Creek at Calgary City Limits	at Mountain View Road	monthly
2 - us Calgary	Nose Creek at Calgary City Limits	near 144 Avenue	biweekly
1 - @ Bow R	Nose Creek at Mouth	at Memorial Drive	monthly

There are numerous storm sewers entering both Nose Creek and West Nose Creek within the City of Airdrie and the City of Calgary, as well as stormwater from the Town of Crossfield. These were not sampled.

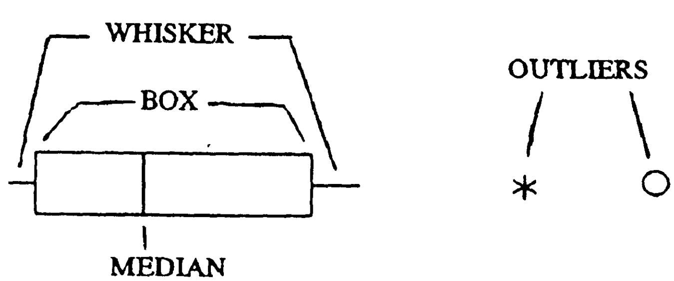
The Town of Crossfield, in accordance with their Approval from Alberta Environment, releases treated wastewater into Nose Creek in the fall. The Town also has an effluent irrigation program during the summer months to reduce the volume of wastewater released. Limited water quality data are collected in conjunction with any wastewater release.

2.2 DATA ANALYSIS

Data were compiled into a database (Table 2, pg 29-32 - at back of report) from spreadsheets and lab result sheets provided. Alberta Environment data often included more than one code for their analytical method. The database for this report used field measurements for temperature, pH, conductivity and dissolved oxygen, dissolved results for major ions and extractable metals in-filled with other forms (e.g. dissolved) if necessary. Previous reports have used dissolved metals, but this was changed to extractable metals to more closely match the City of Calgary data. City of Calgary analysis for metals measured the total form.

Data and trends were assessed graphically by inspection of bar graphs and box and whisker plots. Values below the detection limit were treated as one half of the detection limit value. Detection limits used by the City of Calgary varied for nitrate and ammonia, and non-detects were often listed as ND. In 1999, ND was assumed to be <0.5 mg/L for ammonia and <0.3 mg/L for nitrate. In 2000 and 2001 these detections were reduced to <0.1 mg/L for both parameters. Bar graphs for pesticides did not include values less than the detection limit, but box and whisker plots did include these data.

Bar graphs were produced using Quattro Pro for DOS V5.0. The full database was graphically summarized in box and whisker plots using Statistix V7. Each plot is composed of one box and two whiskers as shown below.



The box encloses the middle half of the data (the data between the 25th and 75th percentile). The box is bisected by a line at the value for the median (one half of the data are greater and one half of the data are less than the median). The lines at both ends of the box are called whiskers, and they indicate the range of "typical" data values. Extreme values are displayed as "*" for possible outliers and "o" for probable outliers. Possible outliers are values that are outside the box boundaries by more than 1½ times the size of the box. Probable outliers are values that are outside the box boundaries by more than 3 times the size of the box. For presentation purposes, several probable outliers were excluded from the box and whisker plots. The number of outliers or values of these outliers are indicated on each plot.

Statistical analyses available in WQStat Plus were used where appropriate. The Seasonal Kendall Test was used to determine significant trends ($p<0.05$). Four seasons were defined as

March/April, May to July, August to October and November to February. The Mann-Whitney test and Kruskal-Wallis test were used to compare the medians between data sets ($p<0.01$). The Mann-Whitney test calculates the significance of the difference between the medians, and the Kruskal-Wallis test is a non-parametric ANOVA (analysis of variance) which determines if there is significant variation between the medians.

2.3 WATER QUALITY GUIDELINES

Water quality guidelines for irrigation, livestock watering, drinking water, freshwater aquatic life and recreation, as used in this study, are summarized in Appendix Table A1 (Alberta Agriculture 1983, CCREM 1987 and updates, Alberta Environment 1999).

Relevant water quality guidelines were indicated on the box and whisker plots by a horizontal line at the guideline value. Data values above the horizontal line violate the guideline and data values below the horizontal guideline are acceptable in relation to the guideline. The exceptions are dissolved oxygen and pH which have a lower limit as well as an upper limit. Data were tabulated to indicate how frequently the guidelines were in compliance.

The Canadian Water Quality Guidelines were developed to provide basic scientific information about the effects of water quality parameters on uses in order to assess water quality issues and concerns and to establish water quality objectives for specific sites. Where site specific objectives have not been developed (as is the case here), these guidelines provide a basis for assessment.

According to the Federal-Provincial Subcommittee on Drinking Water, it is not appropriate to recommend numerical guidelines for raw public water supplies because treatment technology is available to produce drinking water from water of almost any quality (CCREM 1987 and updates). Comparison of water quality data with drinking water guidelines is used here to illustrate when treatment is required.

Freshwater aquatic life guidelines for cadmium, copper, lead and nickel are influenced by the hardness of the water. As the hardness of the water decreases, these metals become more toxic. The freshwater aquatic life guideline concentration used in the analysis was based on a review of water hardness data.

As provided for under the Environmental Protection and Enhancement Act, Alberta developed Surface Water Quality Guidelines in 1999 drawing on previous Alberta guidelines, as well as Canadian and United States Environmental Protection Agency (USEPA) guidelines and criteria. These guidelines are meant to provide general guidance in evaluating surface water quality throughout Alberta. In general, guidelines developed specifically for Alberta supercede other guidelines in this report.

3.0 PRECIPITATION AND FLOW

Water quality is strongly influenced by precipitation, runoff and flow. Flow data provide an instantaneous record on the sampling date, however precipitation data can put these flows into the perspective of the remainder of the study period. Precipitation data are summarized in Figure 2 (pg 34) and flow data are presented in Figure 3 (pg 35).

Higher daily rainfalls (arbitrarily - greater than 10 mm) are summarized in Table 3. Total rainfall from May to September was highest at Calgary Airport (238 mm), followed by Spyhill (221 mm), Country Hills (176 mm), Airdrie (163 mm) and Crossfield (131 mm). Precipitation at the Calgary Airport from May to September was lower in 2001 than in the previous years (289 mm in 2000 and 351 mm in 1999).

Table 3 Daily Precipitation Greater than 10 mm

DATE - 2001	CROSSFIELD	AIRDRIE	SPYHILL	COUNTRY HILLS	AIRPORT
May 16			14.4	17.2	17.7
June 3			12.4		
June 4			32.0		27.4
June 5			10.4		13.2
June 6				20.0	25.4
June 9			10.2		
June 15			10.0	13.2	15.8
June 29					10.8
July 1		15.6	15.8		
July 2		17.2			
July 13		13.4	14.6	10.6	13.2
July 16		13.0			16.0
July 22		10.8			
July 24					12.0
August 8			25.2	19.8	11.6
August 13		11.6			

Figure 3 shows the flow measurements for 2001 in the top graph. Although flow was generally higher at the Bow River than at the upstream sites, this was not the case on July 17, when Nose Creek above Calgary had a higher flow. This may have been the result of a localized storm (high flows below Airdrie) which had not yet moved along Nose Creek as far as the mouth or was attenuated along the length of the creek.

Historical monthly average flow for Nose Creek near the Mouth (Environment Canada) is presented as the bottom graph in Figure 3 (pg 35). Data from Nose Creek at Calgary (1972-1979), which was slightly upstream, were prorated by area and included with the data near the Mouth (1980-89) to calculate the monthly average flow. Maximum and minimum values were also included. Higher flows were generally measured in March and April.

Monthly average flows from historical data and 2001 data were compared, recognizing the fact that in 2001 a single measurement was available in each month from May to September. Except in July, during a likely storm runoff event, flows in 2001 were less than the historical average monthly values.

4.0 WATER QUALITY RESULTS

Water quality results for 2000/2001 are presented as bar graphs in Figures 4 to 9 (pg 38-83, top). Results for the full database available from 1999 to 2001 are presented as box and whisker plots in the same figures (bottom). The discussion of site differences focussed on a comparison of the range of values within the box (middle 50% of the data).

4.1 TEMPERATURE, OXYGEN, SEDIMENTS

Water temperature variations are a natural result of climatic conditions. Temperature will affect biological processes since aquatic organisms have upper and lower limits for optimal growth and other activities. Water temperature (Figure 4, pg 38) ranged to slightly higher values below Airdrie, with highest temperatures in 2000/2001 measured between May and August.

Water temperatures affect the solubility of oxygen in water, with warmer temperatures able to dissolve less oxygen. Dissolved oxygen is also affected by the photosynthesis / respiration of the biological community and the oxygen demand of organic compounds. **Dissolved oxygen** concentrations (Figure 4, pg 39) tended to be lower above Airdrie and above Calgary. Low concentrations in 2000/2001 (less than 5 mg/L) were measured at several sites from October to January and in July and August.

Total suspended solids (TSS) and **turbidity** are measures of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms which are held in suspension in water. Suspended solids can transport nutrients and contaminants downstream and may be aesthetically undesirable. Concentrations of TSS (Figure 4, pg 40) were lowest above Airdrie and highest at the Bow River. In 2000/2001 the highest concentrations of TSS were measured in January above Calgary and in March at the Bow River. Relatively higher concentrations were also measured on July 17, when flows were higher and on June 5 when there was a local rainfall event at the airport.

4.2 SALINITY, MAJOR IONS

Conductivity is a measure of the minerals dissolved in the water (total dissolved solids), or the salinity. 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 added to soils may interfere with extraction of water by the plants. High total dissolved solids may also affect taste and palatability of drinking water, and at high concentrations may have a laxative effect.

Sodium adsorption ratio is a measure of the relative amounts of sodium, calcium and magnesium in the water, or sodicity. Sources of sodium are similar to those for conductivity (total dissolved solids). Sodium in irrigation waters can adversely affect soil structure and permeability, and can adversely affect drinking water for people with cardiac, renal and circulatory problems.

Conductivity (EC), sodium adsorption ratio (SAR) and total dissolved solids (TDS) were lower at West Nose Creek than at the other sites (Figure 5, pg 41-43). SAR was also relatively low at the Bow River. The concentrations of sodium and potassium (Figure 5, pg 46, 47) were generally lower at West Nose Creek and at Nose Creek at the Bow River, while the opposite was true for calcium (Figure 5, pg 44). Magnesium concentrations (Figure 5, pg 45) were more similar at the five sites. Concentrations of sulphate and chloride (Figure 5, pg 48, 49) were lower at West Nose Creek. Bicarbonate (Table 2, pg 29) above Airdrie was slightly higher than below Airdrie. In 2000/2001, highest concentrations tended to occur between November and January at the site above Calgary.

Alkalinity and hardness are associated with the mineral content of the water. **Alkalinity** is a measure of a water's capacity to neutralize an acid. **Hardness** relates to the water's capacity to produce lather from soap. **pH** indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution.

Alkalinity and pH were fairly similar at all sites (Figure 5, pg 50, 51). Seasonally in 2000/2001 higher concentrations of alkalinity and lower pH values occurred in December and January. Water was very hard and similar above and below Airdrie (Table 2, pg 29).

Water at McPherson Coulee (Table 2, pg 29-30) generally had lower concentrations of salinity parameters than Nose Creek above Airdrie.

4.3 NUTRIENTS

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 (including the production of toxins), affect oxygen concentrations (through photosynthesis / respiration and decay of organic matter), affect aesthetics and affect the physical movement of water.

Phosphorus and **nitrogen** are essential plant nutrients. Sources of phosphorus and nitrogen can include animal manures, commercial inorganic fertilizers, human sewage, detergents (phosphorus), legume rotations (nitrogen), atmospheric deposition and natural levels found in soils.

Total phosphorus measures the nutrient in all forms whether particulate or dissolved, organic or inorganic. The dissolved form 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 over time.

Phosphorus concentrations (Figure 6, pg 52, 53) were highest at Nose Creek above Airdrie and lowest at the Bow River and at West Nose Creek. Highest concentrations in 2000/2001 tended to occur from March to July, with the exception of high values for total phosphorus above Calgary in January.

Total Kjeldahl nitrogen (TKN) is a measure of ammonia and organic nitrogen. Nitrate is the most stable form of combined nitrogen in surface waters and nitrite is an intermediate between ammonia and nitrate.

TKN concentrations were lowest at West Nose Creek and at Nose Creek at the Bow River (Figure 6, pg 54). Highest concentrations in 2000/2001 were measured on April 24, with other high concentration above Calgary in January.

Concentrations of nitrate + nitrite were highest at the Bow River and lowest above Airdrie (Figure 6, pg 55). Highest concentrations in 2000/2001 were measured at most sites from November to January.

Ammonia concentrations were lower above and below Airdrie than at the other three sites. This result is influenced by the higher default detection value for the City of Calgary data. Highest concentrations in 2000/2001 were measured in January above Calgary (Figure 6, pg 56).

The algal community was measured above and below Airdrie (Table 2, pg 30). Phytoplankton, measured as chlorophyll a was generally higher below Airdrie than above Airdrie.

Organic **carbon** is related to oxygen demand and is primarily composed of humic substances and partly degraded plant and animal materials (resistant to microbial degradation). Concentrations of organic carbon (Table 2, pg 30) were higher above Airdrie than below Airdrie.

The **colour** of water is derived from the presence of organic (e.g. algae, natural products from decaying vegetation) and inorganic (e.g. iron, manganese) materials. Colour was higher above Airdrie than below Airdrie (Table 2, pg 30).

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen required to oxidize the organic matter by aerobic microbial decomposition to a stable inorganic form. Lowest values (Figure 6, pg 57) were measured at West Nose Creek (not measured above and below Airdrie). Seasonally, highest concentrations in 2000/2001 were measured on January 30 above Calgary and on March 27 at the Bow River. BOD values below 4 mg/L are considered reasonably clean and 33% of the samples were higher than this value.

Nutrient concentrations were generally lower at McPherson Coulee than at Nose Creek above Airdrie (Table 2, pg 30).

4.4 BACTERIA

Fecal coliform bacteria are normally found in the intestinal tract of warm-blooded animals. Their presence in surface water indicates contamination from this source. ***E. coli*** is one species of fecal coliform bacteria. Bacterial contamination also indicates potential viral and parasitic contamination which can affect drinking water, irrigation, livestock watering and recreation. **Total coliform** bacteria include fecal coliform bacteria as well as coliform bacteria associated with soil.

Concentrations of fecal coliform bacteria and *E. coli* were lowest below Airdrie and highest at Nose Creek at the Bow River (Figure 7, pg 58, 59). Concentrations in 2000/2001 tended to be higher from June to August, with the exception of high concentrations at the Bow River from December to April.

Total coliform bacteria concentrations were generally highest at the Bow River (Table 2, pg 30).

Bacteria concentrations at McPherson Coulee fell into a similar range of values as those at Nose Creek above Airdrie (Table 2, pg 30).

4.5 METALS

Metals can be abundant in nature as a part of the soil and the weathering of rocks, and many are essential for plant and animal nutrition (CCREM 1987 and updates). Other sources may increase the concentration of metals in stormwater. In a study of urban runoff in the US (EPA 1983), copper, lead and zinc were the most frequently detected metals.

Copper is used in electrical wiring and electroplating, production of alloys, photography, utensils, antifouling paint, art designs, pesticide formulations, textiles, roofing materials and plumbing. Sources include brass and copper plumbing, sewage treatment plant effluent, soil treatments as fungicide and pesticide, aquatic algacides and effluent and atmospheric fallout from industrial sources. Industrial sources includes mining, smelting, refining, copper wire mills, and coal burning and iron- and steel-producing industries.

Lead is used in acid-storage batteries, manufacture of chemical compounds, electroplating, metallurgy, construction materials, coatings and dyes, electronic equipment, plastics, veterinary medicines, fuels and radiation shielding, as well as for ammunition, corrosive-liquid containers, paints, glassware, fabricating storage tank linings, transporting radioactive materials, solder, piping, cable sheathing, roofing and sound attenuators. Lead sources include precipitation, dust fallout, street runoff and industrial and municipal wastewater discharges. Industrial usage includes burning of leaded fuels, mining, milling, smelting and refining, pulp and paper mills and chemical manufacturing.

Zinc is used in coatings to protect iron and steel, in alloys for die casting and in brass, rolled sheets and strips for dry batteries, roofing and exterior fittings on buildings and some printing processes. Sources are municipal wastewater, mining, wood combustion, waste incineration, iron and steel production and other atmospheric emissions, as well as paints, rubber, textiles, other chemicals, printing, fertilizers, pesticides and burning fossil fuels.

Chromium, cadmium and nickel were also relatively frequently detected. Chromium is used for chrome alloy and chromium metal production, in chrome plating, and in paints, dyes, explosives, ceramics, paper, textile dyeing, glass, photography, drilling muds, heating and cooling coils, fire sprinkler systems, fertilizers and pesticides. Sources of chromium emissions are ferrochromium production, metal plating, coal and oil burning, refractory production, cement manufacturing and production of chromium steels. Cadmium is used in electroplating operations, manufacture of pigments, nickel-cadmium storage batteries, solders, electronic equipment, lubricants, photography supplies, glass, ceramics, biocides, superphosphate fertilizers and plastics (stabilizer). Sources include mining, smelting and manufacturing, agricultural use of sludges, fertilizers and pesticides, burning of fossil fuels and deterioration of galvanized materials. Nickel is used for stainless steel, nickel plating, high-nickel alloys for chemical, marine, electronic, nuclear and aerospace applications and in industrial processes and oil refining. Sources include burning of fossil fuel, processing of nickel ores, metal plating and waste incineration.

For aluminum, chromium, iron, lead, manganese, mercury, tin, titanium and vanadium (Figure 8, pg 60-76), concentrations increased along Nose Creek from above Airdrie to at the Bow River. Boron (pg 62), copper (pg 65) and molybdenum (pg 70) increased from above Airdrie to above Calgary with a decrease at the Bow River. Concentrations of barium (pg 61), cobalt (pg 64), nickel (pg 71), strontium (pg 72), uranium (pg 75) and zinc (pg 77) were fairly similar at all Nose Creek sites. Concentrations at West Nose Creek were often intermediate between concentrations below Airdrie and above Calgary. West Nose Creek was lower for cobalt, lead, manganese, molybdenum and zinc and higher for strontium.

In 2000/2001, concentrations tended to be higher from November to January. Other high concentrations were measured on March 27 at the Bow River and June 5 and July 17 above Calgary.

4.6 PESTICIDES

During the three year study, forty pesticide compounds were measured and thirteen herbicides and one insecticide were detected (Table 4). Of the compounds detected, 2,4-D, mecoprop, MCPA and dicamba were most frequently detected (in more than half the samples), followed by picloram and atrazine. The remaining compounds were detected in less than 25% of the samples.

Table 4 includes an indication of the use pattern and environmental significance (expressed in the table in terms of relative risk to surface waters), which is a combination of mobility and toxicity characteristics. Details of trade names, types of pests controlled, crops applied to and environmental significance (Cotton 1995) are given in Appendix Table A2. The three pesticides most frequently detected include agricultural, domestic and industrial uses, with a range of risks from low to high depending on the formulations.

Table 4 Pesticide Detections 1999-2001

PESTICIDE	USE PATTERN	RELATIVE RISK	% DETECTION					
			Overall	us Airdrie	ds Airdrie	West Nose	us Calgary	@ Bow River
			n=68	n=12	n=14	n=14	n=14	n=14
2,4-D	Ag/Dom/Ind	moderate to high*	82	92	93	36	93	100
Mecoprop (+2,4-D +Dicamba) = Killex	Dom/Ag	moderate	81	83	93	29	100	100
MCPA	Ag	low to high*	65	75	71	50	64	64
Dicamba = Banvel, Dyvel	Ag/Dom/Ind	moderate	57	33	79	0	71	100
Picloram = Tordon	Ind	high	41	67	50	7	50	36
Atrazine = Atrapell, Aatrex	Dom/Ag	moderate	40	17	29	0	64	86
Clopyralid = Transline, Lontrel	Ag	moderate	22	50	21	0	21	21
Bromoxynil = Buctril M	Ag	high	16	17	14	14	14	21
Diazinon	Dom	N/A	13	0	29	0	14	21
Dichlorprop = Weedone, Estaprop	Ag	low	9	25	14	0	0	7
Diuron = Karmex	Ag/Dom/Ind	moderate	6	8	7	0	7	7
Triallate = Avadex	Ag	moderate	4	0	0	7	0	14
Imazamethabenz = Assert	Ag	moderate	3	8	7	0	0	0
gamma-BHC = Lindane	Insect	moderate	1	0	0	0	0	7
NUMBER OF DETECTIONS	1999 (May - Aug)		104	19	28	7	19	31
	2000 (May - Sep)		97	25	19	4	24	25
	2001 (May - Sep)		99	13	24	9	27	26
	TOTAL			57	71	20	70	82
CUMULATIVE CONCENTRATION (μg/L)		1999	125.78	1.15	3.26	0.11	1.71	22.85
		2000	17.57	2.01	4.95	0.14	4.14	6.33
		2001	54.57	16.31	23.81	0.24	7.21	7
		TOTAL		19.47	32.02	0.49	13.06	36.18

* range of relative risk when several formulations were assessed

Overall, the highest number of detections was at the Bow River, followed by below Airdrie and above Calgary. West Nose Creek had the least number of pesticide detections. When the cumulative concentration of pesticides was calculated at each site, it was possible to further distinguish site impacts. The cumulative concentration at the Bow River was highest, followed by below Airdrie. Again, cumulative concentration was lowest at West Nose Creek. Results at above Airdrie may be relatively low because no samples were taken in August and September of 2001 (no flow).

Results varied from year to year, with the highest number of overall detections and cumulative concentration in 1999 and the lowest in 2000.

Concentrations of 2,4-D, mecoprop and dicamba (ingredients in Killex) increased from above to below Airdrie and from above Calgary to at the Bow River, while the concentrations at West Nose Creek were low (Figure 9, pg 78-81). Concentrations of MCPA were more similar between sites and picloram concentrations were similar at the Nose Creek sites, but low at West Nose Creek (Figure 9, pg 82, 83). Atrazine tended to increase along Nose Creek, but there were no detections at West Nose Creek (Figure 9, pg 79).

In 2000/2001, highest concentrations were generally measured on July 17. The exception was picloram, where only the site above Calgary fit this trend.

4.7 PRIORITY POLLUTANTS

Volatile (58 compounds) and extractable (52 compounds) priority pollutants were measured at four site (no flow above Airdrie) in October 2001. Table 5 summarizes the compounds detected. The concentrations were very close to the detection limits.

Table 5 Priority Pollutants Detected in 2001 in μg/L

COMPOUND	DS AIRDRIE	WEST NOSE	US CALGARY	@ BOW R
Extractable				
Bis(2-ethylhexyl)phthalate	0.4			
Di-n-butylphthalate	1.5	2.4	1.3	1.4
Butylbenzylphthalate	0.1		X	X
Diethyl phthalate	X	0.1	X	0.1

X - identified but estimated as less than the method detection limit.

Phthalate esters are widely used as plasticizers in polyvinyl chloride (PVC) resins, adhesives and cellulose film coating, as wells as in cosmetics, rubbing alcohol, insect repellant, insecticides, tablet coating and solid rocket propellants (CCREM 1987 and updates). Sources include PVC manufacturing, textile and paper mills, landfill sites, municipal incinerators and other nonplasticizer manufacturing. Bis(2-ethylhexyl)phthalate was frequently detected (22% of samples) in the US study of urban runoff (EPA 1983). That study also had a significant blank contamination problem with phthalates.

No volatile compounds were detected in 2001, though chloroform and methylene chloride have been detected (at very low concentrations) in previous years.

5.0 GUIDELINE COMPLIANCE

Table 6 summarizes the overall compliance of the data collected in the three year study with the guidelines. Compliance at each site is also given.

The **irrigation** guidelines were most frequently violated for total dissolved solids, dicamba, bacteria, sodium adsorption ratio, conductivity and MCPA. Use of water exceeding the guidelines for salinity related parameters (conductivity, total dissolved solids) may result in accumulation of salts in the root zone and some loss of production for sensitive crops such as raspberries, strawberries, carrots and beans. The use of water with high sodium adsorption ratio may cause a loss in soil permeability because of excess sodium or leaching of calcium. This will depend on local conditions of soil type (CCREM 1987 and updates).

Guideline violations for dicamba and MCPA are crop dependent in terms of the risk of reduced yields. Guidelines for MCPA were violated 35% of the time for crops other than cereals, tame hays and pasture, and 6% of the time for cereals, tame hays and pasture. Irrigation guidelines for dicamba were violated 59% of the time for sensitive crops (e.g. sunflower), 34% of the time for legumes (e.g. peas) and 3% of the time for tame hays and cereals. Water with fecal coliform bacteria concentrations violating the irrigation guidelines would raise concerns when used on raw produce.

Water quality for **livestock watering** was acceptable.

Raw water quality was not acceptable for **drinking water** without some treatment. Drinking water that contains substances in concentrations greater than the guideline limits either is capable of producing deleterious health effects or is aesthetically objectionable (CCREM 1987 and updates). The major violation of drinking water guidelines relates to coliform bacteria, however, bacteria are removed with the appropriate treatment and no surface water in Alberta should be consumed without treatment.

In addition to coliform bacteria, concentrations of colour, iron, total dissolved solids and manganese violated the guidelines relatively frequently. These drinking water guidelines are based primarily on aesthetic considerations. Total dissolved solids concentrations above the guideline value may be unpalatable. At higher concentrations, colour, iron and manganese cause staining of laundry and plumbing fixtures and undesirable tastes in beverages. Their presence in water may lead to the accumulation of microbial growths, leading to the deposition of a slimy coat in piping (CCREM 1987 and updates).

Violations of the **recreation** guideline for fecal coliform bacteria and *E. coli* indicate the potential or increased health risk for recreational users including respiratory, gastrointestinal, eye, ear, skin and allergy illnesses.

Table 6 Guideline Compliance 1999-2001 (%)

PARAMETER AND GUIDELINE VALUE	Overall	us Airdrie	ds Airdrie	West Nose	us Calgary	@ Bow River
IRRIGATION						
Total Dissolved Solids (500 mg/L)	13	10	21	6	11	16
Conductivity (1.0 mS/cm)	47	41	36	91	35	41
Sodium Adsorption Ratio (3)	47	43	18	100	19	79
Chloride (100 mg/L)	85	95	82	100	76	82
Fecal Coliform Bacteria (100/100 mL)	44	24	79	45	53	11
Aluminum (5000 μg/L)	97	100	100	100	93	100
Iron (5000 μg/L)	97	100	100	100	94	100
Manganese (200 μg/L)	92	88	100	94	87	100
Molybdenum (10 μg/L)	98	99	90	100	99	100
Selenium (20 - 50 μg/L)	99	100	100	97	100	100
Uranium (10 μg/L)	95	100	100	100	91	100
Zinc (1000 - 5000 μg/L)	99	100	100	100	100	97
Dicamba (0.006 μg/L)*	41	67	14	100	29	0
Dicamba (0.06 μg/L)	66	83	43	100	50	57
Dicamba (0.6 μg/L)	97	100	93	100	100	100
MCPA (0.03 μg/L)	65	50	50	71	79	71
MCPA (0.16 μg/L)	94	83	93	100	100	93
DRINKING WATER						
Total Dissolved Solids (500 mg/L)	13	10	21	6	11	16
pH (6.5 - 8.5)	65	73	68	79	43	88
Sodium (200 mg/L)	86	95	86	100	74	94
Chloride (250 mg/L)	98	100	96	100	96	100
Sulphate (500 mg/L)	95	100	100	100	87	100
Nitrate (10 mg/L)	99	100	100	100	99	97
Colour (15 TCU)	2	0	4	n/a	n/a	n/a
Iron (300 μg/L)	8	75	30	6	1	3
Lead (10 μg/L)	96	100	100	100	97	88
Manganese (50 μg/L)	43	75	40	70	36	24
Mercury (1 μg/L)	97	100	100	100	96	94
Selenium (10 μg/L)	97	100	100	97	99	91
Zinc (5000 μg/L)	99	100	100	100	100	97

Table 6 cont. Guideline Compliance 1999-2001 (%)

PARAMETER AND GUIDELINE VALUE	Overall	us Airdrie	ds Airdrie	West Nose	us Calgary	@ Bow River
FRESHWATER AQUATIC LIFE						
Dissolved Oxygen (5.0 - 9.5 mg/L)	49	50	29	45	61	44
pH (6.5 - 9.0)	94	95	100	100	86	100
Ammonia (0.08 - 2.5 mg/L)	92	95	96	97	83	97
Total Phosphorus (0.05 mg/L)	4	0	0	15	0	6
Total Nitrogen (1.0 mg/L)	7	5	11	13	6	3
Aluminum (100 µg/L)	10	88	50	6	0	6
Cadmium (0.085 µg/L)*	29	75	70	30	22	21
Chromium (2 µg/L)	30	86	67	45	20	18
Chromium (20 µg/L)	97	100	100	97	97	97
Copper (47 µg/L)	99	100	100	100	97	100
Iron (300 µg/L)	8	75	30	6	1	3
Lead (7 µg/L)	95	100	100	100	96	85
Mercury (0.13 µg/L)*	62	100	100	58	58	56
Nickel (150 µg/L)	98	100	100	97	99	97
Selenium (1 µg/L)*	38	100	100	6	49	18
Silver (0.1µg/L)*	53	88	90	67	43	41
Zinc (30 µg/L)	91	100	90	97	91	82
2,4-D (4 µg/L)	96	92	93	100	100	93
Bis(2-ethylhexyl)phthalate (0.6 µg/L)	87	100	33	100	100	100
RECREATION						
E. coli (200/100 mL)	66	76	93	73	72	49
Fecal Coliform Bacteria (200/100 mL)	59	62	86	61	62	29
LIVESTOCK WATERING[1]						
Sulphate (1000 mg/L)	99	100	100	100	99	100
Mercury (3000 µg/L)	99	100	100	100	100	97

* detection limit exceeds guideline, less than detection assumed to comply

The **freshwater aquatic life** guidelines were most frequently violated by phosphorus and nitrogen, indicating the generally nutrient rich nature of the waters in the Nose Creek watershed which will promote a large aquatic plant community. Violations of the metals guidelines for the protection of freshwater aquatic life may have an effect on several species, restricting their growth and survival. If these metals are principally associated with sediment particles, they are of less concern to aquatic life than if the metals are in the dissolved form. Iron, aluminum, cadmium, chromium and selenium violated guidelines most frequently.

Violations of the freshwater aquatic life guidelines for dissolved oxygen can lead to stress (and under extreme concentrations to death) for fish or aquatic life. The results indicate some level of stress, however, since temperature, dissolved oxygen and pH fluctuate over a 24 hour period, the full extent of the effects of dissolved oxygen cannot be fully assessed with the data available. The violations were often as a result of concentrations greater than 9.5 mg/L (38%), rather than less than 5.0 mg/L (13% violations).

The freshwater aquatic life guideline for bis(2-ethylhexyl)phthalate was violated in one case below Airdrie.

6.0 ISSUES AND TRENDS

The data collected from January 1999 to October 2001 were compared between sites and against guidelines to determine issues, and with historical data to determine trends. The definition of issues and trends is more complete than in previous reports (Madawaska Consulting 1999, 2000a, 2000b) because of the inclusion of a larger database and the use of statistics to test significance.

6.1 SITE SPECIFIC ISSUES

Site specific issues were identified using two levels of significance in terms of compliance with the most sensitive water quality guideline for each parameter. When guideline compliance was less than 50% the issue was important (identified as ➔) and when guideline compliance was between 50% and 75% the issue was still important but less so (identified as ⇨). Results were taken from the compliance data (Table 6, pg 16-17).

Above Airdrie

➔ total dissolved solids, conductivity, sodium adsorption ratio
➔ total phosphorus, total nitrogen, colour
➔ fecal coliform bacteria
⇨ dissolved oxygen, pH
⇨ MCPA, dicamba

Below Airdrie

➔ dissolved oxygen, sodium adsorption ratio, total dissolved solids, conductivity
➔ total phosphorus, total nitrogen, colour
➔ iron, manganese
➔ dicamba
➔ bis(2-ethylhexyl)phthalate
⇨ pH
⇨ aluminum, chromium, cadmium
⇨ MCPA

Above Calgary

➔ total dissolved solids, sodium adsorption ratio, conductivity, pH
➔ total phosphorus, total nitrogen
➔ aluminum, iron, chromium, cadmium, manganese, selenium, silver
➔ dicamba
⇨ dissolved oxygen, sodium
⇨ mercury
⇨ fecal coliform bacteria, *E. coli*

West Nose Creek

- ➔ dissolved oxygen, total dissolved solids
- ➔ total nitrogen, total phosphorus
- ➔ fecal coliform bacteria
- ➔ iron, aluminum, selenium, cadmium, chromium
- ⇨ *E. coli*
- ⇨ mercury, silver, manganese
- ⇨ MCPA

At Bow River

- ➔ dissolved oxygen, total dissolved solids, conductivity
- ➔ total nitrogen, total phosphorus
- ➔ fecal coliform bacteria, *E. coli*
- ➔ iron, aluminum, chromium, selenium, cadmium, manganese, silver
- ➔ dicamba
- ⇨ mercury
- ⇨ MCPA

The most common site specific issues in terms of not complying with water quality guidelines were nutrients and total dissolved solids, followed closely by fecal coliform bacteria, other measures of salinity and dissolved oxygen. Iron, aluminum, cadmium, chromium, manganese and selenium were frequently identified as significant issues except above Airdrie. Dicamba and MCPA were issues at most sites except at West Nose Creek for dicamba and above Calgary for MCPA. Mercury was an issue at West Nose Creek, above Calgary and at the Bow River.

6.2 REACH SPECIFIC ISSUES

Reach specific issues were identified statistically using median testing (Table 7). An increase in concentration between sites, indicates a source in that reach. A decrease indicates biological processing or dilution in that reach. The analytical lab and possibly methods were different for samples collected by Alberta Environment and the City of Calgary. The results for the reach from below Airdrie and above Calgary include any discrepancies which may have resulted from these analytical differences.

Above Airdrie to Below Airdrie

Concentrations increased significantly

- dissolved oxygen, suspended solids, turbidity
- nitrate
- lead
- dicamba

Concentrations decreased significantly

- potassium, bicarbonate, alkalinity

- total and dissolved phosphorus, total Kjeldahl nitrogen, dissolved organic carbon, colour
- fecal coliform bacteria

Table 7 Site Comparison 1999-2001

PARAMETER	SITES SIGNIFICANTLY DIFFERENT			
	us Airdrie vs ds Airdrie	ds Airdrie vs us Calgary	us Calgary vs at Bow R	West Nose vs us Calgary
Dissolved Oxygen	inc	dec	inc	>
Biochemical Oxygen Demand	n/a	n/a		<
pH		inc	dec	<
Conductivity				<
Total Dissolved Solids				<
Total Suspended Solids	inc			
Turbidity	inc	n/a	n/a	n/a
Total Alkalinity	dec			
Sodium Adsorption Ratio			dec	<
Calcium				>
Sodium			dec	<
Potassium	dec		dec	<
Bicarbonate	dec	n/a	n/a	n/a
Sulphate				<
Chloride				<
Total Phosphorus	dec		dec	<
Dissolved Phosphorus	dec		dec	
Total Kjeldahl Nitrogen	dec	inc	dec	<
Ammonia		inc		
Nitrate	inc		inc	
Dissolved Organic Carbon	dec	n/a	n/a	n/a
Colour	dec	n/a	n/a	n/a
Fecal Coliform Bacteria	dec		inc	
E. coli			inc	
Total Coliform Bacteria	n/a	n/a	inc	
Fecal Streptococci	n/a	n/a	inc	

Table 7 cont. Site Comparison 1999-2001

PARAMETER	SITES SIGNIFICANTLY DIFFERENT			
	us Airdrie vs ds Airdrie	ds Airdrie vs us Calgary	us Calgary vs at Bow R	West Nose vs us Calgary
Aluminum		inc		<
Boron		inc	dec	<
Cobalt				<
Chromium		inc		<
Copper		inc	dec	<
Iron		inc		<
Mercury		inc		
Manganese				<
Molybdenum			dec	<
Lead	inc		inc	<
Strontium				>
Titanium		inc		<
Uranium				<
Vanadium		inc		<
Zinc			inc	<
2,4-D			inc	<
Atrazine				<
Dicamba	inc			<
Mecoprop				<
Picloram				<

parameters which showed no significant difference for any comparison were omitted from the table

Below Airdrie to Above Calgary

Concentrations increase significantly

- pH
- total Kjeldahl nitrogen, ammonia
- aluminum, boron, chromium, copper, iron, mercury, titanium, vanadium

Concentrations decreased significantly

- dissolved oxygen

Above Calgary to the Bow River

Concentrations increase significantly

- dissolved oxygen
- nitrate

- fecal coliform bacteria, *E. coli*, total coliform bacteria, fecal streptococci
- lead, zinc
- 2,4-D

Concentrations decrease significantly

- sodium adsorption ratio, sodium, potassium, pH
- total and dissolved phosphorus, total Kjeldahl nitrogen
- boron, copper, molybdenum

Site Comparison - West Nose Creek vs Nose Creek above Calgary

Higher in Nose Creek

- conductivity, total dissolved solids, sodium adsorption ratio, sodium, potassium, sulphate, chloride, pH
- total phosphorus, total Kjeldahl nitrogen, biochemical oxygen demand
- aluminum, boron, chromium, cobalt, copper, iron, lead, manganese, molybdenum, titanium, uranium, vanadium, zinc
- 2,4-D, dicamba, mecoprop, atrazine, picloram

Higher in West Nose Creek

- dissolved oxygen, calcium
- strontium

Dissolved oxygen changes may reflect differences in the time of day when samples were taken, because oxygen is variable over a single day, depending on water temperature and biological community photosynthesis and respiration.

In the reach from above to below Airdrie concentration changes indicate sources of suspended solids, nitrate, lead and dicamba. These water quality changes reflect inputs from Airdrie and local drainage. Many concentrations decreased in this reach including nutrients and bacteria. This reflects a reduction from the high nutrient and bacteria contaminants measured above Airdrie through biological processing or dilution.

Changes along Nose Creek from below Airdrie to above Calgary included increasing total Kjeldahl nitrogen, ammonia and seven metals. One factor which may be contributing to the increase in metals concentrations is the analytical switch from measurement of extractable forms below Airdrie to total forms above Calgary.

A comparison of data between West Nose Creek and Nose Creek above Calgary showed many higher values in Nose Creek including measures of salinity, total phosphorus, total Kjeldahl nitrogen, biochemical oxygen demand, thirteen metals and five pesticides. In contrast, concentrations were higher in West Nose Creek for calcium and strontium. This comparison reflects the largely agricultural inputs from West Nose Creek as compared to the more urban Nose Creek.

Changes from Nose Creek above Calgary to the Bow River incorporated the inputs (dilution) from West Nose Creek as well as local inputs through Calgary. Concentrations decreased for sodium adsorption ratio, sodium, potassium, dissolved phosphorus, total Kjeldahl nitrogen, boron, copper and molybdenum. Concentrations increased for nitrate, bacteria, lead, zinc and 2,4-D.

6.3 COMPARISON WITH 1980 STUDY

Water quality data collected from 1999 to 2001 were compared with data collected in 1980 (not including storm related sampling; Schonekess 1981, Madawaska Consulting 1999) to determine significant differences in the two data sets (Table 8). In some cases the locations being compared did not exactly match, but the closest matching possible was used. The historical data at West Nose Creek and Nose Creek above Calgary were further downstream than the data collected in this study. Results reflect differences in precipitation, flow, sources, land use and in-stream biological processing.

Table 8 Comparison of 1999-2001 and 1980 data

PARAMETER	SITES SIGNIFICANTLY DIFFERENT SINCE 1980s				
	us Airdrie	ds Airdrie	West Nose	us Calgary	@ Bow R
Dissolved Oxygen	inc	inc			
pH	inc	inc		inc	inc
Total Suspended Solids			inc		
Total Dissolved Solids		inc	inc	inc	inc
Dissolved Phosphorus				dec	dec
Total Phosphorus	inc				dec
Ammonia			inc		
Nitrate		inc	inc	inc	
Total Nitrogen		inc	inc	inc	
Fecal Coliform Bacteria		dec			
Fecal Streptococci	n/a	n/a		dec	
Copper			inc	inc	inc
Lead	dec	dec	dec		dec

Parameters with no significant differences with available data were temperature, biochemical oxygen demand, total organic carbon, total coliform bacteria, chromium, zinc

Dissolved oxygen increases above and below Airdrie may reflect differences in the time of day when samples were taken, because oxygen is variable over a single day, depending on water temperature and biological community photosynthesis and respiration. The general increase in pH along Nose Creek indicates an increase in hydrogen ions. This can also be affected by the biological community in a daily variability.

Total suspended solids have increased in West Nose Creek since 1980, indicating more sediments in the water. There is a more general increase in total dissolved solids at all sites except above Airdrie, indicating an increase in the amount of dissolved material being carried in the creek.

While total phosphorus has increased above Airdrie, decreases were measured at the Bow River. Dissolved phosphorus also decreased at the Bow River as well as above Calgary. Concentrations of all three nitrogen forms increased at West Nose Creek, with increases in nitrate and total nitrogen below Airdrie and above Calgary. There were no increases in nitrogen above Airdrie and at the Bow River.

The only trends for bacteria were decreases of fecal coliform bacteria below Airdrie and fecal streptococci above Calgary.

Copper increased above Calgary, at the Bow River and at West Nose Creek, while there was a general decrease in lead concentration at all sites except above Calgary.

6.4 TRENDS OVER TIME

Water quality trends were determined for Nose Creek at the Bow River using the database since 1980 and for Nose Creek above Calgary since 1995. Data were divided into four seasons (March/April, May to July, August to October and November to February) for statistical analyses.

The data at Nose Creek at the Bow River represent the longer term trends since 1980, however the data were collected sporadically between 1980 and 1999 and were less than ideal. Results indicate that water quality at Nose Creek at the Bow River is increasing for pH (0.01862 units per year), total dissolved solids (8.435 mg/L per year) and copper (0.3367 μg/L per year). Decreasing concentrations were dissolved phosphorus (-0.001727 mg/L per year) and lead (-0.2359 μg/L per year).

While the data at Nose Creek above Calgary are ideal for trend analysis, the trends are short term (seven years). At Nose Creek above Calgary, concentrations which are increasing are biochemical oxygen demand (0.2181 mg/L per year), total suspended solids (1.41 mg/L per year), sulphate (8.691 mg/L per year), aluminum (58.4 μg/L per year) and iron (64.35 μg/L per year). Concentrations which are decreasing are potassium (-0.4464 mg/L per year), nitrate (-0.02934 mg/L per year) and total coliform bacteria (-45.04 per year).

Concentrations of three metals also decreased (cadmium -0.5818 μg/L per year, lead -3.528 μg/L per year, nickel -4.044 μg/L per year), but the data indicate a 'step' drop in concentration when the analytical method was changed in late 1998, therefore the trends are unreliable.

6.5 CONCLUSION

The identification of issues and trends can help to focus efforts in the watershed to implement beneficial management practices. The site specific issues identify the water quality parameters which exceed guideline values, restricting water quality uses. The reach specific issues identify increases within the reach of the creek, which may help in source identification.

The comparison with the 1980 study indicates the differences in water quality between the twenty years of activity in the watershed. Results reflect differences in precipitation, flow, sources, land use and in-stream biological processing. The trend analysis above Calgary and at the Bow River indicates some of the changes over time, however the definition of temporal trends is limited by the database available.

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PROFESSIONAL RESPONSIBILITY

Respectfully submitted,

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TABLES AND FIGURES

Table 2 2000/2001 Database

NO.	SITE	Date	Time	Weather	Air	Water	DO	BOD	pH	EC	FR	TDS	TSS	Turb	T. Alk.	P. Alk.	Hard	Ion	SAR	Ca	Mg	Na	K	HCO3	CO3	SO4	Cl
					deg. C	deg. C	mg/L	mg/L	Units	mS/cm	mg/L	mg/L	mg/L	NTU	mg CaCO3/L	mg CaCO3/L	mg/L	meg/L		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
6	McPherson Coulee	05/22/01	13:10		23	21.7	11.66		8.38	0.9	542	518	8.4	8	456	2.4	330	1.02	2.0	64	42	83	6.3	551	2.9	32.9	15
		06/19/01	10:30		20	15.32	10.22		8.26	0.827	512	475	2.8	3	422	L0.1	310	1.02	1.9	57.5	39.7	76.7	5.8	515	L0.5	26.2	13.2
		07/17/01	12:00		22	20.12	12.44		8.51	0.748	446	441	3.4	2	375	10.8	290	1.07	2.0	51.6	38.6	76.9	4.2	431	13	27	13.6
		08/15/01	10:20		23	16.39	6.78		7.86	0.865	552	538	9.6	9	451	13.1	340	1.04	2.2	61	45.4	94	2.9	519	15.7	39.1	14.7
		09/10/01	10:30		10	8.03	7.84		7.99	0.967	582	567	14.8	9	456	L0.5	340	1	2.2	61.4	45.2	94	7.2	556	L0.5	62	19.5
		10/09/01	12:00		8	4.86	12.44		7.76	0.823	546	545	2.4	5	439	8.9	350	1.06	2.2	63.8	45.9	92.2	5.9	514	10.7	57.3	15.1
5	Nose Creek above Airdrie	11/21/00	09:50		2	-0.02	0.9		6.78	3.06																	
		03/29/01	13:37		5	1.58	9.83		8.43	0.705	484	425	2.6	3	266	L0.1	200	1.01	2.5	34.6	28.3	83	11.4	324	L0.5	62.8	35.3
		04/17/01	08:50		5	0.97	9.54		7.43	0.903	624	545	21	18.1	234	L0.1	240	0.99	2.7	45.6	31.6	97.7	16.9	285	L0.5	130	64.3
		05/22/01	14:00		25	19.01	9.91		8.54	1.306	870	749	18.8	20.9	581	21.9	350	1.08	4.1	52.7	52.8	175	16.3	655	26.3	82.3	18.3
		06/19/01	11:30		22	16.35	9.67		8.48	1.432	978	880	4.6	6	537	8.6	410	1.05	3.9	62.6	62.4	184	17.7	634	10.3	171	59
		07/17/01	13:00		22	20.15	9.39		9.72	1	696	623	19	79.2	330	70.3	160	1.02	6.1	23.2	24.7	178	8.6	231	84.4	138	41.5
4	Nose Creek below Airdrie	11/21/00	10:15		2	-0.14	9.52		7.19	1.445	1050	910	11	11.5	434	L0.1	390	1.04	4.3	73.5	51.3	197	13.5	529	L0.5	195	115
		03/29/01	13:55			-0.17	12.67		8.31	0.862	498	513	36	56.4	229	L0.1	190	1.02	3.9	35.1	24.2	122	11.7	279	L0.5	76.4	98.3
		04/17/01	09:15		5	3.63	10.2		7.84	0.926	640	572	21.6	24	244	L0.1	230	0.92	2.9	43.1	30.8	102	16.4	297	L0.5	144	72
		05/22/01	15:10		25	21.41	16.73		8.58	1.046	644	611	12.4	15.5	313	4.4	260	1.02	3.5	50	33	130	10	371	5.3	132	66.3
		06/19/01	12:30		22	19.6	15.43		8.73	1.206	790	743	18.8	38.6	360	4.7	290	1.03	4.3	48.2	40.6	169	10	428	5.6	200	56.6
		07/17/01	14:10		20	19.73	4.75		8.13	0.484	308	291	50	92.5	119	L0.1	110	1.03	2.6	24.2	12.5	64.3	4.6	146	L0.5	76.7	32.5
		08/15/01	11:40		24	20.7	12.47		8.79	0.635	434	416	9.2	11.7	179	9.9	160	1.06	3.4	29.7	20.5	98.3	2.6	194	11.8	125	31.2
		09/10/01	11:20		10	9.89	9.08		8.57	1.319	846	812	10	14.7	307	3.4	270	1.02	5.1	40.4	41.3	194	7	366	4	288	56.3
		10/09/01	13:15		13	8.22	16.95		8.11	1.124	814	807	12.8	20.2	310	3.5	290	1.06	4.9	49.6	40.9	193	7	369	4.2	267	63.1
3	West Nose Creek	11/07/00		Overcast	-12	-0.4	9.85	<2.9	8.17	0.928		754	18.2		402.4	23.8			1.8	100.3	62.8	93.6	7.2			150.8	17.8
		12/05/00		sunny	-1.2	-0.7	5.83	1.4	7.86	0.832		634	54		479.6	0			1.4	95.6	54.6	71	6.6			104.6	10.4
		01/02/01		overcast	-1.4	-0.3	4.06	3.9	7.8	1.27		818	72.3		574.6	0			1.3	108.2	68.4	71.3	12.1			148.8	22.6
		01/30/01		overcast	-1.4	-0.7	4.79	<1.2	7.73	0.877		1000	42		402.2	0			1.0	87.4	49.2	46.5	5.4			78.1	9.9
		03/27/01		sunny	-0.3	-0.8	11.36	2	8.25	0.861		550	38		390.3	0			1.4	70.2	44.4	60.8	6.6			94.1	13.8
		04/24/01		Sunny	13.9	5.3	9.72	2.8	8.28	0.784		484	48		340.41	15.07			1.3	61	34	52	12			82	13
		05/22/01		Sunny	13.7	10.3	9.48	1.8	8.57	1.01		644	9		463.16	16.29			1.8	83	52	86	7.5			131	17
		06/19/01		sunny	22.3	18.7	12.91	1.6	8.67	0.995		674	7.5		441.5	25.1			1.9	74	54	86	8.4			114	15
		07/17/01		rain overnight	24	17.8	9.29	2.7	8.6	0.837		522	6.8		342.8	15.3			1.8	45	49	72	6.3			117	13
		08/14/01		hazy	24	15.7	4.94	<1.8	8.33	0.874		756	1.6		359.2	0			1.6	51	52	67	6.8			123	13
		09/11/01		cloudy	8	8.3	9.81	1.7	8.35	0.835		546	5.5		361.0	10.4			1.3	63.6	48.4	56.6	6.17			96.5	13.4
		10/09/01		cloudy	6	5.4	9.97	1	8.39	0.864		550	13.4		389.1	0			1.3	68.6	48.2	58.6	5.7			108	13.7
2	Nose Creek above Calgary	11/07/00		Overcast	-12	0.3	9.05	2.8	8.5	1.11		848	12		435.5	0			4.0	68.2	52.4	179.6	11.9			199.9	11.5
		11/21/00		Sunny	10	-0.2	5.02	3.8	7.98	1.52			19.8		546.9	0			4.3	81.4	57.7	207.1	12.1			229.2	122
		12/05/00		sunny	-6.6	-11.2	7.76	2.3	7.96	1.53		1240	35.6		573.4	0			4.8	97.9	67.7	251.1	12.9			275.9	128.1
		12/19/00		part, sun	-4	-0.6	2.53	3.3	7.68	2.67			32		813.3	0			5.8	131.6	90.4	351.4	15.7			405.1	204.4
		01/02/01		overcast	1.4	-0.5	1.57	5.2	7.6	3.8		2690	239.7		1068.1	0			6.8	185.2	129.2	494.4	17.2			778.2	305.9
		01/16/01		clear sky	-1.4	-3.3	4.49	7.3	7.52	4.73		N.R.	546.7		1455.8	0			7.6	230.5	159.6	611.0	21.9			857.5	322.5
		01/30/01		overcast	-1.4	-0.7	7.9	13	7.55	5.19		4200	1620		1895.0	0			7.8	242.3	169.2	646.6	22			899.9	338.6
		03/13/01		sunny	2.8	-0.7	9.15	5.3	8.13	1.2		N.R.	5		243.3	0			1.7	4.3	2.5	17.4	1.1			16.6	13.8
		03/27/01		sunny	-1.5	-0.9	12.4	4.6	8.5	1.05		618	12		307	4.89			3.9	45.1	31.2	138.3	12.2			100.3	94.3
		04/10/01		sunny		NR	10.38		8.16	0.917		N.R.	20.8		208.1	0			3.9	36	22	120	11			116	97
		04/24/01		Sunny	17.3	7.7	10.3	5.1	8.62	0.906		2090	17		303.14	27.99			2.7	44	32	95	16			105	39
		05/08/01		Overcast	15.3	10.2	6.93	5.5	8.47	1.25		826	23		443.3	22			3.7	62	44	154	15			156	65
		05/22/01		Sunny	17	13.2	8.28	5.9	8.68	1.38		904	10		480.5	26.23			4.4	66	49	194	14			202	73
		06/05/01		rain	8.1	10.6	5.66	6.9	8.23	0.87		N.R.	80		191.1	0.4			4.3	27	21	122	7.1			107	93
		06/19/01		sunny	19.1	16.4	10.48	2.8	9.11	1.21		796	10		365.6	34.5			5.0	42	42	192	10			216	51
		07/04/01		sunny	23.1	19.3	5.27	3.3	8.05	0.543		N.R.	18		153.6	0			2.4	26	14	62	5.2			68	33
		07/17/01		rain overnight	24	18.5	4.53	3.1	9.01	0.797		536	117		207.3	18.11			4.2	24	20	116	6.7			133	60
		07/31/01		lt. Overcast	20	15.2	4.76	1.7	9.48	0.664		N.R.	16.5		184.9	32.7			3.3	26	19	91	5			98	45
		08/14/01		hazy	24	17.2	4.48	2	9	0.617		424	8.8		168.9	12.1			2.3	14	9.9	46	2.9			53	19
		08/28/01			24	16.1	4.62	9.7	9.72	0.842		N.R.	11.4		209.9	52.3			4.7	19.6	23.2	131	6.23			146	45.8
		09/11/01		cloudy	8	8.2	6.62	2.9	9.56	1.05		674	9.8		241.4	35.9			5.7	21.3	26.1	165	7.93			200	73.9
		09/25/01		clear,sunny	28	11.5	5.47	3.8	8.5	1.28		N.R.	13		287.7	9.1			5.2	45.3	40.9	200	8.71			295	53.4
		10/09/01		cloudy	6	5.4	8.36	4.2	8.85	1.14		744	8.2		285.8	17.2			4.9	33.8	33.3	166	7.44			238	52.7
		10/23/01		ice, fog	5	1.9	8	2.9	8.64	1.21		N.R.	8.5		302.2	13			5.1	41	37.3	186	7.29			236	63.7
1	Nose Creek at the Bow River	11/07/00		Overcast	-12	0	10.55	5.7	8.35	1.32		1090	27		415.7	10.6			3.9	88.8	58.6	194.9	7.3			216	207.7
		12/05/00		sunny	-0.6	-0.5	10.33	2.9	8.28	1.38		1088	21.8		412.1	0.4			3.8	103.4	61.4	198.4	6.9			220.9	180.7
		01/02/01		parly cloudy	28	-0.5	10.2	3.9	8.1	2.04		1148	16.4		366.8	0			4.7	98.7	57.6	236.2	6.5			253.1	277.9
		01/30/01		overcast	-2.2	-0.7	12.2	<1.6	8.27	0.332		600	0.6		145.4	0			0.2	53.8	15.5	6.9	0.8			46.6	6.3
		02/27/01		sunny	2.2	-0.8	12.4	<1.3	8.05	0.368		188	17		145.5	0			0.1	50.9	14.5	3.09	0.55			45	3.25
		03/27/01		sunny	4.3	-0.7	10.4	13	8.2	2.8		1386	112		188.1	0			14.2	44	21.4	459.2	9.6			115.6	795
		04/24/01		sunny	17.5	8.1	10.5	7	8.56	0.971		642	31		321.41	21.14			2.3	56	36	89	13			126	47
		05/22/01		Sunny	20.3	13.2	11.52	4.7	8.65	1.29		796	28.5		389.92	20.61			2.8	82	56	136	8.2			211	63
		06/19/01		sunny	23.8	16.3	9.09	3.2	8.36	1.07		760	10.6		334.8	0			2.5	64	43	105	5.8			181	50
		07/17/01		rain overnight	24	18.5	4.52	5.3	8.08	0.7		460	84		189.6	0			2.0	38	26	65	4.5			128	33
		08/14/01		hazy	24	19.5	7.75	5.4	8.39	1.15		770	40		282.7	1.9			3.1	60	43	129	6.3			282	57
		09/11/01		cloudy	8	10.1	5.3	4.3	8.01	1.08		728	16.3		304.8	0			2.0	83.1	48.1	93.5	5.79			214	50.1
		10/09/01		cloudy	6	8.8	4	7.2	7.98	1.02		142	24		312.3	0			1.7	77.4	47.3	77	5.69			177	39.1

Table 2 2000/2001 Database

NO.	SITE	Date	F mg/L	TP mg/L	DP mg/L	TN mg/L	TKN mg/L	NH3 mg/L	NIT mg/L	SiO2 mg/L	TOC mg/L	DOC mg/L	COLOUR Rel Units	F. Coli. #/100mL	E. coli #/100mL	T. Coli. #/100mL	F. Strep. #/100mL	Fecal Ratio	Chl mg/m3	Chl a-epi mg/m2	Q m3/s	Ag ug/L	Al ug/L	As ug/L	B ug/L	Ba ug/L	Be ug/L
6	McPherson Coulee	05/22/01	0.35	0.172	0.152	0.9	0.89	0.04	0.005	0.85		12.7	50	84	37						0.011						
		06/19/01	0.37	0.099	0.096	0.8	0.8	L0.01	0.004	2.17		13.1	40	510	310						0.017						
		07/17/01	0.3	0.206	0.17	0.45	0.45	0.02	L0.003	4.09		11.8	40	440	250						0.006						
		08/15/01	0.33	0.091	0.049	0.6	0.6	0.02	0.004	9.47		9.9	40	900	620						0.002						
		09/10/01	0.32	0.057	0.032	0.63	0.62	0.01	0.009	4.07		9.1	40	290	260						0.002						
		10/09/01	0.29	0.043	0.019	0.43	0.43	L0.01	0.004	1.32			20	110	46						0.002						
5	Nose Creek above Airdrie	11/21/00																									
		03/29/01	0.22	0.419	0.295	2.05	2.02	0.01	0.025	9.5		17	60	2	L1				32.8								
		04/17/01	0.19	0.578	0.402	3.31	2.74	0.1	0.571	15.8	30.3	29.6	140	23	5				31.8			<0.1	42	2.7	40	95.2	<0.2
		05/22/01	0.3	0.849	0.672	2.06	2.05	0.07	0.009	2.01		36.4	200	100	48						0.006						
		06/19/01	0.35	0.506	0.427	2.03	2.02	0.03	0.005	1.04		38.5	80	270	91						0.022						
		07/17/01	0.24	0.869	0.75	2.68	2.65	0.09	0.025	11	41.4	41	200	720	470						0.005	<0.1	602	9.4	90	80	<0.2
4	Nose Creek below Airdrie	11/21/00	0.32	0.121	0.045	2.28	1.54	0.15	0.738	1		21.4	20	6	L1				41.9								
		03/29/01	0.32	0.326	0.114	1.89	1.61	0.05	0.281	6.07		16.1	60	10	8				46.9								
		04/17/01	0.19	0.443	0.304	2.77	2.48	0.05	0.289	15.8	30	29.9	150	13	3				34.5			<0.1	40	2.7	30	99.8	<0.2
		05/22/01	0.29	0.188	0.094	1.62	1.54	0.07	0.075	1.2		19.5	60	40	L1						0.009						
		06/19/01	0.33	0.144	0.037	2.05	2.05	0.02	0.003	1.71		24.1	50	50	34						0.036						
		07/17/01	0.15	0.187	0.06	1.62	1.18	0.16	0.442	2.57	9.8	9.8	20	2100	1000						0.44	<0.1	629	3.2	40	86.1	<0.2
		08/15/01	0.22	0.064	0.007	0.96	0.86	L0.01	0.096	0.71		11.1	40	23	23						0.037						
		09/10/01	0.34	0.113	0.019	1.06	1.05	L0.01	0.007	0.32		15.9	30	20	14						0.008						
		10/09/01	0.32	0.081	0.023	1.23	1.17	0.03	0.064	0.56	12.4		20	6	5						0.007	<0.1	41	1.5	50	83.8	<0.2
3	West Nose Creek	11/07/00		0.06	0.04		NR	<0.1	0.9					56	100	280	8	7				nd	439	nd	82.7	157	0.088
		12/05/00		0.1	0.02		1.03	<.1	1.1					24	10	120	2	12				nd	920	nd	88	152	0.105
		01/02/01		0.18	0.05		1.12	0.6	2.2					0	0	225	109	0				0.138	2902	0.779	77.3	187	nd
		01/30/01		0.09	0.03		0.60	0.4	1.6					31	0	40	82	0.4				0.273	459	0.465	68	133	0.055
		03/27/01		0.09	0.02		0.89	nd	0.8					13	0	190	0	0				0.202	504	0.193	78.5	100	0.205
		04/24/01		0.21	0.06		2.67	0.3	0.6					41	0	118	38	1.2				0.239	510	1.16	80.4	126	0.451
		05/22/01		0.09	0.04		0.99	nd	nd					295	200	710	139	2.1			0.085	nd	245	0.611	48.3	121	0.026
		06/19/01		0.09	0.04		1.09	<0.5	nd					320	200	430	430	0.5			0.074	0.063	164	2.17	80.2	104	nd
		07/17/01		0.11	0.04		0.95	nd	0.1					2400	1900	3500	2200	1.1			0.05	nd	315	2.44	58.7	81.6	nd
		08/14/01		0.06	0.05		0.7	nd	0.2					440	300	1210	450	0.98			0.036	0.061	112	4.04	57.6	96.7	nd
		09/11/01		0.03	0.01		0.49	nd	0.52					105	0	715	93	1.1			0.03	0.278	1258	3.31	72.8	120	nd
		10/09/01		0.03	0.01		0.57	nd	0.51					42	100	150	92	0.5			0.019	0.345	367	0.163	59.7	113	0.028
2	Nose Creek above Calgary	11/07/00		0.12	0.03		NR	<0.1	0.5					33	0	134	62	0.5				0.387	254	1.28	128	171	0.028
		11/21/00		0.14				<0.1	1.2					22	0	30	50	0.44				0.287	604	1.26	138	201	0
		12/05/00		0.11	0.01		1.99	nd	1.5					37	0	132	20	1.8				nd	908	0.9	130	218	0.157
		12/19/00		0.1				1.5	1.3					0	0	30	7	NR				nd	850	1.42	148	331	0.12
		01/02/01		0.4	0.01		4.26	5.2	nd					0	0	15	2	0				3.62	7365	3.94	217	517	0.193
		01/16/01		0.66	NS		NS	1.1	nd					8	0	50	10	0				0.567	29520	1.83	305	834	0.483
		01/30/01		1.7	0.02		3.51	<5.0	12.2					20	0	25	28	0.7				0.188	11800	7.28	273	830	0.869
		03/13/01		0.19				nd	0.1					12	100	300	16	0.8				0.318	465	nd	66.8	82.9	0.035
		03/27/01		0.19	0.04		1.75	nd	0.4					6	0	44	24	0.25				0.056	202	1.59	83	91.1	0.1
		04/10/01		0.28				0.2	0.7					24	0	72	46	0.5				0.276	643	2.04	60	89.8	0.021
		04/24/01		0.21	0.13		4.39	<0.1	0.4					3	0	104	40	0.08				8.18	196	3.11	81.7	99.5	0.5
		05/08/01		0.26				nd	0.4					6	0	27	19	0.3				0.285	850	3.35	106	148	0.132
		05/22/01		0.27	0.11		2.51	<0.5	nd					146	100	166	30	4.9			0.03	nd	190	3.92	69.3	123	nd
		06/05/01		0.4				nd	0.9					1500	1200	2000	TNTC	.				nd	3236	3.41	43.1	115	0.074
		06/19/01		0.18	0.08		1.83	nd	nd					520	500	630	170	31			0.045	0.057	621	5.04	100	90.3	nd
		07/04/01		0.23				0.1	0.3					1000	1400	2200	1100	0.9				0.104	1722	3.94	58.9	122	0.08
		07/17/01		0.38	0.12		1.58	nd	0.1					11200	3800	13600	1800	0.1			1.1	0.007	5010	4.93	56.4	140	0.22
		07/31/01		0.15	NR		NR	nd	0.1					1260	1200	1800	520	2.4				0.07	1065	5.12	65.7	88	nd
		08/14/01		0.1	0.07		0.72	nd	nd					1700	1100	2700	330	5.2			0.099	0.159	235	5.55	61.1	68.5	nd
		08/28/01		0.13	nr		nr	nd	0.42					250	0	320	124	2				0.042	457	7.89	98.5	79.8	nd
		09/11/01		0.11	0.03		1.74	nd	0.42					226	0	436	170	1.3			0.023	0.653	837	6.41	58.7	90.5	nd
		09/25/01		0.08	nr		nr	nd	1.42					840	500	890	108	7.8				0.198	410	5.73	96.4	118	nd
		10/09/01		0.1	0.01		1.61	nd	0.98					12	100	120	64	0.2			0.006	nd	321	1.69	98.4	97.2	nd
		10/23/01		0.08	nr		nr	nd	0.72					19	0	240	116	0.16				2.02	298	1.94	69.4	97	0.022
1	Nose Creek at the Bow River	11/07/00		0.09	0.02		NR	ND	1.9					420	600	10800	190	2.2				0.232	691	nd	101	136	0.049
		12/05/00		0.06	0.01		1.1	<.5	2.8					4267	400	5900	300	14				nd	478	nd	113	116	0.075
		01/02/01		0.13	0.03		1.24	0.9	3.4					273	tntc	65000	610	0.45				0.072	178	1.09	85.7	97.9	nd
		01/30/01		0.02	0.02		0.20	0.2	2.1					195	100	1050	600	0.3				4.06	97.6	nd	68.9	43.9	nd
		02/27/01		0.03	0.01		0.20	<0.05	0.29					1120	600	7200	840	1.3				0.574	245	nd	31	63.6	nd
		03/27/01		0.28	0.06		2.3	0.7	2.1					26500	900	150000	1900	13.9				0.24	1866	1.57	77.7	121	0.239
		04/24/01		0.25	0.05		3.68	<0.1	0.8					1550	200	3800	1030	1.5				0.065	279	1.72	81	105	0.588
		05/22/01		0.14	0.03		1.51	nd	1.8					100	0	1050	0	0			0.188	nd	822	1.3	57.9	114	nd
		06/19/01		0.09	0.03		1.15	<0.5	1.5					179	200	1733	43	41			0.348	0.144	482	2.02	85.1	98.9	nd
		07/17/01		0.23	0.06		1.5	0.3	0.9					1666	500	26400	2000	0.8			0.682	nd	1374	3.11	51.9	121	0.105
		08/14/01		0.17	0.003		1.36	nd	0.6					590	400	8833	170	3.5			0.298	0.397	1016	4.73	93.5	118	0.02
		09/11/01		0.11	0.02		1.33	0.12	1.12					400	300	11400	210	1.9			0.059	0.271	370	4.05	89.9	99.3	nd
		10/09/01		0.1	<0.01		1.21	nd	1.36					270	900	41000	320	0.8			0.137	nd	813	0.695	94.1	98.1	0.086

Table 2 2000/2001 Database

NO.	SITE	Date	Cd ug/L	Co ug/L	Cr ug/L	Cu ug/L	Fe ug/L	Hg ug/L	Mn ug/L	Mo ug/L	Ni ug/L	Pb ug/L	Sb ug/L	Se ug/L	Sn ug/L	Sr ug/L	Ti ug/L	Tl ug/L	U ug/L	V ug/L	Zn ug/L
6	McPherson Coulee	05/22/01																			
		06/19/01																			
		07/17/01																			
		08/15/01																			
		09/10/01																			
		10/09/01																			
5	Nose Creek above Airdrie	11/21/00																			
		03/29/01																			
		04/17/01	<0.2	0.4	1	3.7	320	<0.05	40	2.9	4.6	0.4	<0.02	<0.02	<1	280	2	<0.02	3.6	2	15
		05/22/01																			
		06/19/01																			
		07/17/01	<0.2	0.6	<1	2.3	770	<0.05	72	1.9	5.7	1.1	0.6	<0.02	<1	218	8	<0.02	1.4	7	21.6
4	Nose Creek below Airdrie	11/21/00																			
		03/29/01																			
		04/17/01	<0.2	0.5	<1	3.6	380	<0.05	46	3.1	4.2	0.8	<0.02	<0.02	<1	327	2	<0.02	3.7	2	9.8
		05/22/01																			
		06/19/01																			
		07/17/01	<0.2	0.5	1	2.7	630	<0.05	66	2.6	4.1	3	0.9	<0.02	<1	141	3	<0.02	1.4	4	29.5
		08/15/01																			
		09/10/01																			
		10/09/01	<0.2	0.4	<1	1	260	<0.05	60	4.4	2.9	0.7	0.7	0.2	<1	392	1	<0.02	3.8	<1	14.8
3	West Nose Creek	11/07/00	0.109	0.377	1.05	4.3	627	0.017	38.5	3.21	5.71	0.912	0.268	4.77	0.583	903	4.75	0.027	5.01	1.66	5.51
		12/05/00	0.057	0.558	1.89	3.64	1215	0.068	259	2.44	5.31	1.27	0.136	4.13	0.182	793	9.79	nd	4.04	2.78	8.98
		01/02/01	nd	0.636	3.64	4.3	1751	0.221	156	3.41	6.64	1.04	0.172	7.24	0.229	857	26.6	nd	5.6	7.29	11
		01/30/01	0.172	0.82	2.55	6.17	810	0.33	64.5	1.7	5.5	1.02	0.846	3.74	nd	663	5.84	nd	3.86	2.33	9.86
		03/27/01	0.048	0.38	1.67	2.5	681	0.153	222	2.25	2.75	0.624	0.212	4.72	0.208	614	5.23	nd	3.83	1.78	21.7
		04/24/01	0.034	0.571	1.12	7.61	1131	0.213	61	2.15	6.33	1.65	0.27	1.77	0.074	549	6.92	nd	3.53	2.03	14.3
		05/22/01	0.101	0.333	0.883	5.84	443	0.007	32	1.99	4.01	0.967	0.171	3.55	0.055	747	2.79	nd	3.28	1.49	7.27
		06/19/01	0.039	0.159	1.34	9.83	357	0.025	24.1	1.91	4.47	1.02	0.212	3.73	0.119	723	1.58	nd	3	1.44	5.66
		07/17/01	0.133	0.333	5.13	10.2	367	0.028	12.1	2.59	4.11	1.09	0.176	2.09	0.055	545	2.94	0.004	2.91	1.94	4.85
		08/14/01	0.059	0.169	2.6	9.62	151	0.283	5.77	2.63	1.7	0.904	0.217	3.81	nd	571	0.852	nd	3.26	1.37	2.82
		09/11/01	0.05	0.211	2.3	8.17	316	0.235	8.64	2.95	5.76	1.02	0.244	5.8	nd	638	1.46	nd	4.1	0.939	6.18
		10/09/01	nd	0.226	1.33	16	452	0.067	15.9	2.71	6.17	1.54	0.342	4.73	0.124	646	3.5	nd	4.06	1.27	10.1
2	Nose Creek above Calgary	11/07/00	0.172	0.497	1.11	4.57	617	0.134	16.5	5.88	5.86	1.05	0.494	0.545	1.08	553	2.75	0.002	6.71	1.07	8.55
		11/21/00	0.186	0.579	2.39	8.94	844	0.086	29	5.87	8.02	1.62	0.515	0.31	1.23	678	4.75	0.006	7.55	2.05	23.5
		12/05/00	0.205	0.631	1.97	5.35	1117	0.299	38.1	5.78	7.56	1.41	0.503	nd	0.163	750	7.19	nd	7.76	2.69	13.1
		12/19/00	0.066	0.963	2.04	14.3	1189	0.145	256	7.13	9.39	0.963	0.569	1.2	0.149	1128	6.99	nd	10.7	2.79	9.35
		01/02/01	nd	3.84	8.8	12.6	5852	0.842	1426	8.13	17.6	4.49	1.03	0.753	0.994	1590	48.8	nd	14.3	18.3	39.3
		01/16/01	nd	6.62	30.9	27.1	14653	0.033	1317	9.42	35.3	11.2	1.2	0.426	1	2467	400	0.107	20.8	68.2	85.3
		01/30/01	0.968	9.96	13.9	46.9	18950	0.442	1000	6.89	45.2	22.2	0.831	nd	0.074	2935	59.6	0.089	20.5	24.9	146
		03/13/01	0.032	0.423	1.14	10.8	518	0.099	105	2.36	3.77	1.07	0.279	0.93	0.132	296	4.35	nd	2.49	1.68	12.5
		03/27/01	0.039	0.512	1.28	3.28	490	0.111	39.1	2.85	3.49	1.08	0.337	0.319	0.081	331	2.64	nd	3.21	1.3	10.2
		04/10/01	0.305	0.84	1.95	5.39	1045	0.184	99.3	2.65	4.87	4.63	0.419	1.41	0.044	238	12.4	nd	2.46	2.34	18.1
		04/24/01	0.119	0.641	1.09	8.89	602	0.48	57.5	2.93	7.31	1.73	0.487	0.257	0.151	332	4.18	nd	3.65	2.54	14.3
		05/08/01	0.157	0.683	2.02	14.3	851	0.106	74.8	4.36	7.39	2.51	0.526	1.04	0.417	503	6.81	nd	4.93	4.4	13.7
		05/22/01	0.231	0.618	0.922	18.2	474	0.052	78	4.59	8.04	1.44	0.572	1.11	0.019	519	2.83	nd	5.03	2.94	7.95
		06/05/01	0.136	1.16	4.84	24.9	2783	0.041	97.6	3.71	8.18	3.34	0.629	0.644	0.146	222	26	0.057	3.25	10.3	28.2
		06/19/01	0.095	0.426	2.07	4.92	588	0.052	41.5	4.94	5.82	1.56	0.608	1.34	0.248	396	4.91	nd	4.76	3.98	8.93
		07/04/01	0.211	0.664	4.35	9.81	1746	nd	46.2	2.37	6.64	3.12	0.465	nd	0.212	179	16.2	0.034	1.39	5.13	22.1
		07/17/01	0.19	1.59	7.13	16.5	3735	0.047	65.9	4.31	7.04	3.46	0.552	0.692	0.169	228	33.8	0.094	3.49	14	23.2
		07/31/01	0.128	0.504	5.2	18.7	793	0.343	21.1	3.4	4.08	1.39	0.469	1.27	0.006	208	6.49	nd	2.2	4.37	10.8
		08/14/01	0.021	0.319	2.28	24.1	381	0.349	25.8	2.92	2.11	0.79	0.441	0.913	nd	203	2.13	nd	1.96	2.13	4.41
		08/28/01	0.162	0.437	2.24	16.6	498	0.107	23.7	4.16	4.02	1.13	0.687	0.928	nd	212	2.72	nd	3.18	4.01	8.33
		09/11/01	0.345	0.913	3.4	27	1339	1.18	32.9	7.46	7.78	9.31	0.91	1.23	0.091	227	7.48	0.054	4.55	4.26	25.2
		09/25/01	0.084	0.266	3.42	14.3	430	0.004	20	6.19	5.18	1.24	0.621	1.49	nd	368	3.19	nd	5.42	1.53	8.35
		10/09/01	0.006	0.269	7.04	23.6	386	0.027	13	5.98	5.84	1.55	0.623	0.174	0.091	348	2.28	nd	4.5	1.07	9.68
		10/23/01	0.183	0.235	1.58	9.98	310	nr	9.83	5.59	4.61	0.943	0.521	0.52	0.814	360	2.29	nd	4.34	0.939	7.99
1	Nose Creek at the Bow River	11/07/00	0.167	0.682	2.01	8.94	1008	0.061	71.4	3.83	6.72	3.93	0.369	6.75	1.8	822	7.3	0.017	6.46	2.2	15.6
		12/05/00	0.085	0.507	2.01	4.79	753	0.113	49.6	3.23	5.86	2.45	0.243	8.53	0.181	837	5.41	nd	6.02	1.67	13.4
		01/02/01	nd	0.361	1.6	11	449	0.286	48.3	2.71	4.95	1.72	0.21	9.15	0.176	807	8.24	nd	5.85	0.783	15
		01/30/01	0.061	0.097	1.71	13.5	188	0.224	4.74	0.436	4.37	1.19	0.152	nd	0.935	196	0.882	nd	0.682	0.246	8.88
		02/27/01	0.016	0.171	0.505	4.51	332	0.025	14.6	0.395	3.36	1.19	0.069	nd	0.12	193	3.12	nd	0.622	nd	6.48
		03/27/01	0.524	1.55	13.5	20	2846	0.283	129	3.55	7.73	21.5	1.2	3.69	0.647	328	24.8	nd	2.32	5.48	118
		04/24/01	0.098	0.695	1.57	12.4	807	0.185	71.4	2.84	6.97	3.36	0.345	2.62	0.202	457	4.91	nd	3.95	2.22	18
		05/22/01	0.105	0.698	2.1	8.96	916	0.027	106	2.96	5.88	4.81	0.416	4.05	0.128	691	8.14	0.003	4.73	3.37	14.7
		06/19/01	0.096	0.361	2.22	7.84	560	0.088	50.8	2.7	5.28	2.19	0.509	3.43	0.346	565	4.03	nd	3.95	2.38	11.9
		07/17/01	0.21	1.15	3.93	13.1	2119	0.023	81.3	2.37	5.88	6.23	0.465	4.2	0.18	338	17.9	0.035	2.61	4.42	27.7
		08/14/01	0.069	0.652	3.72	11.2	1038	0.384	93.1	3.72	4.09	5.54	0.536	4.77	0.009	553	9.95	nd	4.71	4.09	13.8
		09/11/01	0.179	0.49	2.57	9.46	644	0.352	87.5	3.33	7.88	3.46	0.428	3.13	0.112	611	4.68	nd	4.03	1.76	14.6
		10/09/01	0.08	0.53	1.83	18.3	833	0.045	86.8	3.53	7.4	4.17	0.47	4.93	0.153	624	8.01	nd	4.39	2.52	16.9

TABLE 2 2001 Database

	Date	2,4-D	Atrazine	Bromoxynil	Clopyralid	Diazinon	Dicamba	MCPA	Mecoprop	Picloram	Triallate
Detection Limit (ug/L)		0.005	0.005	0.005	0.02	0.005	0.005	0.005	0.005	0.005	0.005
Nose Creek above Airdrie	May 22	0.113							0.39	0.101	
	June 19	0.178			0.091			0.042	0.21	0.056	
	July 17	5.068					0.561	0.078	9.387	0.033	
Nose Creek below Airdrie	May 22	2.156					0.144		3.045		
	June 19	0.368			0.056		0.117	0.075	0.401	0.033	
	July 17	4.355	0.161				0.709	0.105	7.555	0.028	
	Aug 15	1.08	0.111				0.28		1.25	0.259	
	Sept 10	0.46					0.226		0.53	0.31	
West Nose Creek	May 22	0.013							0.007		
	June 19							0.012		0.009	
	July 17	0.063		0.013				0.112	0.008		0.003
	Aug 15										
	Sept 10										
Nose Creek above Calgary	May 22	0.313			0.084		0.043		0.744	0.1	
	June 19	0.086			0.089		0.094	0.013	0.22	0.147	
	July 17	1.637	0.083				0.227	0.051	1.203	0.523	
	Aug 15	0.044	0.05		0.054		0.405		0.103	0.38	
	Sept 10		0.058				0.166		0.061	0.23	
Nose Creek at the Bow River	May 22	0.504	0.018		0.066		0.036		0.419		
	June 19	0.387	0.072				0.112	0.037	0.503	0.081	
	July 17	1.201	0.137			0.029	0.164	0.037	1		
	Aug 15	0.067	0.034		0.051		0.058		0.17	0.049	
	Sept 10	0.8					0.158		0.81		

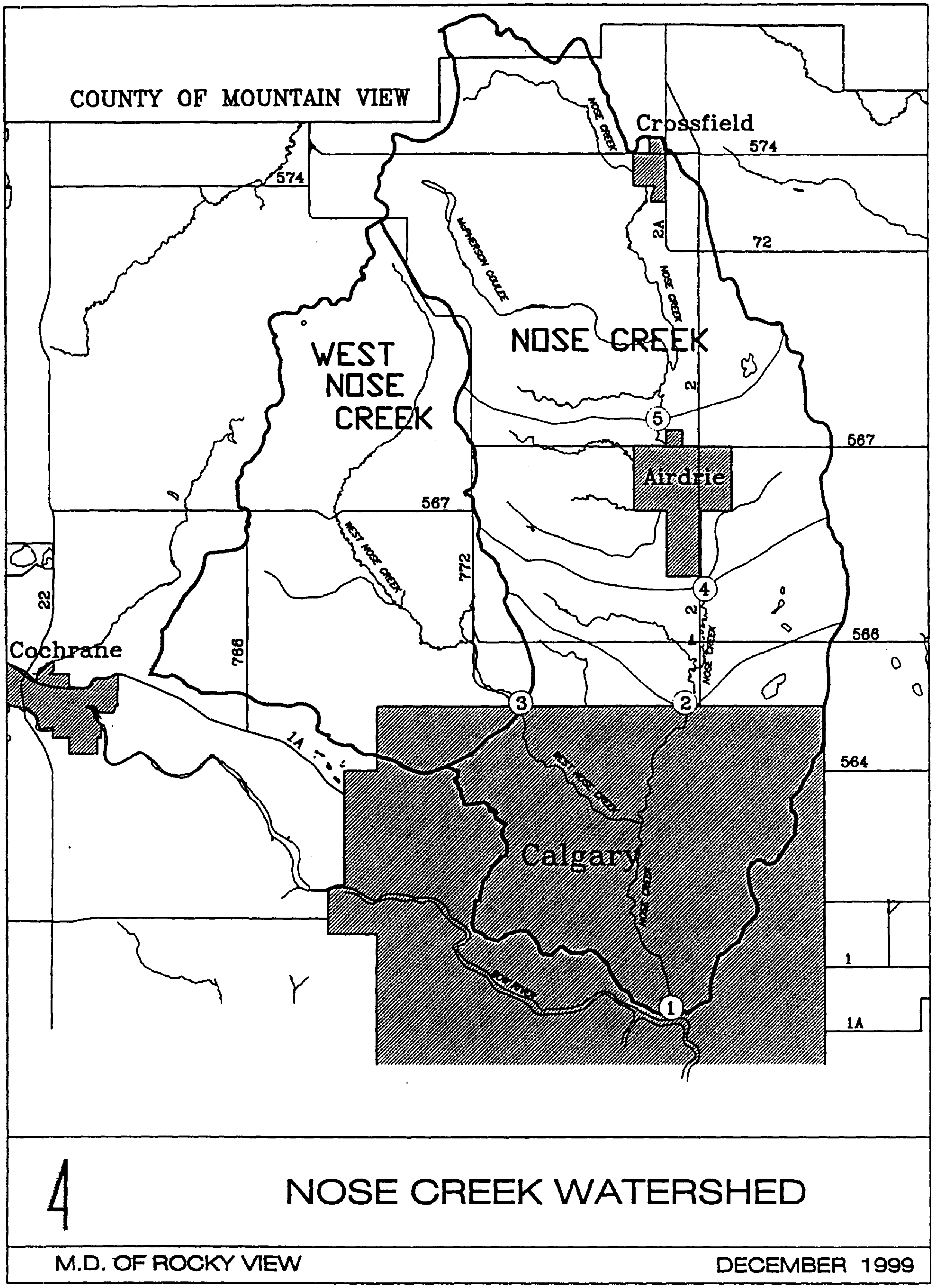


Figure 1 Study Area

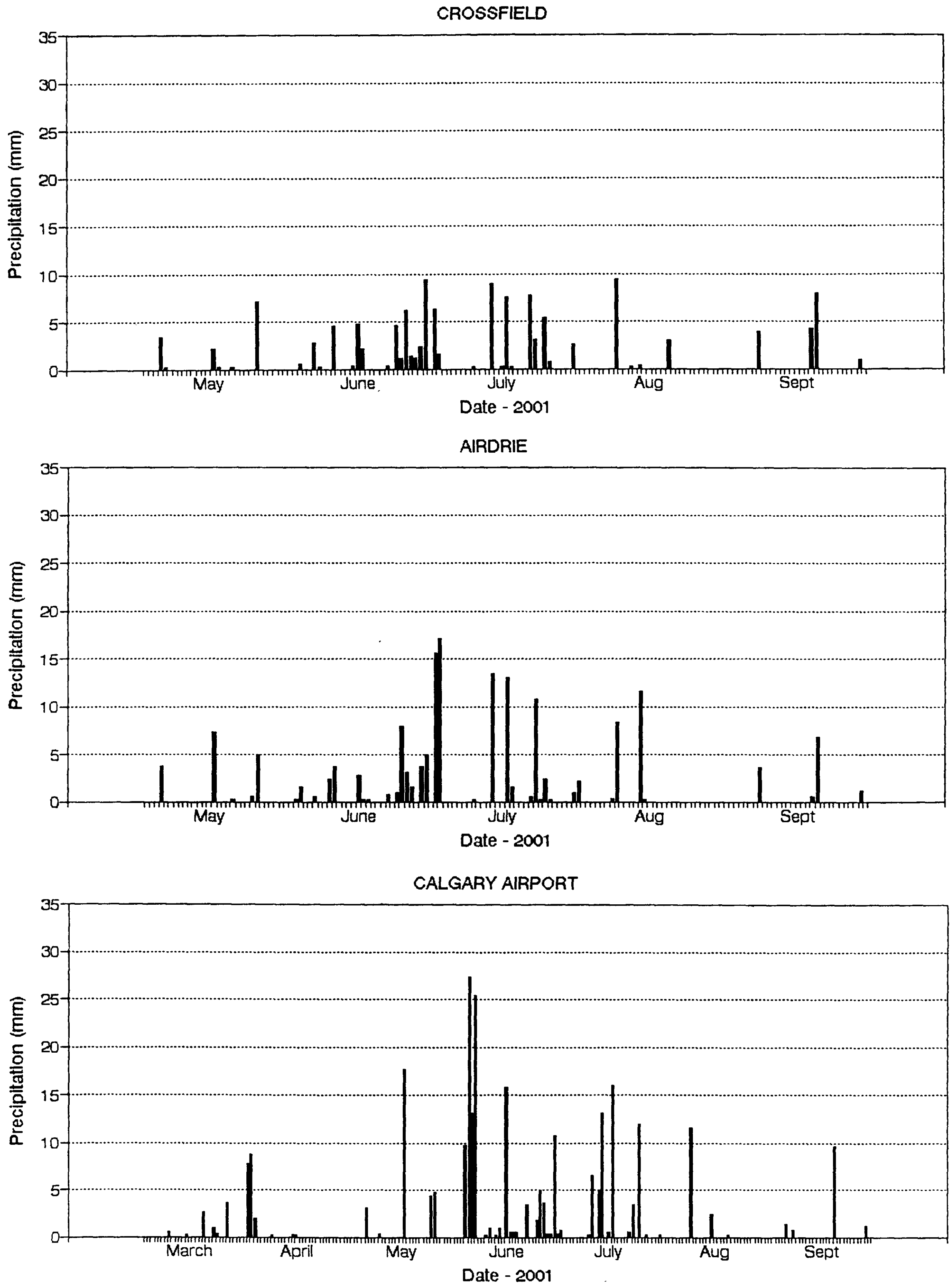


Figure 2 Precipitation

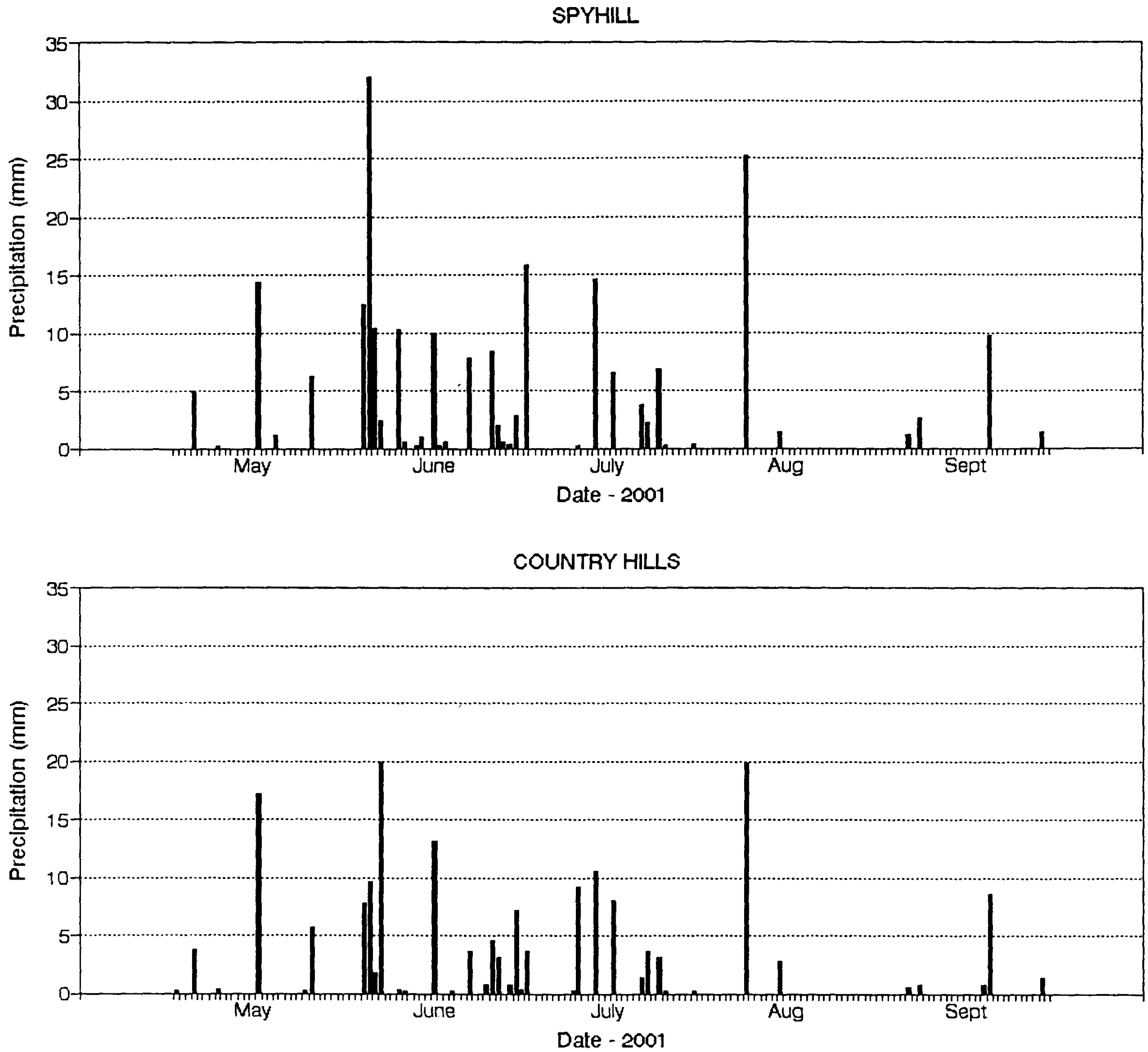
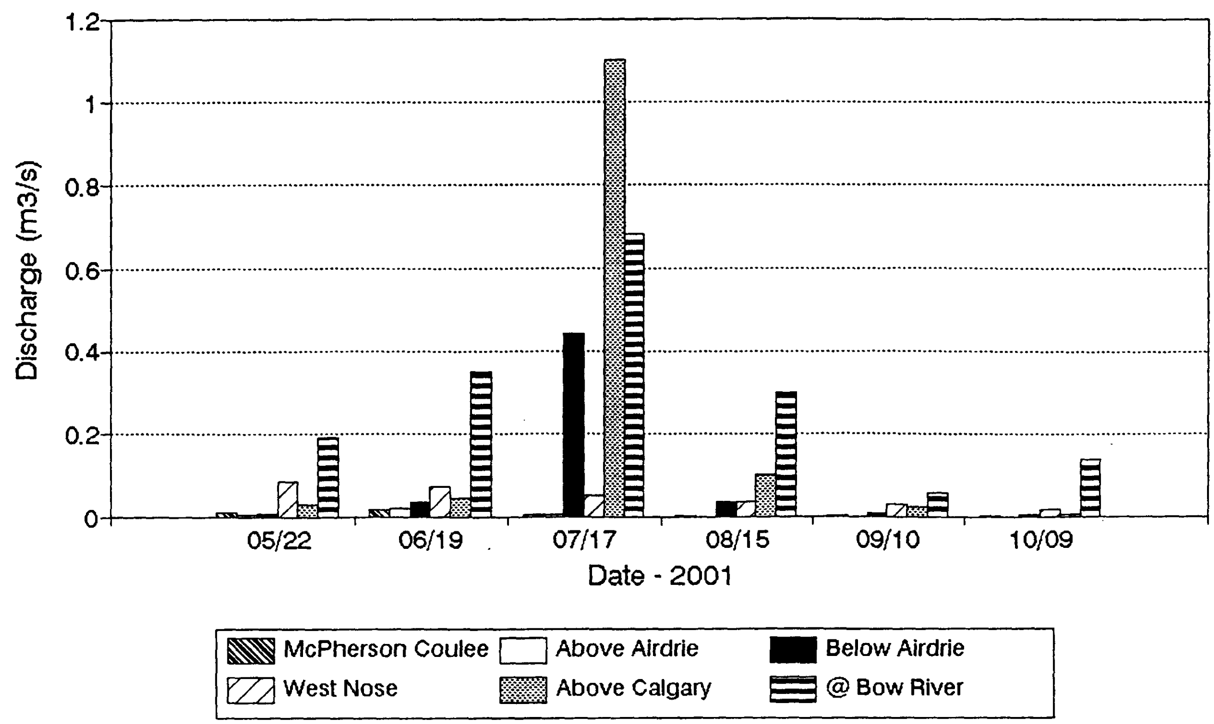


Figure 2 cont.



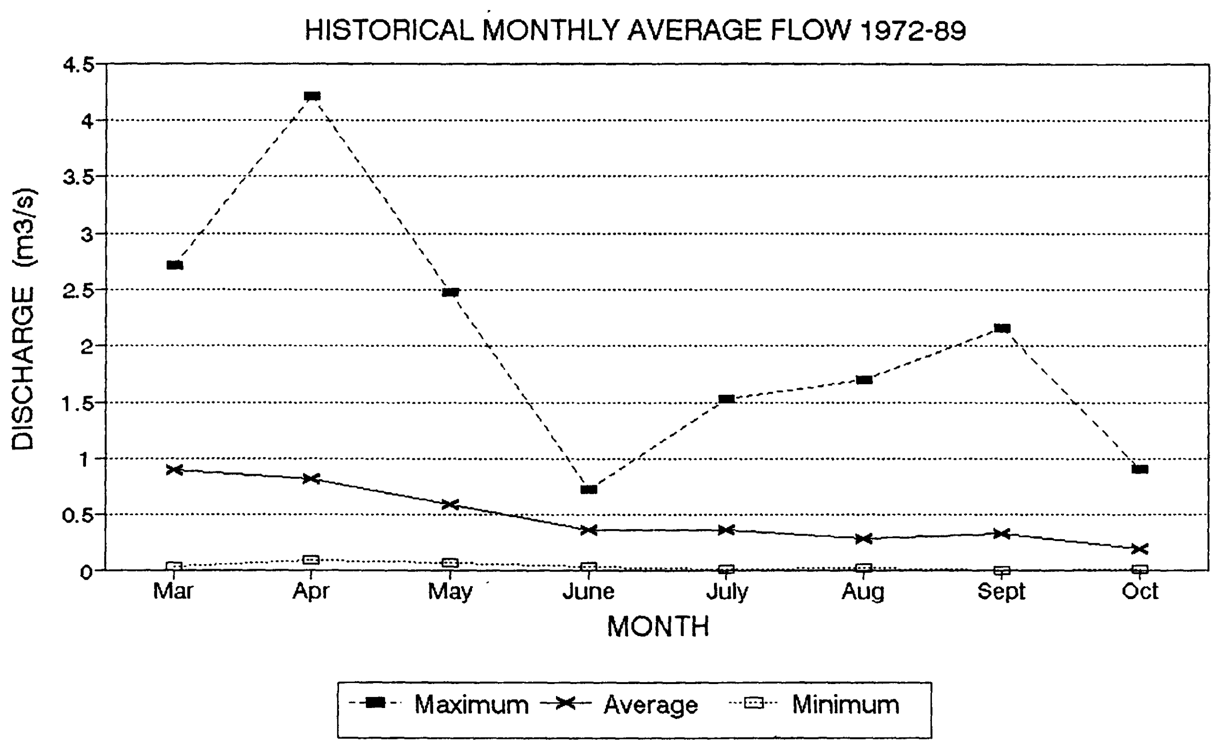


Figure 3 Flow

WHAT CAN A BOX AND WHISKER PLOT TELL ME?

A box and whisker plot is a way of looking at data - much easier than looking at pages of numbers. It summarizes the data as grouped by site or time etc.

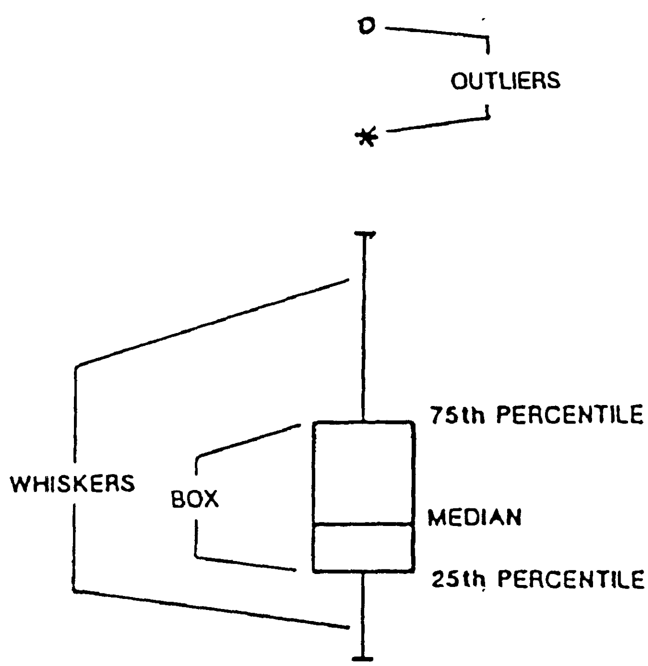
High and low values - end of whiskers or "o", "⋆" (outliers - statistically extreme values)

Middle value (median) - line through box

Middle 50% of the data - box (central block of data)

How data from several sites compare - relative position of box and whisker

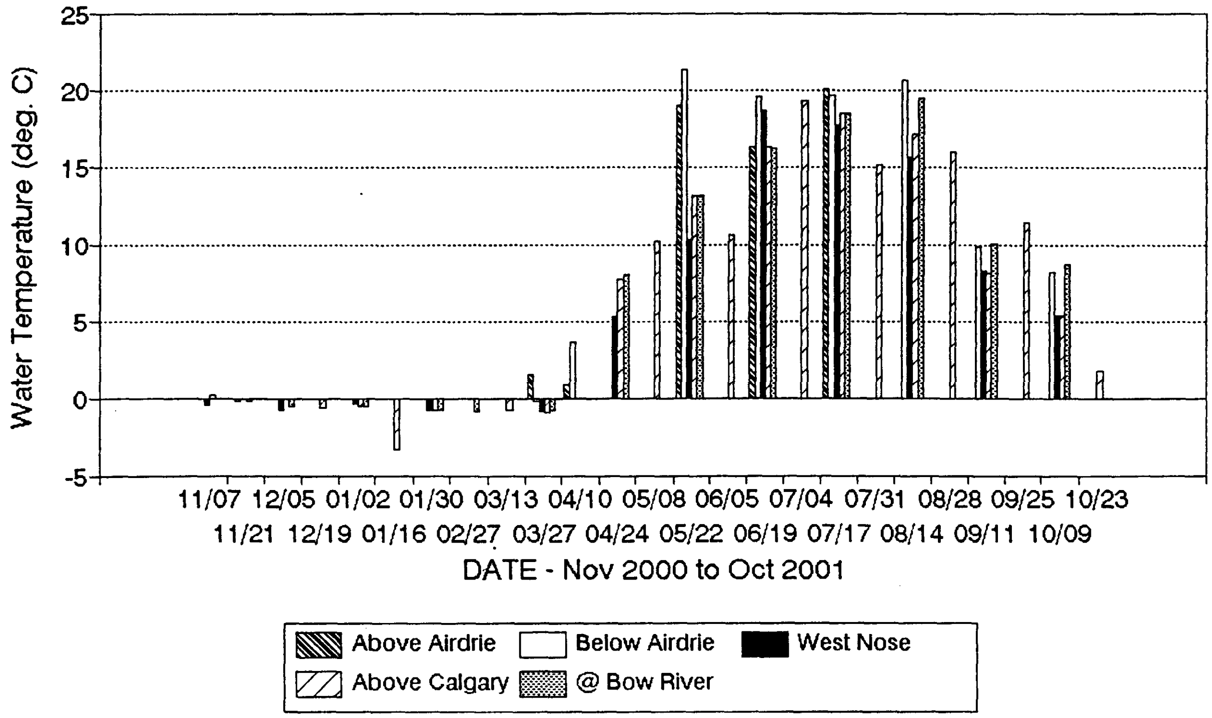
How data compare to water quality guideline - position of box and whisker compared to guideline value drawn on plot



Water quality guidelines are indicated by a horizontal line at the guideline value. Data values above the horizontal line violate the guideline and data values below the horizontal line are acceptable in relation to the guideline.

Outliers are extreme values which do not "fit' statistically into the distribution of the "typical" data values (box and whiskers).

The **median** is the middle value. Half of the data are greater and half of the data are less than the median value.



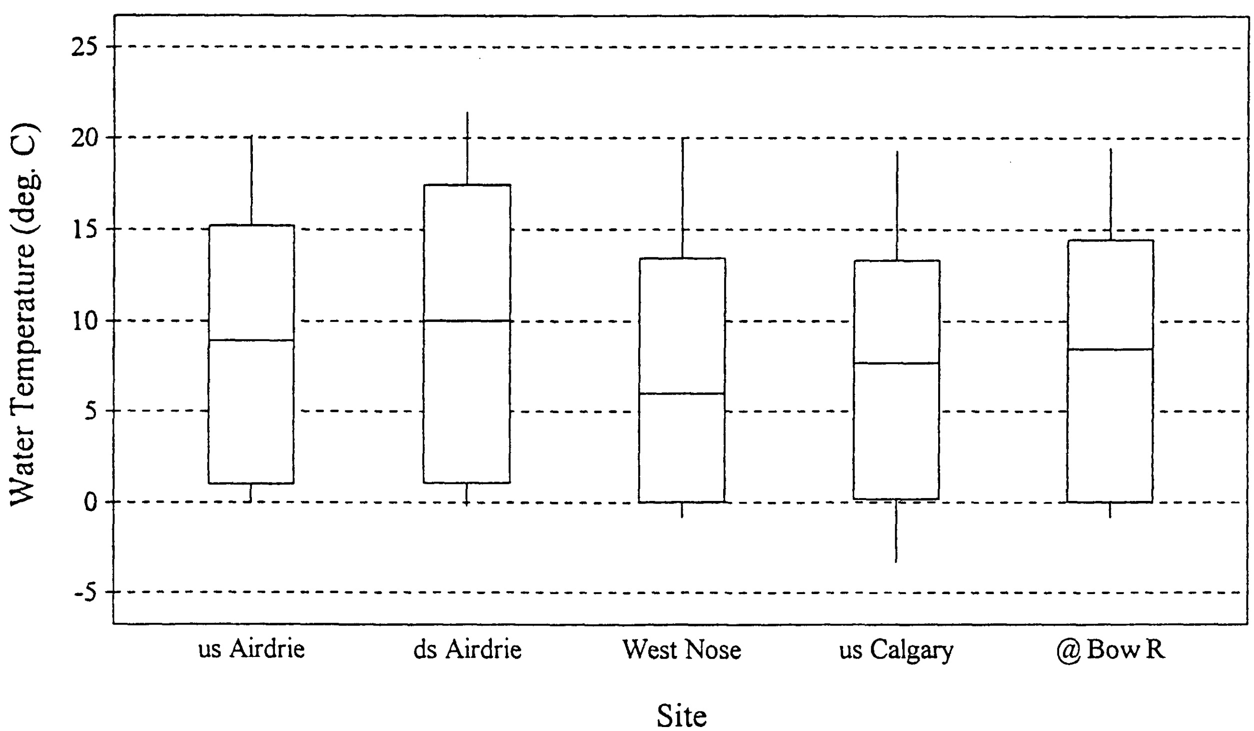
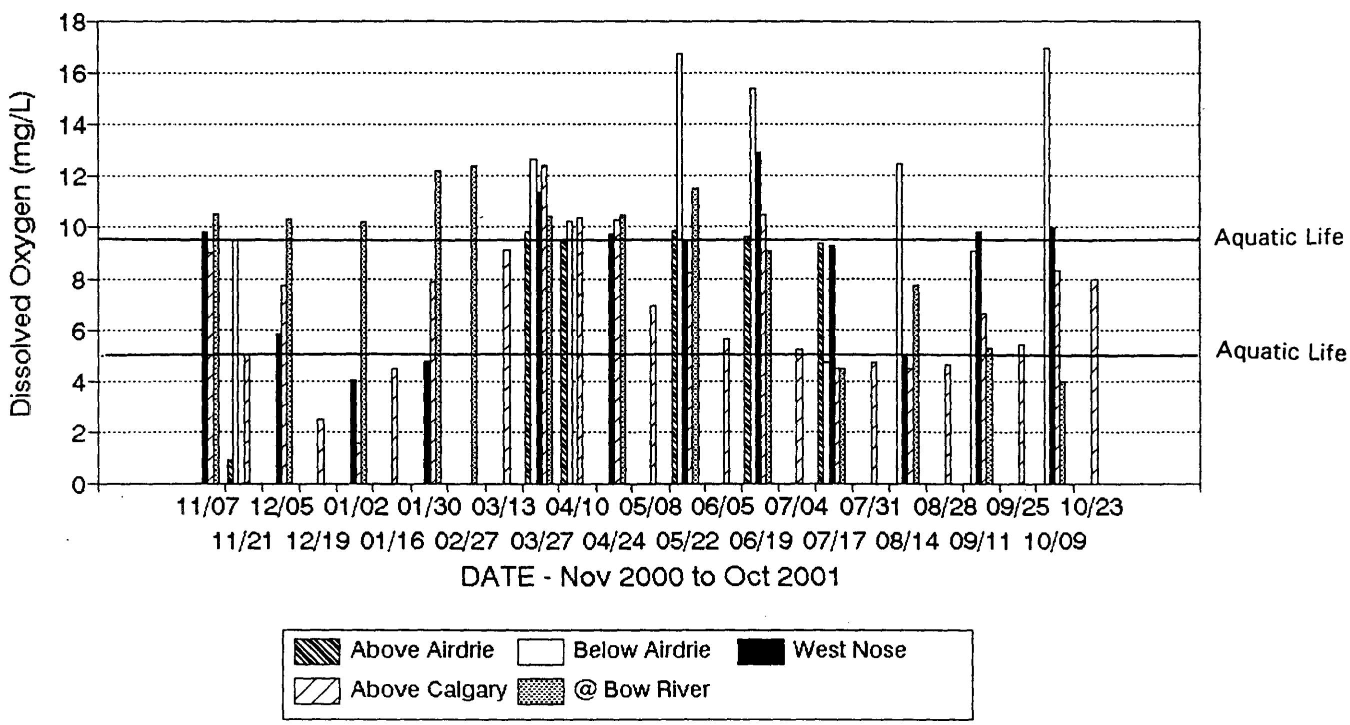


Figure 4 Temperature, Oxygen, Sediment



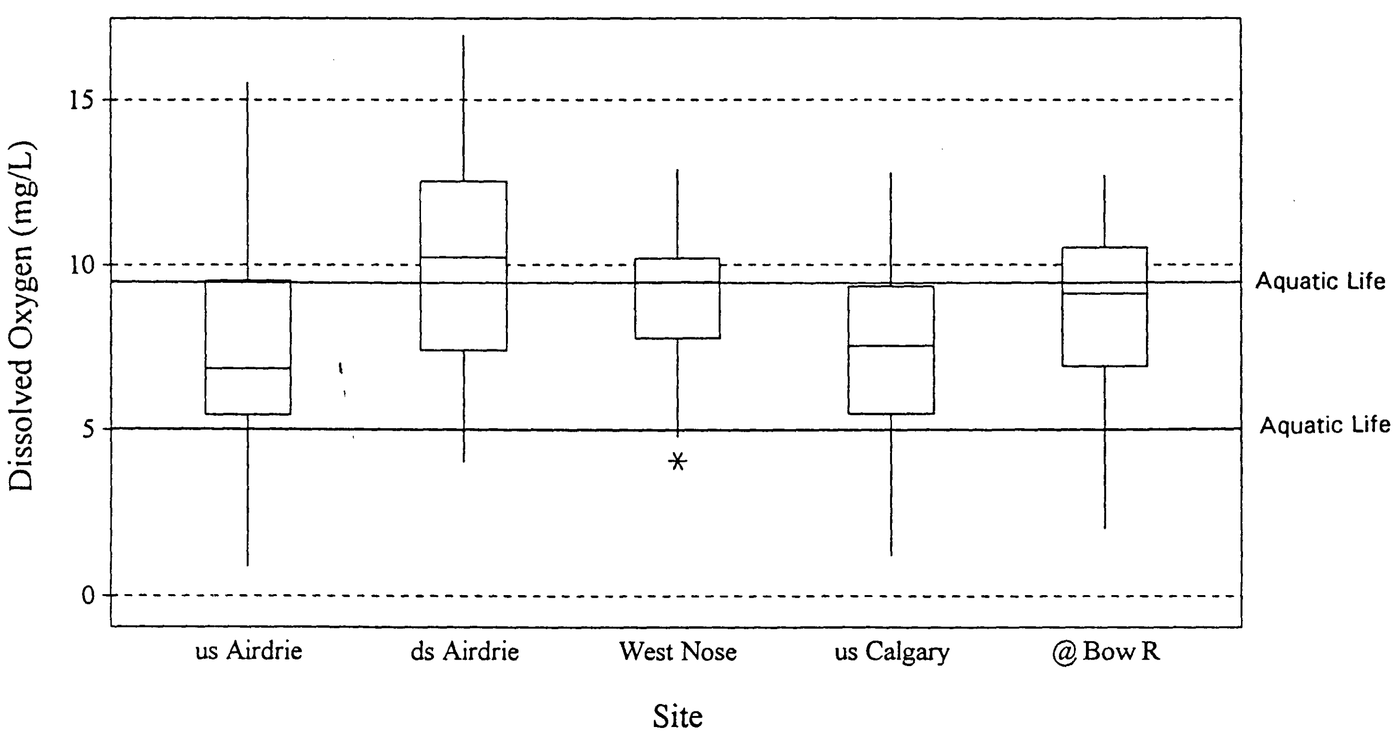
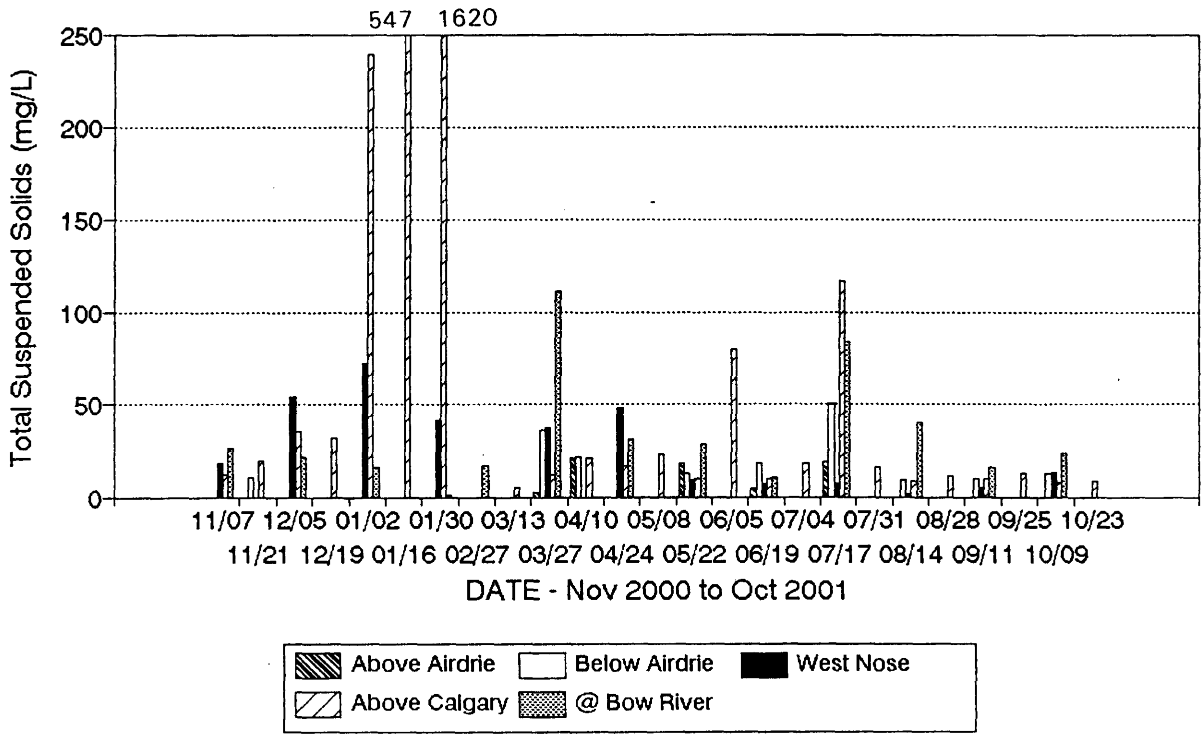


Figure 4 cont.



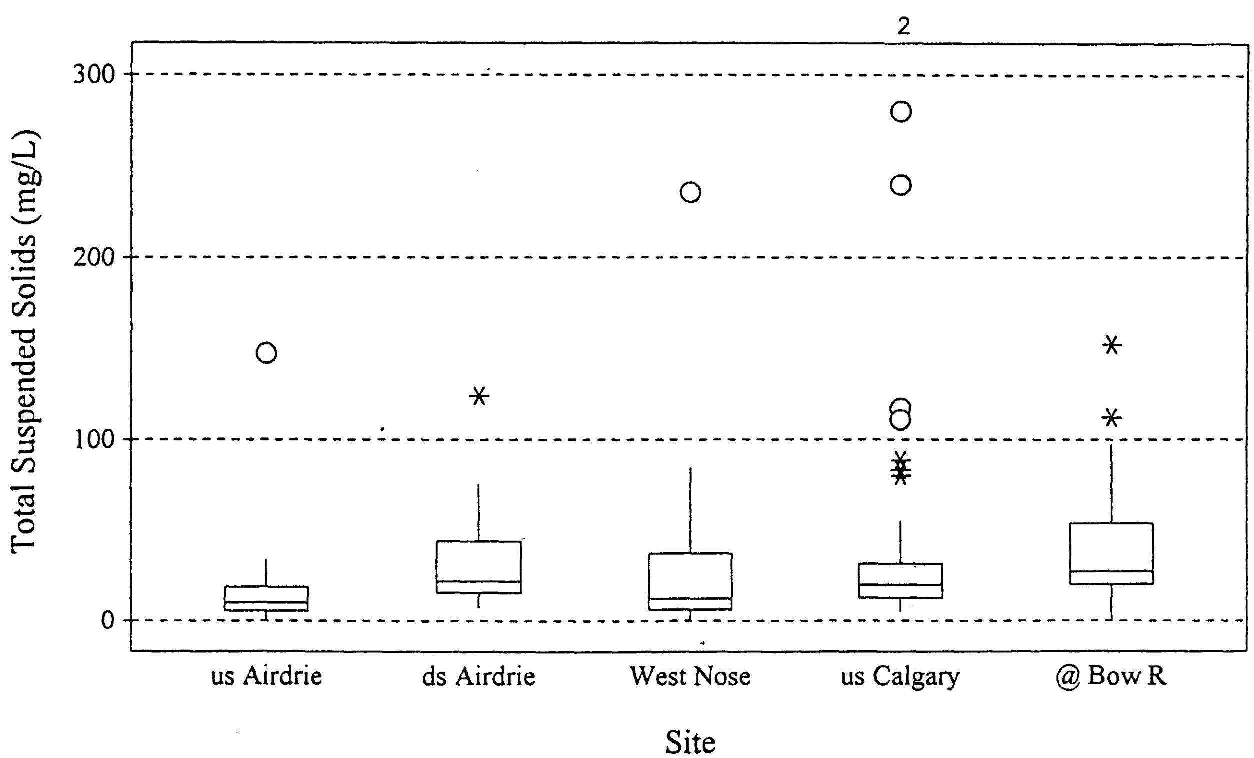
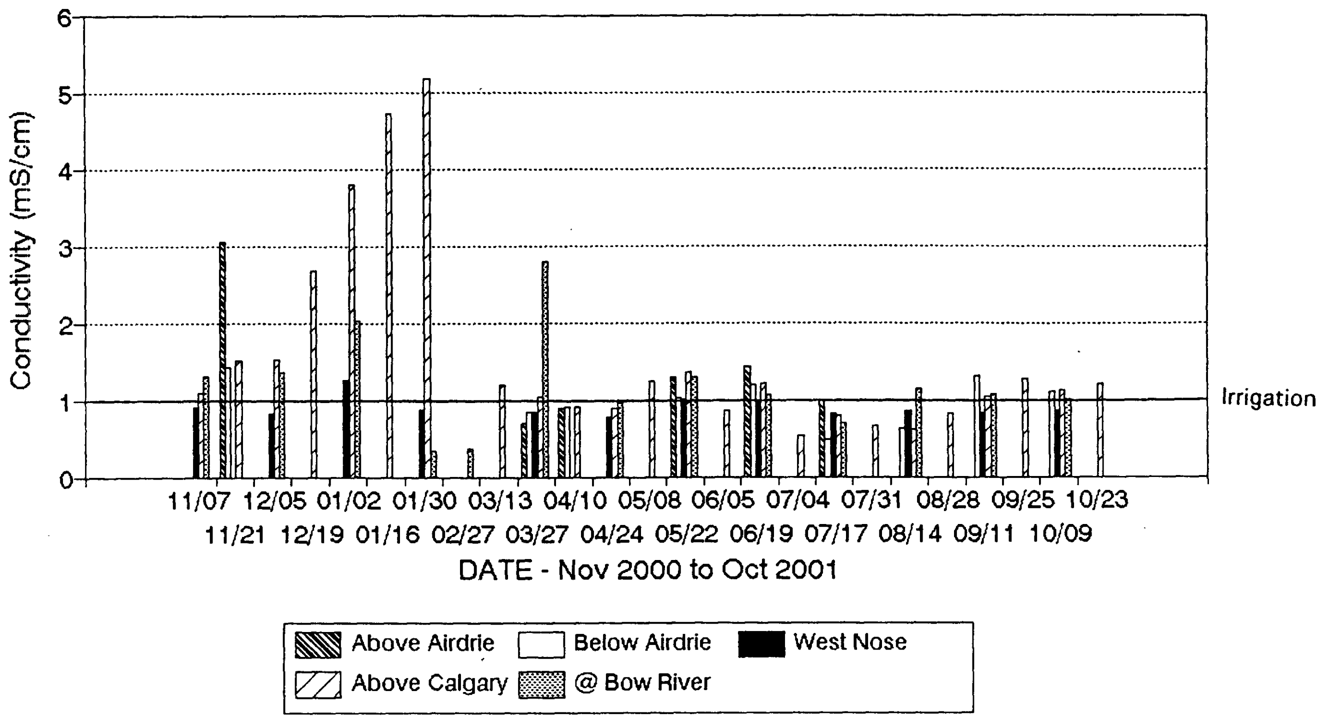


Figure 4 cont.



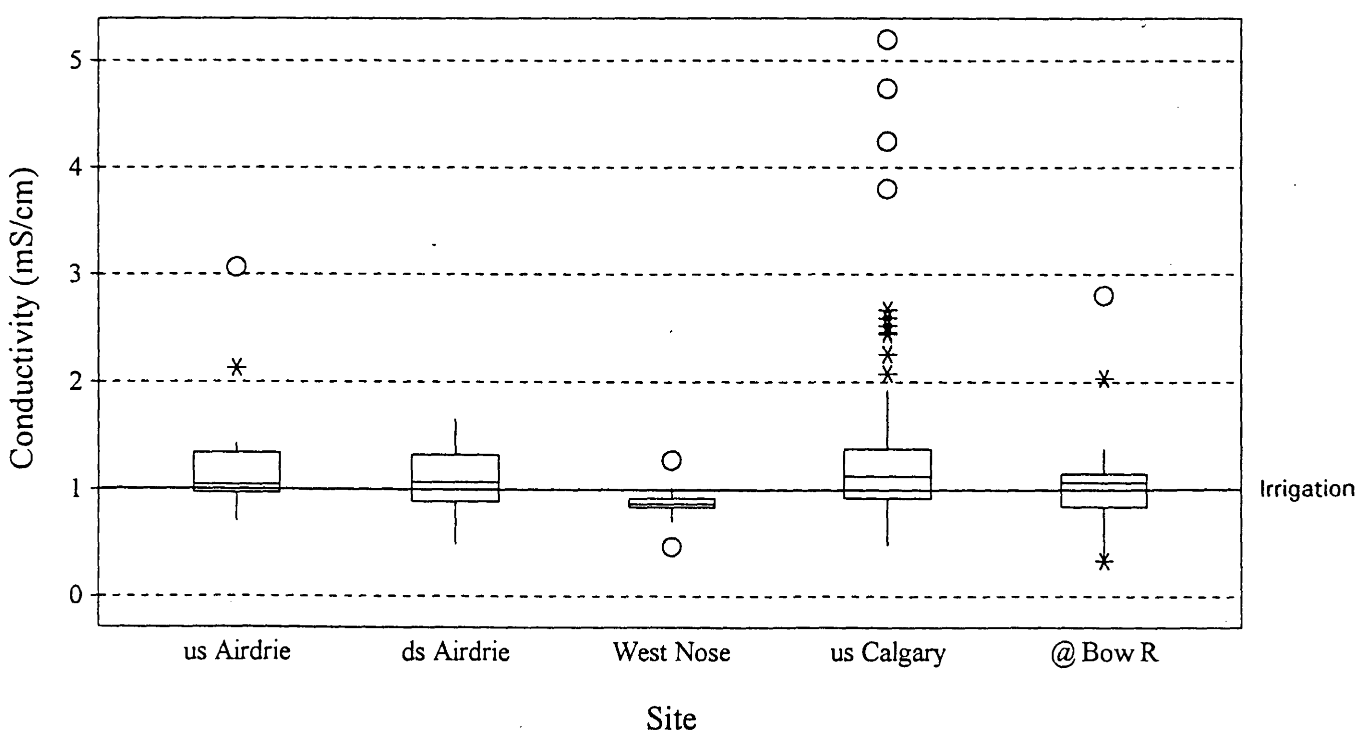
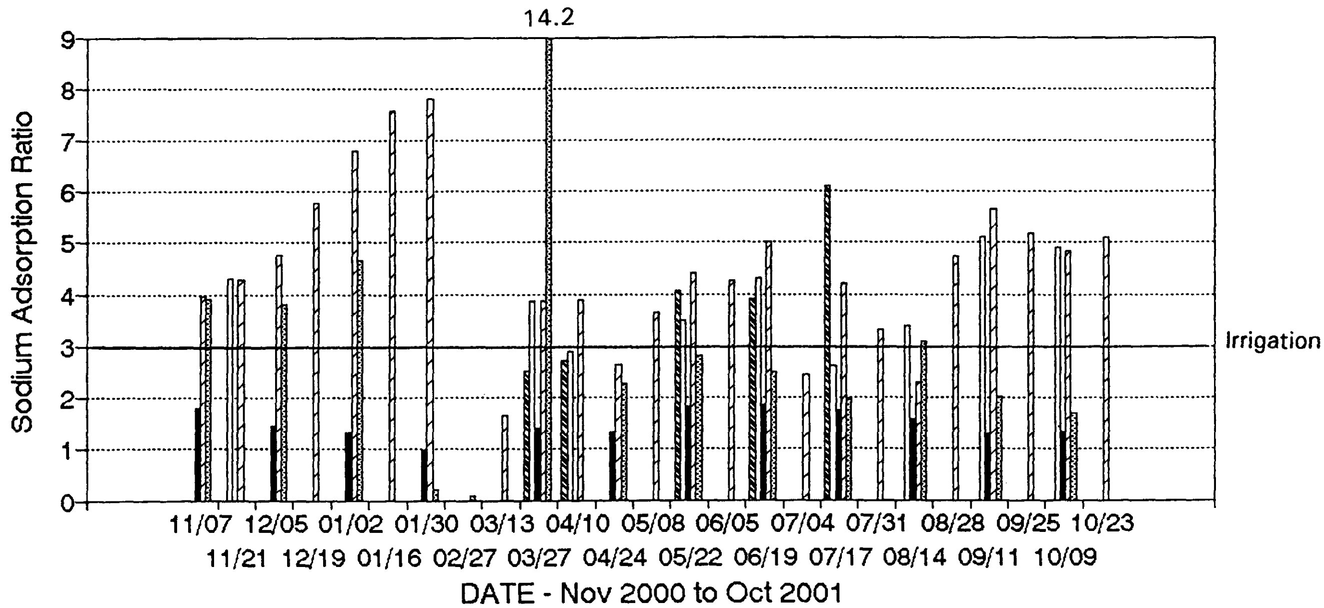
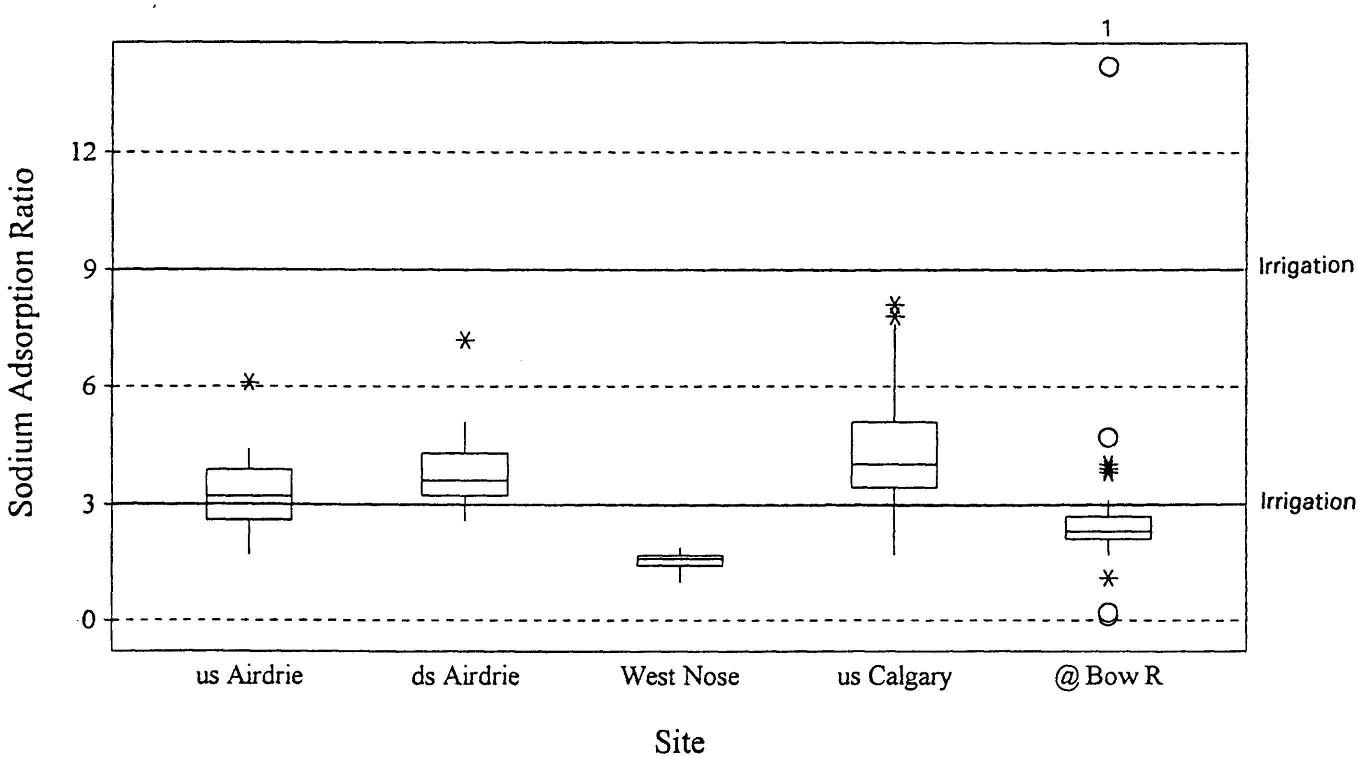


Figure 5 Salinity, Major Ions





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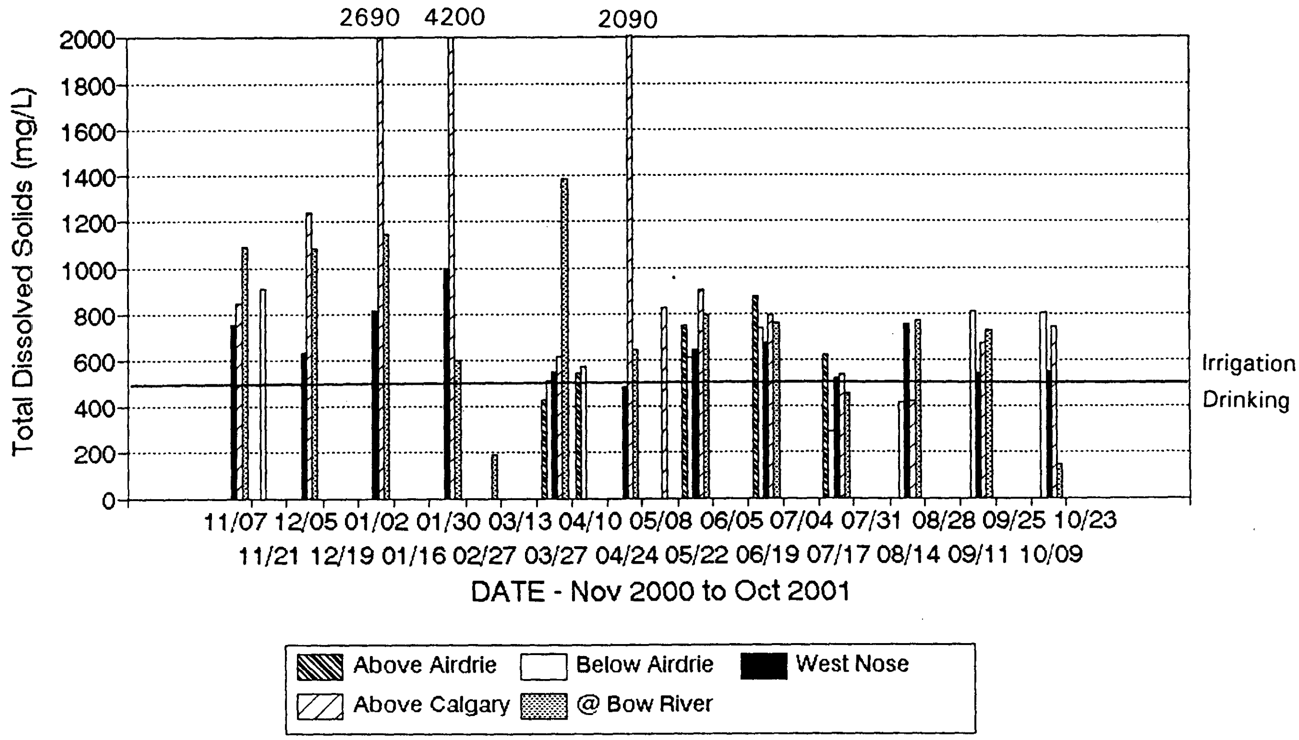

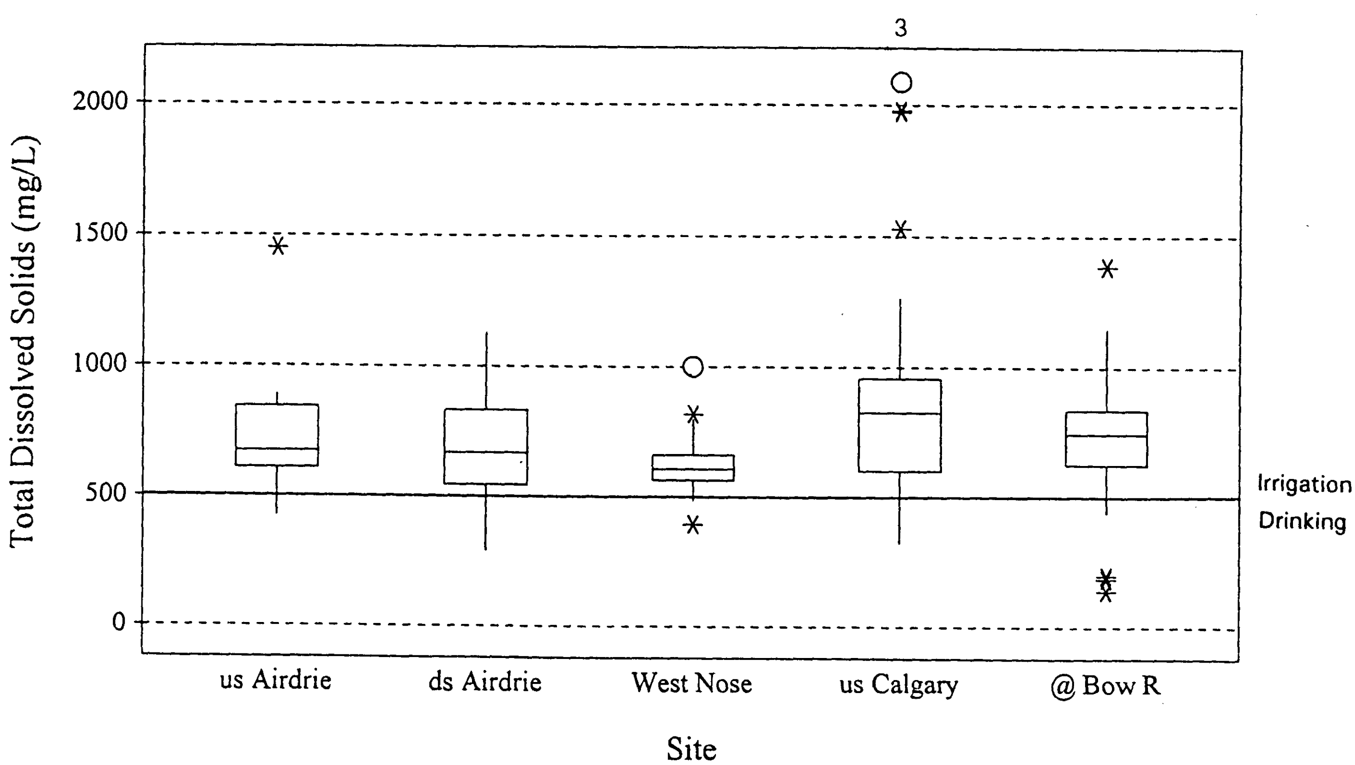

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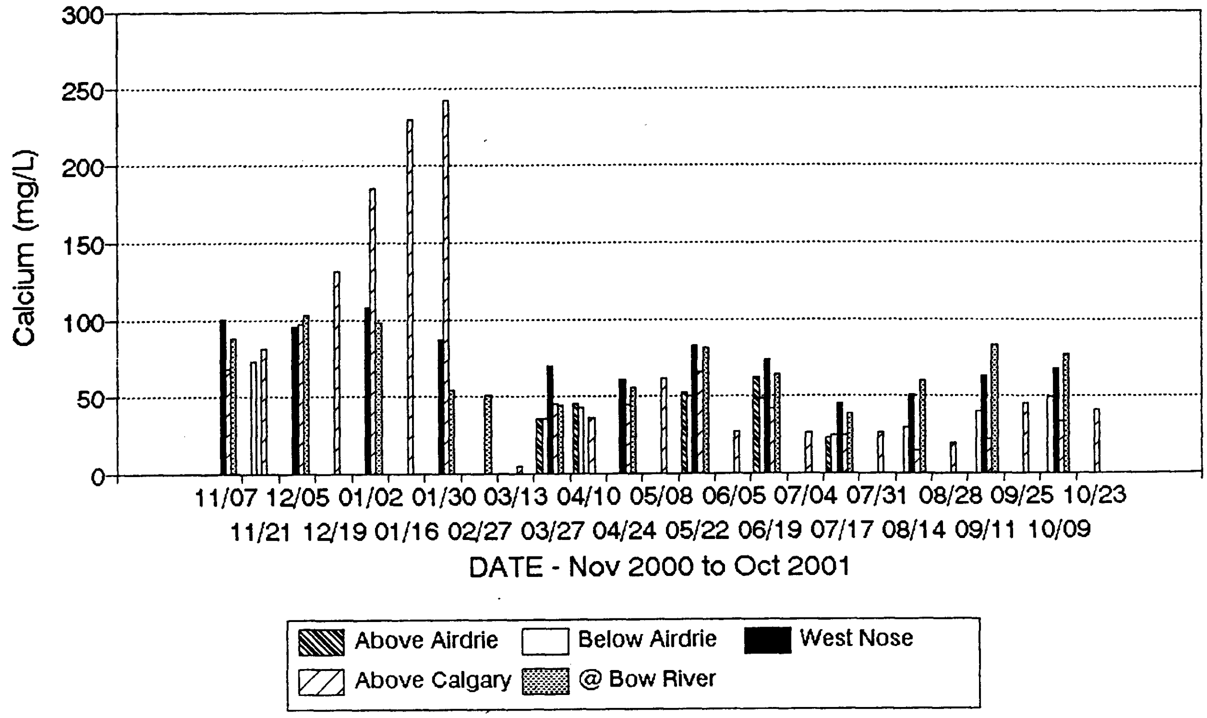

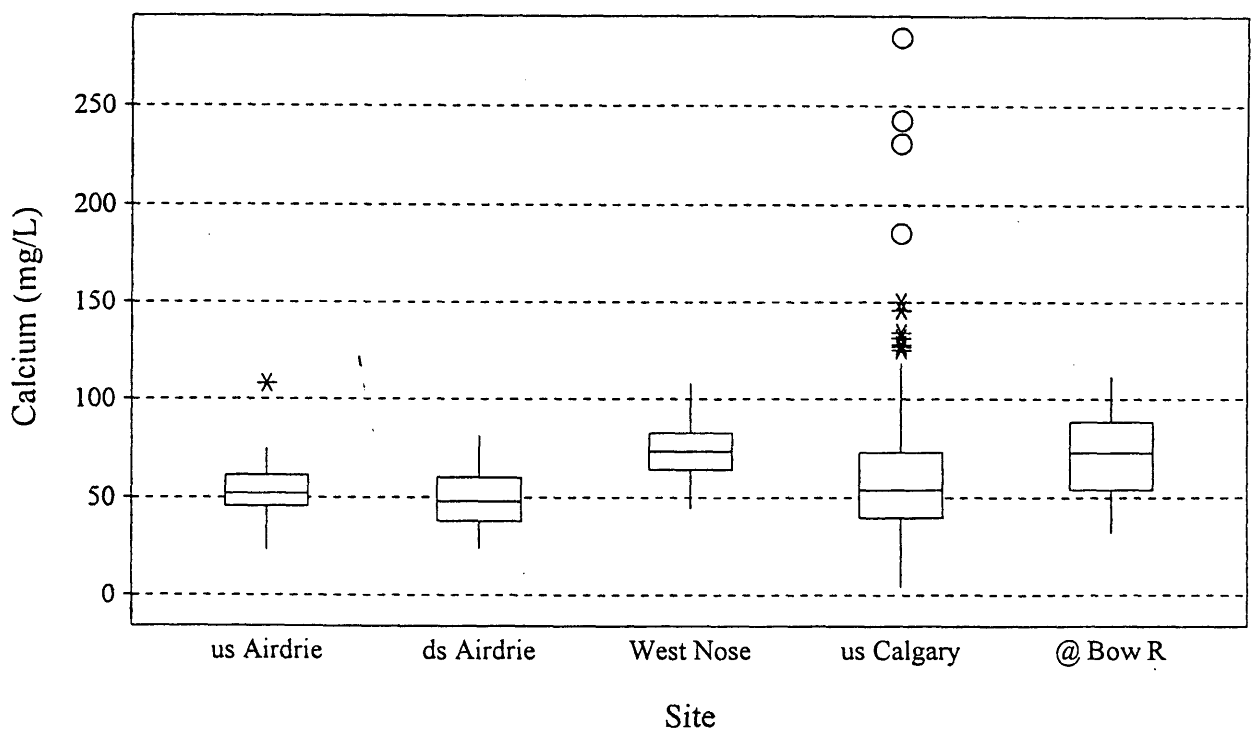

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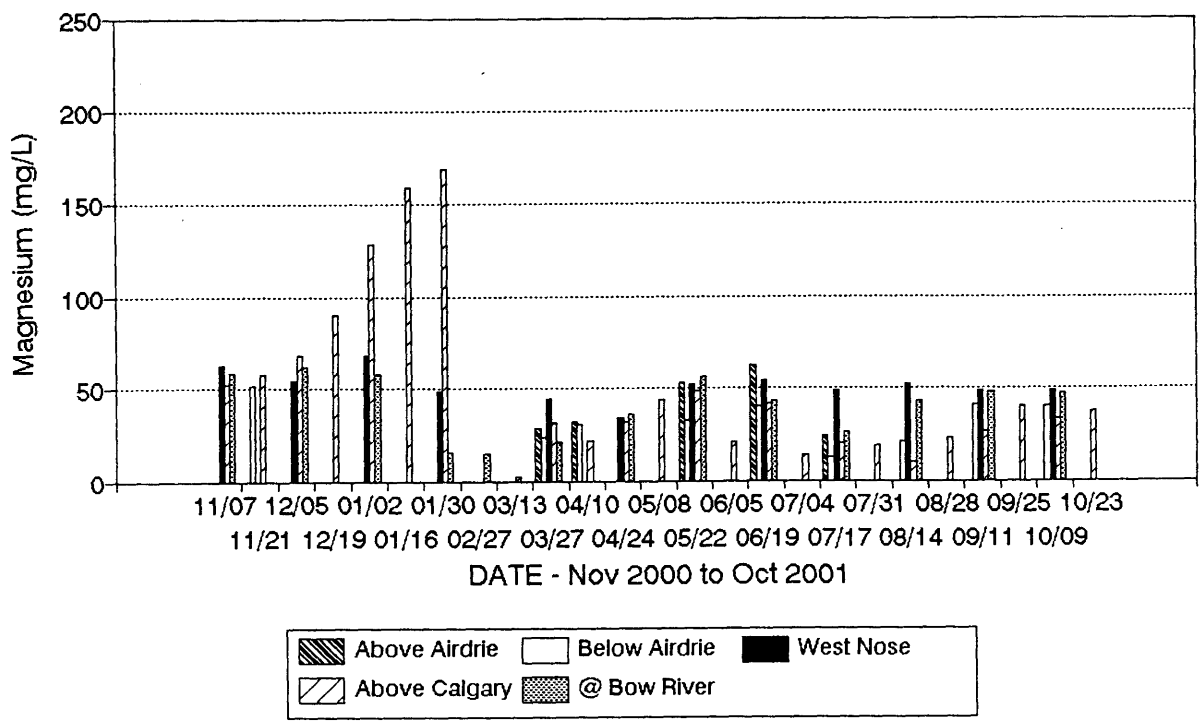

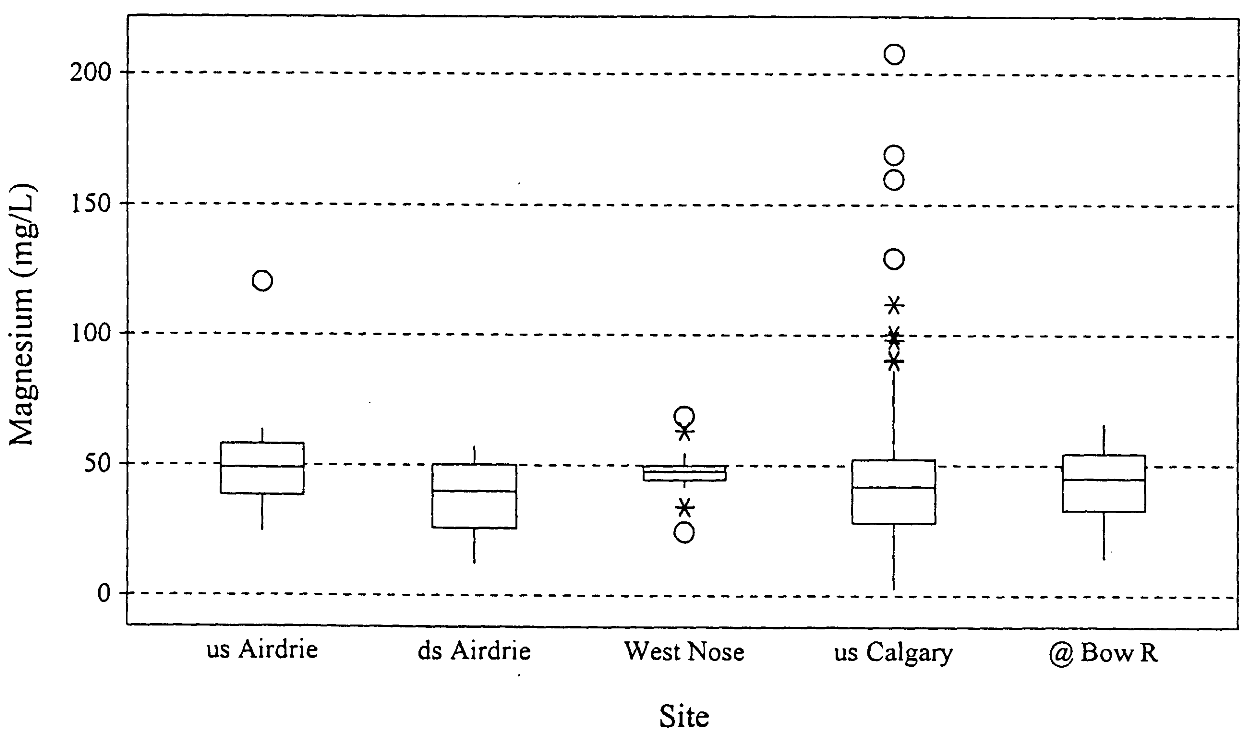

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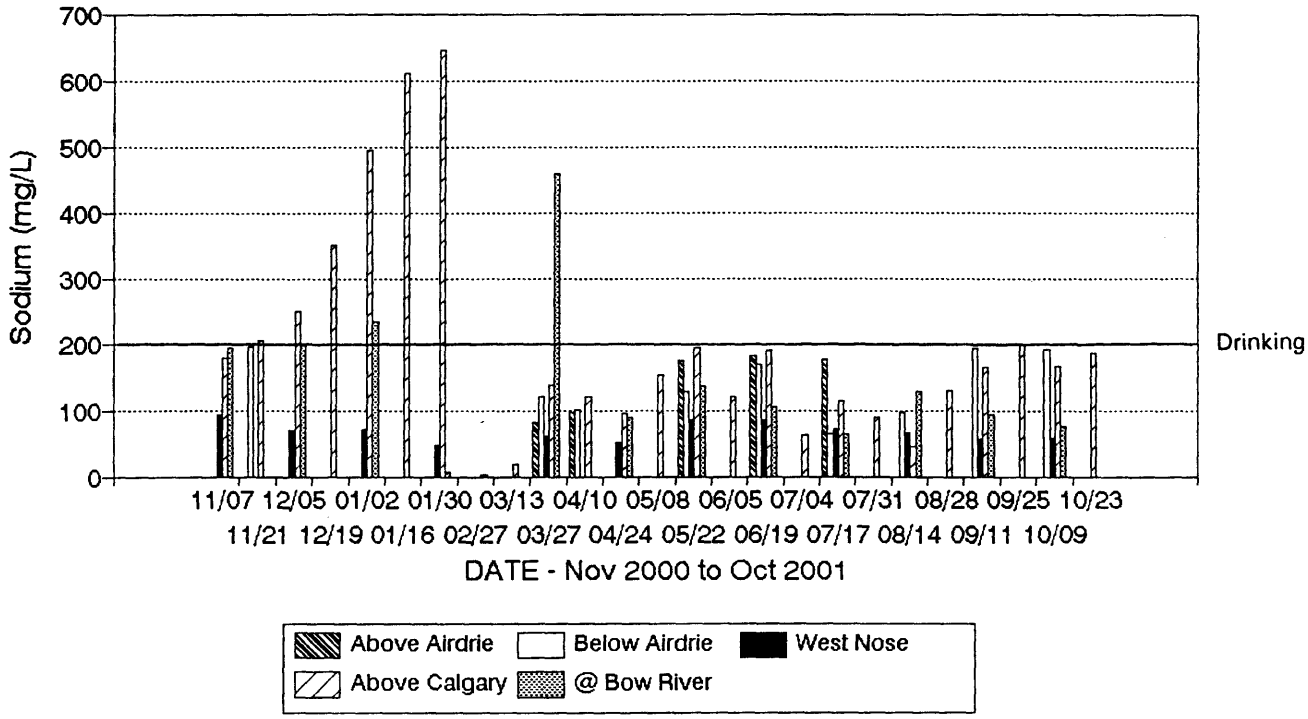

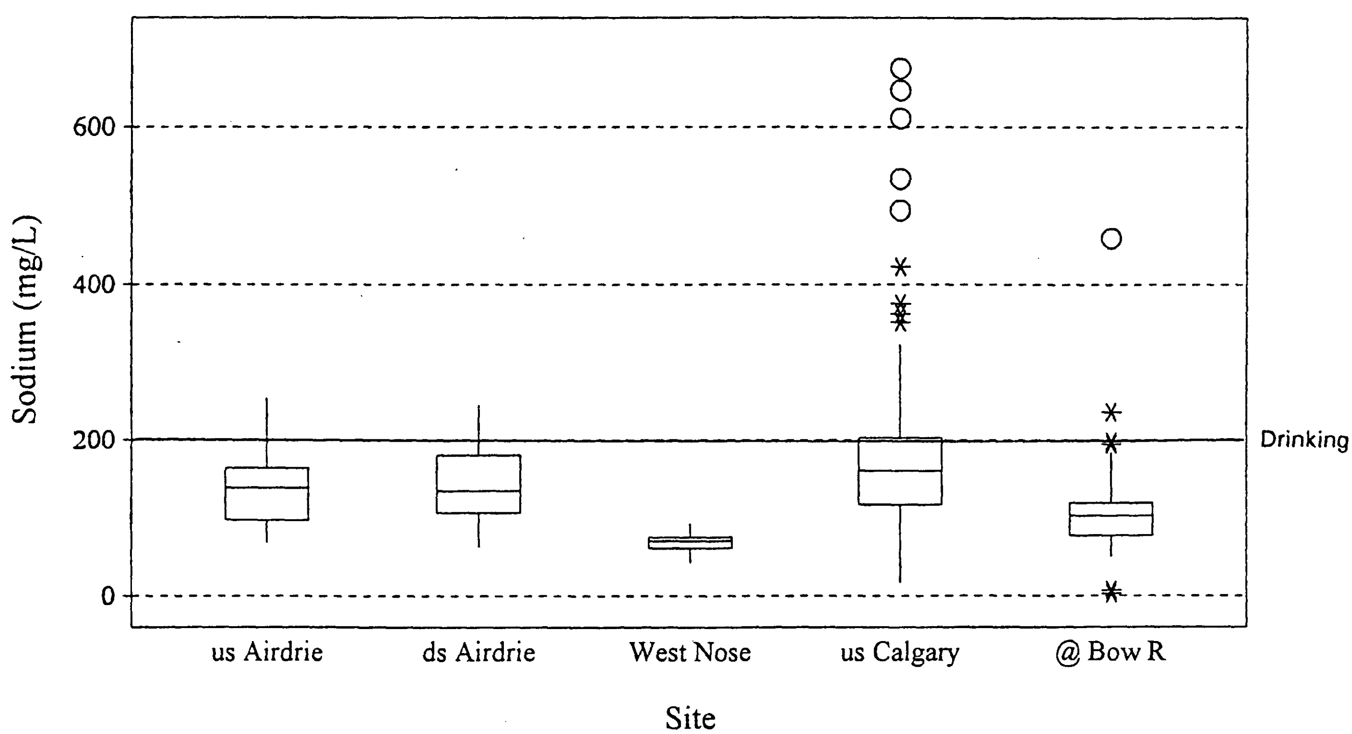

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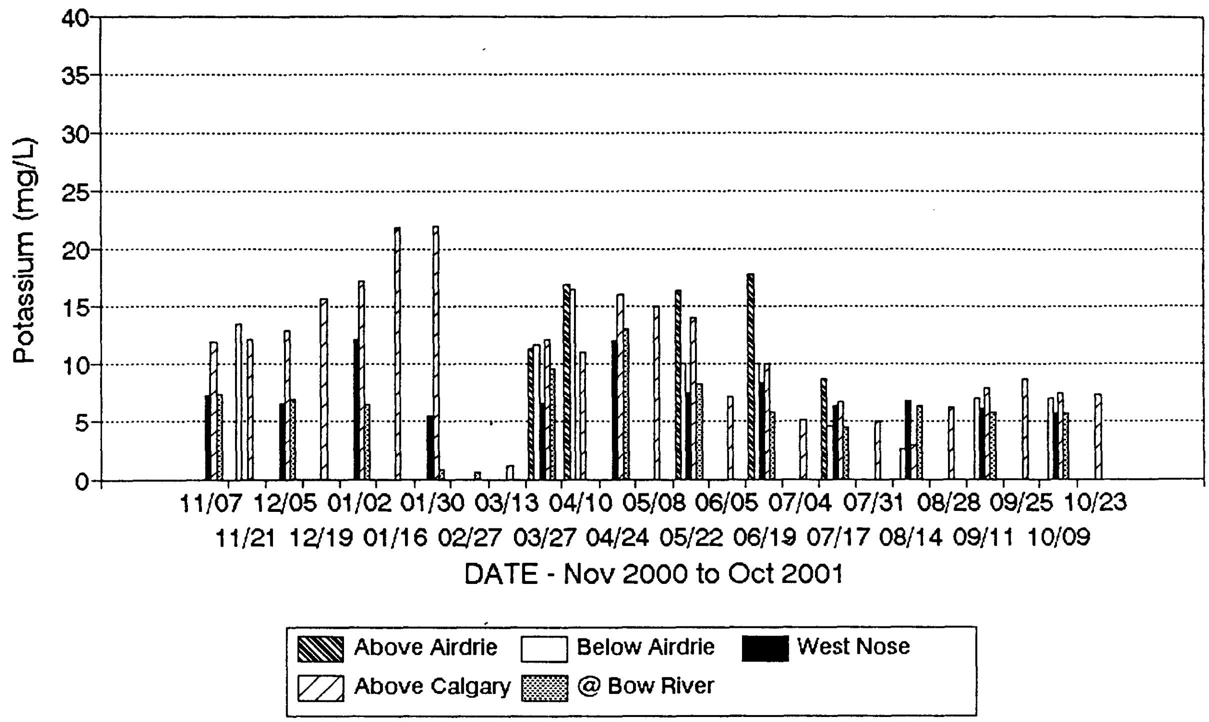

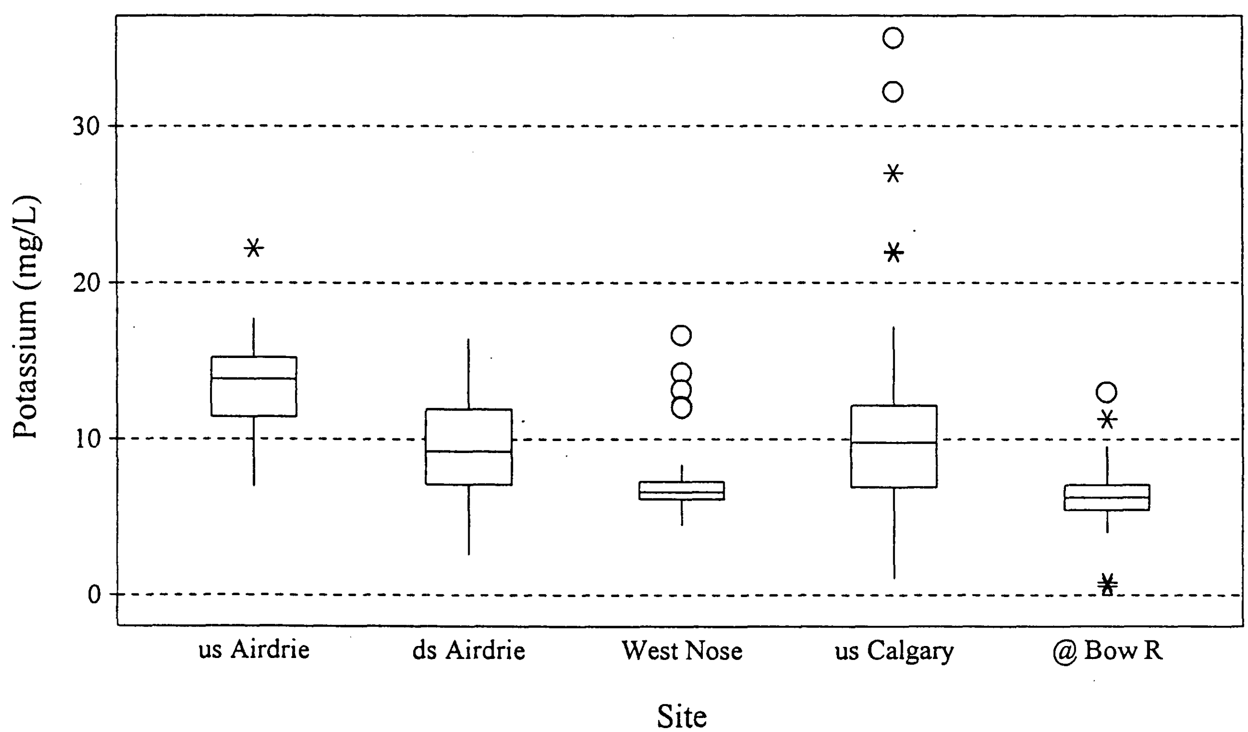

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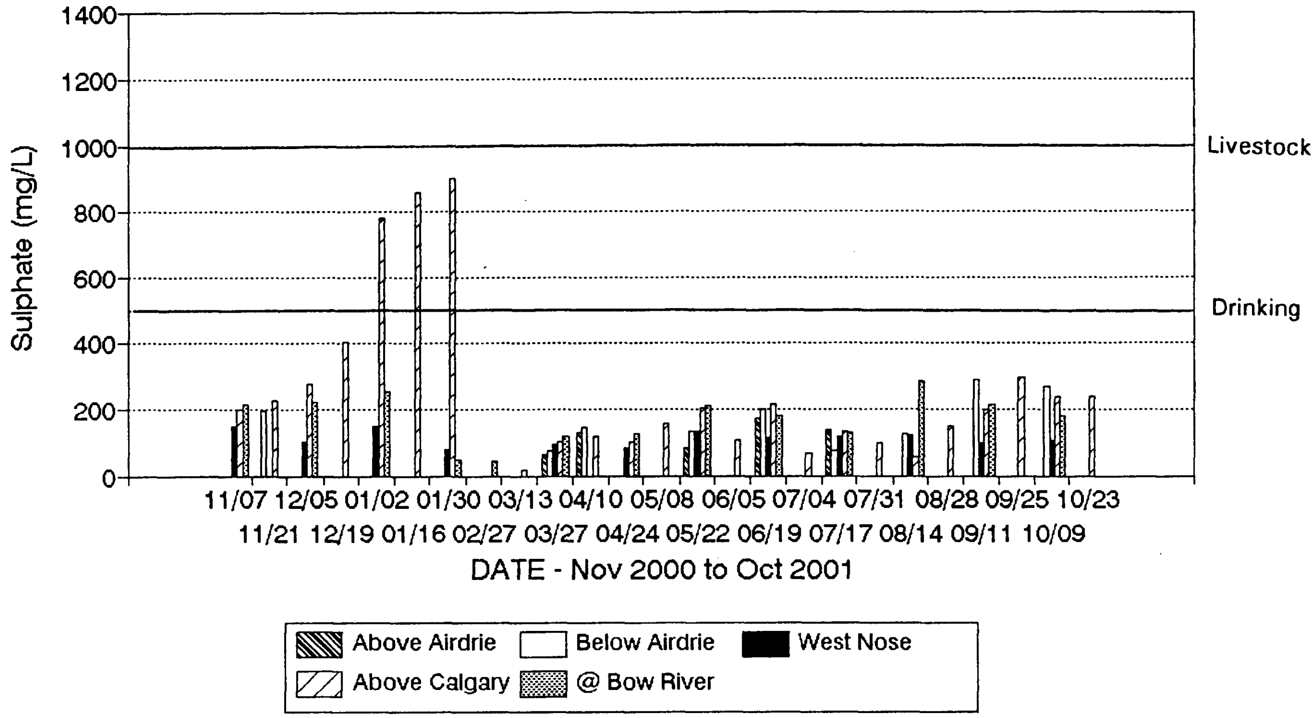

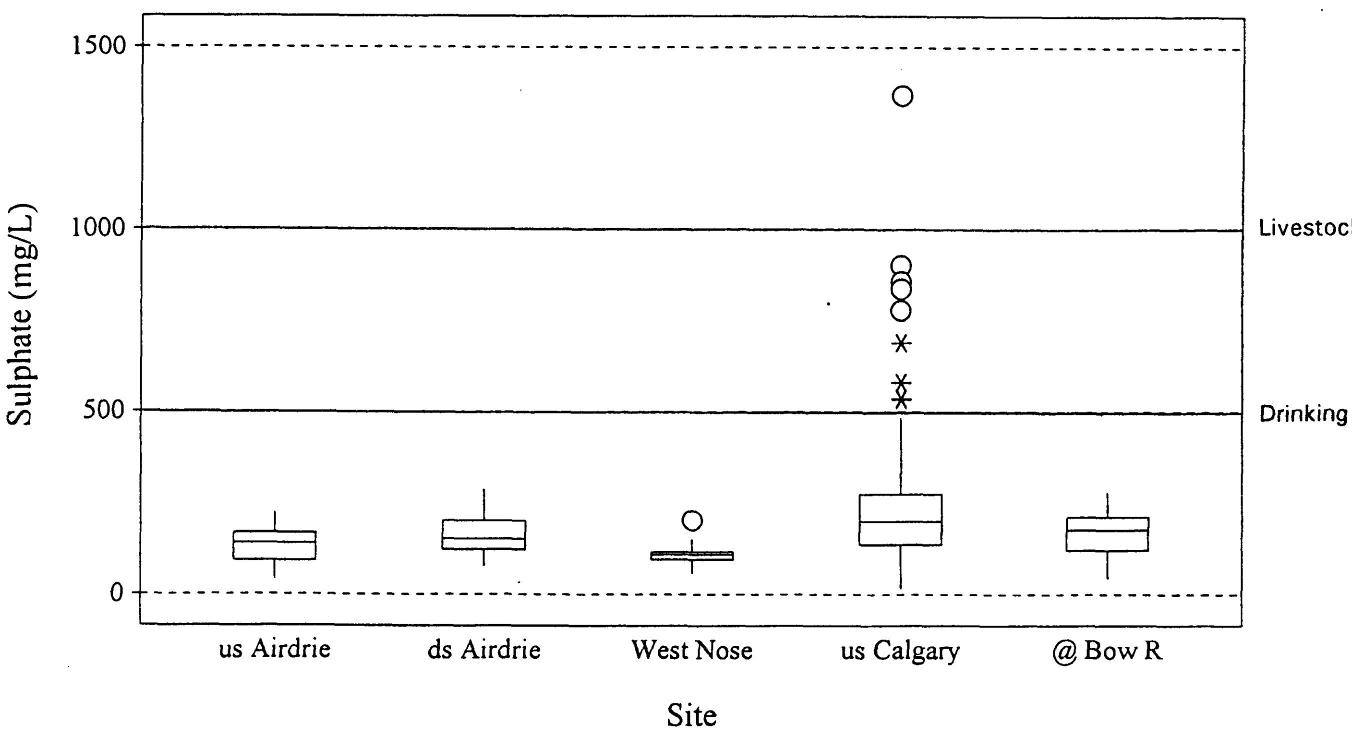

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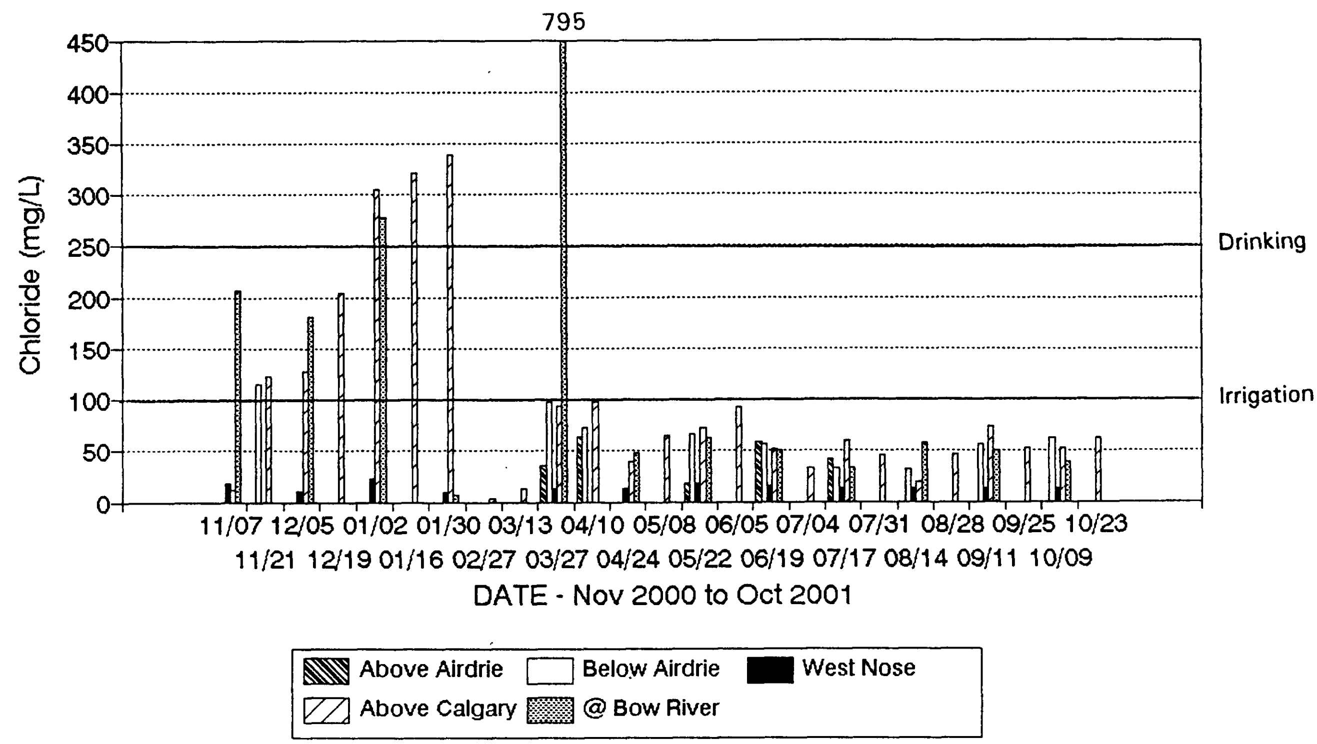

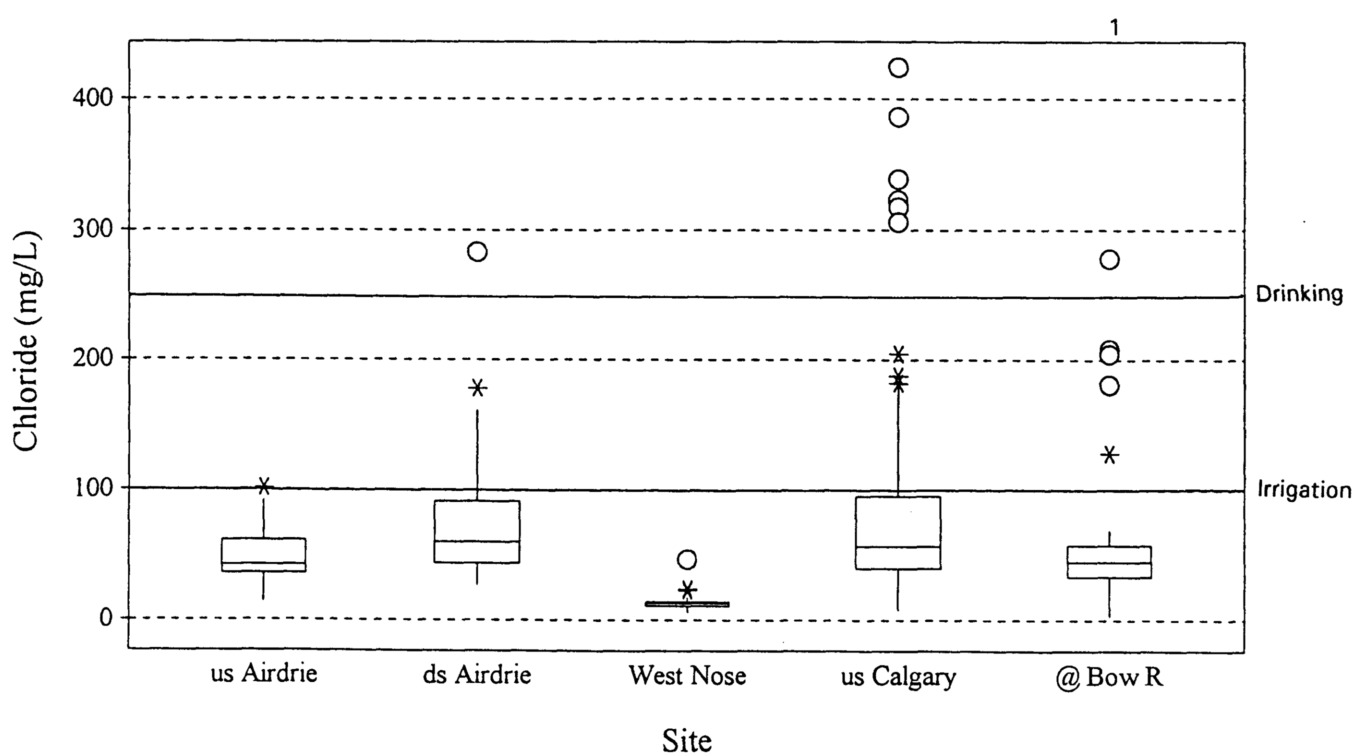

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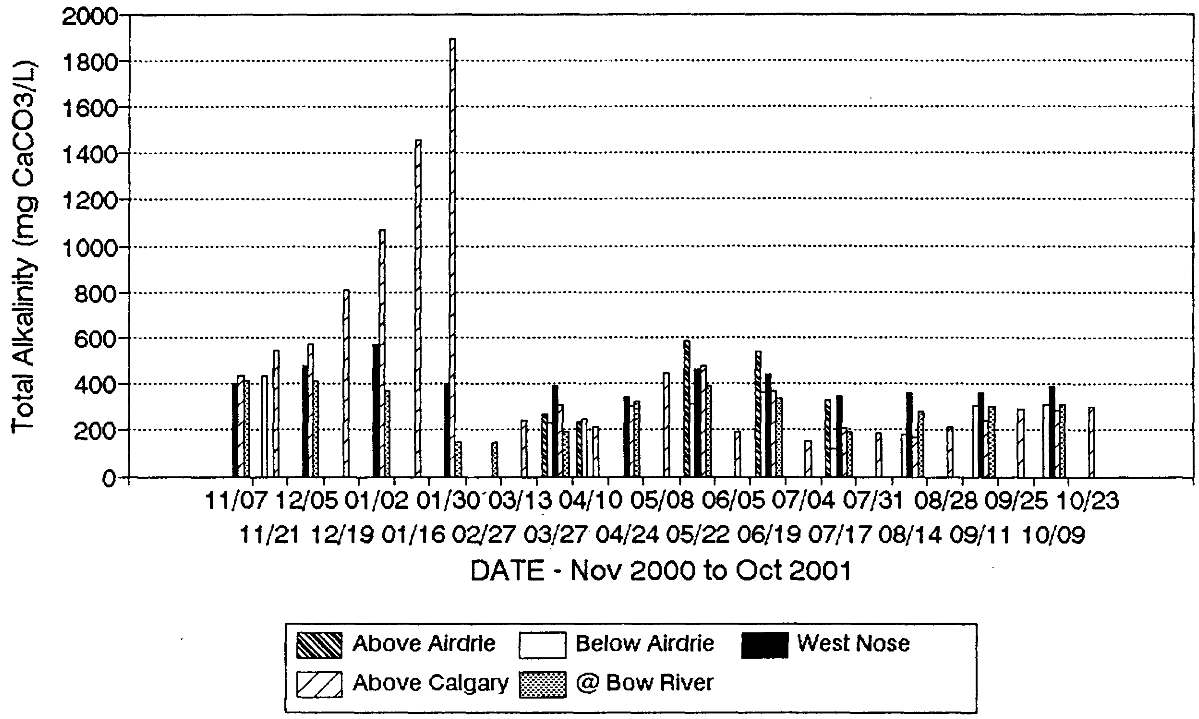

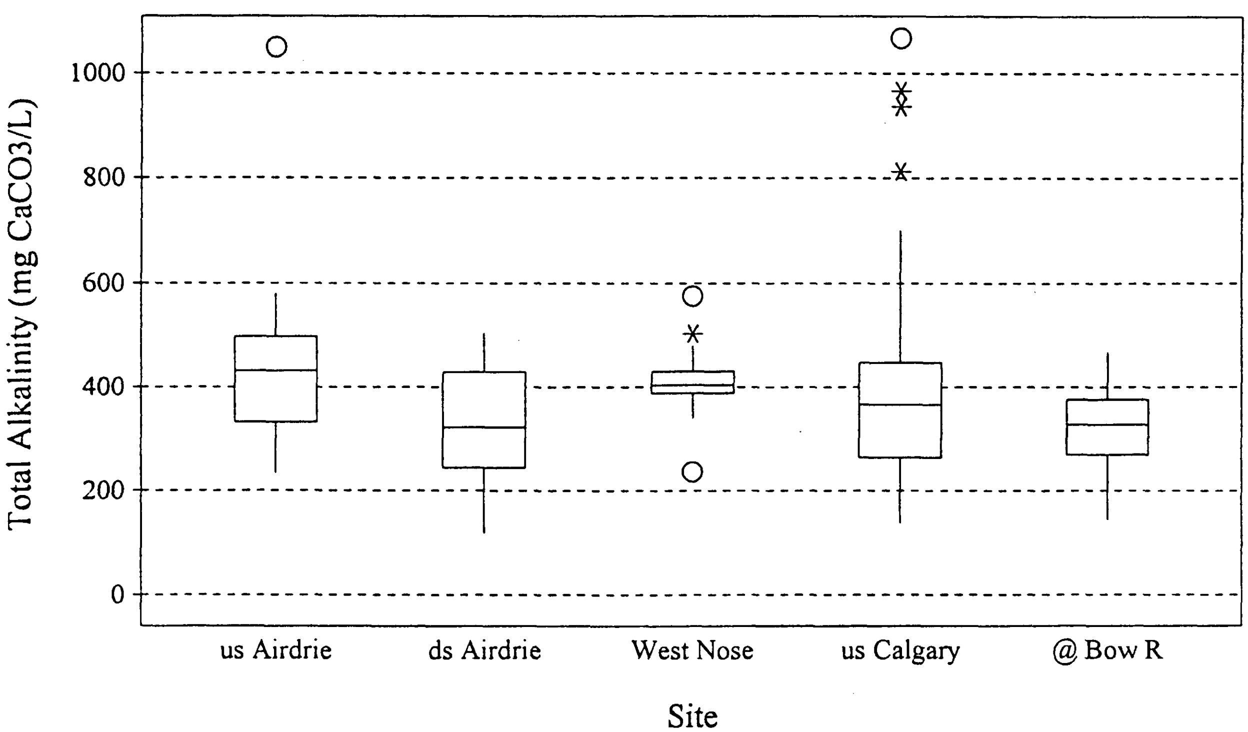

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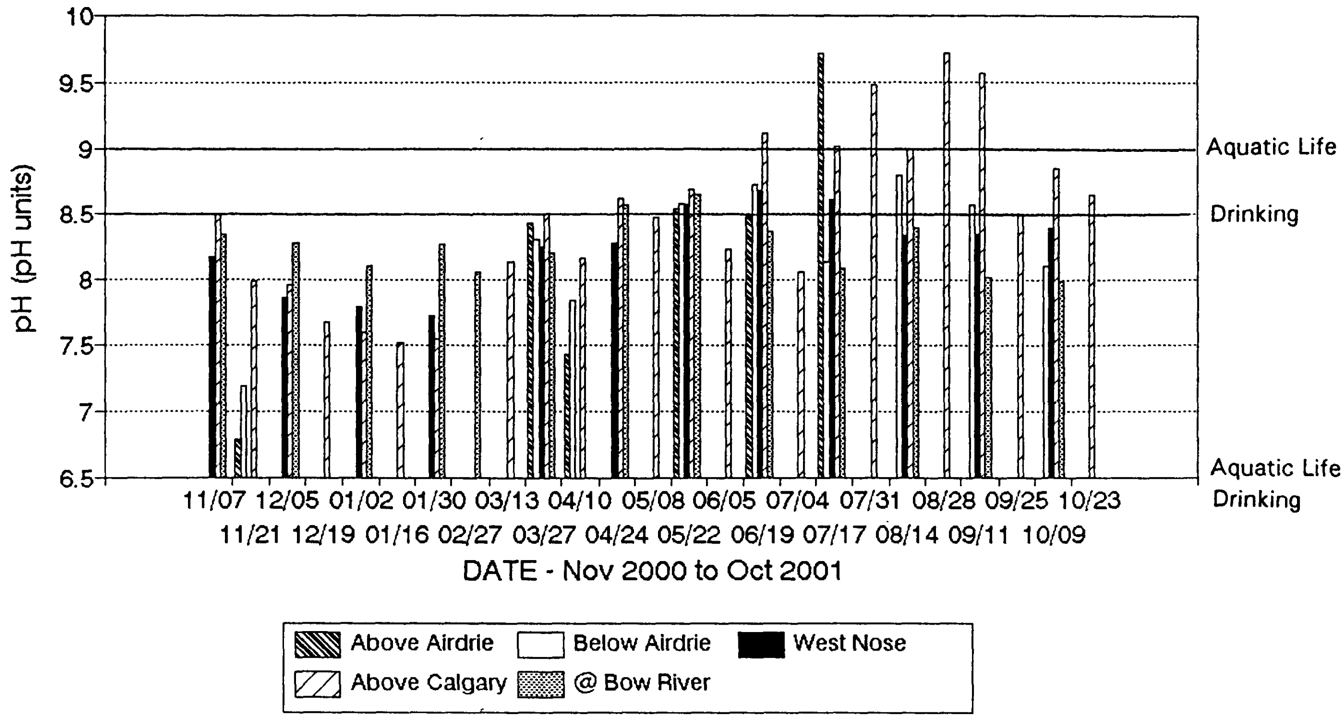

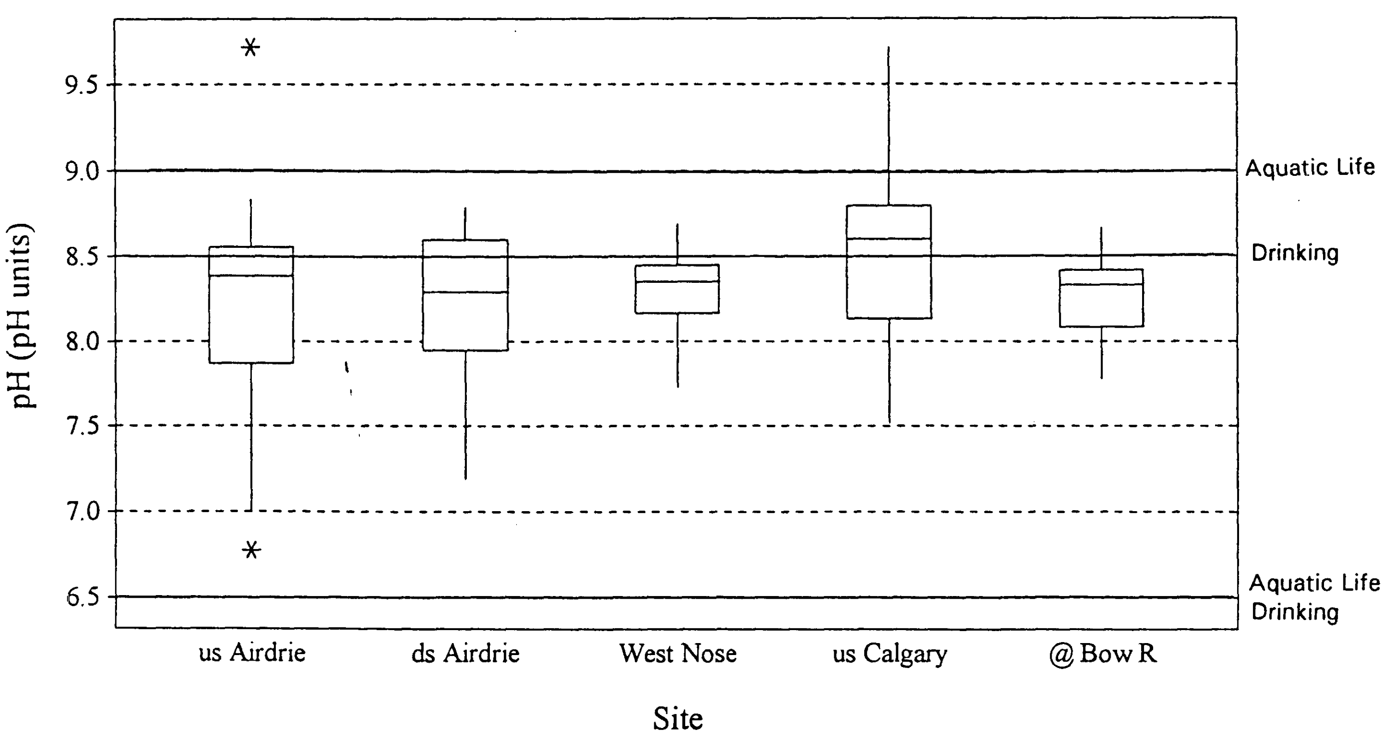

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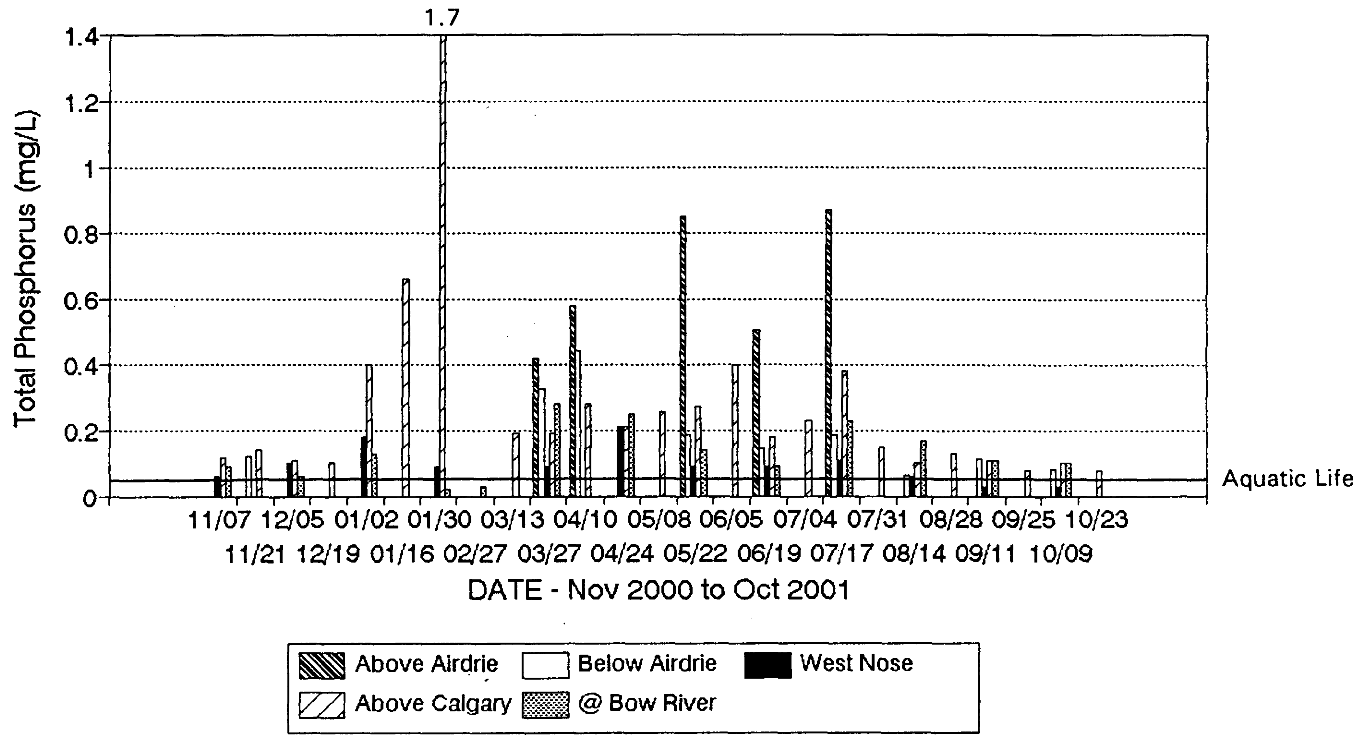


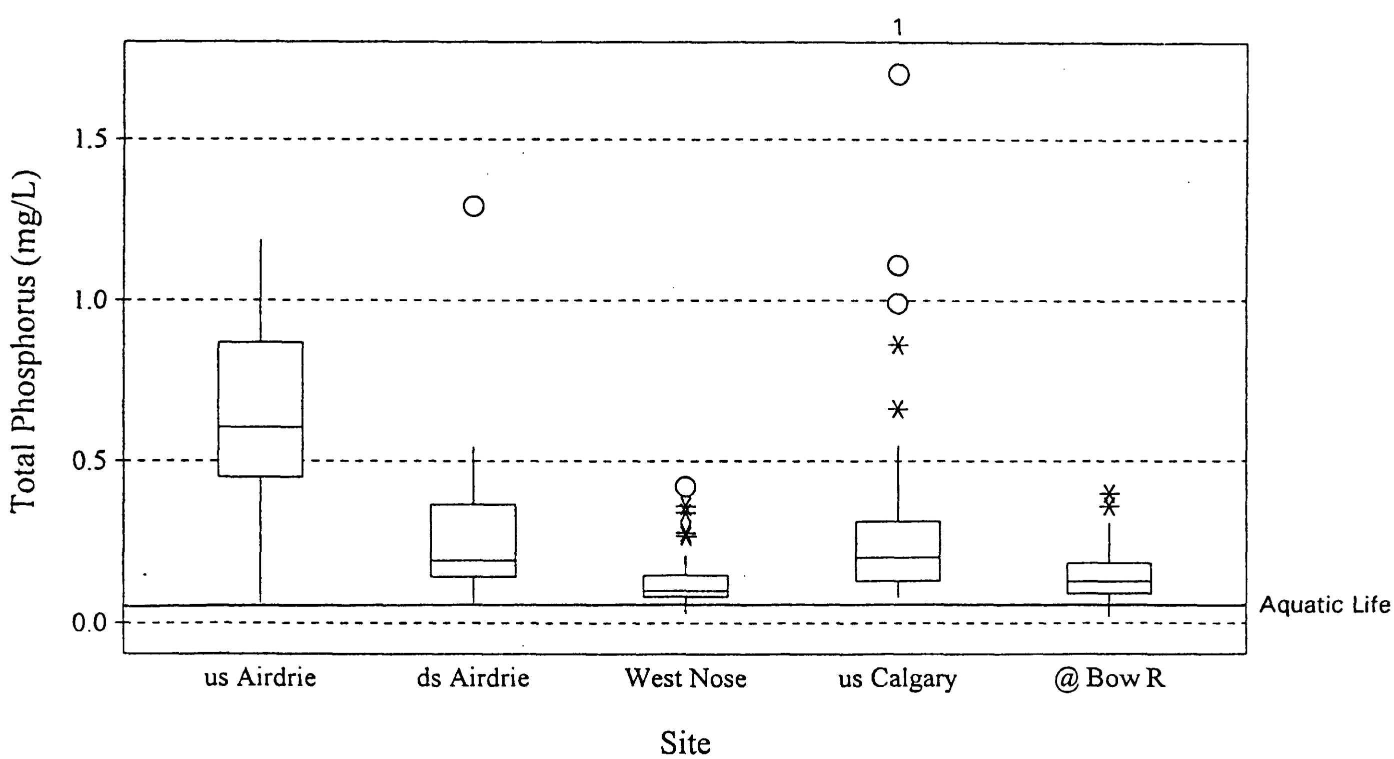
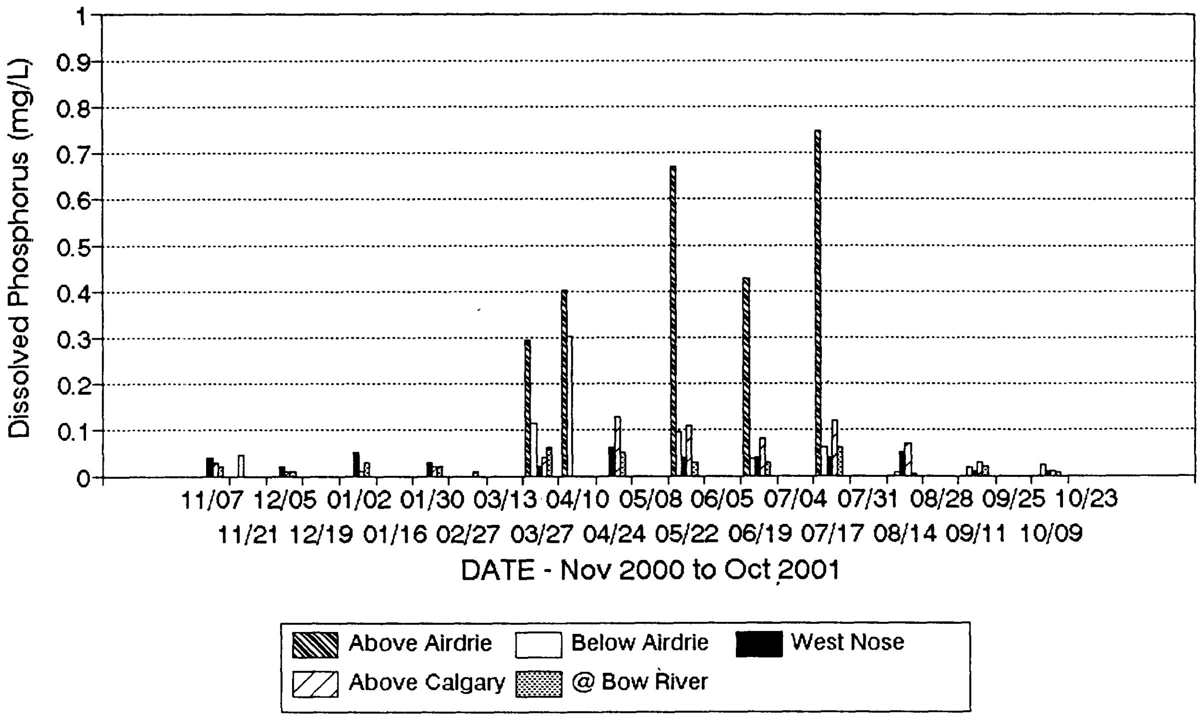
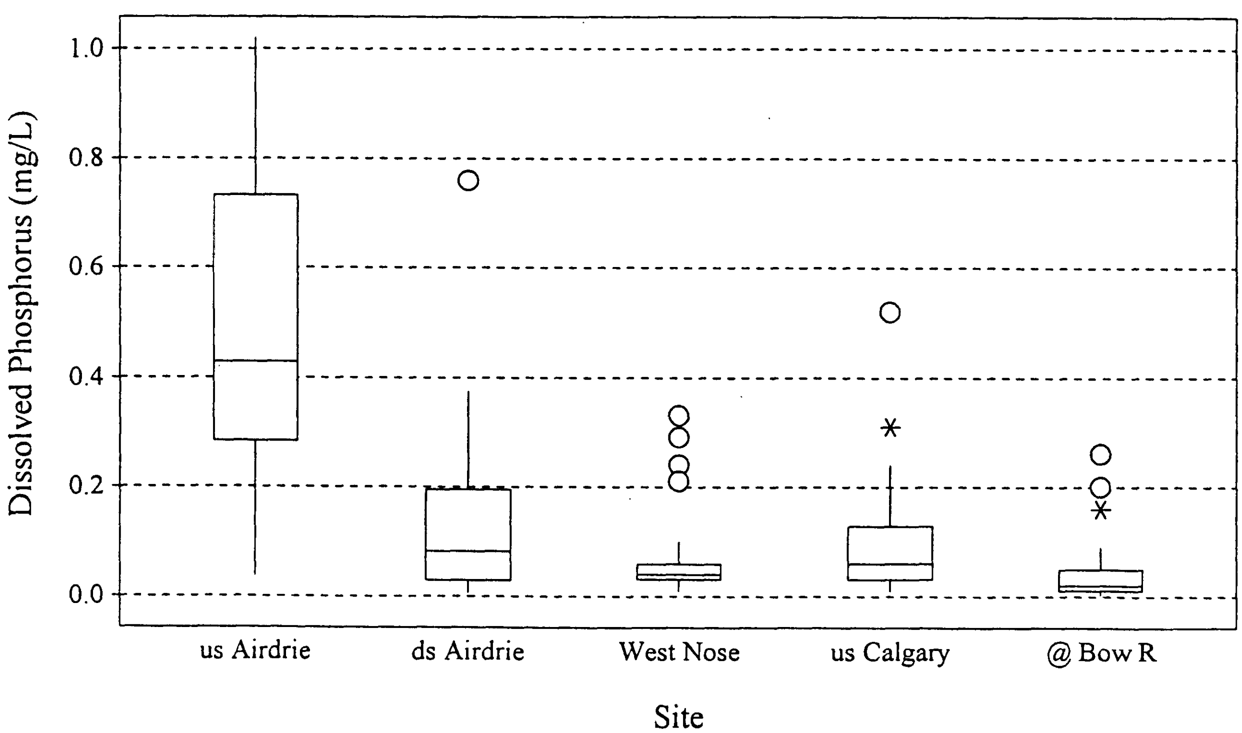


Figure 6 Nutrients





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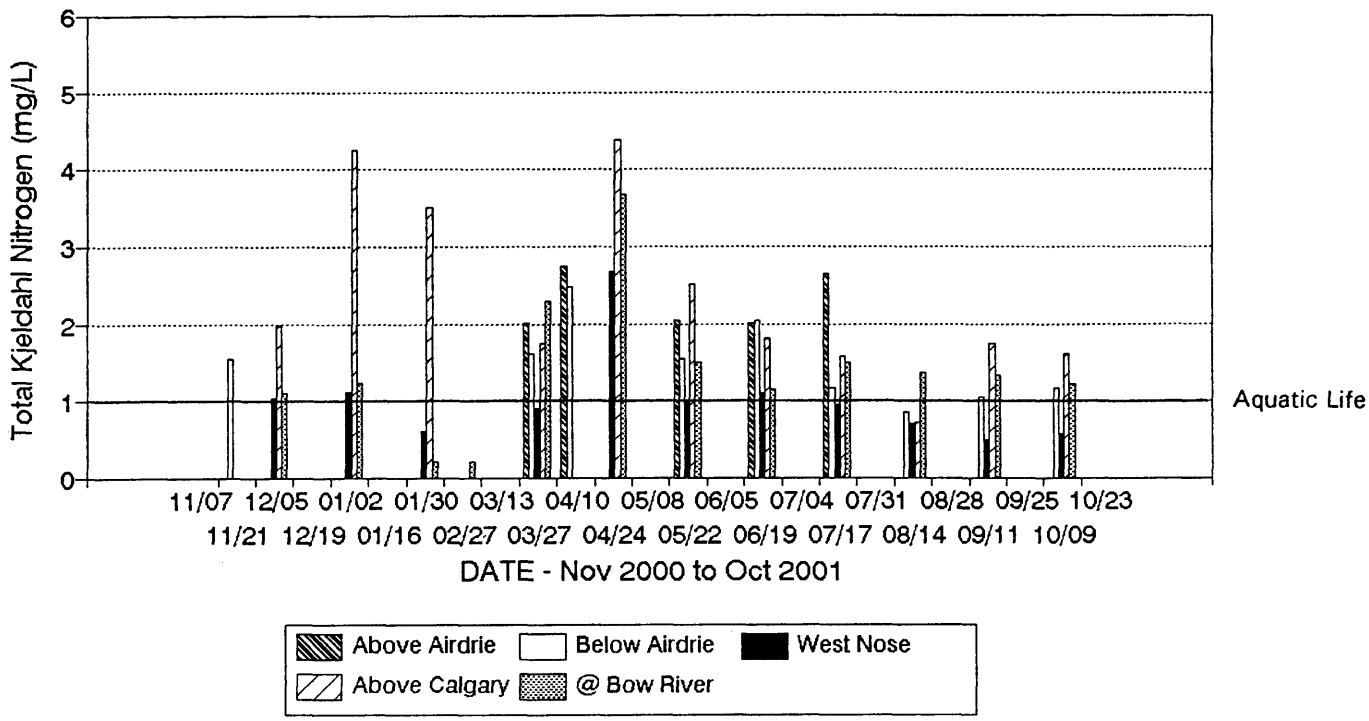

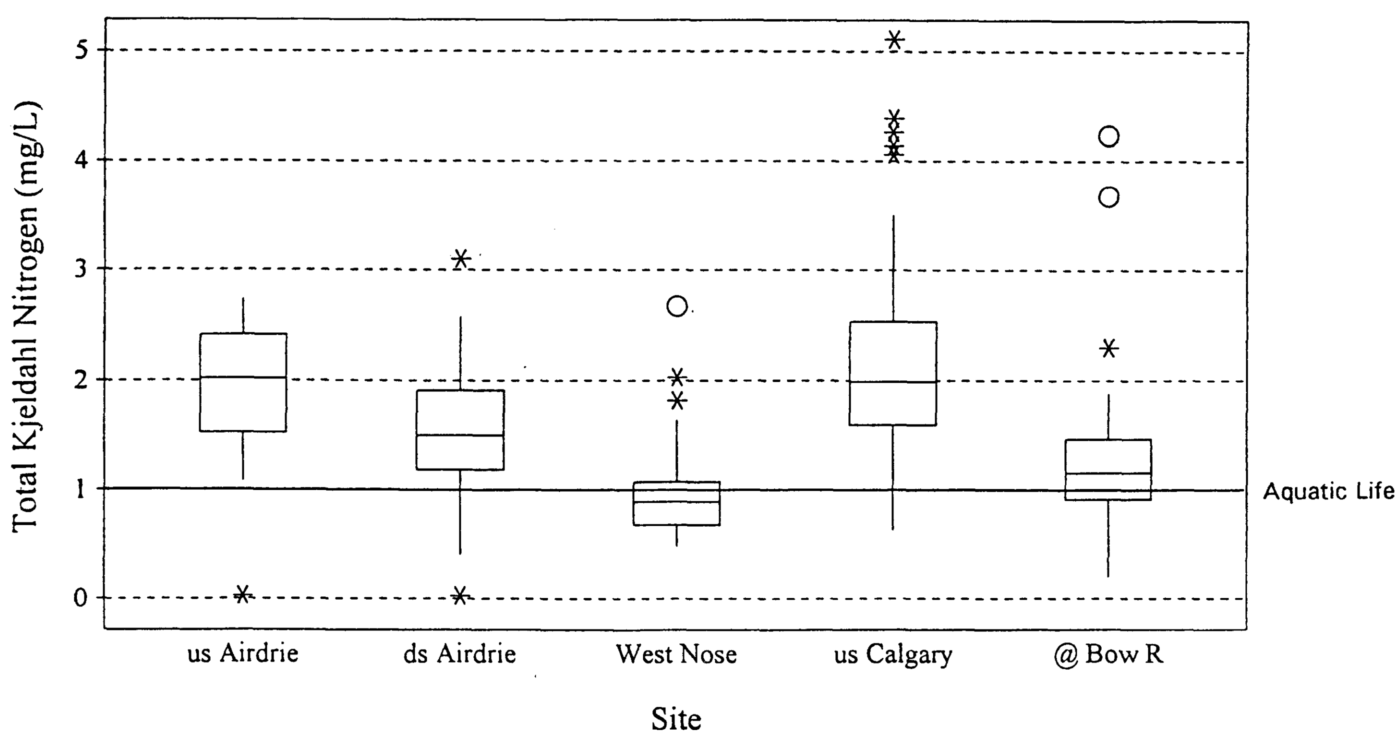

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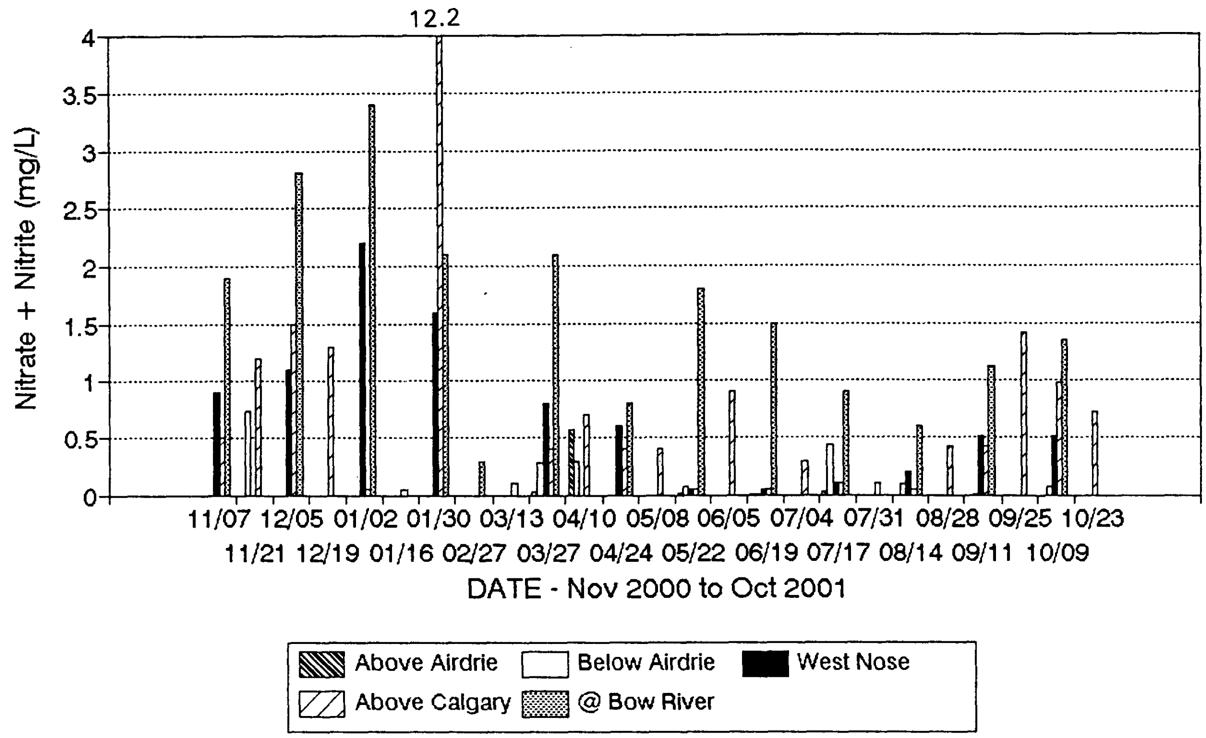

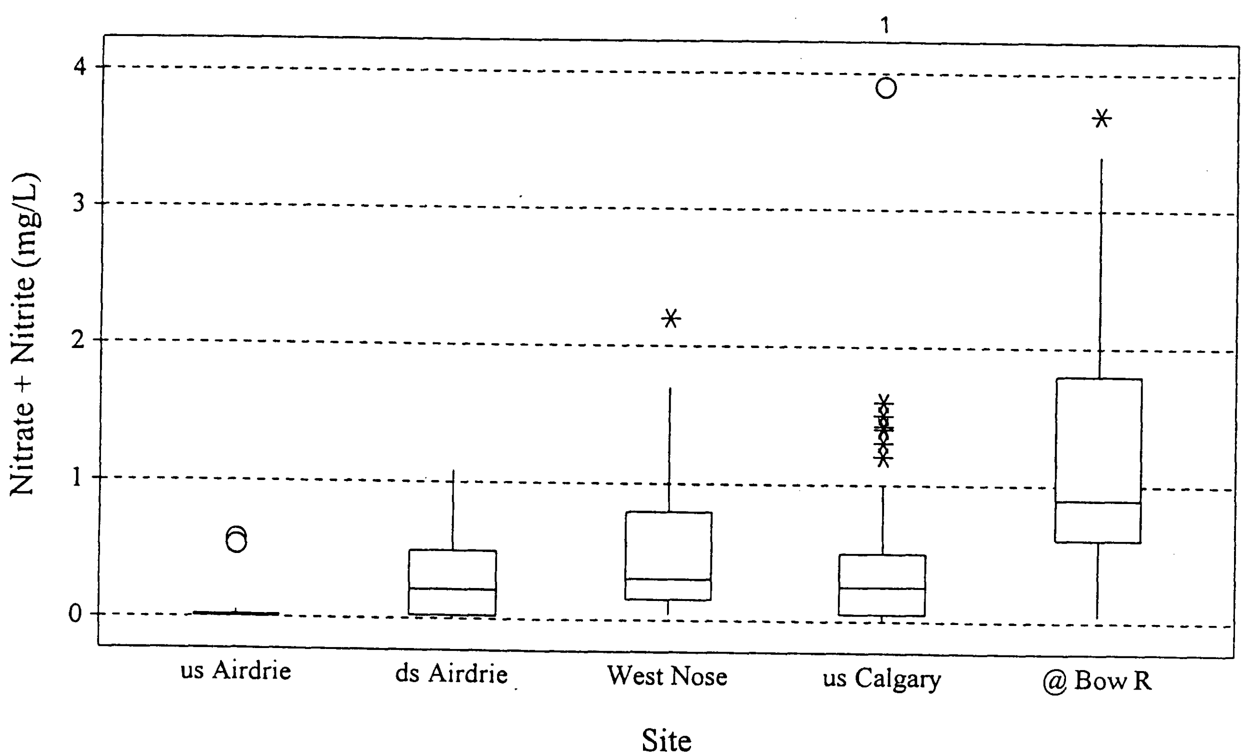

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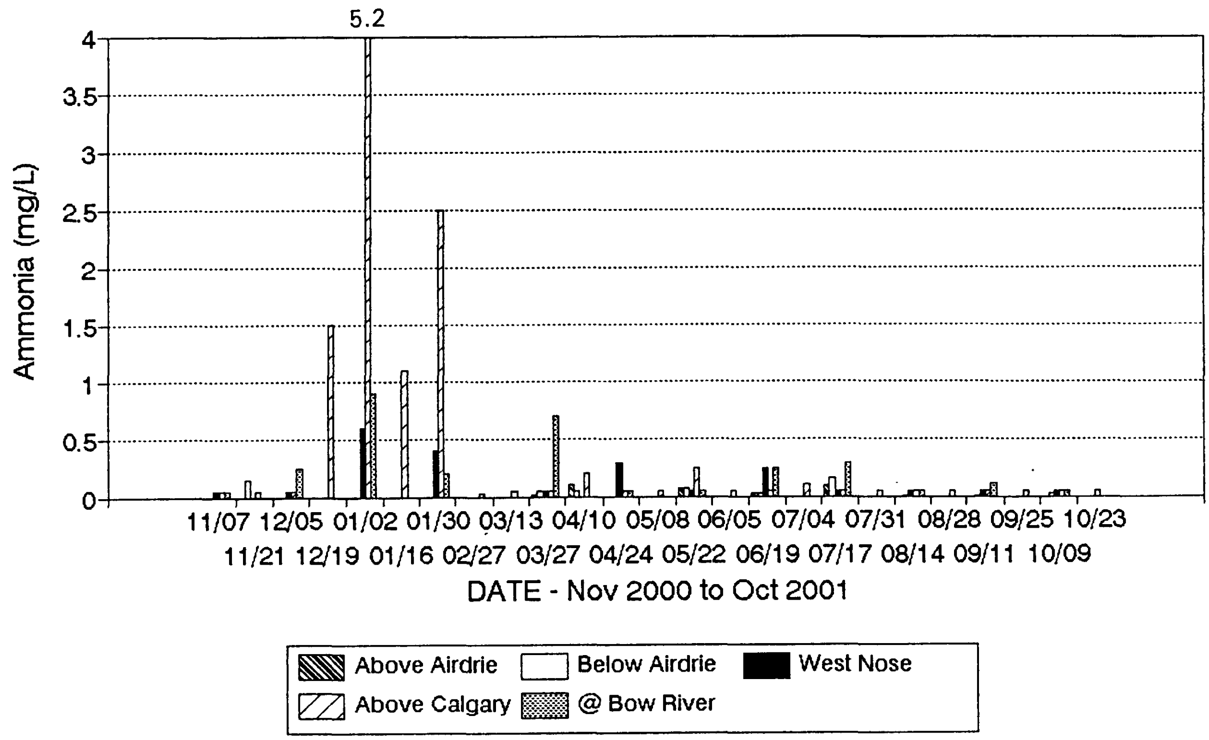

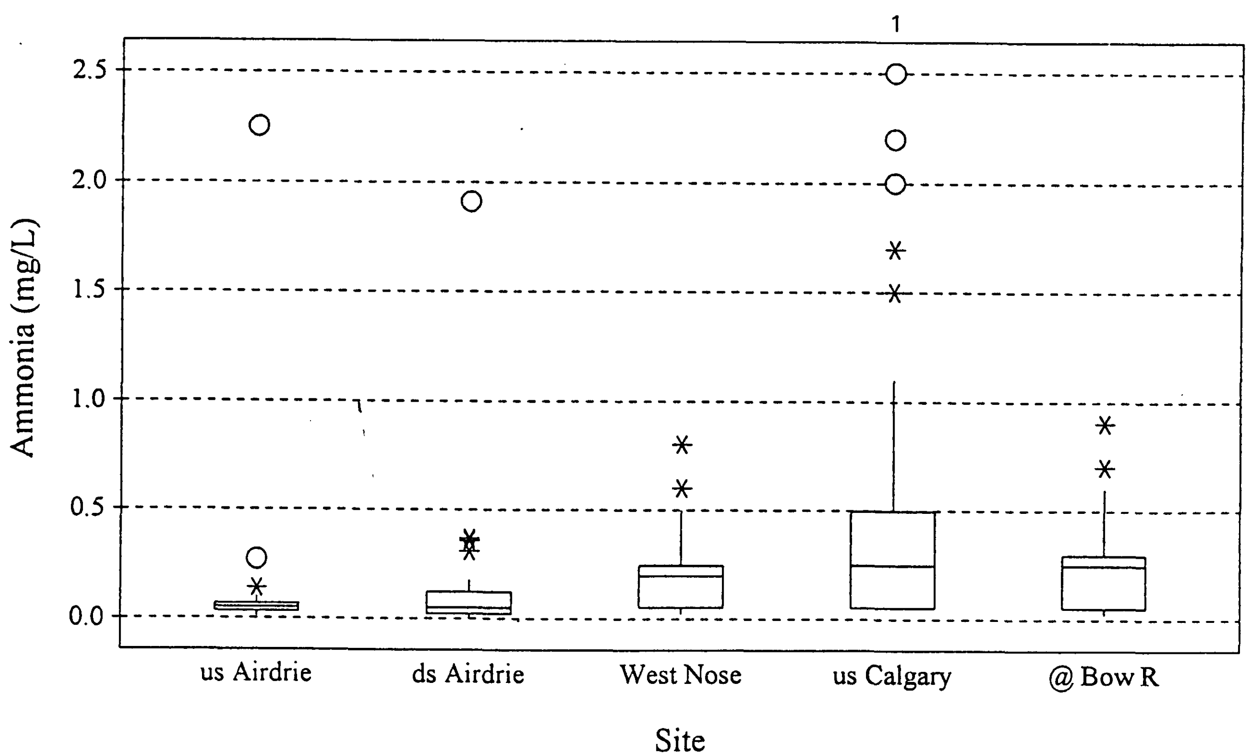

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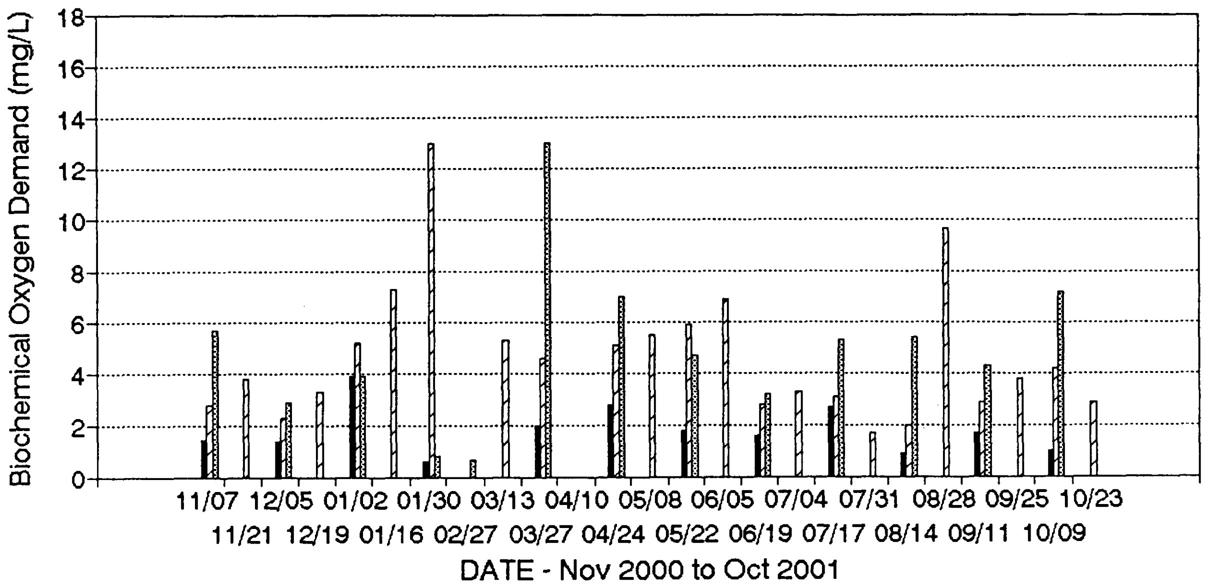

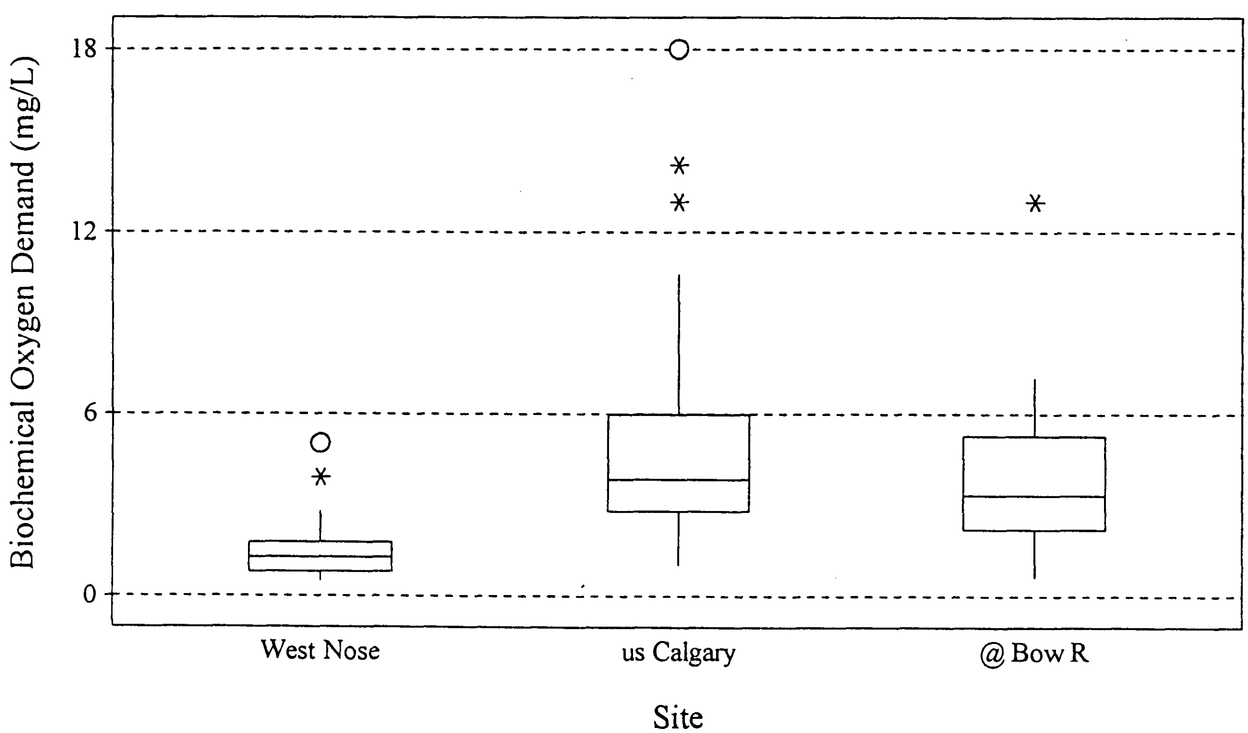

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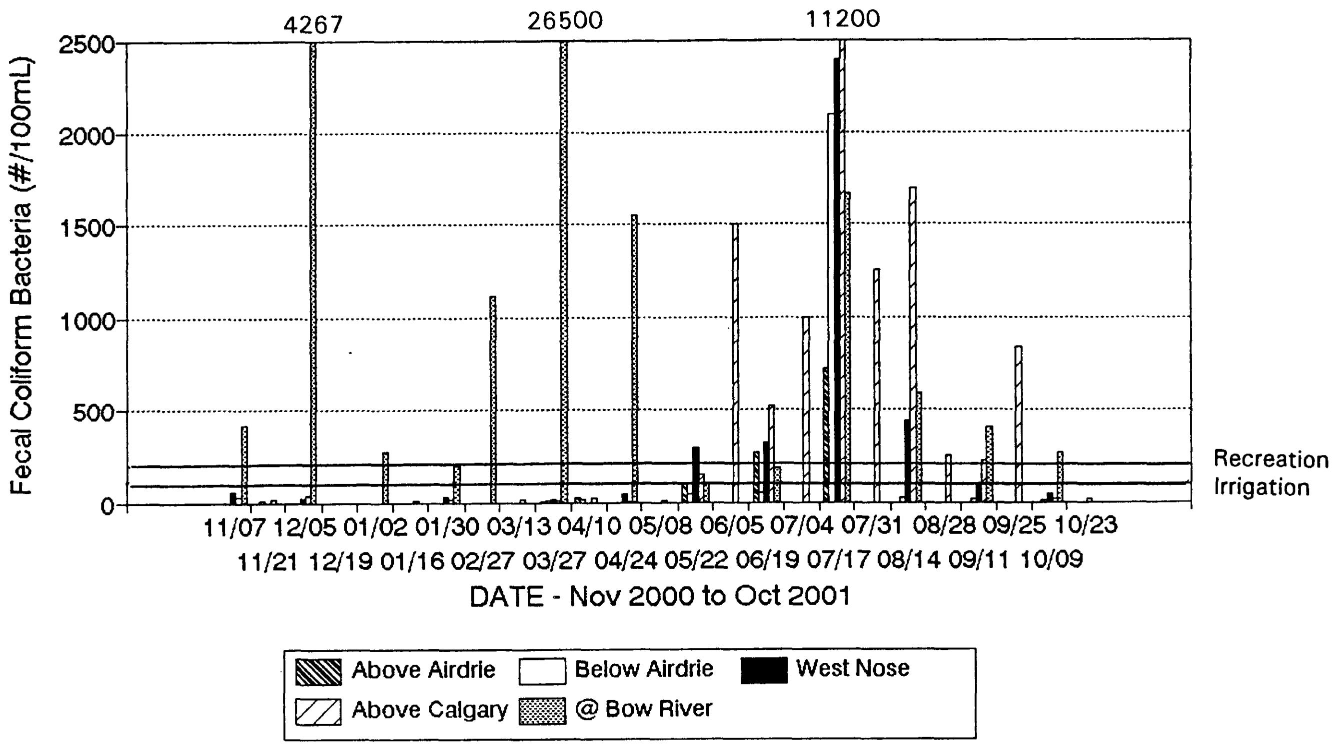


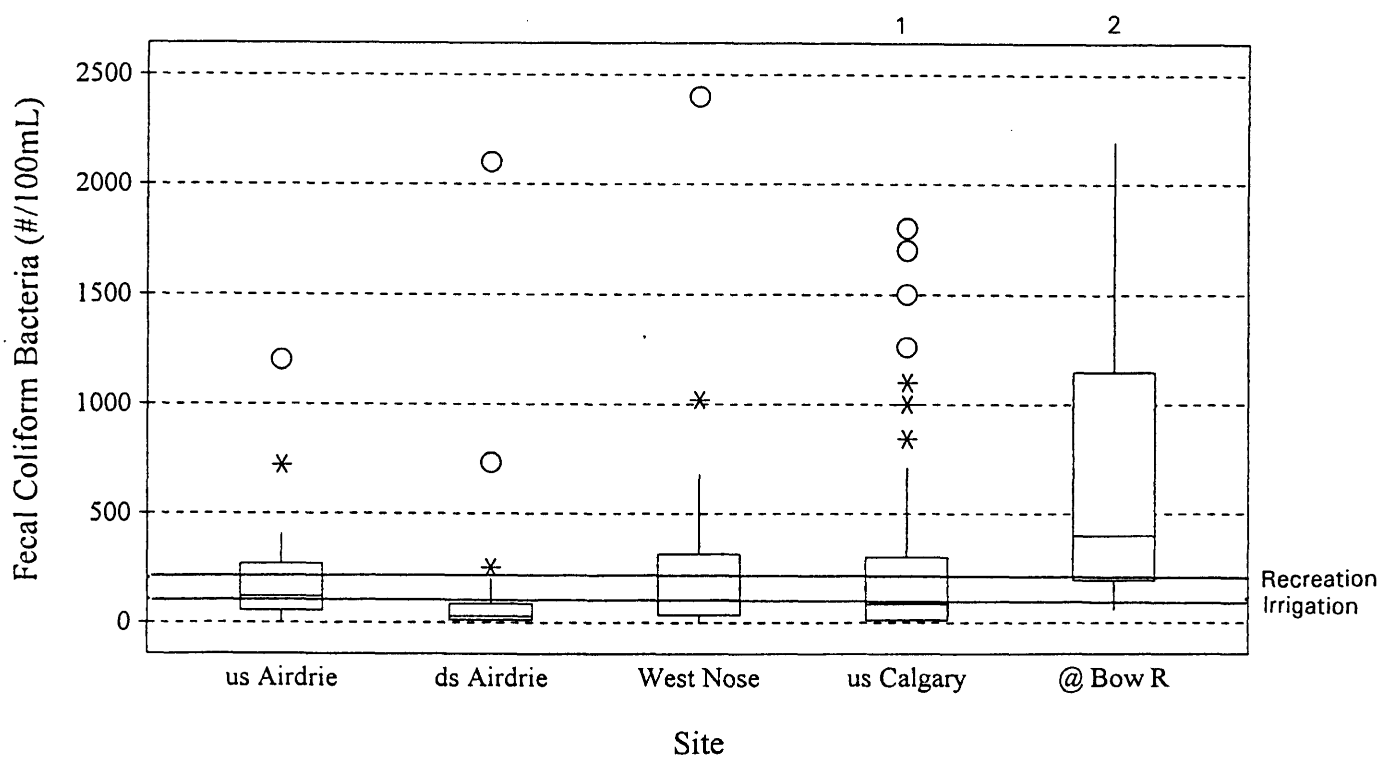
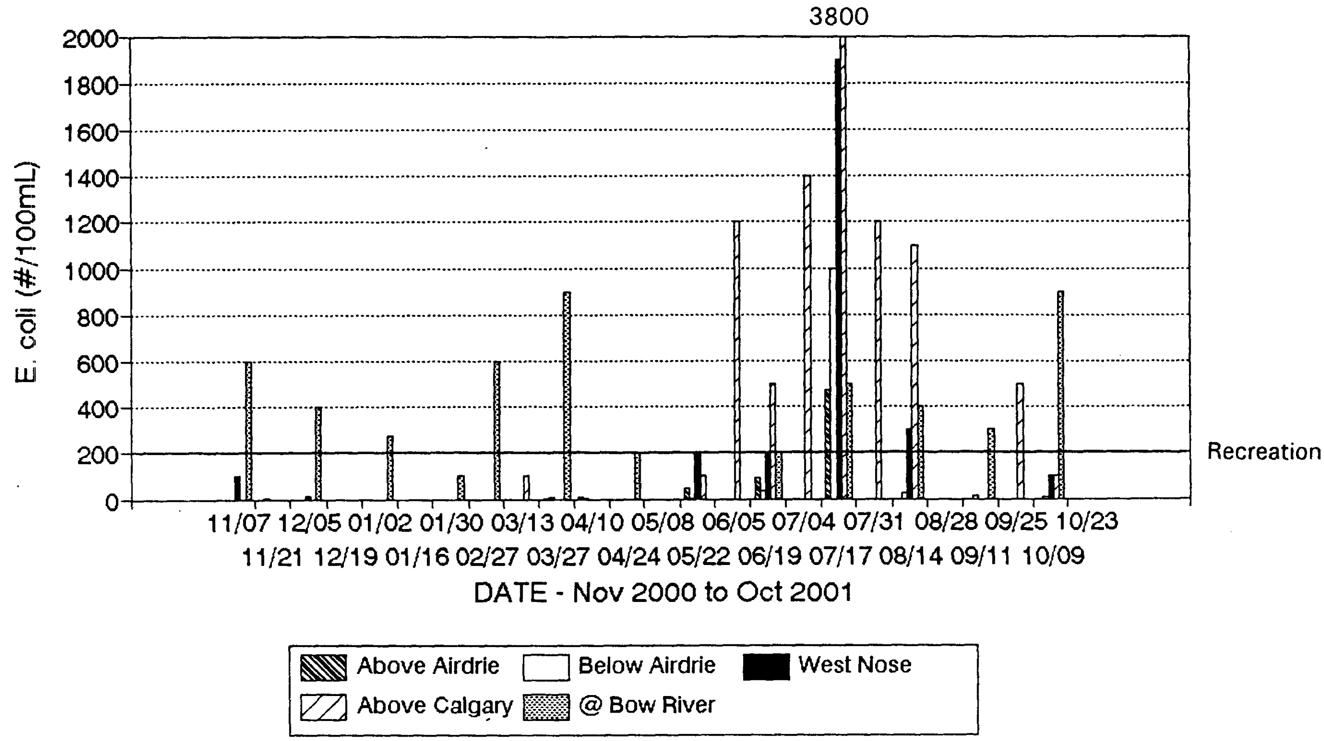
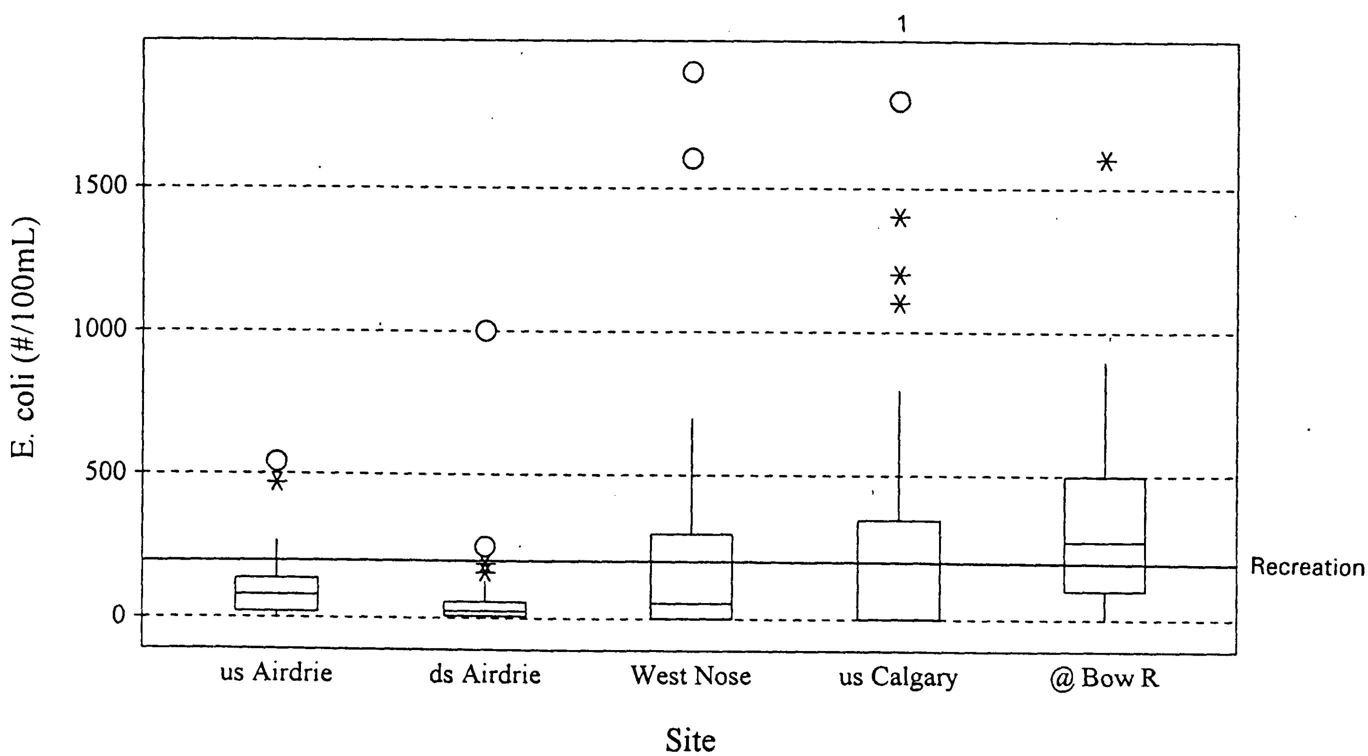


Figure 7 Bacteria





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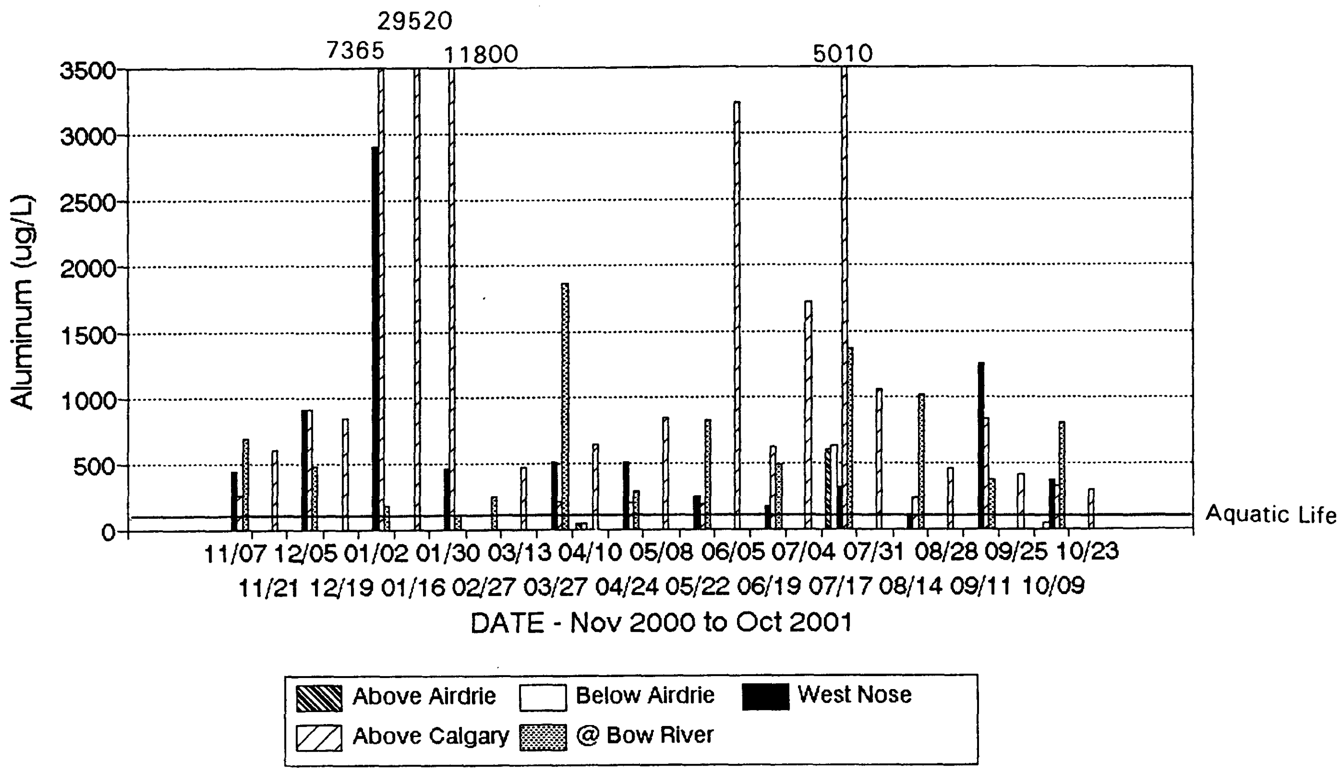


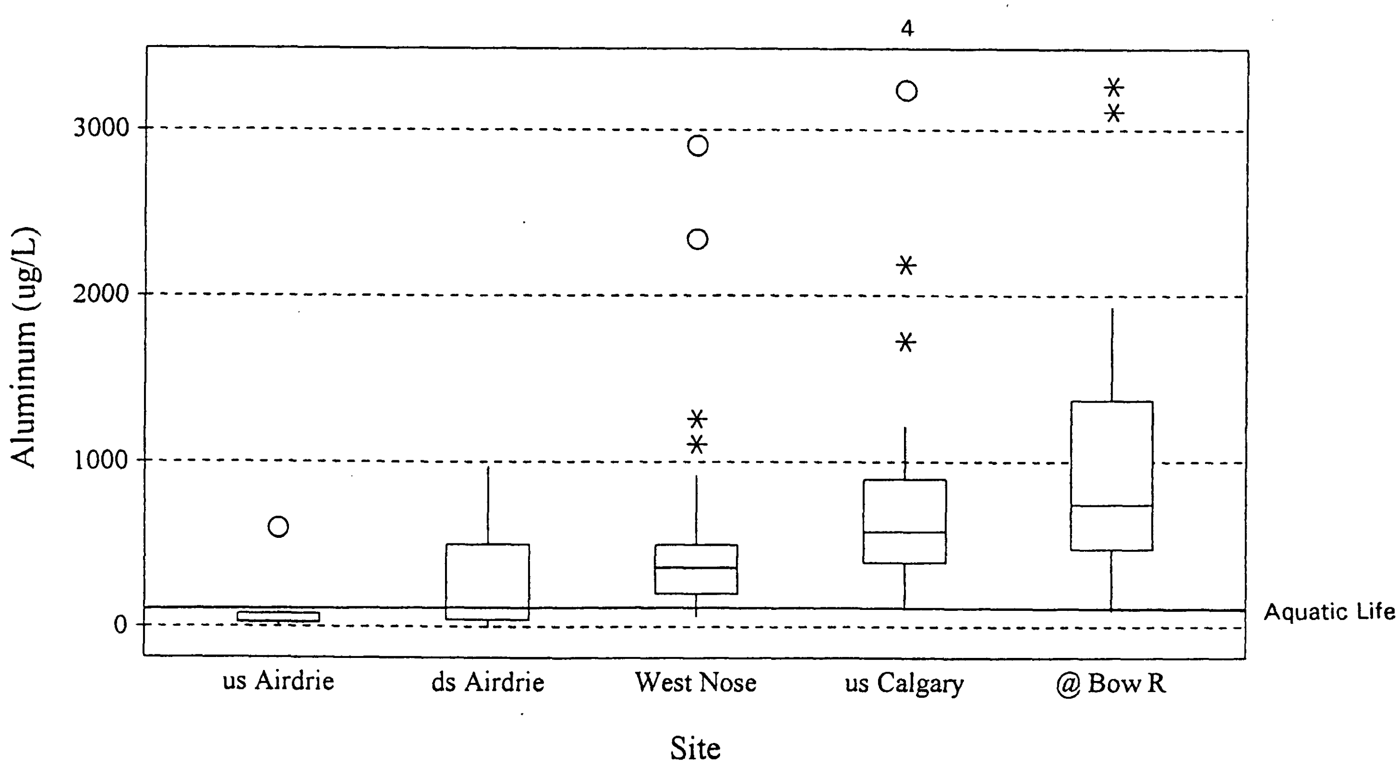
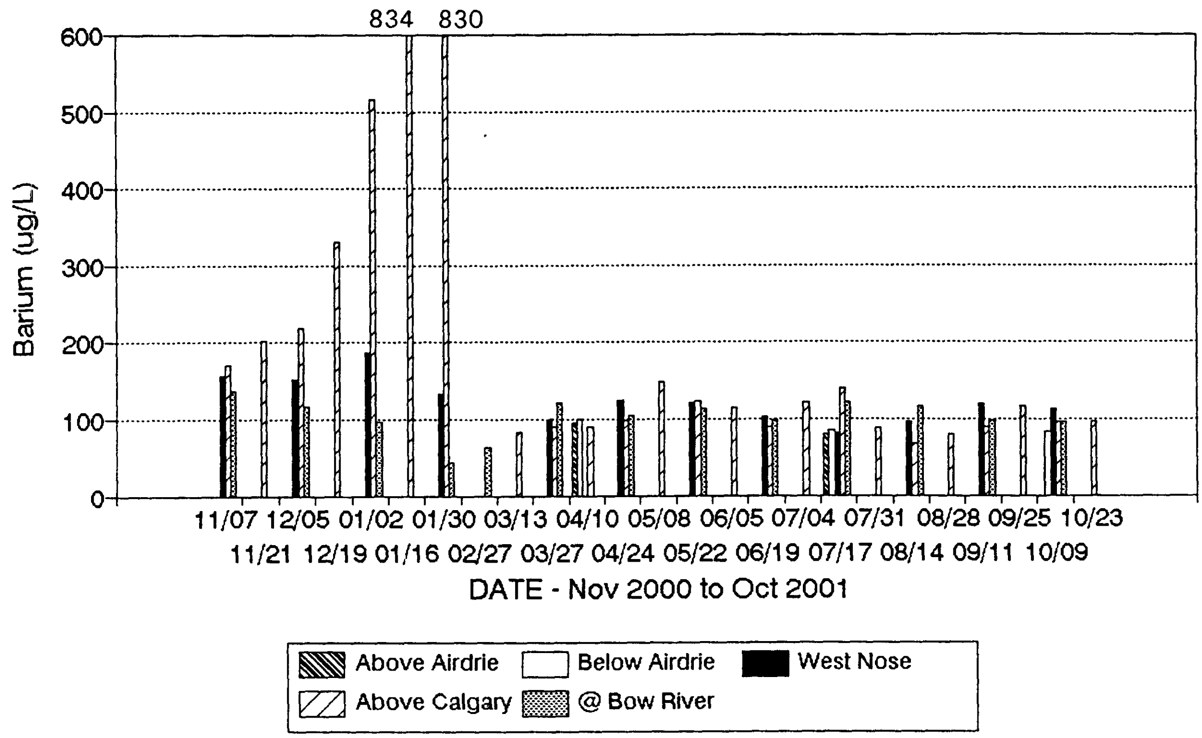
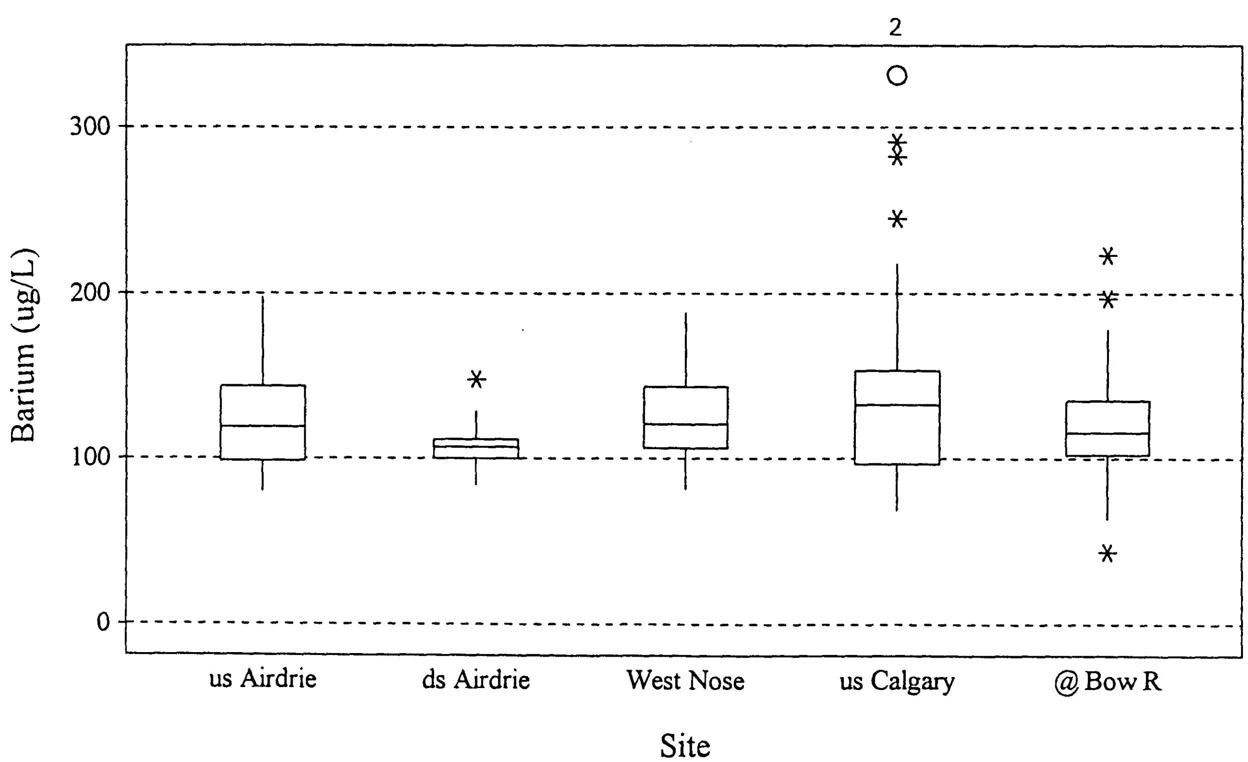


Figure 8 Metals





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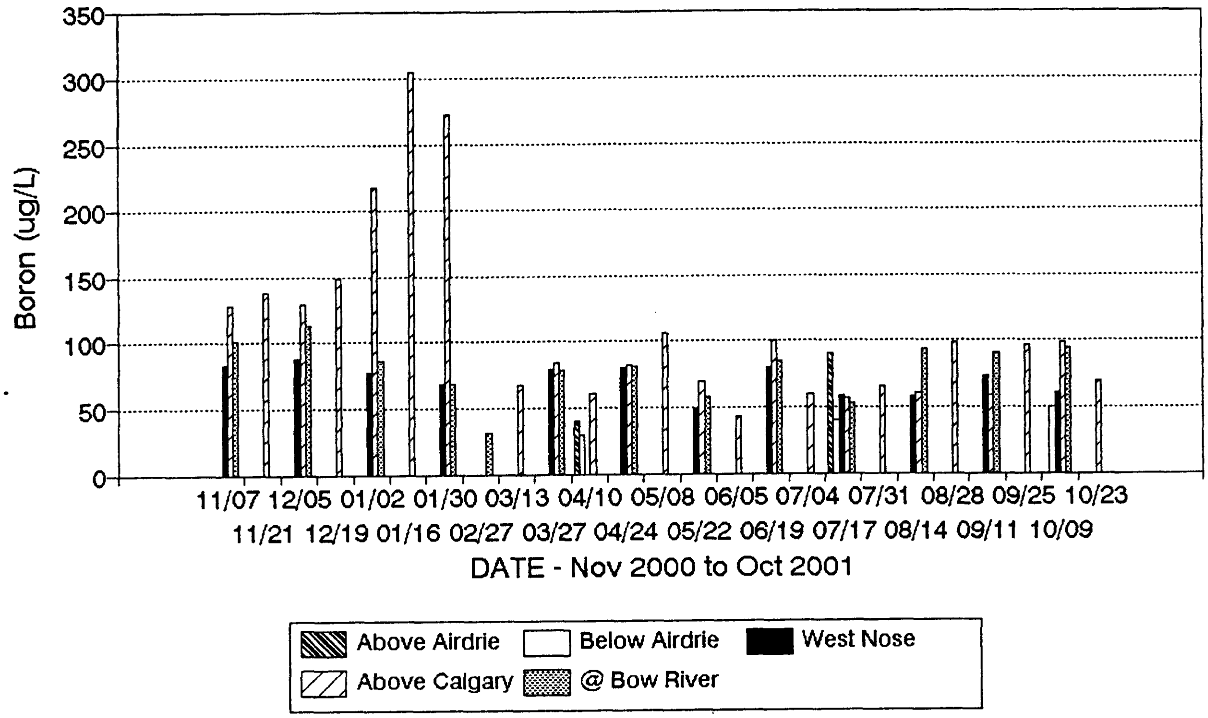

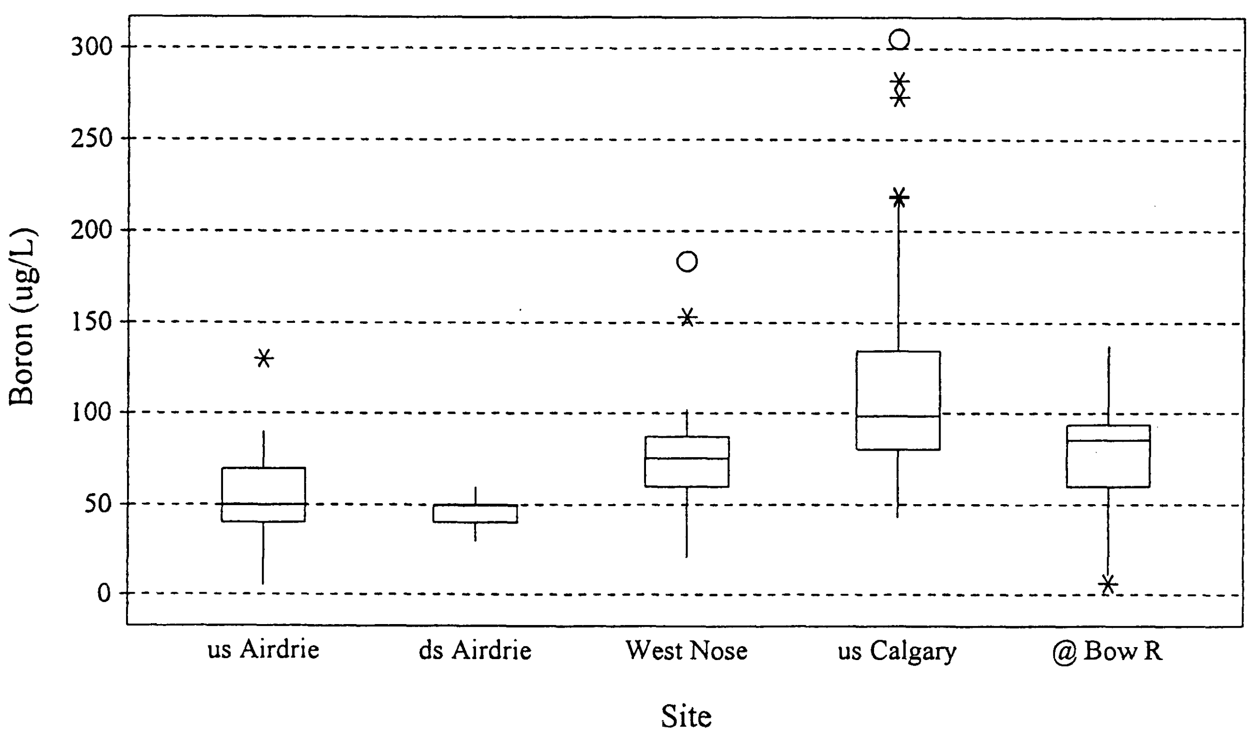

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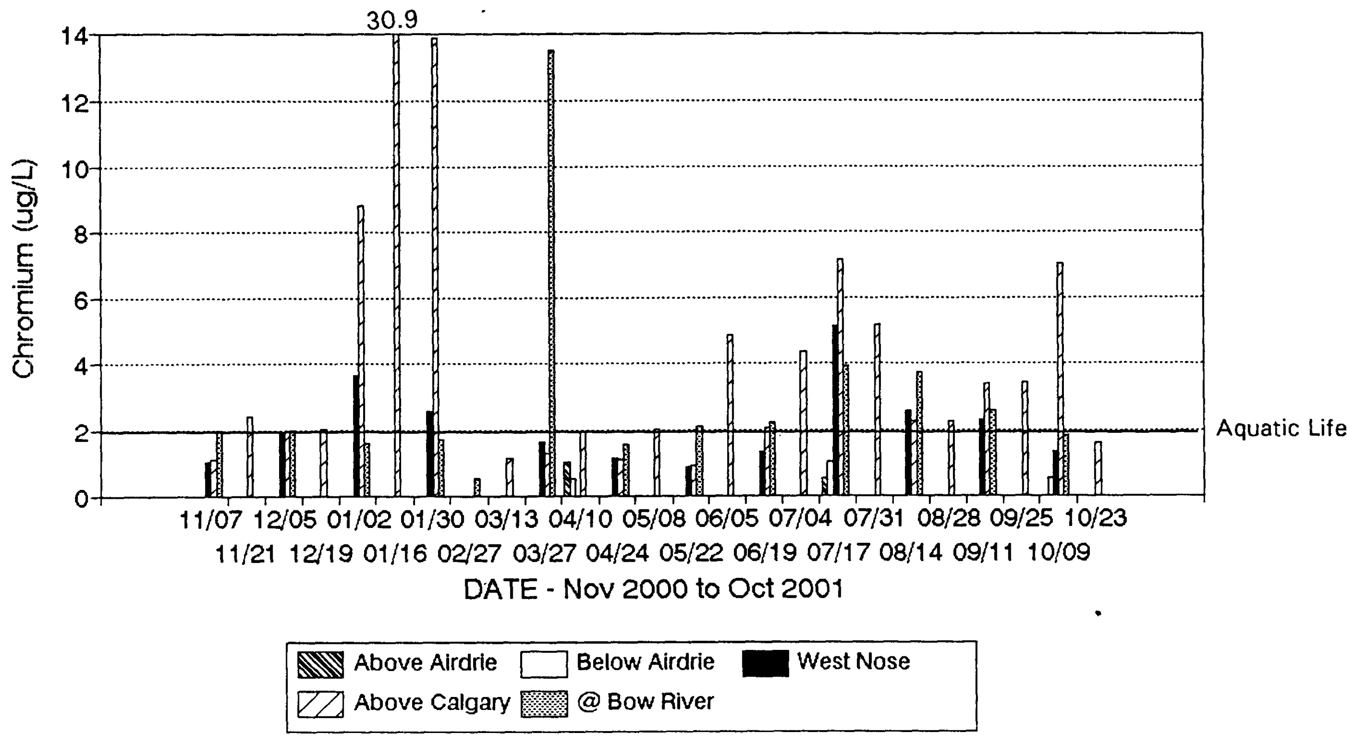

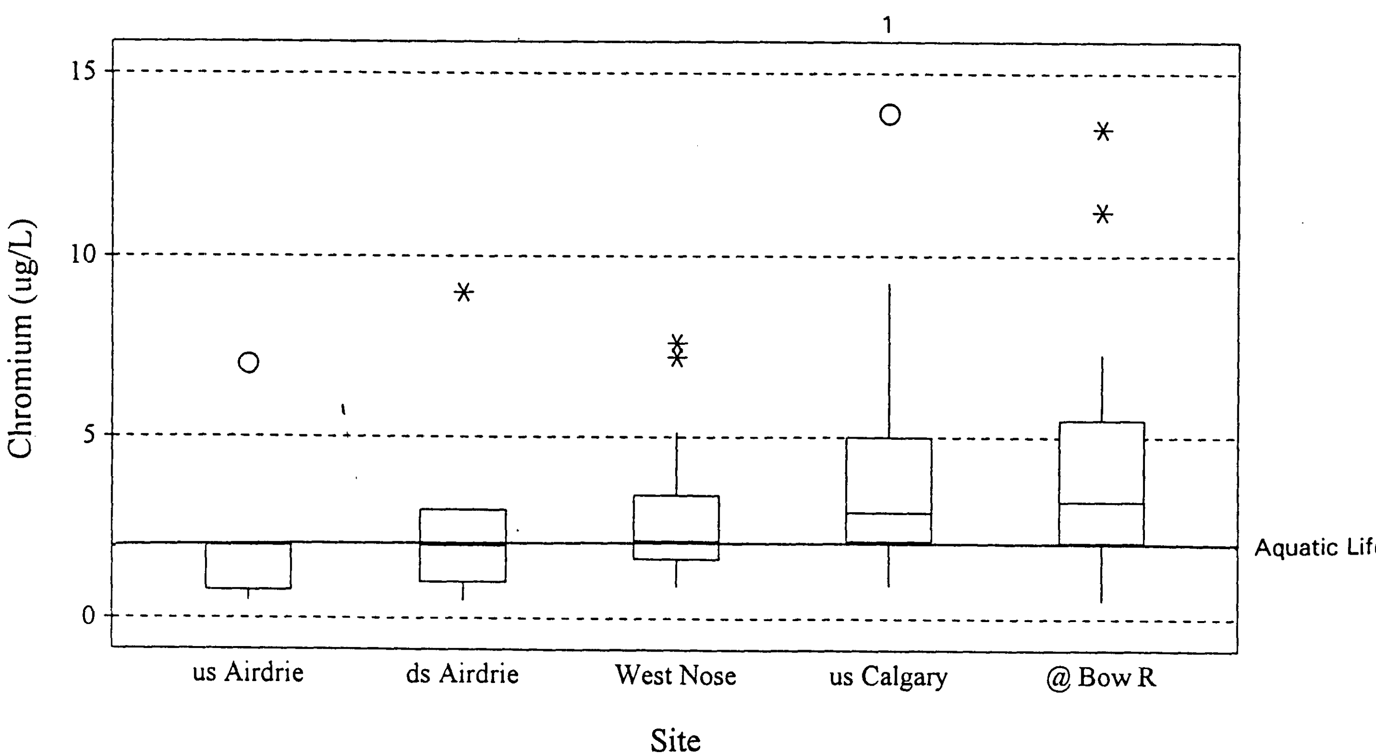

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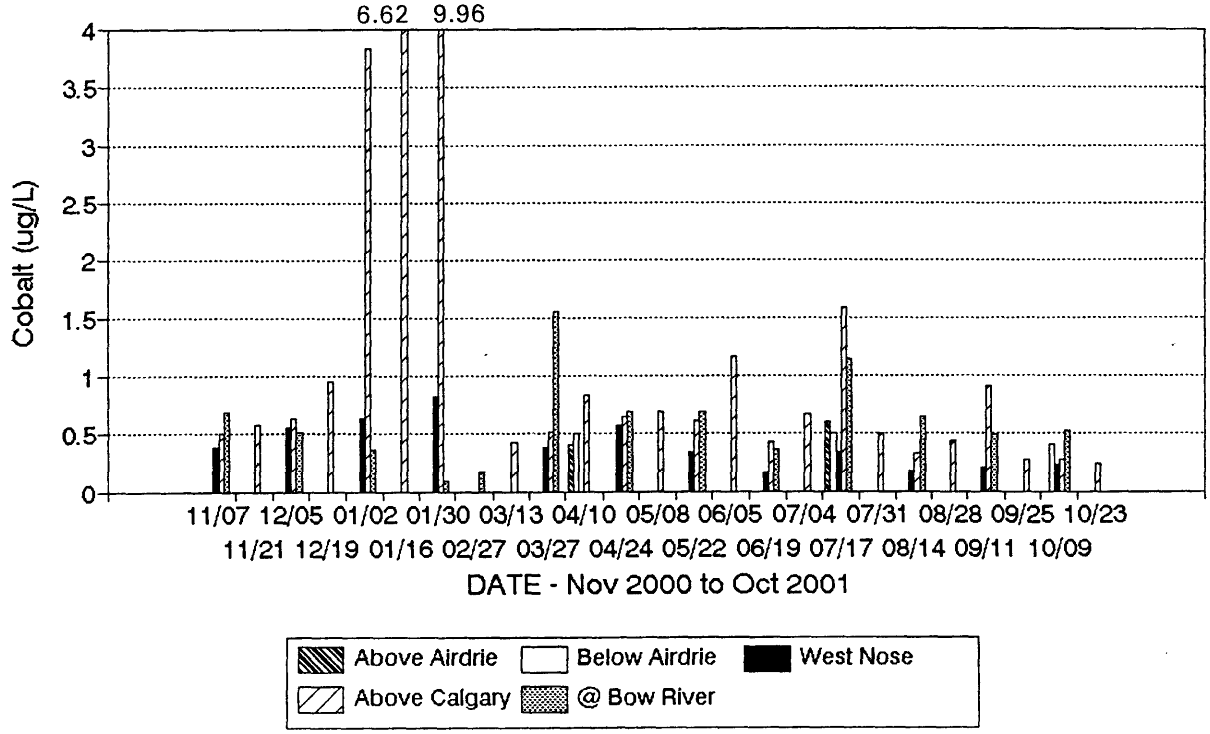

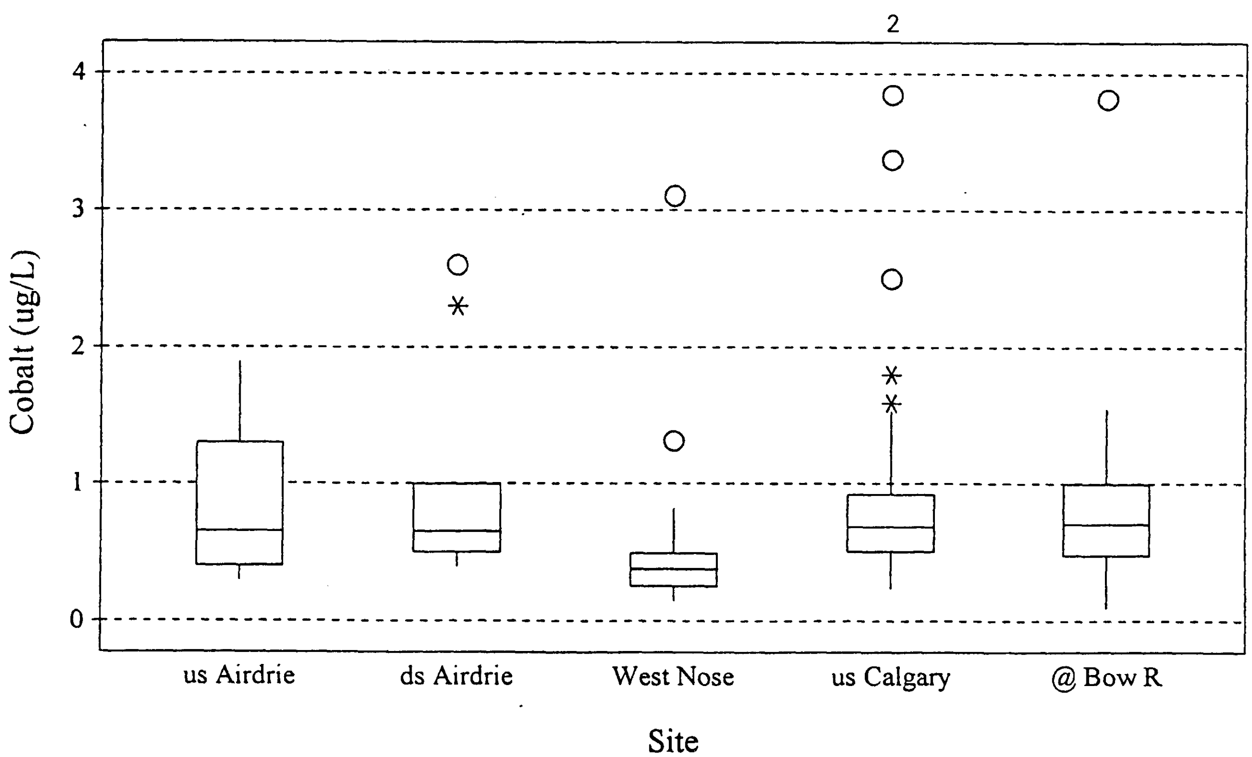

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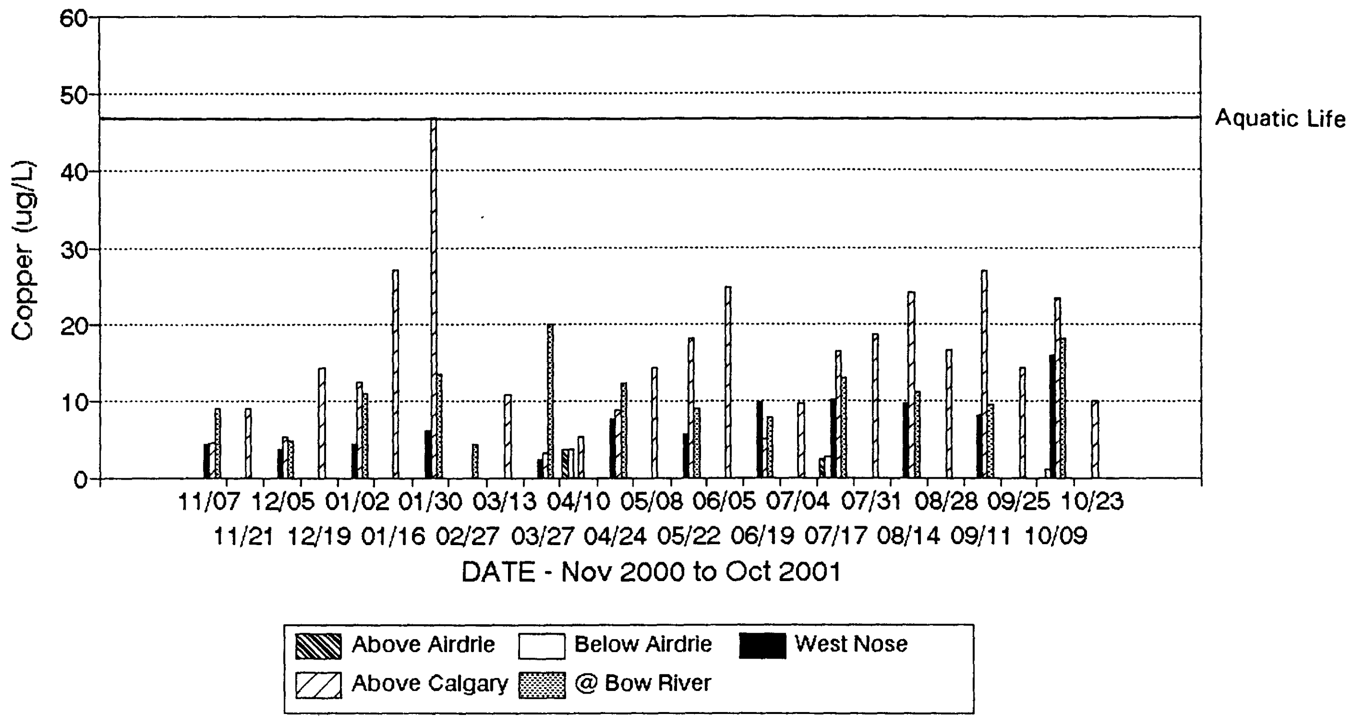

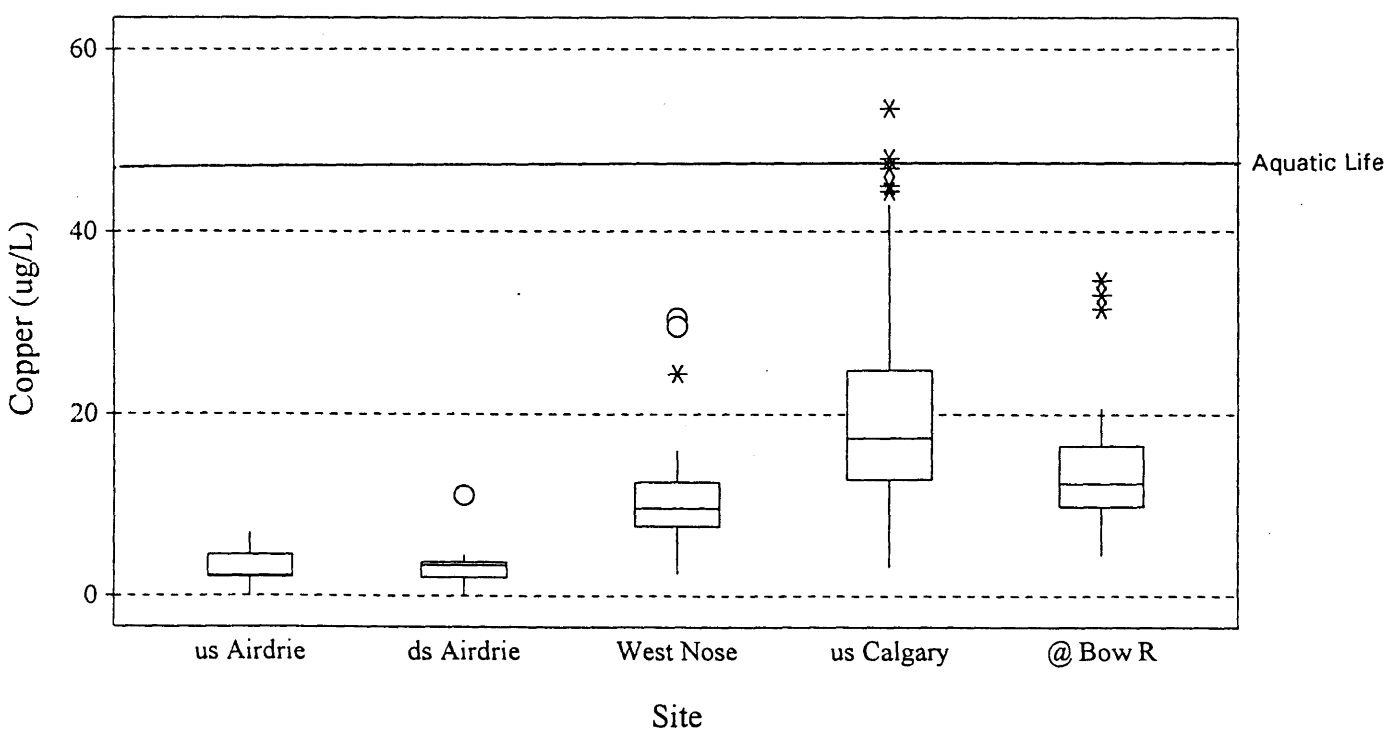

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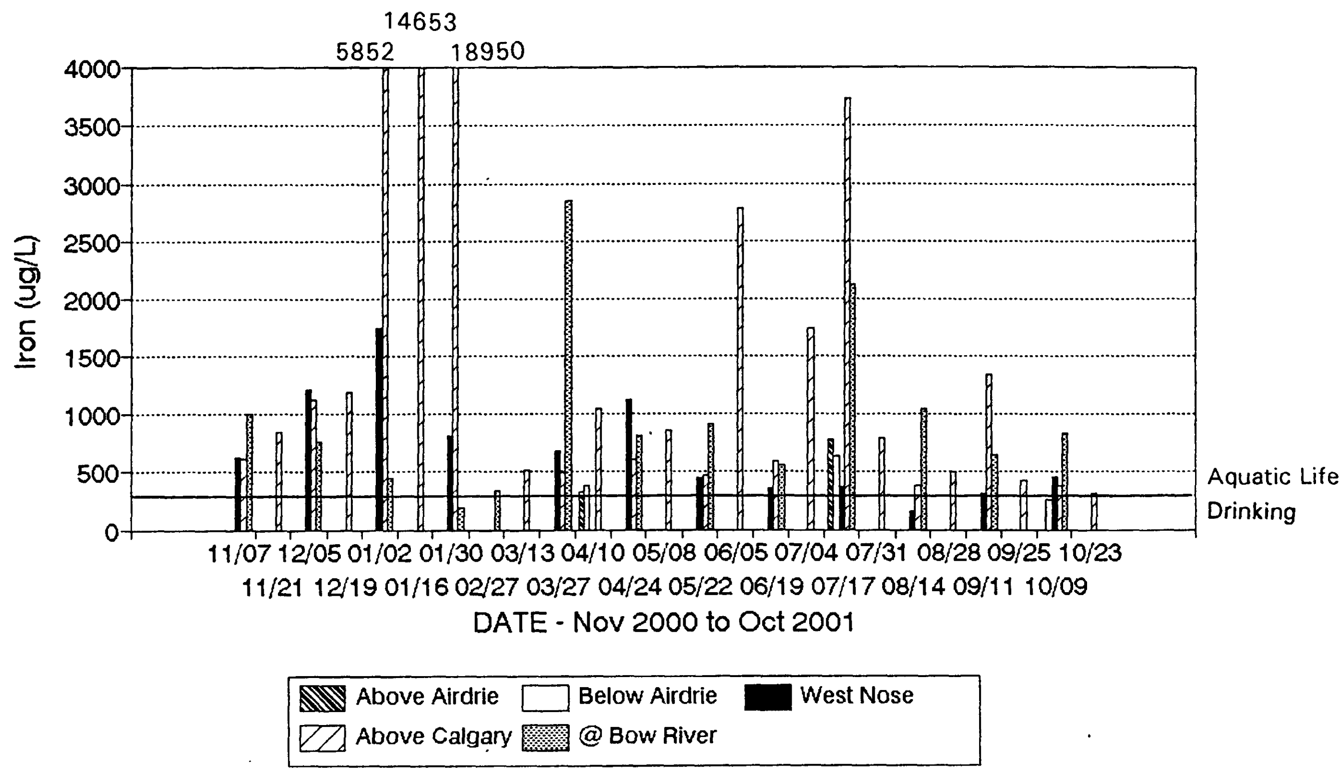

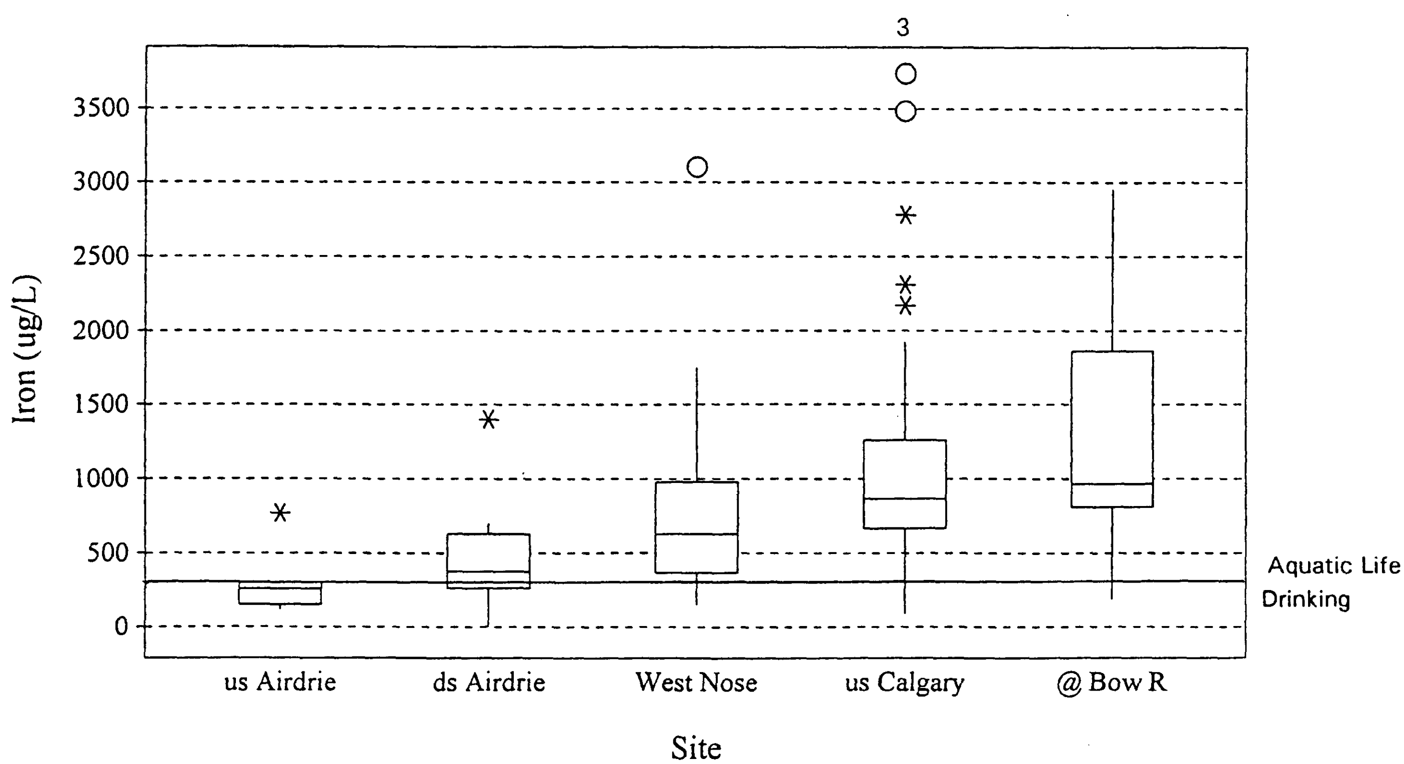

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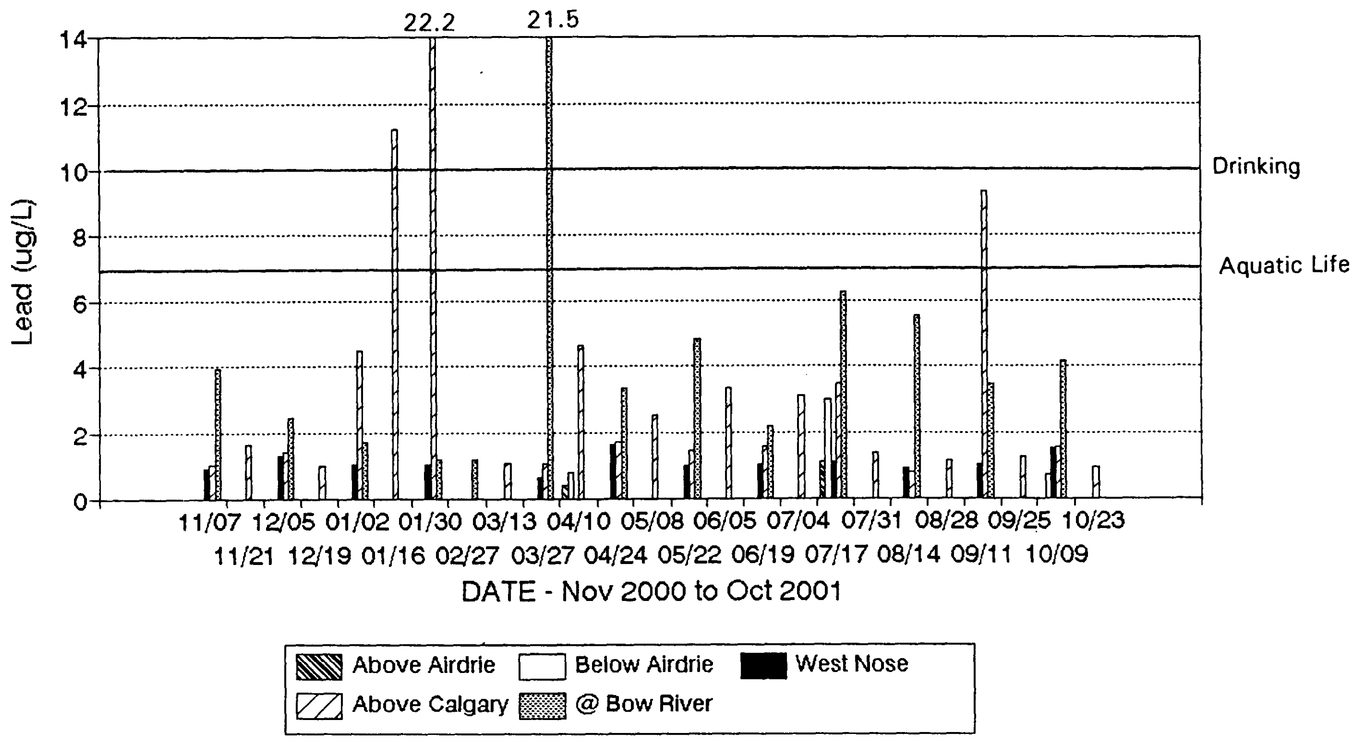

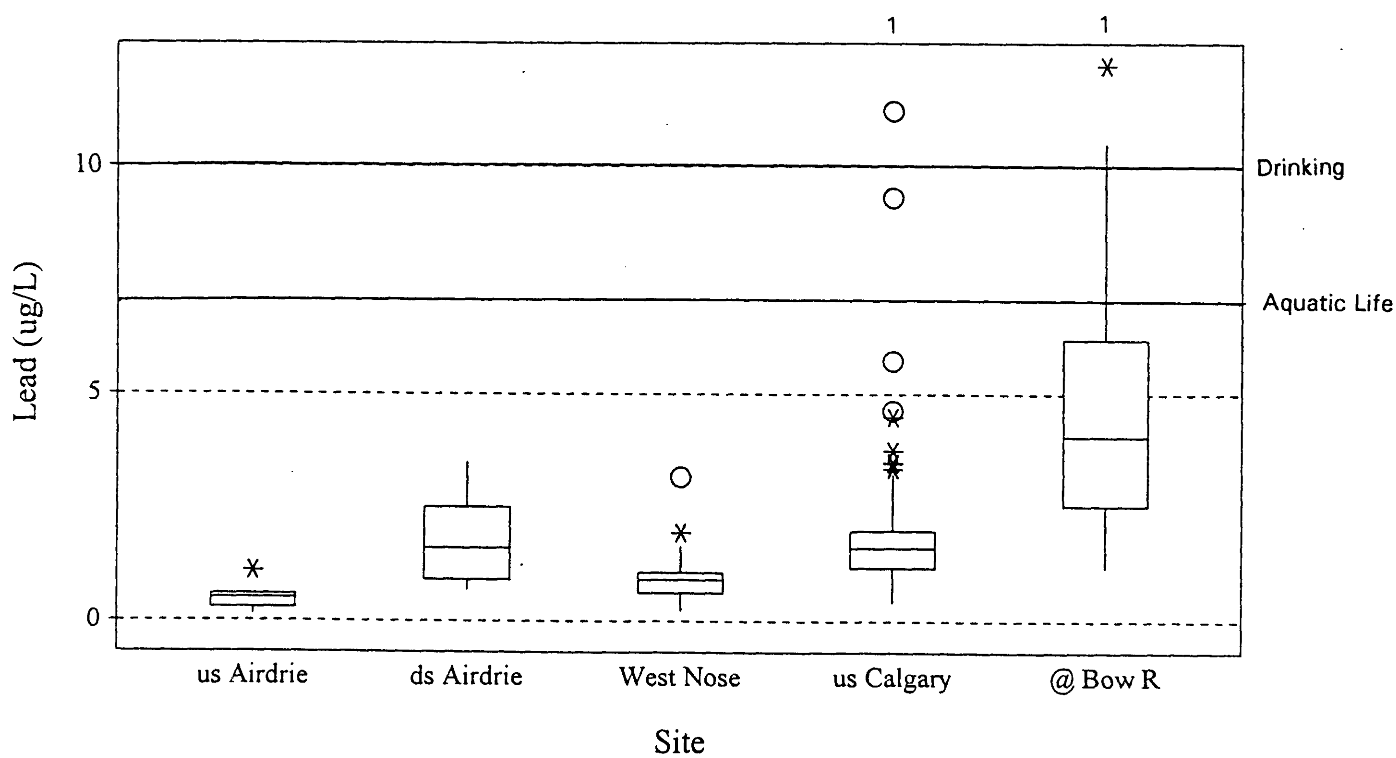

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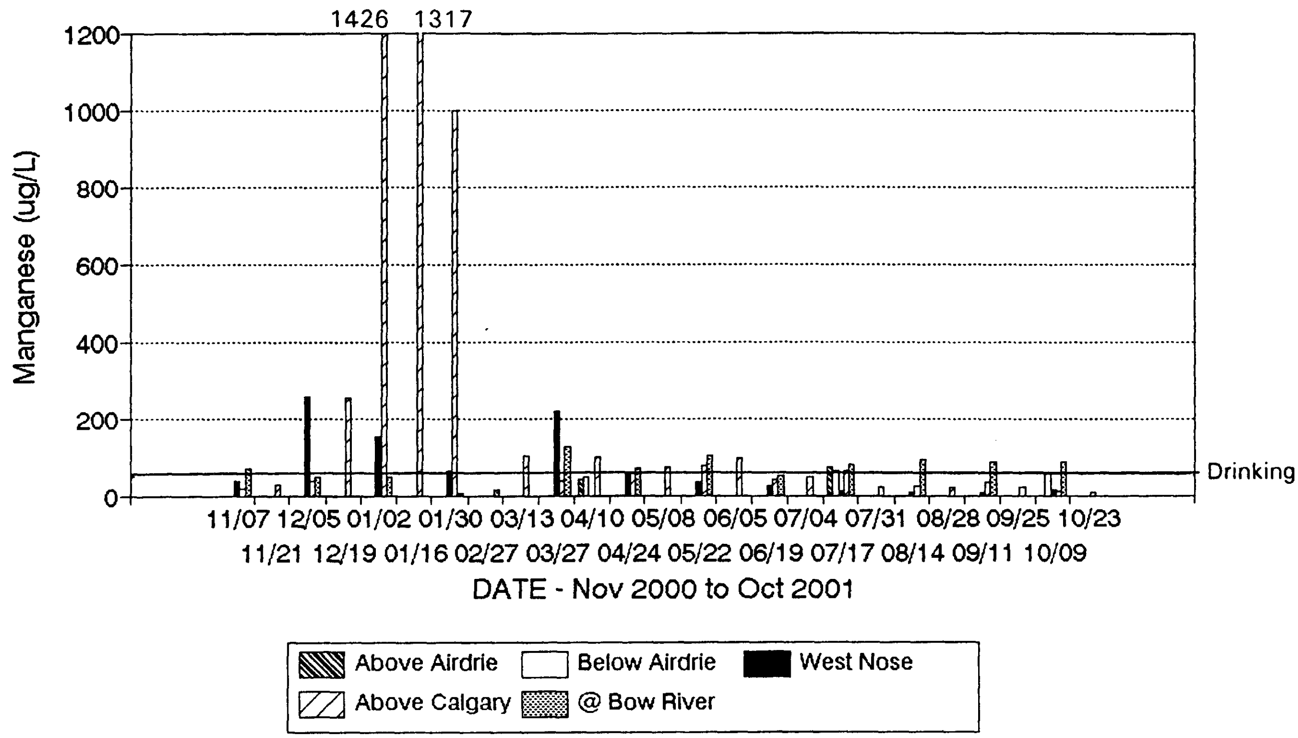

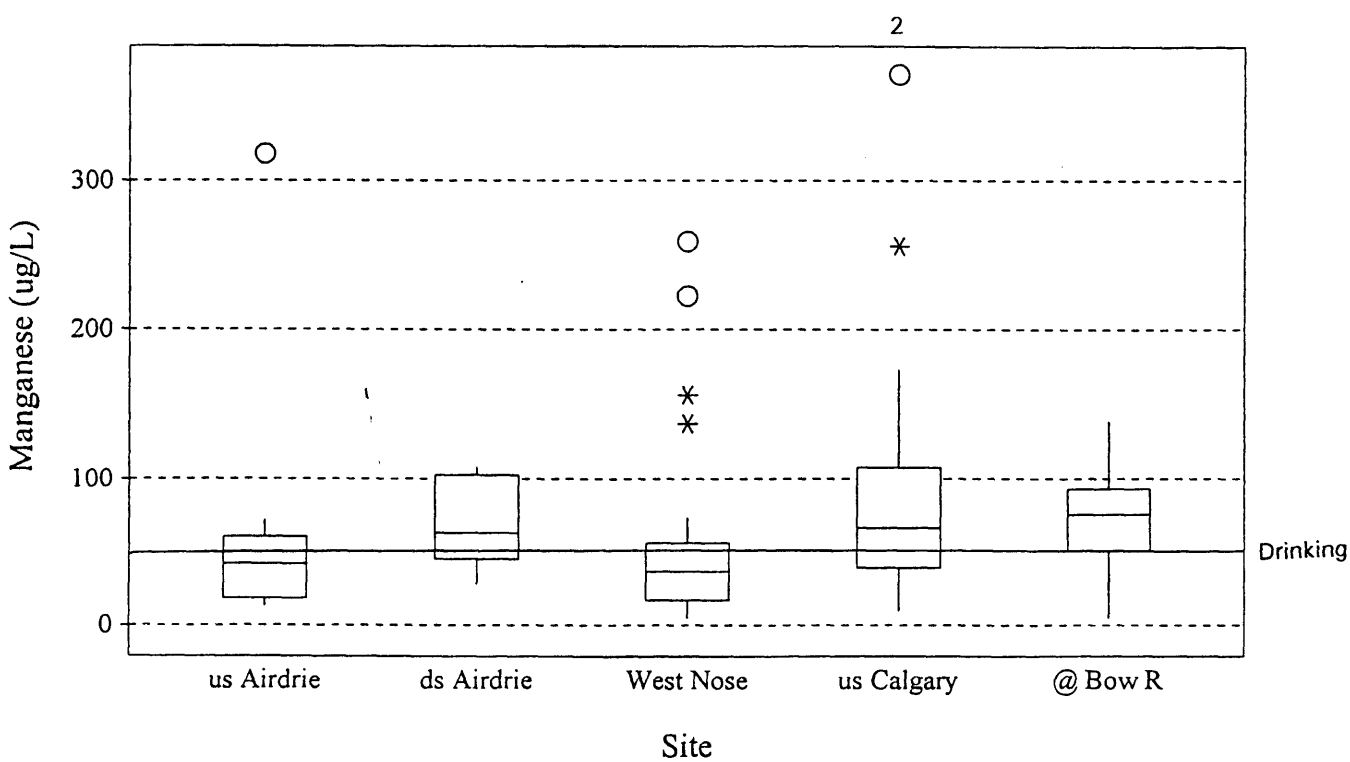

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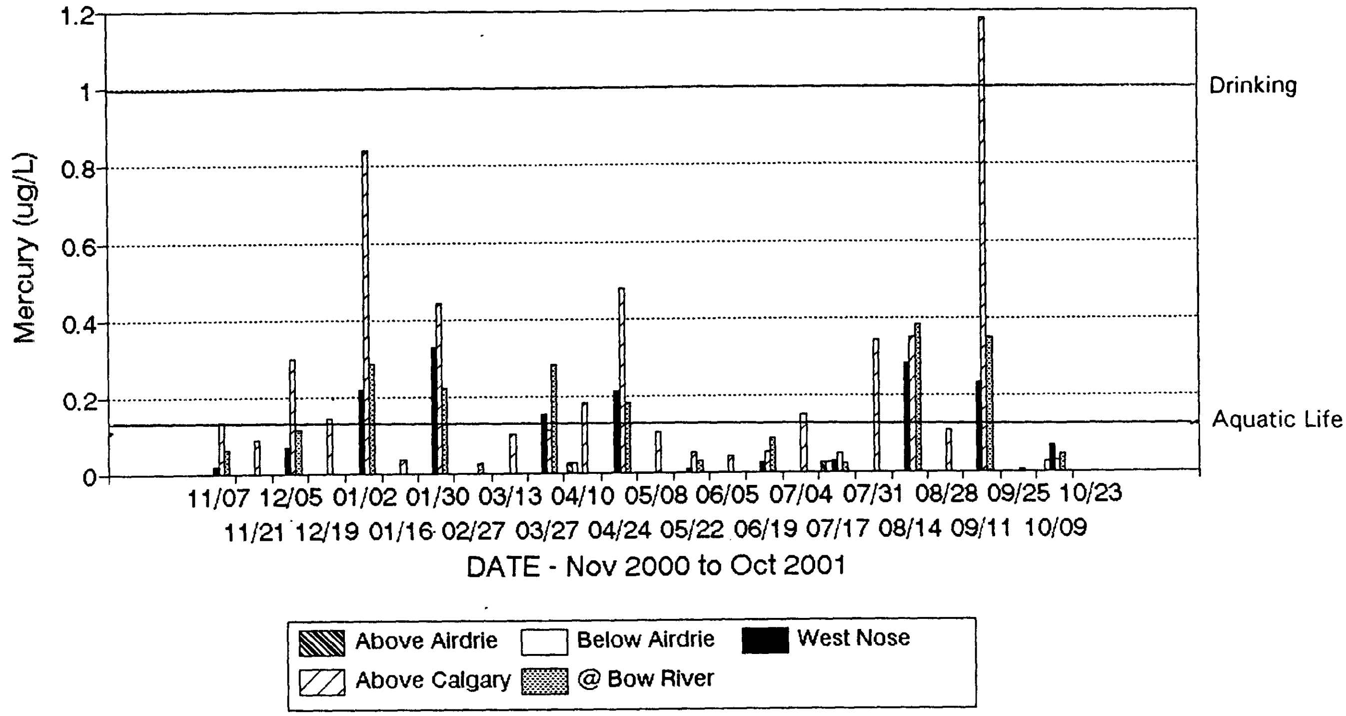

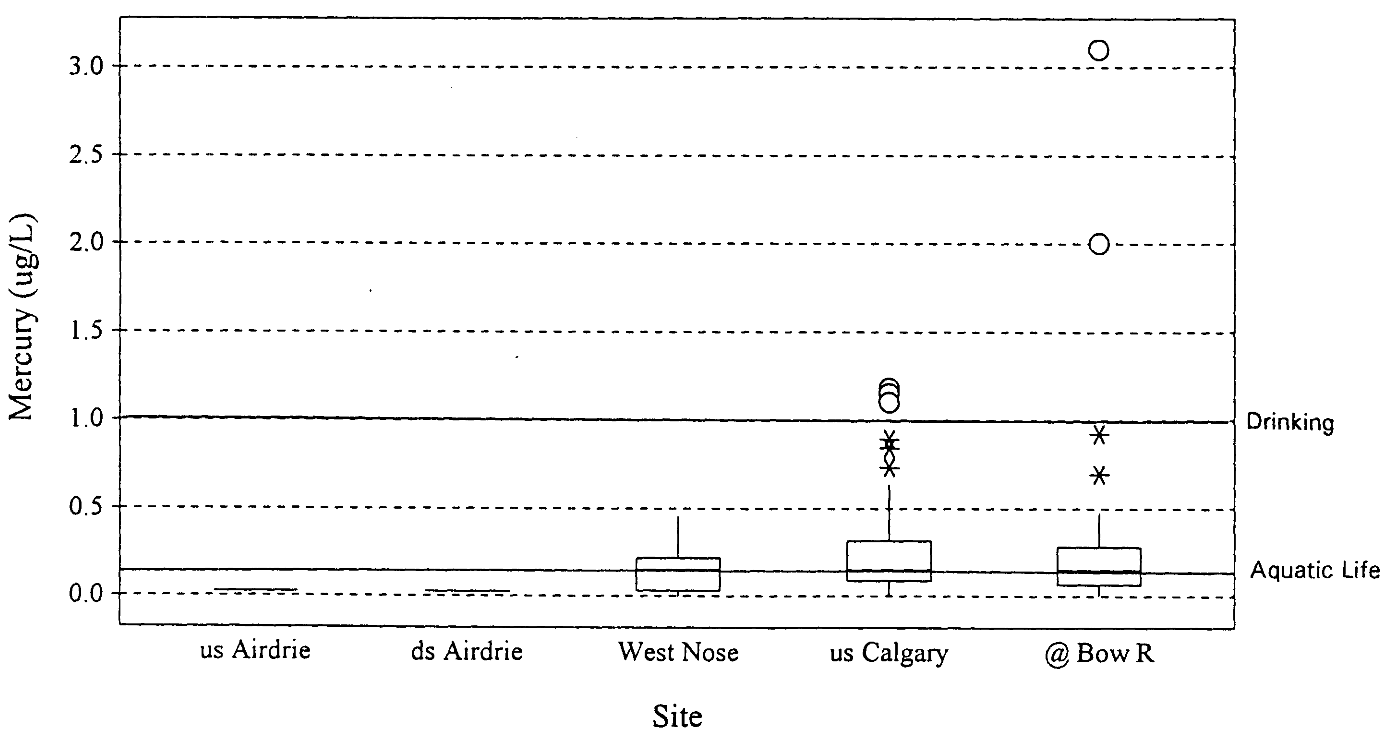

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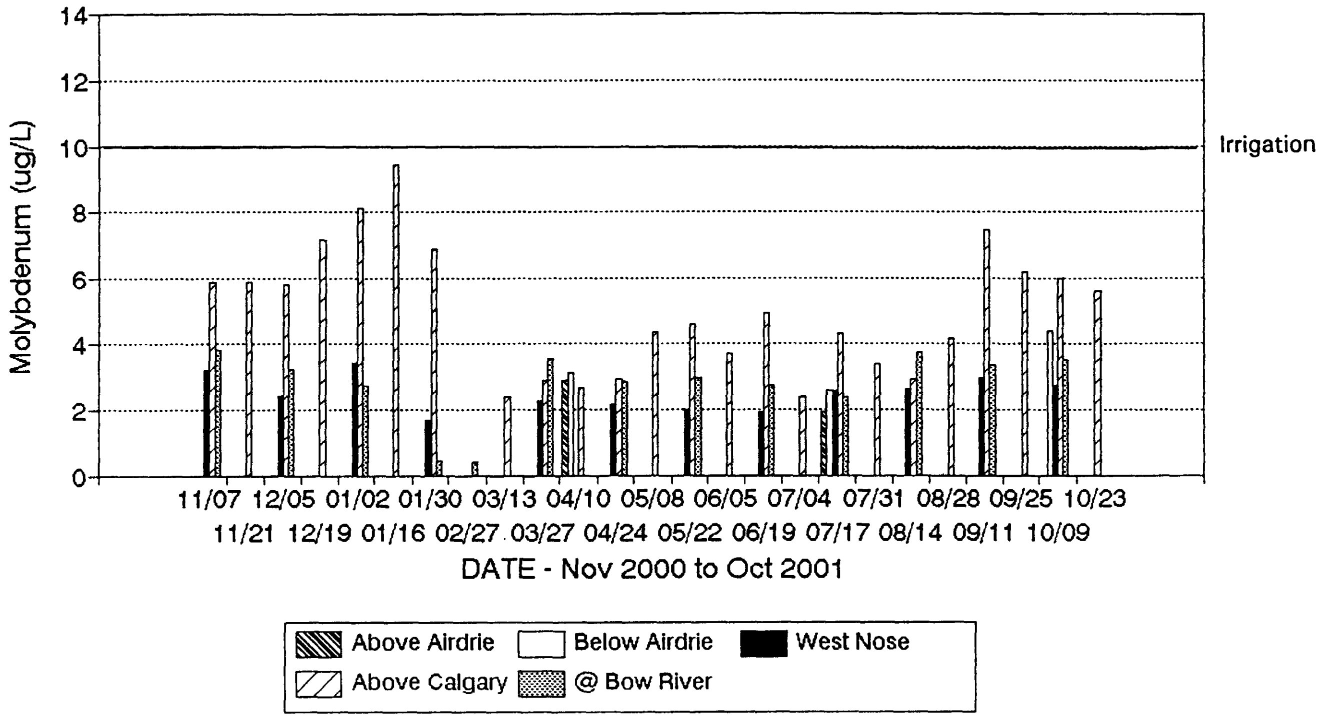

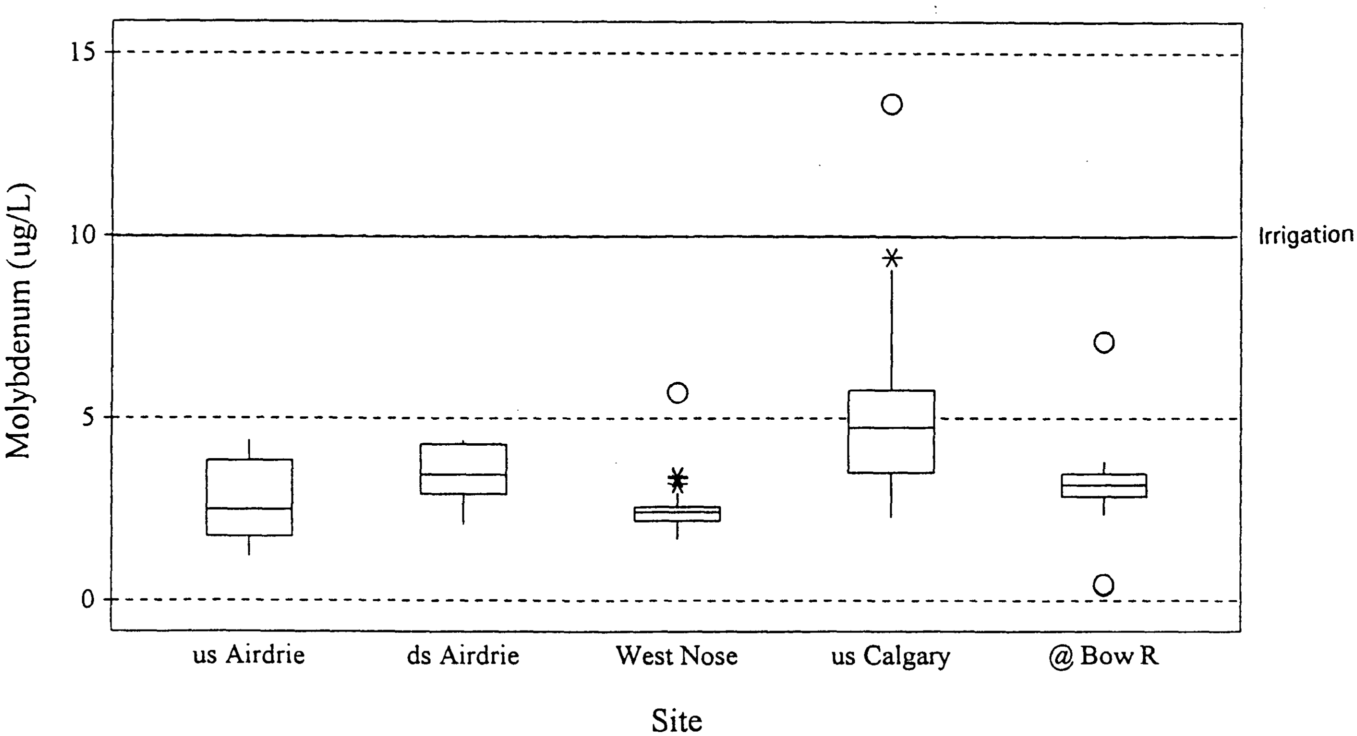

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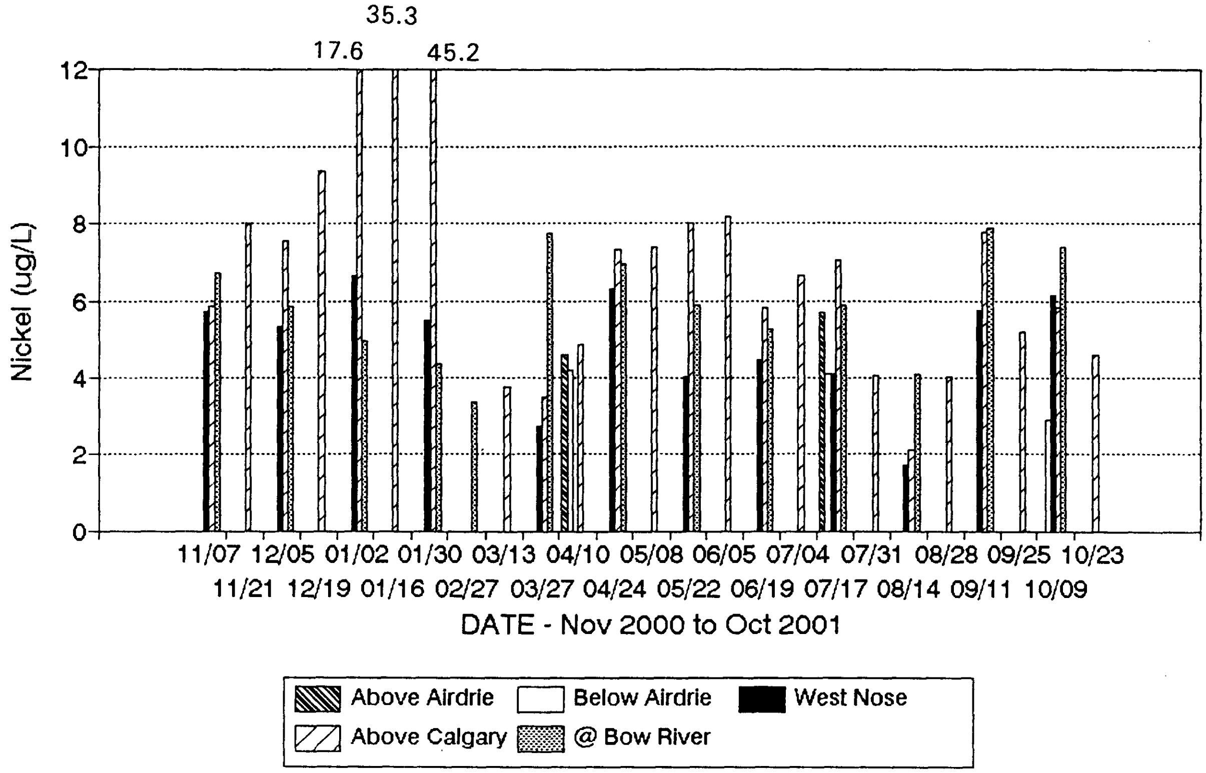

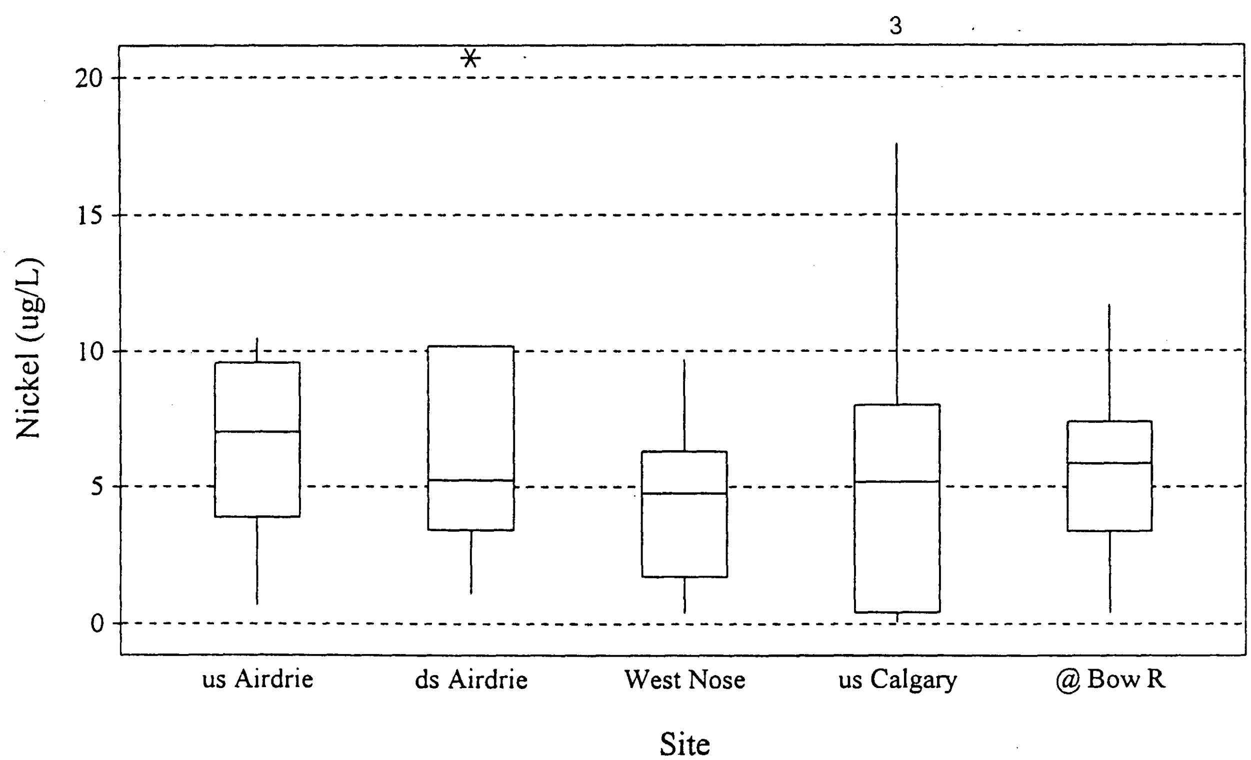

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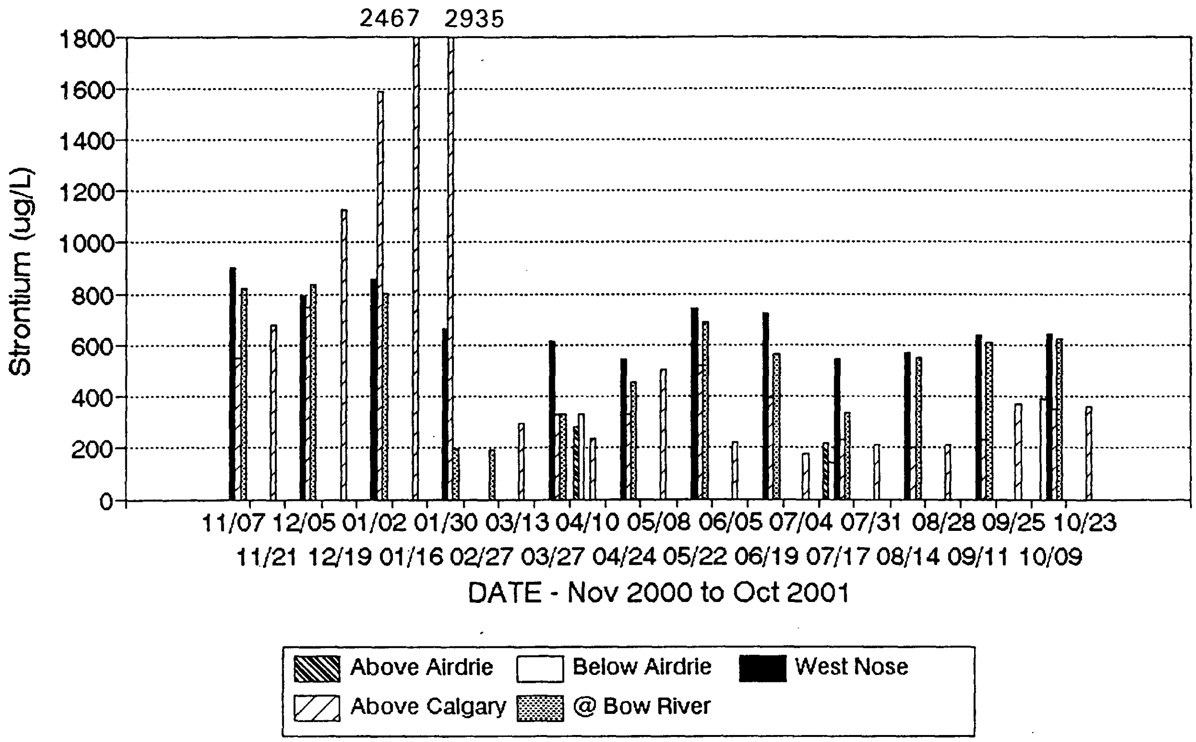

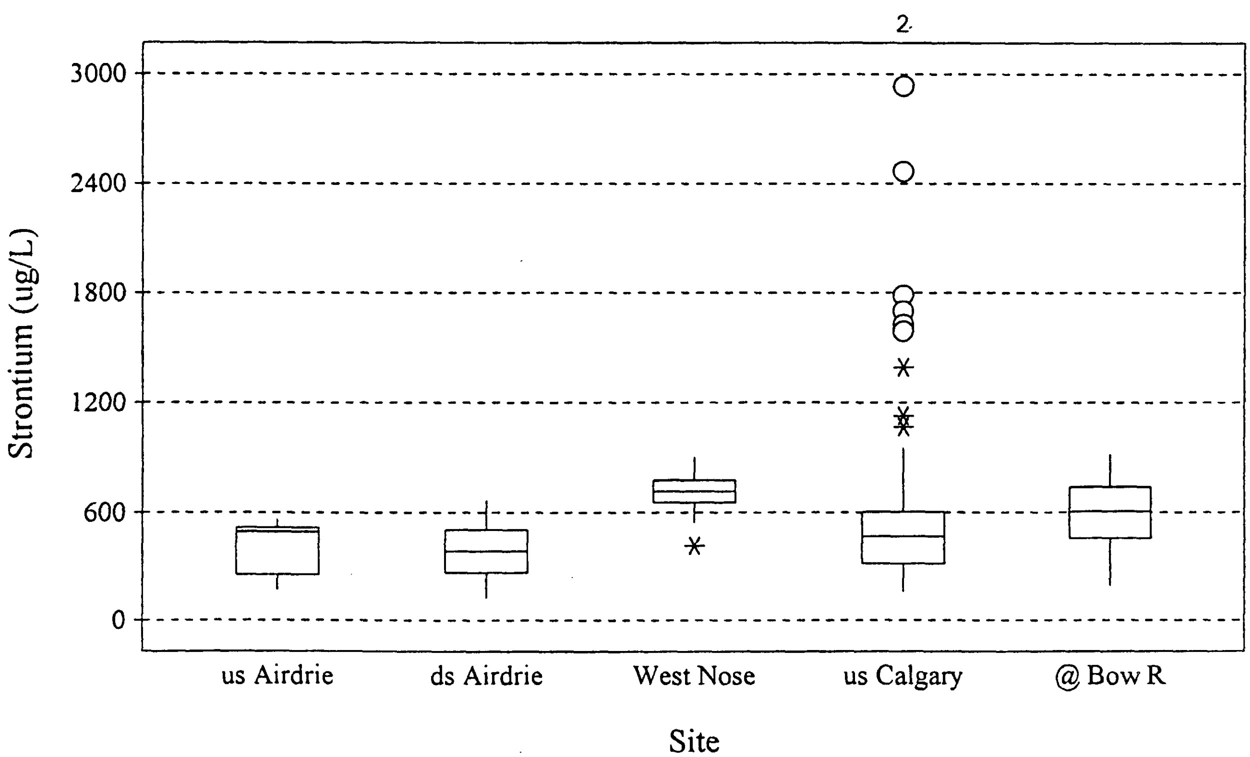

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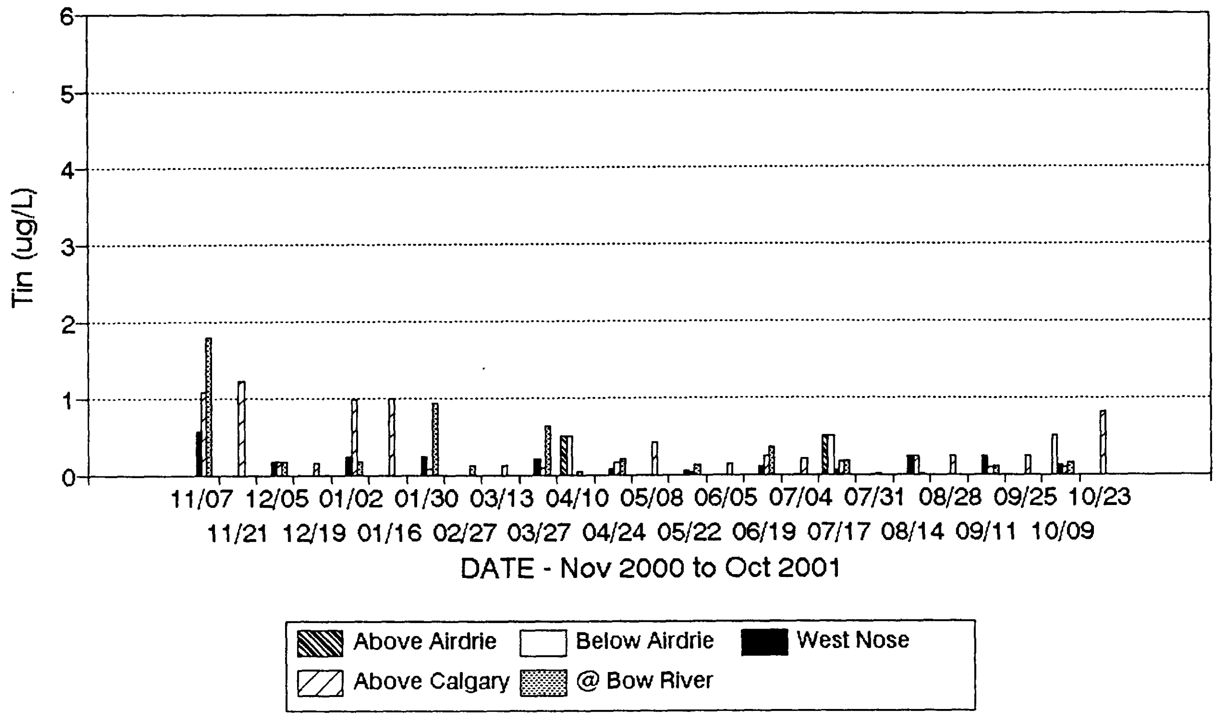

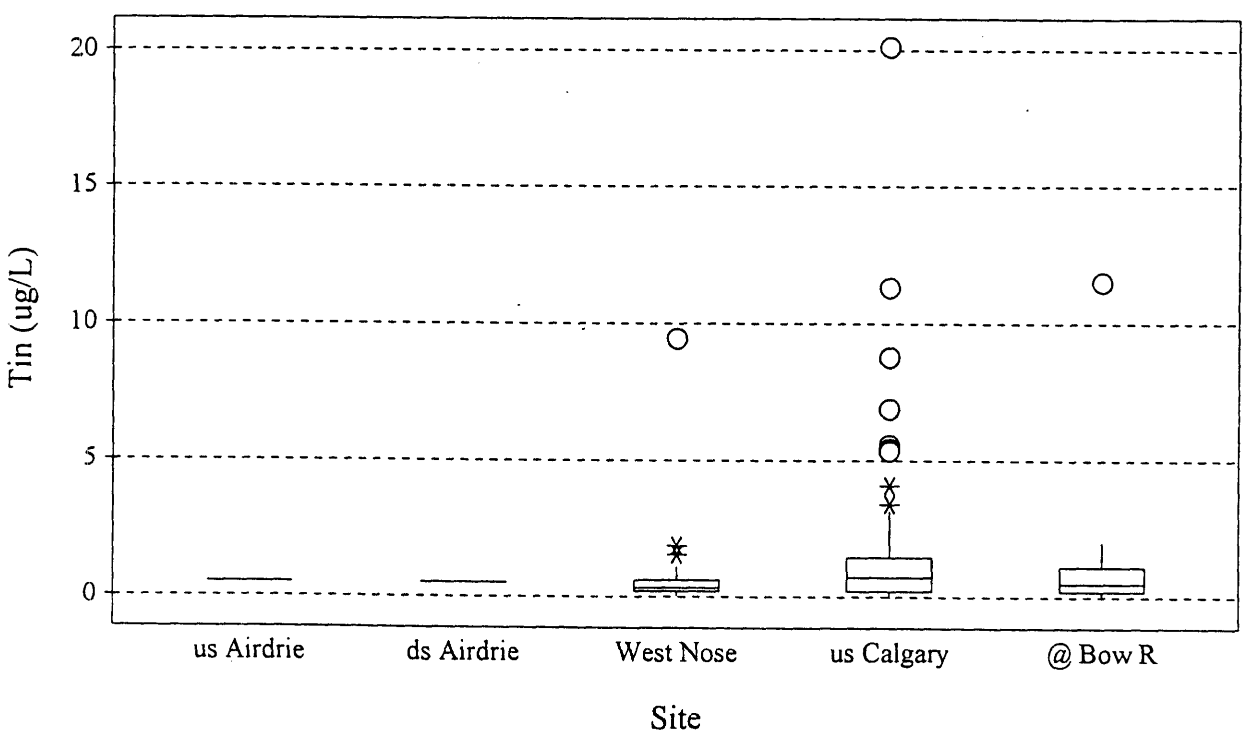

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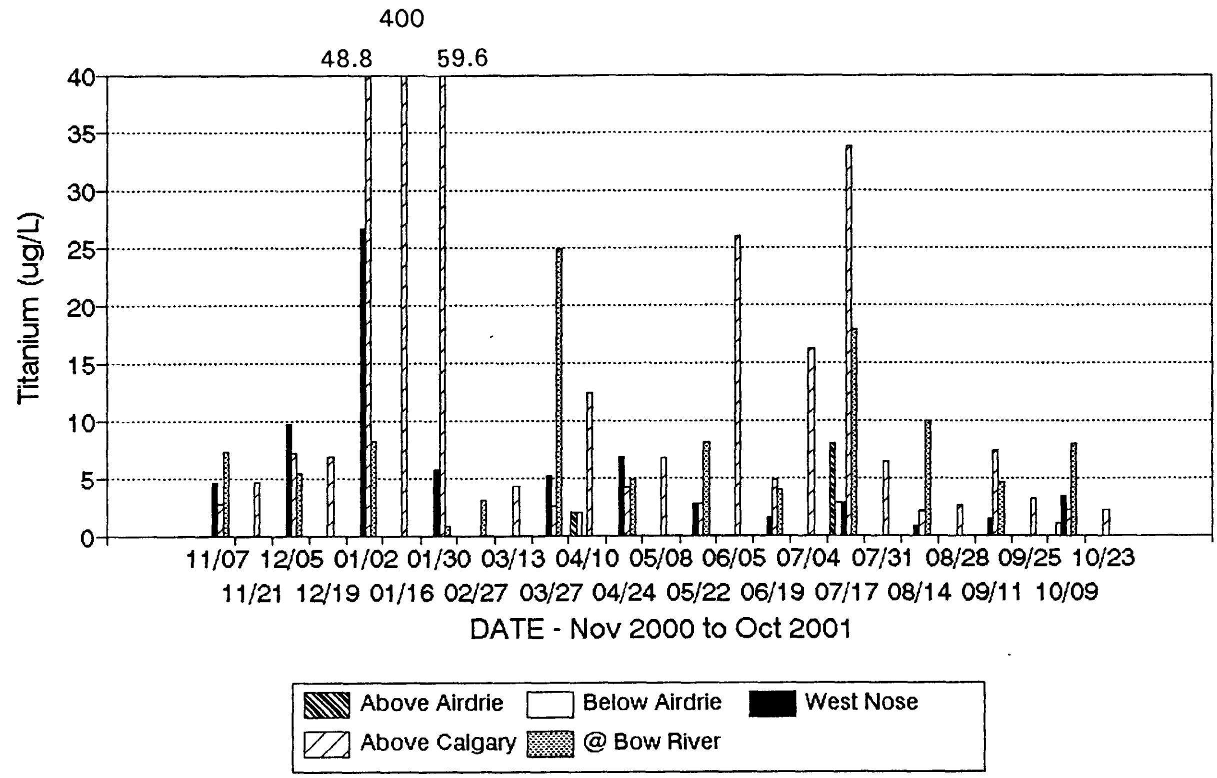

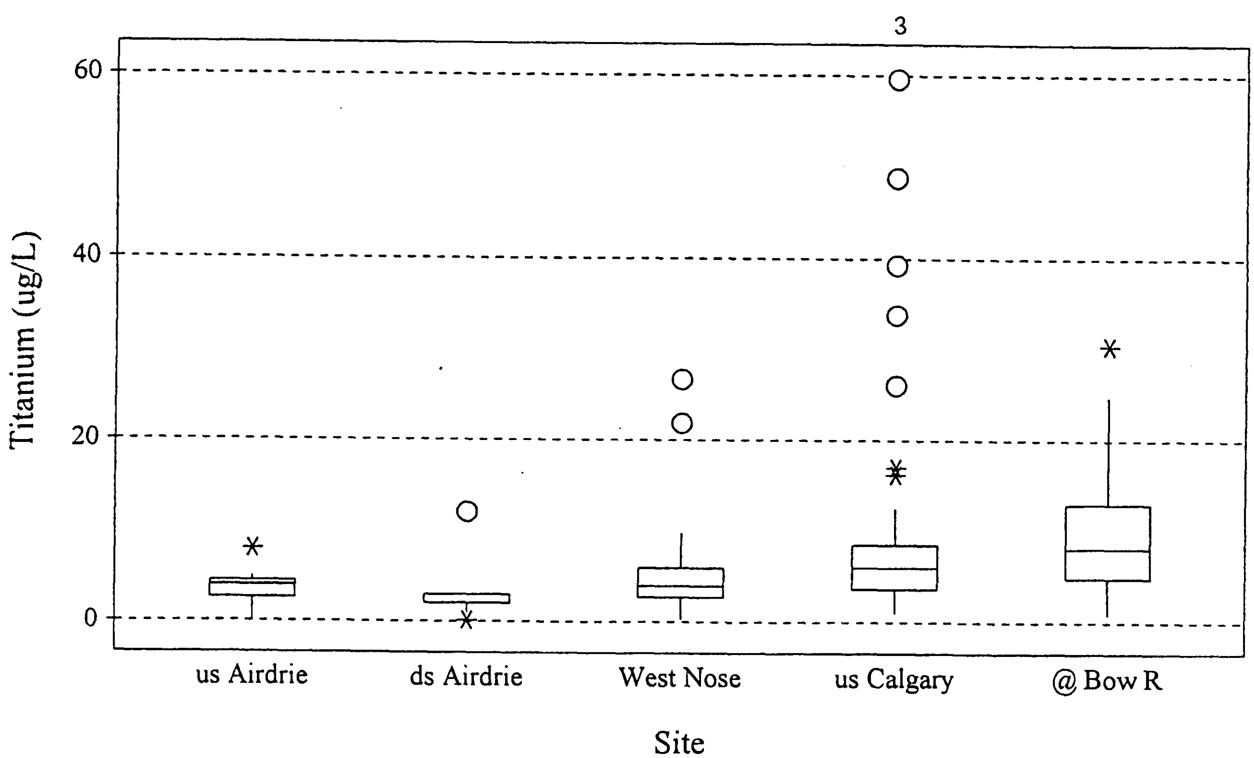

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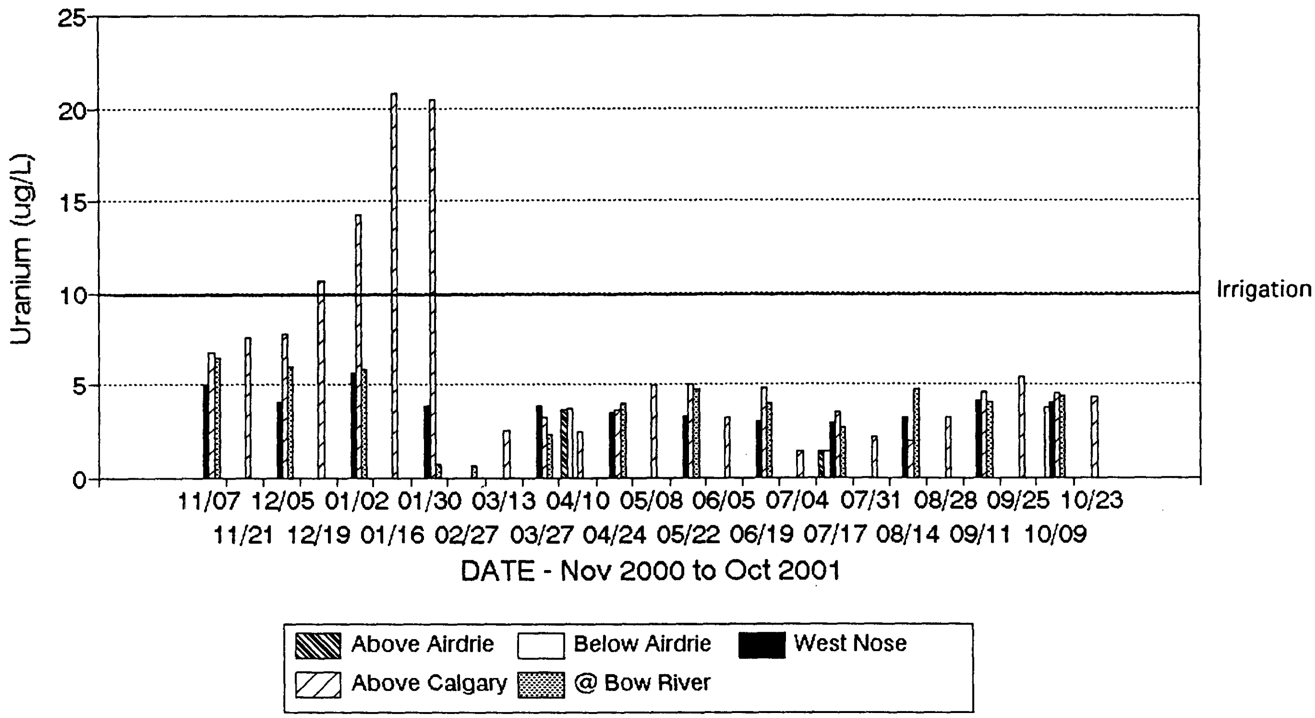

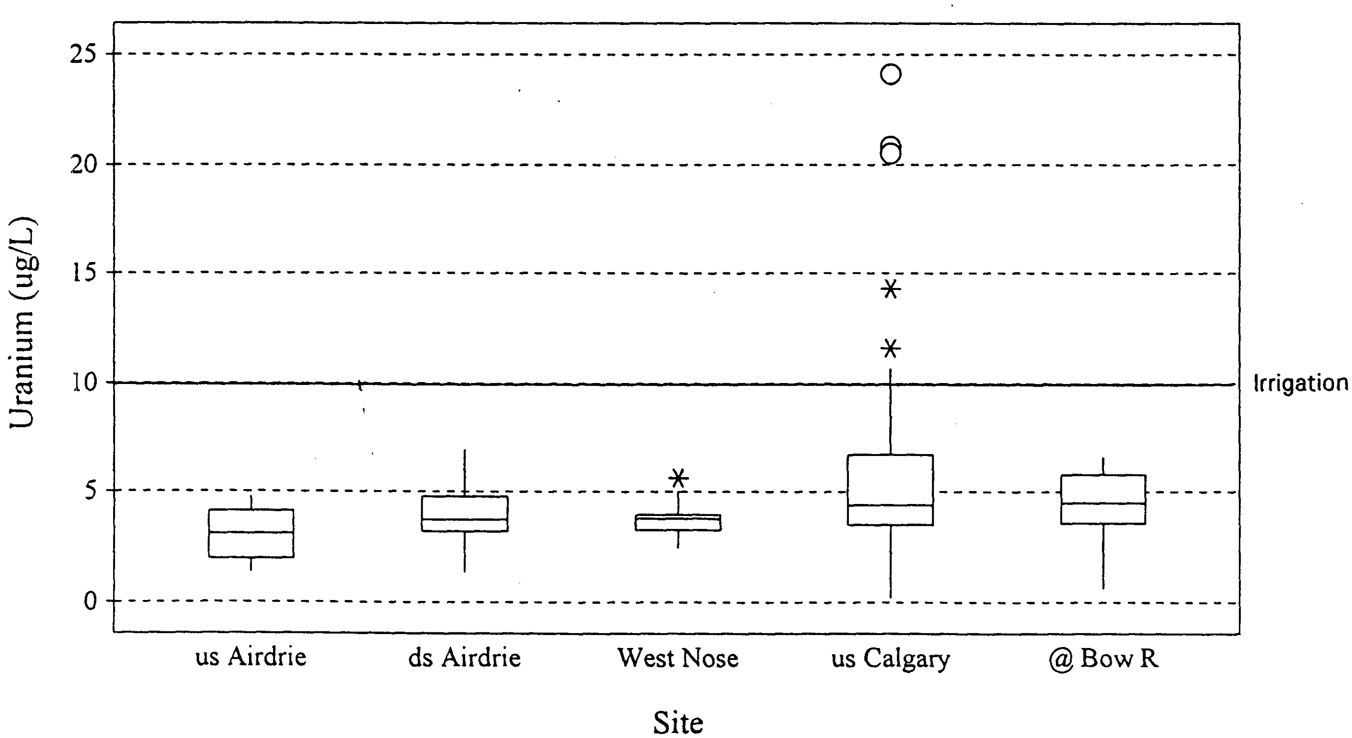

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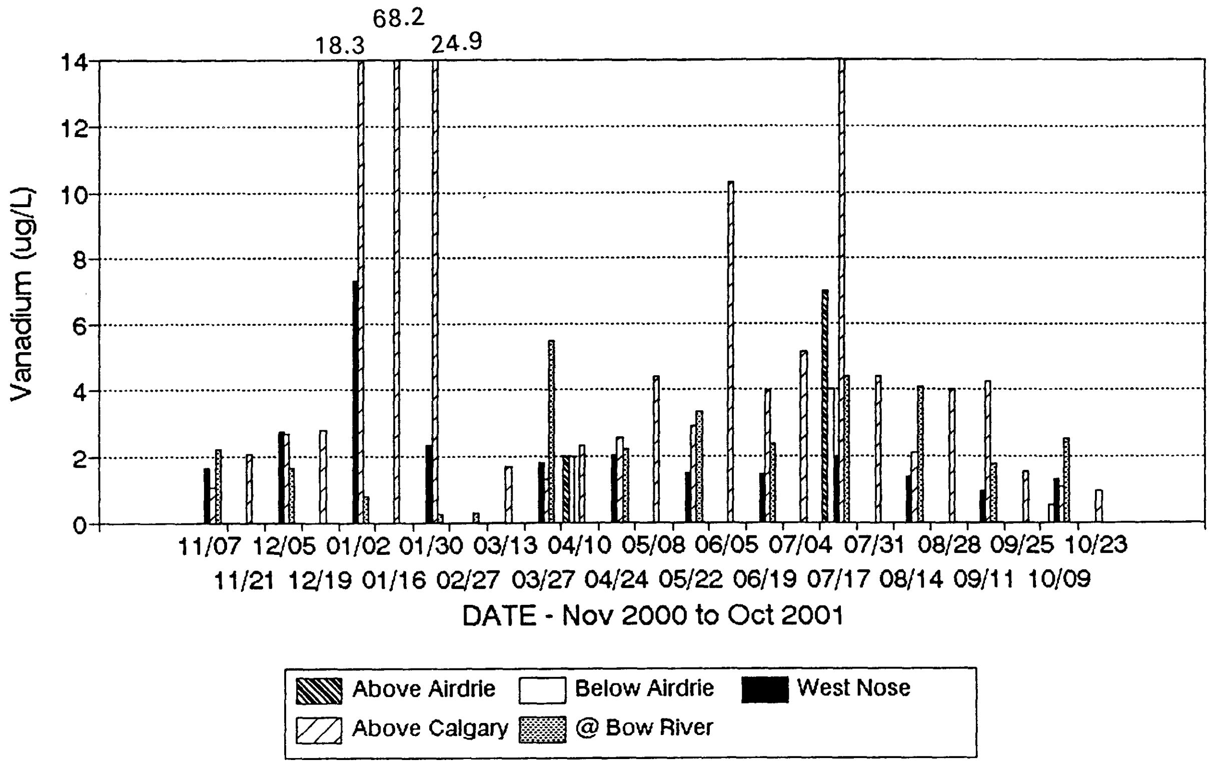

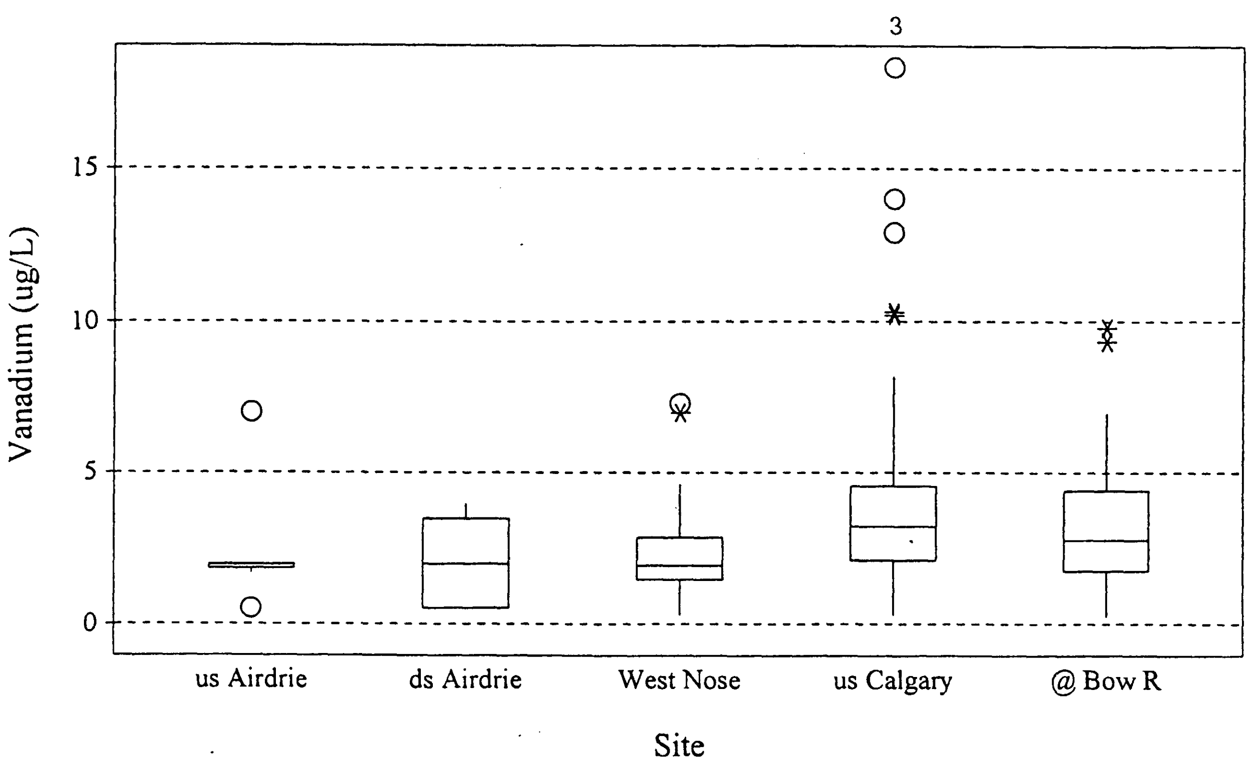

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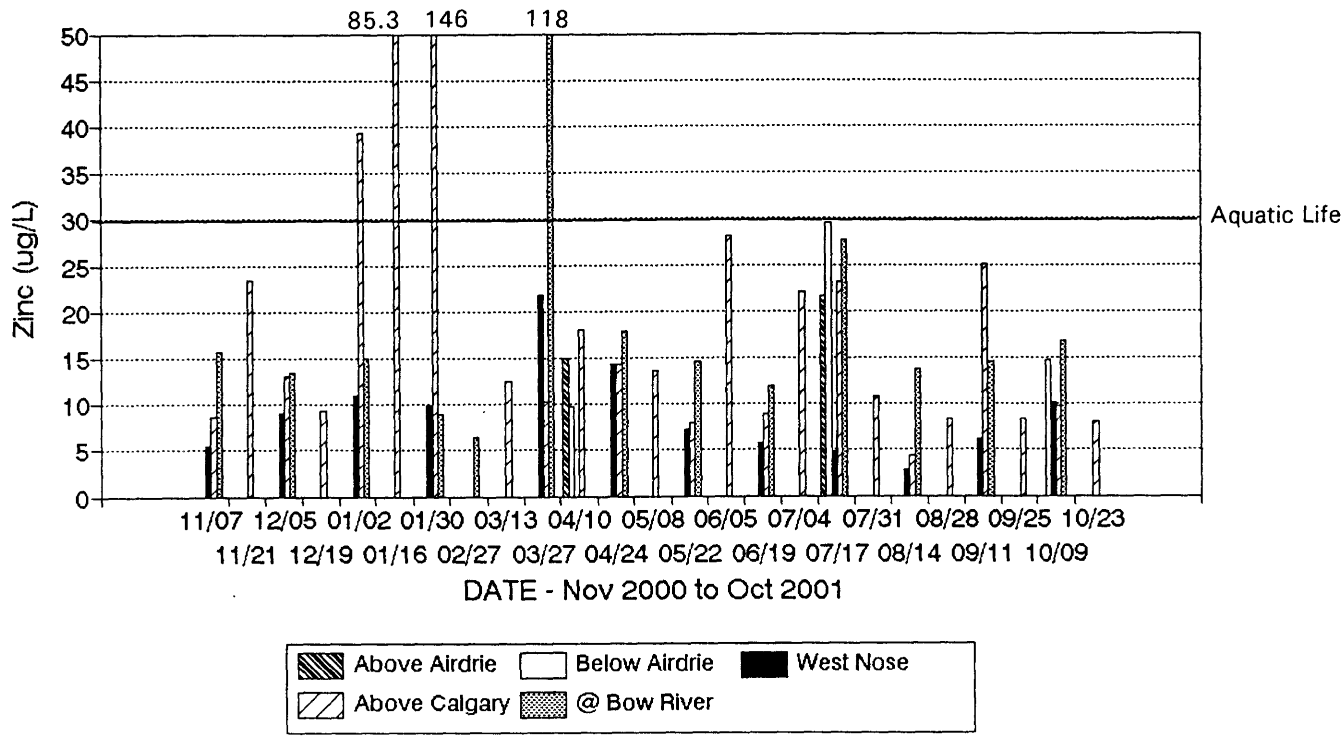

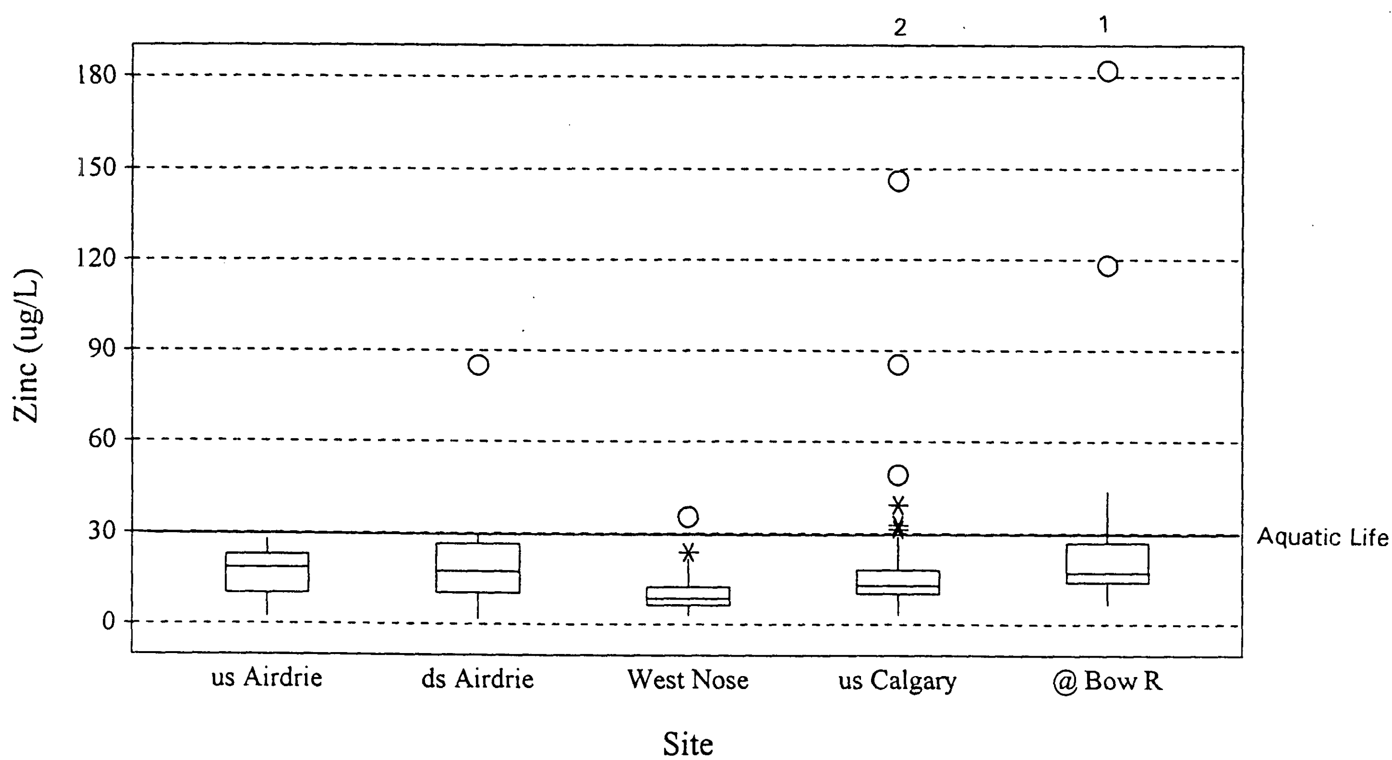

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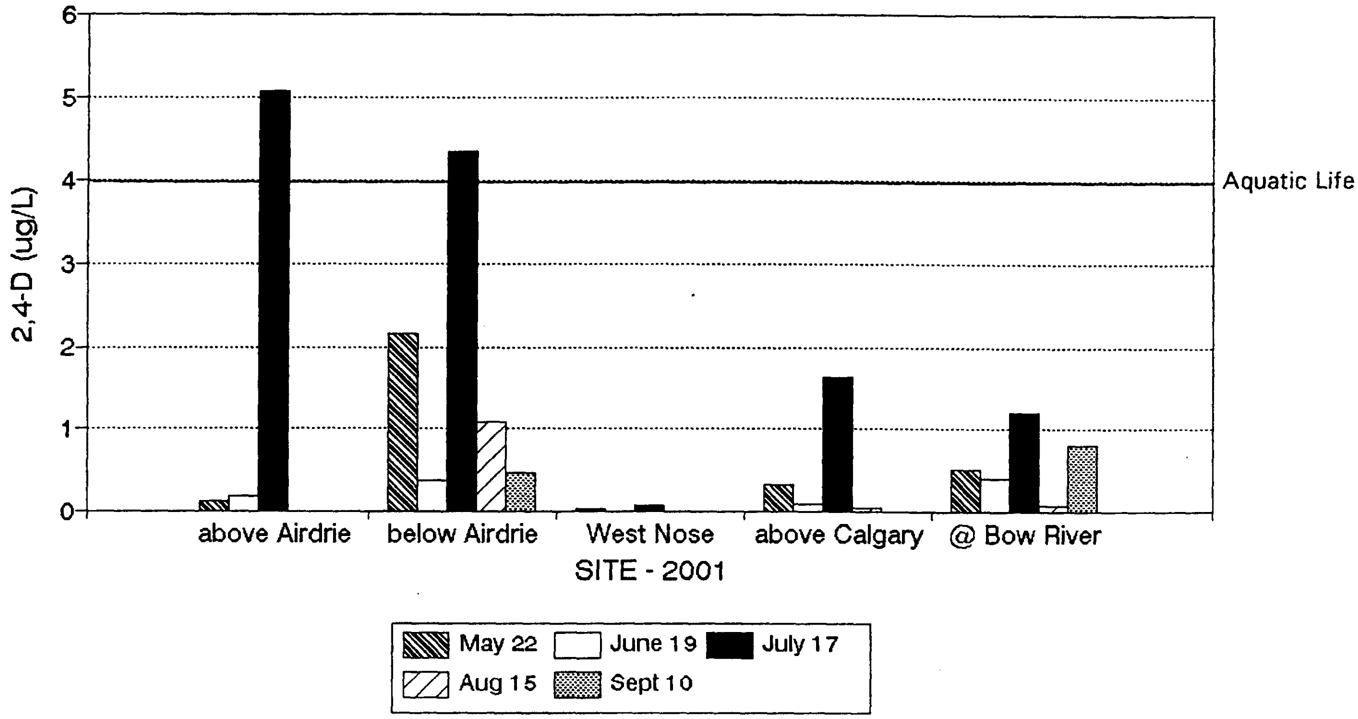


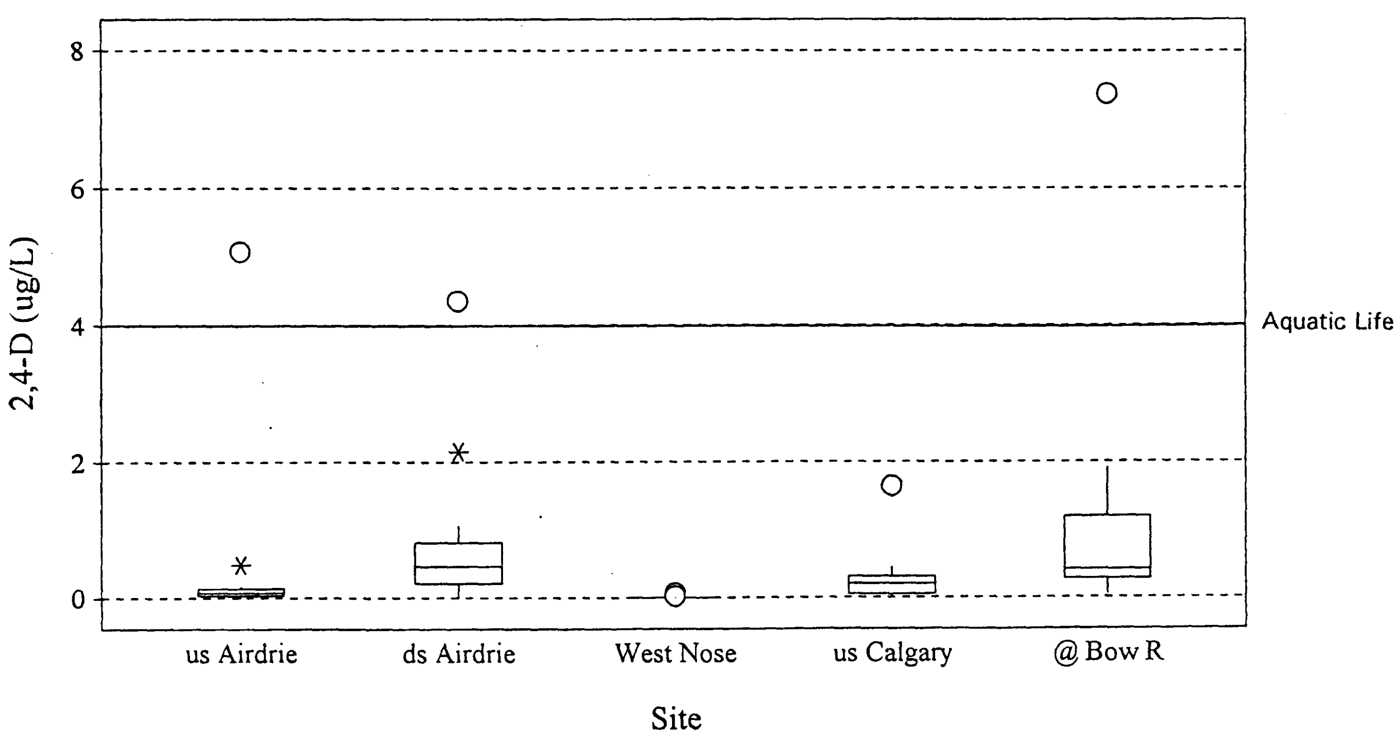
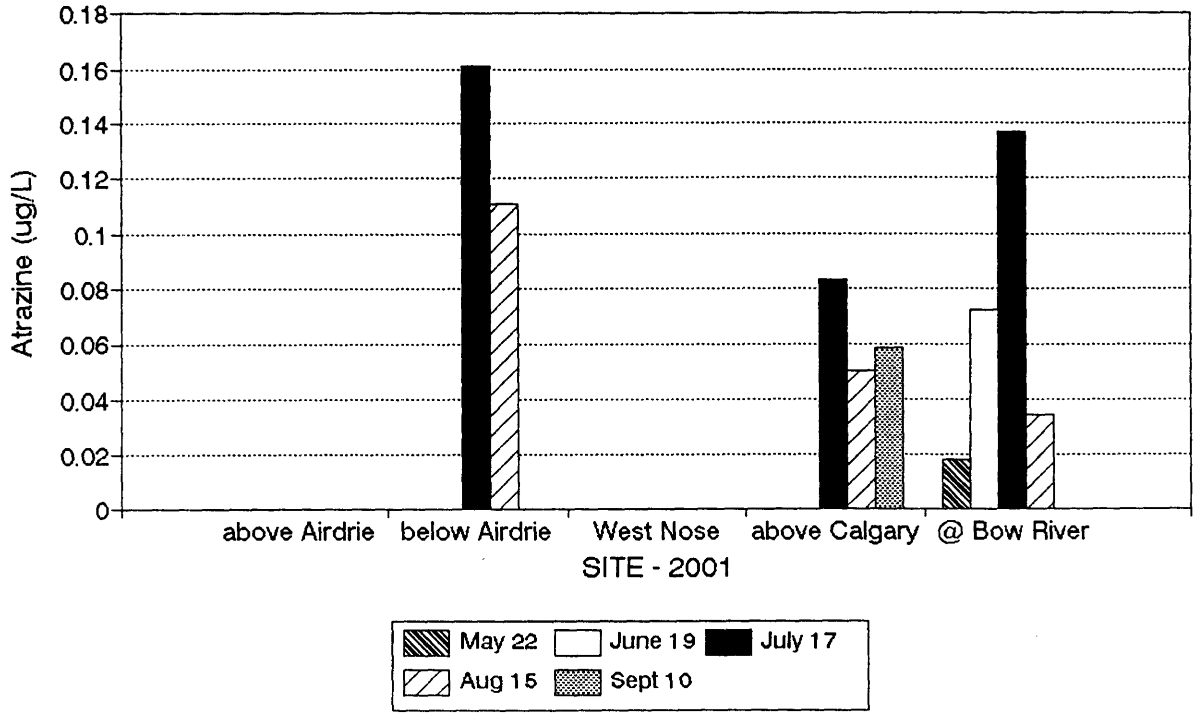


Figure 9 Pesticides



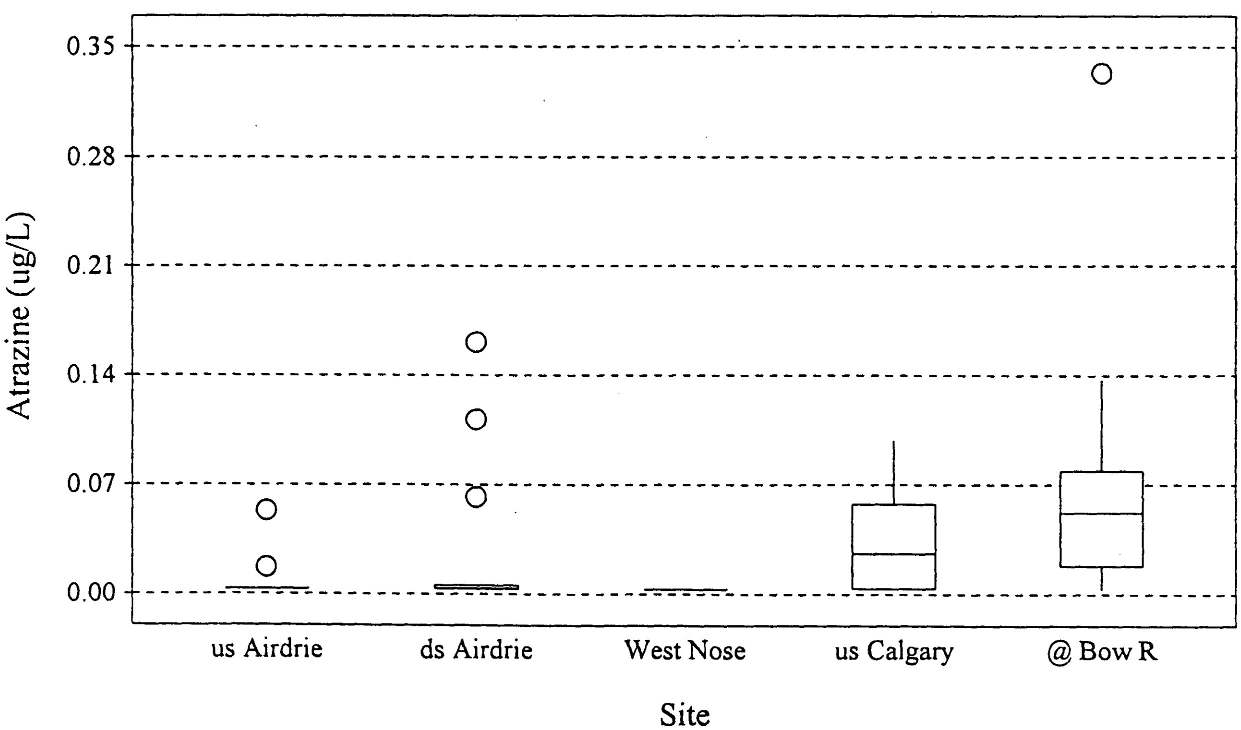
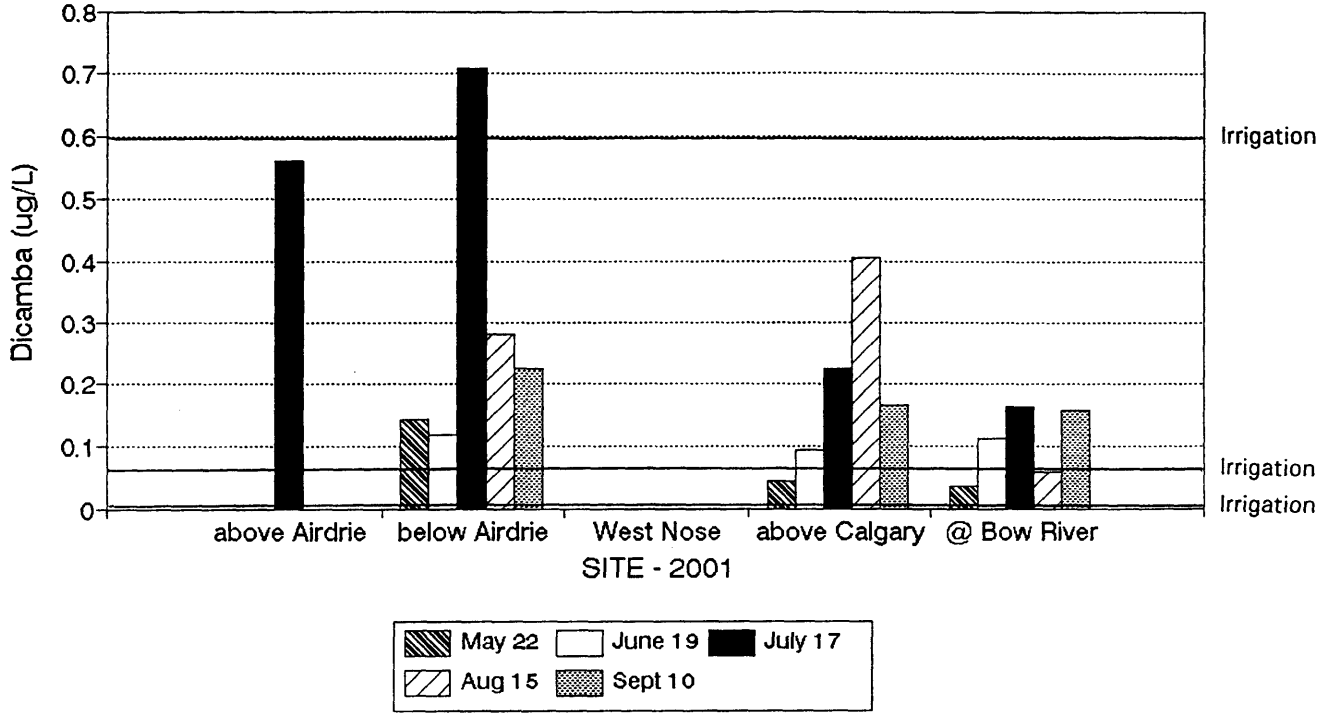


Figure 9 cont.



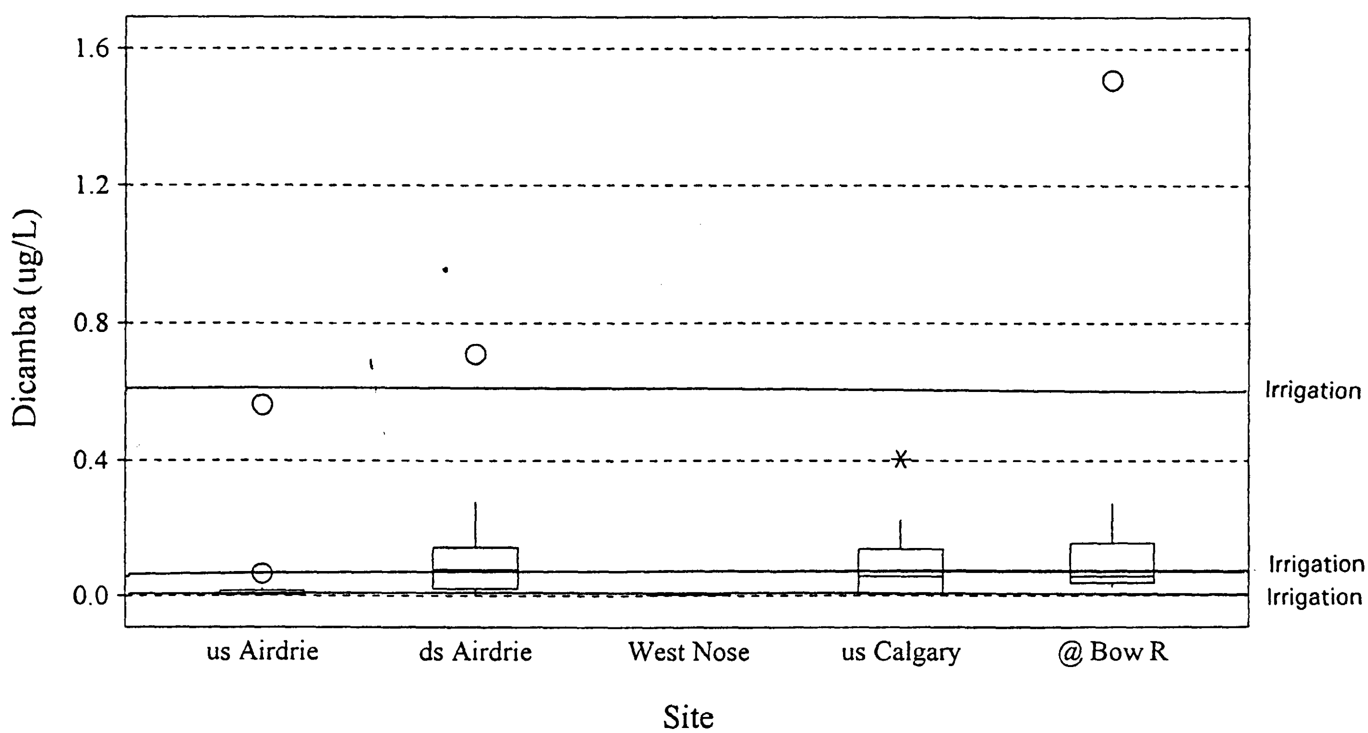
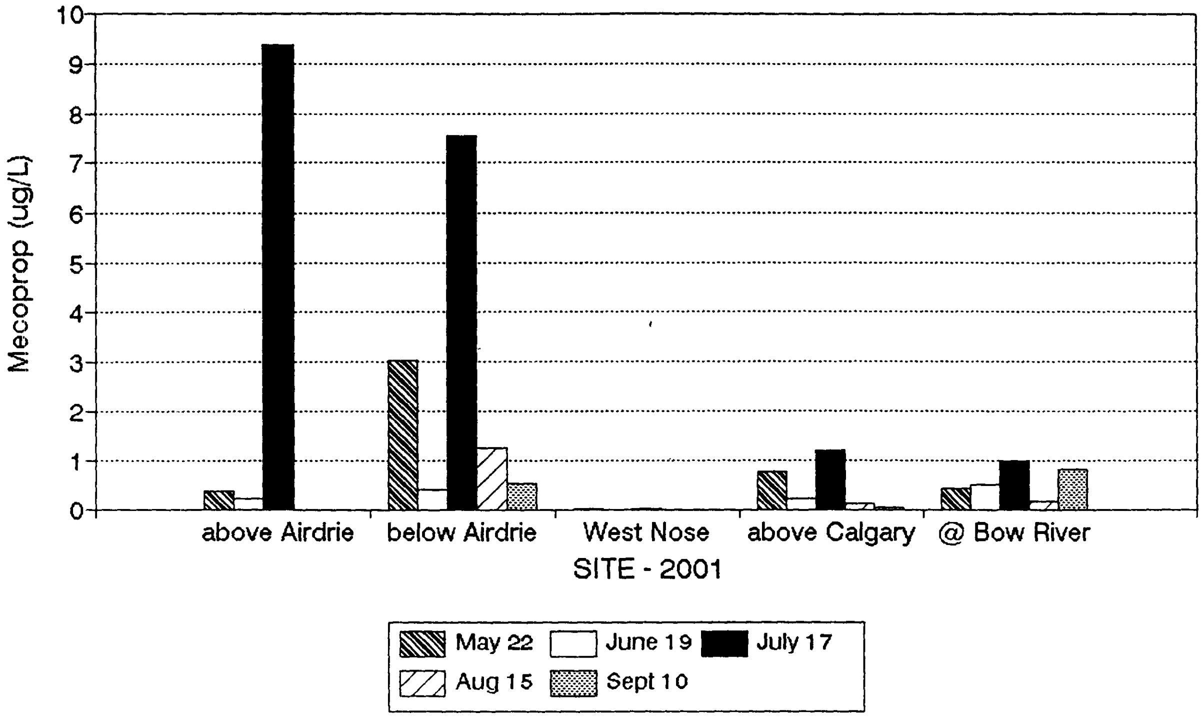


Figure 9 cont.



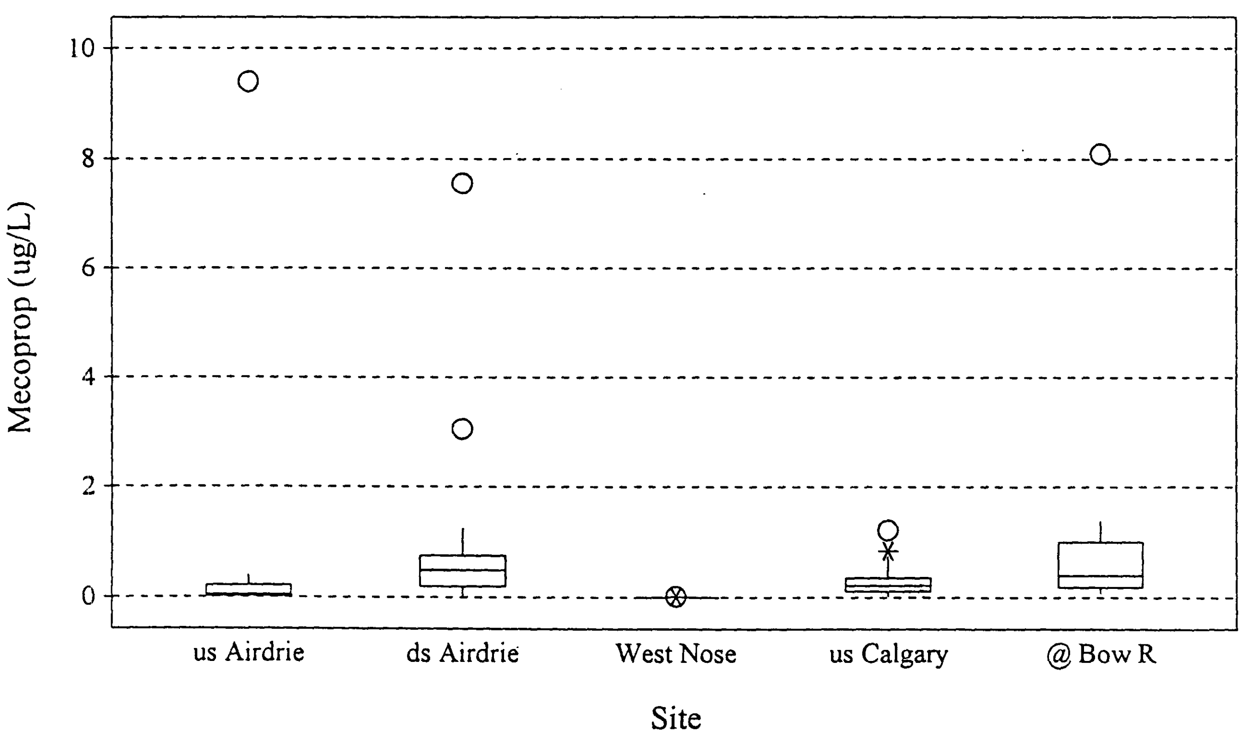
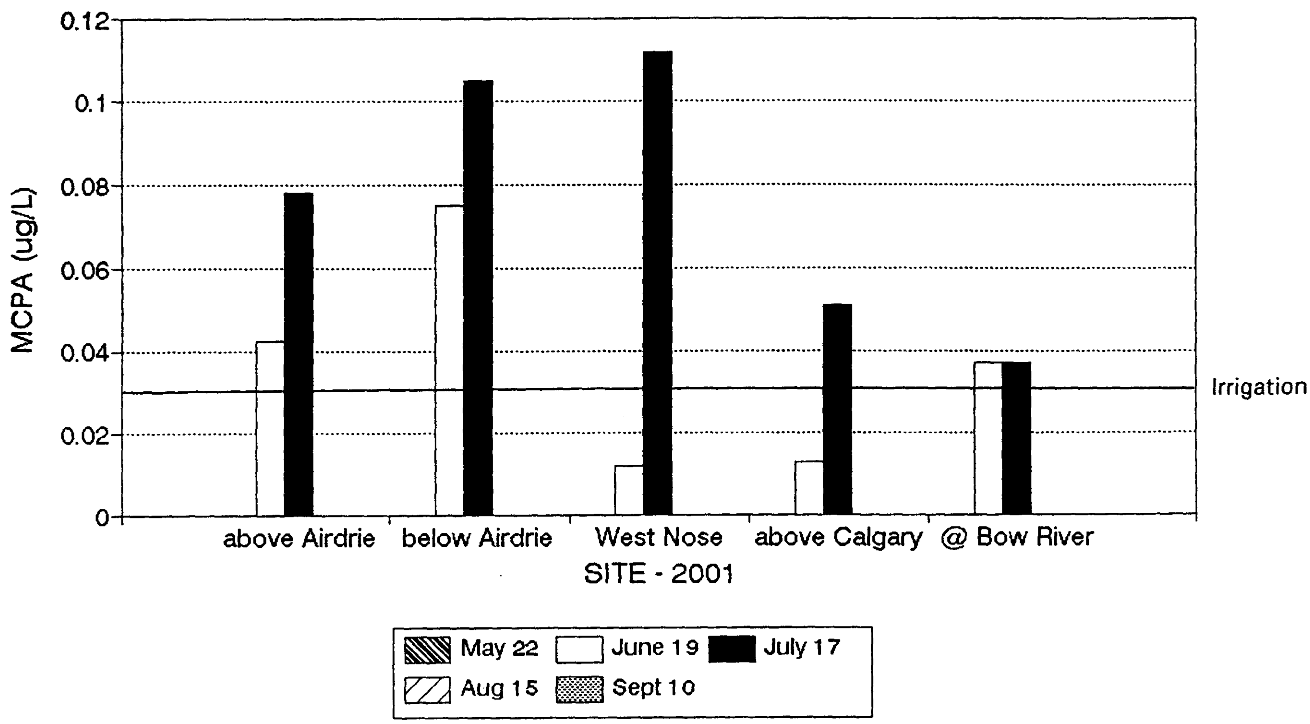


Figure 9 cont.



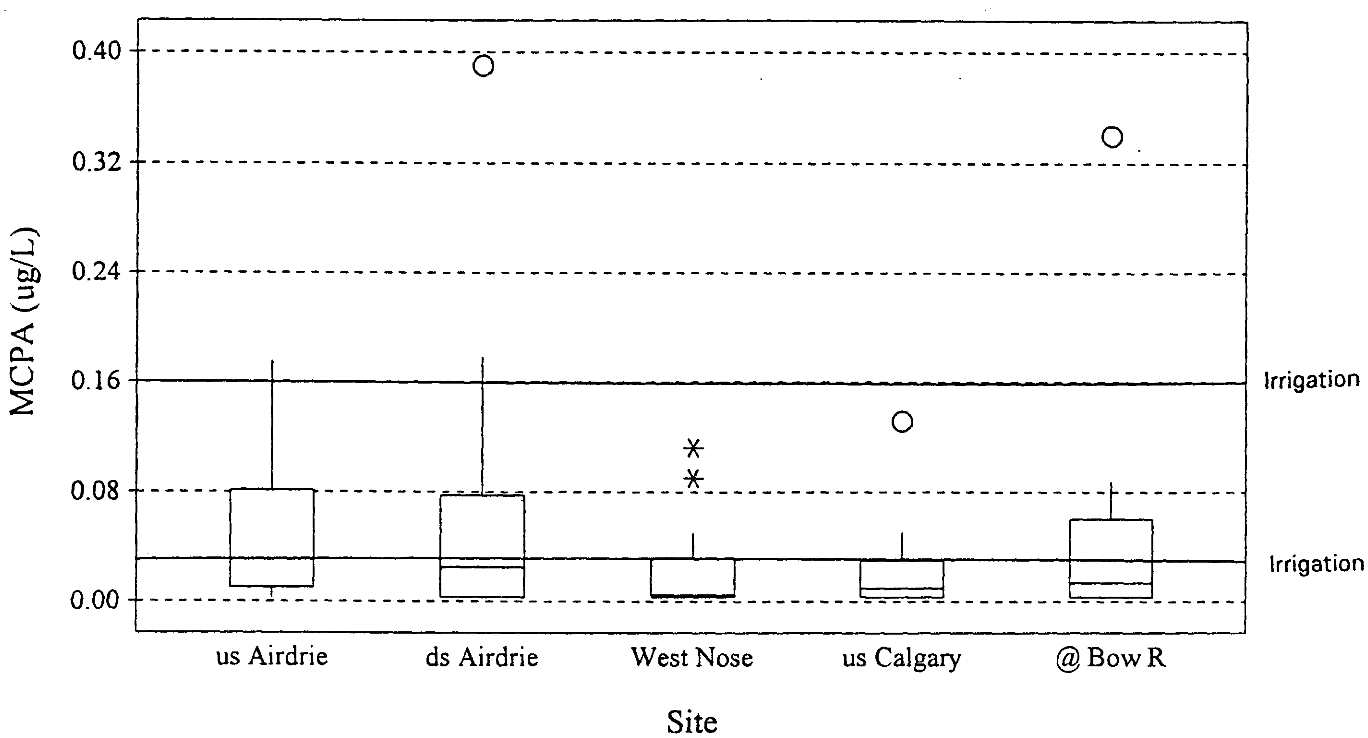
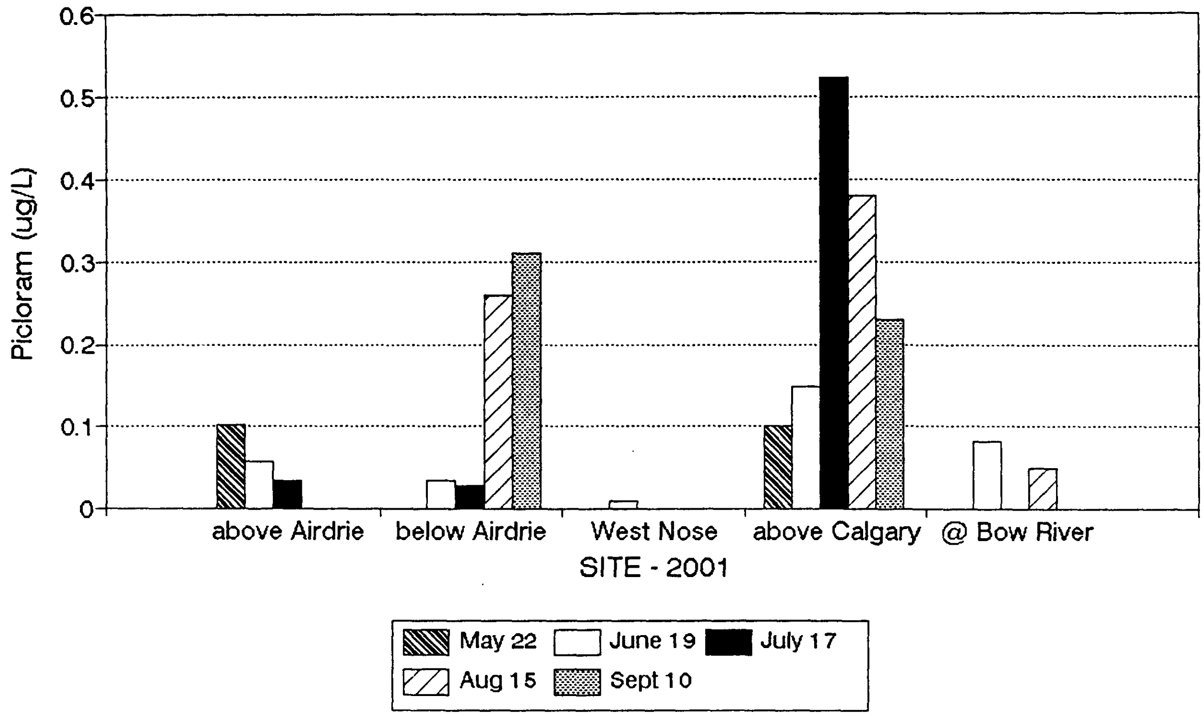


Figure 9 cont.



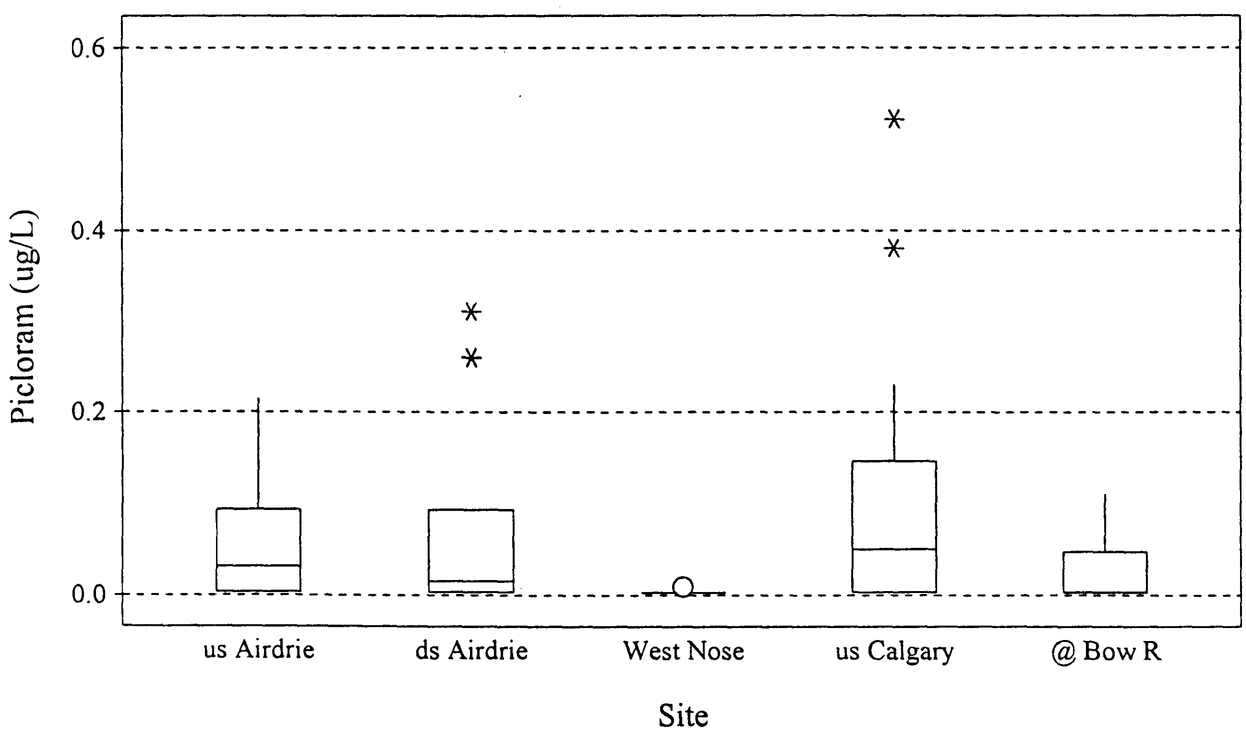


Figure 9 cont.

APPENDIX A

Water Quality Guidelines and Pesticide Characteristics

Table A1 Selected Water Quality Guidelines

PARAMETER	IRRIGATION	LIVESTOCK WATERING	DRINKING WATER	FRESHWATER AQUATIC LIFE
Aluminum (total)	5	5.0		0.1
Ammonia (total)				0.08 - 2.5
Arsenic (total)	0.1	0.5 - 5.0	0.025	0.05
Barium			1.0	
Beryllium	0.1	0.1		
Boron (total)	0.5 - 6.0	5	5.0	
Cadmium (total)	0.005	0.08	0.005	0.000085
Calcium		1000		
Chloride (total)	100 - 700		250	
Chromium (total)	0.1	1	0.05	0.002 - 0.02
Cobalt (total)	0.05	1.0		
Colour			15	
Conductivity (EC)	1.0 mS/cm			
Copper (total)	0.2 - 1.0	0.5 - 5.0	1.0	0.047
Fluoride (total)	1.0	1.0 - 2.0	1.5	
Iron (total)	5.0		0.3	0.3
Lead (total)	0.2	0.1	0.01	0.007
Manganese (total)	0.2		0.05	
Mercury (total)		0.003	0.001	0.00013
Molybdenum (total)	0.01 - 0.05	0.5		
Nickel (total)	0.2	1.0		0.15
Nitrate N		100	10	avoid prolific weed growth
Total Nitrogen				1
Oxygen, dissolved				5.0 - 9.5
Total Phosphorus				0.05
pH			6.5 - 8.5	6.5 - 9.0
Selenium (total)	0.02 - 0.05	0.05	0.01	0.001
Silver (total)				0.0001
Sodium			200	
Sodium Adsorption Ratio	3 - 9			
Sulphate		1000	500	
Total dissolved solids	500 - 3500	3000	500	
Uranium (total)	0.01	0.2	0.1	

Table A1 (cont.) Selected Water Quality Guidelines

PARAMETER	IRRIGATION	LIVESTOCK WATERING	DRINKING WATER	FRESHWATER AQUATIC LIFE
Vanadium (total)	0.1	0.1		
Zinc (total)	1.0 - 5.0	50.0	5.0	0.03
Coliforms, fecal	100/100 mL		0/100 mL	
Coliforms, total	1000/100 mL		10/100 mL	
2,4-D		100	100	4
Atrazine	10	60	5	2
Bromoxynil	0.35	11	5	5
Diazinon			20	
Dicamba	0.006 - 0.6	122	120	10
Diuron			150	
Lindane		4	4	0.01
MCPA	0.03 - 0.16	25	under review	2.6
Picloram		190	190	29
Triallate		230	230	0.24
Chloroform			100*	2
Bis(2-ethylhexyl)phthalate				0.6
Di-n-butylphthalate				4

Units are mg/L except for conductivity (mS/cm), pH (pH units), SAR (no units), coliform bacteria (#/100 mL), pesticides and priority pollutants (μg/L). 1 mg/L = 1000 μg/L.
* trihalomethanes

RECREATION

Fecal coliform bacteria and *E. coli* guidelines generally specify a geometric mean of several samples taken over a defined period. Since sampling frequency does not meet these requirements, the absolute value of 200/100mL was used.

Table A2 Selected Pesticide Characteristics

Taken from Cotton 1995. Environmental risk is based on pesticide mobility, persistence and toxicity.

Active Ingredient	Trade Names	Type of Pests Controlled	Crops Applied to	Environmental Risk
2,4-D	numerous	broadleaf weeds	cereal crops, turf, pastures, non-crop land	moderate to high
Atrazine	Aatrex liquid, Aatrex nine-o, Atrazine 500, Atrazine 90W	selective for broadleaf and grassy weeds	corn, sorghum, rangeland	moderate
Bromoxynil	Pardner, Torch, Buctril M	broadleaf weeds	wheat, barley, oats, rye, corn, triticale, etc.	high
Clopyralid	Lontrel	many broadleaf annual and perennial weeds and woody plants	small grains, fallow lands, rangeland non-crop areas	moderate
Diazinon				
Dicamba	Banvel, Dycleer	annual and perennial broadleaf weeds	field and silage corn, grain, sorghum, small grains, asparagus, grass seed, turf, pasture, rangelands, non-crop land	moderate
Dichlorprop (2,4-DP)	Diphenoprop BK700, Estaprop, Weedone CB	(with 2,4-D) bluebur, buckwheat, burdock, catchfly, cocklebur, flixweed, goosefoot, kochia, lady's-thumb, lamb's-quarters, mallow, mustard, pigweed, ragweeds, volunteer rapeseed, shepherd's-purse, smartweeds, sow-thistle, stinkweed, stork'sbill, etc.	(with 2,4-D) barley, wheat	low
Diuron	Karmex	broadleaf and grassy weeds	alfalfa, asparagus, non-crop areas	moderate
Imazamethabenz-methyl	Assert 300	wild oats, mustards, buckwheat	sunflowers, barley, wheat	moderate
MCPA	MCPA amine, Estemine MCPA, MCPA K, MCPA ester, MCPA sodium	wide spectrum of broadleaf weeds	barley, oats, flax, rye, wheat, corn, clover, asparagus, peas, turf, pasture, rangeland	low to high
MCPP (Mecoprop)	Mecoprop, Compitox	broadleaf weed killer	wheat, oats, barley	moderate
Picloram	Tordon 101, Tordon 202C, Tordon 22K	many annual and perennial broadleaf weeds	grass crops	high
Triallate	Avadex BW	wild oats	barley, flax, mustard, peas, canola, sugar beets, wheat	moderate