Analysis of Water Quality Conditions and Trends for the Long-Term River Network: Oldman River, 1966-2005

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EXECUTIVE SUMMARY

Over the past fifty years, major rivers throughout the province of Alberta have been undergoing regular monthly sampling for a wide range of water quality variables. Known as the Long-Term River Network (LTRN), this monitoring program has resulted in an extensive database of water quality information for the Province. Due to the broad temporal coverage and continuity of many of these data, they lend themselves particularly well to statistical trend assessment – a very useful way of examining changes in water quality over time. Where detected, statistically significant trends in various aspects of water quality can be used for several purposes, including the evaluation of human impacts on water quality, the development and assessment of watershed management initiatives, and the prediction of future conditions.

Continuous water quality monitoring has taken place on the Oldman River since 1966. Of three LTRN monitoring sites on the river, the farthest upstream is located at Brocket, less than 10 kilometres downstream of the Oldman River Dam. Established in 2000, this location has not yet been sampled for a sufficient length of time to facilitate reliable trend assessments. The second site, at Highway 3, is roughly 150 kilometres downstream of the Brocket site and slightly upstream of the City of Lethbridge. This station permits effects assessment of various human activities, including forestry, agriculture, and natural resource extraction, on water quality in the river. Water quality at the third site, situated near Highway 36 (~100 km downstream of Lethbridge), likely reflects the impacts of Lethbridge – a moderately large urban centre – and additional agricultural operations.

The purpose of this report was to provide both a general summary of water quality conditions in the Oldman River and to subject the extensive long-term dataset to a thorough series of trend assessments. Although monitoring on the Oldman River has frequently addressed a host of trace organic contaminants, including pesticides, pharmaceuticals, personal care products, and numerous other compounds, most of these data are insufficient for statistical evaluation of trends. Hence, analysed data are largely restricted to conventional water quality variables, including such things as ions, nutrients, bacteria, and metals. Results of trend assessment on these data suggest that a number of variables have undergone significant changes over the years. Despite ongoing expansion of livestock operations, irrigation activities, and human population in the Oldman River basin, all but one significant trend detected at the two sites after 1987 are decreasing and largely indicative of improving water quality. Significant downward trends at the Highway 3 site include those for total Kjeldahl nitrogen, total phosphorus, total dissolved phosphorus, fecal coliform bacteria, and dissolved fractions of iron and selenium. Similar reductions in non-filterable residue, dissolved Kjeldahl nitrogen, total ammonia nitrogen, total Kjeldahl nitrogen, total phosphorus, total dissolved phosphorus, and reactive silica at the Highway 36 site may be related to upgrades at the Lethbridge Wastewater Treatment Plant as well as regulated flows provided by the Oldman River Dam. Aside from a downward tendency in water temperature at both sampling locations and an upward trend in nitrate and nitrite nitrogen at the Highway 3 site, none of the other analysed variables demonstrated significant long-term trends.

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1.0 INTRODUCTION

The Oldman River arises from a small, unnamed alpine lake (elev. 1791 m) on Mount Lyall in southwestern Alberta (Figure 1). From its source near the Alberta/British Columbia border, the river flows generally eastward across the Province, traversing foothills and prairie in its 440 km journey to The Great Forks, where its confluence with the Bow River marks the beginning of the South Saskatchewan River (Davies *et al*. 1977, OMRBSMC 1978, Koning *et al*. 2006). The Oldman River Basin, a sub-basin of the much larger South Saskatchewan River Basin, occupies an area of approximately 26,000 km^2, of which 23,800 km^2 are situated in Alberta. The remaining 2200 km^2 of the watershed are located in northern Montana (AENV 1999). The basin supports a wide variety of natural resources, including forests, minerals, wildlife, and agricultural lands. Highly fertile soils and relatively long hours of sunshine during the growing season have made agriculture one of the mainstays of the regional economy. However, the basin receives fairly limited amounts of precipitation, with annual averages ranging from about 60 cm in the foothills to 35 cm in the eastern plains (OMRBSMC 1978). Less than half the annual precipitation of 30-45 cm (basin average) falls during the growing season of May-August (Oldman Watershed Council 2005).

The Oldman River and its major tributaries, including the Castle, Crowsnest, Belly, St. Mary, and Little Bow Rivers, as well as Willow Creek, derive most of their flow from snowmelt. Hence, 60% of annual natural flows typically occurs between mid-May and mid-July (Figure 95). Lowest natural flows tend to occur from late July to October (AENV 1999). Soil moisture deficiencies, particularly in the areas of Lethbridge and more eastern parts of the basin, have led to a dependency on irrigation as a means of ensuring agricultural stability in the Oldman River Basin (OMRBSMC 1978). Currently, irrigation demands comprise more than 80% of water allocation in the basin. In response to this, as well as to ensure a reliable water supply for municipal and industrial consumption, considerations of aquatic ecosystem health, related instream flow needs, and cross-border agreements with neighbouring provinces, the Province of Alberta announced the construction of a dam in 1984 (Cross & Anderson 1986). Situated at the Three Rivers Site, near the western edge of the semi-arid grasslands and the town of Cowley, Alberta, the Oldman River Dam was completed in 1991. At full supply level, the Oldman River Reservoir covers an area of 2420 ha and inundates 15 km of the mainstem (including 3 km of the north fork), 8 km of the lower Castle River, and 5.5 km of the lower Crowsnest River (AENV 1999). Construction of the Oldman River Dam, together with numerous additional control structures that supply water to nine irrigation districts, as well as other developments of various types in the basin, have demonstrably affected aspects of water quality in the Oldman River (Clearwater 2004, Hazewinkel and Saffran 2007).

Long-term water quality monitoring sites, located on major rivers and lakes throughout Alberta, are used for a variety of purposes. Among their numerous applications, they may facilitate assessment of provincial regulatory programs, point- and non-point source pollution, pollution abatement technologies, watershed development activities, human population growth, and climate change, relative to their impacts on surface water quality. As part of the provincial Long-Term River Network (LTRN), a major water quality monitoring initiative, Environment Canada established two monitoring sites on the Oldman River in 1966. In 1987, Alberta Environment took over operation of both sites. The first of these sites, located upstream of

Lethbridge at Highway 3, facilitates monitoring and evaluation of potential water quality effects caused by anthropogenic activities, including dam construction, forestry, agriculture, and mineral resource extraction, in the Oldman basin. The second site, located downstream of Lethbridge at Highway 36 near the town of Taber, Alberta, incorporates the added effects of a fairly high-density urban environment (City of Lethbridge) and further agricultural and irrigation activities. As the municipal boundaries of Lethbridge grew outward over time, the city and its inherent potential for affecting water quality began to impinge upon the Highway 3 site. In 1998, in response to this expanding footprint, as well as relatively intense agricultural activity upstream of Lethbridge, Alberta Environment designated a third LTRN sampling location farther upstream, at Brocket. Located 6.41 km downstream of the Oldman River Dam (Hazewinkel & Saffran 2005), this site lies in a reach of relatively unimpaired water quality and provides data that are of considerable interest.

Due to a broad range of natural and anthropogenic influences, the water quality of rivers can vary substantially over time and space. Although single water samples have considerable value in describing general water quality conditions at a specific point in time, long-term monitoring can provide datasets that support the use of statistical trend assessment to help evaluate the influences of human activity and other factors over longer periods. These temporal tendencies, reported as trends in specific water quality variables, can be increasing (statistically significant positive slope), decreasing (statistically significant negative slope), or lacking a distinct tendency (statistically insignificant slope). In the case of LTRN sites, some of which have been monitored for upwards of 40 years, trend assessment can be a powerful tool in the evaluation of change.

The primary objectives of this report were a) to provide a general summary of water quality conditions for LTRN sites on the Oldman River; and b) to examine long-term trends in those data since 1966. Although some points are briefly discussed, the intent was not to elucidate on potential causes for any perceived trends. Rather, the main purpose was to statistically assess the now-extensive dataset in order to establish the existence of real trends in water quality variables over time and lay the groundwork for subsequent investigations into what has changed and why it might have done so. This is hoped to provide a solid foundation for further evaluation, reporting, planning, and management in the future.

The ensuing report addresses the trend assessment process, water quality variable selection criteria for that process, and trend assessment results for an extensive suite of variables monitored since 1966 at both the Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) LTRN sites on the Oldman River (Figure 1). Since the site now situated at Brocket has been active for only eight years, it has not accumulated sufficient data for reliable trend assessments and will not be considered at this time.

2.0 METHODS

2.1 Variable Selection and Treatment

For the sake of statistically defensible trend assessments on a given variable, an absolute minimum five years' worth of continuous monthly monitoring data is required (Schertz *et al*. 1991, Stevens 2003). However, a minimum 10 years' worth of results is generally recommended to ensure the robustness of specific trend analysis methodologies (Aroner 1994). With a few exceptions, variables not meeting this latter criterion were immediately excluded from trend analyses. In a small number of cases, variables with eight or nine years of continuous data with values consistently above method detection limits were included in statistical analyses. Following removal of variables with insufficient temporal coverage, all remaining data were examined graphically for the presence of extreme outliers (i.e. >2 standard deviations from the mean). Unless these could be explained by the field notes of technical personnel or corroborated by similar departures of related variables, they were excluded from analyses.

An extensive range of water quality variables has been examined as part of LTRN sampling in the Oldman River over the years (Table 1). However, depending on the parameter under consideration, the continuity of accumulated data can vary considerably (Figures 2-5). With this in mind, and for the purpose of creating a more comprehensive overview of water quality conditions in the Oldman River, a number of parameters were variously manipulated. In some instances, variables deemed sufficiently similar after careful consideration were combined to create longer datasets. Specifically, turbidity values (formerly measured in Jackson Turbidity Units (JTU) and more recently in Nephelometric Turbidity Units (NTU)) were merged over the entire sampling history. For pH, values measured in the laboratory were incorporated where field measurements were unavailable for a given sampling date (pH values were not converted to hydrogen ion concentration prior to statistical manipulation). Similarly, gaps in dissolved oxygen concentrations obtained from field data were filled with those derived in the laboratory via Winkler titration. Chlorophyll *a* data were obtained using colourimetry prior to 1987 and via flourometry thereafter. Identified as belonging to statistically distinct populations, these were deemed incompatible with one another and only examined post-1987 (i.e. fluorometric data). Due to the relatively brief record for apparent colour, fundamental differences in the ways that apparent colour and true colour are measured, and the integer (essentially categorical) nature of the latter, these two variables were not subjected to trend assessments**.** Further information regarding surface water quality, sampling methods, and guidelines can be obtained from the Alberta Environment water quality sampling manual (AENV 2006), the Canadian Environmental Quality Guidelines (CCME 1999), or through the Surface Water Quality homepage (http://www3.gov.ab.ca/env/water/SWQ/index.cfm).

An extensive list of metals has been analysed in samples collected at the Oldman River LTRN sites over the past 40 years. However, several complicating factors limit the number of metal analytes to which trend tests can be applied. The first, and most restrictive, of these considerations is the particular fraction, be it dissolved, extractable, or total, of a given metal that was examined. In response to changing analytical tools and evolving scientific opinion over the years, this may have changed several times for each of the metals under consideration. Unfortunately, due to differing analytical methodologies for the various fractions, it is frequently difficult to establish which fractions can reliably be treated as the same entity. An additional consideration for many metals was the number of data points that were reported as concentrations falling below the ability of contemporary analytical techniques to accurately detect them. Reported as less-thans, non-detects, or 'censored data' (explained below), these data can have a marked influence on trend assessment, particularly if the detection limit varies over time. Hence, those metals demonstrating a high (>50%) incidence of values falling below detection were also eliminated from trend analyses. Finally, quality control processes within Alberta Environment have helped identify a small number of metals that have historically shown a tendency toward inaccurate or questionable results. These were omitted from the suite of statistically assessed variables.

A broad range of trace organic compounds, including hydrocarbons, pesticides, pharmaceuticals, antibacterial agents, surfactants, artificial fragrances, and a host of other emerging contaminants are also monitored at LTRN sites. However, these variables often have a short period of record, are usually only sampled a few times per year, are mostly below detection, and, hence, do not lend themselves to trend assessment. An inventory of data for all LTRN sites can be accessed through Alberta Environment's online water quality reports at http://www3.gov.ab.ca/env/water/reports/water_quality_reports.cfm.

2.2 Statistical Analyses

LTRN data were statistically analysed using the USGS Library for the Analysis of Water Resource Data (United States Geological Survey, http://water.usgs.gov/software/library.html) in S-Plus (Insightful Corporation). Graphs were prepared with SigmaPlot (SPSS Inc.), while supporting statistical analyses were completed with WQHYDRO (Aroner 1994), a comprehensive software package designed for the assessment of water data.

2.2.1 Step Trends

The step 'trend' – not a true trend in the strictest sense – is one of two primary hypotheses that should be considered in trend estimation. This hypothesis postulates that data collected prior to a specific point in time belong to a distinctly different population (i.e., have a significantly different median value) from data originating after that time (Hirsch *et al*. 1991). The second hypothesis – a monotonic trend – assumes that a data population shifts monotonically (i.e., increases or decreases with no reversal of direction) over time. Since, as indicated in the introduction, the operation of LTRN sites changed hands in 1987, each water quality variable was examined for the potential influence of a step trend in 1987. This was accomplished using a seasonal Wilcoxon-Mann-Whitney test in WQHydro. Previous analyses (Hebben 2005) have demonstrated that the transfer of monitoring sites from Environment Canada to Alberta Environment resulted in a step trend for several of the variables in question. This unintended upward or downward shift in the median value of a given parameter, if neglected, can a cause a Type I error during monotonic trend evaluation. In other words, a monotonic trend analysis of data containing a positive step may cause the statistician to reject the null hypothesis (i.e., no monotonic trend in the data over time) and report an increasing trend for a particular variable, despite the fact that the presumed trend was entirely the product of some overlooked artefact, such as a change in analytical equipment, facilities, or techniques. Hence, in cases where the direction (increasing or decreasing) of a statistically significant monotonic trend coincided with that of a significant step, the monotonic trend results were rejected. For those parameters that exhibited a significant step in 1987, subsequent monotonic trend analyses were performed separately on pre- and post-1987 data.

2.2.2 Seasonality and Autocorrelation

Numerous water quality variables are known to undergo seasonal fluctuations in response to changing environmental conditions, such as ambient temperature, precipitation, or biotic activity, for example. If left unaccounted for, these fluctuations may mask the presence of real trends. Therefore, data for all variables were graphed in seasonal box and whisker plots using the USGS library for S-Plus. A key to box and whisker plot interpretation is provided in Figure 6. By breaking down data on a monthly (12 'season') basis, these boxplots facilitated visual examination of the data and helped to determine whether or not the seasonal term was included during trend assessment.

A given variable may also be subject to autocorrelation or 'serial correlation', meaning that the measured value for a specific parameter may be dependant on (correlated with) the immediately preceding value in a sampling sequence. For example, if dissolved oxygen concentration in a particular river is low in January, it is likely that a subsequent measurement of dissolved oxygen at the same site in February would also yield a low value. This phenomenon may be a complicating factor during trend assessment. The USGS library for S-Plus takes autocorrelation into account by providing both a p-value (significance of the trend) and a corrected p-value (significance of the trend when autocorrelation is taken into account) in trend assessment output. In all instances, the corrected p-value was used in assessing the significance of detected trends.

2.2.3 Censored Data

For many variables, the inability of contemporary instrumentation or analytical techniques to accurately measure a given substance below a certain concentration gives rise to what is referred to as a 'detection limit'. When concentrations fall below the detection limit, data are referred to as 'censored'. Typically reported as being less than the detection limit (e.g., <0.05 µg/L), this type of data can significantly influence trend assessments. To further complicate the issue, changing detection limits over time may also contribute to the generation of step trends. Until recently, the accepted (USEPA 1996) approach to censored data was to convert any value that was below detection to a real number equivalent to half the detection limit. Using this approach, for example, a total mercury concentration falling below a detection limit of 0.05 µg/L would be reported as a real value of 0.025 µg/L. Provided that the number of censored values was less than a predetermined proportion of the entire data set (e.g., 50%), these ½ detections were subsequently used in trend estimates. Unfortunately, results obtained in this manner may not be entirely reliable (Helsel 2006).

For the purposes of this report, censored data were treated as real values equivalent to the appropriate detection limit but denoted with a less-than (<) symbol. Hence, using the example above, a total mercury data point with a concentration falling below the detection limit of 0.05 µg/L would be entered into trend assessments as <0.05 µg/L. As explained below, the USGS library for S-Plus is equipped to deal with both censored and uncensored data in performing trend assessments. Hence, this obviated the need for ½ values.

2.2.4 Flow Adjustment

Stream flow has the ability to modify the outcome of trend analyses. During high-flow years, typically the result of high precipitation, certain products of non-point source runoff/overland flow (e.g., phosphorus) may appear in greater concentrations than they otherwise would. Conversely, during periods of low flow, the impacts of point source effluents (such as those originating at wastewater treatment plants) may be amplified, since the reduced volume of water in a given stream will lead to less dilution of the effluent in question. Hence, in a hypothetical scenario, if stream flow were to show a significantly decreasing trend over a period of ten years, a specific component of the aforementioned effluent (e.g., nitrogen), despite having experienced the identical input every year during those ten years, may end up demonstrating a significantly increasing trend. Flow-dependent changes may or may not be of interest, depending on the needs of the user. Therefore, the ensuing report addresses trends in both raw data and flow-adjusted data. Flow adjustment for each water quality variable was accomplished via the USGS library for S-Plus, which can evaluate a series of regression equations to determine which one is most effective in describing the correlation between flow and a given variable. The selected equation is then used to adjust the data and facilitate subsequent trend assessment on flow-adjusted residuals. For the purposes of this report, flow values used for both the Highway 3 and Highway 36 sites were based on daily means as measured at the Lethbridge monitoring station (Station #05AD007, Figures 1 and 95).

2.2.5 Monotonic Trends

The monotonic trend hypothesis, as noted previously, assumes that the median of a dataset increases or decreases, with no reversal of direction, over time. If significant, the results of a monotonic trend test can be very useful in assessing the state of water quality in a river. For example, a significant downward trend in phosphorus concentration over time (a common occurrence in Alberta rivers) might suggest that upgrades to a wastewater treatment plant have helped reduce the amount of nutrients entering a river. Conversely, a significant downward trend in dissolved oxygen concentration might be indicative of deteriorating water quality conditions, which could make the riverine environment less hospitable to aquatic organisms.

In this report, the type of trend assessment used and how it was applied were contingent upon several factors, most of which are detailed above. The steps described below (and outlined in Figure 7) assume that the variable under investigation had at least 10 years' worth of continuous data (with a small number of exceptions) and no more than 50% censored data. Note that all trend analyses mentioned here were rerun using flow-adjusted data. Initially, complete data sets (1966-2006) for all water quality variables were imported into WQHydro for step trend analysis using a Wilcoxon-Mann-Whitney test. The purpose of this analysis, designed to compare medians in the data prior to and after 1987 (the point of agency change), was to establish whether or not a significant step existed in the data and might be driving the results of subsequent monotonic trend tests. Data were then subjected to monotonic trend assessments using the USGS library for S-Plus. Parameters with uncensored data were tested using an uncensored seasonal Kendall analysis, while those with censored values were examined using a tobit regression (on log-transformed data), which assumes that data are censored above or below certain values. In situations where the direction of a significant monotonic trend coincided with that of a significant step, the overall (1966-2005) monotonic trend results were rejected. For example, if dissolved calcium demonstrated a negative overall trend and a negative step in 1987, the overall trend was essentially negated. In all instances where monotonic trend and step analyses yielded significant results in the same direction (positive or negative), data were subsequently subdivided into two separate sets (pre- and post-1987). Monotonic trend analyses were then rerun on the resulting smaller data sets.

2.3 Comparison to Water Quality Guidelines

Water quality data examined for the purposes of this report were compared to surface water quality guidelines for use in Alberta (AENV 1999a) and more recent updates from the Canadian Council of Ministers of the Environment (CCME 2003 and updates). Guidelines selected for comparison were the more stringent of those available for protection of aquatic life (PAL), recreation, or agricultural use.

3.0 RESULTS AND DISCUSSION

Basic descriptive statistics for all variables are listed in Tables 2-5. Due to the presence of step trends for several variables, descriptive statistics are presented both for the entire sampling frame (1966-2005) and for post-1987 data. Trend and seasonality graphs for most analysed variables are depicted in Figures 8 through 96. Seasonality boxplots are explained in Figure 2. For various reasons, including brief records and high frequency of censored data, some parameters are not displayed in graphical format. Raw results of statistical analyses can be viewed in the appendices. Throughout the report, the term 'routine variables' is used in reference to physical characteristics (e.g. pH, temperature, dissolved oxygen), ions, nutrients, biotic variables, and certain routinely sampled constituents (Table 1), while the term 'metals' refers to metals, a handful of nonmetals (arsenic, boron, and selenium), and cyanide (Table 1).

3.1 Highway 3 (Upstream of Lethbridge) Routine variables, Trends

3.1.1 Raw Data, 1966-2005

Long-term trend assessment of data collected at the Highway 3 site since 1966 identified nine variables that have undergone significant trends over the past forty years (Table 6). Of these, however, all but two trends were overtly linked to corresponding step trends. Bearing in mind that any significant monotonic trend in the overall data that coincided with a significant step trend in the same direction was immediately rejected, this means that only two true monotonic trends were identified in unadjusted data for the 1966-2005 timeframe. Dissolved magnesium (Figure 38) demonstrated a negative (downward) monotonic trend that was not related to a 1987 step in the data, while nitrate and nitrite nitrogen (Figure 68) described a slightly positive (increasing) trend. Due to a brief period of markedly higher method detection limits between 1974 and 1976, nitrate and nitrite nitrogen data were only examined for trends after 1977. Trend assessment of daily average flow values for all days over the entire time frame (as measured by Environment Canada in the vicinity of the Highway 3 sampling site) did not identify any significant tendencies in the data (Figure 96).

3.1.2 Flow-Adjusted Data, 1966-2005

Following adjustment to account for the influence of stream flow, 9 variables showed significant monotonic trends (Table 6). Of these, only one was not potentially attributable to a significant step in the data during 1987. Flow-adjusted data for particulate nitrogen (Figure 58) underwent a significant decline over the period of available information (1978-1999).

3.1.3 Pre-1987

Prior to 1987, three variables demonstrated significant monotonic trends in raw data. Dissolved nitrogen (Figure 60), total ammonia nitrogen (Figure 64), and total phosphorus (Figure 72) all underwent significant decreases during the time frame in question. Following adjustment to account for the influence of flow on the data, four variables – conductivity (Figure 12), sulphate (Figure 48), dissolved nitrogen (Figure 60), and total ammonia nitrogen (Figure 64) – showed significant decreases in the Oldman River at Highway 3 (Table 6). Trends in both raw and flow-adjusted data for total ammonia nitrogen, however, were clearly driven by a distinctly visible step in the data caused by a 1985 change in detection limits (Figure 64). Flow data underwent a significant decline prior to 1987 (Figure 96), but this tendency was not evident after 1987.

3.1.4 Post-1987

In instances where a significant overall monotonic trend (1966-2005) for a given water quality variable may have been influenced by a significant step trend in 1987, monotonic trends in post-1987 data, as a reflection of recent tendencies, were generally approached as the most meaningful trend information that could be obtained from the dataset. At the Highway 3 site post-1987 (Table 6), five routine water quality variables described significant trends. Water temperature (Figure 8), total Kjeldahl nitrogen (Figure 66), total phosphorus (Figure 72), total dissolved phosphorus (Figure 74), and fecal coliform bacteria (Figure 80) all demonstrated downward tendencies prior to flow adjustment. Following correction for the influence of stream flow, four variables – non-filterable residue (Figure 26), total Kjeldahl nitrogen (Figure 66), total dissolved phosphorus (Figure 74), and fecal coliform bacteria (Figure 80) – all yielded significantly decreasing monotonic trends.

3.2 Highway 3 Metals, Trends

For a variety of reasons, AENV datasets for metals are highly complex. Over the years, different fractions (i.e. dissolved, extractable, total) may have been analysed for any given metal. Furthermore, detection limits may have changed multiple times since sampling began. In some instances, a given metal may have been rarely detected, giving rise to a high frequency of non-detects/censored values, which can represent a substantial barrier to trend assessment. In other cases, sampling frequency may have changed over time. With this latter point in mind, it is important to note that, although AENV metals data extend to March of 2005, sampling frequency for many of these was reduced from monthly to quarterly in 1999. Since prior analyses have suggested that a change in sampling frequency can lead to a Type I error (i.e., rejection of the null hypothesis of no significant trend in the data), most metals data were only examined for trends up to 1999.

Despite the complexity of the dataset, a handful of metal fractions were analysed for trends (Table 7). Of these, only dissolved arsenic (Figure 86) had sufficient reliable data prior to 1987 to facilitate trend assessment over a substantial portion (pre- and post-1987) of the 40-year sampling frame. However, no significant trends in this variable were detected for the Highway 3 site.

Examination of post-1987 metals data from the Highway 3 site revealed three significant downward trends, all of which persisted after flow-adjustment. Dissolved iron (Figure 90), manganese (Figure 92), and selenium (Figure 94) showed significant downward tendencies after 1987. However, it is very likely that the negative trend demonstrated by dissolved manganese was largely generated by a downward shift in MDL toward the middle of the post-1987 sampling frame. The negative tendency in dissolved selenium data, on the other hand, may have been driven by an increased frequency of censored (below detection) values toward the latter half of the period in question.

3.3 Highway 3, Guideline Comparison

Measured values for water quality variables at the Highway 3 site were largely compliant with available guidelines, as stipulated by the Alberta Surface Water Quality Guidelines (ASWQG) and Canadian Council of Ministers of the Environment Water Quality Guidelines (CCMEWQG, Table 6). Based on the ASWQG, pH values were in excess of the 8.5 maximum 4.8% of the time. However, based on the less conservative CCMEWQG upper limit of 9.0, pH values were 100% compliant between 1966 and 1987. In the case of dissolved oxygen concentration, values were 100% compliant with the ASWQG chronic exposure guideline of 6.5 mg/L. ASWQG nutrient guidelines for total nitrogen (1.0 mg/L maximum) and total phosphorus (0.05 mg/L) were exceeded on 5.6% and 2.1% of occasions, respectively. CCMEWQG for total coliform bacteria and fecal coliform bacteria were both exceeded roughly 13% of the time. For various reasons, the former are no longer monitored as part of the LTRN program. Additional CCMEWQG for calcium, chloride, fluoride, total ammonia nitrogen, and nitrate and nitrite nitrogen were never exceeded (Table 6).

Metals data for those variables subjected to trend analyses were generally in compliance with CCMEWQG at the Highway 3 sampling location (Table 7). Exceptions were dissolved aluminum (maximum guideline - 100 µg/L) and dissolved arsenic (maximum guideline - 5 µg/L), which were exceeded in 10.2% and 1.3% of samples, respectively.

3.4 Highway 36 (Downstream of Lethbridge) Routine variables, Trends

3.4.1 Raw Data, 1966-2005

Prior to flow adjustment, 15 variables showed significant monotonic trends at the Highway 36 sampling site (Table 8). Of these, four were not coincident with step trends in 1987. Water temperature (Figure 8), reactive silica (Figure 50), total nitrogen (Figure 70), and fecal coliform bacteria (Figure 80) all demonstrated significant negative tendencies between 1966 and 2005 that appeared to be independent of the 1987 change in monitoring agencies. Downward trends in both total nitrogen and fecal coliforms are likely linked to major improvements to the Lethbridge wastewater treatment plant, which were completed in 1999.

3.4.2 Flow-Adjusted Data, 1966-2005

Following adjustment to account for stream flow, significant monotonic trends were detected in 14 water quality variables at the downstream site (Table 8). Of these, only three could not be explained by a 1987 step trend in the data. Reactive silica (Figure 50), nitrite and nitrate nitrogen (Figure 68), and fecal coliform bacteria (Figure 80) all displayed significant downward trends over the time interval in question.

3.4.3 Pre-1987

Prior to 1987, three variables monitored at the Highway 36 site underwent significant trends in raw data (Table 8). Dissolved calcium (Figure 36) and total ammonia nitrogen (Figure 64) exhibited negative tendencies, while total dissolved phosphorus (Figure 74) showed an upward trend. Following correction for stream flow, only total dissolved phosphorus demonstrated a significant monotonic trend in pre-1987 data, maintaining the increasing tendency seen prior to flow adjustment.

3.4.4 Post-1987

Following the 1987 transition in monitoring agencies, seven water quality variables at the Highway 36 site underwent significant monotonic trends, all of which were decreasing (Table 8). Possibly a response to upgrades in the treatment process at the Lethbridge wastewater treatment plant, these downward tendencies in non-filterable residue (Figure 26), dissolved Kjeldahl nitrogen (Figure 62), total ammonia nitrogen (Figure 64), total Kjeldahl nitrogen (Figure 66), total phosphorus (Figure 72), total dissolved phosphorus (Figure 74), and *Escherichia coli* (Figure 82) are generally indicative of improving water quality. As noted previously, major improvements to the Lethbridge wastewater treatment facility were completed in 1999. Generally higher summer flows, resulting from construction of the Oldman River Dam, may also have contributed to decreasing trends in nutrient concentrations and bacterial counts.

Flow adjustment of post-1987 data collected downstream of Lethbridge had limited effects on trends detected in unadjusted data (Table 8), with negative tendencies in non-filterable residue (Figure 26), total ammonia nitrogen (Figure 64), total Kjeldahl nitrogen (Figure 66), total phosphorus (Figure 72), and *E. coli* (Figure 82) persisting. Only dissolved Kjeldahl nitrogen concentration (Figure 62) no longer exhibited a significant trend once stream flow was accounted for.

3.5 Highway 36 Metals, Trends

With the exception of dissolved arsenic (Figure 86), metals data collected downstream of Lethbridge at Highway 36 were inadequate for trend assessments over the entire sampling period (Table 9). Sampling for dissolved aluminum (Figure 84) simply did not begin until 1987. In the cases of dissolved boron (Figure 88) and dissolved selenium (Figure 94), analytical technology prior to 1987 was not yet sufficiently advanced to provide accurate, reliable data for trend assessment. Due to excessive variability in these pre-1987 data, they were not included in the report. Lastly, high method detection limits for dissolved iron (Figure 90) and dissolved manganese (Figure 92) prior to 1987 resulted in very high degrees of censorship for both variables. Hence, these data were not included in trend assessments. Statistical examination of available data for dissolved arsenic revealed a significantly decreasing tendency (Figure 86). However, this trend was concurrent with a negative step in 1987 and consequently rejected. No trends were seen in flow-adjusted arsenic data.

Prior to 1987, only dissolved arsenic data (Figure 86) were adequate for trend assessment. However, no significant trends were identified in pre-87 data for this variable. Evaluation of post-1987 data from the Highway 36 monitoring station, on the other hand, yielded significantly decreasing concentrations for four parameters (Table 9), including dissolved arsenic (Figure 86), boron (Figure 88), manganese (Figure 92), and selenium (Figure 94). Adjustment to account for stream flow did not alter the significance or direction of these tendencies (Table 9). However, visual examination of the data for manganese (Figure 92) strongly suggests that the trends identified for this variable were probably the result of a lower method detection limit toward the middle segment of the 1987-2005 sampling period.

3.6 Highway 36, Guideline Comparison

Overall, measured values for water quality variables at the Highway 36 sampling site were well aligned with both ASWQG and CCMEWQG (Table 8). In terms of pH, ASWQG were met in 76.9% of samples, while 99.2% of measurements conformed to CCMEWQG. This discrepancy is attributable to the slightly higher upper threshold provided by the CCME (9.0, vs. 8.5 in the ASWQG). In terms of dissolved oxygen concentration, 1.6% of samples did not meet the ASWQG chronic exposure guideline of 6.5 mg/L. ASWQG nutrient guidelines for total nitrogen (1.0 mg/L) and total phosphorus (0.05 mg/L) were exceeded in 11% and 1.7% of samples, respectively. Compliance with CCMEWQG for total coliform bacteria (1000 cells/100 ml) and fecal coliform bacteria (100 cells/100 ml) was 84.5% and 78.5%, respectively.

Guideline exceedances for metals at the Highway 36 site were very low and, with the exception of fewer aluminum exceedances at the downstream site (3.2% vs. 10.2% upstream), quite similar to those at the upstream sampling location (Table 9). Dissolved fractions of aluminum, arsenic, iron, and selenium exceeded available guidelines 3.2%, 0.6%, 1.5%, and 1.3% of the time, respectively. As was the case at the Highway 3 site, dissolved boron did not exceed the irrigation water guideline of 500-6000 mg/L

4.0 CONCLUSION

Long-term trend analyses of water quality data collected on the Oldman River since 1966 indicate that a number of variables have undergone significant changes over time. For many of these variables, a transfer of monitoring agencies in 1987 (from Environment Canada to Alberta Environment) generated statistically significant step trends. The existence of these steps precluded trend analyses on the full data range for numerous parameters. Hence, the majority of statistically significant trends were restricted to post-1987 data.

With the exception of an increasing trend for nitrate and nitrite nitrogen at the Highway 3 site, all significant post-1987 and overall trends not affected by a step in 1987 were downward at both the Highway 3 and Highway 36 sampling locations. Generally indicative of improving water quality, a pronounced majority of these trends were in nutrient (nitrogen and phosphorus) concentrations and bacterial counts. This tends to suggest that enhancements to wastewater treatment facilities and processes at Lethbridge (Saffran 2005) and smaller upstream municipalities, possibly in concert with generally higher summer flows and increased dilution capacity arising from the Oldman River Dam (Saffran 2005, Hazewinkel and Saffran 2007), may have reduced the prevalence of these contaminants in the Oldman River over time. Evolving livestock management practices may have further contributed to improved water quality, although previous work (Koning *et al.* 2006) suggests that at least a portion of bacterial contamination may be associated with wildlife (ungulates, skunks, waterfowl) in the basin. At the same time, however, the upward trend in nitrate and nitrite nitrogen (a common component of fertilizers) at Highway 3 indicates the possibility that crop production may be having an increasing impact on the Oldman River. Negative trends in water temperature at both sites, although not entirely understood at this time, appear to be related to river flow and could potentially be a product of the Oldman River Dam. A downward tendency in summer water temperature, predicted prior to dam construction, has been demonstrated at the Brocket site (Hazewinkel and Saffran 2007). However, it is unclear if a similar impact of the dam would be detectable as far downstream as the Highway 36 site.

Although a handful of variables have demonstrated guideline exceedances at both the Highway 3 and Highway 36 sampling locations, most have done so infrequently. It is important to note that those few variables demonstrating a higher incidence of guideline exceedance, such as nutrients (phosphorus, nitrogen) and bacteria (fecal coliforms, *E. coli*), have also undergone significantly decreasing trends over time. In general, downward trends described by these and other water quality variables measured in the Oldman River at the Highway 3 and Highway 36 sampling sites reflect improving river water quality and can probably be attributed to both flow regulation capacity provided by the Oldman River Dam and enhanced wastewater treatment processes.

5.0 LITERATURE CITED

Alberta Environment (AENV). 1999. Environmental Monitoring of the Oldman River Dam: Eight Years of Progress. Report prepared by Oldman River Dam Environmental Committee. Pub. No. T/447. 84 pp.

Alberta Environment (AENV). 1999a. Surface Water Quality Guidelines for Use in Alberta. Environmental Service, Environmental Sciences Division, Alberta Environment.

Alberta Environment (AENV). 2006. Aquatic Ecosystems Field Sampling Protocols. Environmental Monitoring and Evaluation Branch, Environmental Assurance Division, Alberta Environment, Edmonton. 136 pp.

Aroner, E.R. 1994. WQHYDRO: Water Quality/Hydrology/Graphics/Analysis System – User's Manual. Portland, Oregon. 220 pp.

Canadian Council of Ministers of the Environment. 1999. Canadian Environmental Quality Guidelines. Environment Canada. Hull, Québec. http://www2.ec.gc.ca/ceqg-rcqe/English/ceqg/water/default.cfm

Cross, P.M. & A.M. Anderson. 1986. Oldman River Dam – Assessment of Downstream Water Quality Effects and Conditions. Water Quality Control Branch, Pollution Control Division, Alberta Environmental Protection.

Davies, R.W., J. Culp, R. Green, M. O'Connell, G. Scott, & C. Zimmerman. 1977. River Classification Study of the South Saskatchewan River Basin: Volume I. 201 pp.

Hazewinkel, R.R.O. & K.A. Saffran. 2007. Temperature and Dissolved Oxygen in the Oldman River Following Construction of the Oldman River Dam. *Prepared for* the Oldman River Environmental Monitoring Committee *by* the Environmental Monitoring and Evaluation Branch, Alberta Environment.

Hebben, T. 2005. Analysis of Water Quality Trends for the Long-Term River Network: North Saskatchewan River, 1977-2002. Environmental Monitoring and Evaluation Branch, Environmental Assurance Division, Alberta Environment.

Helsel, D.R. 2006. Fabricating data: how substituting values for nondetects can ruin results, and what can be done about it. Chemosphere 65: 2434-2439.

Hirsh, R.M., R.B. Alexander & R.A. Smith. 1991. Selection of methods for the detection and estimation of trends in water quality. *Water Resour Res* 27: 803-813.

Koning, C.W., K.A. Saffran, J.L. Little & L. Fent. 2006. Water quality monitoring: the basis for watershed management in the Oldman River Basin, Canada. *Water Sci Technol* 53: 153-161.

Oldman River Basin Study Management Committee (OMRBSMC). 1978. Oldman River Basin – Phase II Studies: Report and Recommendations. 75 pp.

Oldman Watershed Council. 2005. Oldman River Basin Water Quality Initiative, Five Year Summary Report. 37 pp.

Saffran, K.A. 2005. Oldman River Basin Water Quality Initiative Surface Water Quality Summary Report, April 1998 – March 2003. *Prepared for* the Oldman River Basin Water Quality Initiative. 395 pp.

Schertz, T.L., R.B. Alexander & D.J. Ohe. 1991. The computer program estimate trend (ESTREND), a system for the detection of trends in water-quality data. U.S. Geological Survey, Water-Resources Investigations Report 94040, 62 pp.

Stevens, M.R. 2003. Water quality and trend analysis of Colorado–Big Thompson System reservoirs and related conveyances, 1969 through 2000. U.S. Geological Survey, Water-Resources Investigations Report 03-4044, 150 pp.

U.S. Environmental Protection Agency. 1996. Practical Methods for Data Analysis, Guidance for Data Quality Assessment. EPA QA/G-9, QA00 Version.

Table 1 Core water quality variables sampled as part of Long-Term River Network monitoring on the Oldman River since 1966.

Routine Variables	Years of Record	Units
Temperature	1966-2005	°C
pH	1966-2005	
Conductivity	1966-2005	µS/cm
Total Alkalinity	1966-2005	mg/L $CaCO_3$
Hardness	1966-2005	mg/L $CaCO_3$
DO	1974-2005	mg/L CaCO3
Turbidity (JTU)	1966-1986	JTU
Turbidity (NTU)	1987-2005	NTU
Apparent Colour	1966-1981	Relative Units
	1987	
True Colour	1981-2005	Relative Units
Non-Filterable Residue	1966-2005	mg/L
Total Dissolved Solids	1974-1977	mg/L
	1985-1986	
	1996-2005	
Filterable Residue	1987-2005	mg/L
Potassium	1966-2005	mg/L
Sodium	1966-2005	mg/L
Calcium	1966-2005	mg/L
Magnesium	1966-2005	mg/L
Bicarbonate	1985-2005	mg/L
Carbonate	1985-2005	mg/L
Chloride	1966-2005	mg/L
Sulphate	1966-2005	mg/L
Fluoride	1966-2005	mg/L
Reactive Silica	1966-2005	mg/L
Total Organic Carbon	1971-2005	mg/L
Particulate Organic Carbon	1978-1999	mg/L
Dissolved Organic Carbon	1977-2005	mg/L
Particulate Nitrogen	1978-1999	mg/L
Dissolved Nitrogen	1978-1987	mg/L
Dissolved Kjeldahl Nitrogen	1987-1999	mg/L
Total Ammonia Nitrogen	1977-2005	mg/L
Total Kjeldahl Nitrogen	1976-1978	mg/L
	1987-2005	
Nitrite and Nitrate	1966-2005	mg/L
Total Nitrogen	1976-2005	mg/L
Nitrate	1999-2005	mg/L
Total Organic Nitrogen	1997	mg/L
Nitrite	1998-2005	mg/L
Total Phosphorus	1966-2005	mg/L
Total Dissolved Phosphorus	1967-2005	mg/L
Particulate Phosphorus	1996-1999	mg/L
Chlorophyll a	1980-2005	mg/L
Total Coliform Bacteria	1970-1994	cells/100 mL
Fecal Coliform Bacteria	1970-2005	cells/100 mL
Fecal Streptococcal Bacteria	1977-1994	cells/100 mL
Escherichia coli	1994-2005	cells/100 mL

Metals*	Years of Record	Units
Aluminum	1988-2005	mg/L
Arsenic	1971-2005	mg/L
Barium	1971-2005	mg/L
Beryllium	1999-2005	mg/L
Boron	1978-2005	mg/L
Cadmium	1971-2005	mg/L
Chromium	1971-1980	mg/L
	1995-2005	
Cobalt	1971-1980	mg/L
	1983-2005	
Copper	1980-1980	mg/L
	1983-2005	
Cyanide	1999-2005	mg/L
Iron	1966-2005	mg/L
Lead	1967-1980	mg/L
	1983-2005	
Lithium	1978-1980	mg/L
	1999-2005	
Manganese	1967-2005	mg/L
Mercury	1972-2005	mg/L
Molybdenum	1971-1980	mg/L
	1995-2002	
Nickel	1971-1980	mg/L
	1983-2005	
Selenium	1978-2005	mg/L
Silver	1971-2005	mg/L
Strontium	1971-1974	mg/L
	1978-1980	
	1999-2005	
Thallium	1999-2005	mg/L
Titanium	1999-2005	mg/L
Uranium	1999-2005	mg/L
Vanadium	1983-2005	mg/L
Zinc	1967-1980	mg/L
	1983-2005	
Zirconium	1999-2002	mg/L

*Years of record incorporate all fractions for each particular variable.

Table 2 Summary statistics for routine water quality variables in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1966-2005**.

	Flow (m^3/s)	Temperature (°C)	pH	Conductivity (µS/cm)	Alkalinity (mg $CaCO_3$/L)	Hardness (mg $CaCO_3$/L)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Non-Filterable Residue (mg/L)	Total Dissolved Solids (mg/L)	Filterable Residue (mg/L)	Dissolved Potassium (mg/L)	Dissolved Sodium (mg/L)
Upstream (Hwy 3)													
Minimum	2.12	-1.10	7.00	168.0	47.6	59.20	7.34	0.0	0.4	121.0	110.0	0.1	1.2
First Quartile	17.20	0.80	7.99	307.0	128.0	140.00	9.39	4.5	4.0	172.3	180.0	0.9	9.0
Mean	70.46	8.24	8.13	349.9	144.1	161.24	10.93	36.2	76.1	197.6	208.7	1.3	12.9
Median	28.90	7.01	8.20	350.5	143.0	160.00	10.90	8.0	9.2	199.5	206.0	1.1	12.7
Third Quartile	62.30	15.15	8.30	393.8	159.0	180.51	12.53	19.1	27.0	222.3	235.5	1.4	16.0
Maximum	4100.00	26.30	8.87	560.0	236.0	244.00	14.35	1650.0	3700.0	271.0	310.0	7.6	41.0
n	14609	430	441	438	433	351	346	427	353	134	199	439	438
Standard Deviation	126.24	7.60	0.28	67.2	23.6	28.26	1.77	109.4	287.5	35.5	41.6	0.7	5.3
Standard Error	1.04	0.37	0.01	3.2	1.1	1.51	0.10	5.3	15.3	3.1	3.0	0.0	0.3
Begin Year	1966	1966	1966	1966	1966	1966	1971	1966	1966	1996	1987	1966	1966
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
Censored Values	-	-	-	-	-	-	-	-	20	-	-	2	-
Downstream (Hwy 36)													
Minimum	-	-0.24	7.10	170.0	82.4	97.00	0.30	0.1	0.4	118.3	122.0	0.3	0.7
First Quartile	-	0.50	8.00	327.8	127.0	140.66	9.40	3.5	3.0	178.0	186.8	1.3	12.6
Mean	-	9.25	8.24	379.7	147.1	165.37	10.98	28.5	65.2	206.8	222.9	1.7	16.8
Median	-	8.80	8.29	371.0	144.0	160.00	10.80	7.5	8.0	205.0	220.0	1.6	16.3
Third Quartile	-	16.59	8.50	430.8	161.0	185.00	12.60	18.0	30.8	238.0	260.0	1.9	21.4
Maximum	-	26.60	9.30	733.0	304.0	295.00	17.60	950.0	3700.0	328.3	376.0	20.8	34.8
n	-	351	368	364	357	266	329	356	336	65	140	361	362
Standard Deviation	-	8.18	0.37	82.1	28.1	31.75	2.26	73.5	260.0	42.9	49.9	1.2	6.5
Standard Error	-	0.44	0.02	4.3	1.5	1.95	0.12	3.9	14.2	5.3	4.2	0.1	0.3
Begin Year	-	1967	1967	1967	1967	1967	1971	1967	1967	1996	1987	1967	1967
End Year	-	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
Censored Values	-	-	-	-	-	-	-	-	36	-	-	1	-

Table 2 Summary statistics for routine water quality variables in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1966-2005** (continued).

	Dissolved Calcium (mg/L)	Dissolved Magnesium (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Silica (mg/L)	Total Organic Carbon (mg/L)	Particulate Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Particulate Nitrogen (mg/L)	Dissolved Nitrogen (mg/L)
Upstream (Hwy 3)													
Minimum	15.6	3.1	58.00	0.00	0.1	0.025	5.0	0.05	0.25	0.09	0.50	0.01	0.04
First Quartile	35.2	13.0	158.35	0.50	1.2	0.100	31.5	1.80	1.80	0.20	1.60	0.03	0.11
Mean	40.8	14.9	175.39	1.30	2.0	0.128	42.5	2.72	3.24	0.78	2.34	0.18	0.18
Median	40.0	14.9	174.66	0.50	1.7	0.120	42.1	2.65	2.30	0.20	2.00	0.06	0.15
Third Quartile	45.6	16.7	191.25	0.50	2.1	0.140	52.0	3.60	3.28	0.47	2.80	0.13	0.23
Maximum	68.0	27.0	252.00	10.00	28.8	0.860	107.0	11.00	19.60	17.00	12.50	2.92	0.58
n	417	380	236	236	440	386	439	361	338	234	321	234	101
Standard Deviation	7.7	3.0	27.01	1.80	2.1	0.05	16.4	1.36	3.09	1.89	1.48	0.39	0.10
Standard Error	0.4	0.2	1.76	0.12	0.1	0.00	0.8	0.07	0.17	0.12	0.08	0.03	0.01
Begin Year	1966	1967	1985	1985	1966	1966	1966	1966	1971	1978	1977	1978	1978
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	1999	2005	1999	1986
Censored Values	-	-	-	167	-	-	-	1	-	76	-	26	-
Downstream (Hwy 36)													
Minimum	20.4	8.6	90.90	0.00	0.1	0.025	12.7	0.01	0.25	0.02	0.40	0.01	0.09
First Quartile	35.1	13.8	153.90	0.50	2.5	0.120	38.0	0.28	2.30	0.20	2.00	0.04	0.15
Mean	41.5	15.8	176.18	2.11	4.6	0.142	49.5	1.73	3.52	0.96	2.75	0.22	0.31
Median	40.1	15.7	171.95	0.50	4.1	0.135	48.0	1.10	2.90	0.30	2.40	0.09	0.23
Third Quartile	46.6	18.1	195.25	2.95	6.0	0.150	60.1	3.20	3.80	0.70	3.10	0.17	0.35
Maximum	87.3	25.3	283.00	12.30	20.0	0.940	174.0	6.60	20.90	44.60	18.40	8.06	1.30
n	361	333	248	247	361	342	360	306	347	236	323	236	101
Standard Deviation	9.0	3.1	32.98	2.81	2.9	0.069	18.3	1.63	2.44	3.17	1.58	0.64	0.25
Standard Error	0.5	0.2	2.09	0.18	0.2	0.004	1.0	0.09	0.13	0.21	0.09	0.04	0.02
Begin Year	1967	1967	1982	1982	1967	1967	1967	1967	1969	1978	1970	1978	1978
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	1999	2005	1999	1986
Censored Values	-	-	-	142	-	-	-	22	-	73	-	14	-

Table 2 Summary statistics for routine water quality variables in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1966-2005** (continued).

	Dissolved Kjeldahl Nitrogen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Total Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phophorus (mg/L)	Chlorophyll *a* (mg/L)	Total Coliform Bacteria (cells/100mL)	Fecal Coliform Bacteria (cells/100mL)	*Escherichia coli* (cells/100mL)
Upstream (Hwy 3)													
Minimum	0.01	0.01	0.01	0.00	0.02	0.003	0.001	0.000	0.000	0.0001	0.5	0.5	1.0
First Quartile	0.14	0.01	0.15	0.01	0.21	0.006	0.003	0.009	0.003	0.0007	16.0	2.0	2.0
Mean	0.21	0.03	0.36	0.11	0.43	0.111	0.013	0.074	0.007	0.0017	502.0	151.6	116.6
Median	0.18	0.02	0.22	0.06	0.30	0.055	0.003	0.017	0.004	0.0010	70.0	10.0	6.0
Third Quartile	0.24	0.05	0.34	0.17	0.44	0.192	0.009	0.048	0.006	0.0018	300.0	41.5	23.0
Maximum	1.09	0.20	5.40	1.47	6.39	0.957	0.050	2.380	0.147	0.0188	12000.0	7700.0	6001.0
n	141	320	240	438	338	75	108	375	316	212	229	370	129
Standard Deviation	0.17	0.03	0.56	0.15	0.55	0.146	0.018	0.209	0.013	0.0025	1388.7	702.1	574.5
Standard Error	0.01	0.00	0.04	0.01	0.03	0.017	0.002	0.011	0.001	0.0002	91.8	36.5	50.6
Begin Year	1987	1977	1973	1966	1973	1987	1973	1967	1978	1987	1970	1970	1994
End Year	1999	2005	2005	2005	2005	2005	2005	2005	2005	2005	2004	2005	2005
Censored Values	1	92	1	37	-	15	57	9	115	-	-	65	25
Downstream (Hwy 36)													
Minimum	0.01	0.01	0.05	0.00	0.03	0.003	0.001	0.003	0.003	0.0002	0.5	0.5	1.0
First Quartile	0.17	0.01	0.22	0.01	0.28	0.003	0.003	0.021	0.005	0.0012	40.0	5.0	2.0
Mean	0.29	0.07	0.47	0.13	0.57	0.135	0.007	0.101	0.040	0.0036	751.2	105.8	84.6
Median	0.26	0.04	0.32	0.06	0.42	0.034	0.003	0.058	0.020	0.0021	164.0	20.0	8.0
Third Quartile	0.36	0.07	0.46	0.22	0.64	0.231	0.008	0.110	0.054	0.0034	700.0	81.3	25.5
Maximum	0.92	1.00	8.20	1.13	8.33	1.100	0.062	2.370	0.430	0.0406	18000.0	2800.0	2600.0
n	137	320	235	359	335	75	88	356	318	212	174	312	128
Standard Deviation	0.17	0.12	0.74	0.17	0.70	0.190	0.008	0.194	0.056	0.0052	1919.7	270.1	314.2
Standard Error	0.01	0.01	0.05	0.01	0.04	0.022	0.001	0.010	0.003	0.0004	145.5	15.3	27.8
Begin Year	1987	1977	1970	1967	1970	1987	1987	1967	1978	1987	1977	1977	1994
End Year	1999	2005	2005	2005	2005	2005	2005	2005	2005	2005	2004	2005	2005
Censored Values	-	64	1	51	-	22	43	6	41	-	-	34	19

Table 3 Summary statistics for routine water quality variables in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1987-2005**.

	Flow (m^3/s)	Temperature (°C)	pH	Conductivity (µS/cm)	Alkalinity (mg $CaCO_3$/L)	Hardness (mg $CaCO_3$/L)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Non-Filterable Residue (mg/L)	Total Dissolved Solids (mg/L)	Filterable Residue (mg/L)	Dissolved Potassium (mg/L)	Dissolved Sodium (mg/L)
Upstream (Hwy 3)													
Minimum	4.26	-1.10	7.00	168.0	47.6	59.20	7.34	1.2	0.4	127.0	110.0	0.2	3.7
First Quartile	19.00	0.10	7.90	307.0	132.0	140.00	9.32	5.0	3.9	175.5	180.0	0.9	9.3
Mean	64.53	8.59	8.09	341.0	146.3	160.62	10.87	42.7	76.8	196.5	207.2	1.3	12.4
Median	29.50	8.60	8.10	343.0	145.0	160.00	10.76	8.7	8.0	198.0	203.0	1.1	12.1
Third Quartile	54.80	15.50	8.30	377.0	159.0	180.00	12.50	18.6	22.0	216.5	232.0	1.4	14.9
Maximum	4100.00	26.30	8.87	504.0	207.0	237.61	14.35	1650.0	3700.0	268.0	310.0	7.6	27.4
n	6939	217	217	217	217	217	217	214	216	107	213	217	217
Standard Deviation	123.05	7.85	0.30	56.2	21.9	27.04	1.79	140.7	336.7	31.6	39.9	0.7	4.4
Standard Error	1.48	0.53	0.02	3.8	1.5	1.84	0.12	9.6	22.9	3.1	2.7	0.0	0.3
Begin Year	1987	1987	1987	1987	1987	1987	1987	1987	1987	1989	1987	1987	1987
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
Censored Values	-	-	-	-	-	-	-	-	20	-	-	2	-
Downstream (Hwy 36)													
Minimum	4.70	-0.24	7.10	220.0	95.9	105.50	6.10	0.1	0.4	134.0	122.0	0.3	4.3
First Quartile	18.48	0.11	8.00	326.0	130.0	143.60	9.63	3.5	2.0	185.8	190.0	1.3	12.6
Mean	68.51	9.23	8.24	369.0	148.9	165.52	11.33	34.2	70.4	213.5	222.2	1.7	16.2
Median	28.20	9.00	8.26	363.0	147.0	160.15	11.14	7.1	7.0	210.5	222.0	1.6	15.7
Third Quartile	51.65	16.70	8.50	408.0	162.0	185.00	12.97	18.0	26.0	238.0	248.0	1.9	19.6
Maximum	1590.00	26.60	9.00	660.0	232.0	265.46	17.60	950.0	3700.0	302.0	376.0	6.5	32.0
n	218	217	217	217	217	217	216	214	216	108	212	217	217
Standard Deviation	138.42	8.44	0.36	66.9	25.1	29.97	2.13	90.8	303.5	38.8	47.3	0.8	5.7
Standard Error	9.37	0.57	0.02	4.5	1.7	2.03	0.14	6.2	20.6	3.7	3.3	0.1	0.4
Begin Year	1987	1987	1987	1987	1987	1987	1987	1987	1987	1989	1987	1987	1987
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
Censored Values	-	-	-	-	-	-	-	-	31	-	-	1	-

Table 3 Summary statistics for routine water quality variables in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1987-2005** (continued).

	Dissolved Calcium (mg/L)	Dissolved Magnesium (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Silica (mg/L)	Total Organic Carbon (mg/L)	Particulate Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Particulate Nitrogen (mg/L)	Dissolved Kjeldahl Nitrogen (mg/L)
Upstream (Hwy 3)													
Minimum	15.6	4.9	58.00	0.50	0.3	0.025	10.5	0.05	1.00	0.20	0.60	0.01	0.01
First Quartile	35.3	12.9	159.00	0.50	1.3	0.110	31.8	1.70	1.70	0.20	1.60	0.02	0.14
Mean	40.2	14.6	176.51	1.33	2.2	0.136	39.5	2.65	2.77	0.37	2.47	0.19	0.21
Median	39.6	14.6	175.00	0.50	1.7	0.130	39.1	2.60	2.30	0.20	2.10	0.06	0.18
Third Quartile	44.6	16.3	193.00	0.50	2.1	0.150	46.9	3.56	3.00	0.20	2.90	0.14	0.24
Maximum	60.8	20.8	252.00	10.00	28.8	0.860	90.8	6.45	19.60	8.00	12.50	2.92	1.09
n	217	217	217	217	217	215	216	165	213	138	216	136	141
Standard Deviation	7.0	2.6	26.94	1.82	2.8	0.062	12.3	1.25	2.18	0.79	1.57	0.45	0.17
Standard Error	0.5	0.2	1.83	0.12	0.2	0.004	0.8	0.10	0.15	0.07	0.11	0.04	0.01
Begin Year	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	1999	2005	1999	1999
Censored Values	-	-	-	167	-	-	-	1	-	76	-	18	1
Downstream (Hwy 36)													
Minimum	21.8	8.9	105.00	0.50	0.6	0.025	12.7	0.01	1.10	0.02	0.40	0.01	0.01
First Quartile	35.0	13.9	156.00	0.50	2.6	0.120	37.6	0.20	2.20	0.20	2.10	0.03	0.17
Mean	40.7	15.6	177.73	2.21	4.3	0.153	47.4	1.68	3.09	0.69	2.78	0.25	0.29
Median	39.9	15.4	175.00	0.50	4.0	0.140	46.5	1.00	2.70	0.20	2.55	0.07	0.26
Third Quartile	45.8	17.4	196.00	3.03	5.2	0.160	56.1	3.15	3.60	0.30	3.20	0.16	0.36
Maximum	67.0	23.8	283.00	12.30	18.8	0.940	97.4	6.25	19.50	44.60	8.60	8.06	0.92
n	217	217	217	216	217	216	216	165	213	139	216	136	137
Standard Deviation	7.9	2.8	32.10	2.89	2.6	0.081	15.3	1.68	1.82	3.81	1.18	0.83	0.17
Standard Error	0.5	0.2	2.18	0.20	0.2	0.006	1.0	0.13	0.12	0.32	0.08	0.07	0.01
Begin Year	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	1999	2005	1999	1999
Censored Values	-	-	-	143	-	-	-	22	-	73	-	8	0

Table 3 Summary statistics for routine water quality variables in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1987-2005** (continued).

	Total Ammonia Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Total Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phophorus (mg/L)	Chlorophyll *a* (mg/L)	Total Coliform Bacteria (cells/100mL)	Fecal Coliform Bacteria (cells/100mL)	*Escherichia coli* (cells/100mL)
Upstream (Hwy 3)												
Minimum	0.01	0.01	0.00	0.02	0.003	0.001	0.003	0.000	0.0001	1.0	0.5	1.0
First Quartile	0.01	0.16	0.01	0.23	0.006	0.003	0.008	0.003	0.0007	30.0	5.0	2.0
Mean	0.02	0.35	0.10	0.46	0.111	0.005	0.064	0.007	0.0017	725.8	182.7	116.6
Median	0.01	0.22	0.06	0.32	0.055	0.003	0.014	0.003	0.0010	123.5	14.0	6.0
Third Quartile	0.02	0.34	0.17	0.44	0.192	0.004	0.030	0.006	0.0018	440.0	62.0	23.0
Maximum	0.19	5.40	0.99	6.39	0.957	0.028	2.380	0.147	0.0188	12000.0	7000.0	6001.0
n	214	215	217	215	75	88	217	216	212	94	213	129
Standard Deviation	0.03	0.57	0.13	0.63	0.146	0.004	0.234	0.015	0.0025	1826.1	724.4	574.5
Standard Error	0.00	0.04	0.01	0.04	0.017	0.000	0.016	0.001	0.0002	188.4	49.6	50.6
Begin Year	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1994
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	2004	2005	2005
Censored Values	92	1	40	-	15	57	6	86	-	-	22	25
Downstream (Hwy 36)												
Minimum	0.01	0.05	0.00	0.03	0.003	0.001	0.003	0.003	0.0002	0.5	0.5	1.0
First Quartile	0.01	0.21	0.00	0.28	0.003	0.003	0.014	0.004	0.0012	40.0	5.0	2.0
Mean	0.06	0.45	0.14	0.60	0.135	0.007	0.096	0.030	0.0036	484.0	97.2	84.6
Median	0.02	0.31	0.07	0.41	0.034	0.003	0.042	0.012	0.0021	149.0	18.0	8.0
Third Quartile	0.06	0.44	0.25	0.65	0.231	0.008	0.090	0.036	0.0034	450.5	56.0	25.5
Maximum	0.91	8.20	1.13	8.33	1.100	0.062	2.370	0.349	0.0406	13000.0	2800.0	2600.0
n	214	212	217	212	75	88	217	217	212	96	212	128
Standard Deviation	0.10	0.78	0.18	0.85	0.190	0.008	0.236	0.045	0.0052	1402.6	285.7	314.2
Standard Error	0.01	0.05	0.01	0.06	0.022	0.001	0.016	0.003	0.0004	143.2	19.6	27.8
Begin Year	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1987	1994
End Year	2005	2005	2005	2005	2005	2005	2005	2005	2005	2004	2005	2005
Censored Values	64	1	56	-	22	43	6	41	-	-	18	19

Table 4 Summary statistics for selected metals in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1966-2005**.

	Dissolved Aluminum (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Boron (mg/L)	Dissolved Iron (mg/L)	Dissolved Manganese (mg/L)	Dissolved Selenium (mg/L)
Upstream (Hwy 3)						
Minimum	0.0100	0.0002	0.0100	0.0070	0.0010	0.0001
1st Quartile	0.0100	0.0003	0.0100	0.0100	0.0040	0.0002
Mean	0.0527	0.0005	0.0154	0.0259	0.0075	0.0002
Median	0.0300	0.0004	0.0100	0.0100	0.0040	0.0002
3rd Quartile	0.0700	0.0005	0.0200	0.0400	0.0100	0.0002
Maximum	0.4330	0.0020	0.1000	0.2400	0.0690	0.0007
n	157	266	168	291	316	168
Standard Deviation	0.0613	0.0003	0.0122	0.0280	0.0073	0.0001
Standard Error	0.0049	0.0000	0.0009	0.0016	0.0041	0.0000
Begin Year	1966	1971	1987	1966	1967	1987
End Year	2005	2005	2005	2005	2005	2005
Censored Values	28	53	77	189	196	103
Downstream (Hwy 36)						
Minimum	0.0010	0.0002	0.0100	0.0010	0.0010	0.0001
1st Quartile	0.0100	0.0004	0.0100	0.0100	0.0040	0.0002
Mean	0.0251	0.0006	0.0168	0.0302	0.0083	0.0003
Median	0.0100	0.0005	0.0100	0.0100	0.0040	0.0002
3rd Quartile	0.0200	0.0007	0.0200	0.0400	0.0100	0.0003
Maximum	0.4500	0.0063	0.0800	0.9300	0.2900	0.0030
n	156	267	168	291	303	165
Standard Deviation	0.0477	0.0005	0.0116	0.0694	0.0184	0.0003
Standard Error	0.0038	0.0000	0.0009	0.0040	0.0011	0.0000
Begin Year	1988	1974	1987	1979	1980	1987
End Year	2005	2005	2005	2005	2005	2005
Censored Values	73	30	71	179	177	82

Table 5 Summary statistics for selected metals in the Oldman River at the Highway 3 and Highway 36 sampling stations for the period **1987-2005**.

	Dissolved Aluminum (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Boron (mg/L)	Dissolved Iron (mg/L)	Dissolved Manganese (mg/L)	Dissolved Selenium (mg/L)
Upstream (Hwy 3)						
Minimum	0.0100	0.0002	0.0100	0.0100	0.0005	0.0001
1st Quartile	0.0100	0.0003	0.0100	0.0100	0.0020	0.0001
Mean	0.0527	0.0004	0.0154	0.0215	0.0042	0.0002
Median	0.0300	0.0004	0.0100	0.0100	0.0020	0.0001
3rd Quartile	0.0700	0.0005	0.0200	0.0200	0.0040	0.0002
Maximum	0.4330	0.0019	0.1000	0.2400	0.0690	0.0007
n	157	169	168	213	216	169
Standard Deviation	0.0613	0.0002	0.0122	0.0314	0.0070	0.0001
Standard Error	0.0049	0.0000	0.0009	0.0022	0.0005	0.0000
Censored Values	28	15	77	118	106	103
Downstream (Hwy 36)						
Minimum	0.0010	0.0002	0.0100	0.0050	0.0005	0.0001
1st Quartile	0.0100	0.0003	0.0100	0.0050	0.0020	0.0001
Mean	0.0251	0.0006	0.0168	0.0238	0.0041	0.0003
Median	0.0100	0.0005	0.0100	0.0050	0.0020	0.0002
3rd Quartile	0.0200	0.0007	0.0200	0.0200	0.0040	0.0003
Maximum	0.4500	0.0063	0.0800	0.9300	0.1200	0.0200
n	156	168	168	213	216	166
Standard Deviation	0.0477	0.0006	0.0116	0.0817	0.0087	0.0016
Standard Error	0.0038	0.0000	0.0009	0.0056	0.0006	0.0001
Censored Values	73	6	71	116	107	83

Table 6 Water quality trends and guideline comparisons of long-term routine variables data collected from the Oldman River upstream of Lethbridge at Highway **3**, 1966-2005.

Variable	Overall Trend	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Temperature	-	NS	-	NS	NS	-	NS	Downward trend in temperature post-87.				
pH	NS	NS						No trends.	6.5-8.5	95.2	6.5-9.0	100
Conductivity	NS	-	-	NS	-	NS	NS	Decreasing trend pre-87.				
Total Alkalinity	NS	NS						No trends.				
Hardness				NS	NS	NS	NS	No trends. Data gap 1978-1985.				
DO	NS	NS						No trends.	6.5[a]	100		
Turbidity	NS	NS						No trends.				
Non-Filterable Residue	-	-	-	NS	NS	NS	-	Post-87 decrease in flow-adjusted data.				
Total Dissolved Solids						NS	NS	No trends.				
Filterable Residue						NS	NS	No trends.				
Potassium	NS	NS						No trends.				
Sodium	NS	NS						No trends.				
Calcium	NS	NS						No trends.			1000[ls]	100
Magnesium	-	NS	NS					Overall declining trend.				
Flow	NS							No trends.				
Bicarbonate	NS	NS						No trends.				
Carbonate	NS	NS						No trends.				
Chloride	NS	NS						No trends.			100-700[irr]	100
Fluoride	NS	NS						No trends.			1.0	100
Sulphate	NS	-	-	NS	-	NS	NS	Pre-87 decline in flow-adjusted data.				
Silica	NS	NS						No trends.				
Total Organic Carbon	NS	NS						No trends.				
Particulate Organic Carbon	-	-	-	NS	NS	NS	NS	Negative step trend in 1987.				
Dissolved Organic Carbon	NS	NS						No trends.				

Table 6 Water quality trends and guideline comparisons of long-term routine variables data collected from the Oldman River upstream of Lethbridge at Highway **3**, 1966-2005 (continued).

Variable	Overall Trend	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Particulate Nitrogen	NS	-	NS					Overall downward trend in flow-adjusted data.				
Dissolved Nitrogen				-	-			Very brief record (1978-1987)				
Dissolved Kjeldahl Nitrogen						NS	NS	No trends.				
Total Ammonia Nitrogen	-	-	-	-	-	NS	NS	Pre-1987 trend driven by change in MDL.			0.042-18.5[b]	100
Total Kjeldahl Nitrogen						-	-	Insufficient pre-87 data. Negative trend post-87.				
Nitrite and Nitrate Nitrogen	+	NS						Increasing overall trend.			100[ls]	100
Total Nitrogen	NS	NS						No trends.	1.0	94.4		
Total Phosphorus	-	-	-	-	NS	-	NS	Downward post-87 trend.	0.05	97.9		
Total Dissolved Phosphorus	-	-	-	NS	NS	-	-	Decreasing post-87 trend.				
Chlorophyll a	NS	NS						No trends.				
Total Coliforms	NS	NS						No trends.			1000/100ml	87.8
Fecal Coliforms	+	+	+	NS	NS	-	-	Declining trend in raw and flow-adjusted post-87 data.	100/100 mL[c]	87.0	100/100ml incl. *E. coli*	87.0
Escherichia coli						NS	NS	Brief record. No trends.	400/100mL[c]	94.6		

*ASWQG = Alberta Surface Water Quality Guideline
**CCMEWQG = Canadian Council of Ministers of the Environment Guideline
Unless otherwise indicated, presented ASWQG and CCMEWQG values relate to the protection of aquatic life.
[a]Chronic exposure guideline based on life stages of aquatic biota.
[b]Calculated as a function of pH and water temperature.
[c]Based on Alberta River Water Quality Index objectives.
[ls]As determined for livestock consumption.
[irr]As determined for irrigation water.
(-) - Decreasing trend, significant at a p-value of 0.05
(+) - Increasing trend, significant at a p-value of 0.05
NS - Not Significant. Any trends not reporting significance at p-value of 0.05.
Crossed out cells indicate that the analysis was not performed. Reasons are explained in the methods section.

Table 7 Water quality trends and guideline comparisons of selected long-term metals data collected from the Oldman River upstream of Lethbridge at Highway **3**, 1966-2005.

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG[*]	CCMEWQG[**]	% Compliance
Dissolved Aluminum						NS	NS	No trend.		100 µg/L[a]	89.8
Dissolved Arsenic	NS	NS	-	NS	NS	NS	NS	Negative step trend in 1987. No monotonic trends.		5 µg/L	98.7
Dissolved Boron						NS	NS	No trend.		500-6000[irr]	100.0
Dissolved Iron			-	ID	ID	-	-	Declining post-87 trend.		300 µg/L	100.0
Dissolved Manganese			-	ID	ID	-	-	Decreasing post-87 trends likely driven by change in MDL.			
Dissolved Selenium						-	-	Downward post-87 trends in raw and flow-adjusted data.		1.0 µg/L	100.0

[*]ASWQG = Alberta Surface Water Quality Guideline
[**]CCMEWQG = Canadian Council of Ministers of the Environment Guideline
Unless otherwise indicated, presented ASWQG and CCMEWQG values relate to the protection of aquatic life.
+/- indicate increasing or decreasing trends, respectively.

[a]Based on pH≥6.5 & [Ca2+]>4 mg/L.
[irr]As determined for irrigation water.
ID - Insufficient integer data (i.e., excessive censorship).
(-) - Decreasing trend, significant at a p-value of 0.05
(+) - Increasing trend, significant at a p-value of 0.05
NS - Not Significant. Any trends not reporting significance at a p-value of 0.05.

Table 8 Water quality trends and guideline comparisons of long-term routine variables data collected from the Oldman River downstream of Lethbridge at Highway **36**, 1966-2005.

Variable	Overall Trend	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Temperature	-	NS	NS					Decreasing trend overall.				
pH	NS	NS						No trends.	6.5-8.5	76.9	6.5-9.0	99.2
Conductivity	NS	NS						No trends.				
Total Alkalinity	NS	NS						No trends.				
Hardness						NS	NS	No trends. Insufficient data pre-1987.				
DO	+	+	+	NS	NS	NS	NS	Overall trend may be a result of step in data.	6.5[a]	98.4		
Turbidity	NS	NS						No trends.				
Non-Filterable Residue	-	-	-	NS	NS	-	-	Declining post-87 trend in raw and adjusted data.				
Total Dissolved Solids						NS	NS	No trends.				
Filterable Residue						NS	NS	No trends.				
Potassium	NS	NS						No trends.				
Sodium	NS	NS						No trends.				
Calcium	-	NS	-	-	NS	NS	NS	Downward trend in raw data prior to 1987.			1000[ls]	100
Magnesium	NS	NS						No trends.				
Flow	NS							No trends.				
Bicarbonate	NS	NS						No trends.				
Carbonate	NS	NS						No trends.				
Chloride	NS	NS						No trends.			100-700[irr]	100
Fluoride	+	+	+	NS	NS	NS	NS	Overall trend likely be a result of step in data.			1.0	100
Sulphate	NS	NS						No trends.				
Silica	-	-	NS					Decreasing overall trend in raw and adjusted data.				
Total Organic Carbon	-	-	-	NS	NS	NS	NS	Trend may be a result of step in data.				
Particulate Organic Carbon	-	-	-	NS	NS	NS	NS	Trend may be a result of step in data.				
Dissolved Organic Carbon	NS	NS						No trends.				

Table 8 Water quality trends and guideline comparisons of long-term routine variables data collected from the Oldman River downstream of Lethbridge at Highway **36**, 1966-2005 (continued).

Variable	Overall Trend	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Particulate Nitrogen	-	-	-	NS	NS	NS	NS	Trend may be a result of step in data.				
Dissolved Nitrogen				NS	NS			Brief record (1978-1987).				
Dissolved Kjeldahl Nitrogen						-	NS	Downward post-87 trend in raw data.				
Total Ammonia Nitrogen	-	-	-	-	NS	-	-	Downward post-87 trend in raw and adjusted data.			0.042-18.5[b]	100
Total Kjeldahl Nitrogen	-	-	-	ID	ID	-	-	Negative post-87 trend in raw and adjusted data.				
Nitrite and Nitrate Nitrogen	NS	-	NS					Declining overall trend in flow-adjusted data.			100[ls]	100
Total Nitrogen	-	NS	NS					Downward overall trend in raw data.	1.0	89.0		
Total Phosphorus	-	-	-	NS	NS	-	-	Downward post-87 trend in raw and adjusted data.	0.05	98.3		
Total Dissolved Phosphorus	-	-	-	+	+	-	-	Negative post-87 trend in raw and adjusted data.				
Chlorophyll a	NS	-	-	ID	ID	NS	NS	No trends.				
Total Coliforms	NS	NS						No trends.			1000/100ml	84.5
Fecal Coliforms	-	-	NS					Decreasing overall trend in raw and flow-adjusted data.	100/100 mL[c]	78.5	100/100ml incl. E. coli	78.5
Escherichia coli						-	-	Declining post-87 trends.	400/100mL[c]	95.3		

*ASWQG = Alberta Surface Water Quality Guideline
**CCMEWQG = Canadian Council of Ministers of the Environment Guideline
Unless otherwise indicated, presented ASWQG and CCMEWQG values relate to the protection of aquatic life.
[a]Chronic exposure guideline based on life stages of aquatic biota.
[b]Calculated as a function of pH and water temperature.
[c]Based on Alberta River Water Quality Index objectives.
[ls]As determined for livestock consumption.
[irr]As determined for irrigation water.
NS - Not Significant. Any trends not reporting significance at a p-value of 0.05.
ID - Insufficient Data to complete a trend analysis.
(-) - Decreasing trend, significant at a p-value of 0.05.
(+) - Increasing trend, significant at a p-value of 0.05.

Table 9 Water quality trends and guideline comparisons of selected long-term metals data collected from the Oldman River downstream of Lethbridge at Highway **36**, 1966-2005.

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	CCMEWQG**	% Compliance
Dissolved Aluminum						NS	NS	No trend. Excessive censorship in pre-87 data.		100 µg/L[a]	96.8
Dissolved Arsenic	-	NS	-	NS	NS	-	-	Downward post-87 trend in raw and adjusted data.		5 µg/L	99.4
Dissolved Boron						-	-	Downward post-87 trend in raw and adjusted data.		500-6000[irr]	100.0
Dissolved Iron			-	ID	ID	NS	NS	Negative step. No monotonic trends.		300 µg/L	98.5
Dissolved Manganese			-	ID	ID	-	-	Decreasing post-87 trends likely driven by change in MDL.			
Dissolved Selenium						-	-	Declining post-87 trend in raw and adjusted data.		1.0 µg/L	98.7

*ASWQG = Alberta Surface Water Quality Guideline

**CCMEWQG = Canadian Council of Ministers of the Environment Guideline

Unless otherwise indicated, presented ASWQG and CCMEWQG values relate to the protection of aquatic life.

[a]Based on pH≥6.5 & [Ca2+]>4 mg/L.

[b]Based on hardness of 60-200 mg/L CaCO3.

[irr]As determined for irrigation water.

ID - Insufficient integer data (i.e., excessive censorship).

NS - Not Significant. Any trends not reporting significance at a p-value of 0.05.

(-) - Decreasing trend, significant at a p-value of 0.05.

(+) - Increasing trend, significant at a p-value of 0.05.

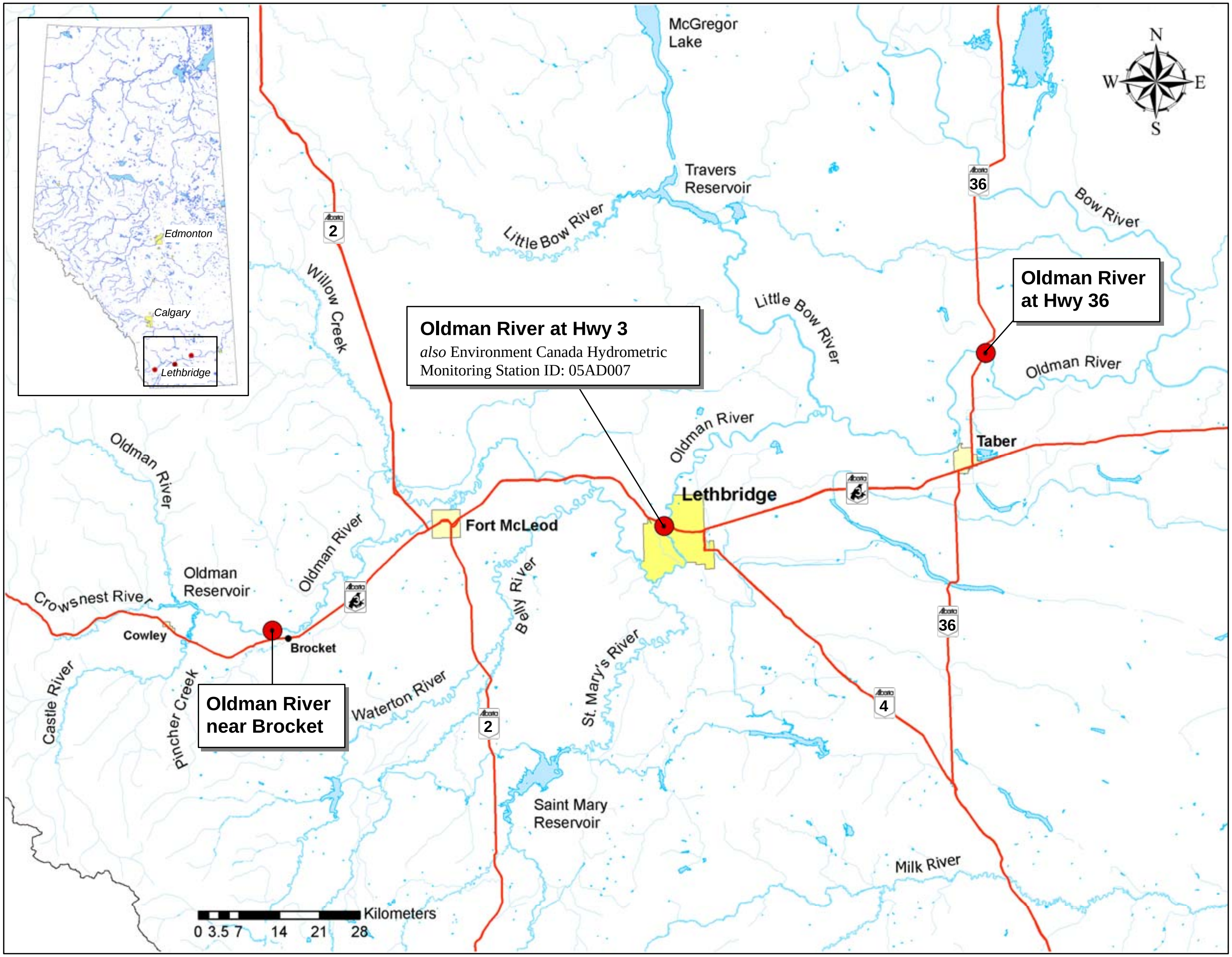


Figure 1 Long-Term River Network monitoring stations situated on the Oldman River in Southern Alberta.

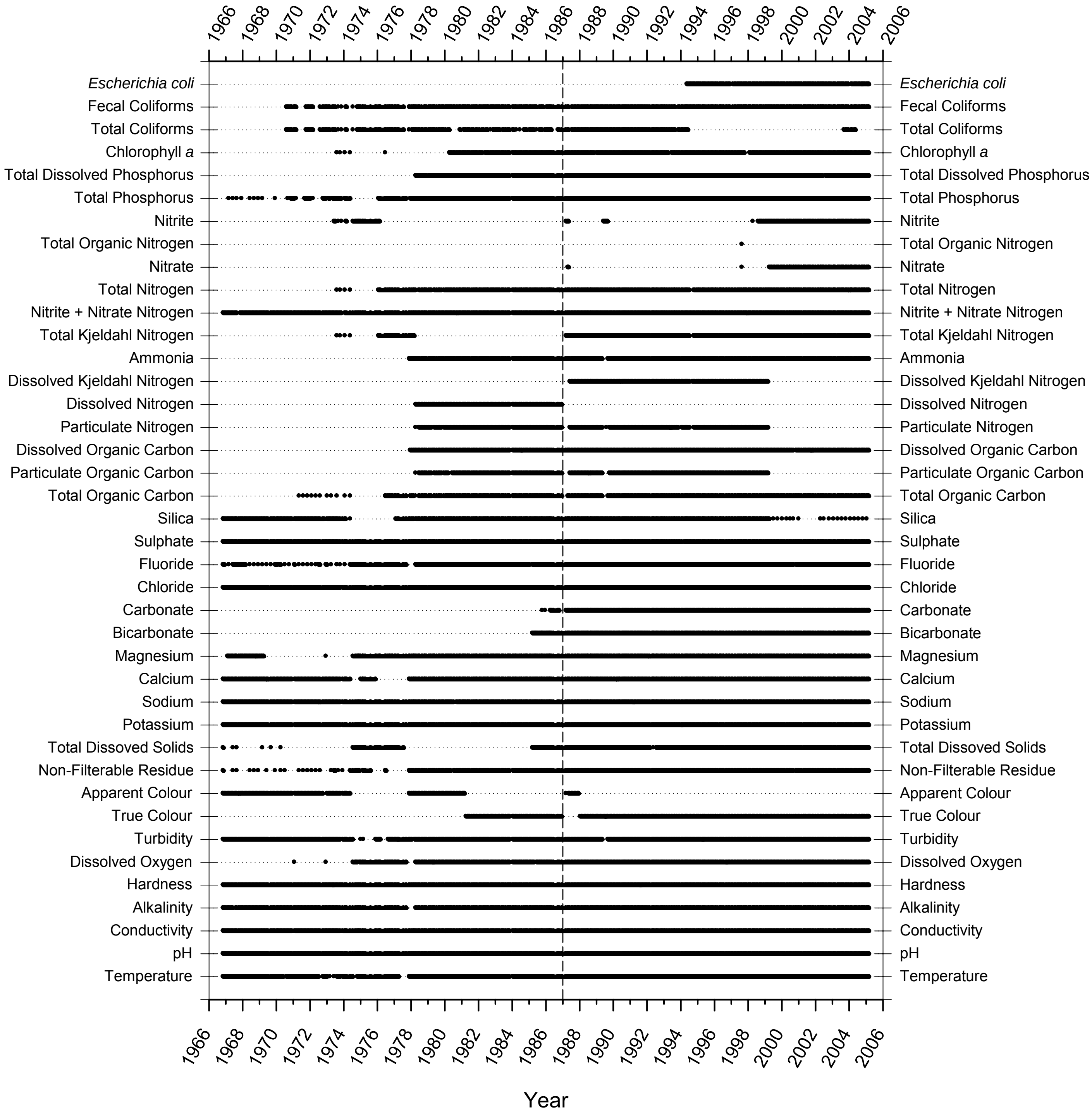


Figure 2 Data continuity for routine water quality variables sampled in the Oldman River at the Highway **3** site, upstream of Lethbridge. Each point on the graph represents a measured value for the associated variable at that point in time. The hashed vertical line represents a change in sampling agencies (from Environment Canada to Alberta Environment).

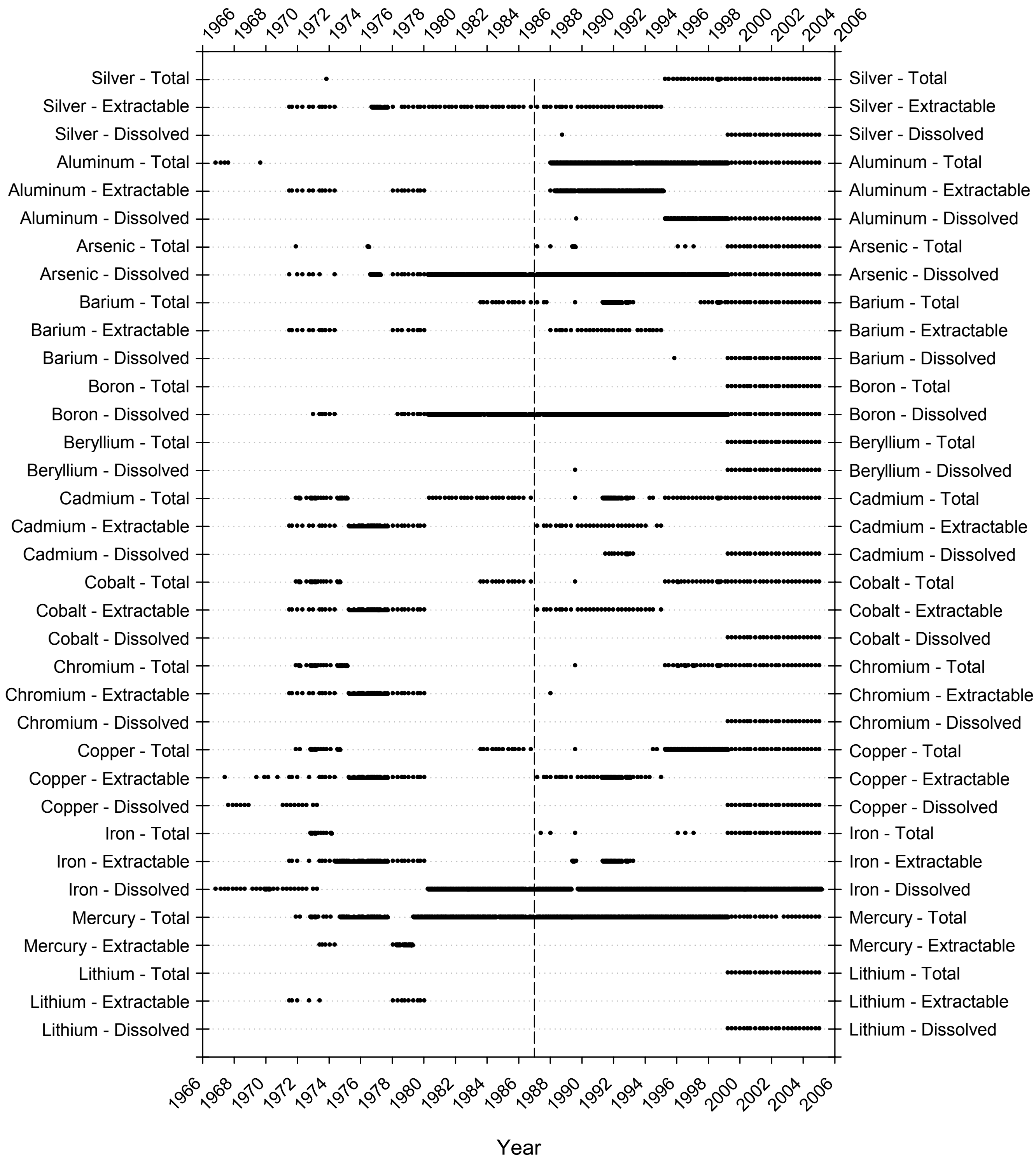


Figure 3 Data continuity for metal fractions sampled in the Oldman River at the Highway **3** site, upstream of Lethbridge. Each point on the graph represents a measured value for the associated variable at that point in time. The hashed vertical line represents a change in sampling agencies (from Environment Canada to Alberta Environment).

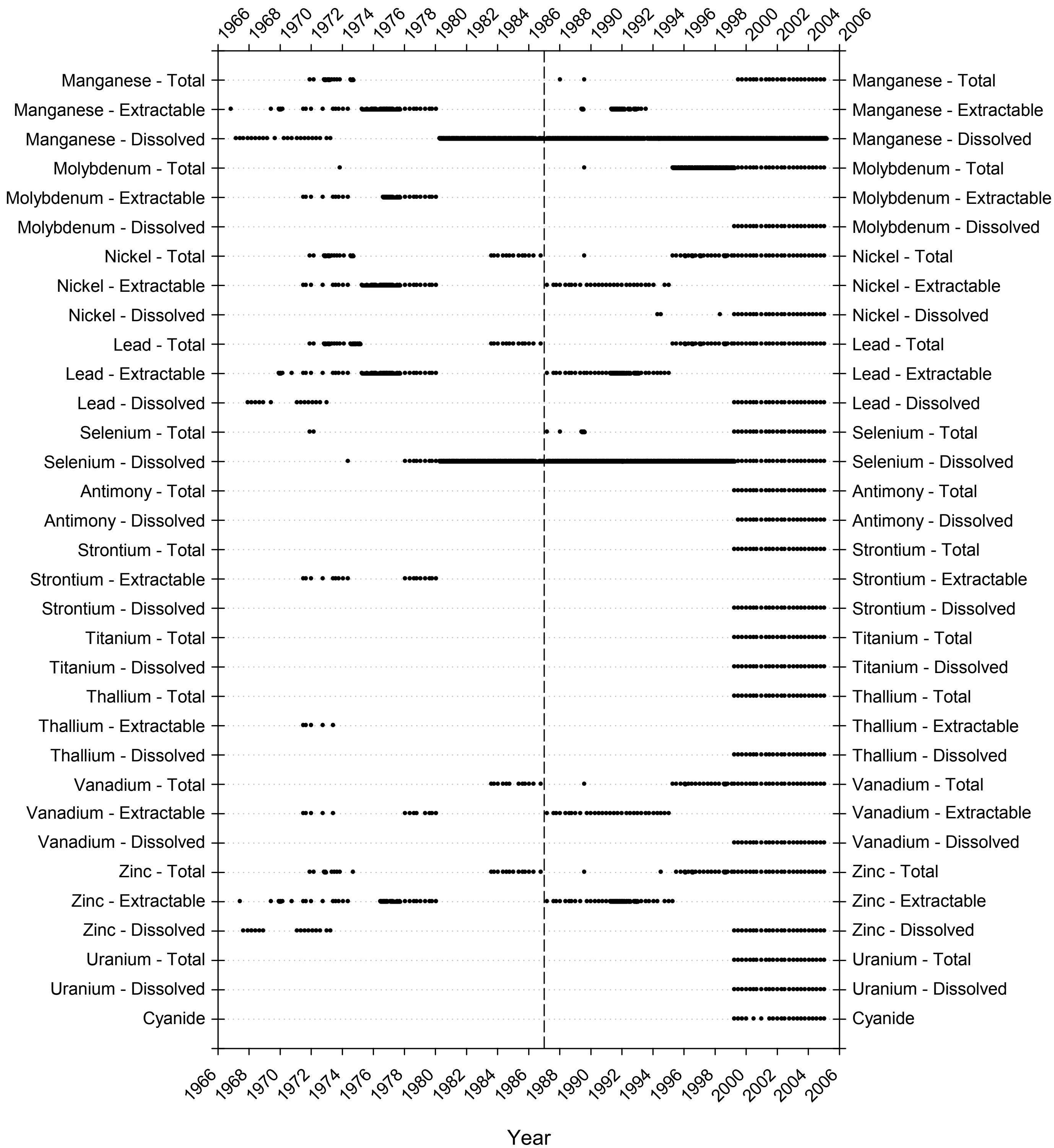


Figure 3 Data continuity for metal fractions sampled in the Oldman River at the Highway **3** site, upstream of Lethbridge. Each point on the graph represents a measured value for the associated variable at that point in time. The hashed vertical line represents a change in sampling agencies (from Environment Canada to Alberta Environment).

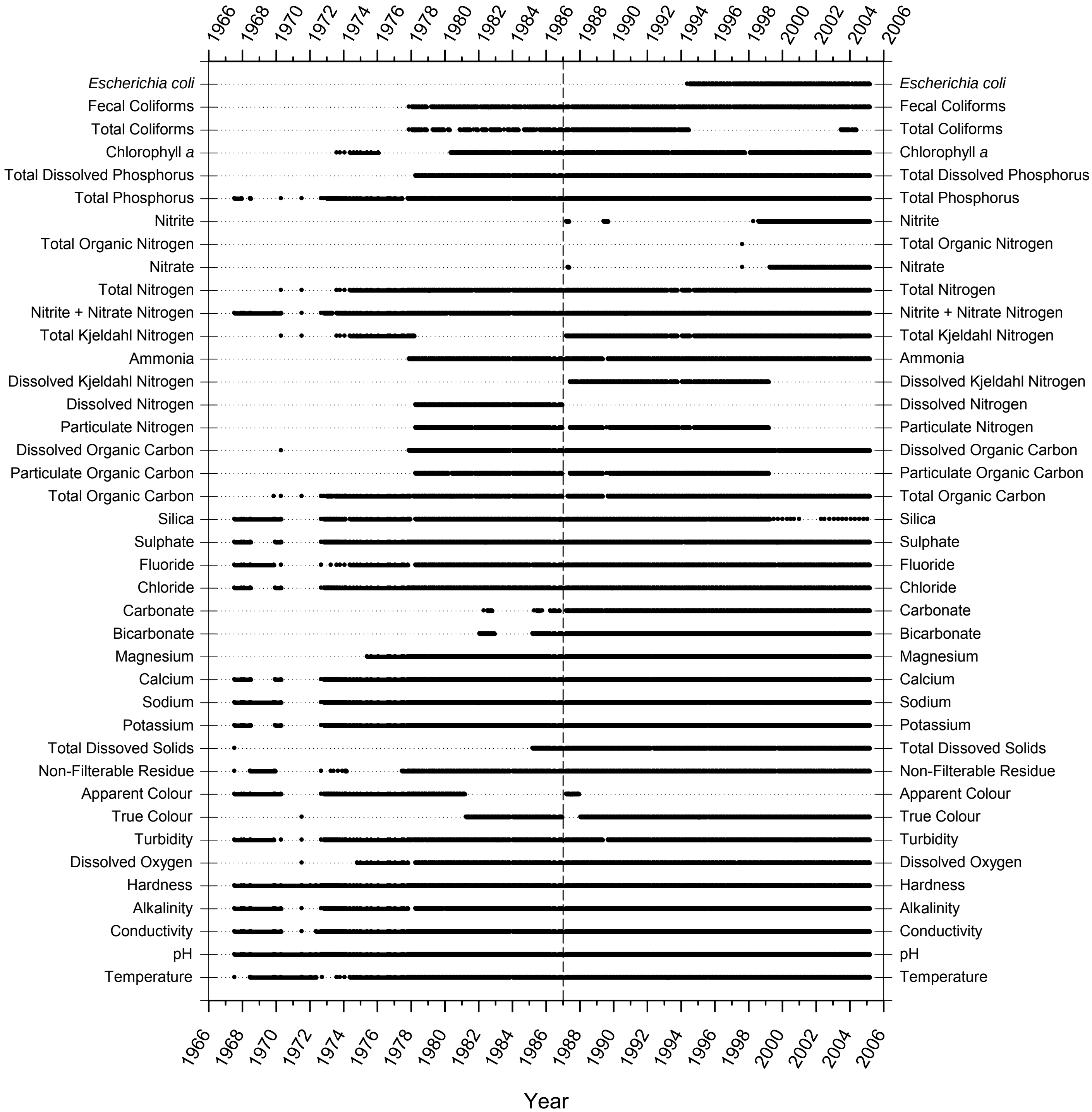


Figure 4 Data continuity for routine water quality variables sampled in the Oldman River at the Highway **36** site, downstream of Lethbridge. Each point on the graph represents a measured value for the associated variable at that point in time. The hashed vertical line represents a change in sampling agencies (from Environment Canada to Alberta Environment).

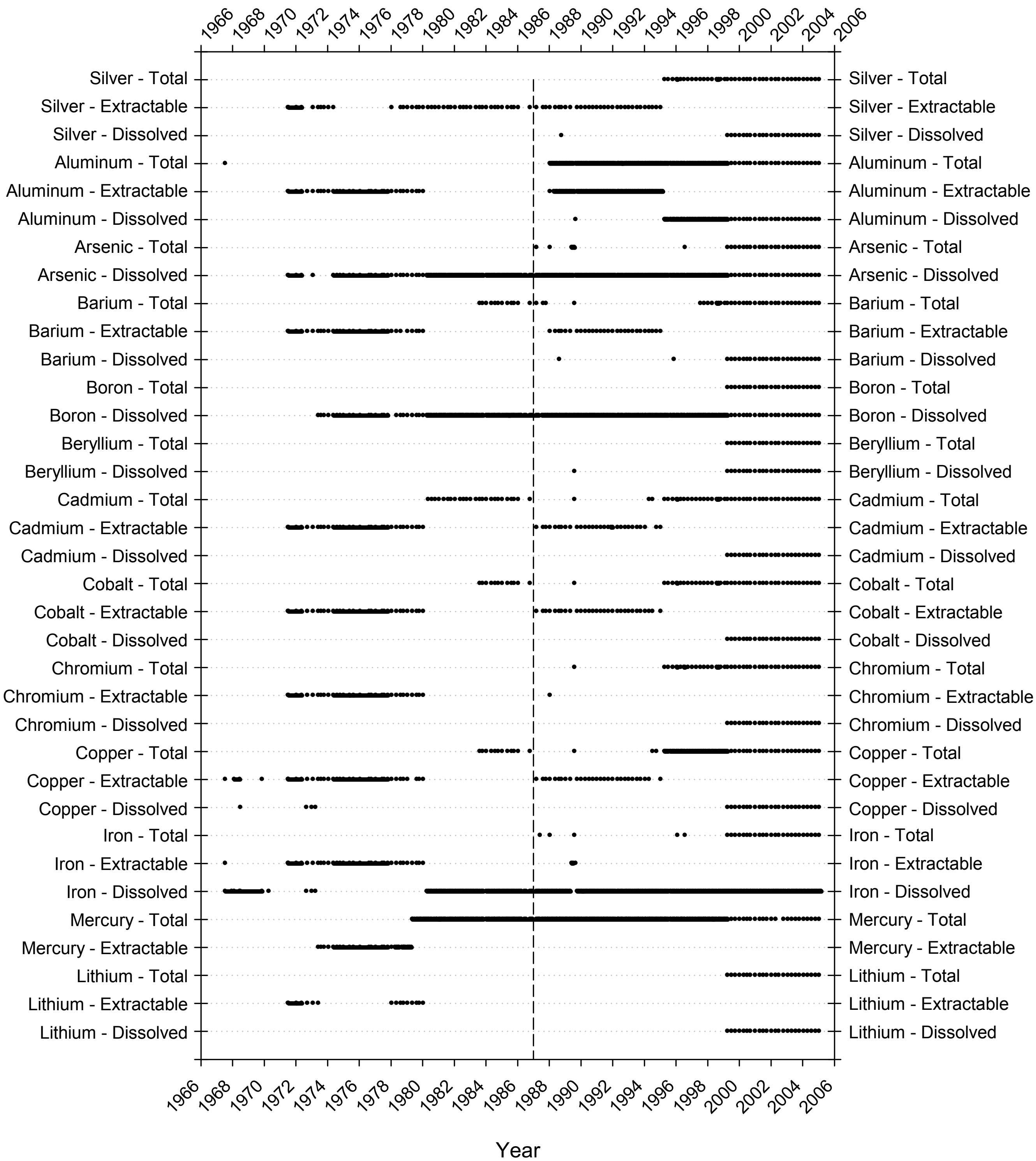


Figure 5 Data continuity for metal fractions sampled in the Oldman River at the Highway **36** site, downstream of Lethbridge. Each point on the graph represents a measured value for the associated variable at that point in time. The hashed vertical line represents a change in sampling agencies (from Environment Canada to Alberta Environment).

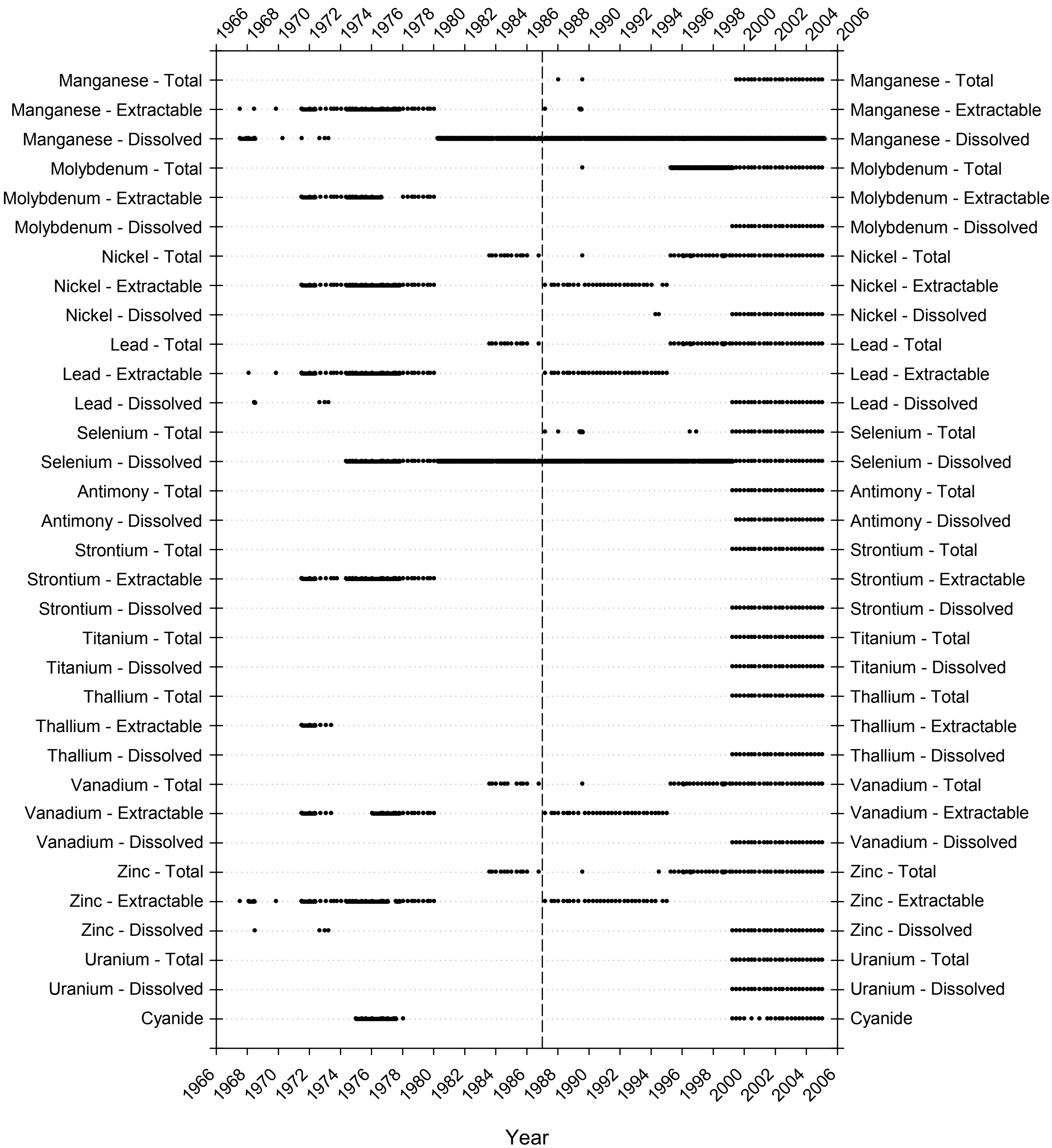


Figure 5 Data continuity for metal fractions sampled in the Oldman River at the Highway **36** site, downstream of Lethbridge. Each point on the graph represents a measured value for the associated variable at that point in time. The hashed vertical line represents a change in sampling agencies (from Environment Canada to Alberta Environment).

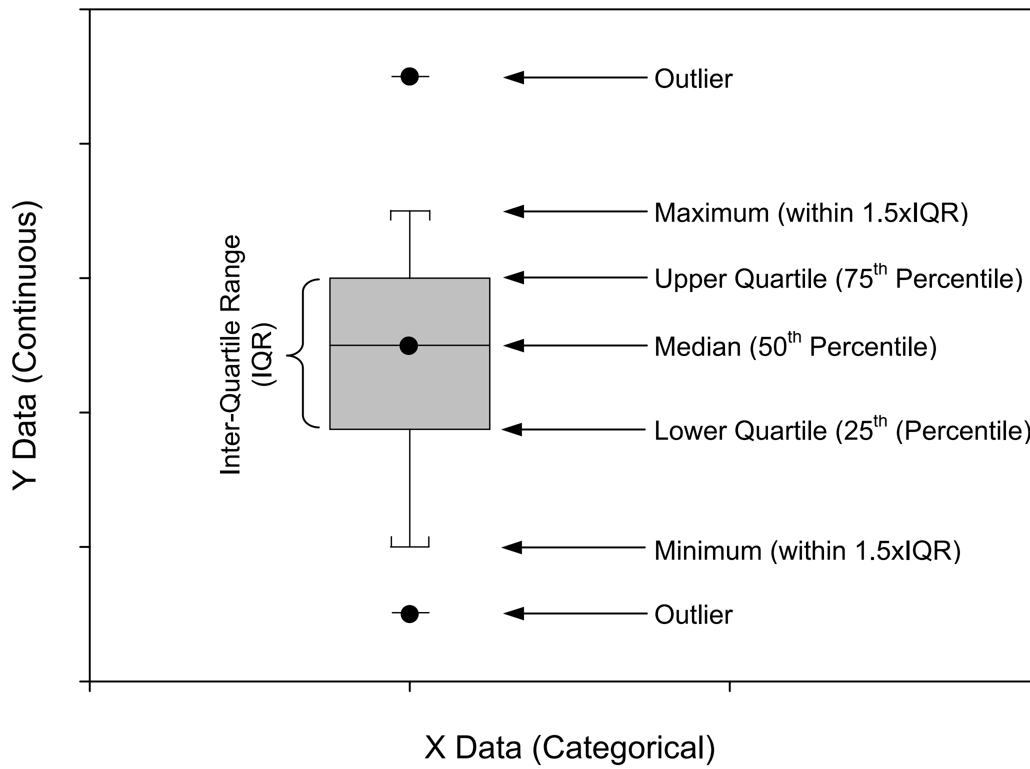


Figure 6 Key to box and whisker plot components.

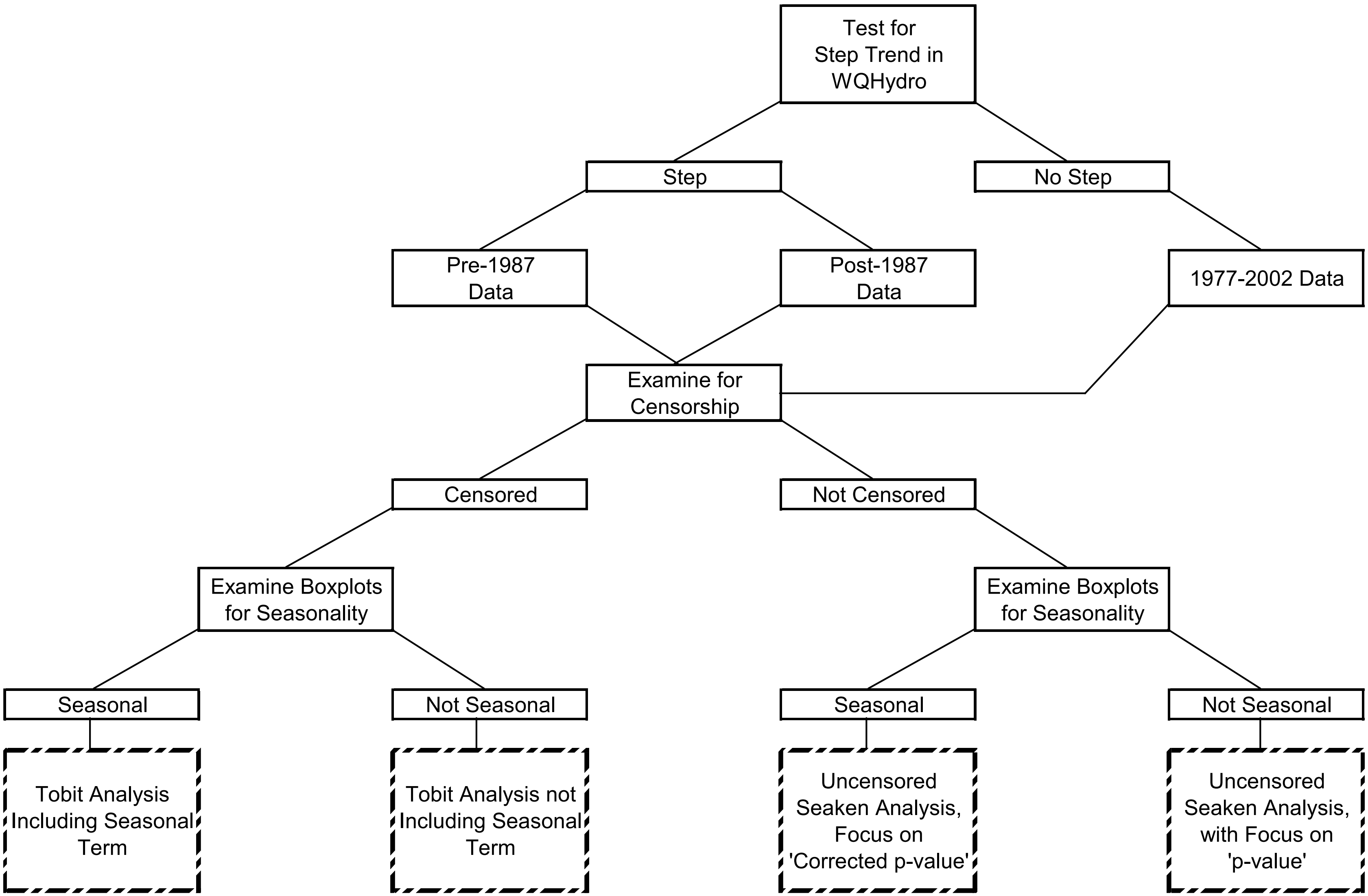
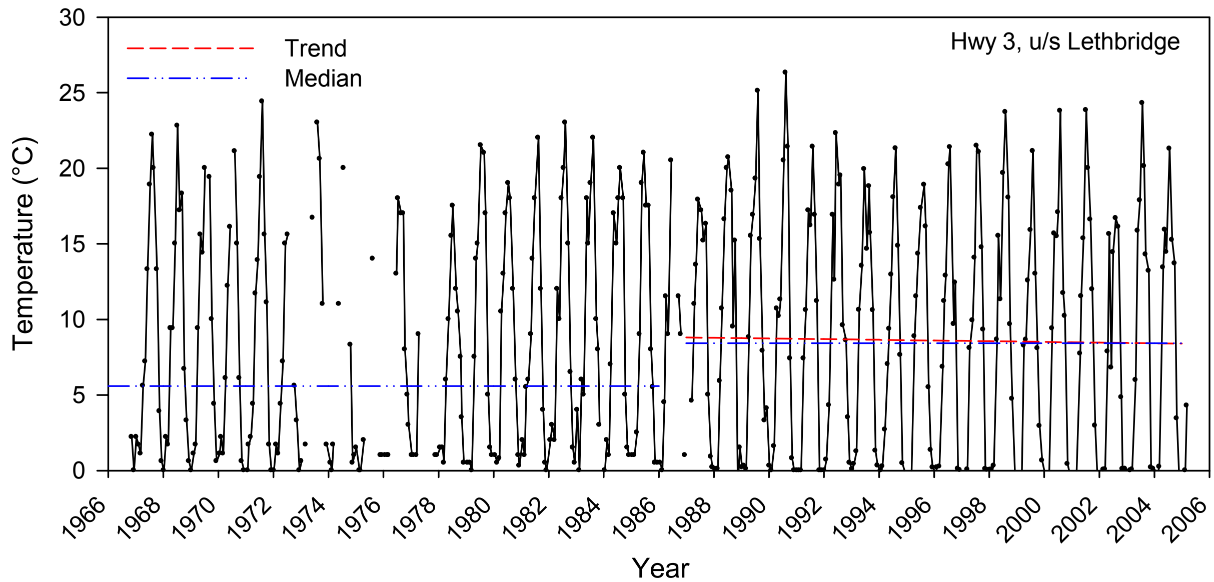
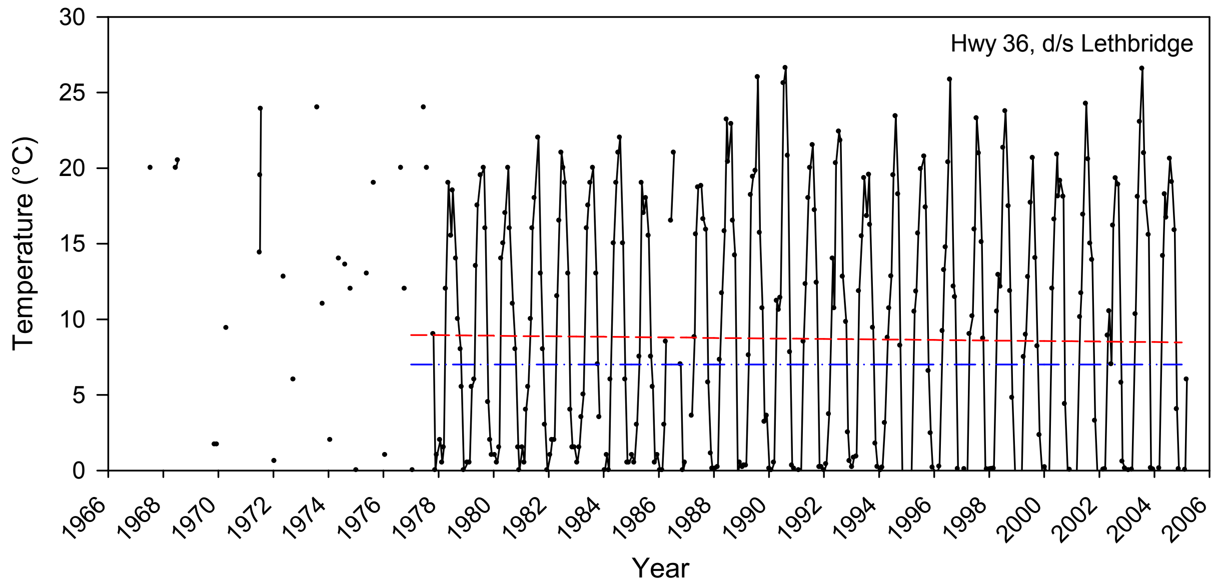


Figure 7 Flow diagram depicting the process used to identify the appropriate trend analysis to apply for each variable at each long-term sampling location.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0220	Down	***	5.60	0.0000	NS	8.43	-0.0229	Down
Flow Adjusted								
-0.0148	NS			0.0665	NS		-0.0336	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.2059	Down	NS	7.75			8.98		
Flow Adjusted								
-0.0377	NS							

Figure 8 Water temperature in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 through 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

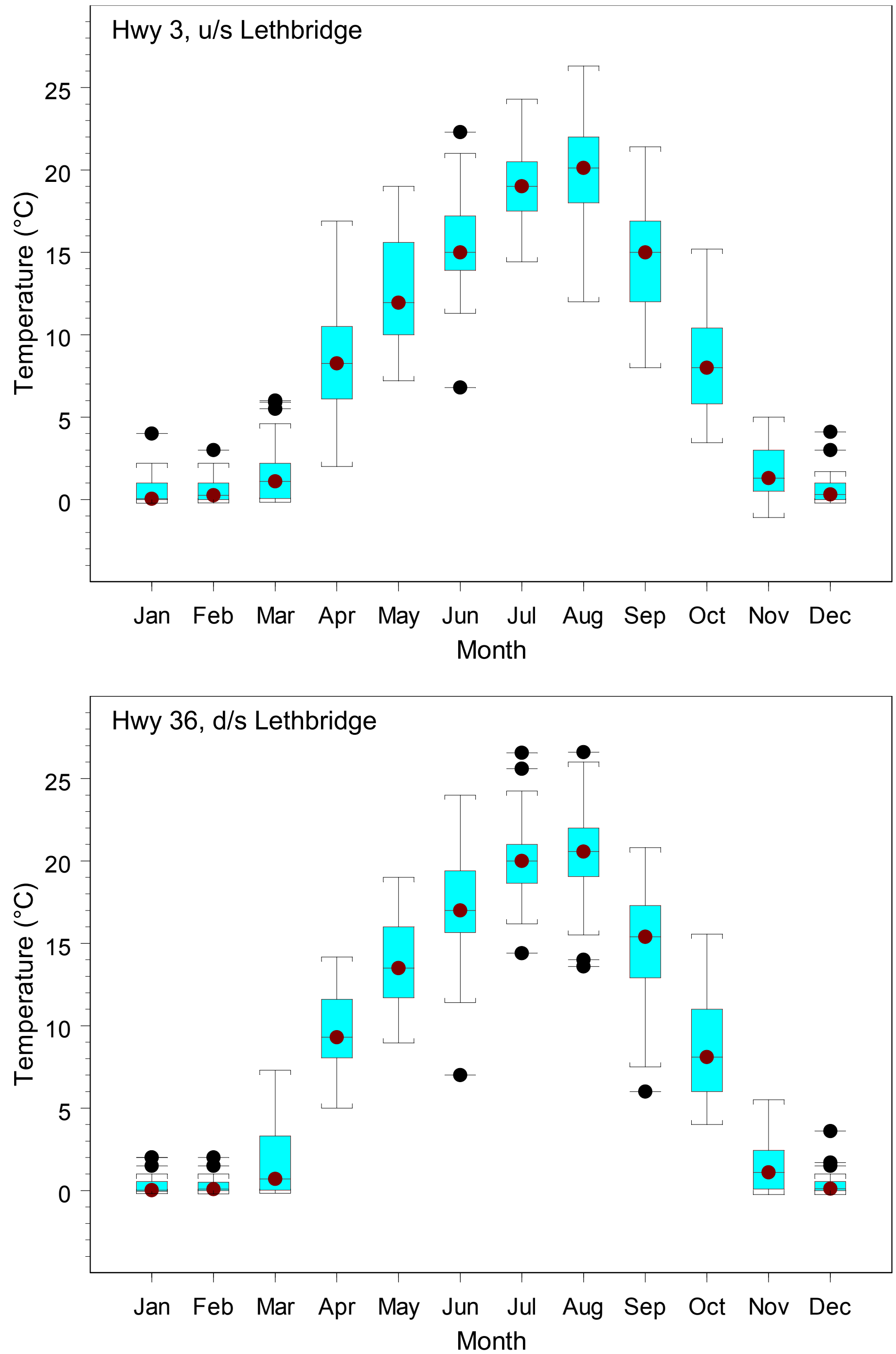
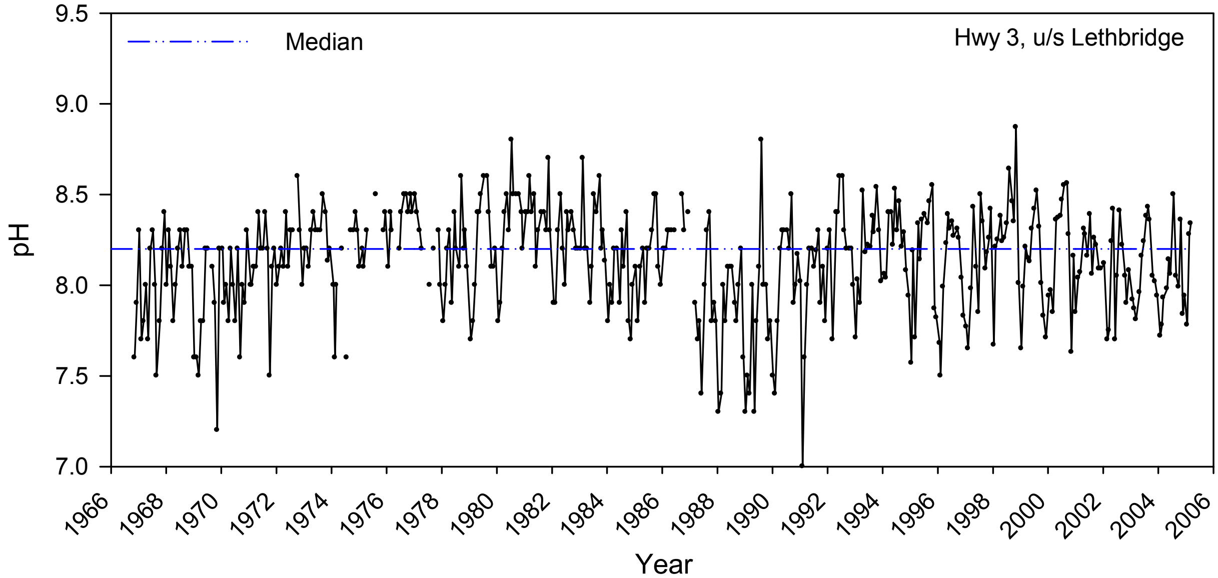
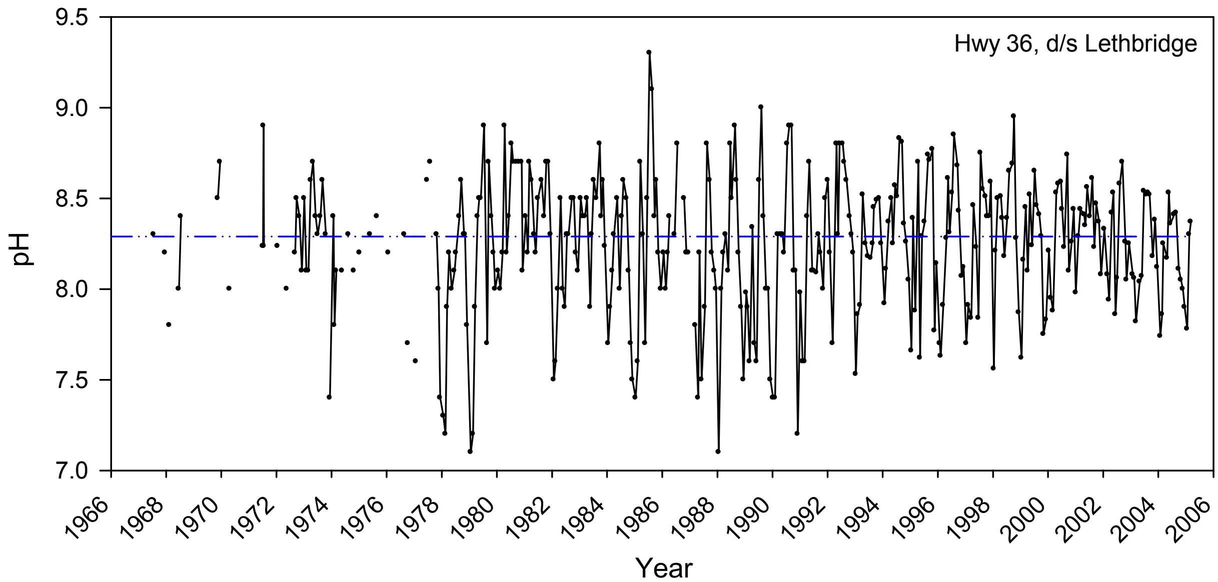


Figure 9 Seasonality of Water Temperature data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0011	NS	***	8.20			8.10		
Flow Adjusted								
-0.0020	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0009	NS		8.30			8.26		
Flow Adjusted								
-0.0377	NS							

Figure 10 pH in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

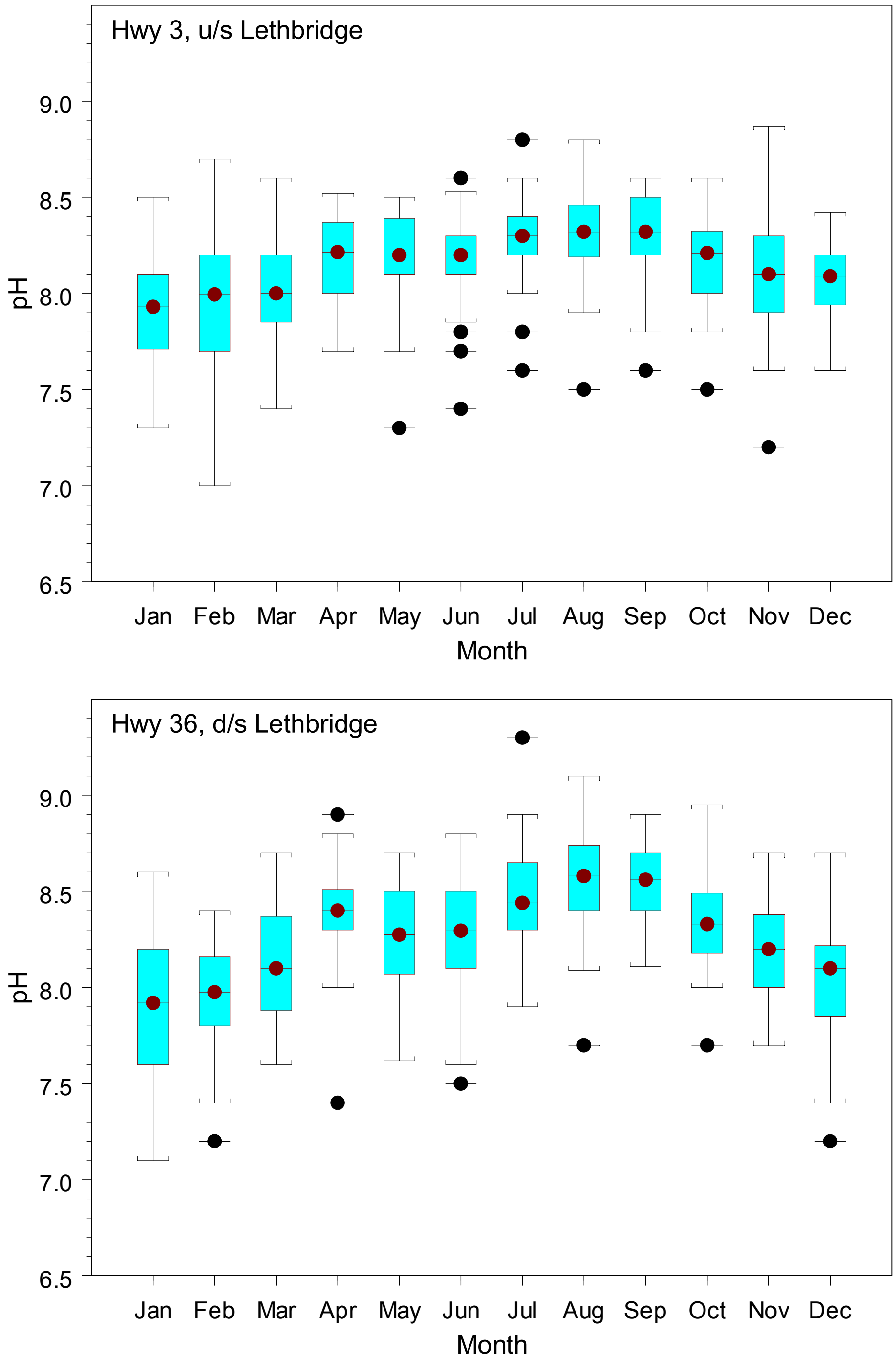
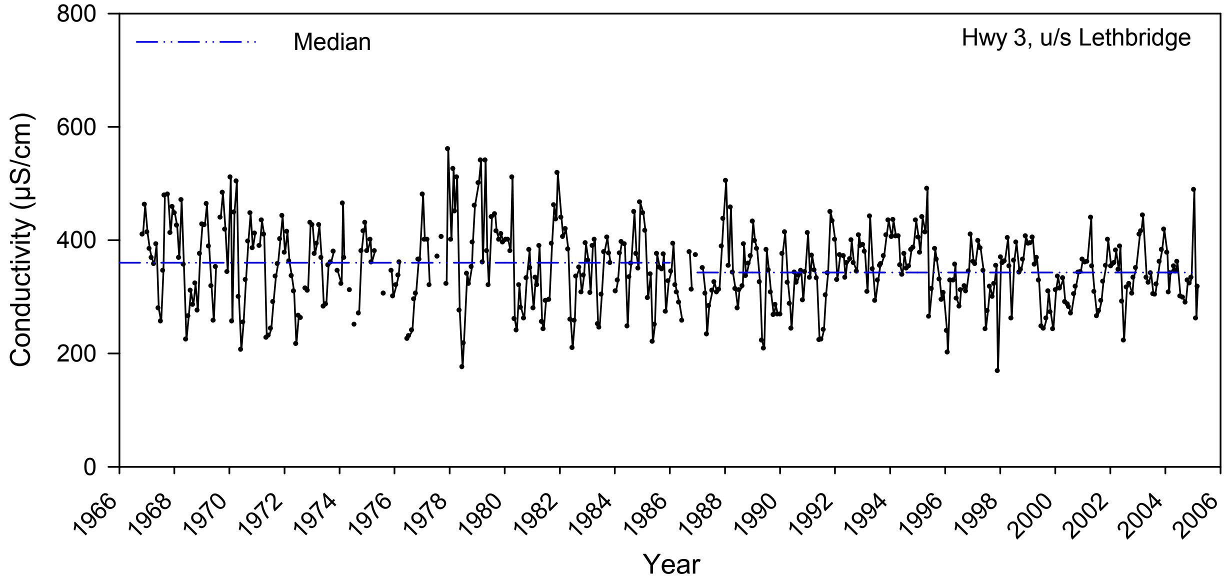
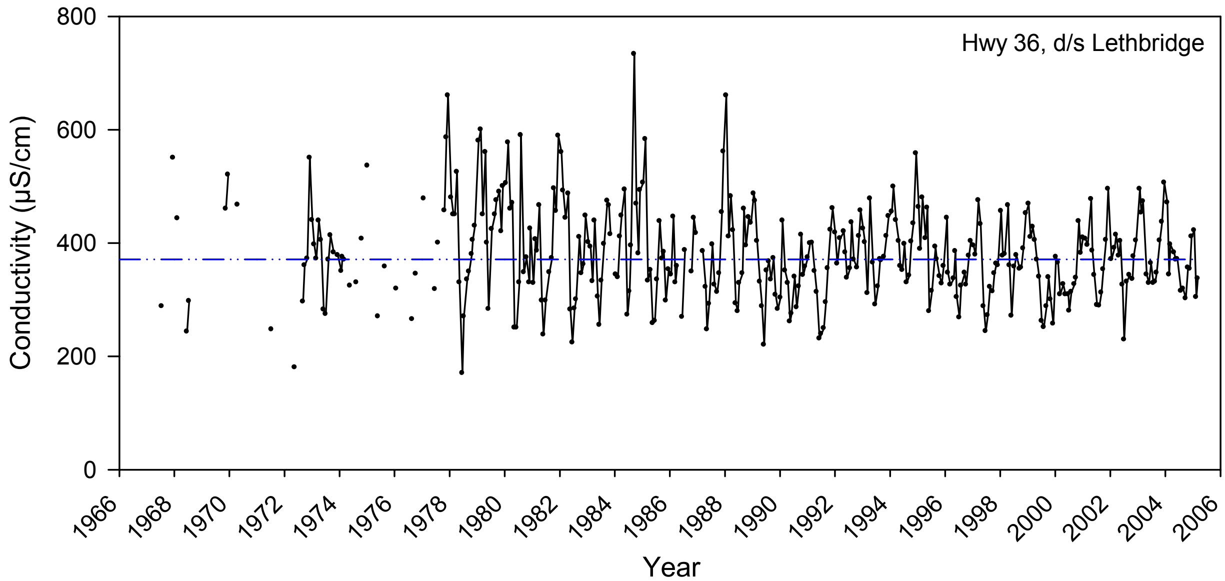


Figure 11 Seasonality of pH data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.6286	NS	**	360.00	-1.0000	NS	343.00	-1.2071	NS
Flow Adjusted								
-0.8265	Down			-2.3697	Down		-0.9787	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-1.0635	NS		386.50			363.50		
Flow Adjusted								
-1.0620	NS							

Figure 12 Specific Conductance in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

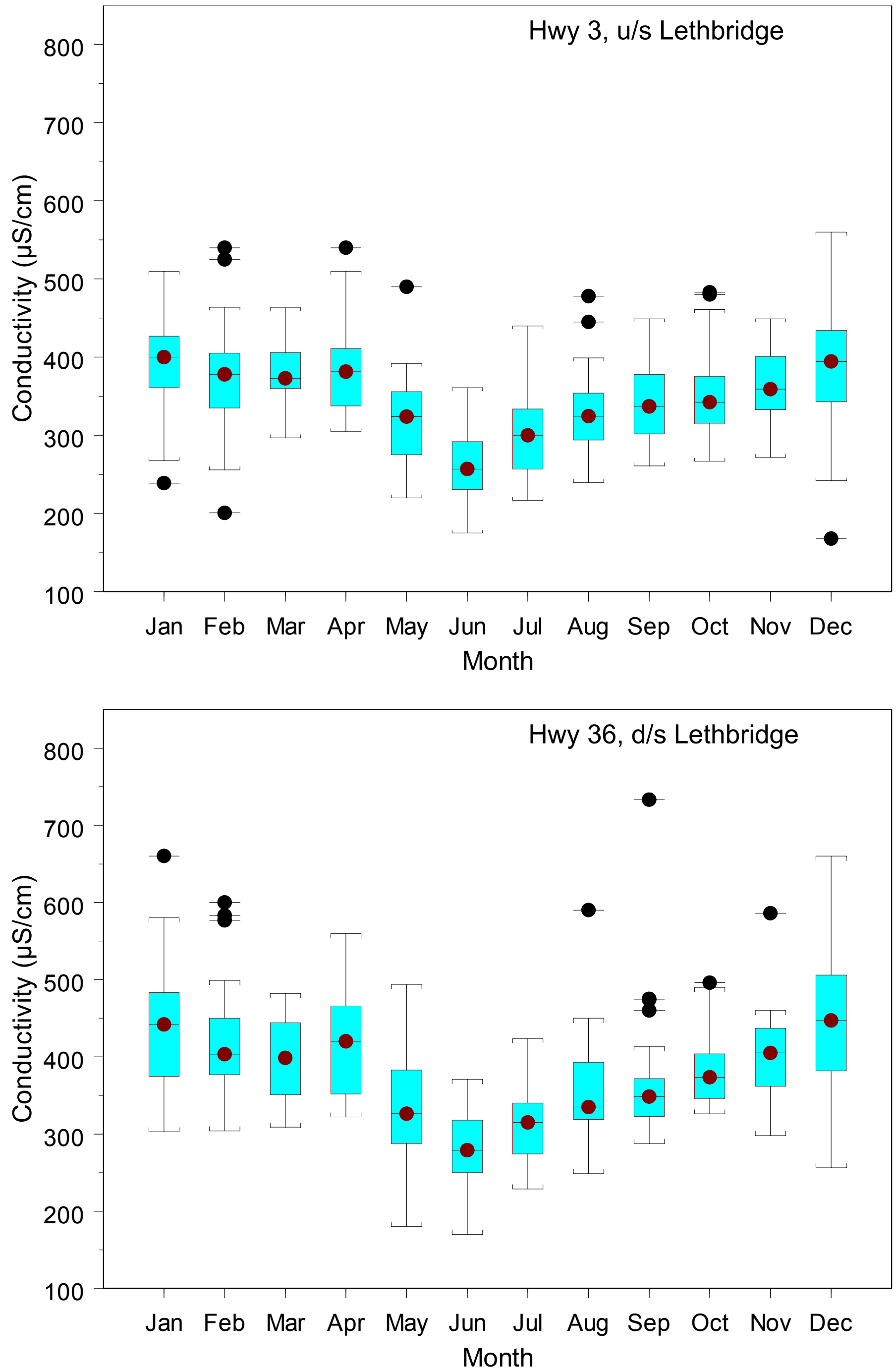
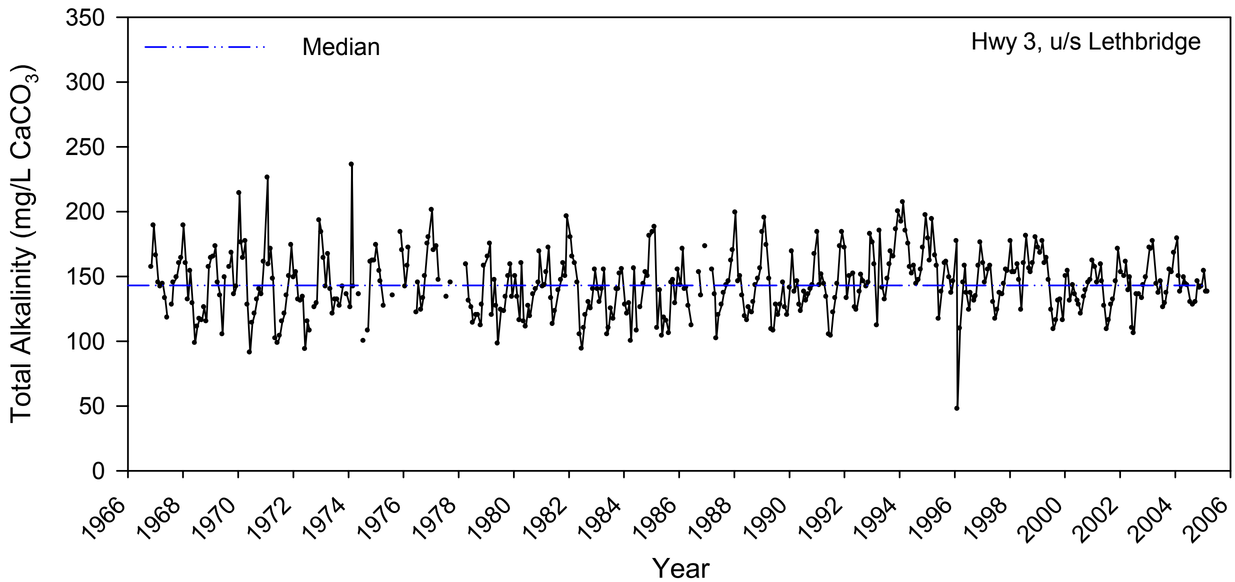
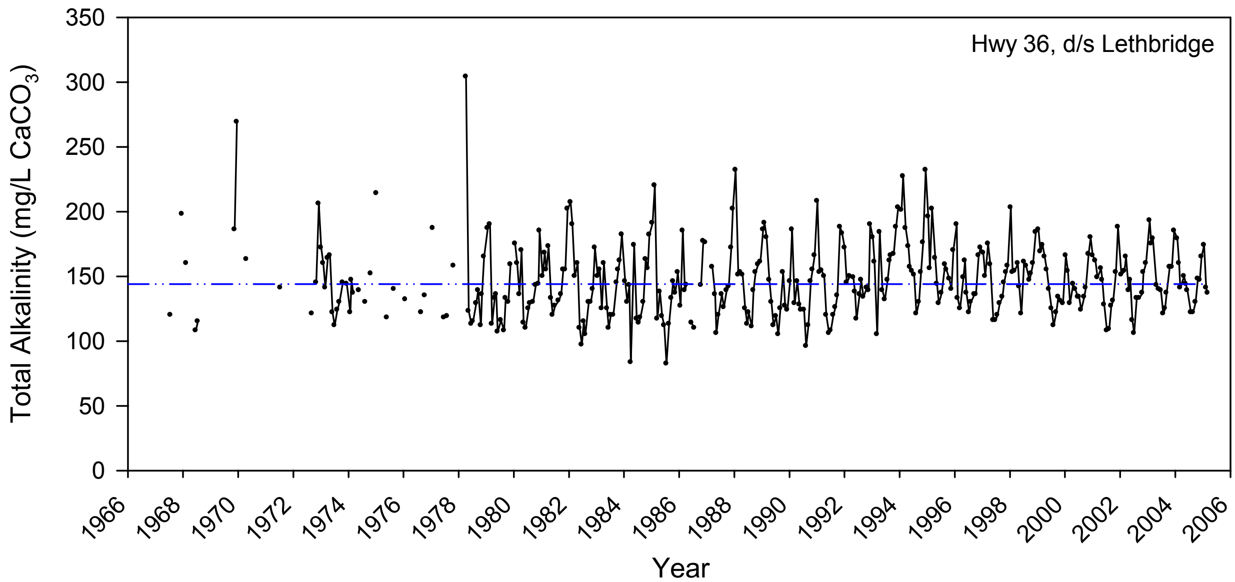


Figure 13 Seasonality of Specific Conductance in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.2222	NS		140.00			145.00		
Flow Adjusted								
0.0915	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.2352	NS		138.50			147.00		
Flow Adjusted								
0.2028	NS							

Figure 14 Total Alkalinity in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

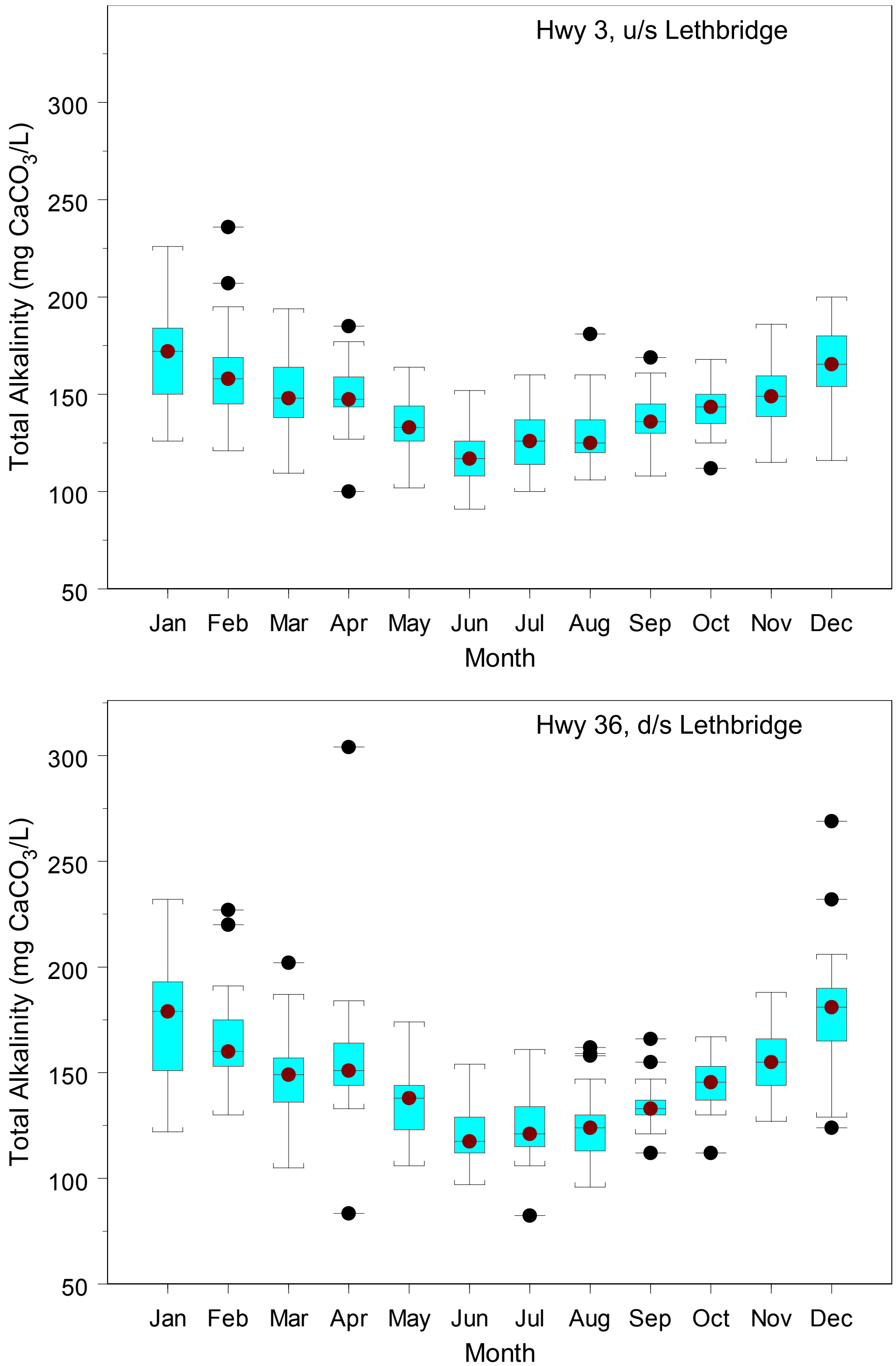
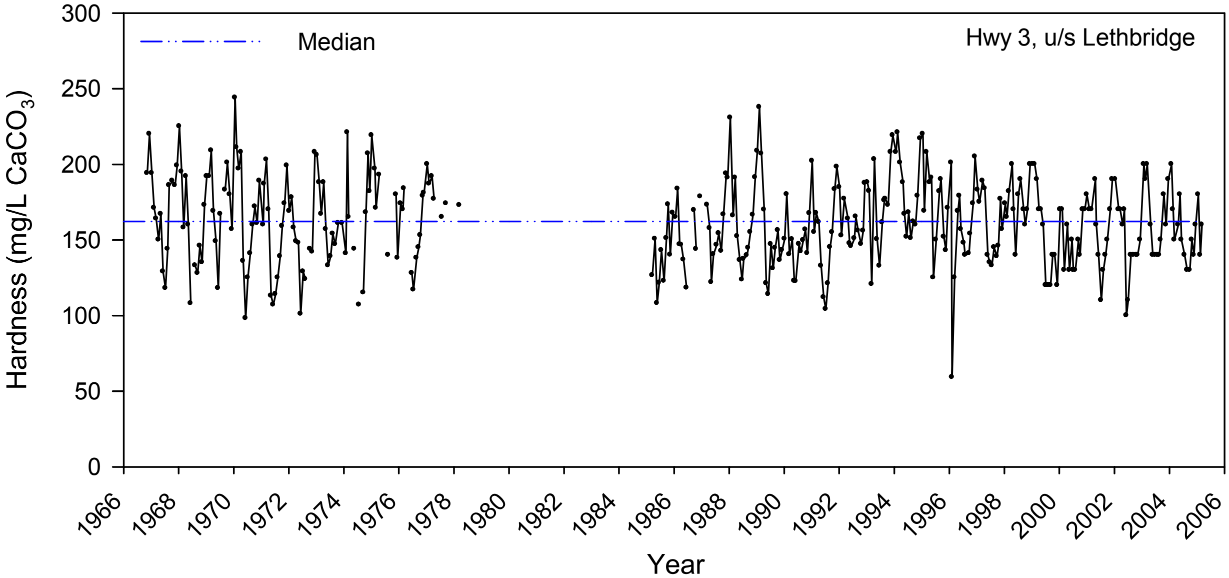
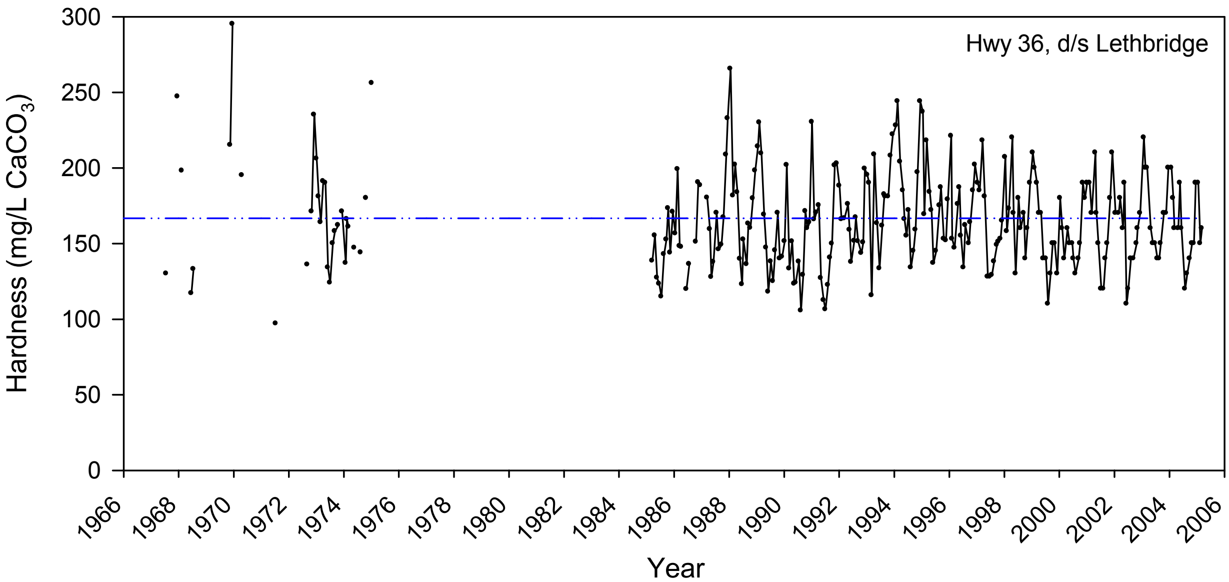


Figure 15 Seasonality of water Total Alkalinity in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
			165.00	-0.7500	NS	160.00	-0.3451	NS
Flow Adjusted								
				-1.0505	NS		-0.3489	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS		158.00			160.93	-0.3507	NS
Flow Adjusted								
-0.1668	NS						-0.2863	NS

Figure 16 Hardness in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

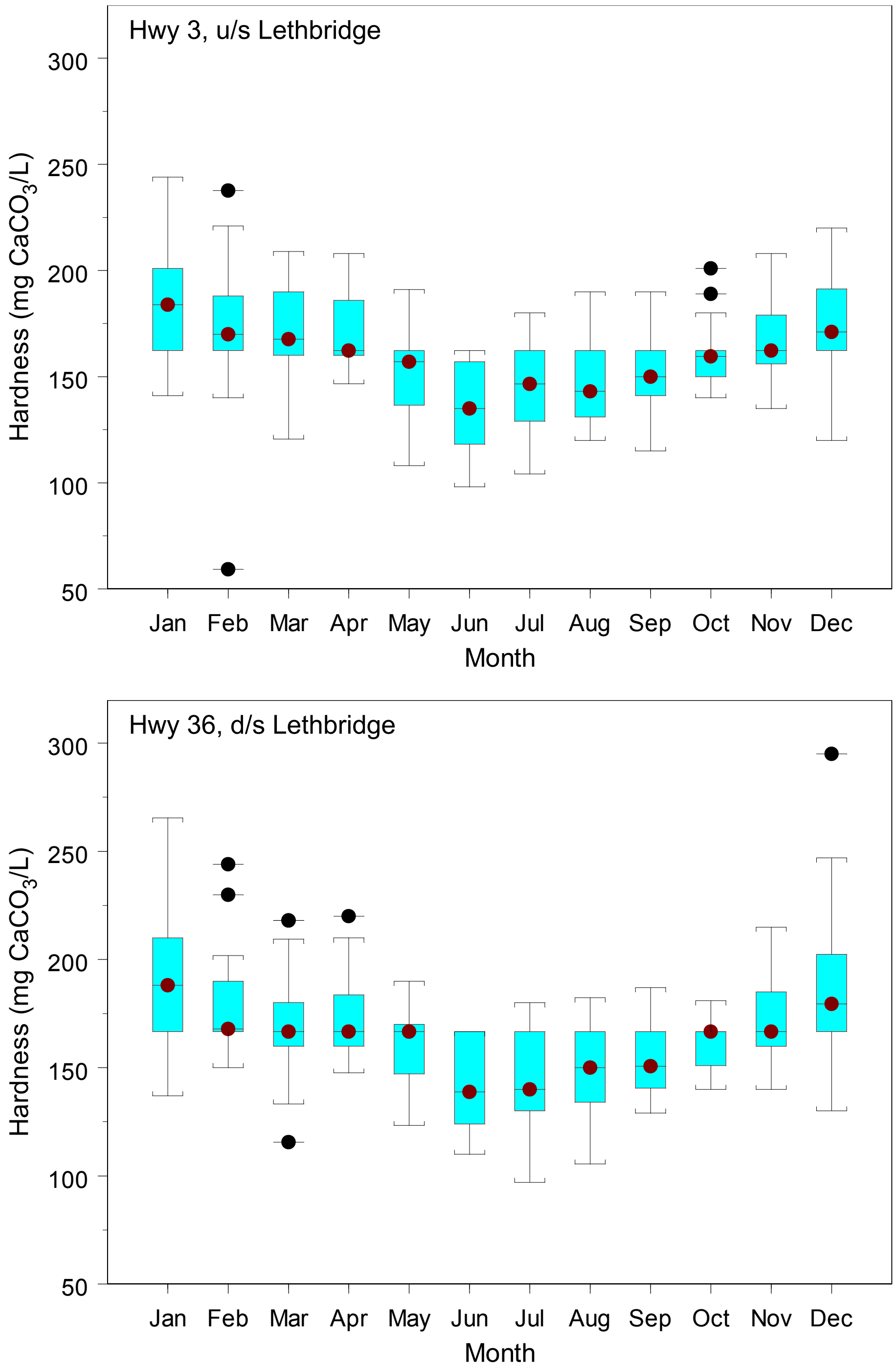
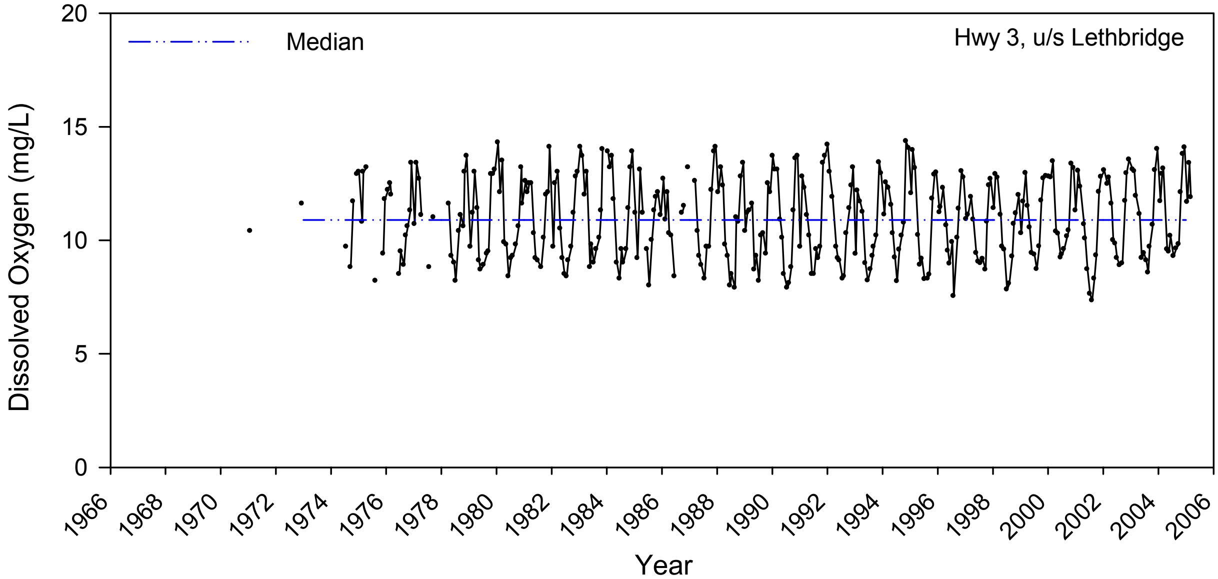
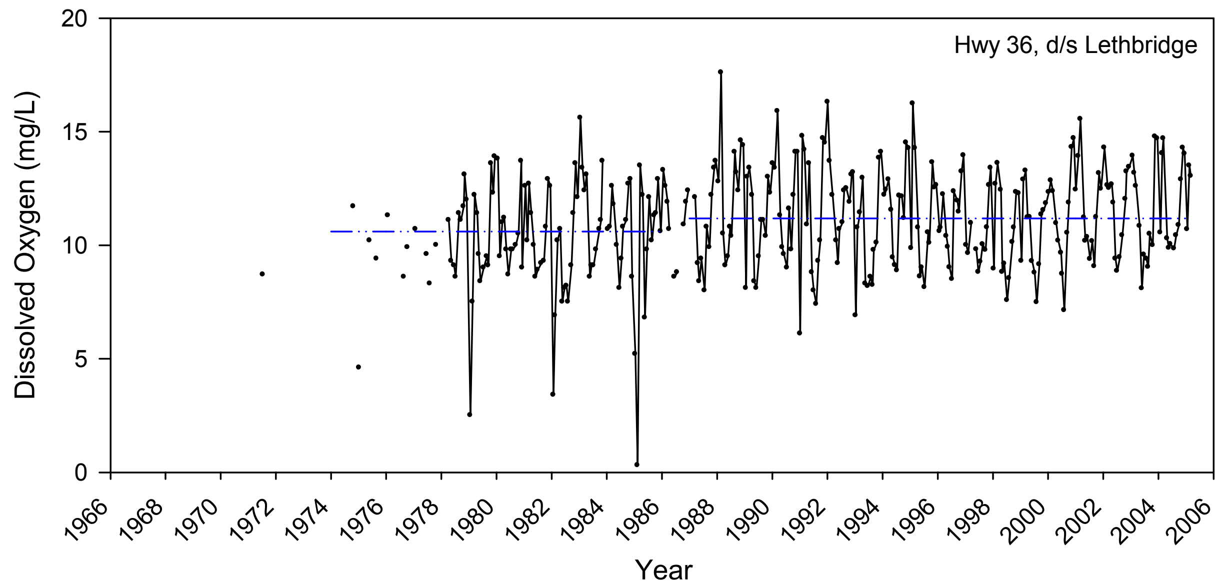


Figure 17 Seasonality of Hardness data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS		11.10			10.78		
Flow Adjusted								
0.0008	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0305	Up	***	10.60	0.0250	NS	11.18	0.0000	NS
Flow Adjusted								
0.0299	Up			-0.0341	NS		-0.0202	NS

Figure 18 Dissolved Oxygen concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

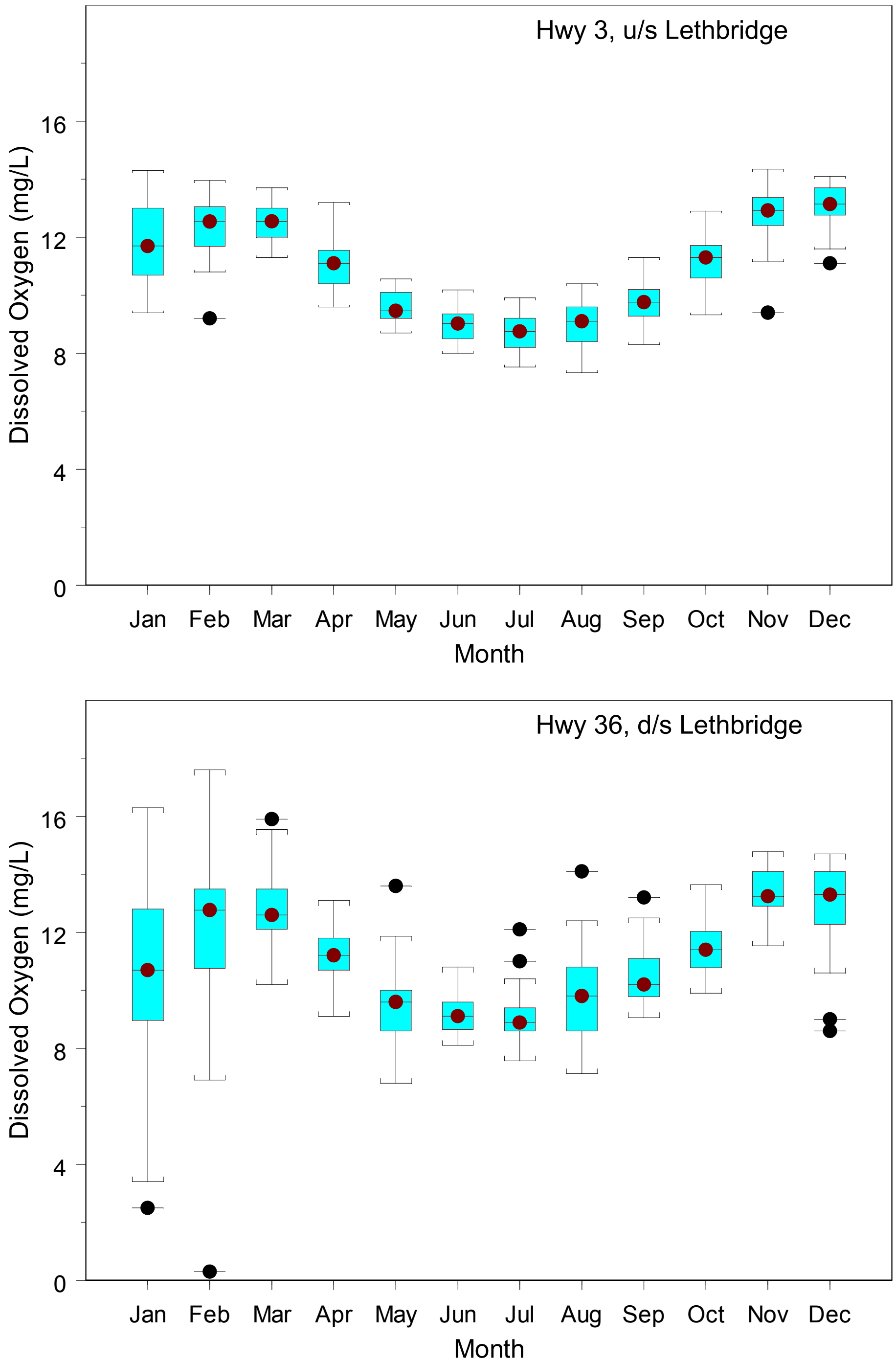
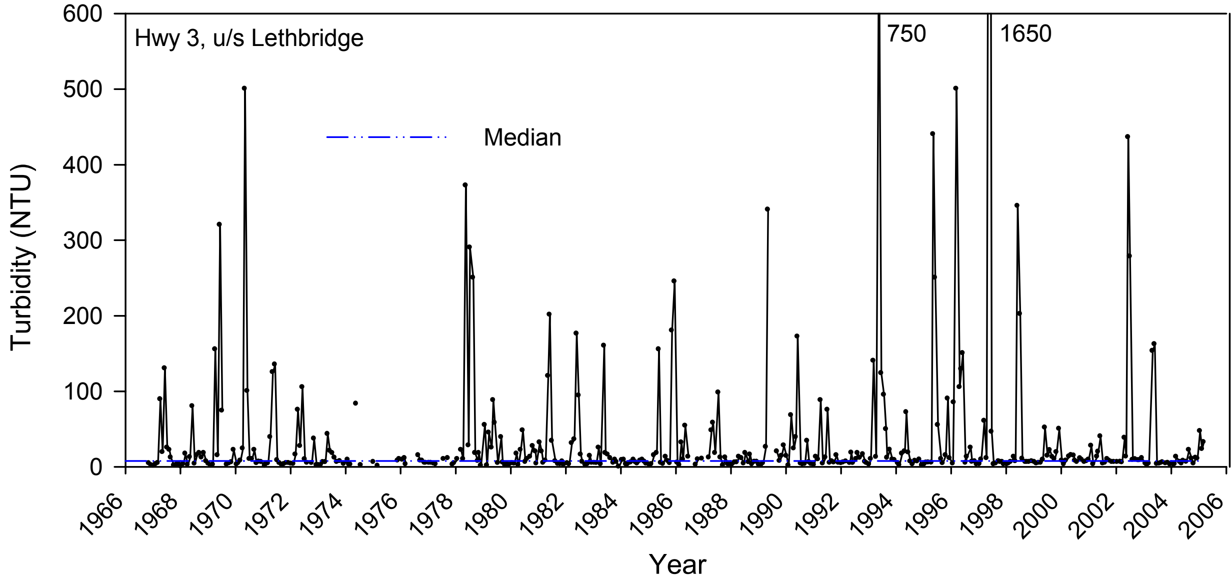
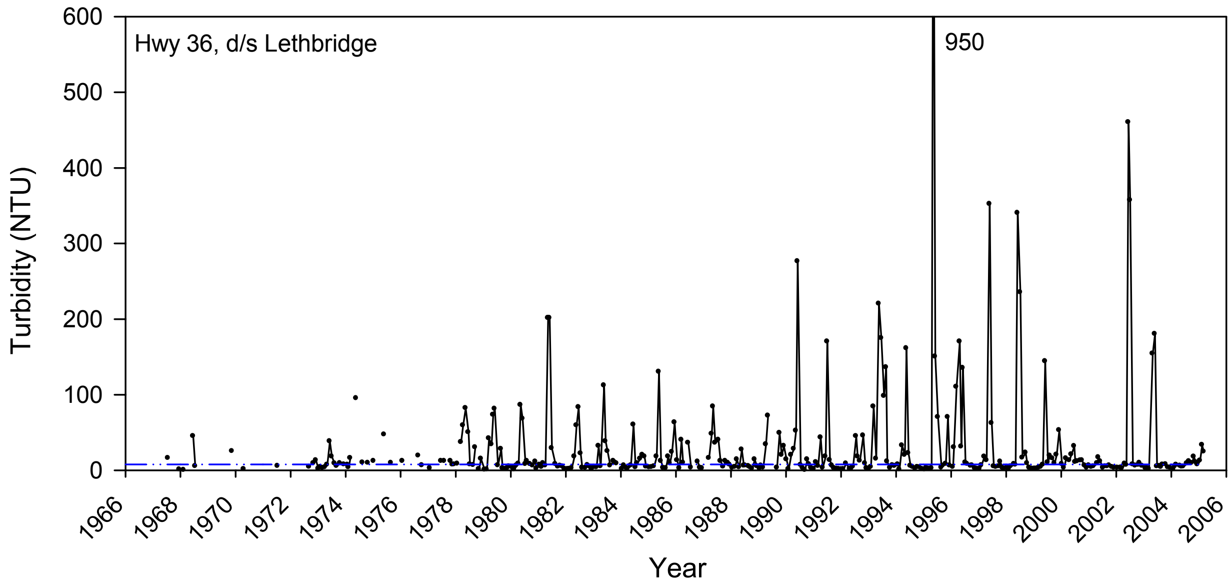


Figure 19 Seasonality of Dissolved Oxygen concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0386	NS		8.00			8.50		
Flow Adjusted								
0.1734	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0200	NS		8.00			7.20		
Flow Adjusted								
-0.1036	NS							

Figure 20 Turbidity in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

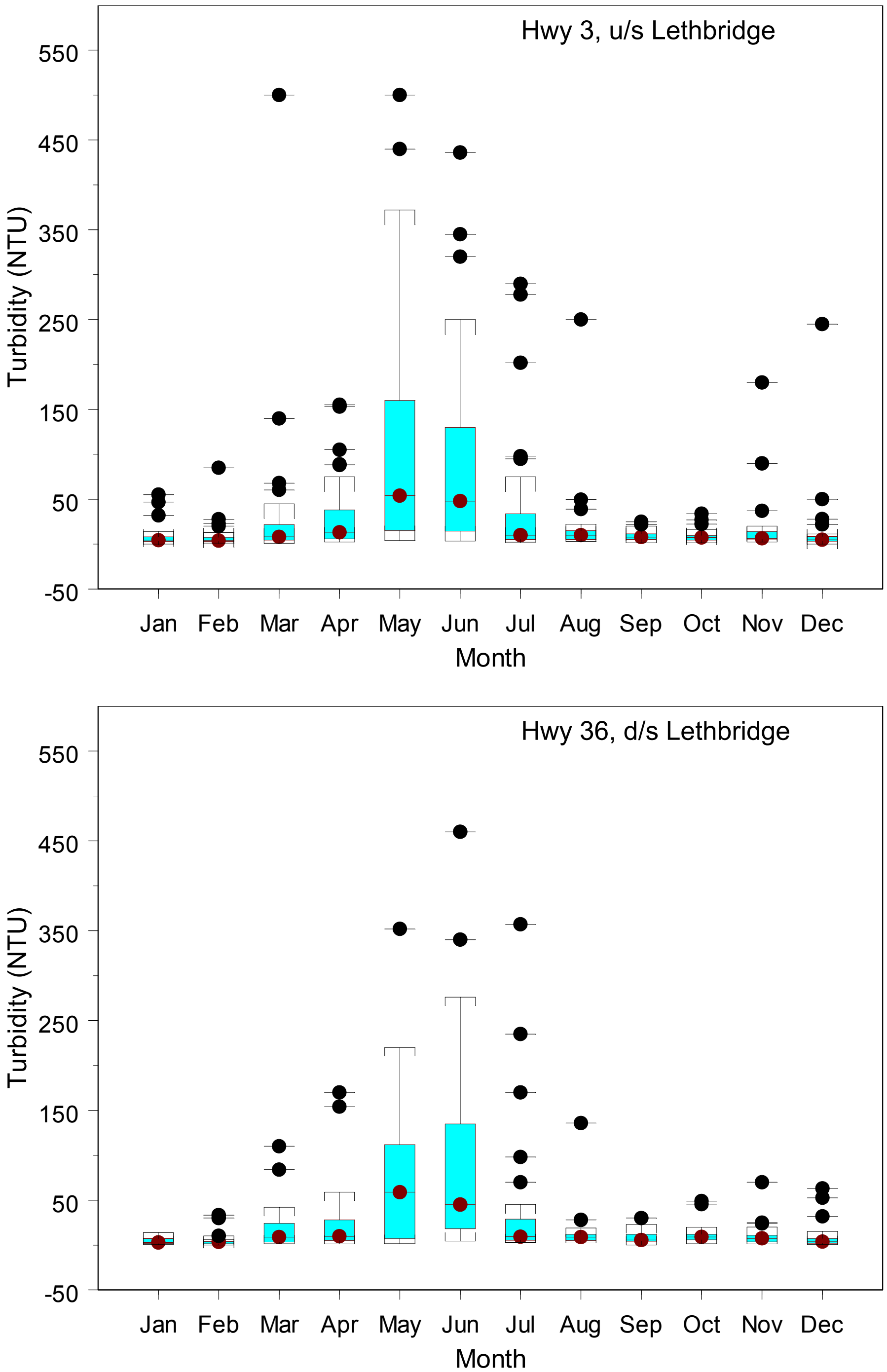
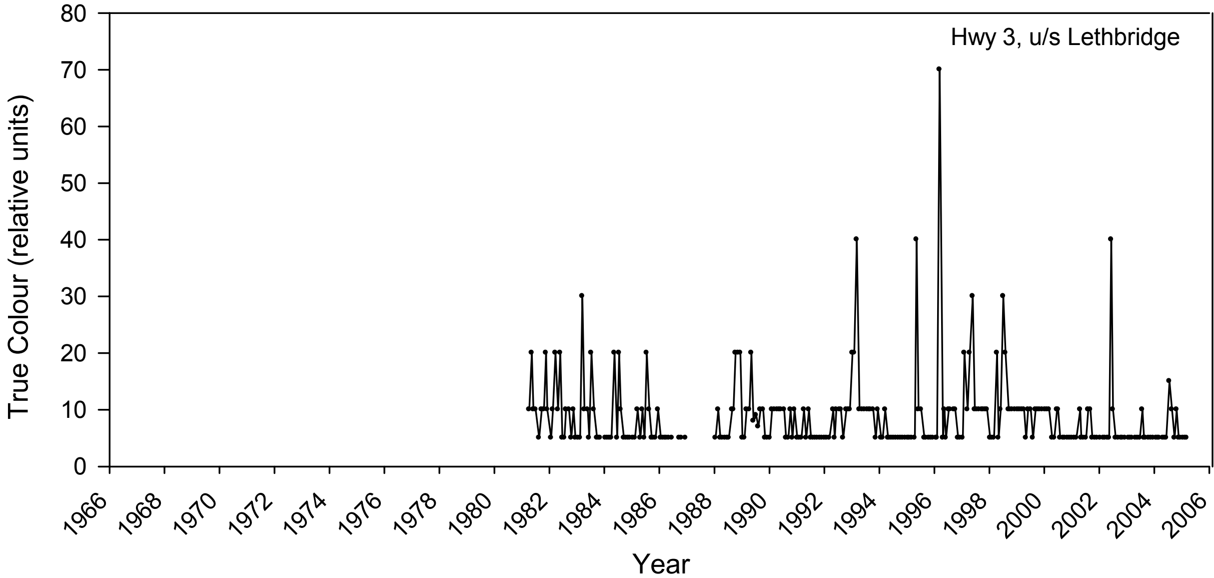
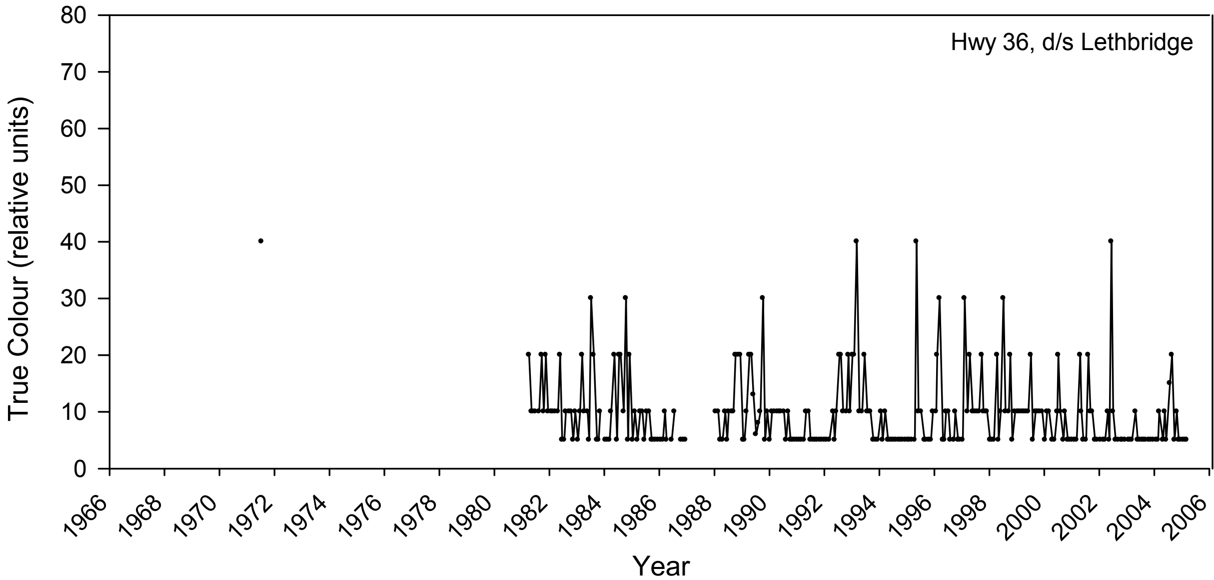


Figure 21 Seasonality of Turbidity data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

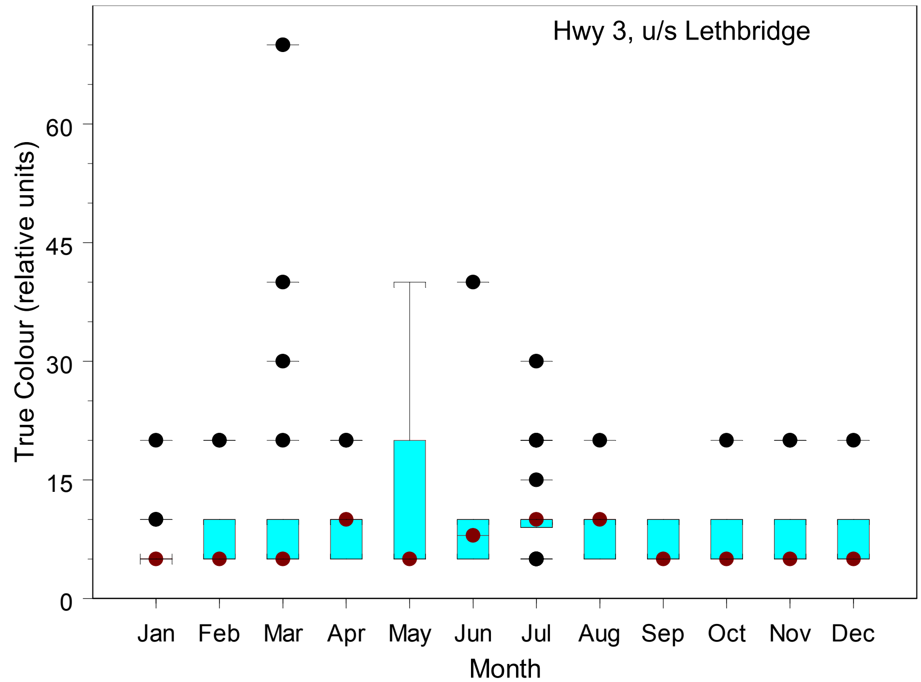


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
Flow Adjusted								



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
Flow Adjusted								

Figure 22 True Colour in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Available data were inadequate for statistical trend assessment.



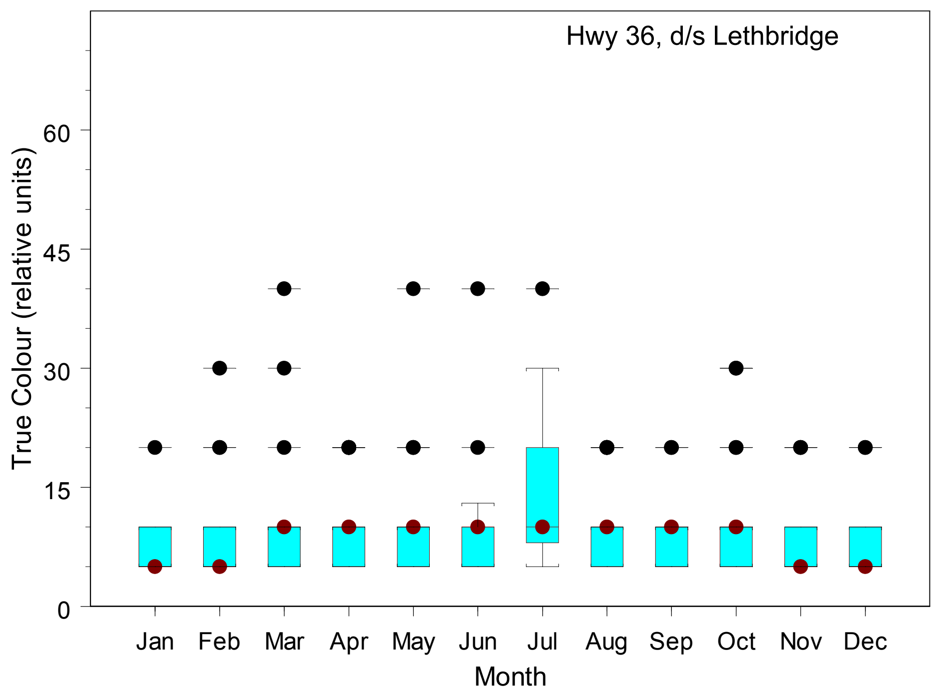
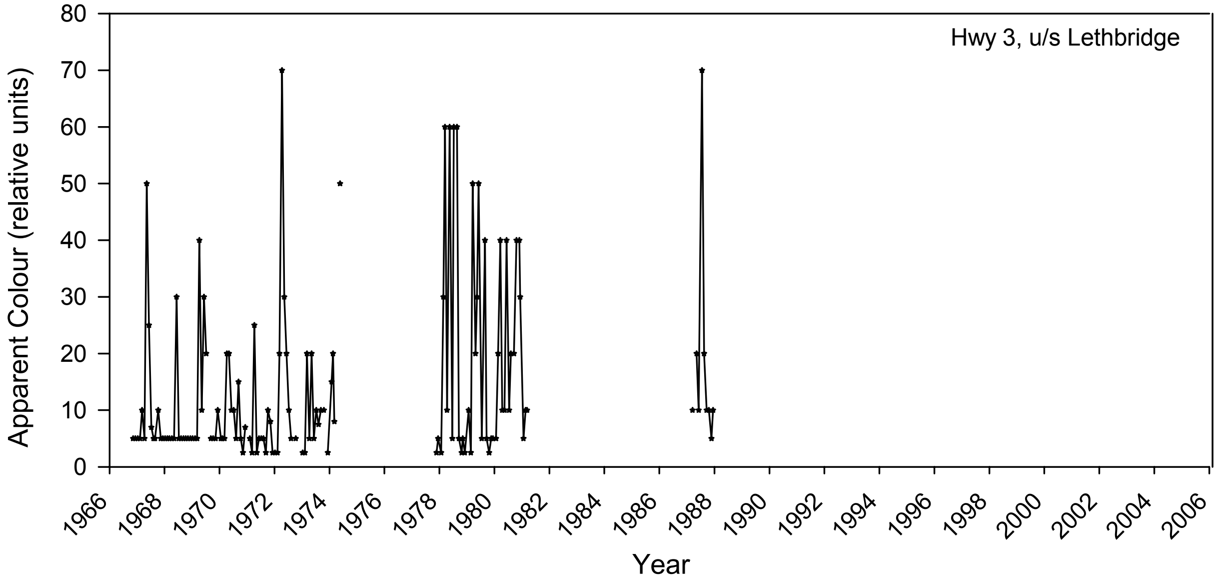
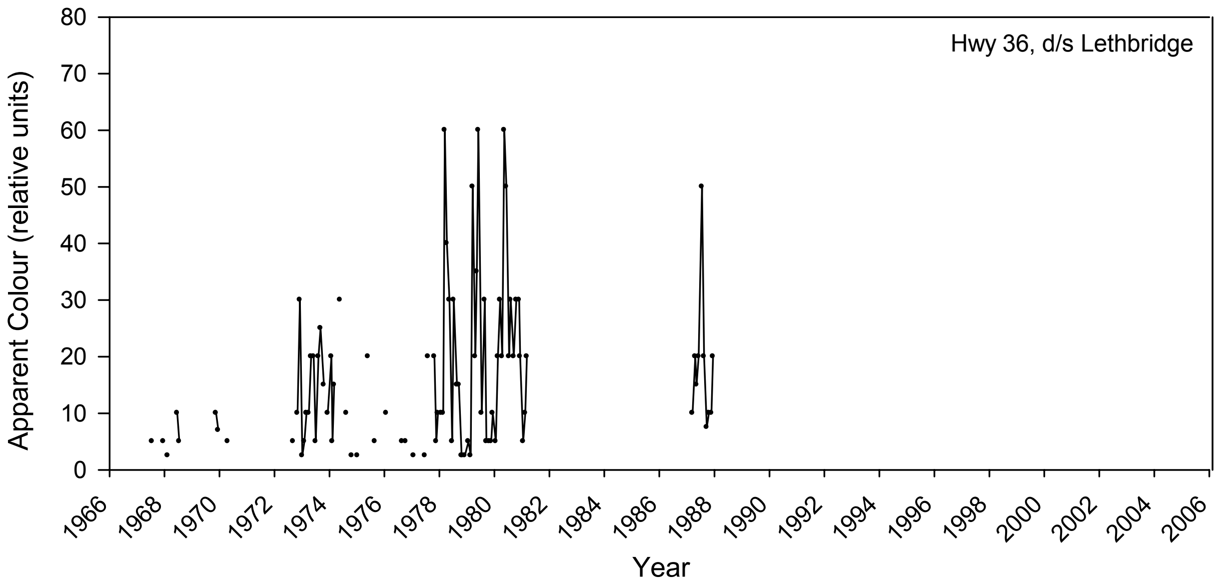


Figure 23 Seasonality of True Colour in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
Flow Adjusted								



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
Flow Adjusted								

Figure 24 Apparent Colour in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Available data were inadequate for statistical trend assessment.

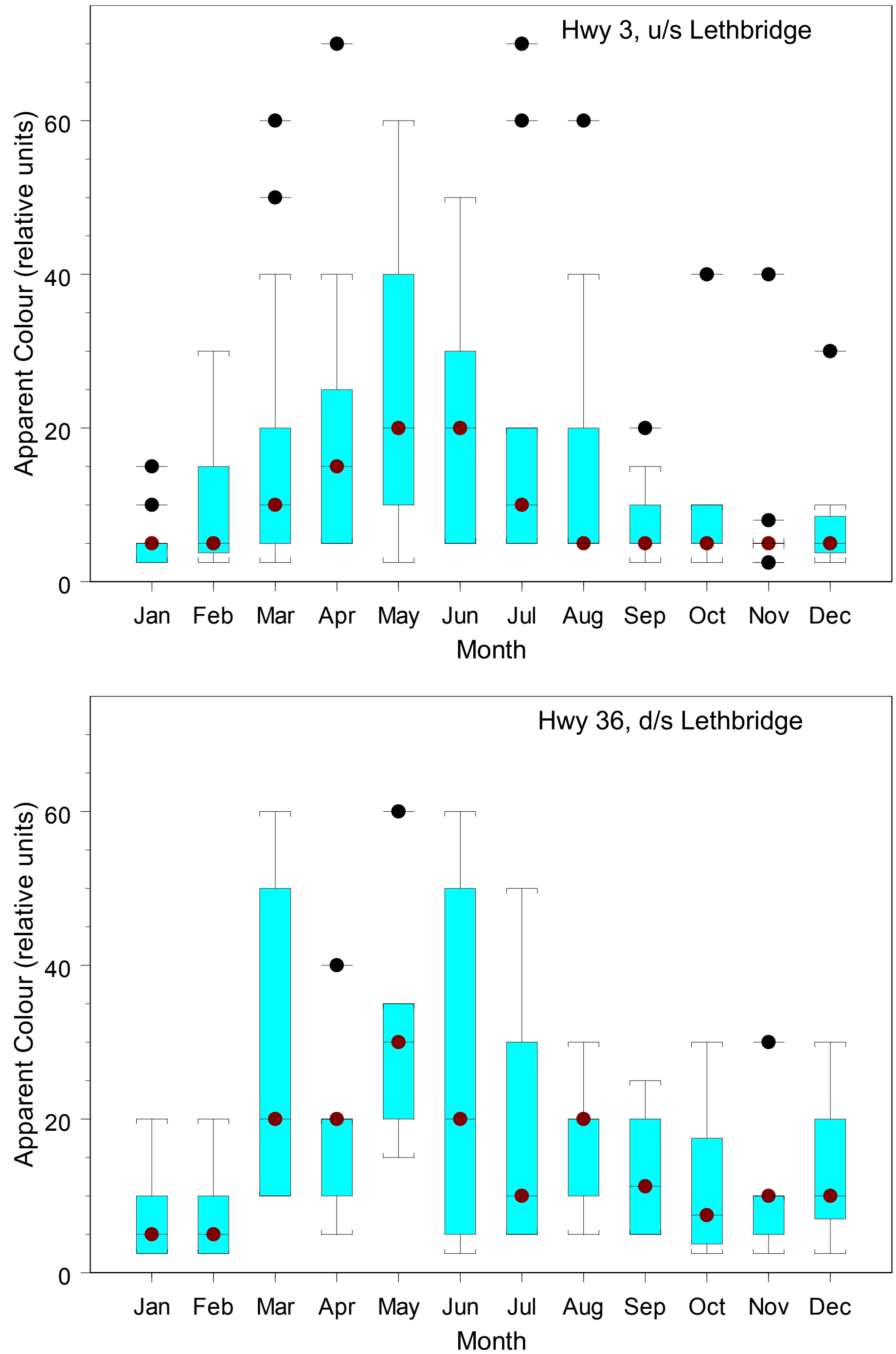
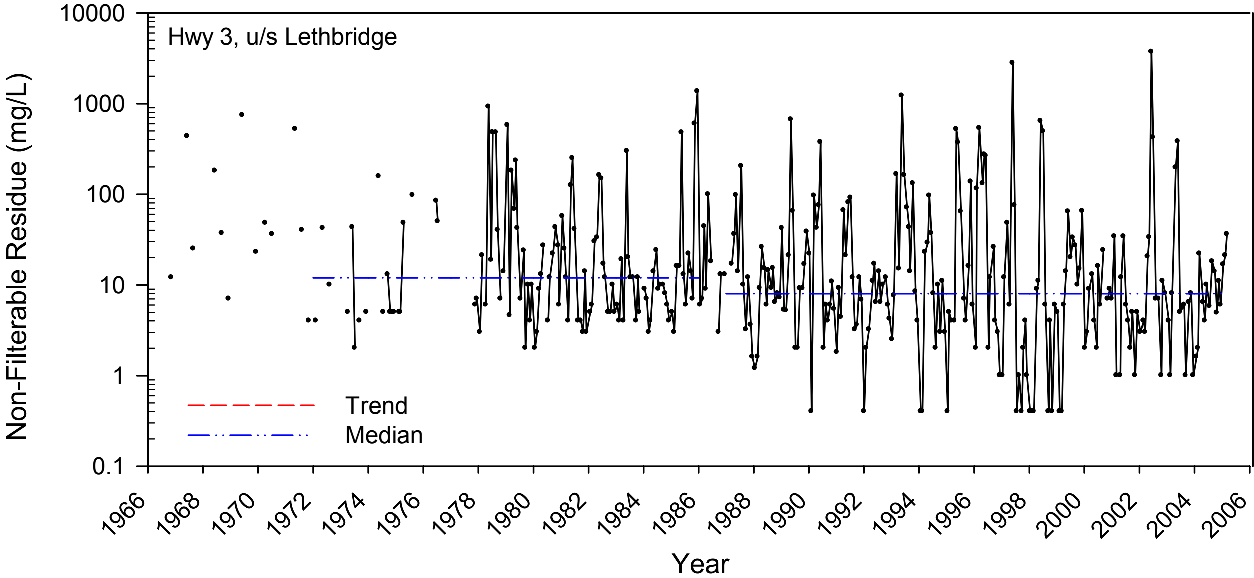
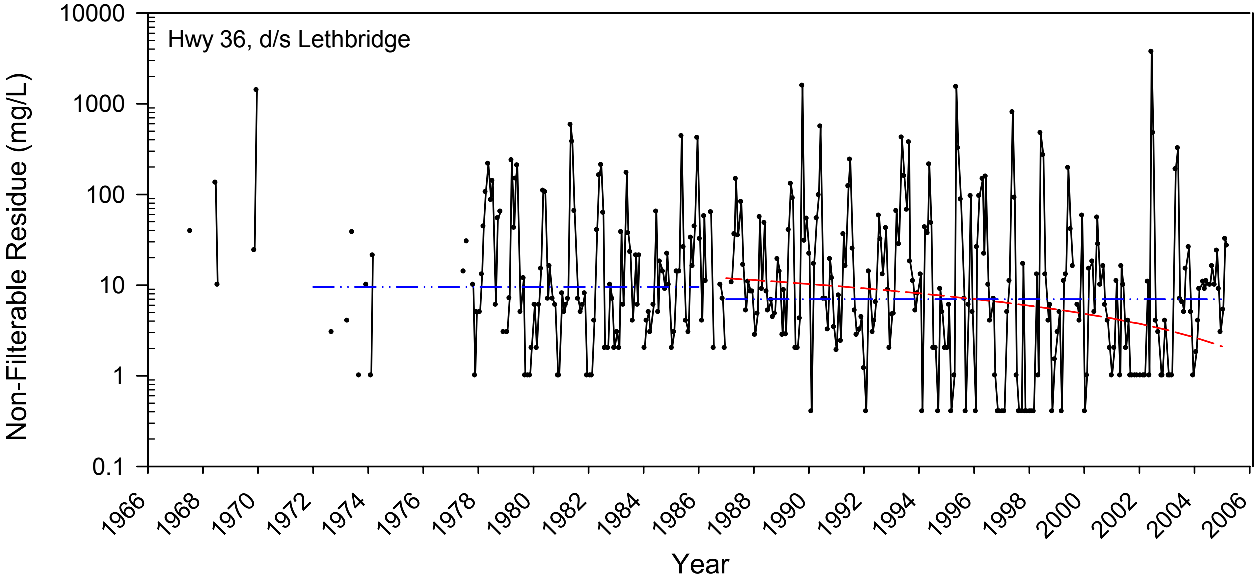


Figure 25 Seasonality of Apparent Colour in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-4.25%	Down	***	12.00	-6.34%	NS	8.00	-4.08%	NS
Flow Adjusted								
-5.65%	Down			2.67%	NS		-4.66%	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-4.78%	Down	*	9.50	5.18%	NS	7.00	-7.78%	Down
Flow Adjusted								
-6.06%	Down			5.44%	NS		-8.10%	Down

Figure 26 Non-Filterable Residue in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

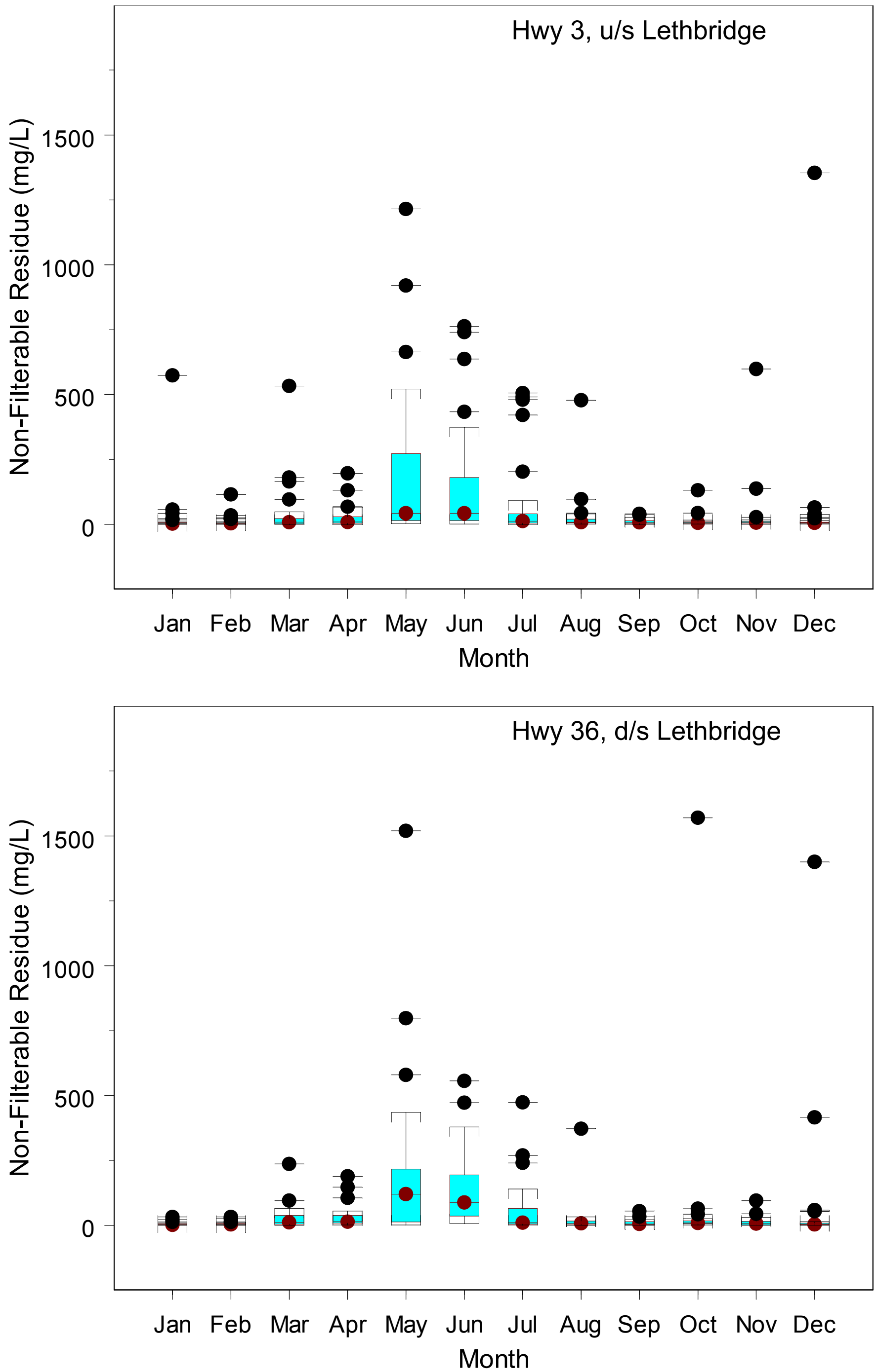
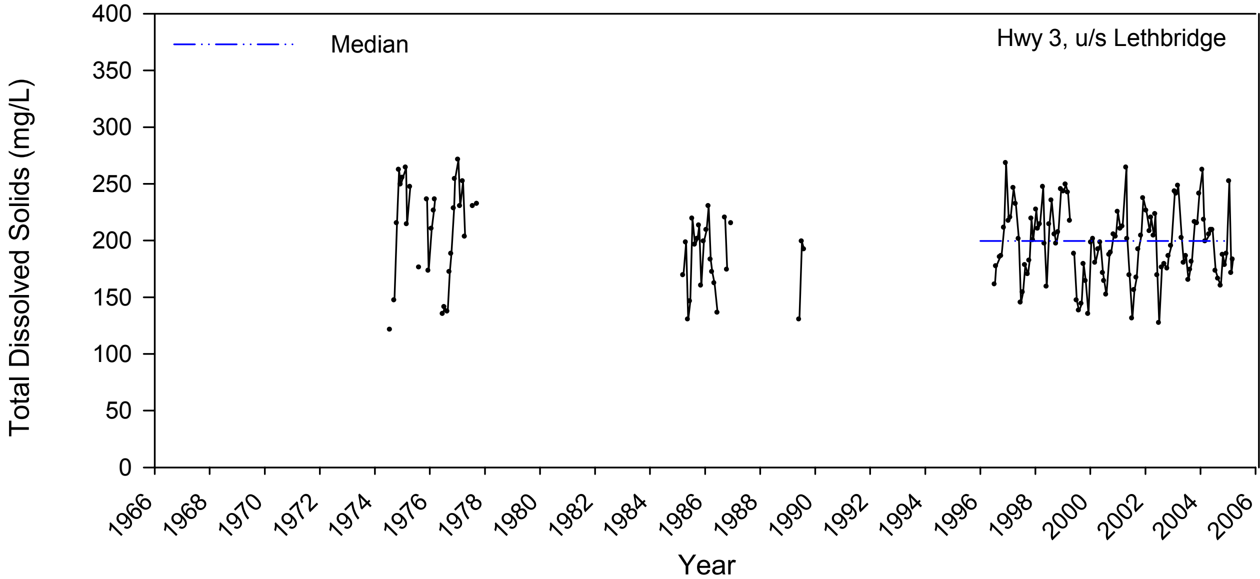
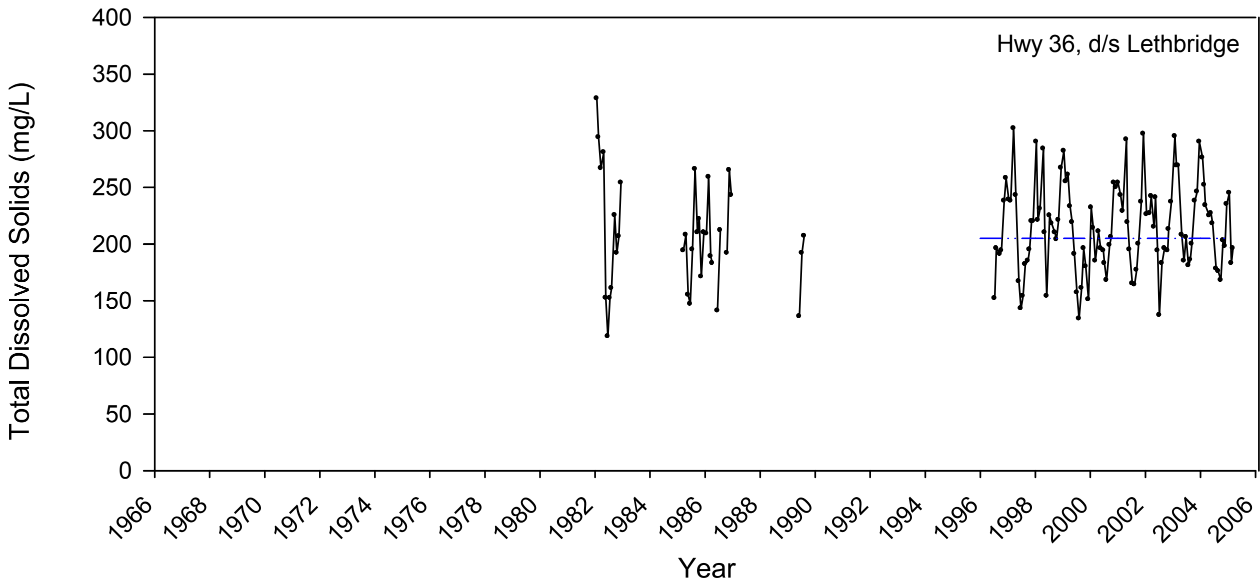


Figure 27 Seasonality of Non-Filterable Residue in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						199.50	-0.5000	NS
Flow Adjusted								
							-1.1100	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						205.00	1.0000	NS
Flow Adjusted								
							-0.5900	NS

Figure 28 Total Dissolved Solids in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

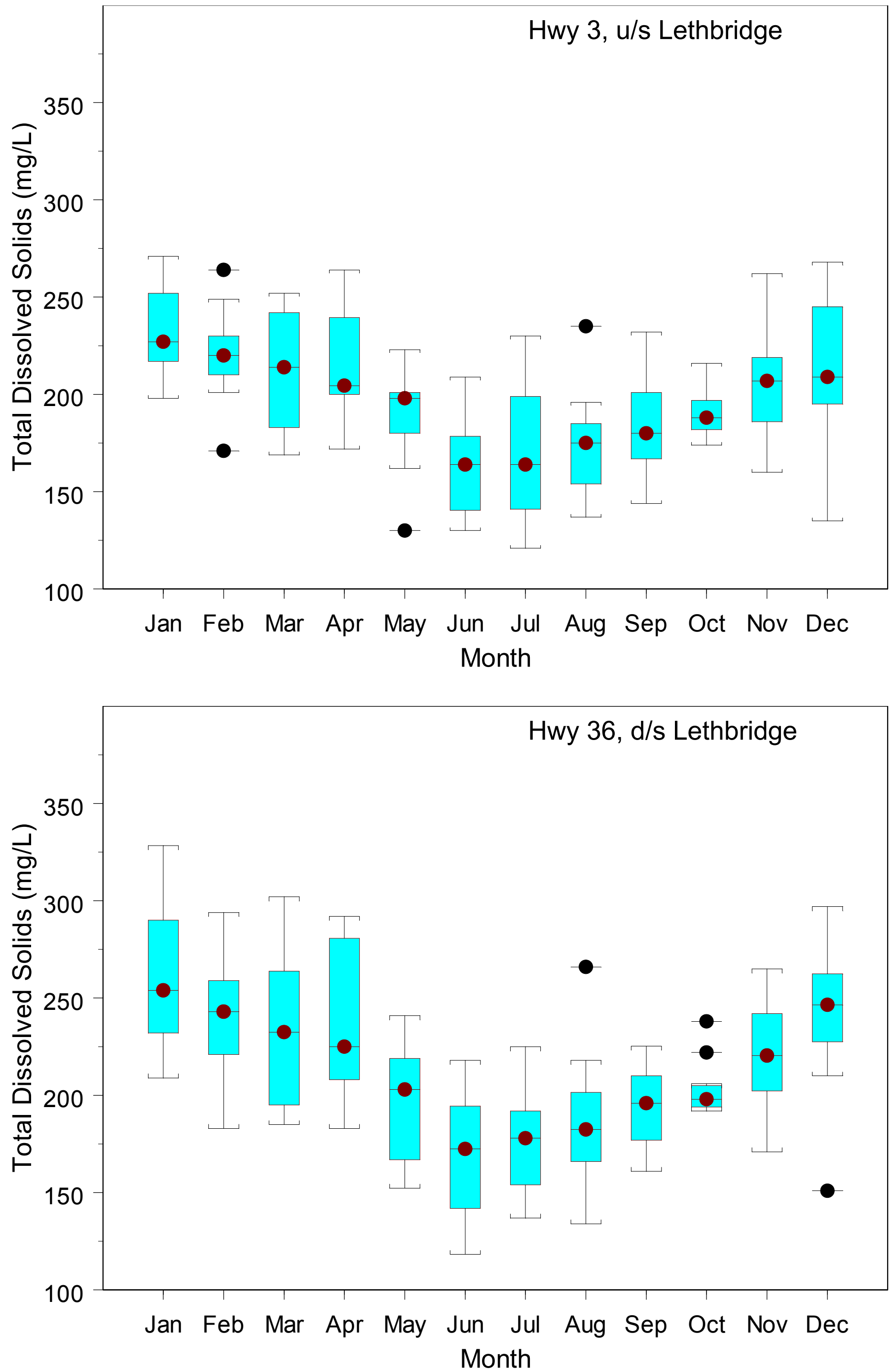
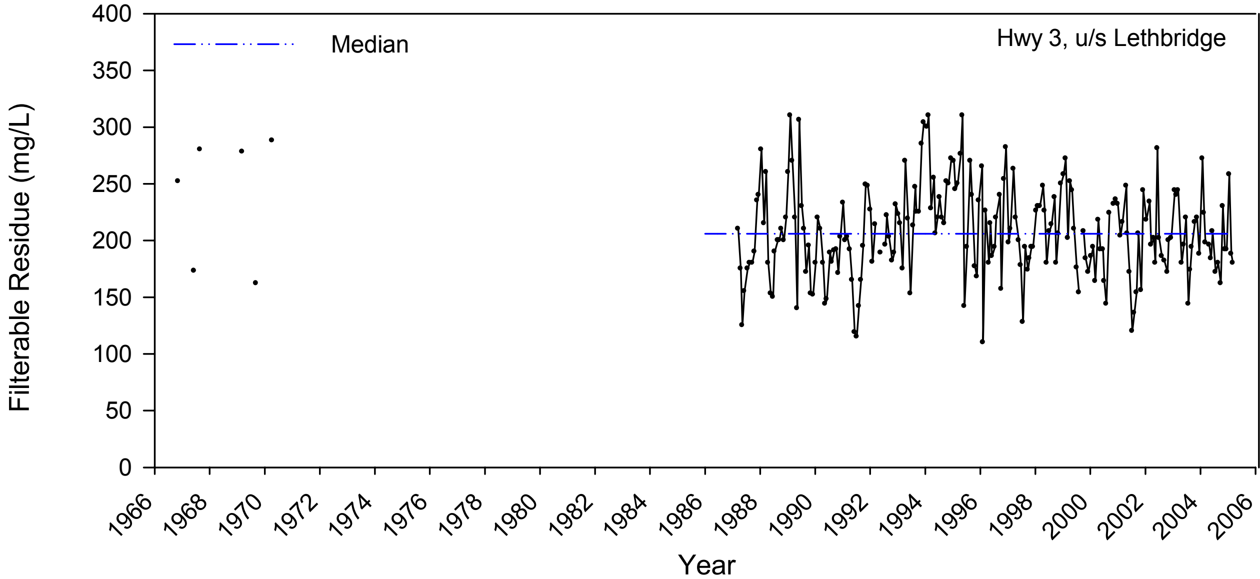
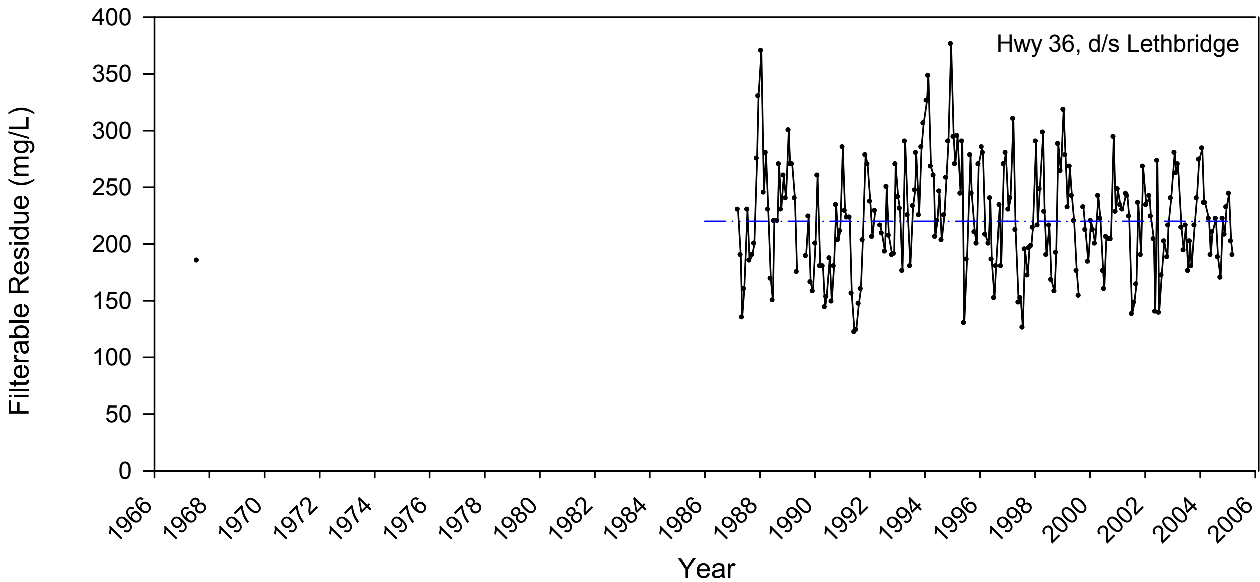


Figure 29 Seasonality of Total Dissolved Solids in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						206.00	-0.6250	NS
Flow Adjusted								
							-0.0640	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						220.00	-0.5000	NS
Flow Adjusted								
							-0.3200	NS

Figure 30 Filterable Residue in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

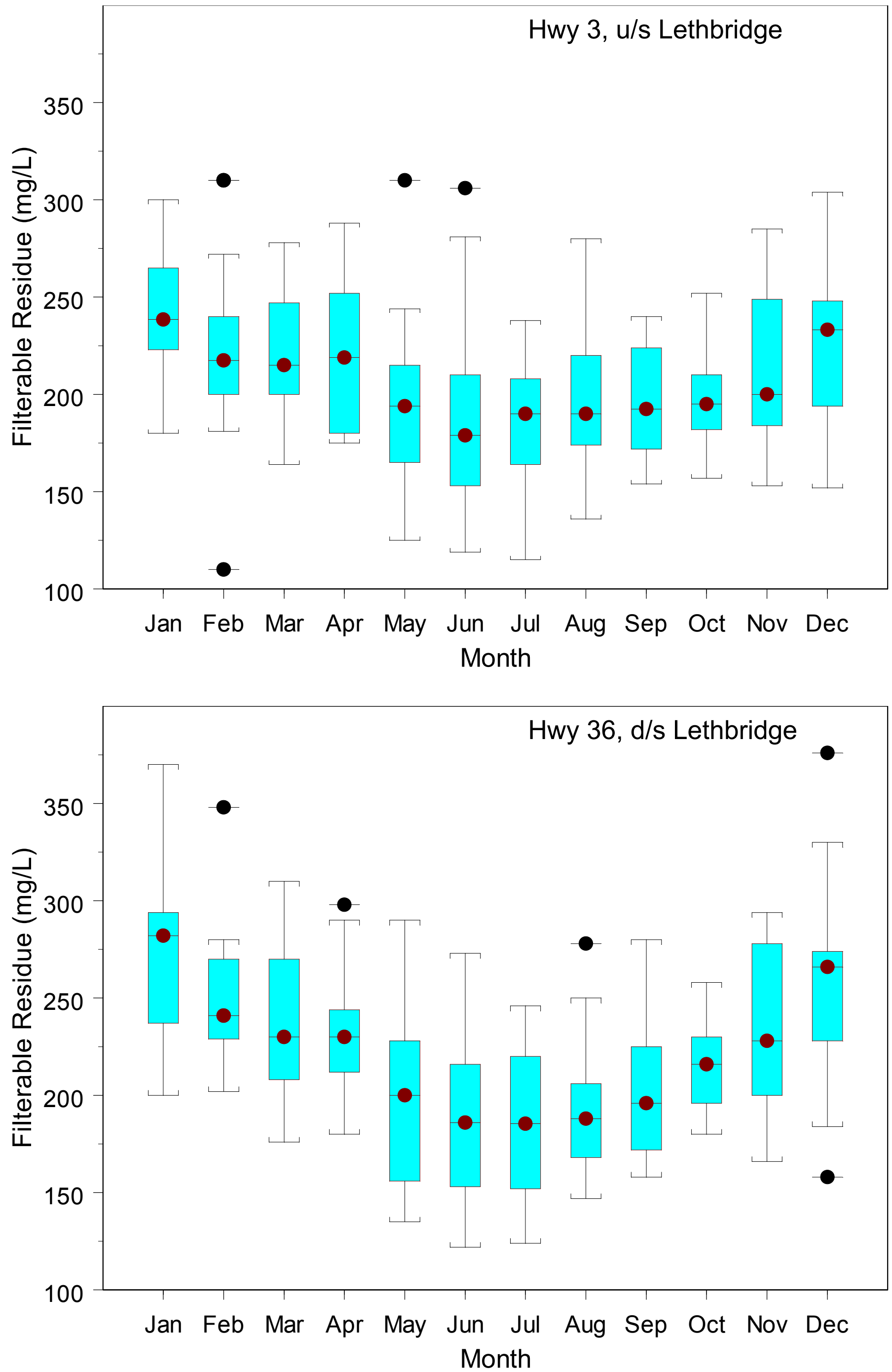
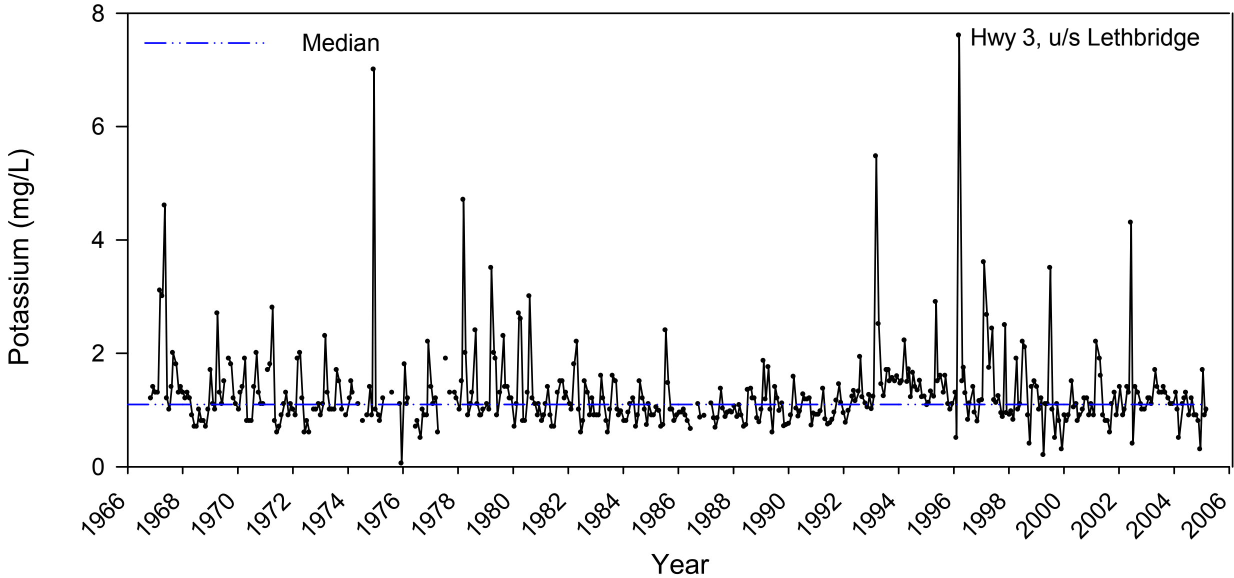
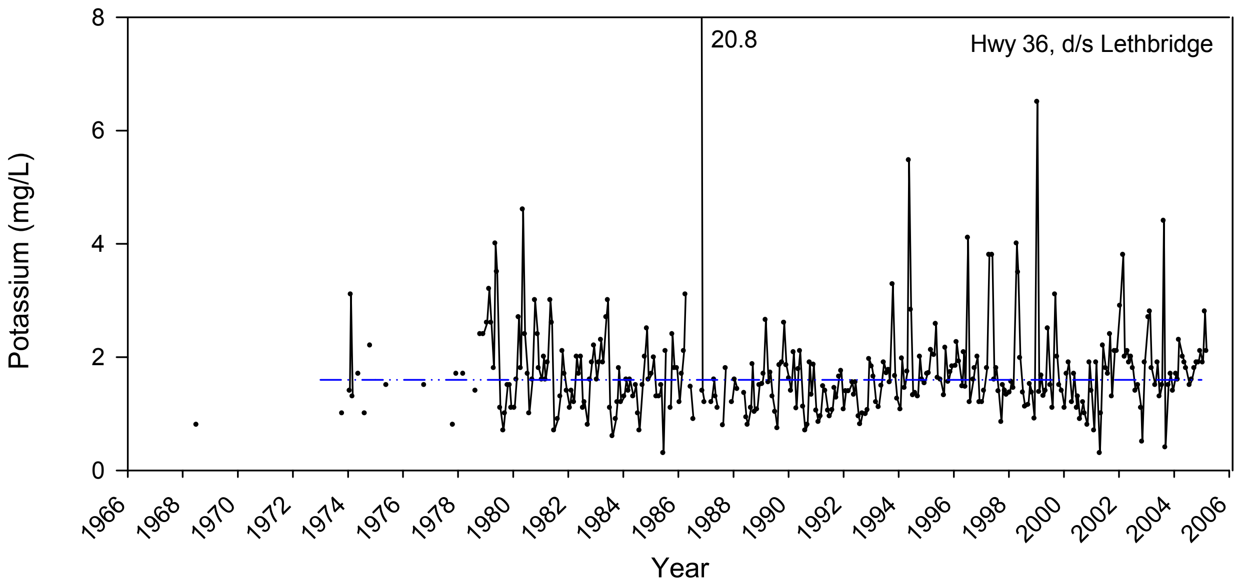


Figure 31 Seasonality of Filterable Residue in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

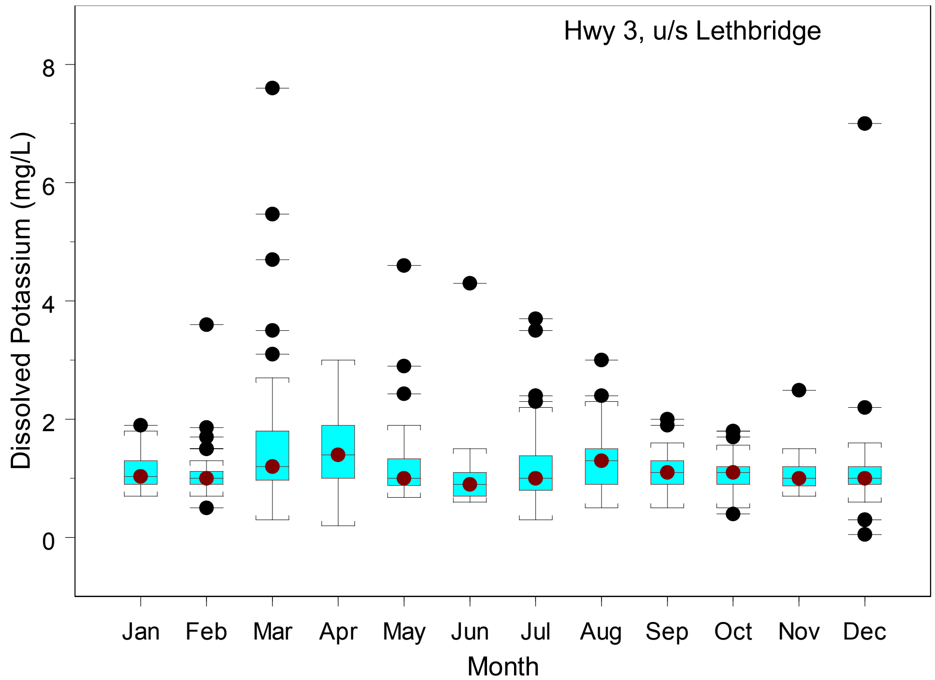


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS		1.10			1.12		
Flow Adjusted								
0.0000	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0039	NS		1.60			1.58		
Flow Adjusted								
0.0081	NS							

Figure 32 Dissolved Potassium in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



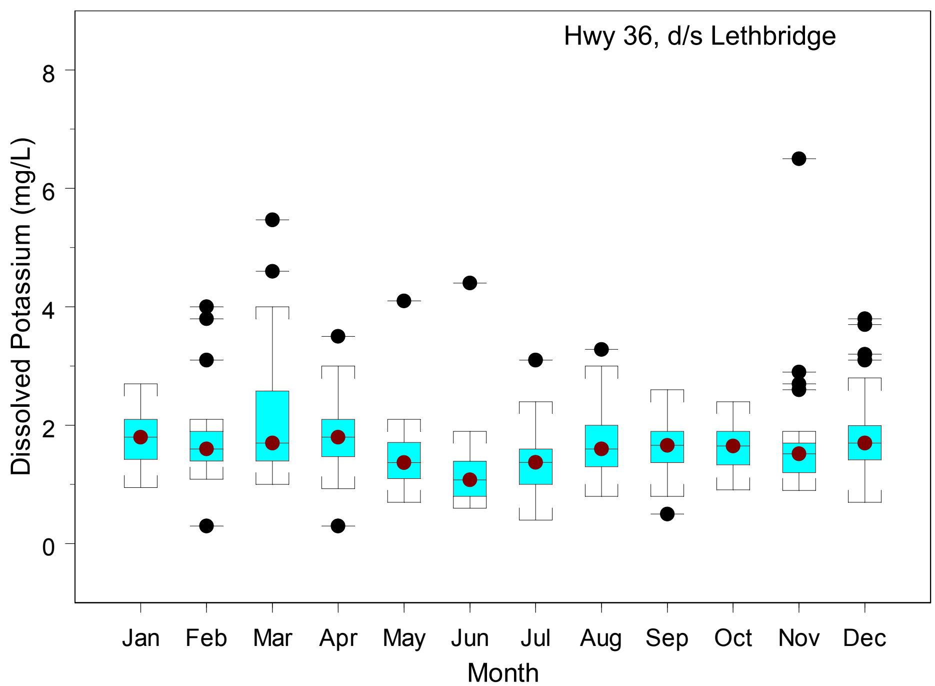
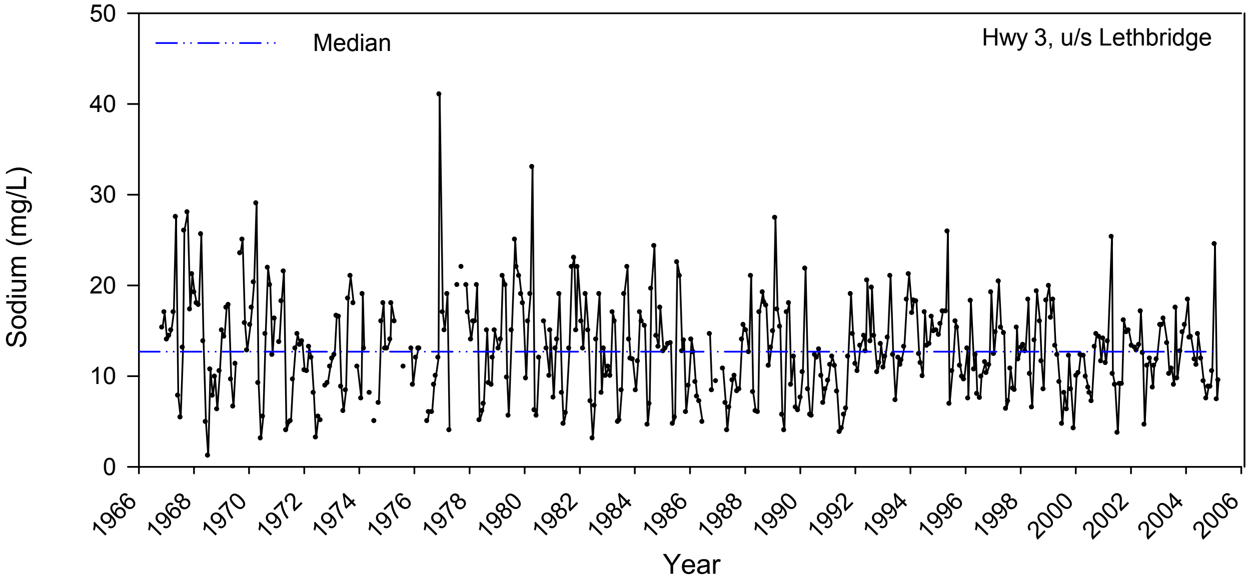
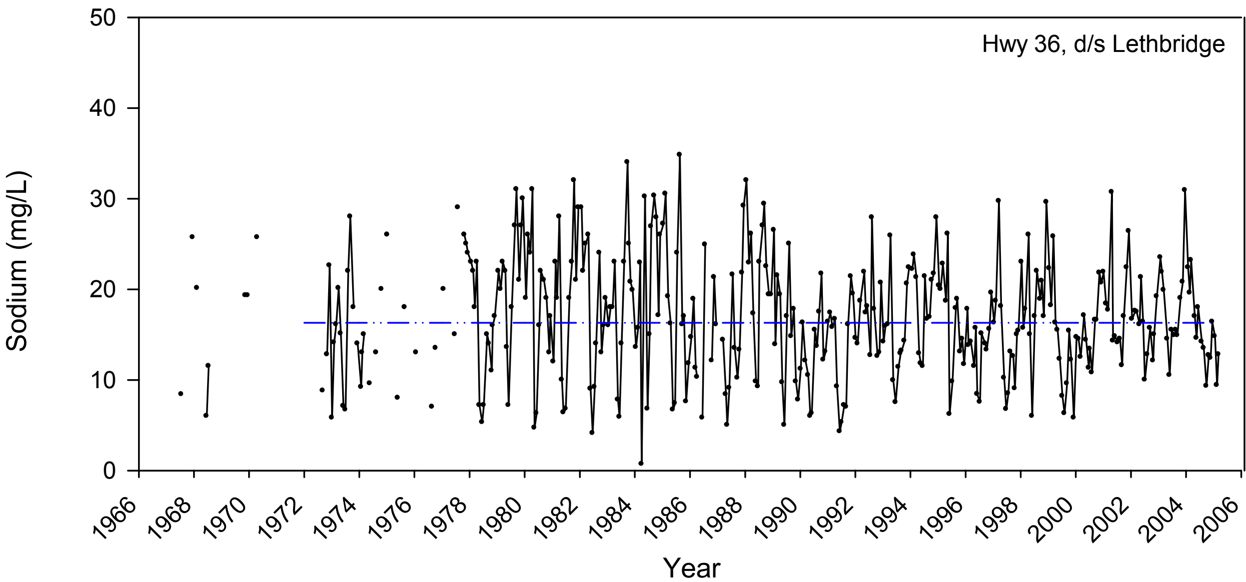


Figure 33 Seasonality of Dissolved Potassium concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

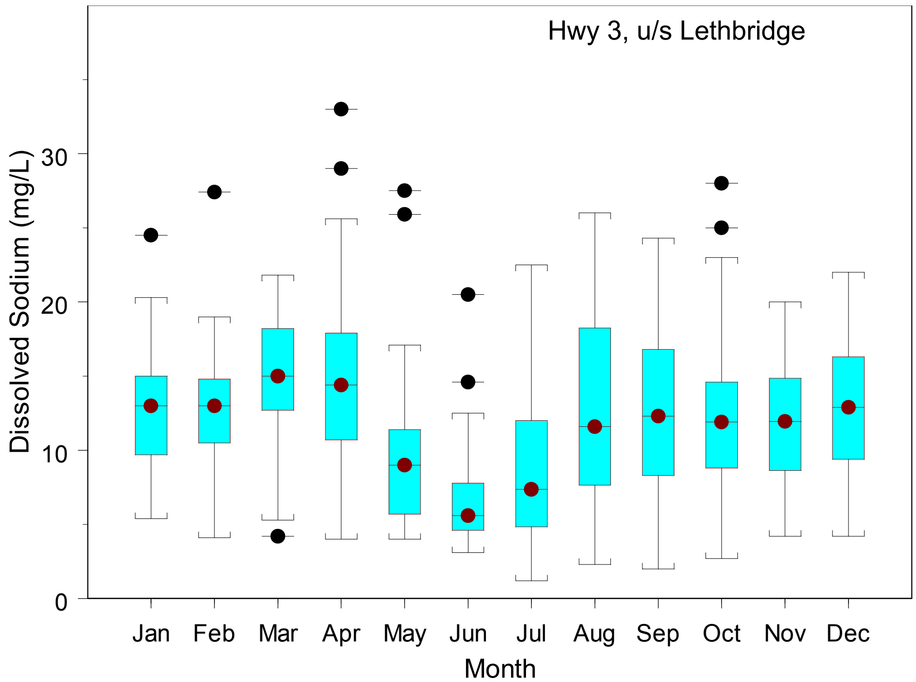


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0193	NS		13.00			12.10		
Flow Adjusted								
-0.0431	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0286	NS		18.00			15.70		
Flow Adjusted								
-0.0069	NS							

Figure 34 Dissolved Sodium in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



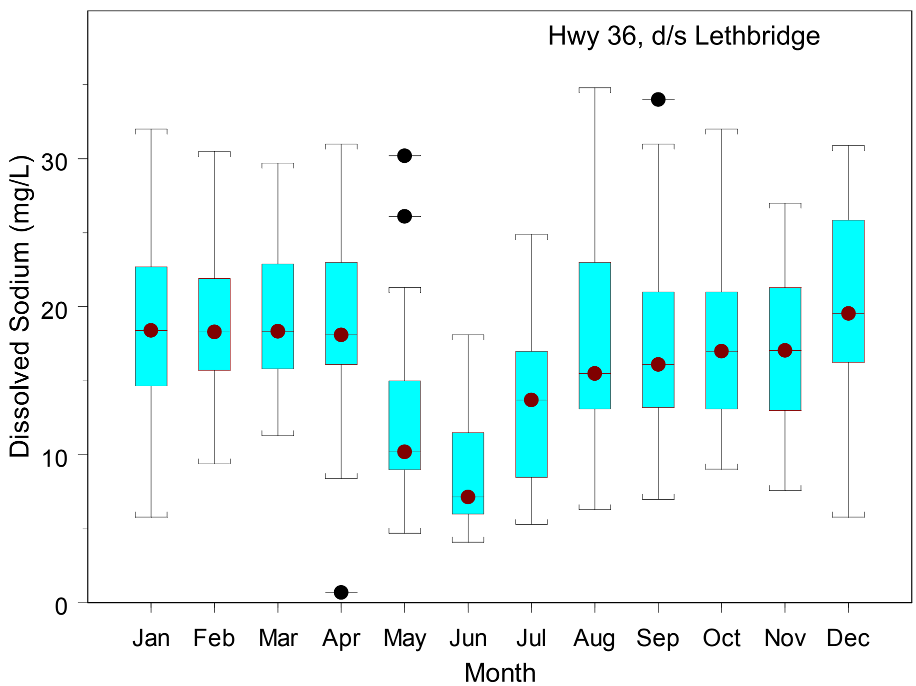
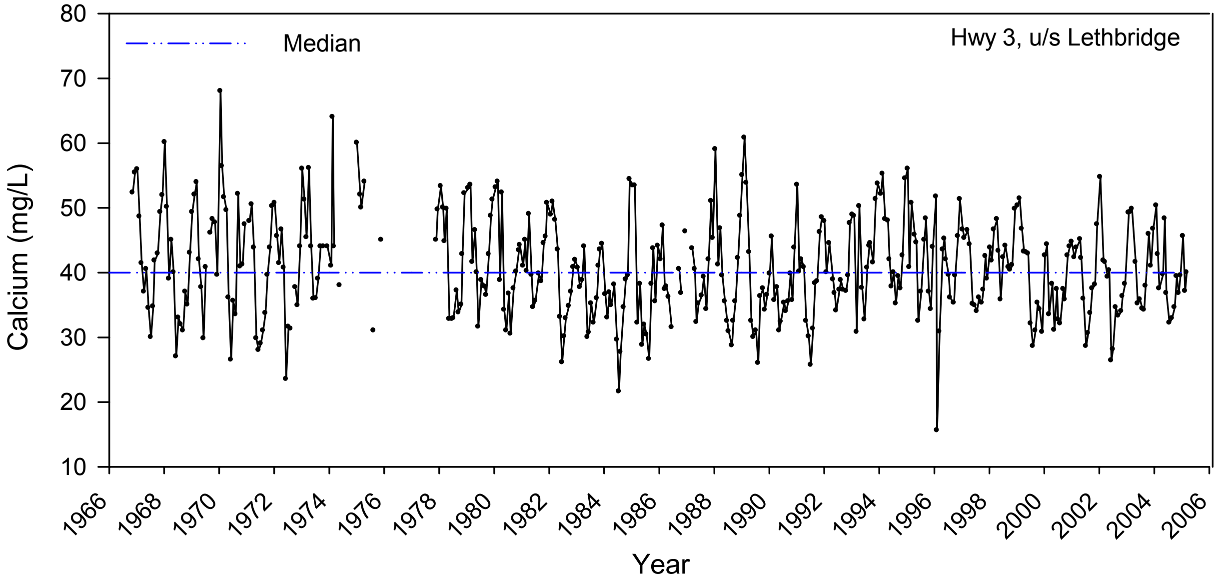
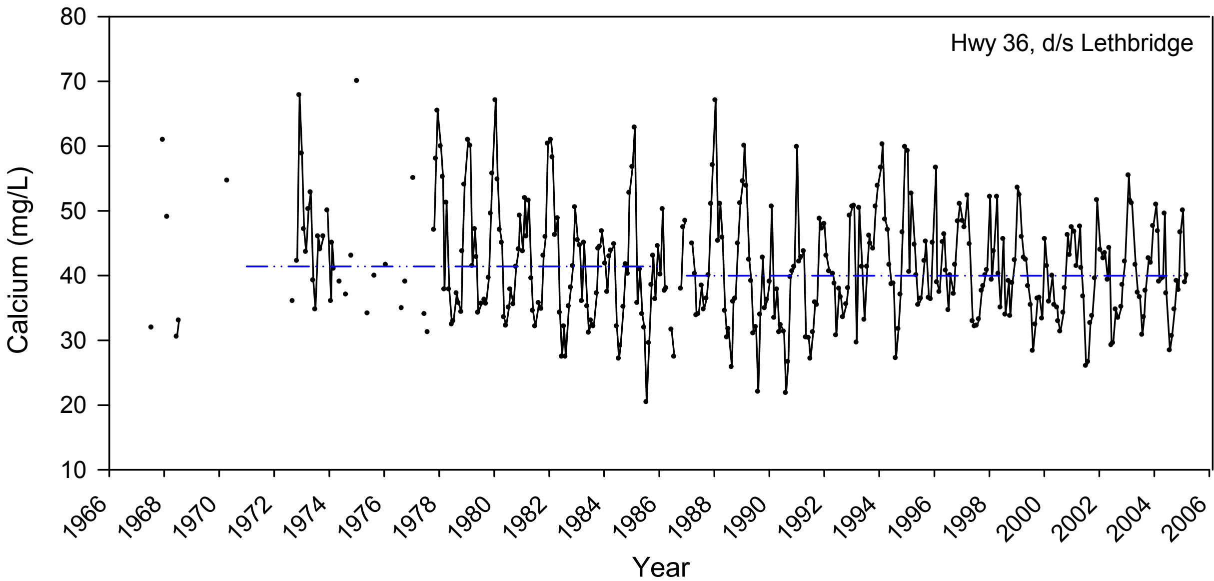


Figure 35 Seasonality of Dissolved Sodium concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0635	NS	NS	40.70			39.65		
Fow Adjusted								
-0.0973	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.1047	Down	***	41.40	-0.5708	Down	39.95	-0.0846	NS
Flow Adjusted								
-0.0938	NS			-0.5412	NS		-0.1240	NS

Figure 36 Dissolved Calcium in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

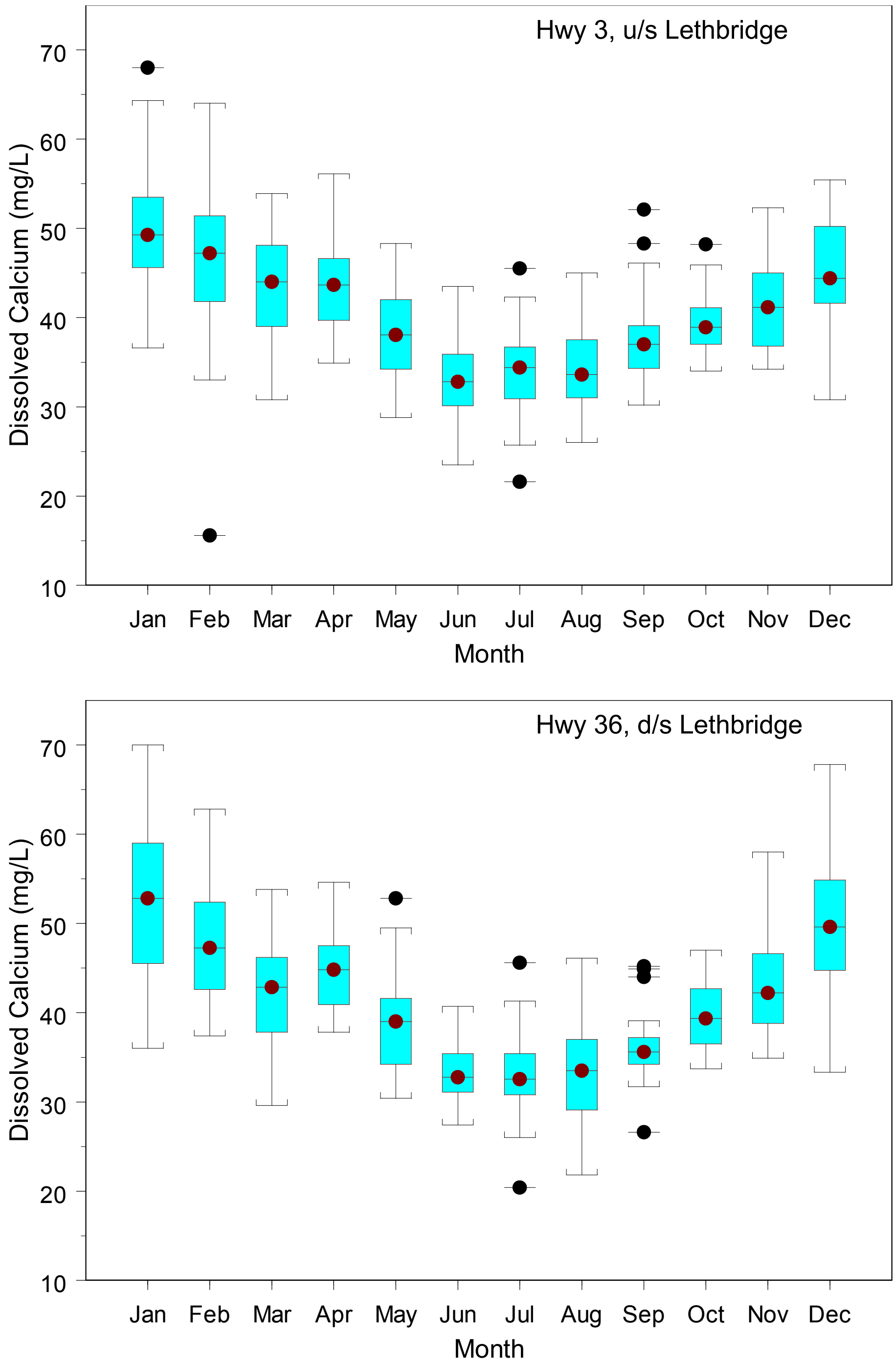
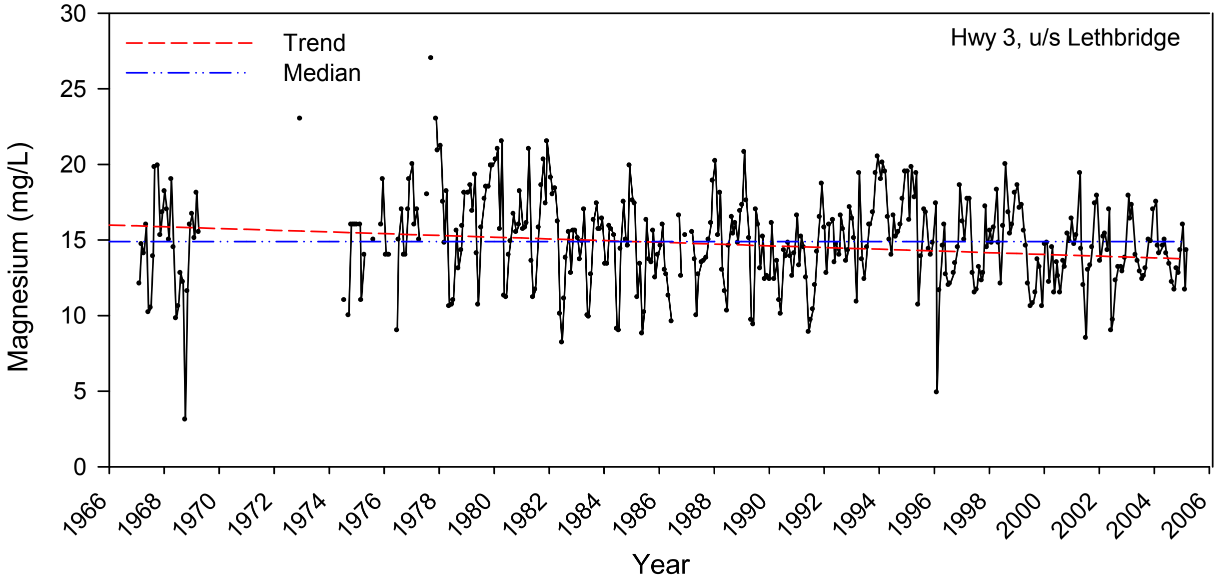
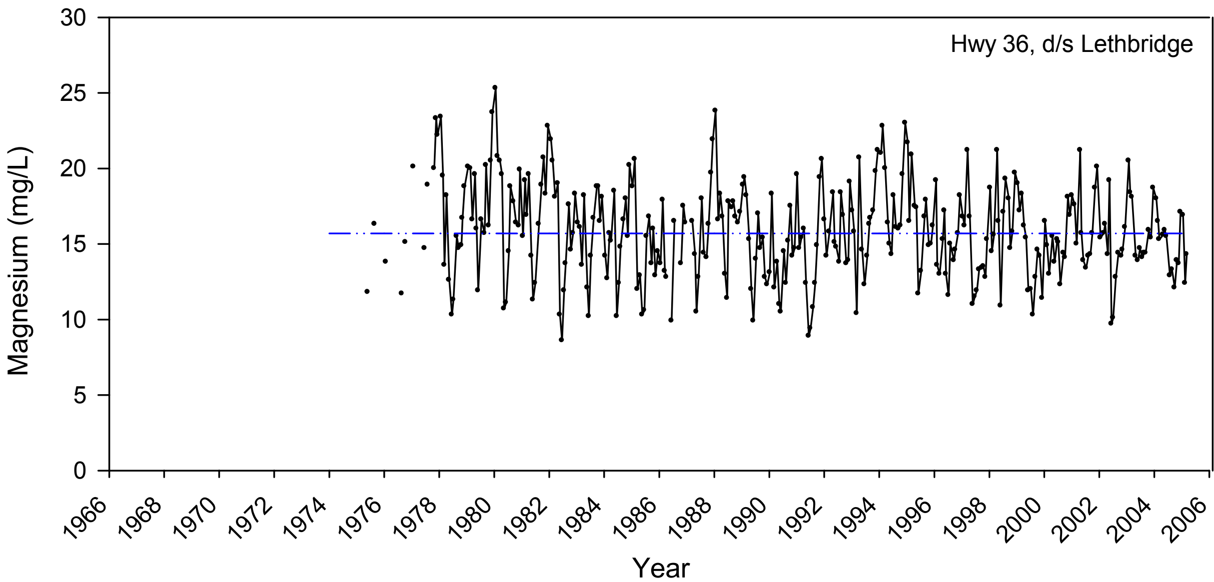


Figure 37 Seasonality of Dissolved Calcium concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

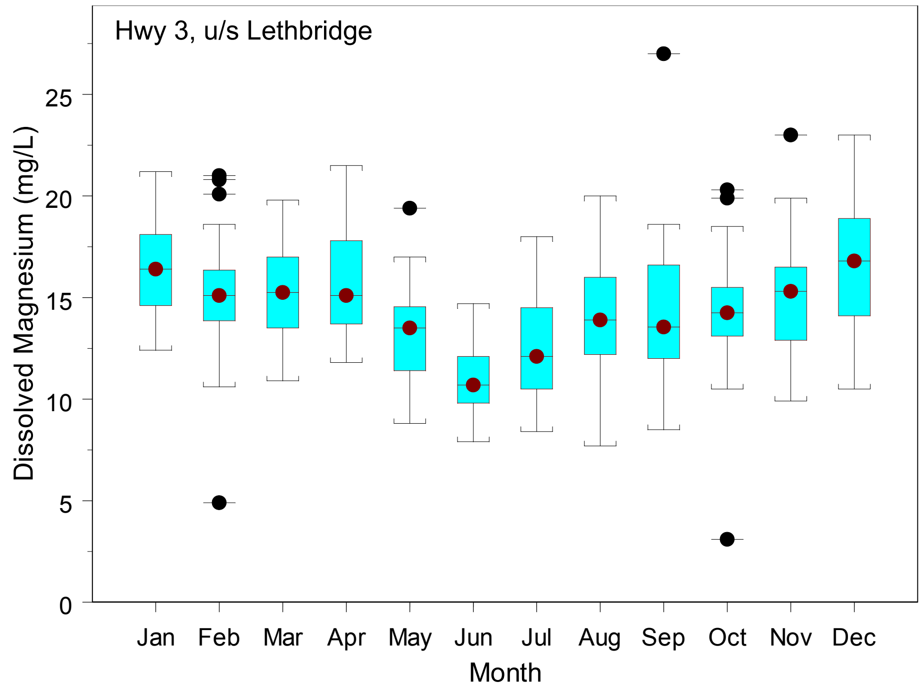


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0571	Down	NS	15.55			14.60		
Flow Adjusted								
-0.0365	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0636	NS		16.30			15.40		
Flow Adjusted								
-0.0226	NS							

Figure 38 Dissolved Magnesium in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



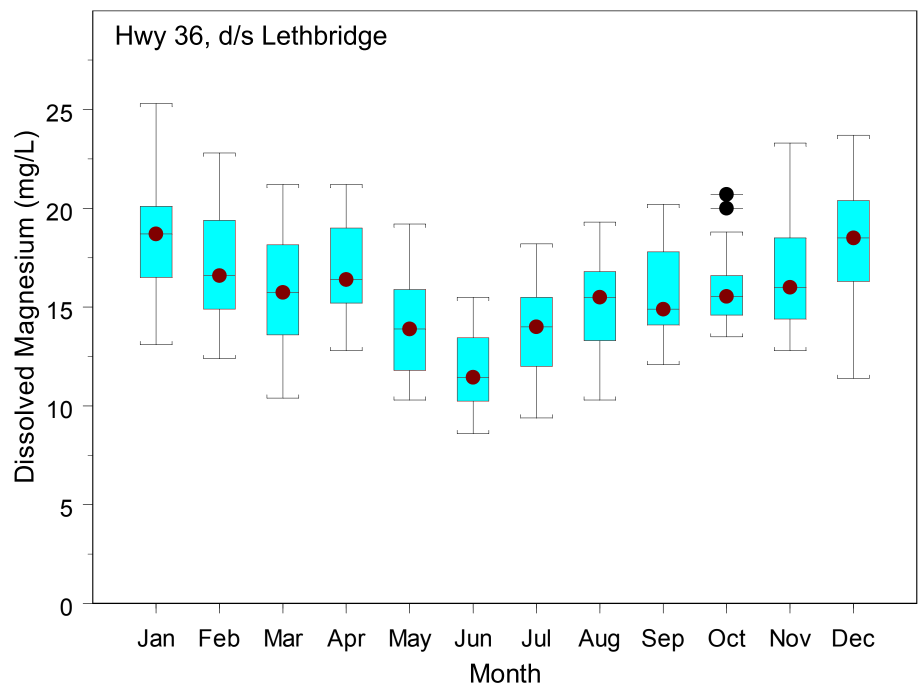
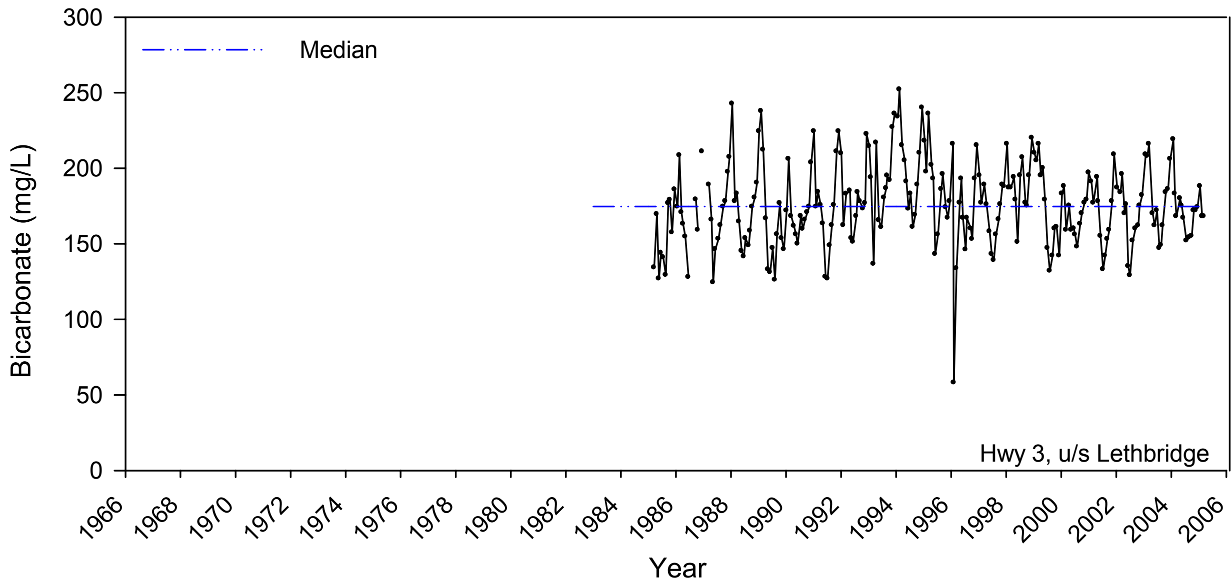
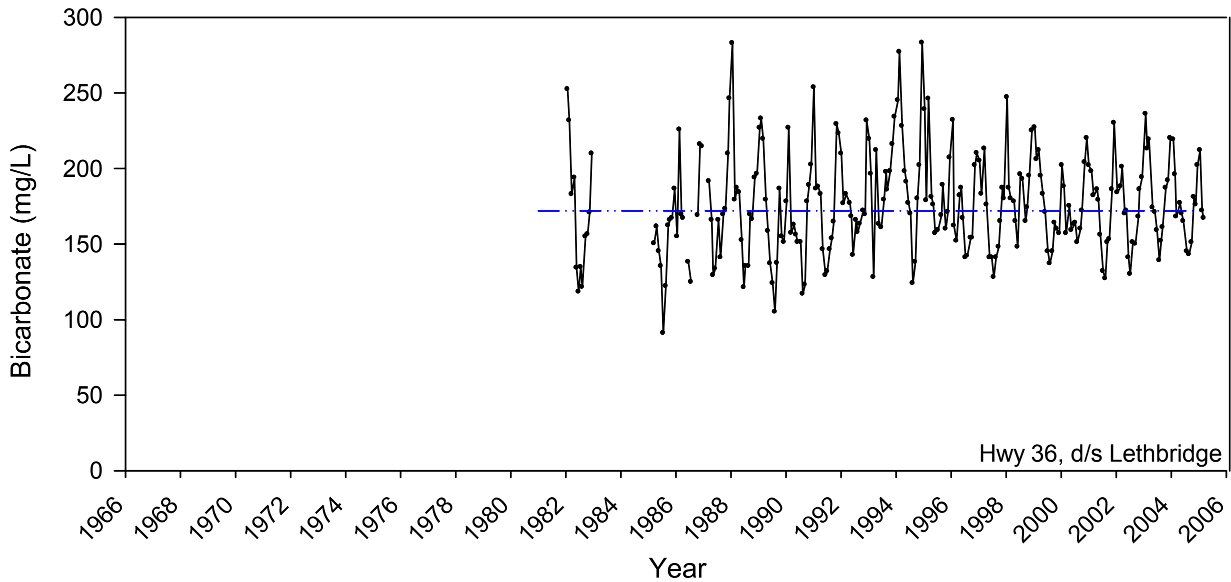


Figure 39 Seasonality of Dissolved Magnesium concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

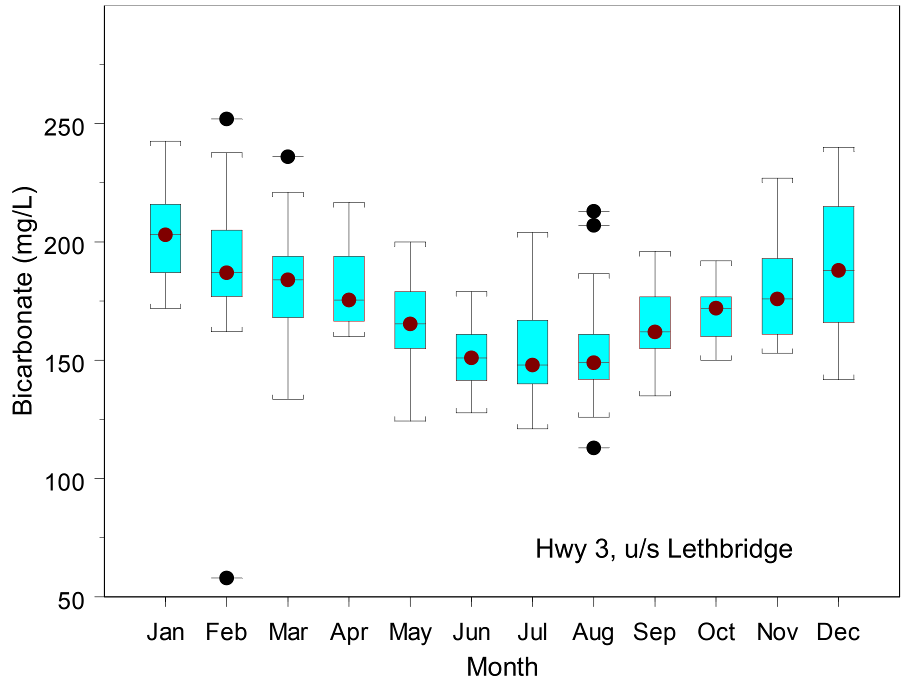


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0645	NS		163.00			175.25		
Flow Adjusted								
-0.1959	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.2460	NS		162.10			175.50		
Flow Adjusted								
-0.0758	NS							

Figure 40 Bicarbonate concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



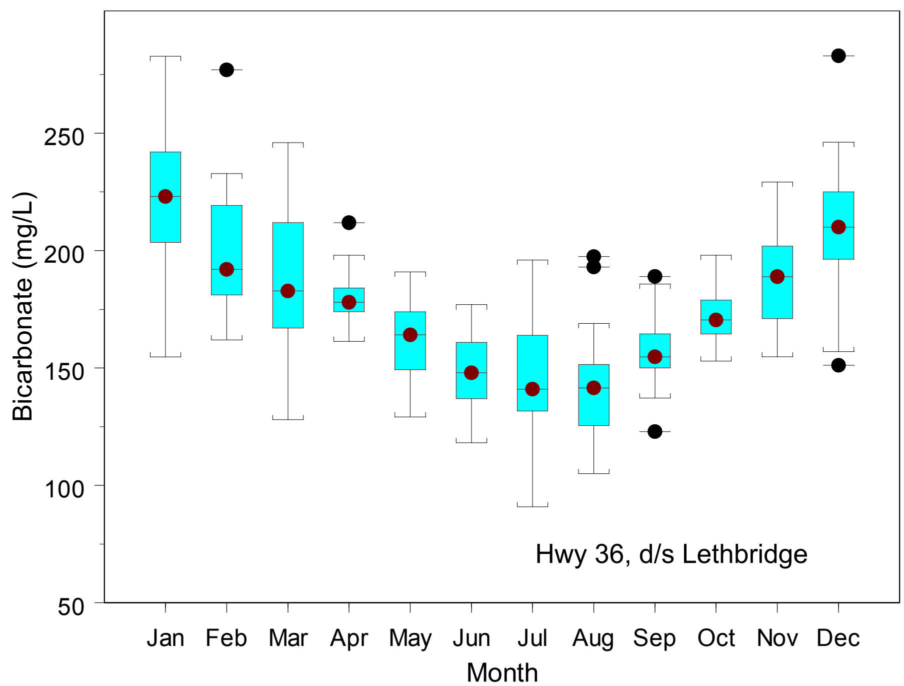
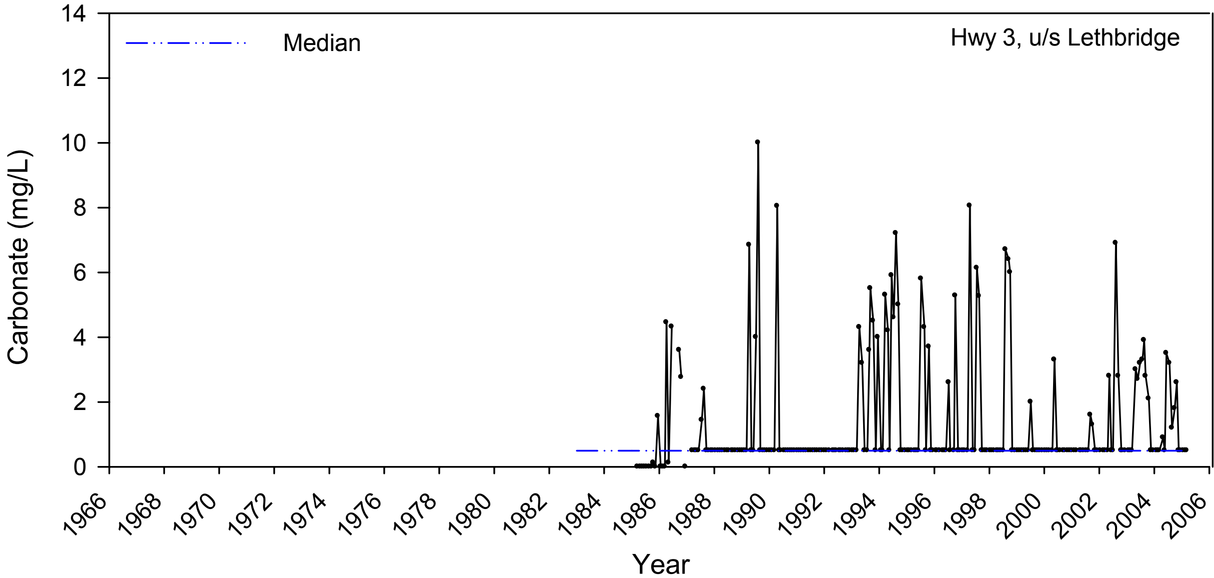
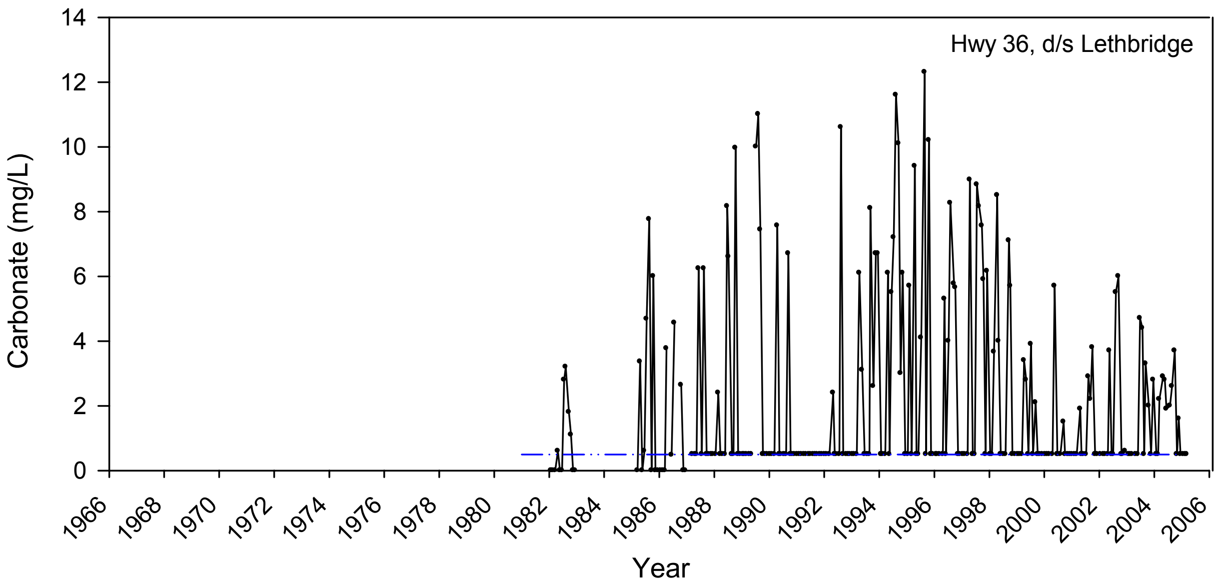


Figure 41 Seasonality of Bicarbonate data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
5.91%	NS		0.00			0.25		
Flow Adjusted								
5.88%	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
3.73%	NS		0.00			0.25		
Flow Adjusted								
4.34%	NS							

Figure 42 Carbonate concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

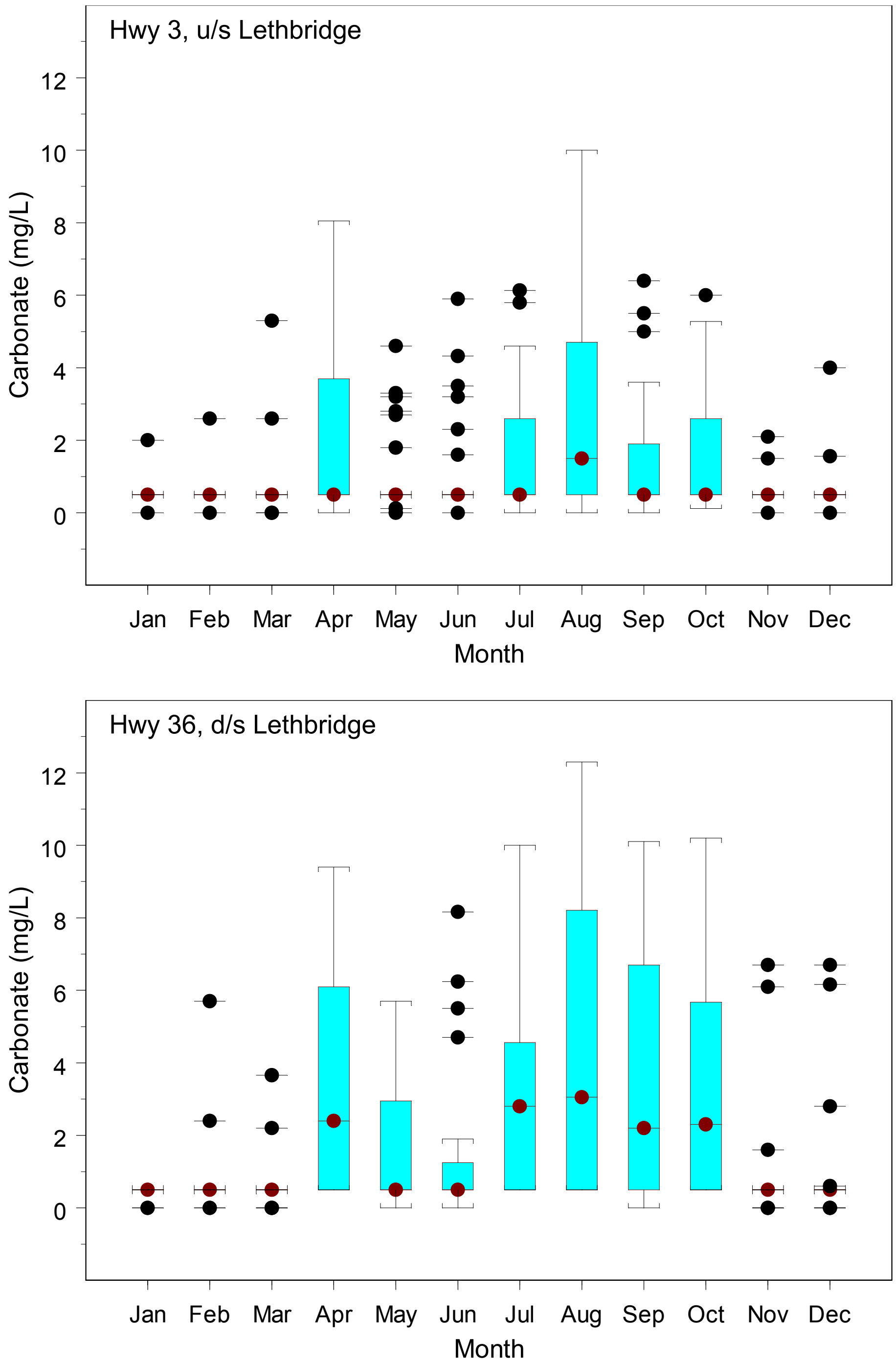
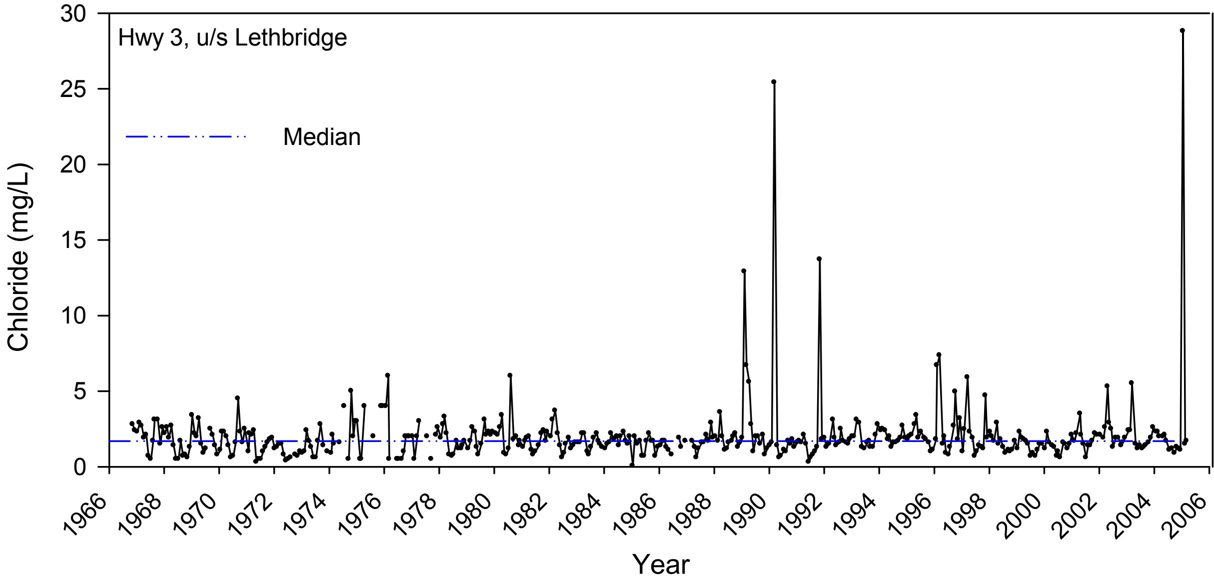
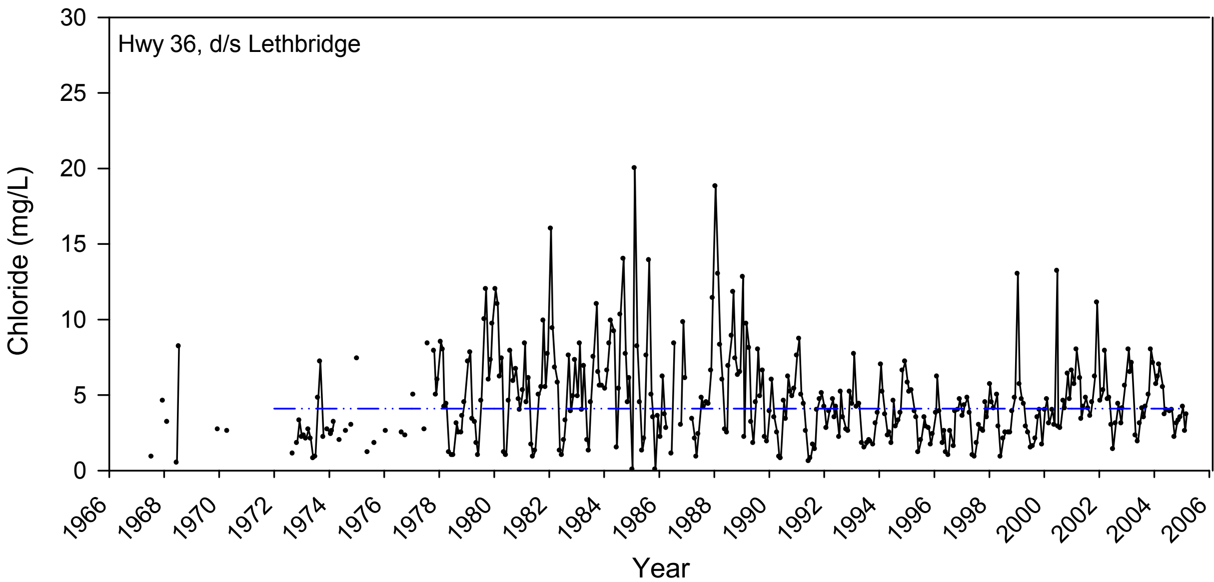


Figure 43 Seasonality of Carbonate data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0045	NS		1.70			1.70		
Flow Adjusted								
0.0030	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0167	NS		4.50			4.00		
Flow Adjusted								
-0.0155	NS							

Figure 44 Dissolved Chloride in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

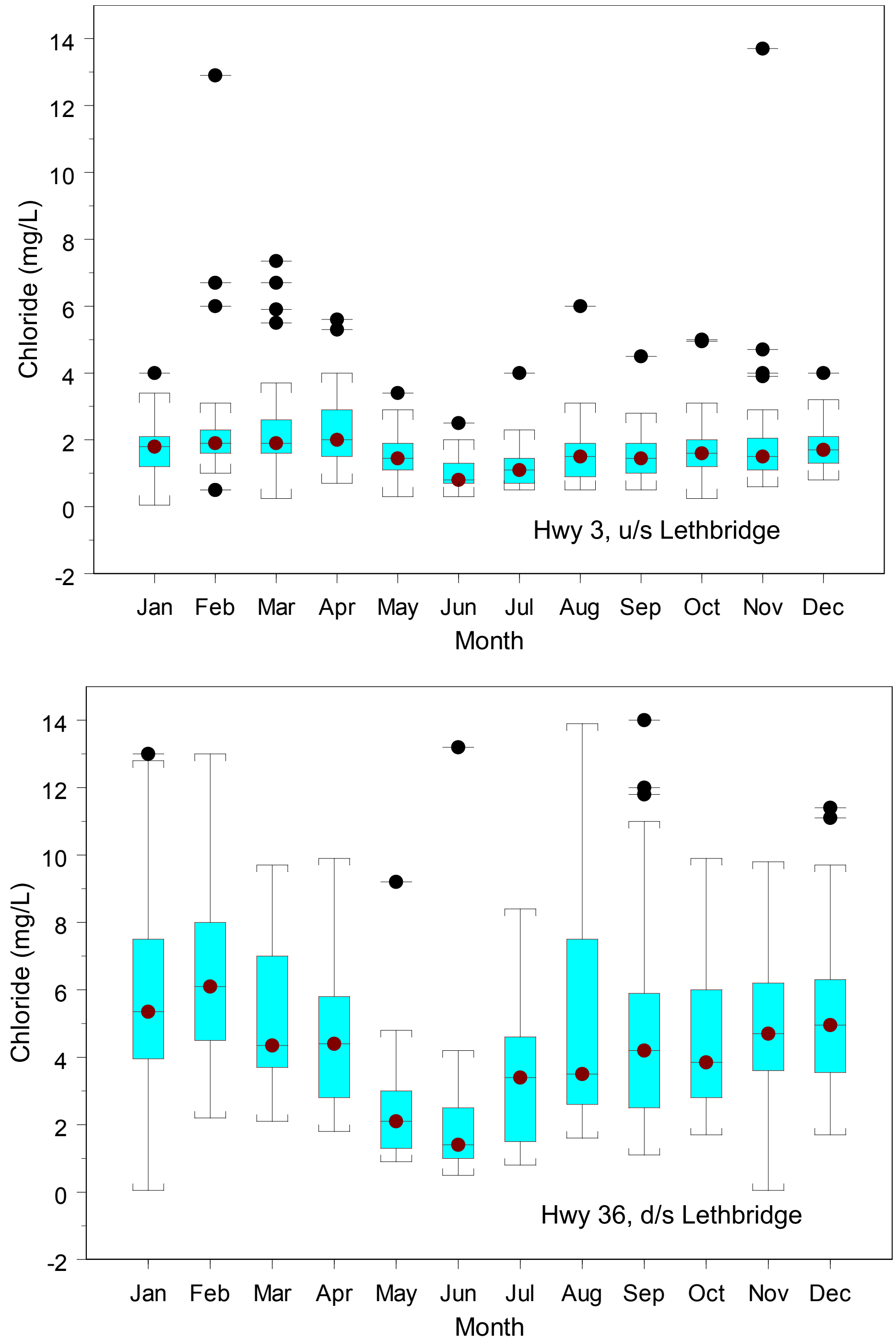
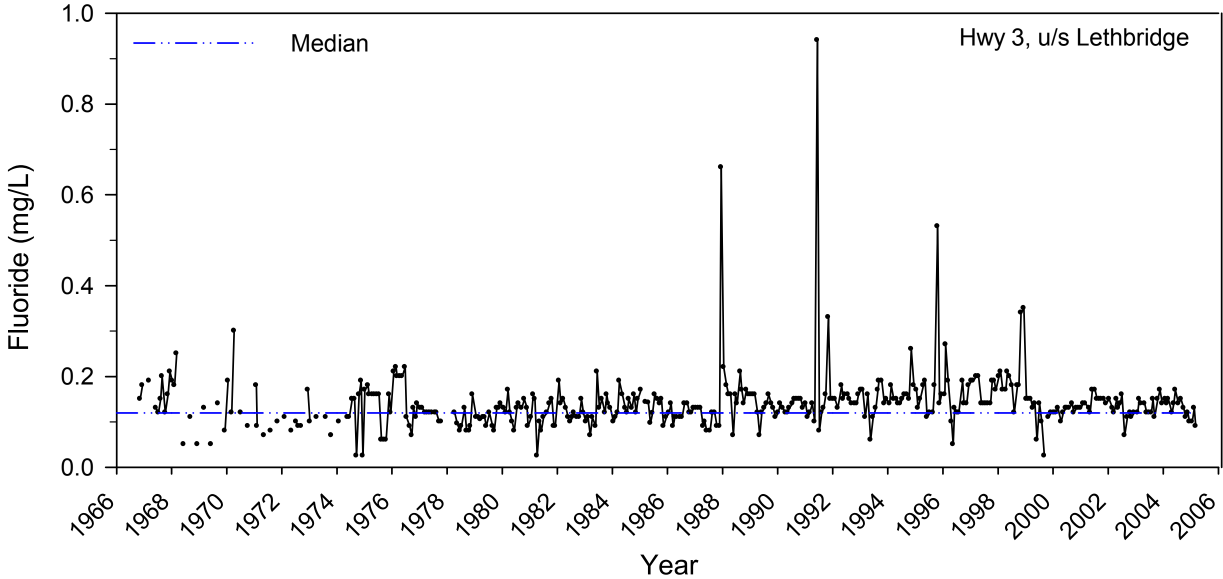
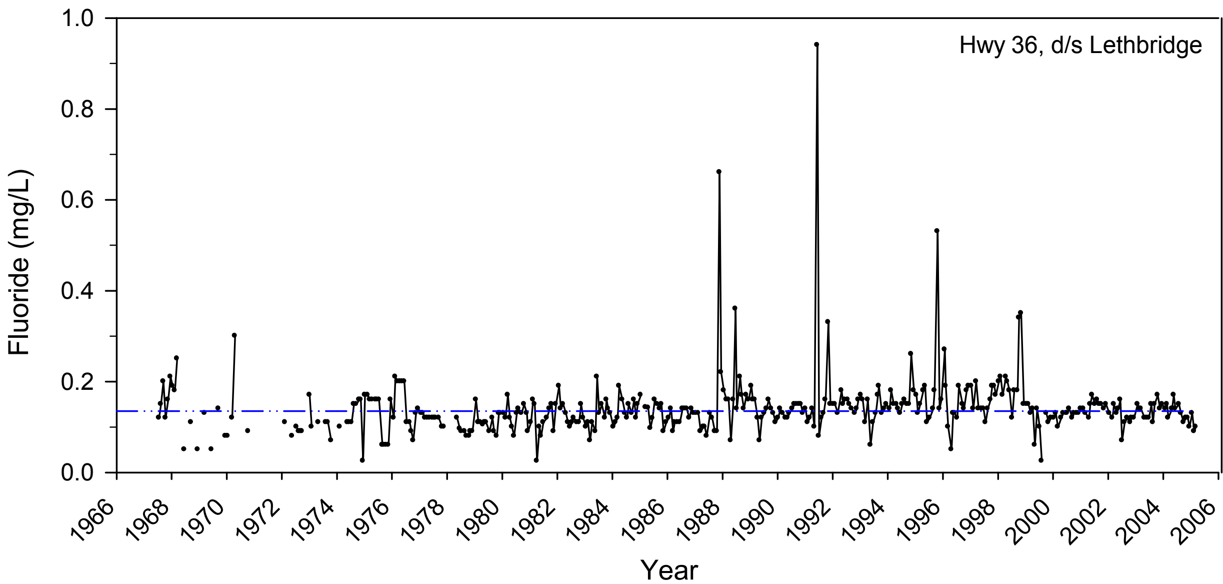


Figure 45 Seasonality of Dissolved Chloride concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0006	NS		0.12			0.13		
Flow Adjusted								
0.0006	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0007	Up	***	0.12	-0.0020	NS	0.14	-0.0010	NS
0.0010	Up			0.0013	NS		-0.0011	NS

Figure 46 Dissolved Fluoride in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

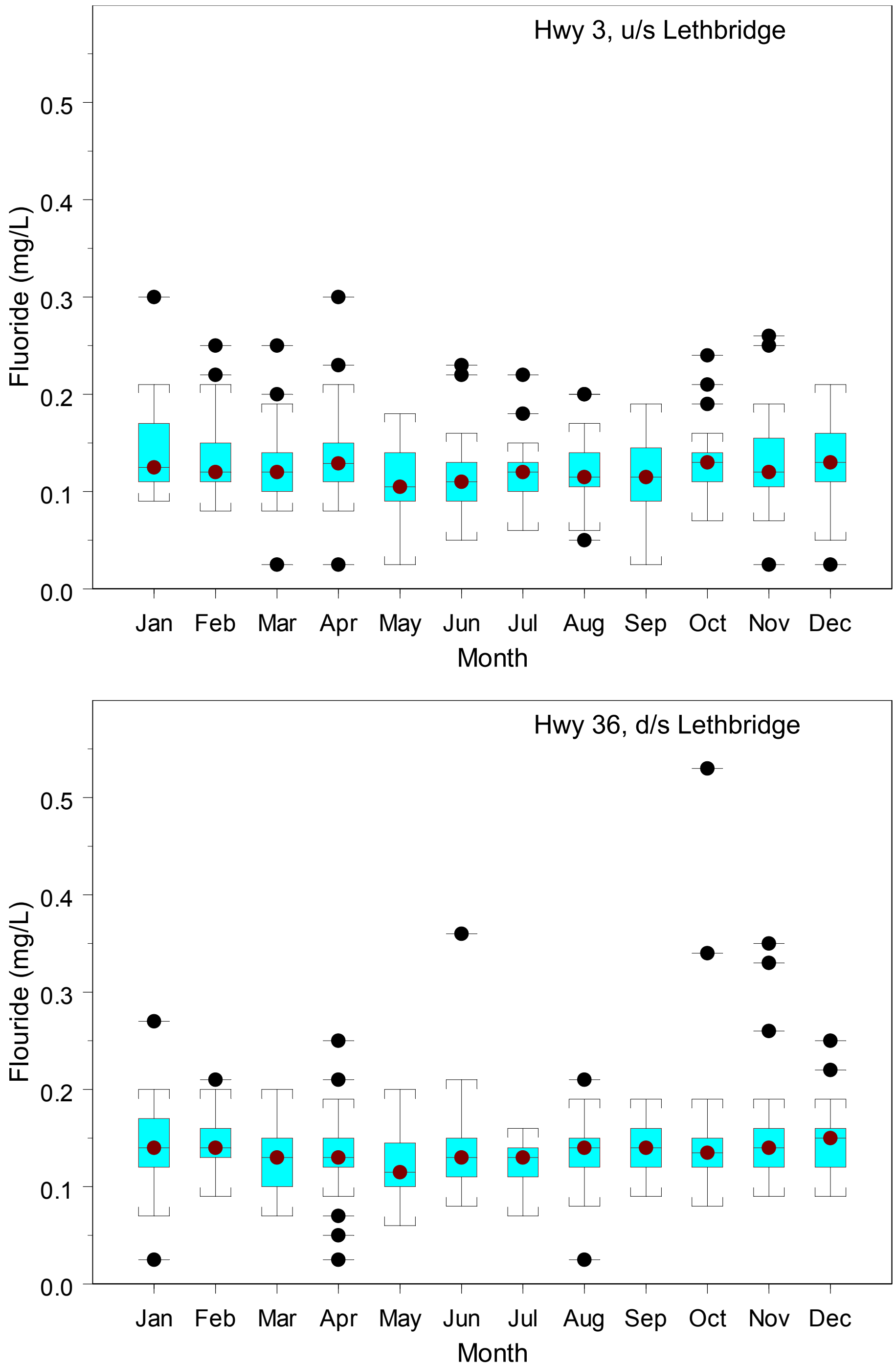
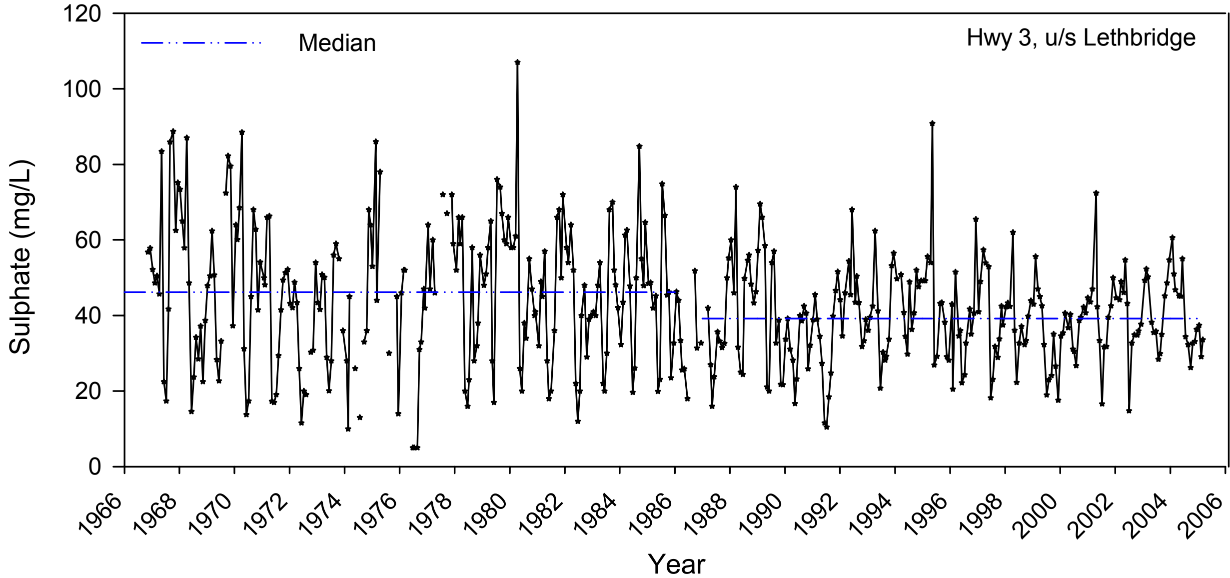
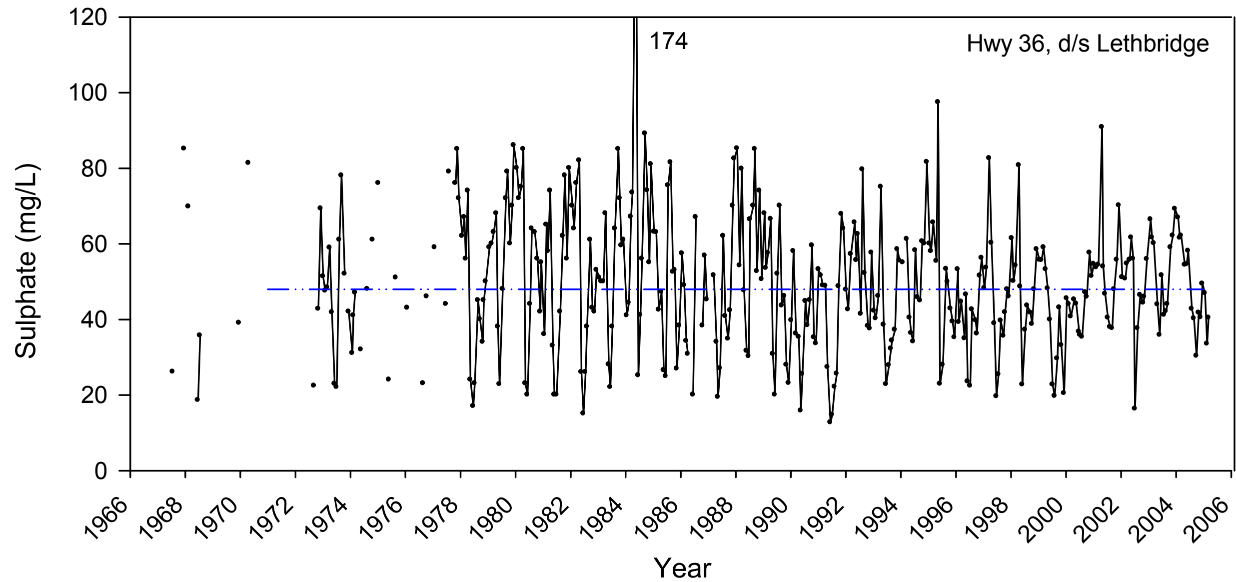


Figure 47 Seasonality of Dissolved Fluoride concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.1737	NS	***	46.20	-0.2000	NS	39.20	-0.0750	NS
Flow Adjusted								
-0.2286	Down			-0.5808	Down		-0.0417	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.1778	NS		51.65			46.40		
Flow Adjusted								
-0.0429	NS							

Figure 48 Dissolved Sulphate in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

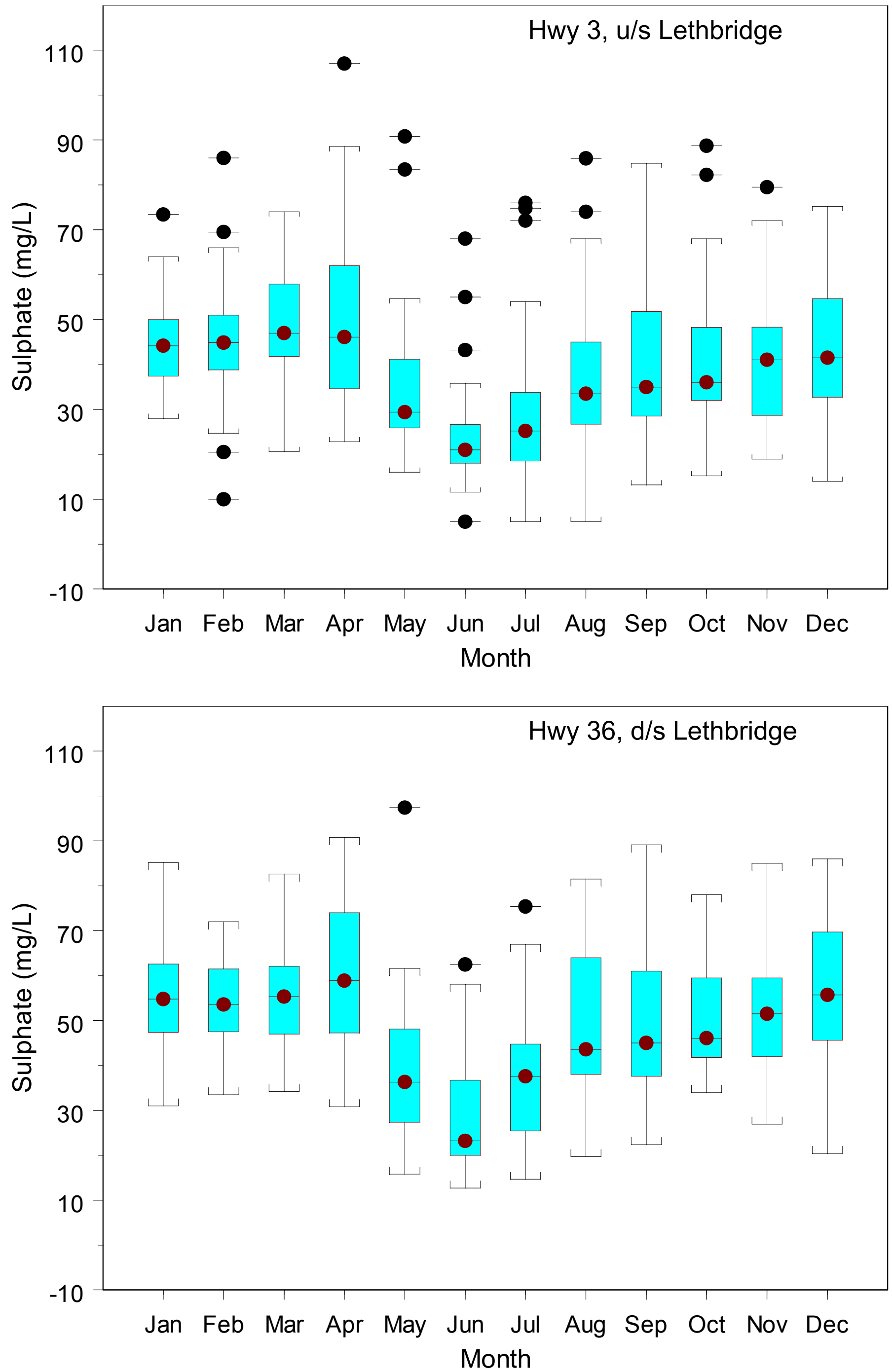
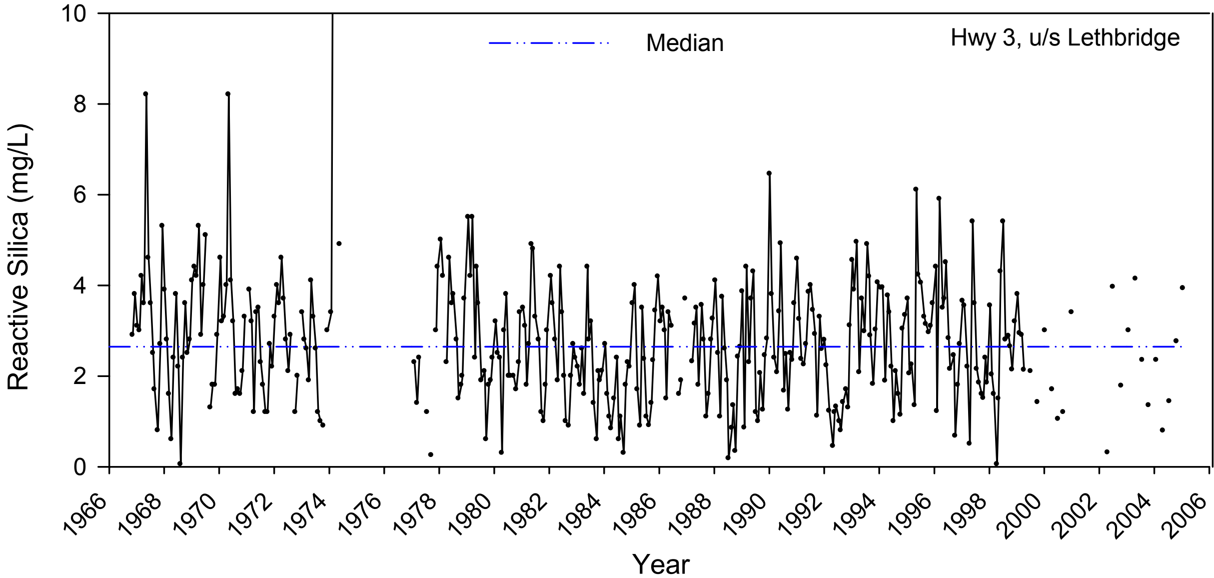
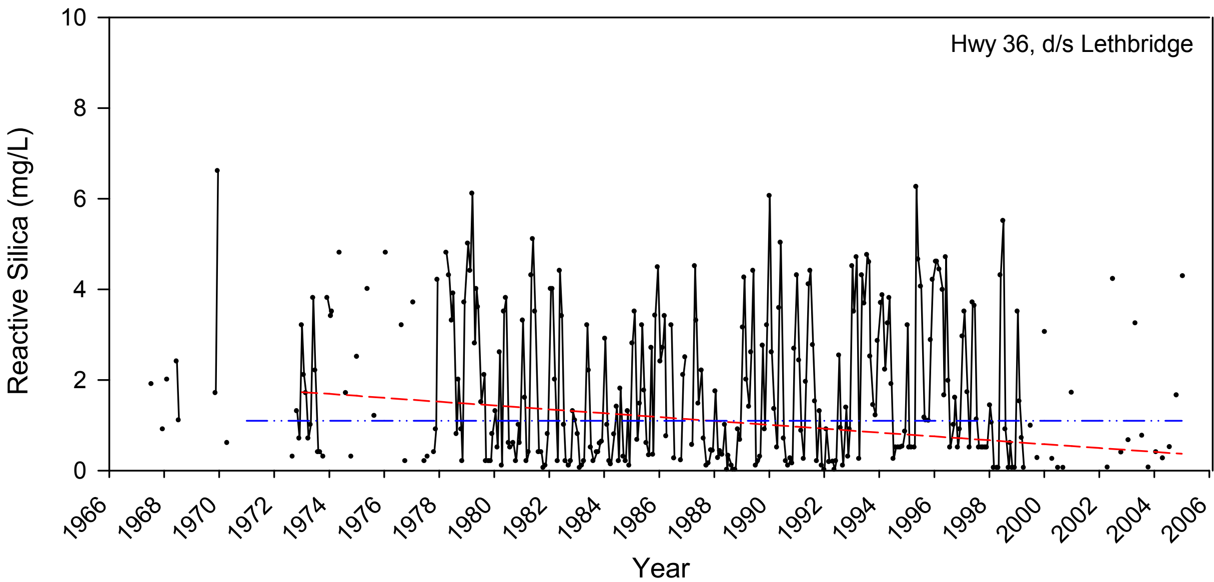


Figure 49 Seasonality of Dissolved Sulphate concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

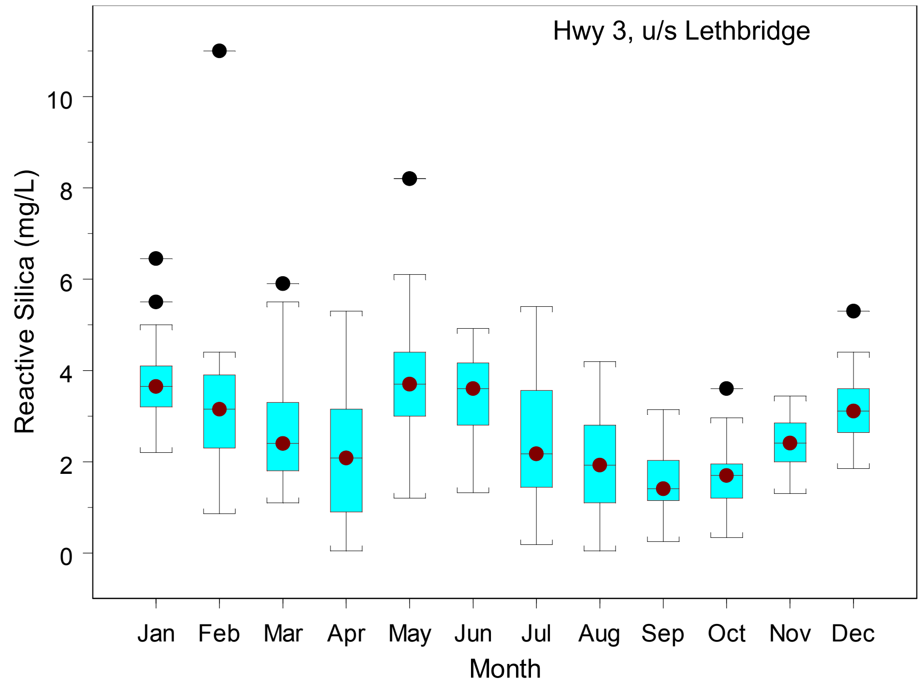


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS		2.70			2.62		
Flow Adjusted								
-0.0032	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-4.06%	Down	NS	1.30			1.00		
Flow Adjusted								
-5.87%	Down							

Figure 50 Reactive Silica in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



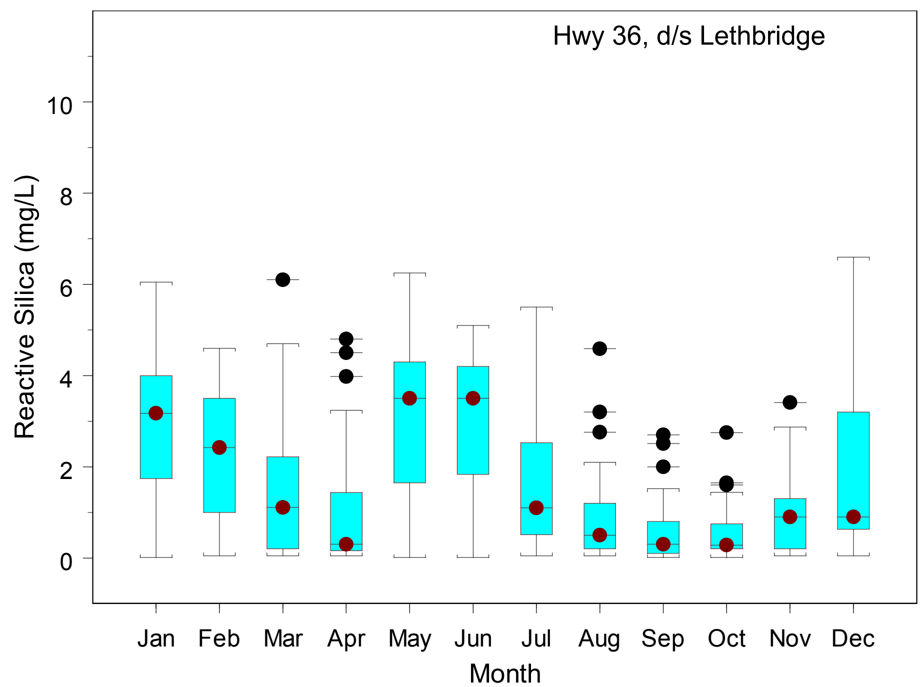
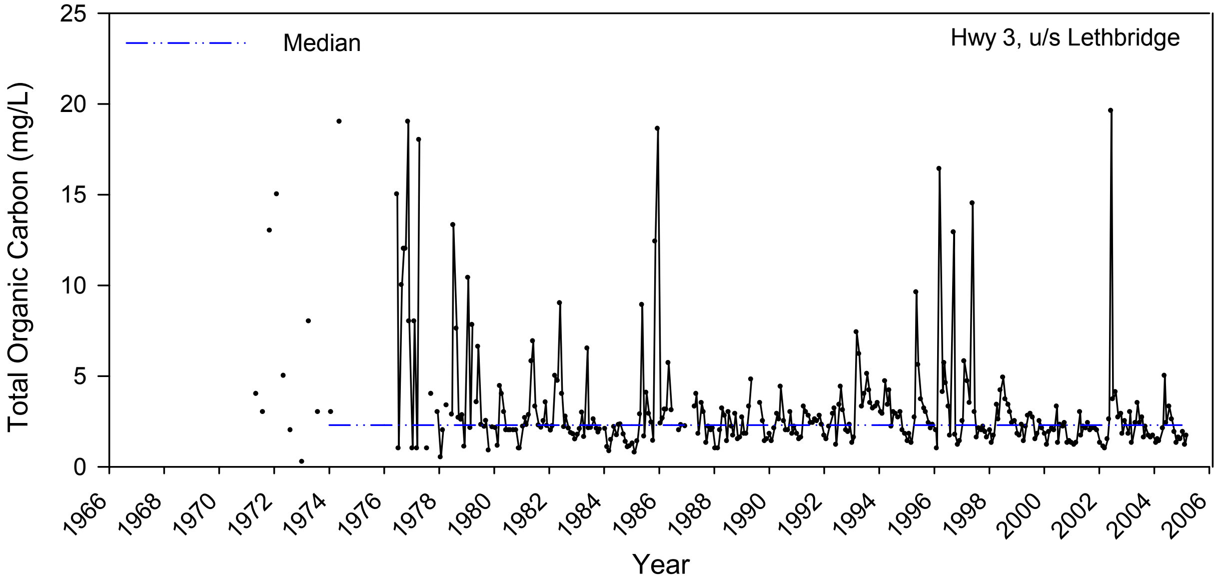
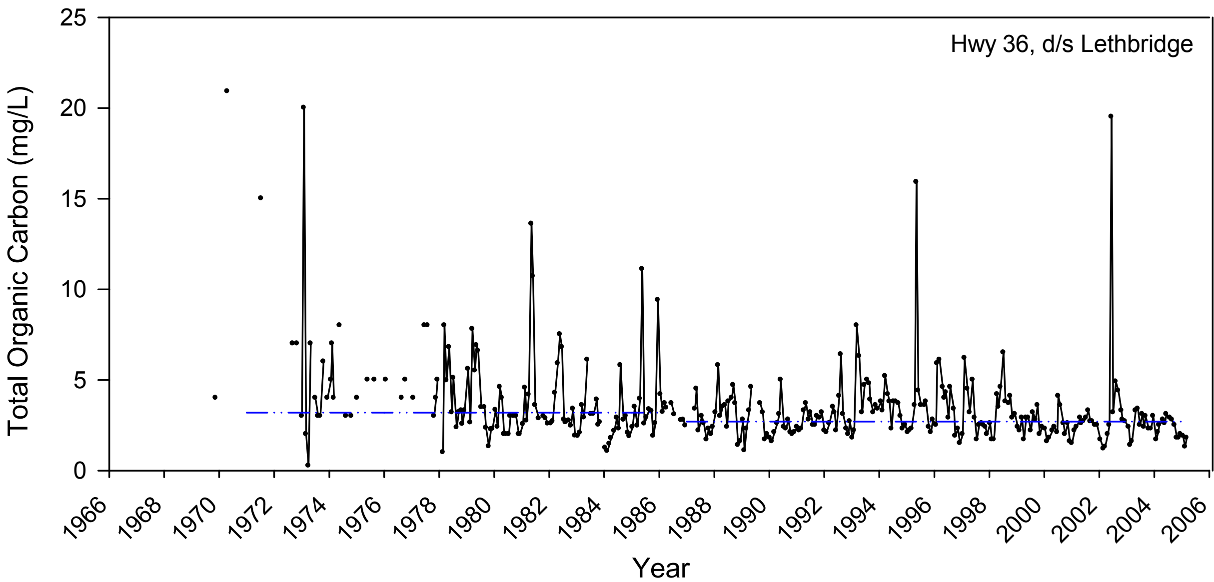


Figure 51 Seasonality of Reactive Silica concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0086	NS		2.32			2.30		
Flow Adjusted								
-0.0128	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0250	Down	***	3.20	-0.0800	NS	2.70	-0.0333	NS
Flow Adjusted								
-0.0288	Down			0.0640	NS		-0.0246	NS

Figure 52 Total Organic Carbon in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

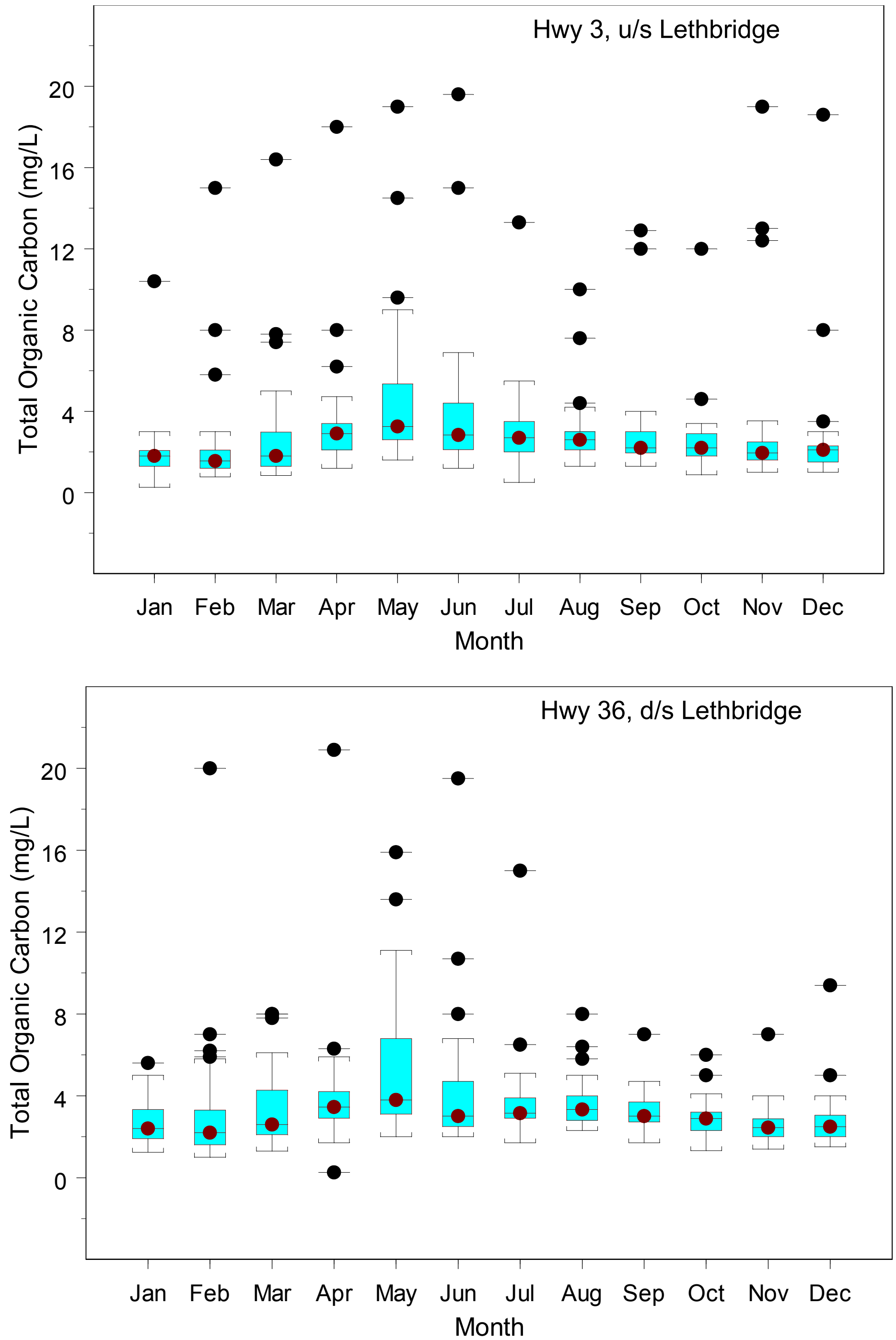
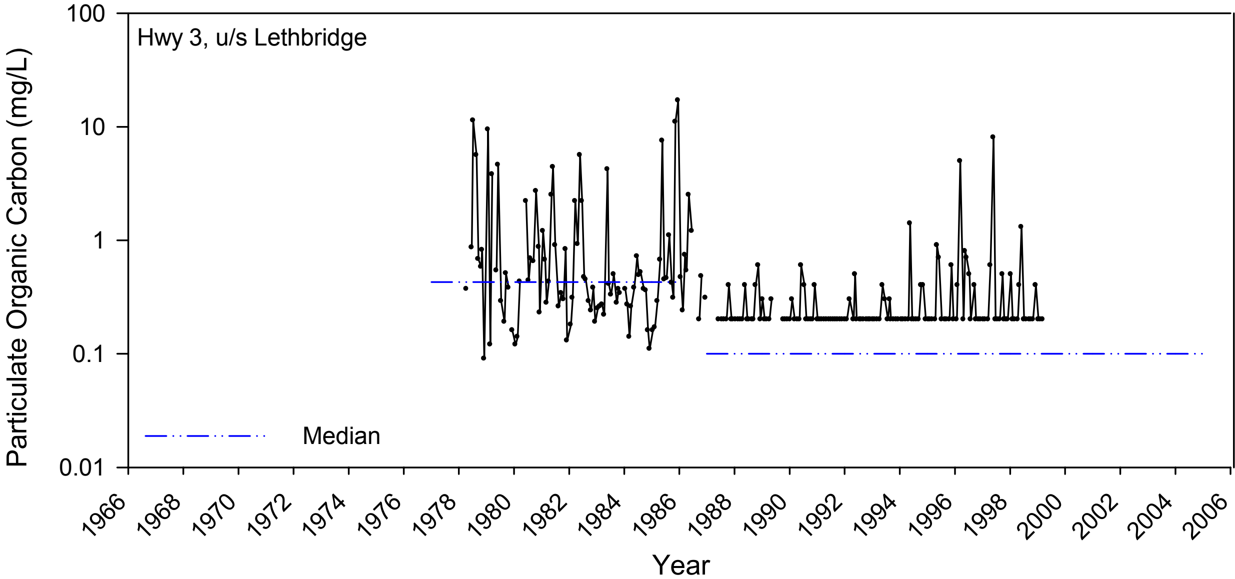
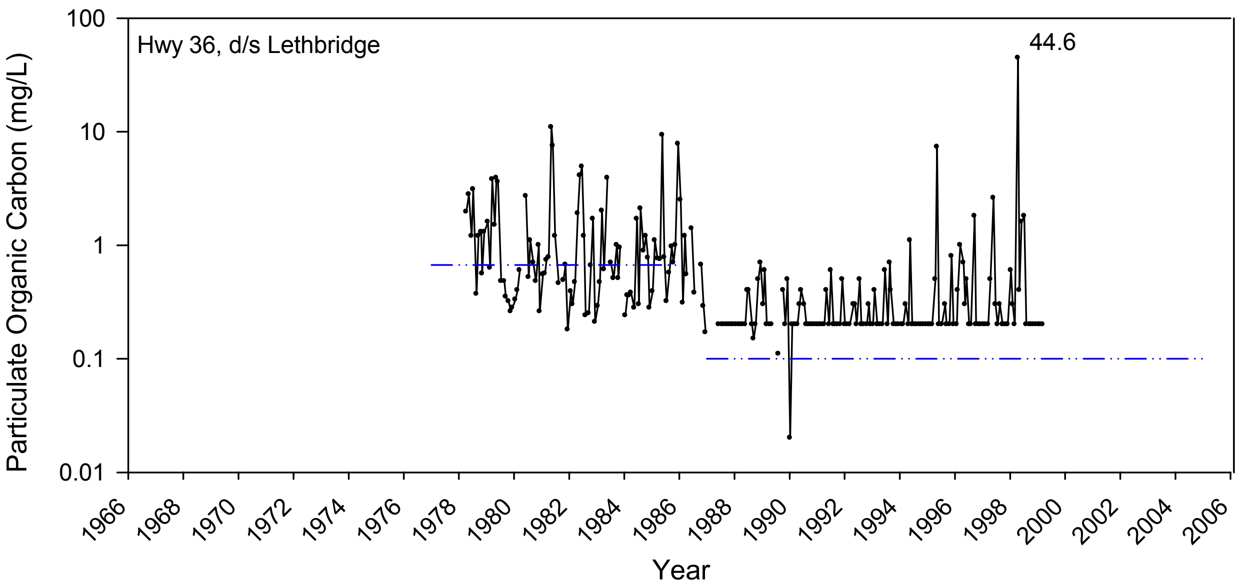


Figure 53 Seasonality of water Total Organic Carbon in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-8.85%	Down	***	0.43	-3.77%	NS	0.10	3.74%	NS
Flow Adjusted								
-9.94%	Down			0.53%	NS		1.37%	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-9.87%	Down	***	0.67	0.87%	NS	0.10	5.86%	NS
Flow Adjusted								
-9.94%	Down			1.00%	NS		4.34%	NS

Figure 54 Particulate Organic Carbon in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). Post-1987 medians are the result of censored data. NS = Not Significant.

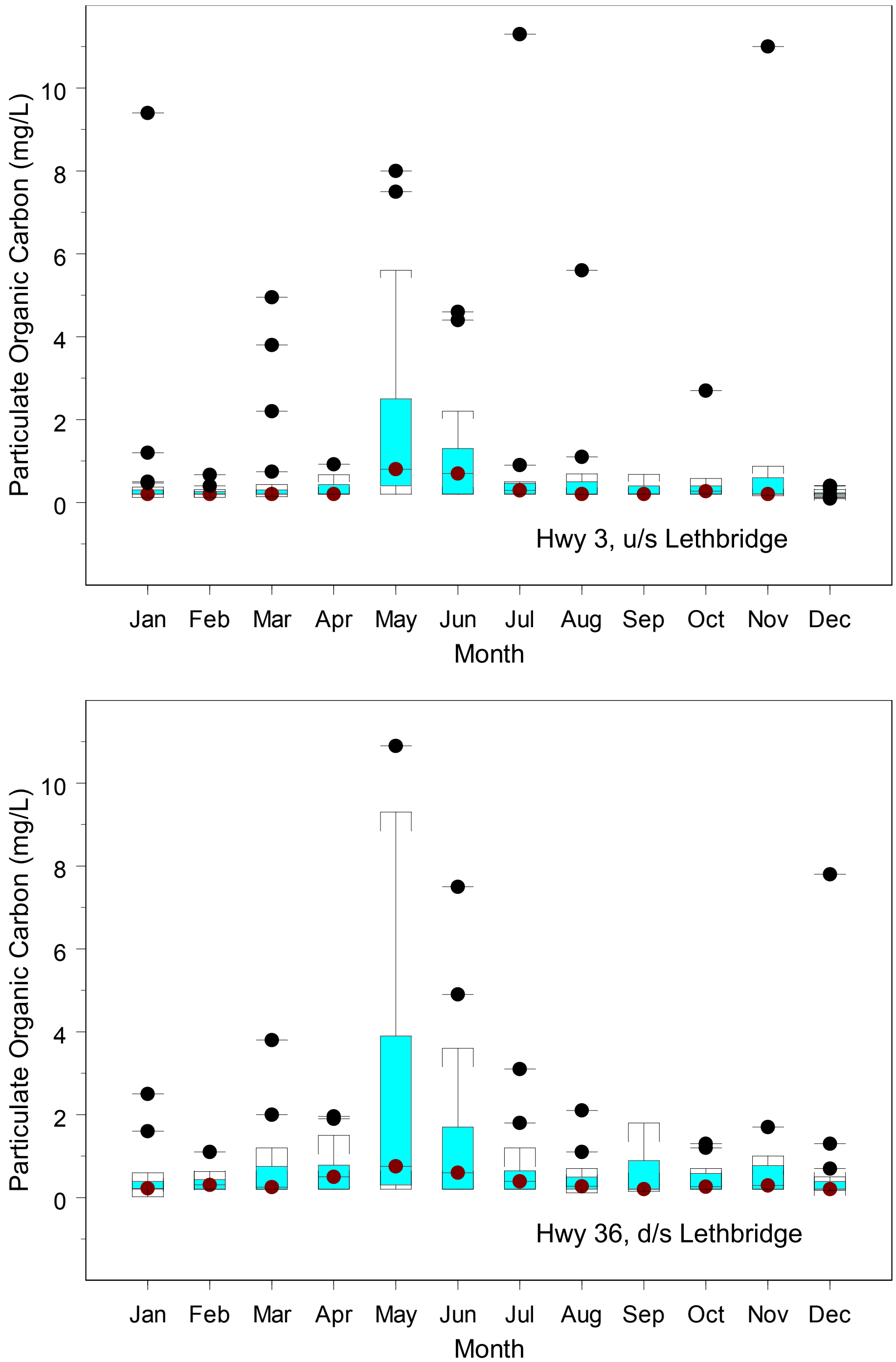
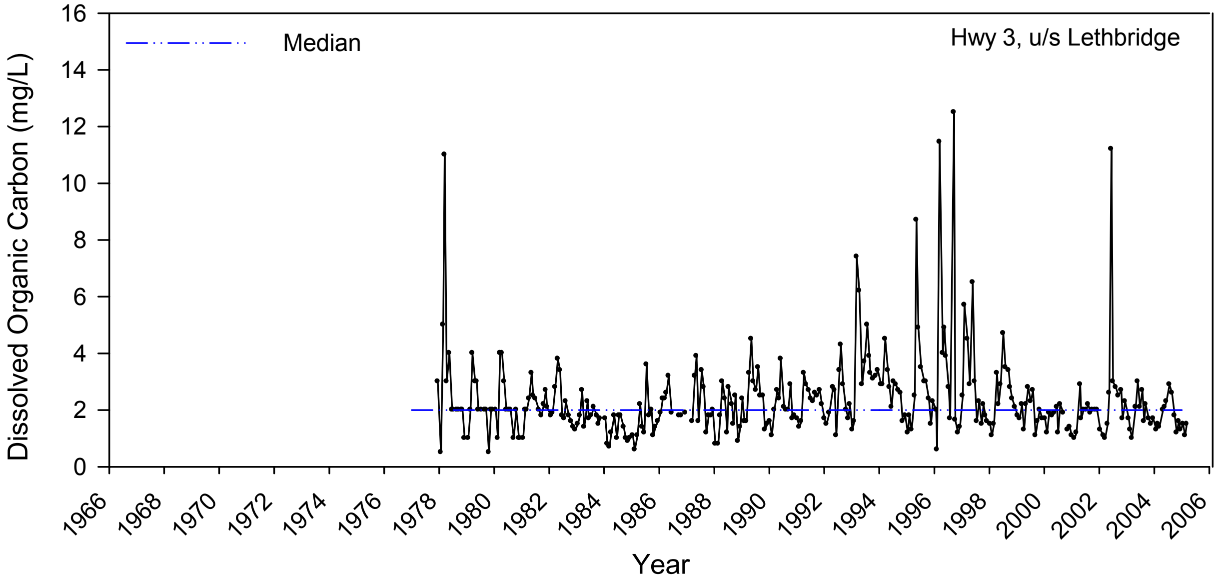
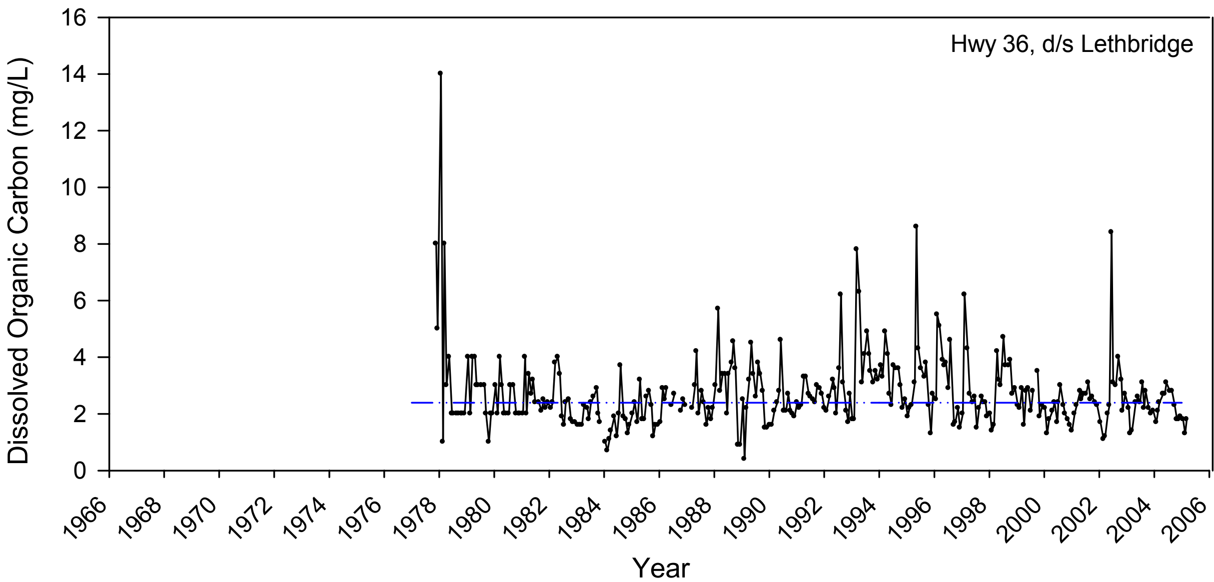


Figure 55 Seasonality of Particulate Organic Carbon in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

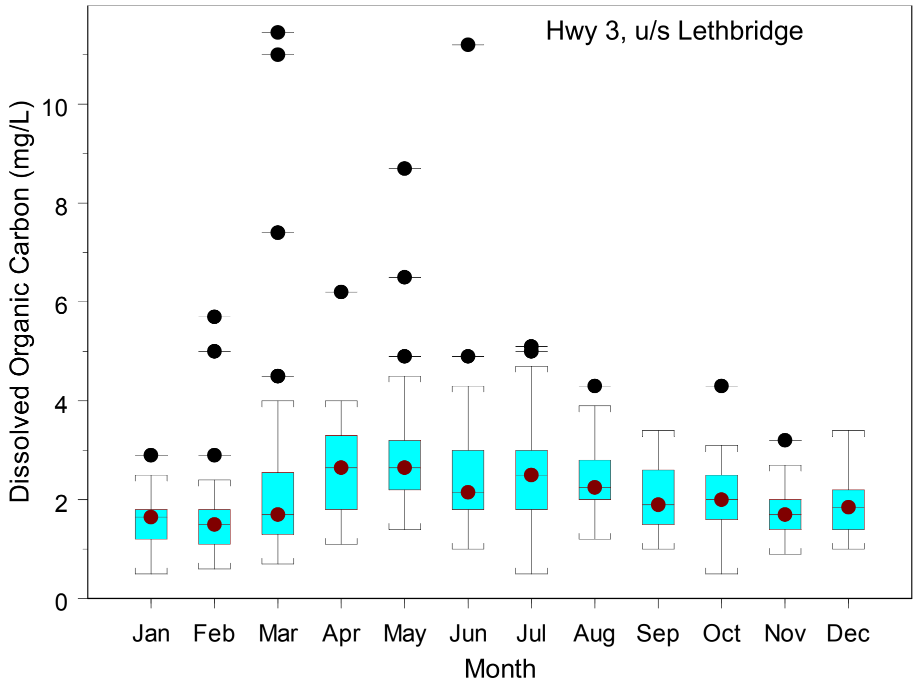


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0056	NS		2.00			2.10		
Flow Adjusted								
0.0071	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0053	NS		2.10			2.50		
Flow Adjusted								
0.0062	NS							

Figure 56 Dissolved Organic Carbon in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



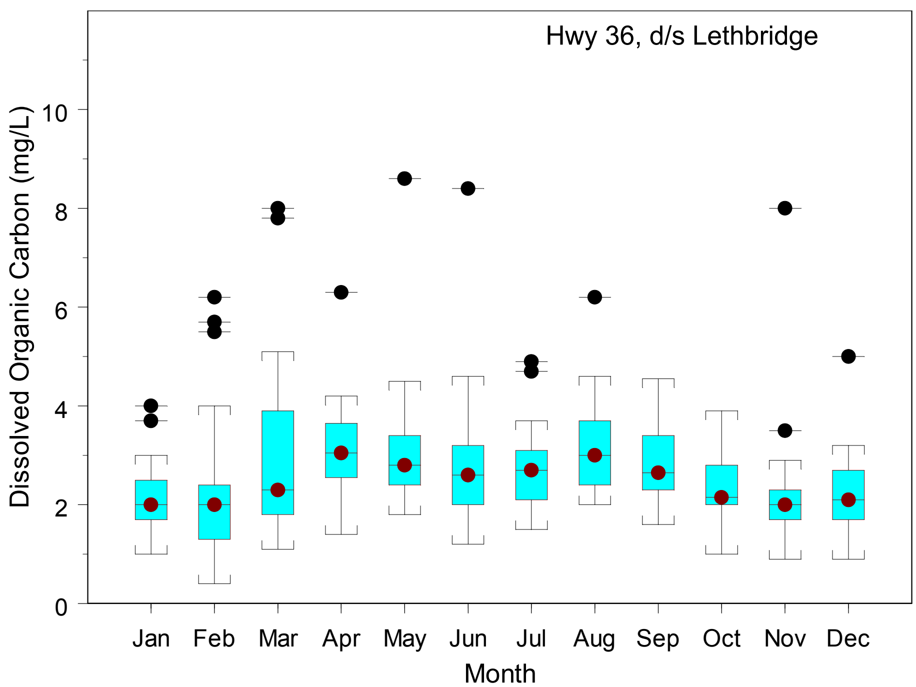
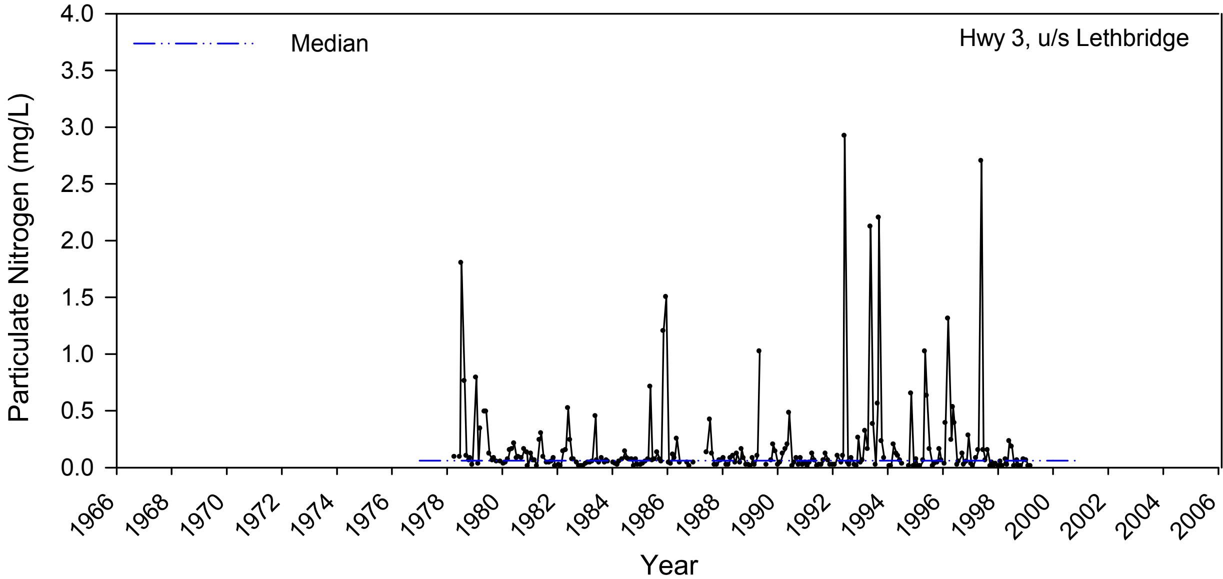
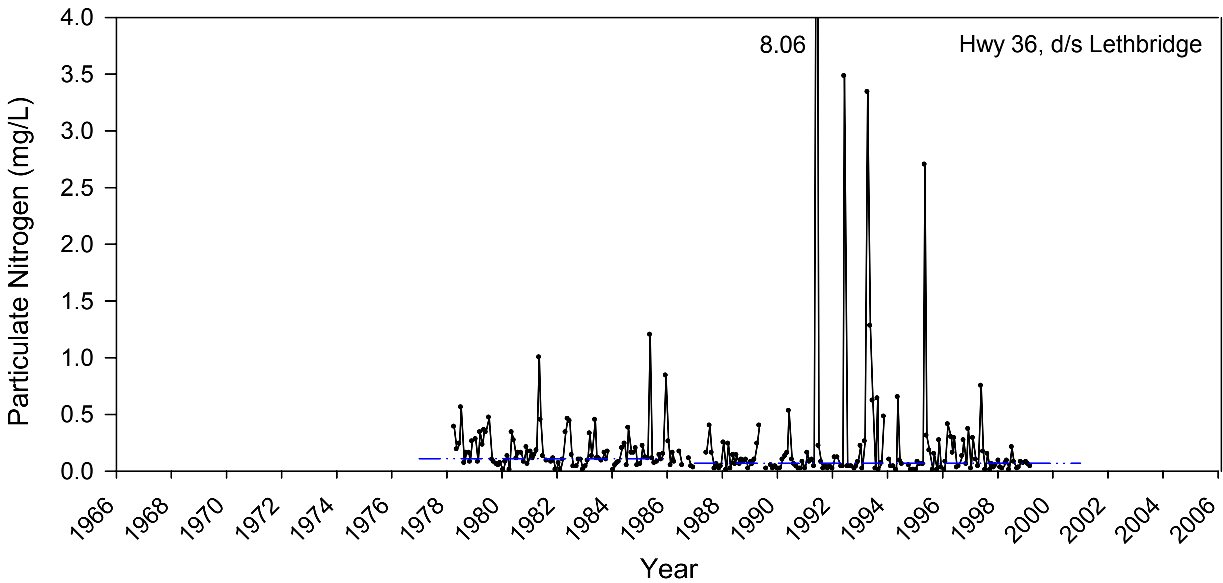


Figure 57 Seasonality of water temperature data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-1.72%	NS	NS	0.07			0.06		
Flow Adjusted								
-3.51%	Down							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-3.61%	Down	***	0.11	0.03%	NS	0.07	-1.74%	NS
Flow Adjusted								
-4.68%	Down			-0.35%	NS		-4.46%	

Figure 58 Particulate Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

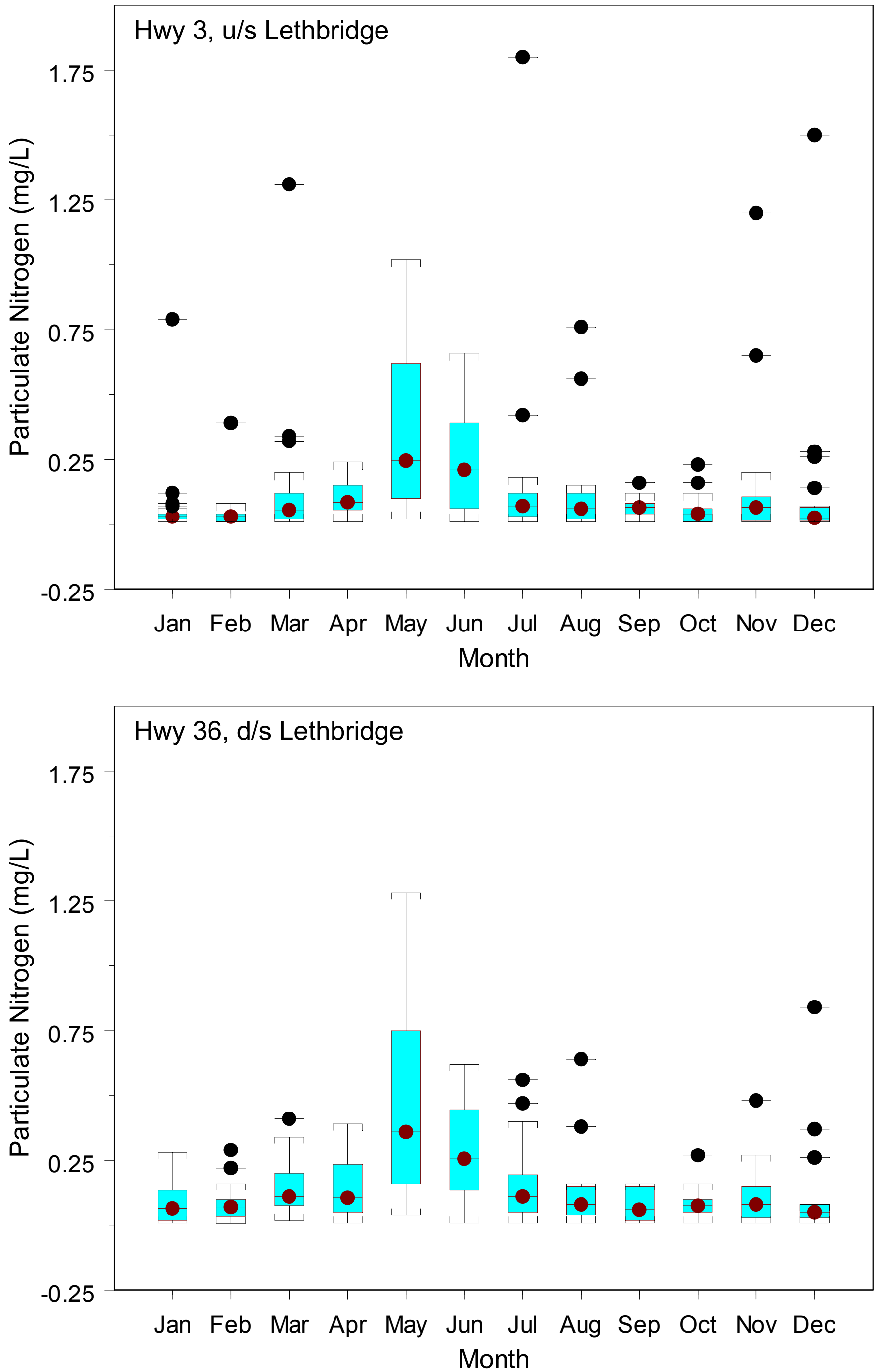
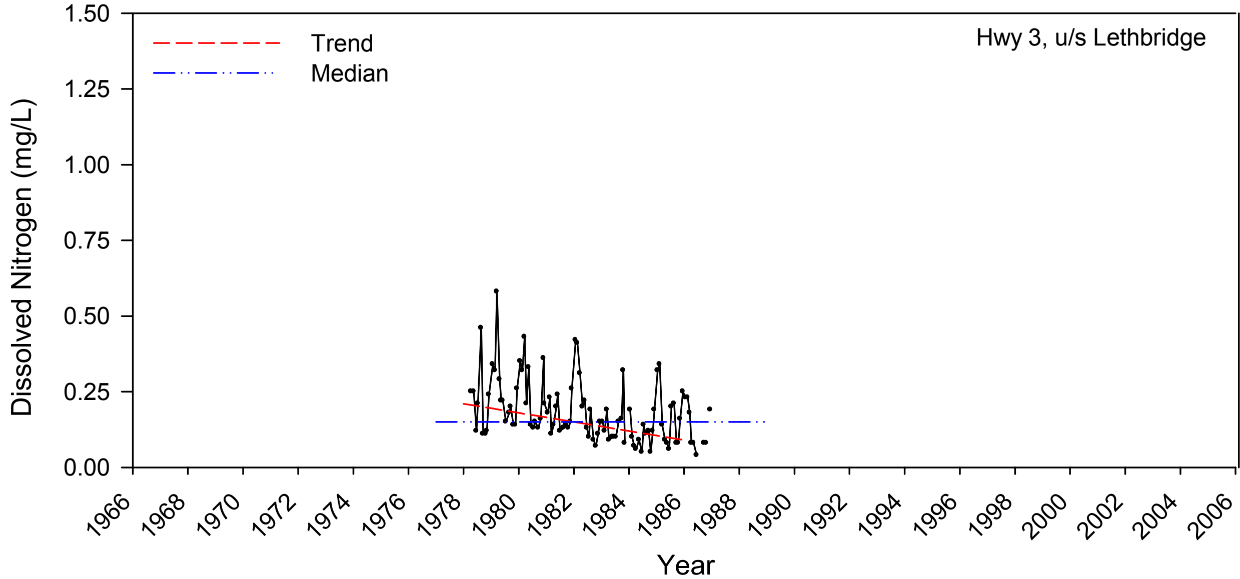
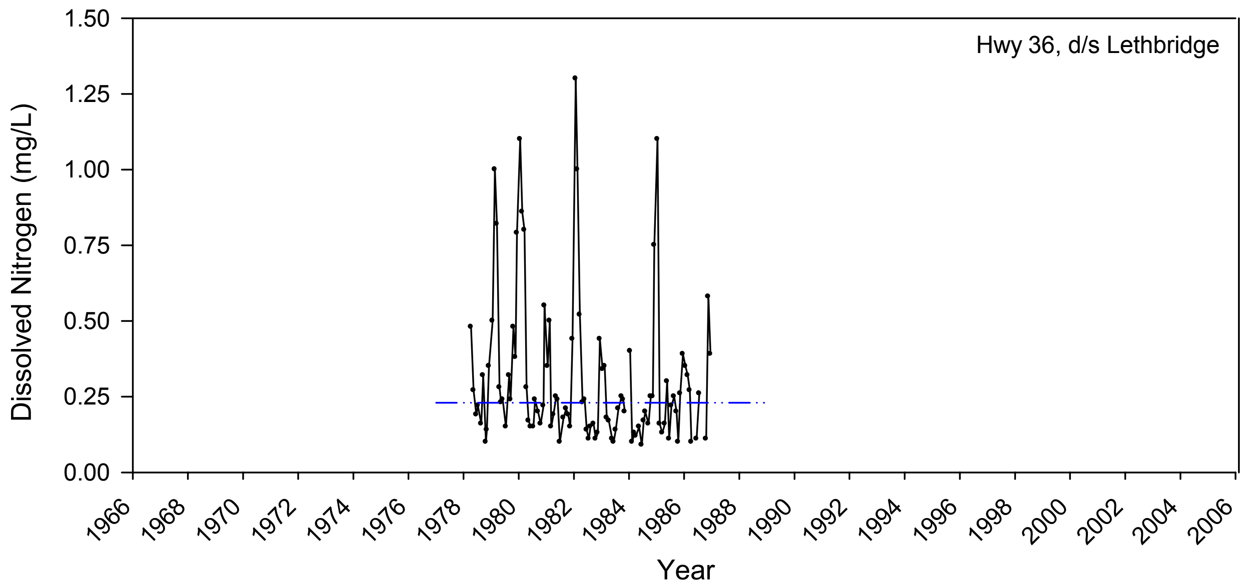


Figure 59 Seasonality of Particulate Nitrogen data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0150	Down		0.15					
Flow Adjusted								
-0.0134	Down							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0100	NS		0.23					
Flow Adjusted								
-0.0171	NS							

Figure 60 Dissolved Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

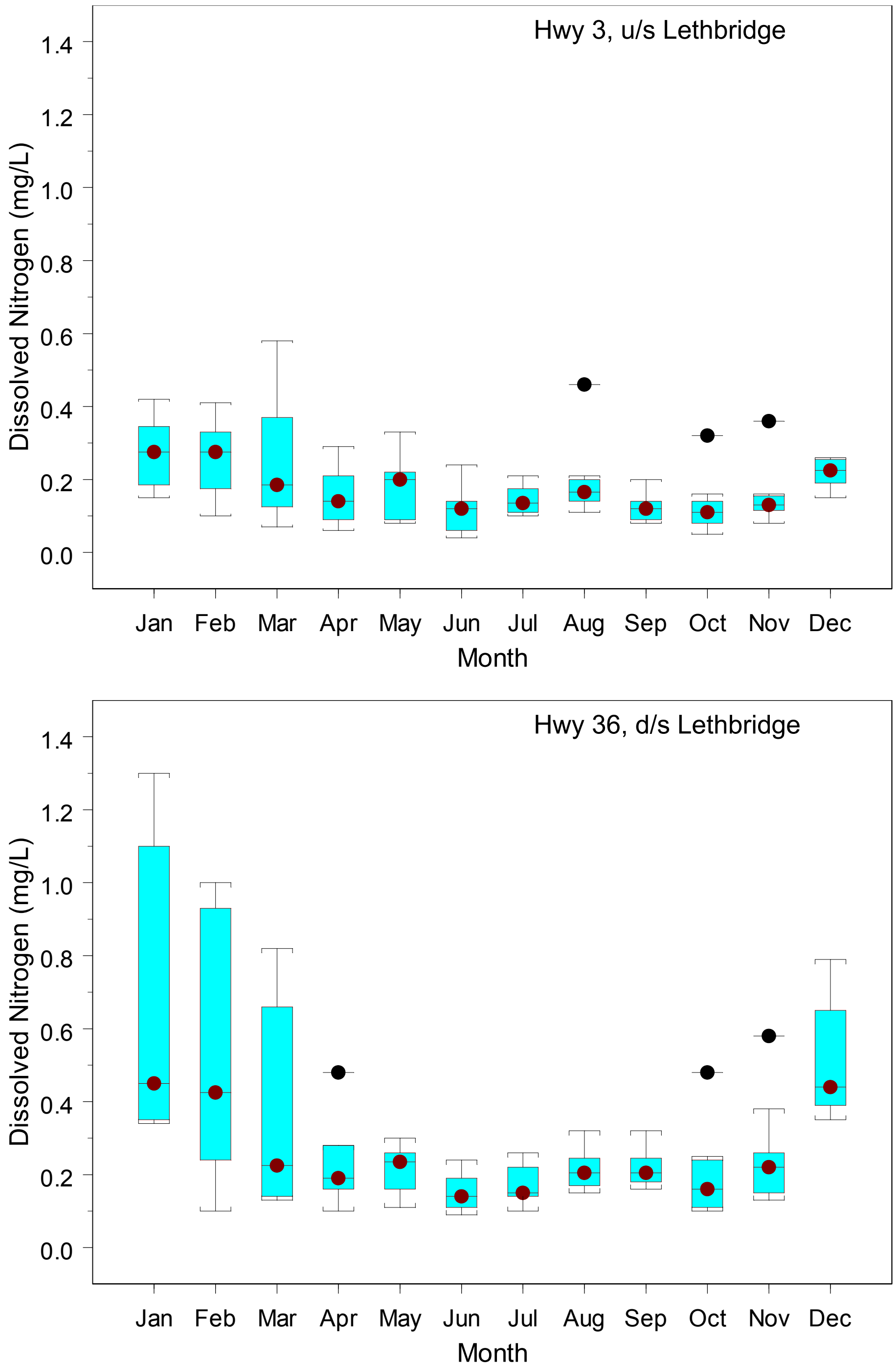
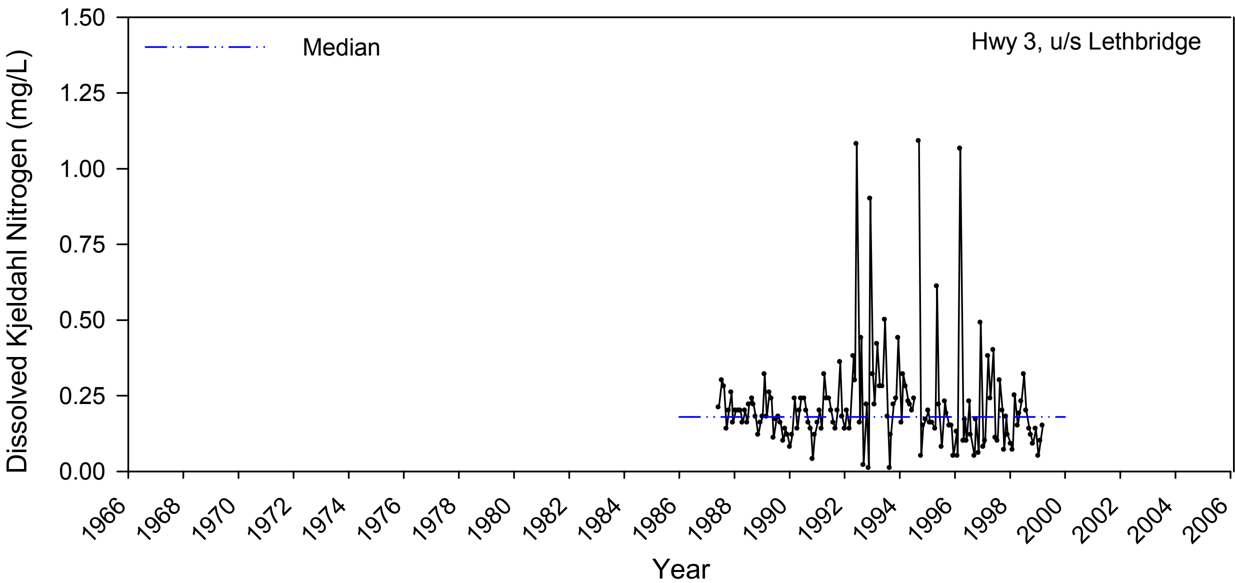
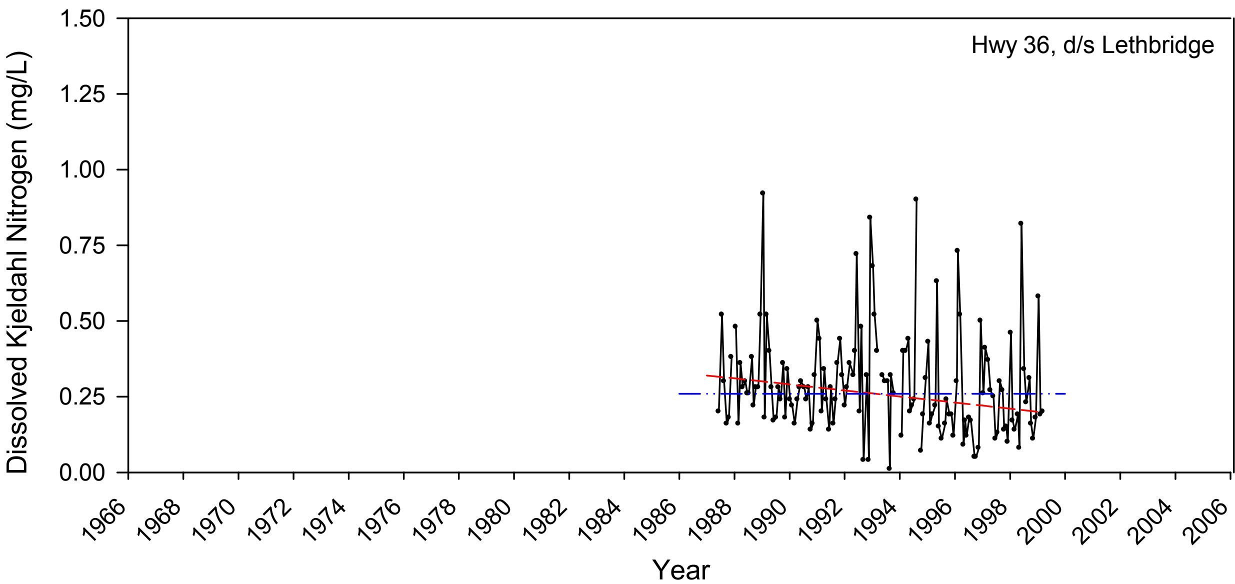


Figure 61 Seasonality of Dissolved Nitrogen data in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0040	NS					0.18		
-0.0047	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0100	Down					0.26		
Flow Adjusted								
-0.0072	NS							

Figure 62 Dissolved Kjeldahl Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

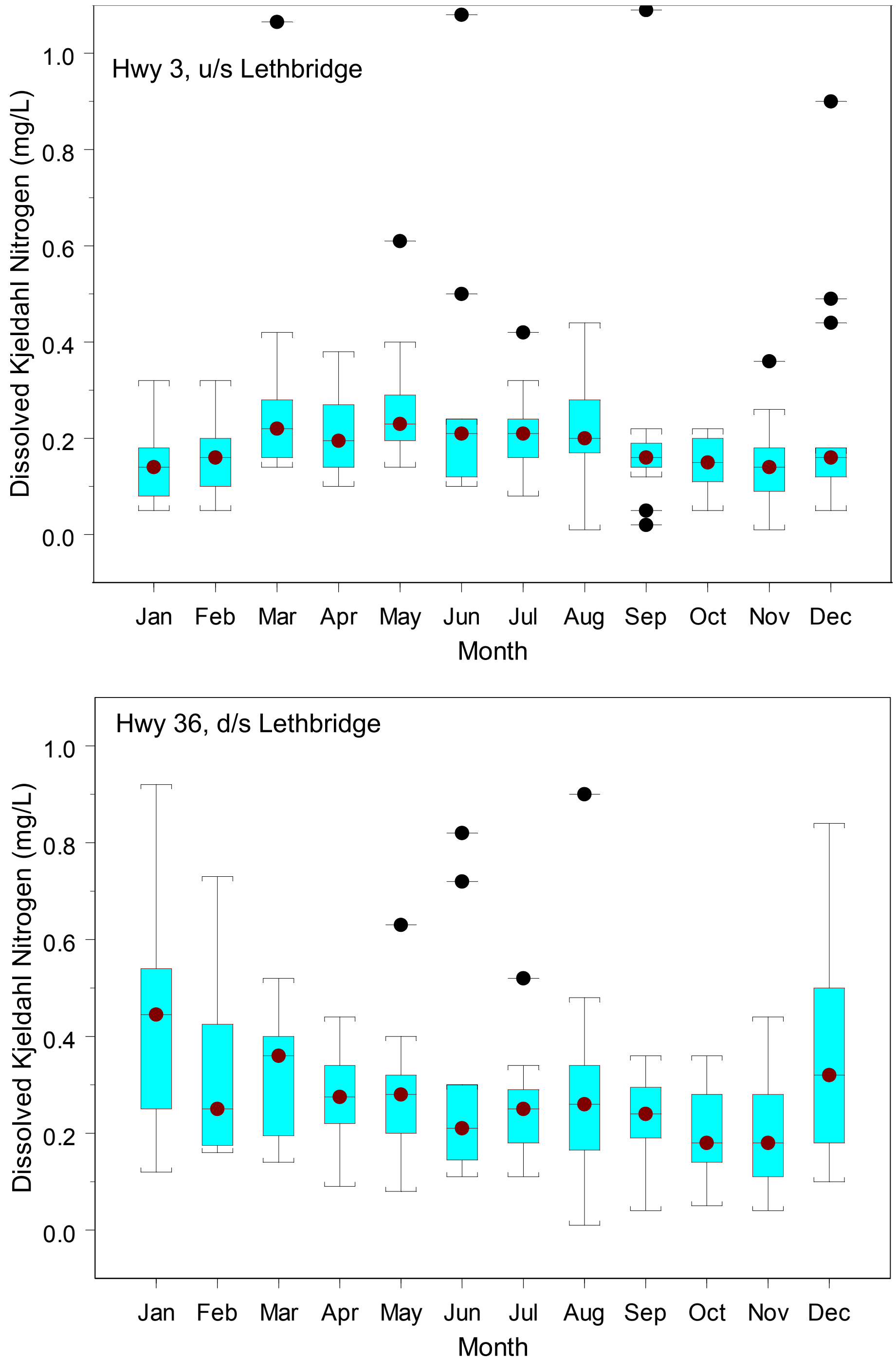
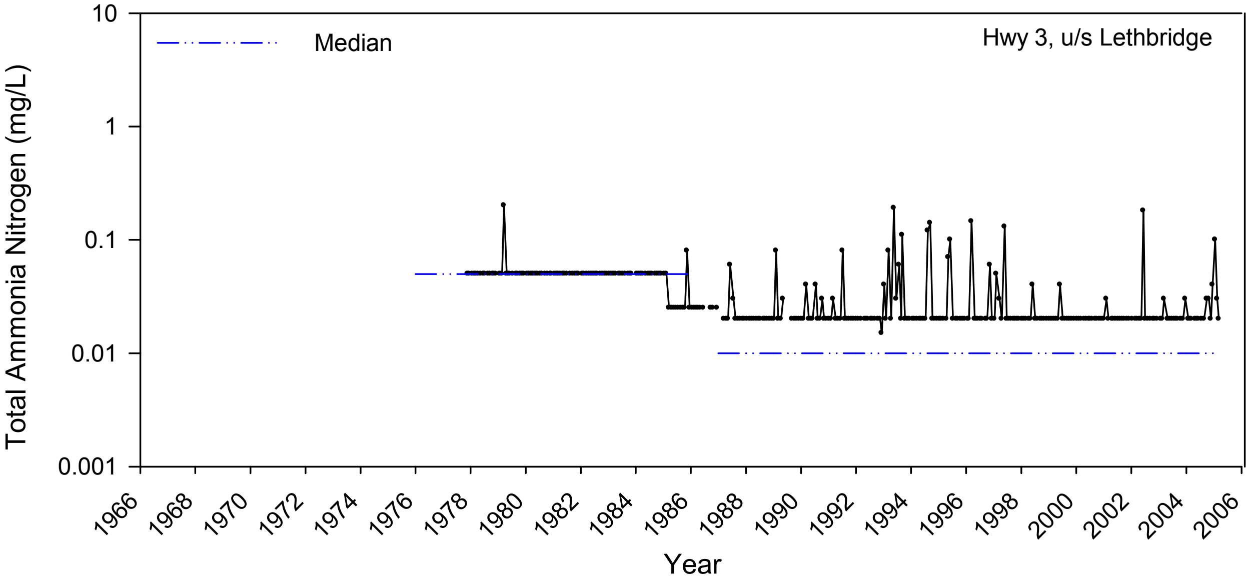
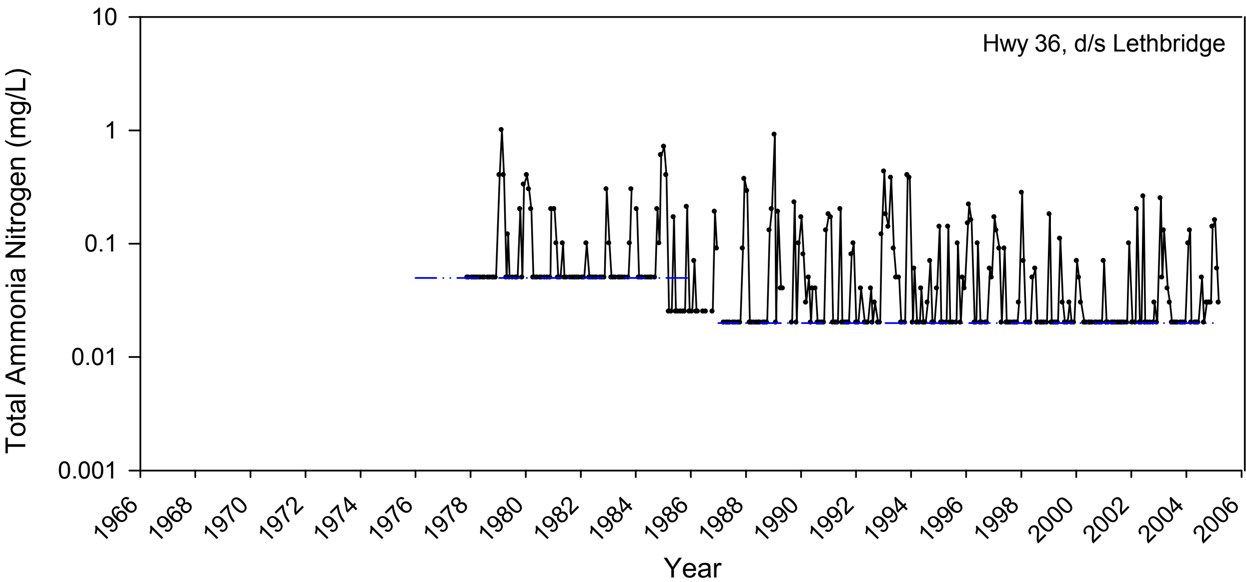


Figure 63 Seasonality of Dissolved Kjeldahl Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-7.42%	Down	***	0.05	-4.37%	Down	0.01	-2.03%	NS
Flow Adjusted								
-7.56%	Down			-4.29%	Down		-2.12%	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-6.83%	Down	***	0.05	-5.62%	Down	0.02	-4.77%	Down
Flow Adjusted								
-7.04%	Down			-5.04%	NS		-4.90%	Down

Figure 64 Total Ammonia Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). Medians are driven by censored values (i.e. non-detects). NS = Not Significant.

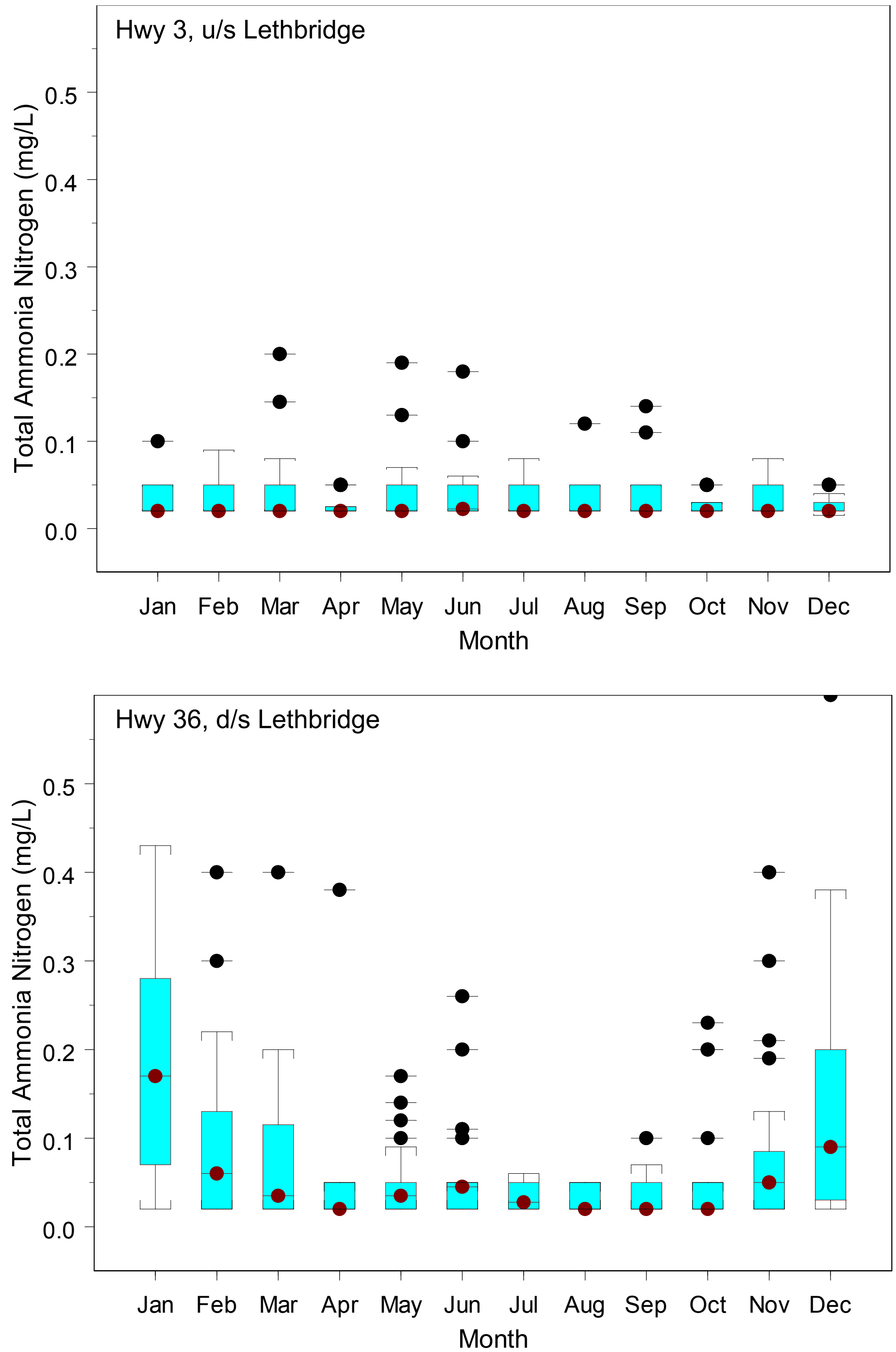
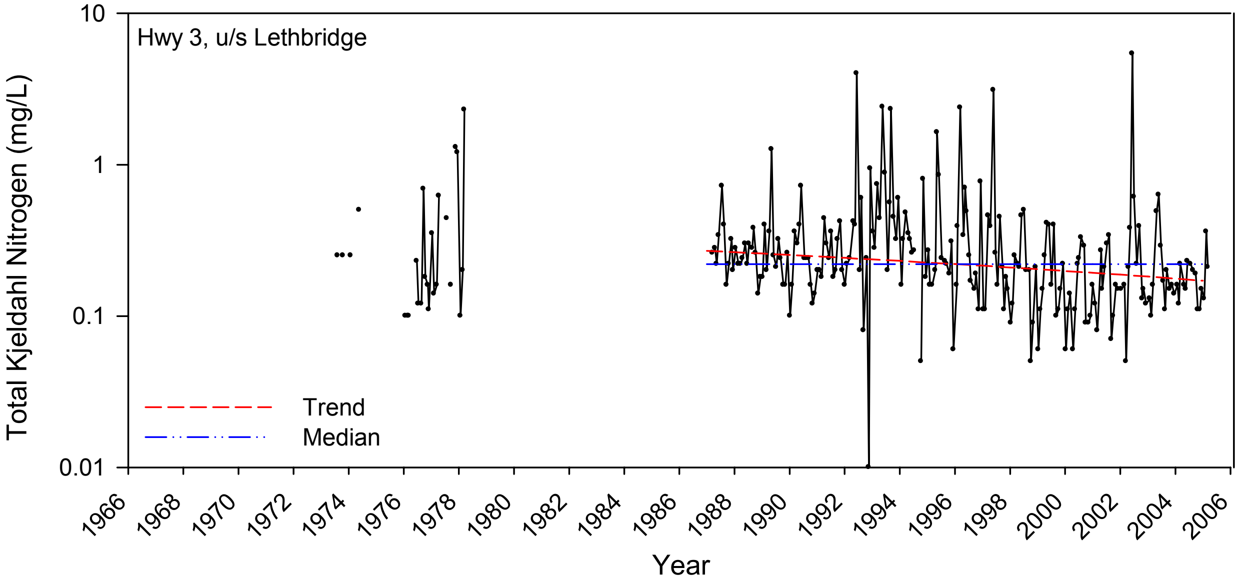
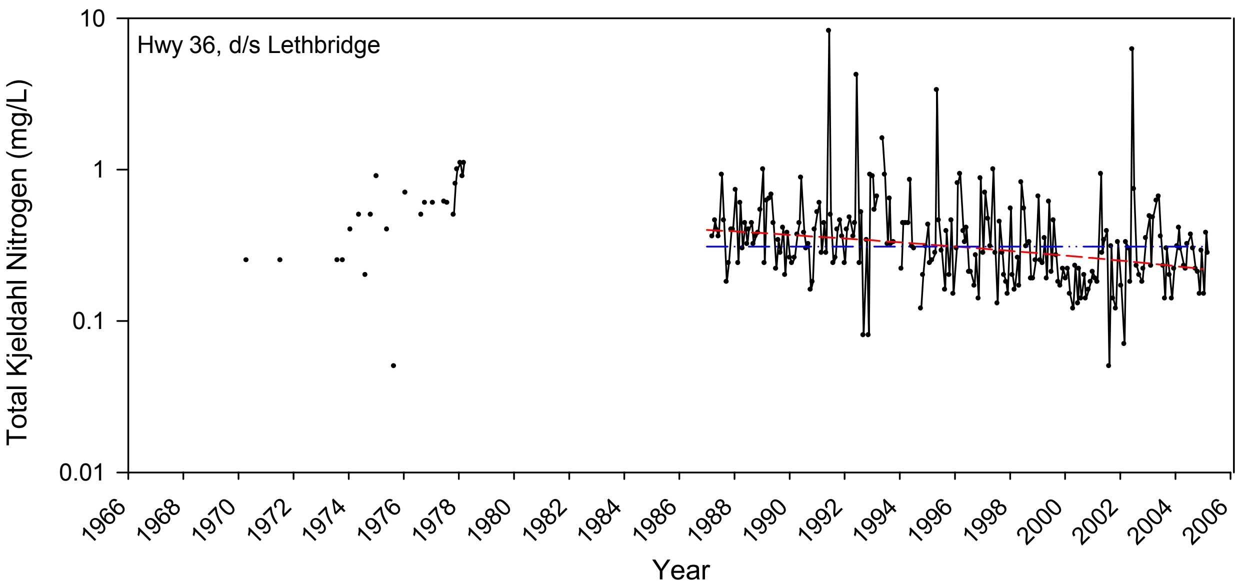


Figure 65 Seasonality of Total Ammonia Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID		0.20			0.22	-0.0055	Down
Flow Adjusted								
ID	ID						-0.0059	Down



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID		0.50			0.31	-0.0100	Down
Flow Adjusted								
ID	ID						-0.0074	Down

Figure 66 Total Kjeldahl Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant, ID = Insufficient Data..

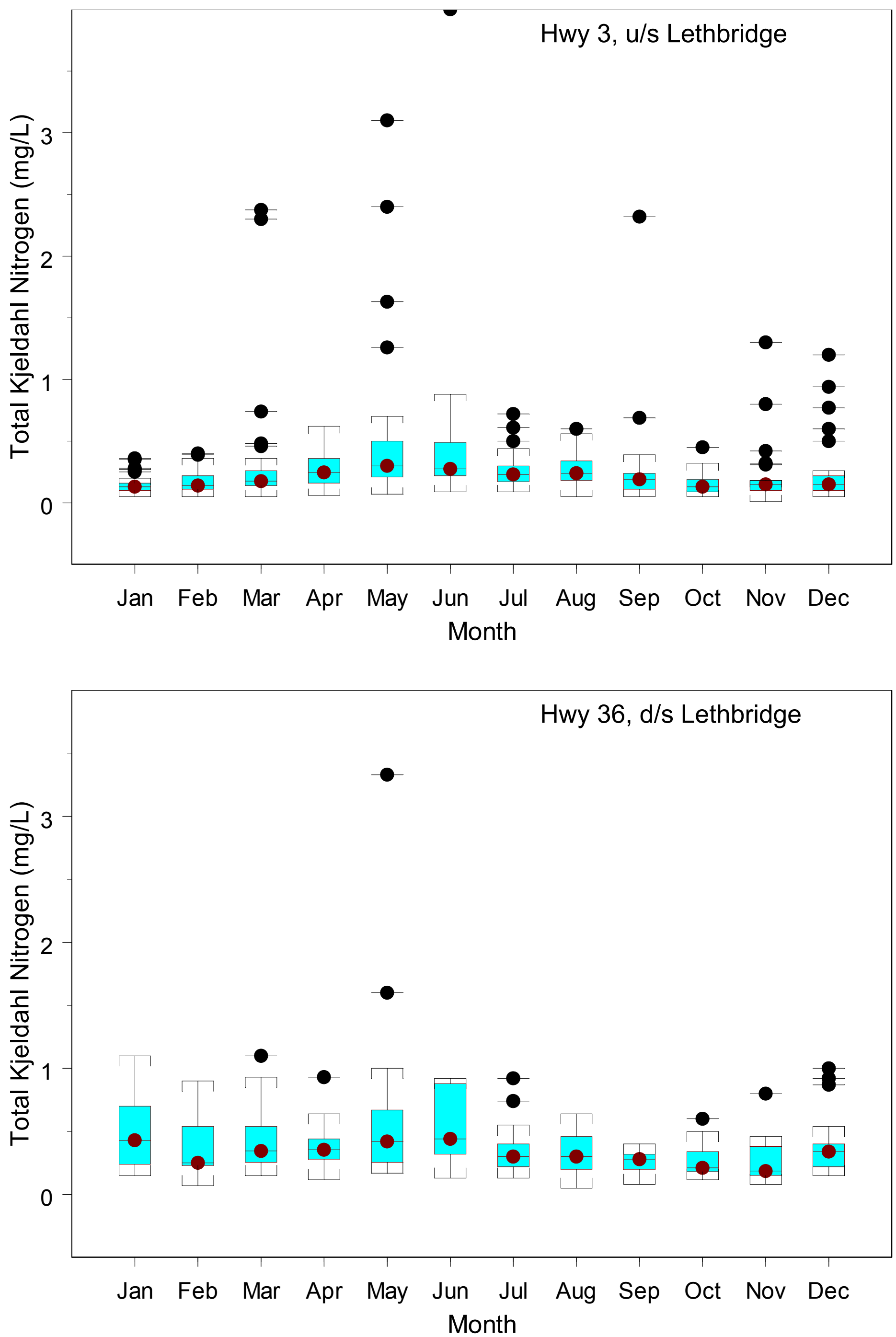
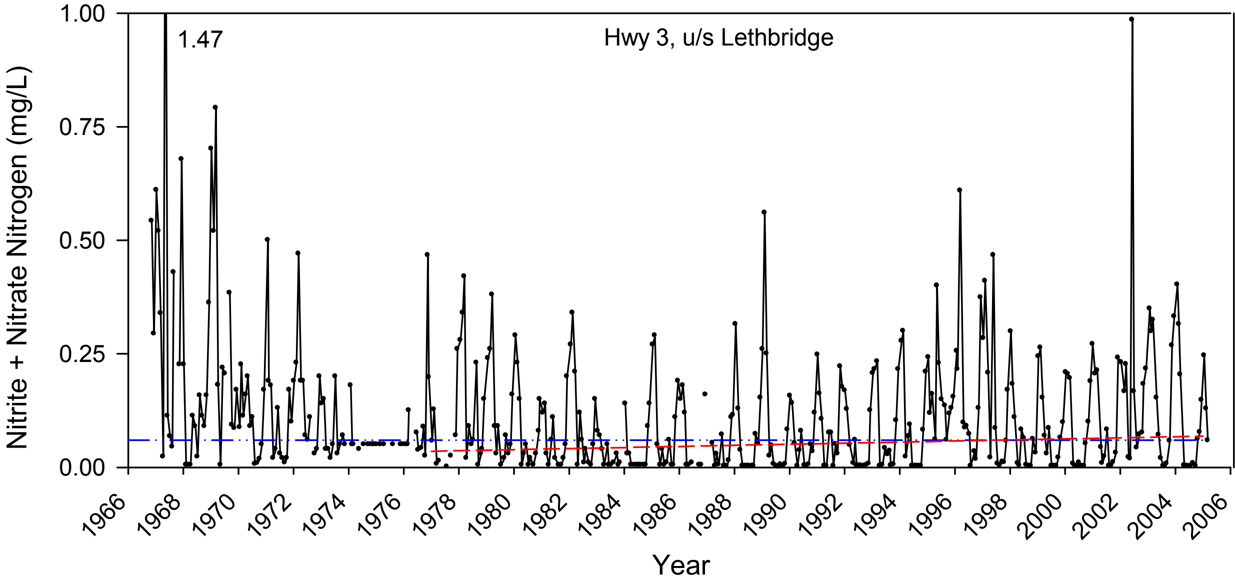
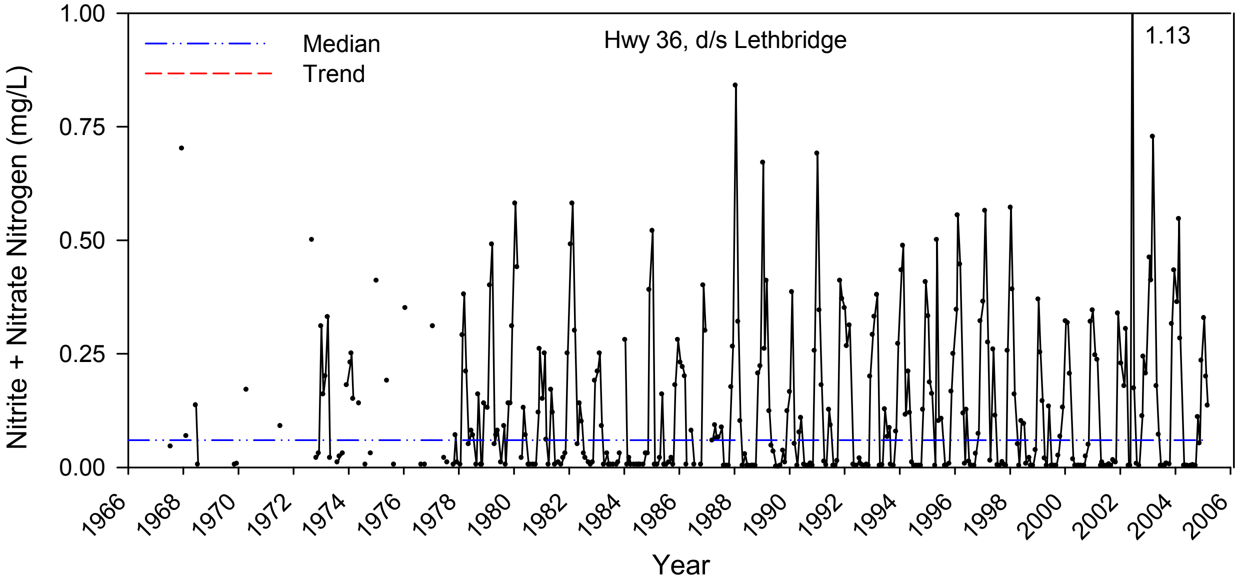


Figure 67 Seasonality of Total Kjeldahl Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
2.28%	Up	NS	0.05			0.06		
Flow Adjusted								
1.32%	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-1.70%	NS	NS	0.05			0.07		
Flow Adjusted								
-2.35%	Down							

Figure 68 Nitrite and Nitrate Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

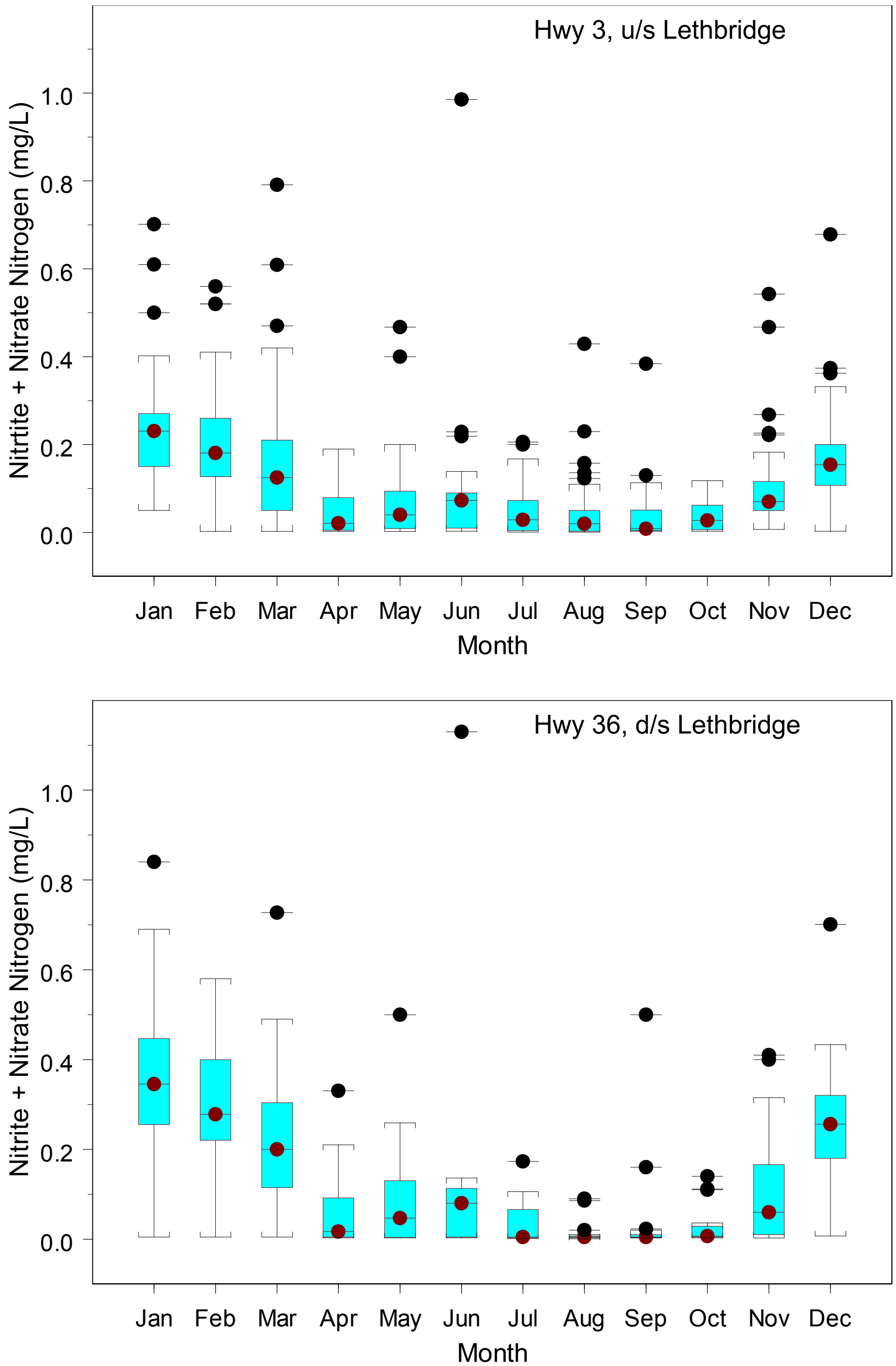
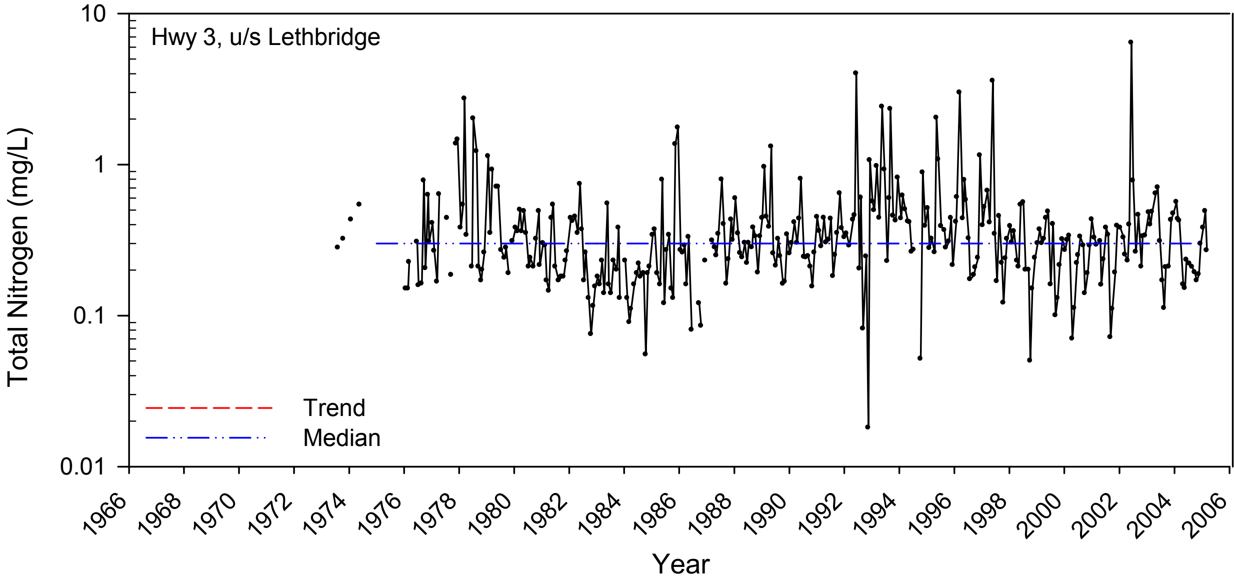
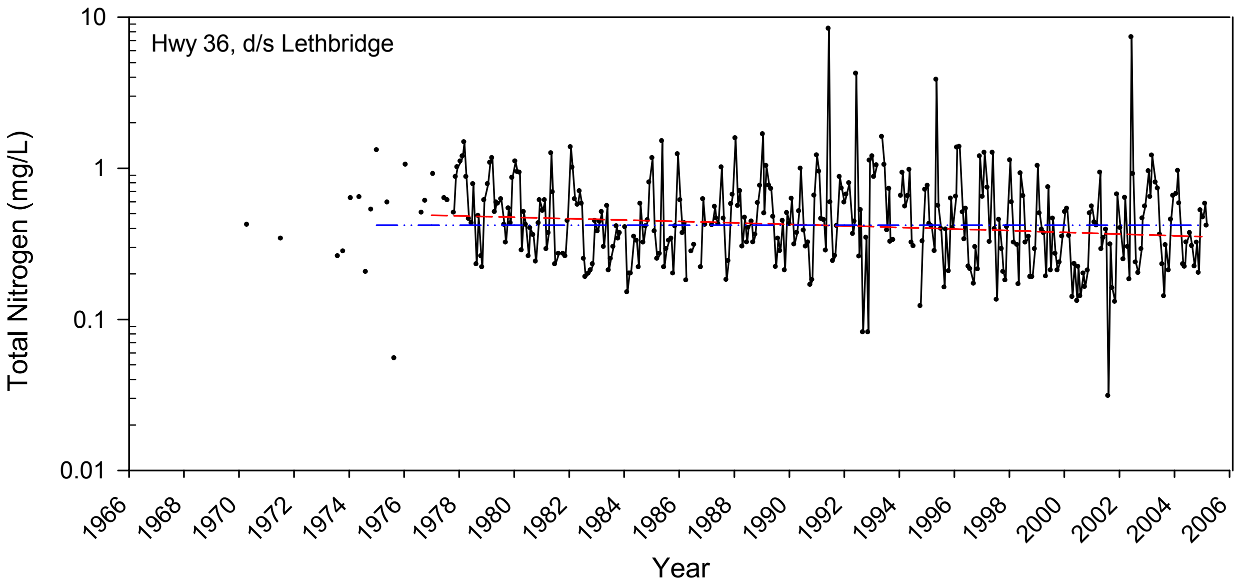


Figure 69 Seasonality of Nitrite and Nitrate Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0006	NS		0.26			0.32		
Flow Adjusted								
0.0015	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0048	Down	NS	0.43			0.41		
Flow Adjusted								
-0.0035	None							

Figure 70 Total Nitrogen in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

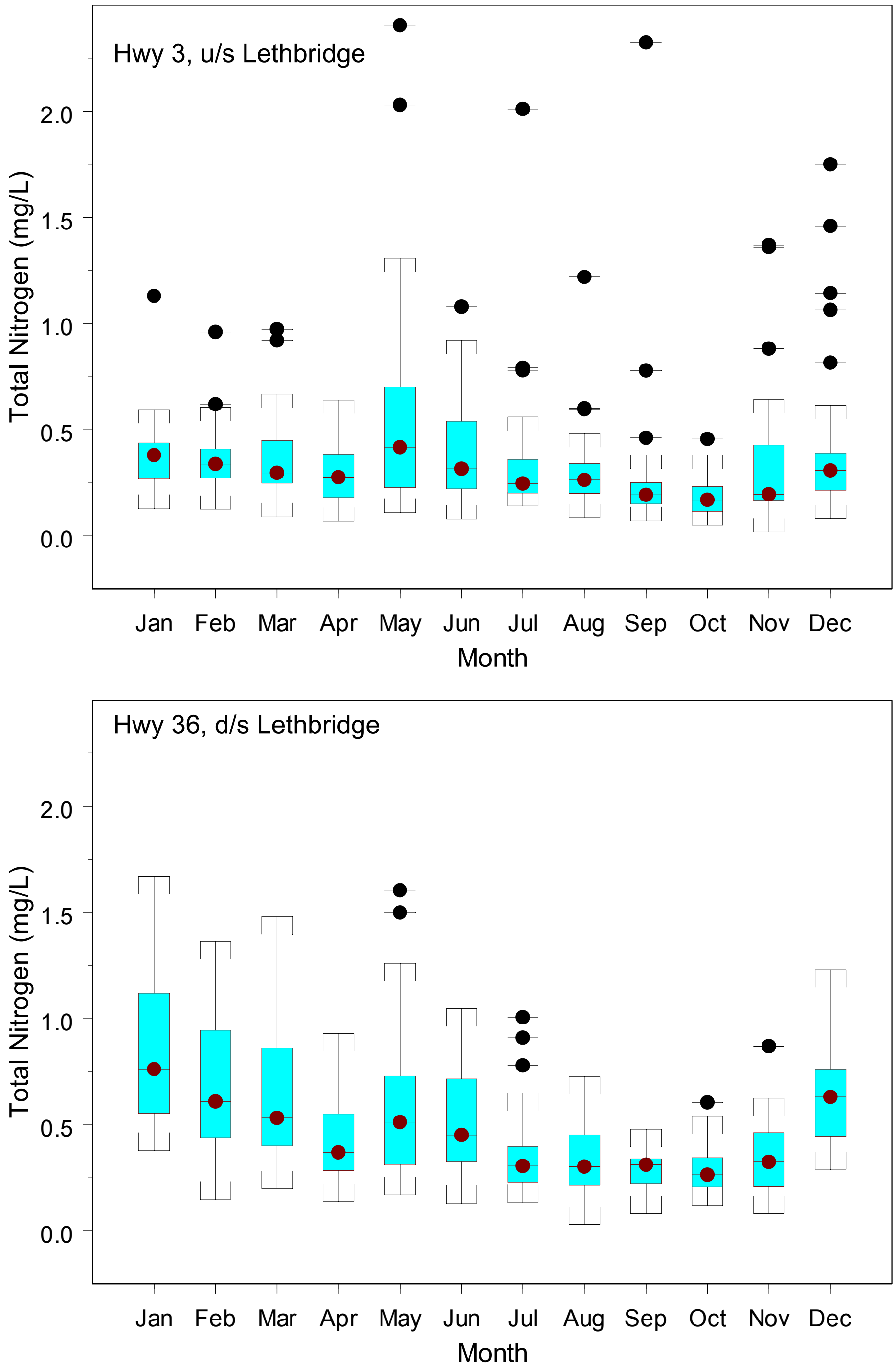
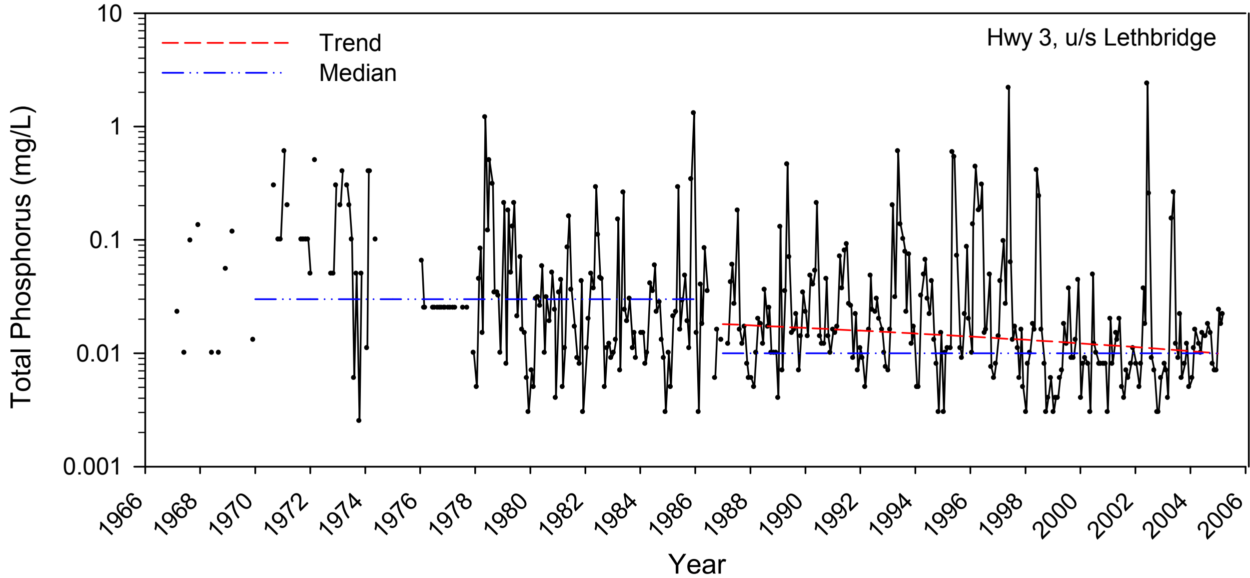
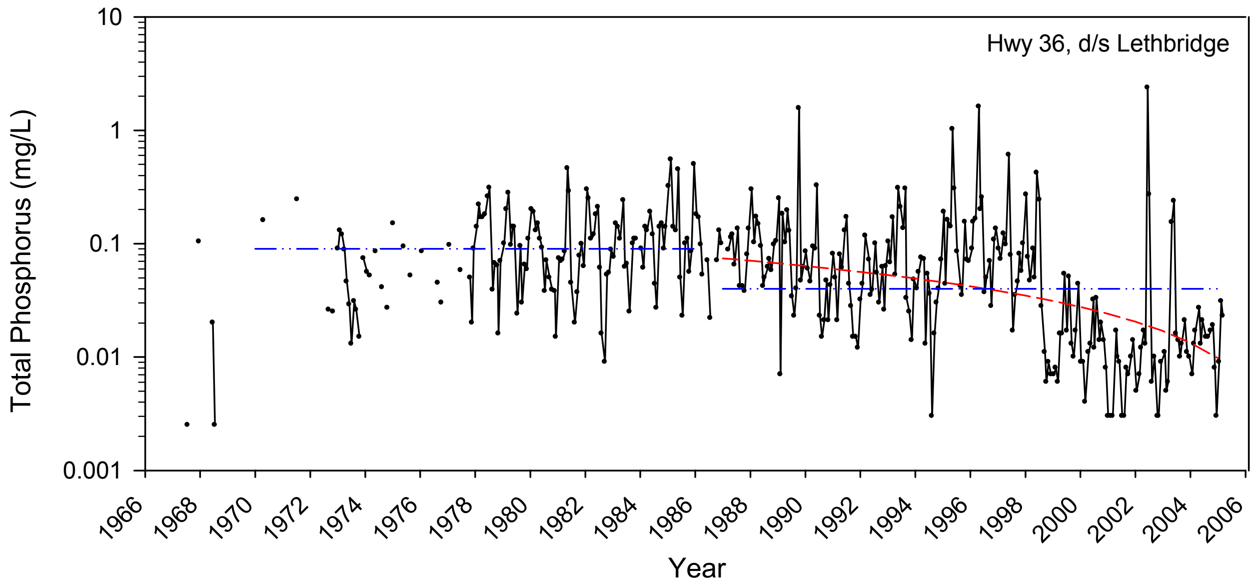


Figure 71 Seasonality of Total Nitrogen concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0004	Down	***	0.03	-0.0020	Down	0.01	-0.0004	Down
Flow Adjusted								
-0.0004	Down			-0.0009	NS		-0.0002	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0029	Down	***	0.09	0.0026	NS	0.04	-0.0036	Down
Flow Adjusted								
-0.0026	Down			0.0071	NS		-0.0031	Down

Figure 72 Total Phosphorus in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

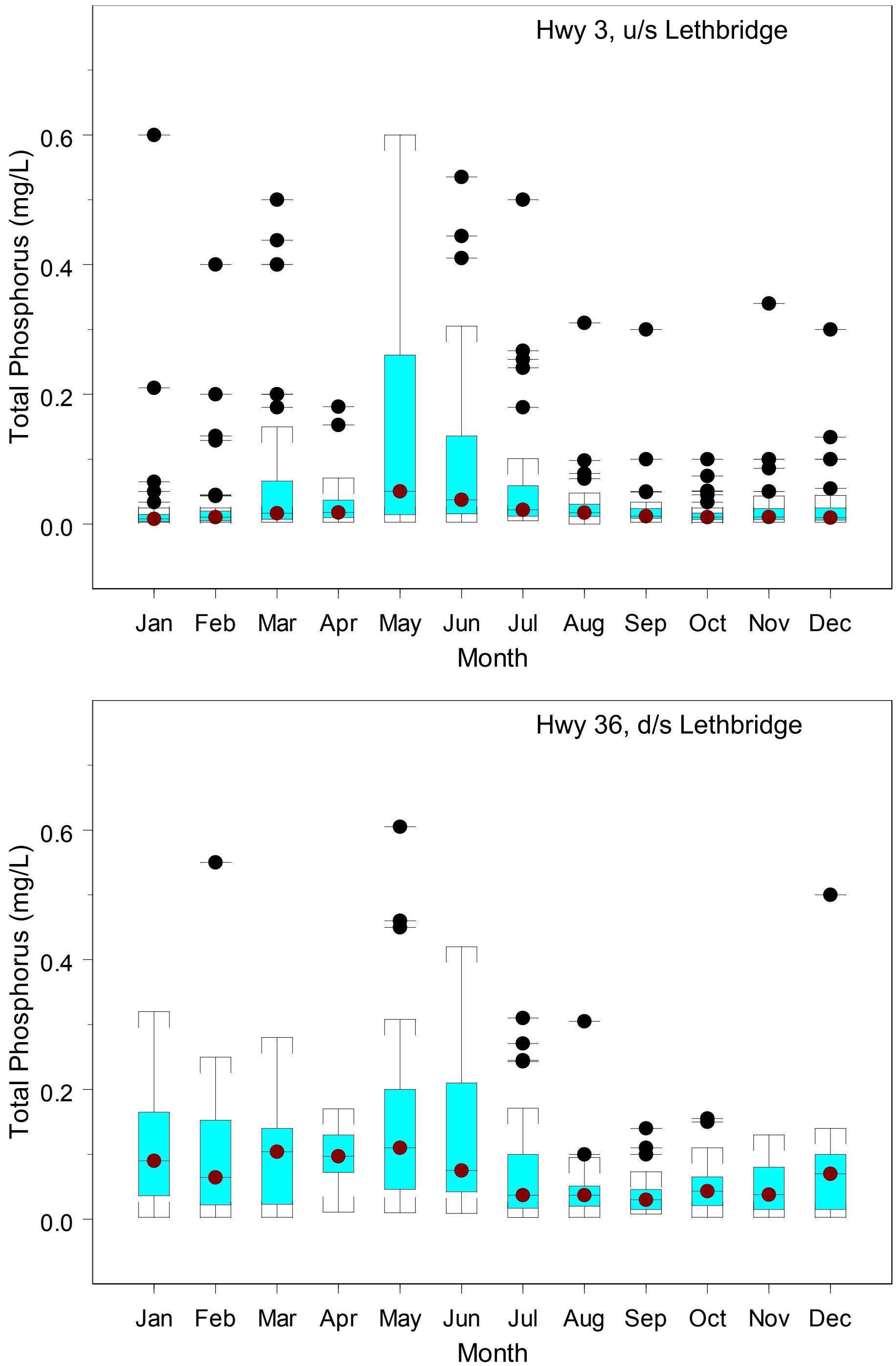
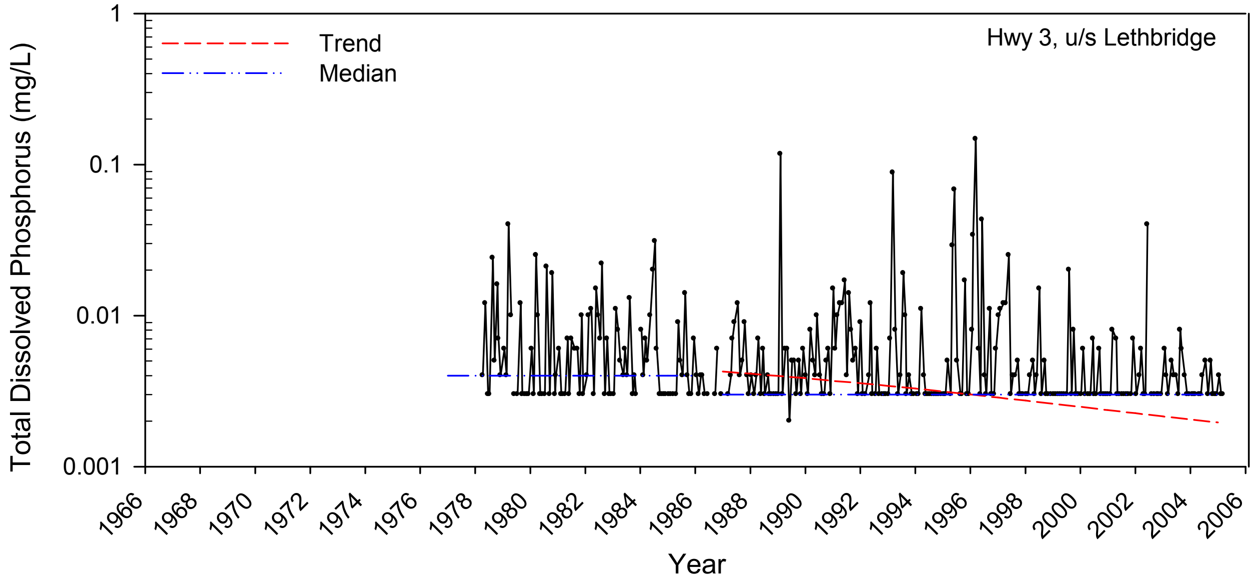
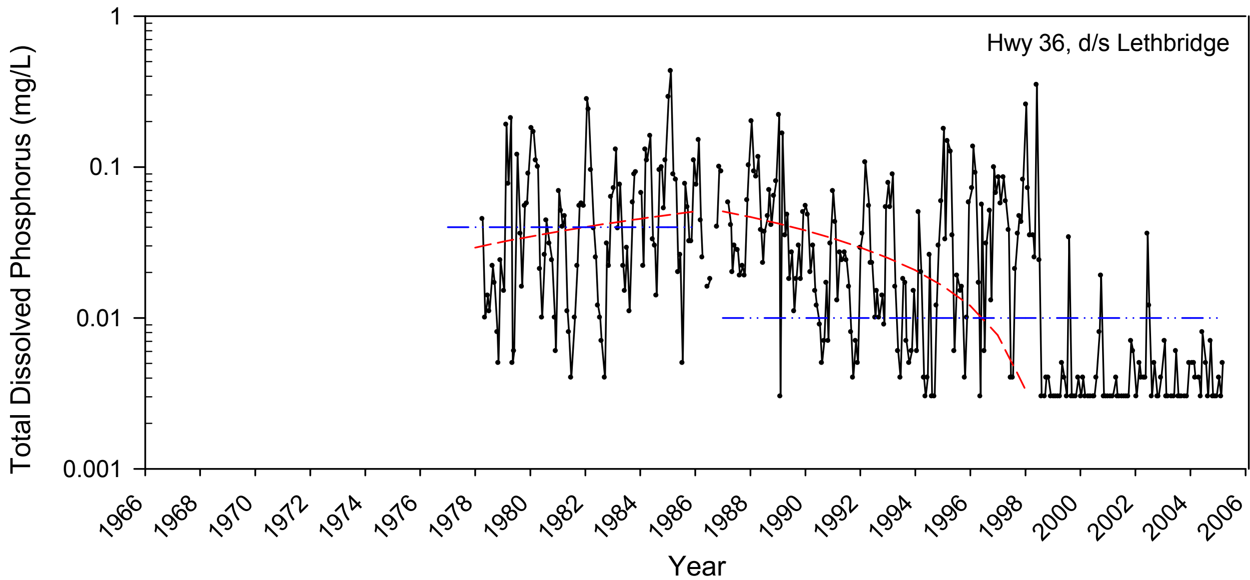


Figure 73 Seasonality of Total Phosphorus concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-2.68%	Down	*	0.004	-2.09%	NS	0.003	-4.65%	Down
Flow Adjusted								
-2.84%	Down			-2.89%	NS		-4.80%	Down



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-10.18%	Down	***	0.04	6.73%	Up	0.01	-16.51%	Down
Flow Adjusted								
-10.10%	Down			6.53%	Up		-16.62%	Down

Figure 74 Total Dissolved Phosphorus in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

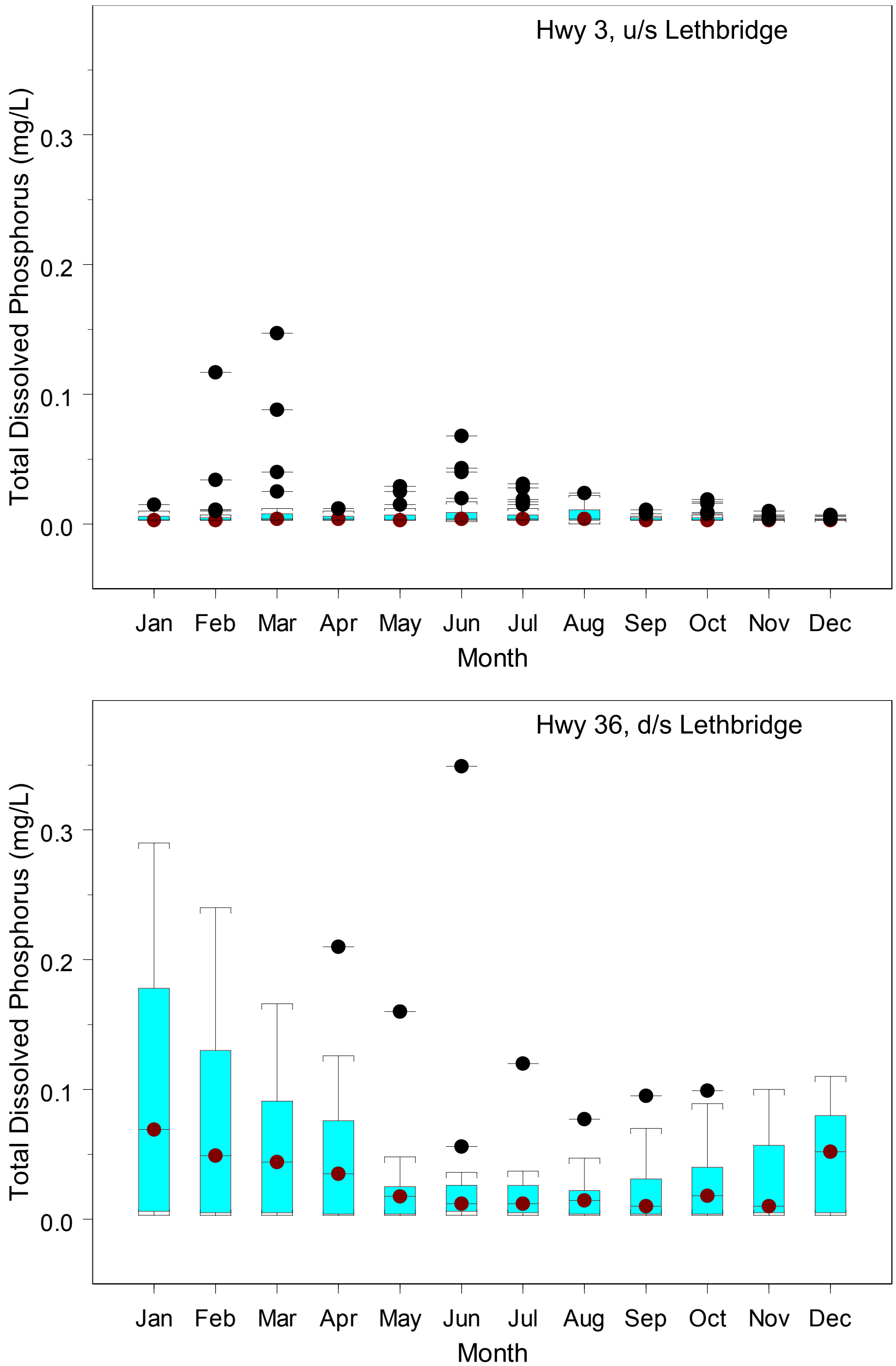
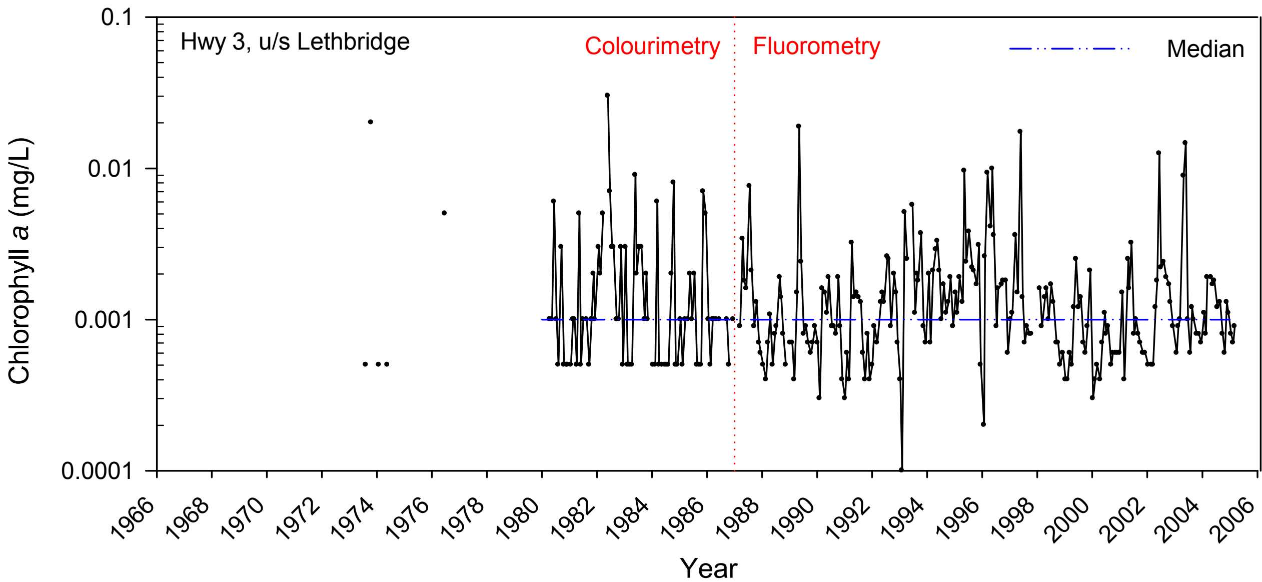
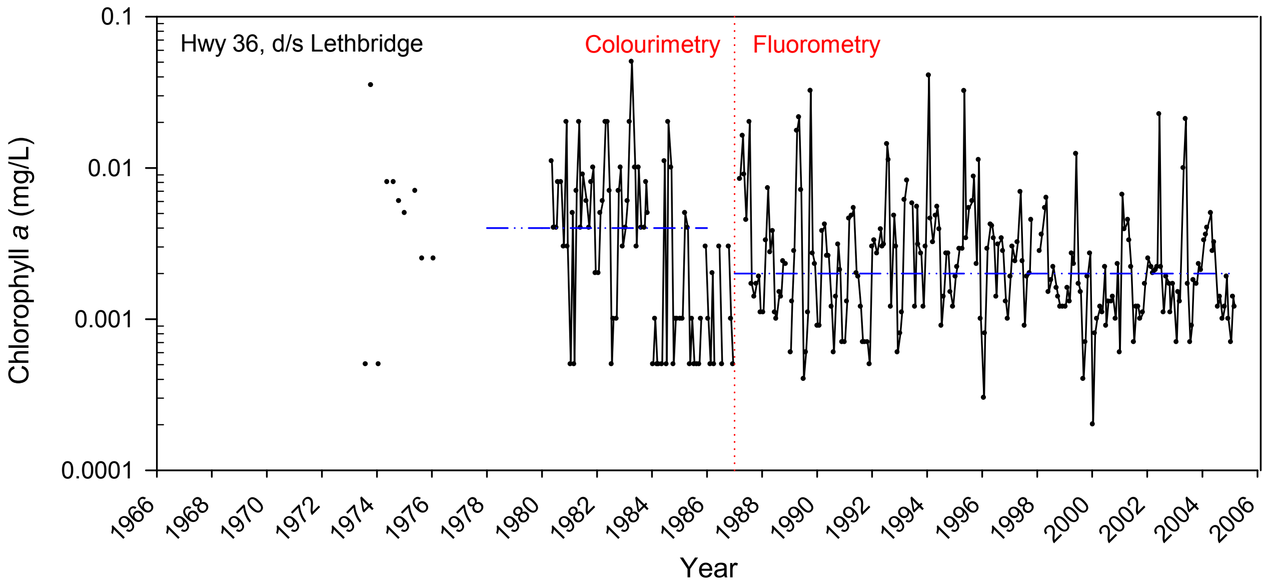


Figure 75 Seasonality of Total Dissolved Phosphorus in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.001	0.0000	NS
Flow Adjusted								
							0.0000	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.002	0.0000	NS
Flow Adjusted								
							0.0000	NS

Figure 76 Chlorophyll *a* concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant. The red line denotes a change of analytical methods in 1987.

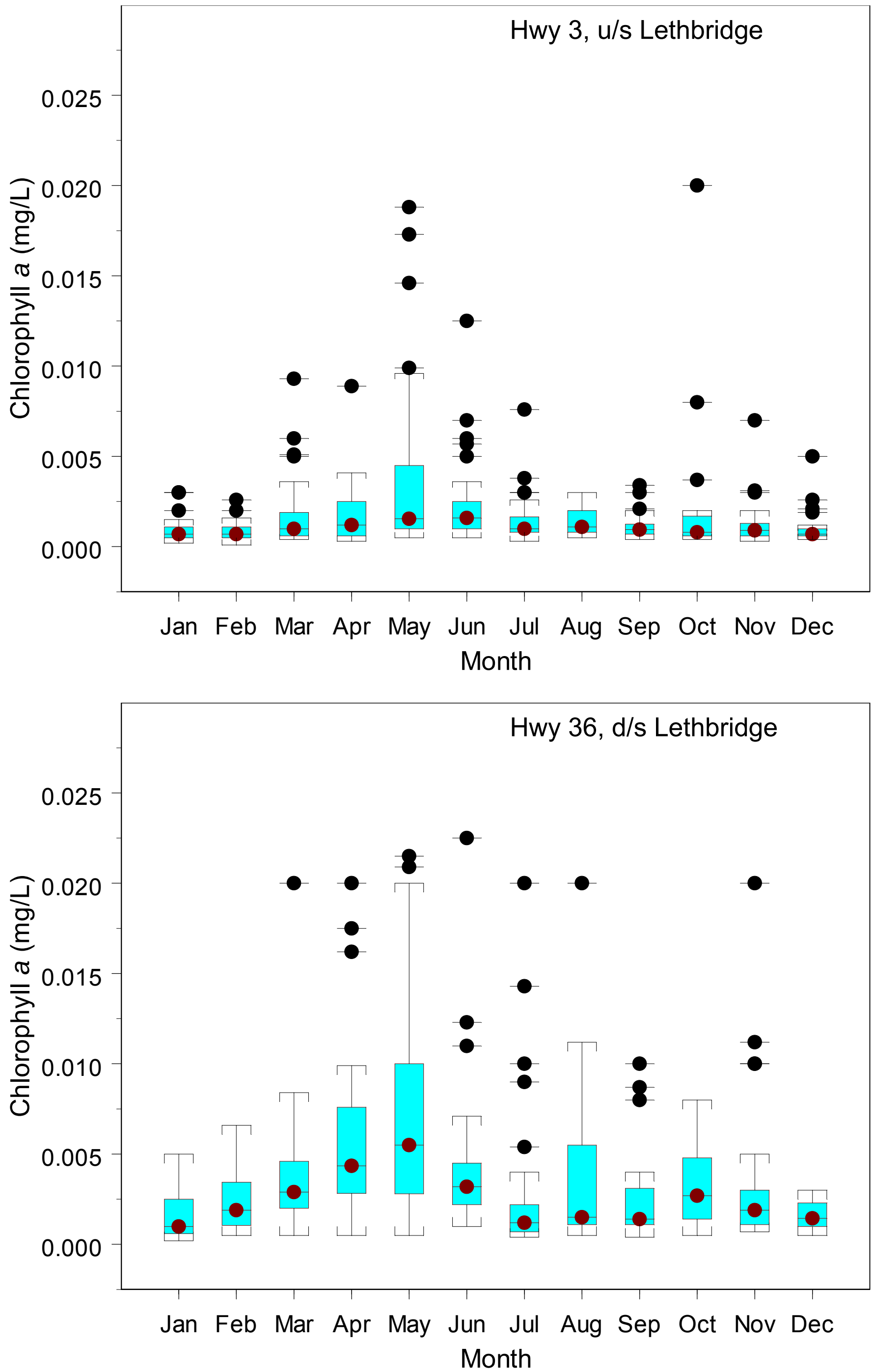
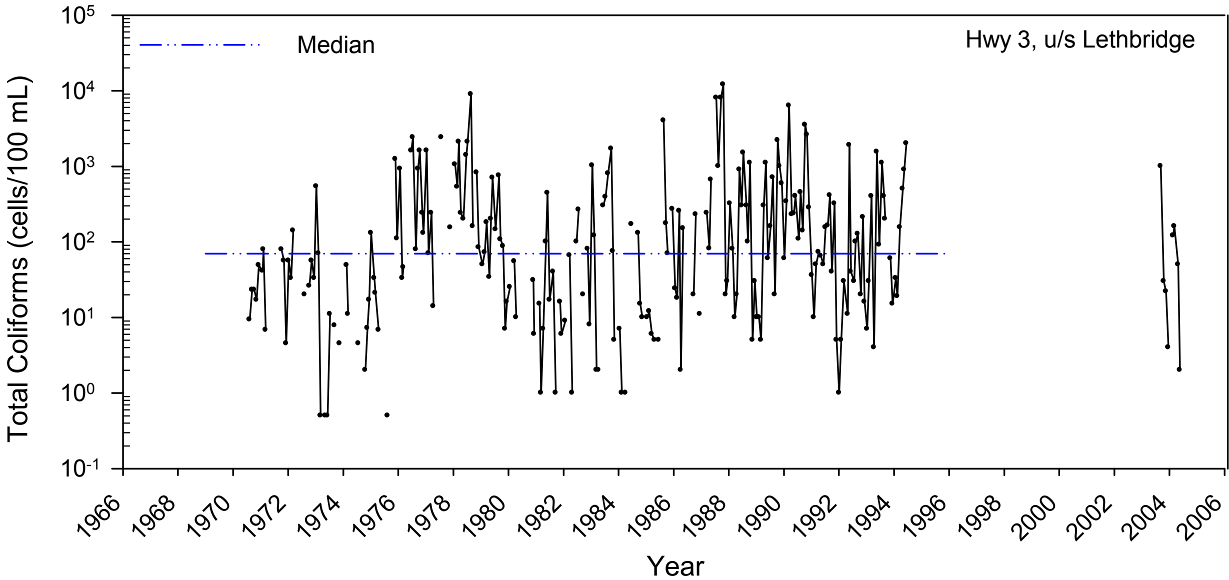
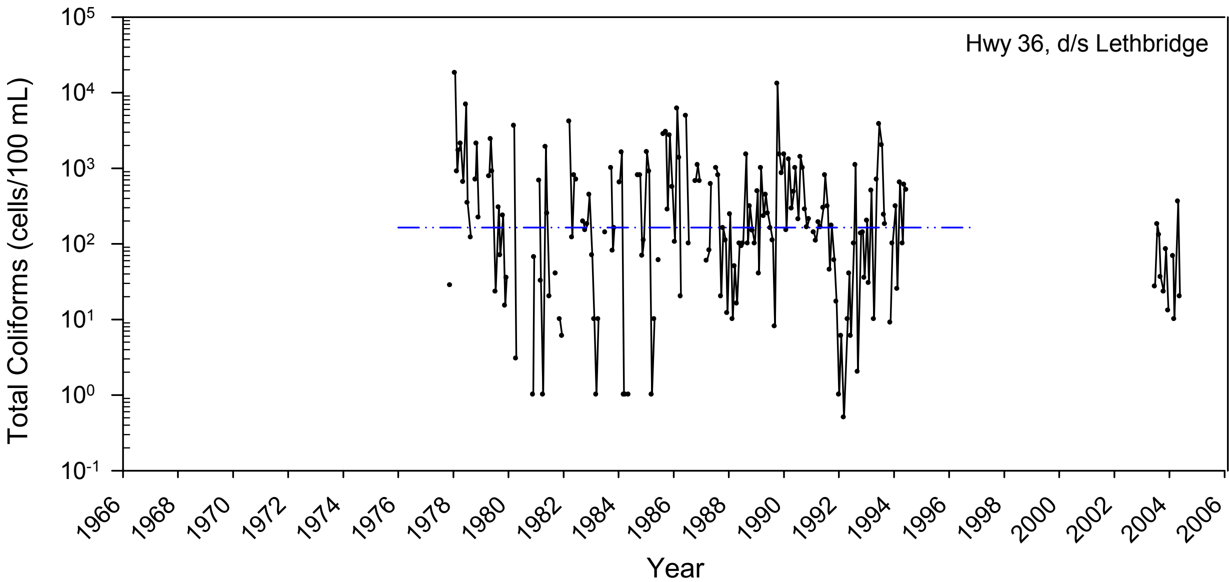


Figure 77 Seasonality of Chlorophyll *a* concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.

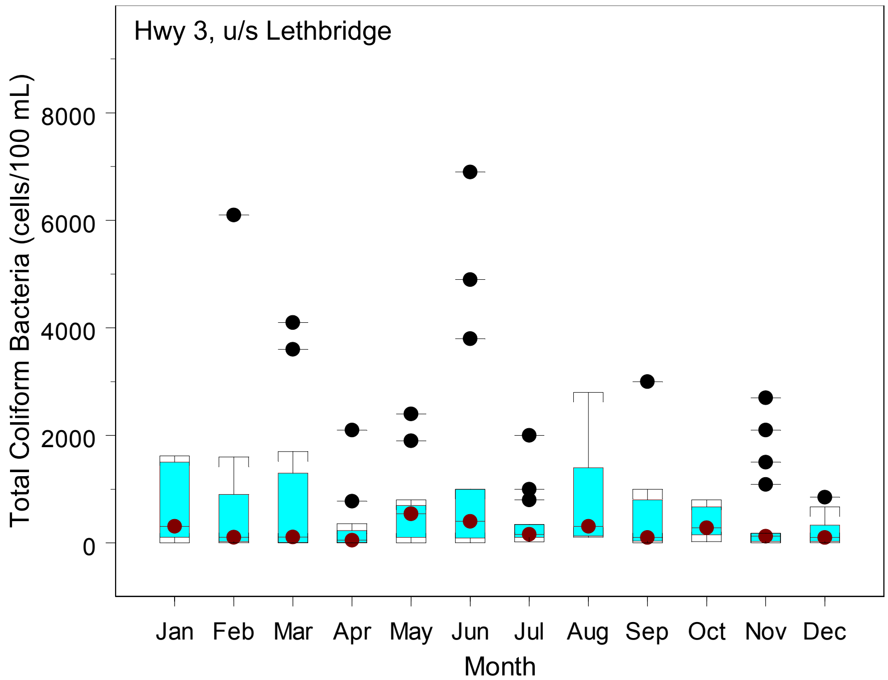


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
4.00%	NS		49.00			123.50		
Flow Adjusted								
3.91%	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.77%	NS		242.50			148.00		
Flow Adjusted								
-1.35%	NS							

Figure 78 Total Coliform Bacteria in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.



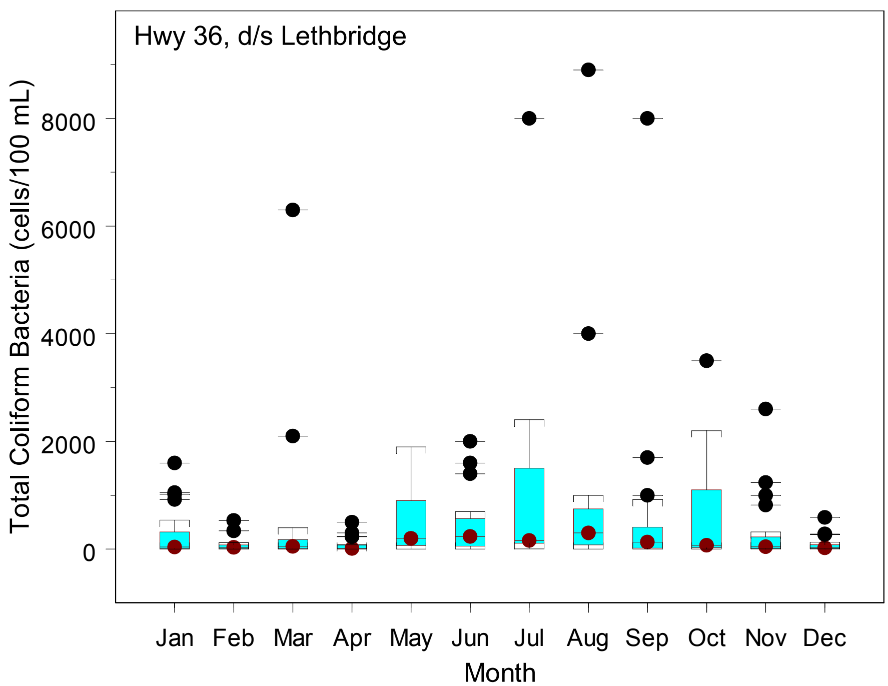
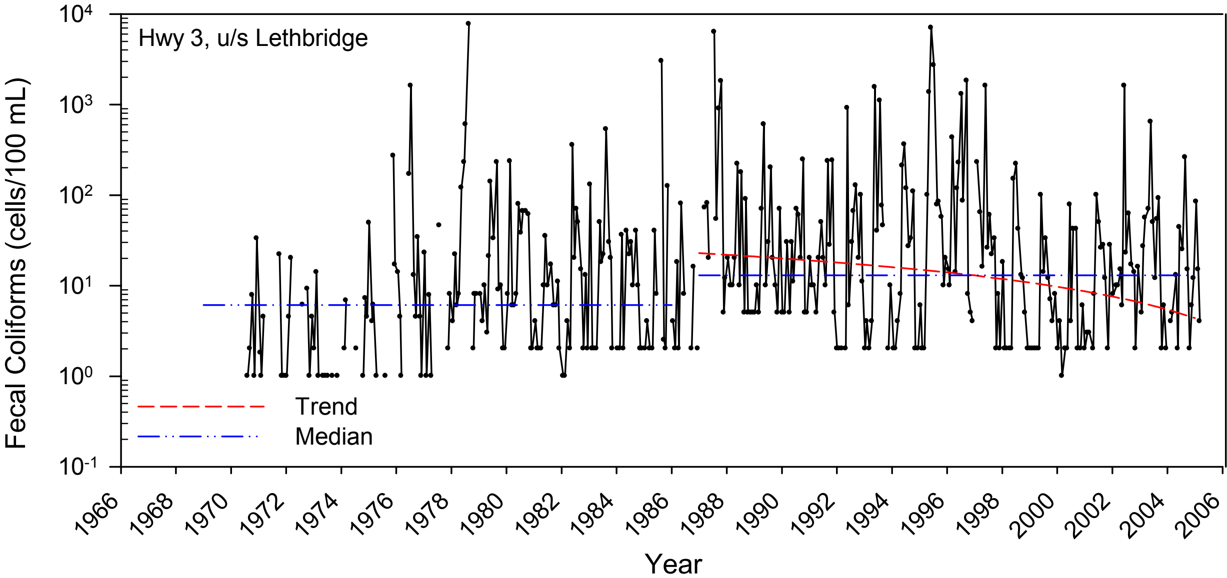
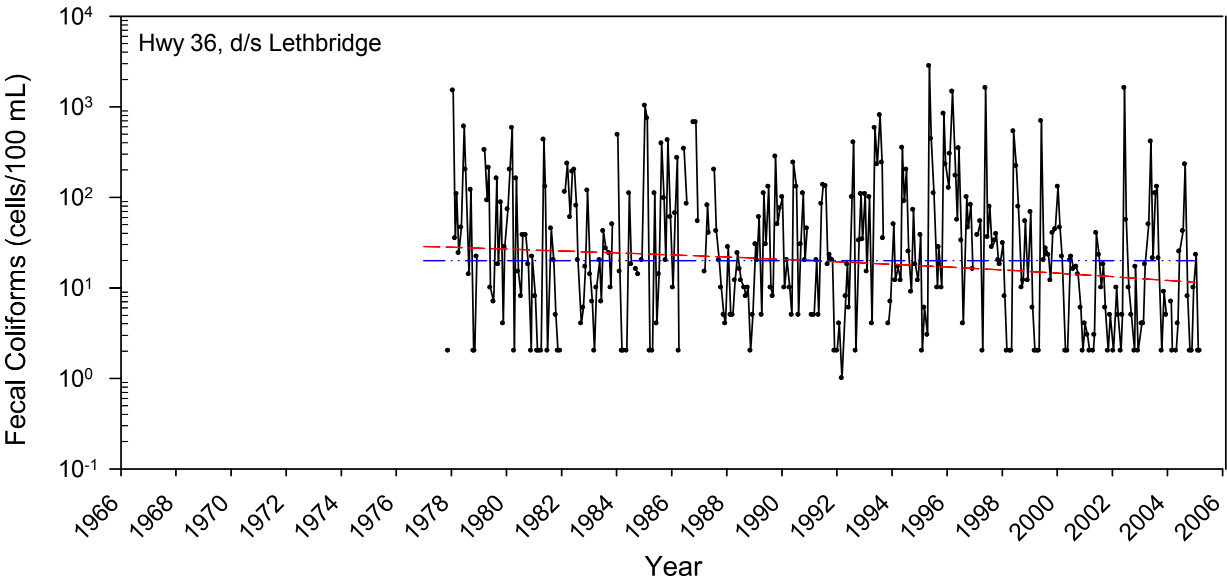


Figure 79 Seasonality of Total Coliform Bacteria in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
3.04%	Up	***	6.10	-2.19%	NS	13.00	-7.06%	Down
Flow Adjusted								
2.70%	Up			8.58%	NS		-7.52%	Down



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-3.06%	Down	NS	23.00			18.00		
Flow Adjusted								
-3.94%	Down							

Figure 80 Fecal Coliform Bacteria in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

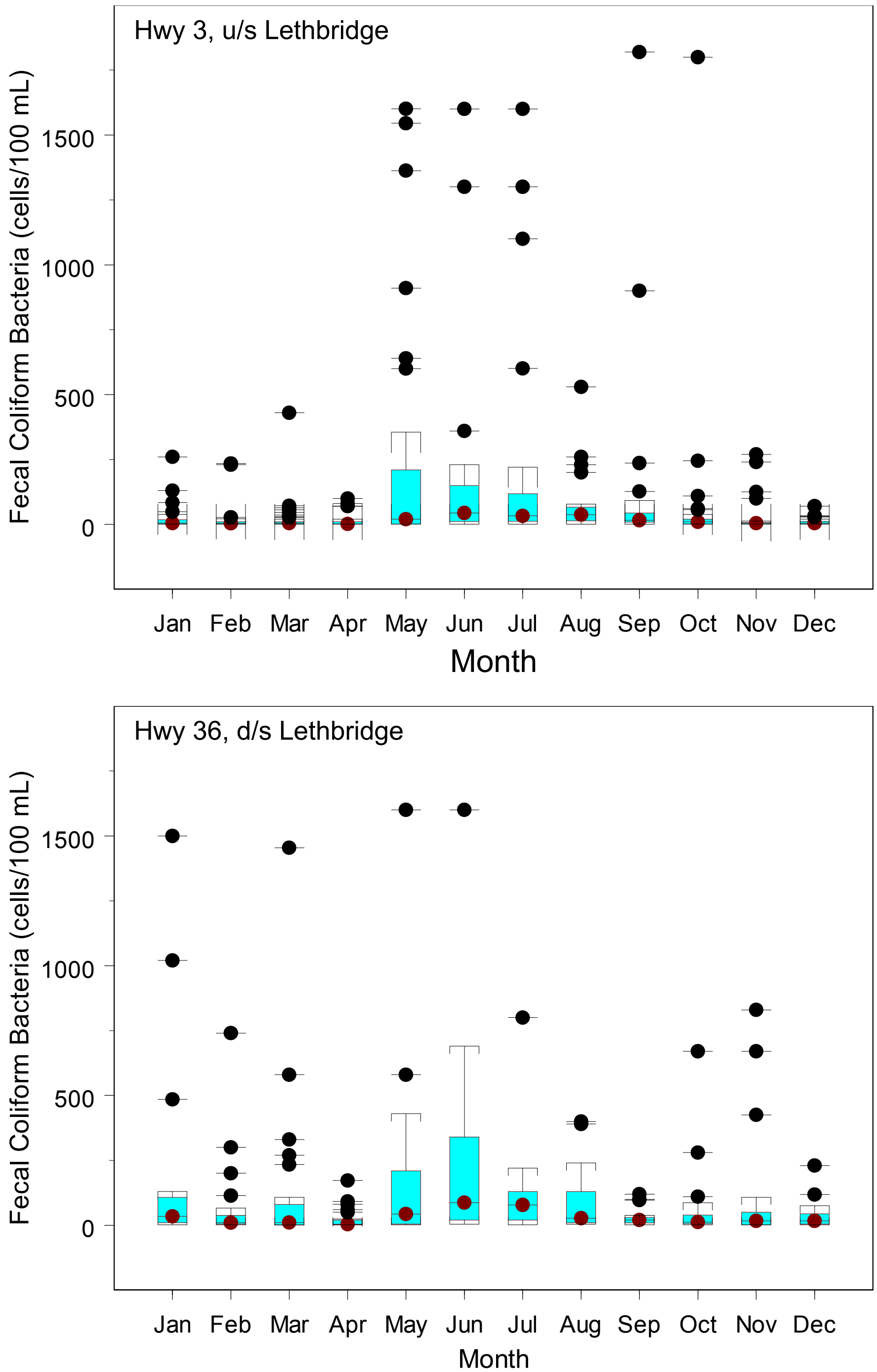
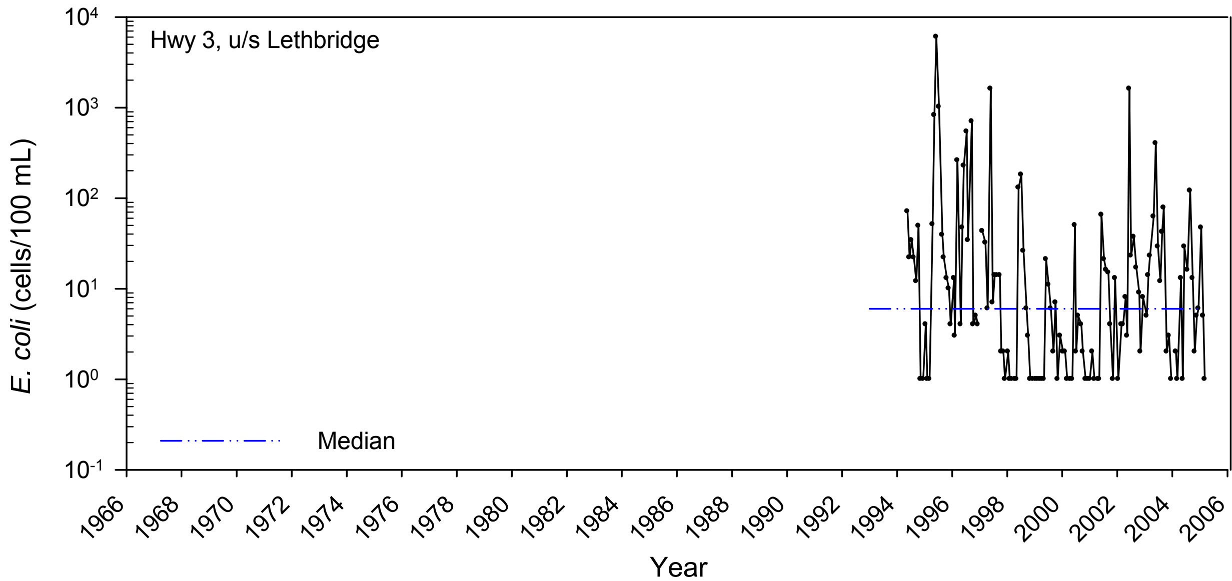
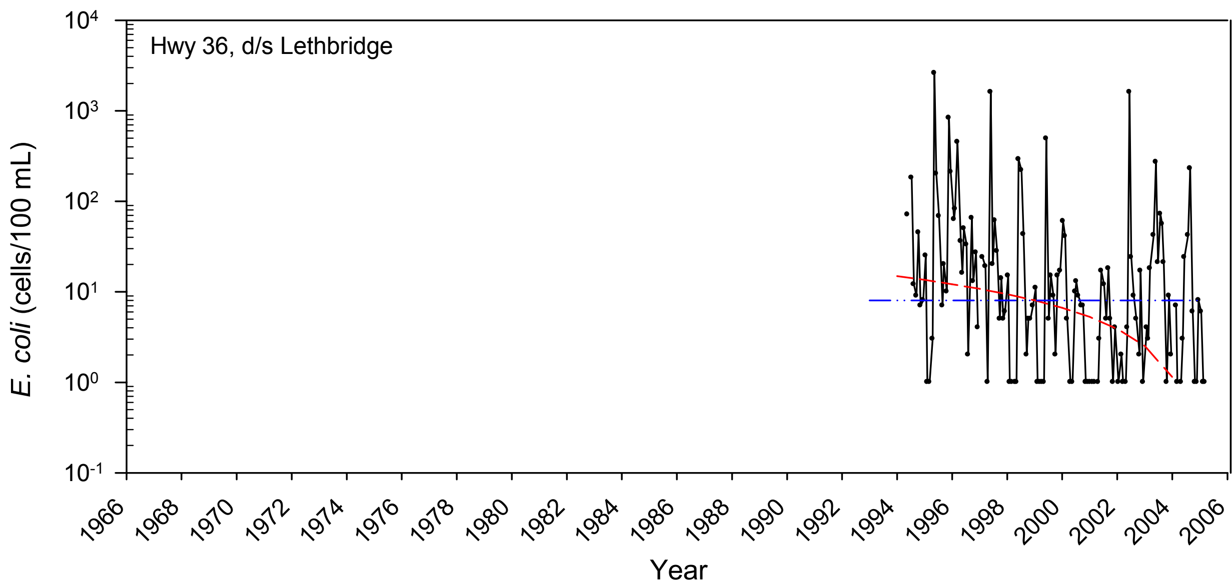


Figure 81 Seasonality of Fecal Coliform Bacteria in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-9.34%	NS					6.00		
Flow Adjusted								
-0.50%	NS							



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-17.13%	Down					8.00		
Flow Adjusted								
-8.30%	NS							

Figure 82 *Escherichia coli* bacteria in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. NS = Not Significant.

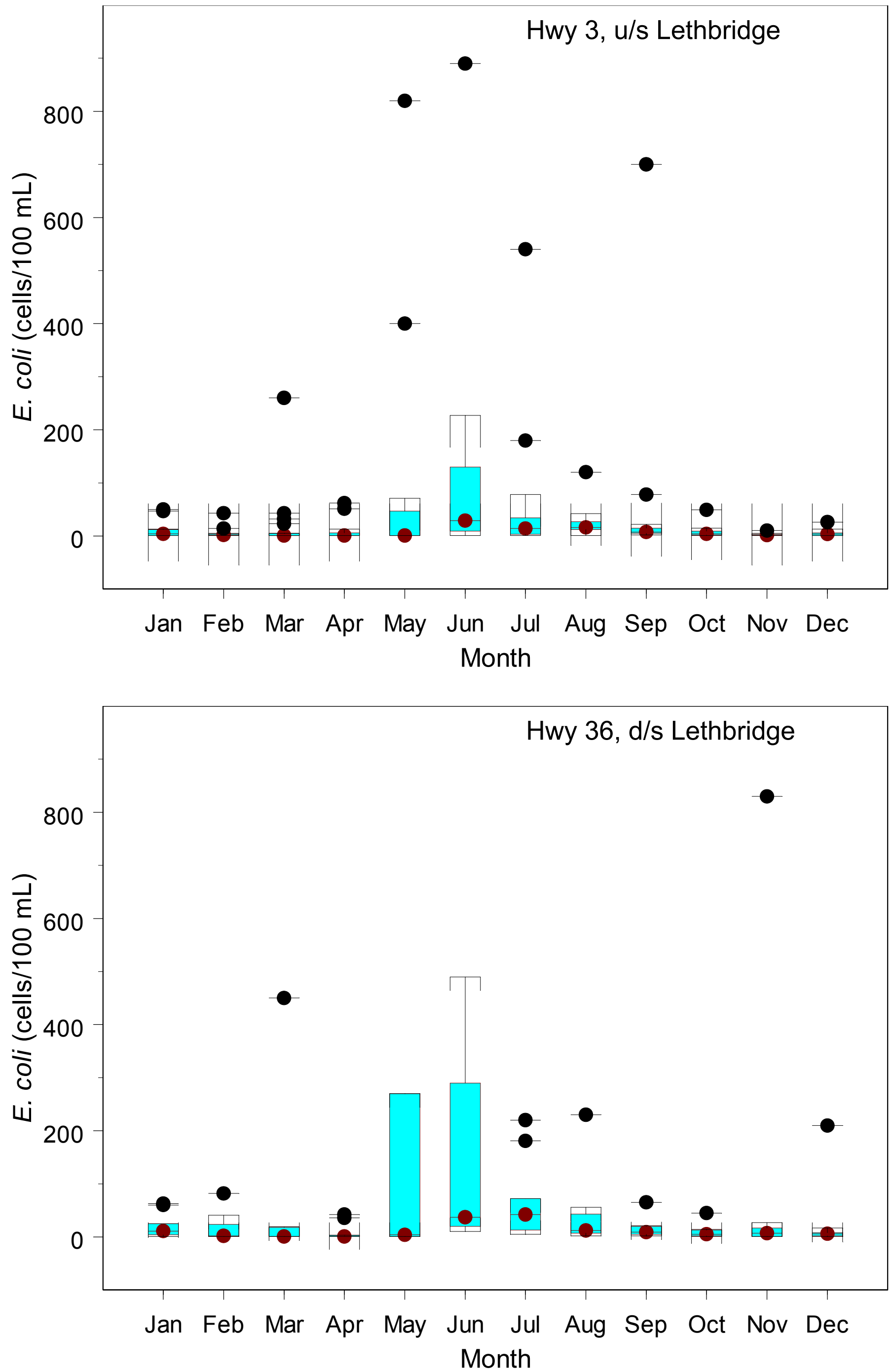
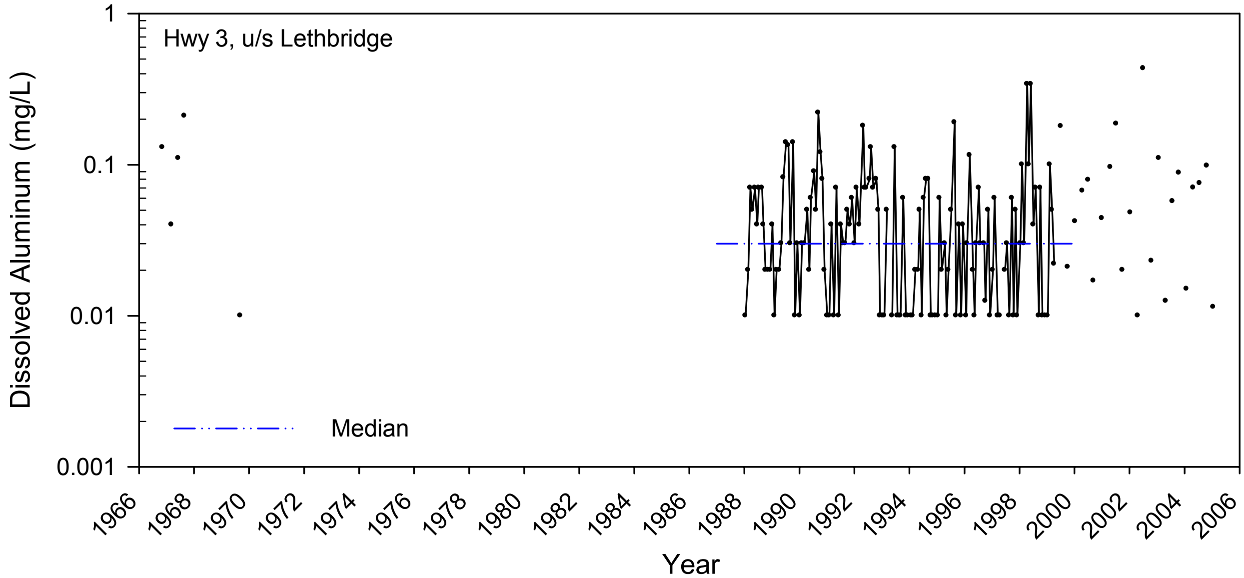
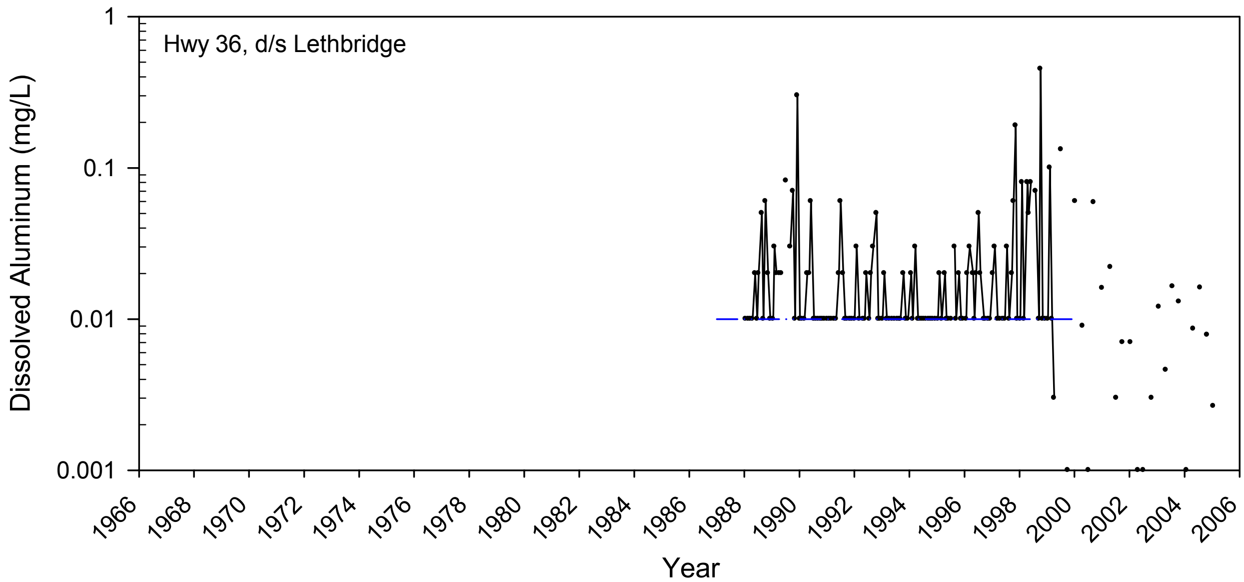


Figure 83 Seasonality of *Escherichia coli* in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.030	-3.28%	NS
Flow Adjusted								
							-0.81%	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.01	3.77%	NS
							4.12%	NS

Figure 84 Dissolved Aluminum in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. The downstream median is the result of censored data. NS = Not Significant.

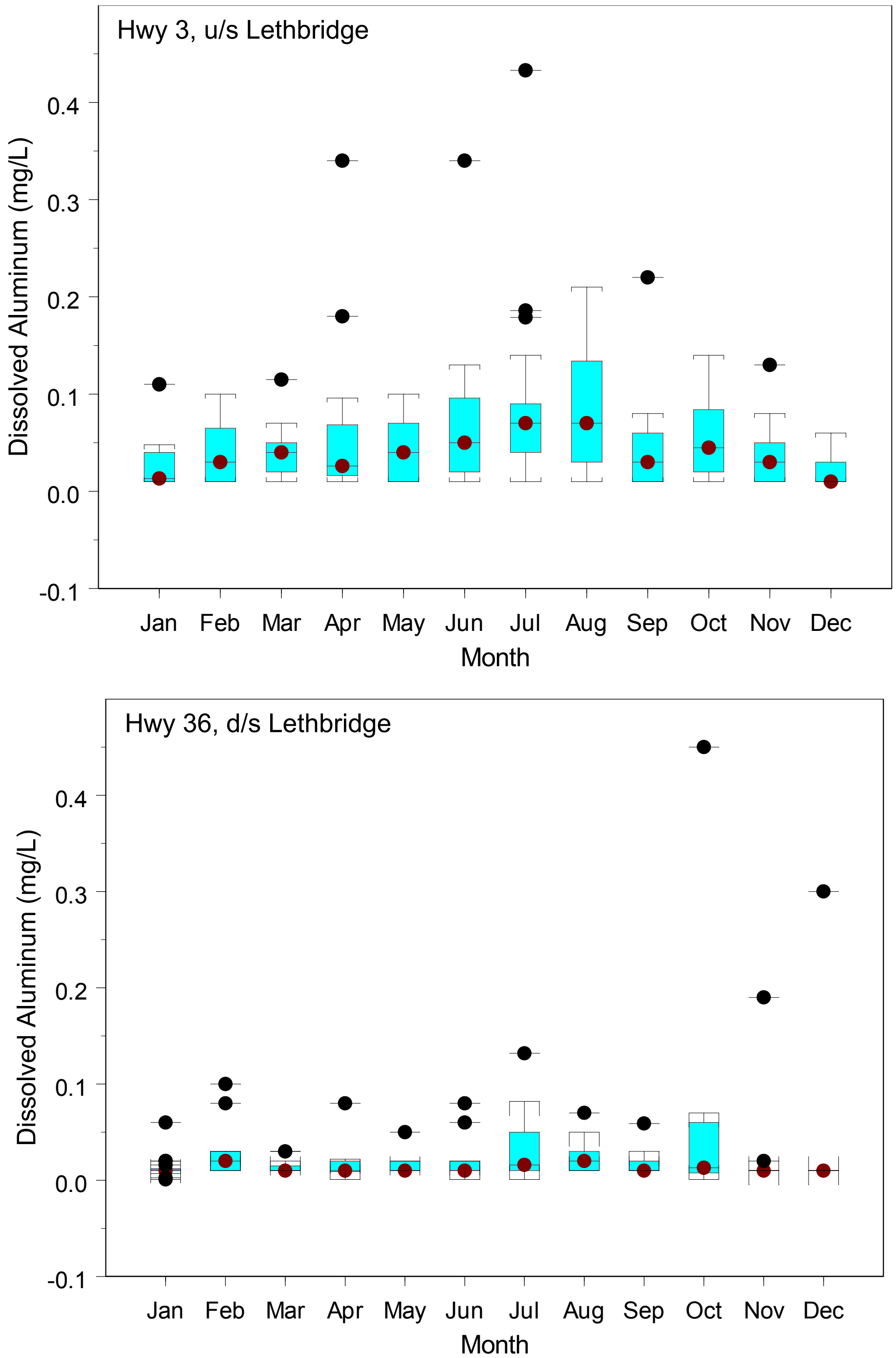
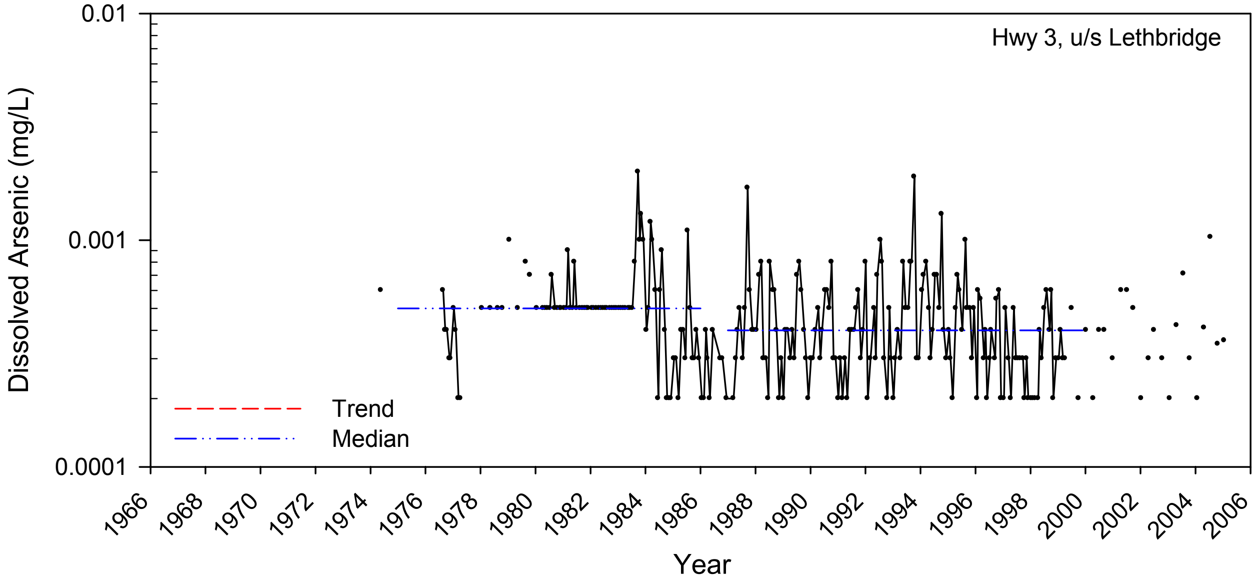
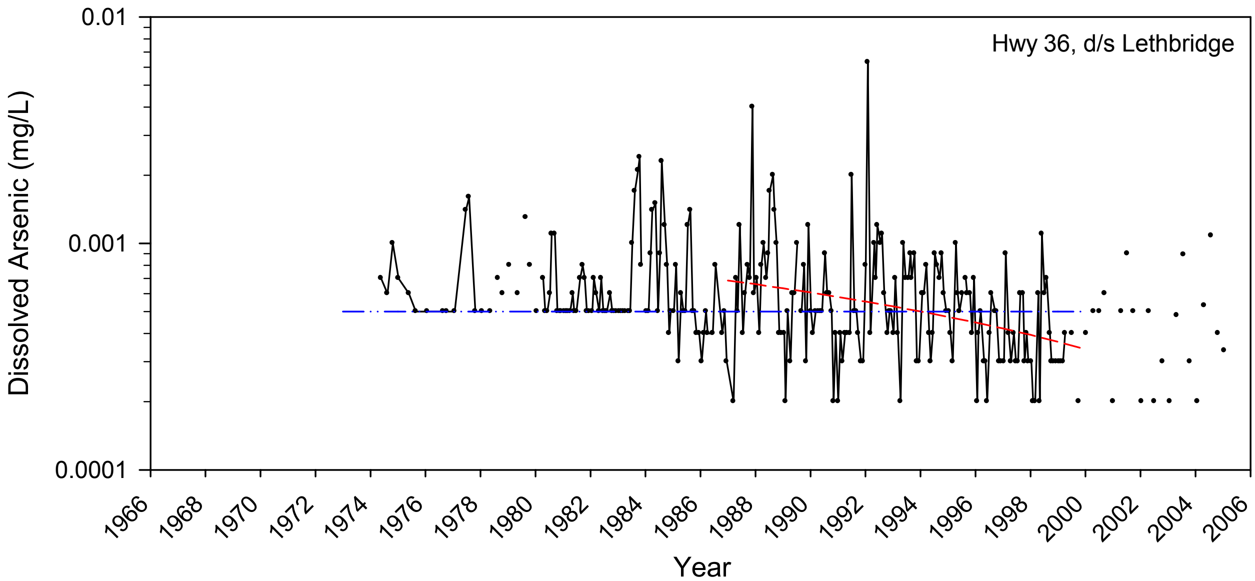


Figure 85 Seasonality of Dissolved Aluminum concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.45%	NS	***	0.0005	2.10%	NS	0.0004	-1.97%	NS
Flow Adjusted								
-0.06%	NS			2.25%	NS		-1.93%	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-1.99%	Down	***	0.0005	3.70%	NS	0.0005	-5.31%	Down
Flow Adjusted								
-1.17%	NS			2.25%	NS		-4.87%	Down

Figure 86 Dissolved Arsenic in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

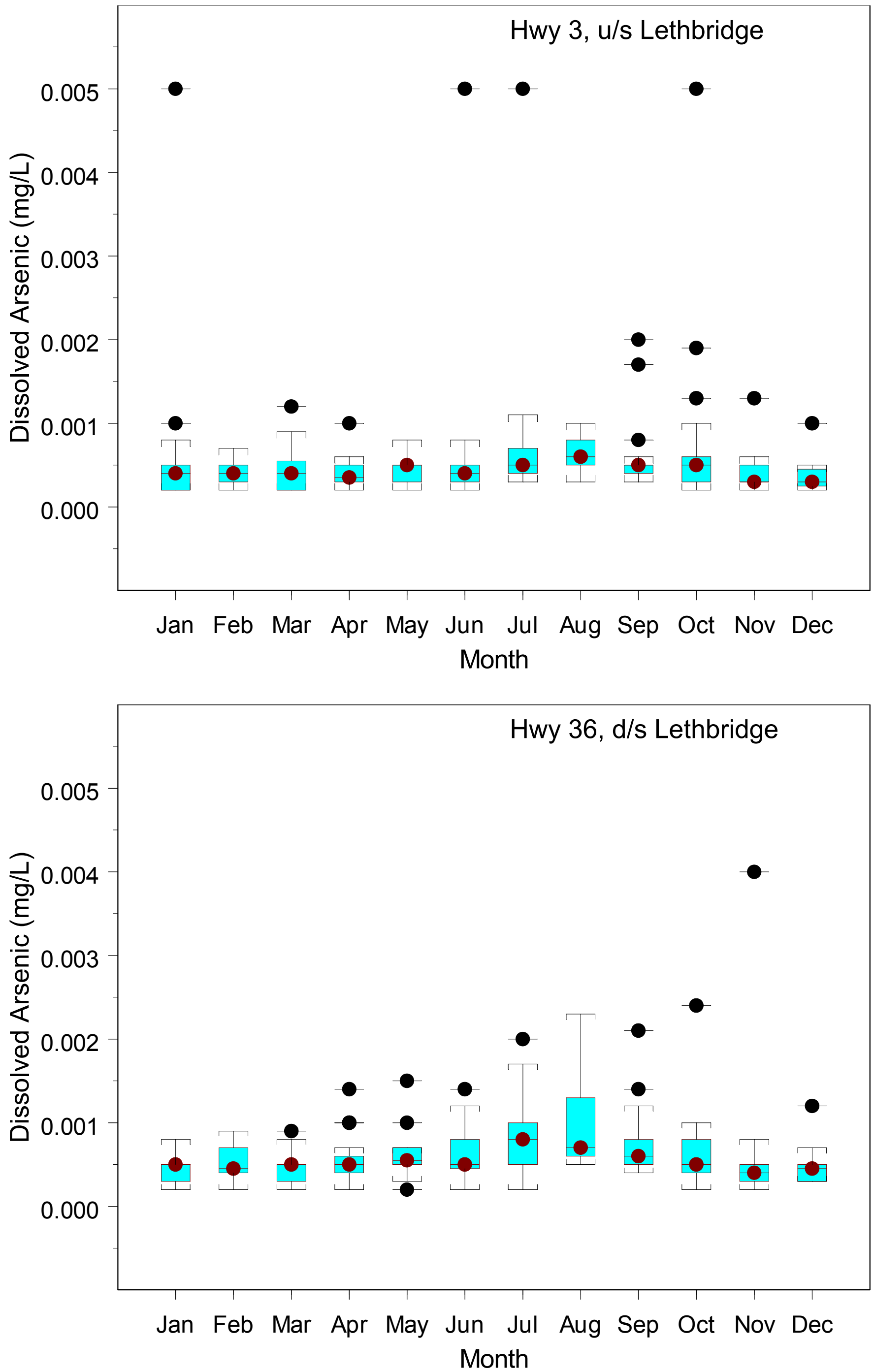
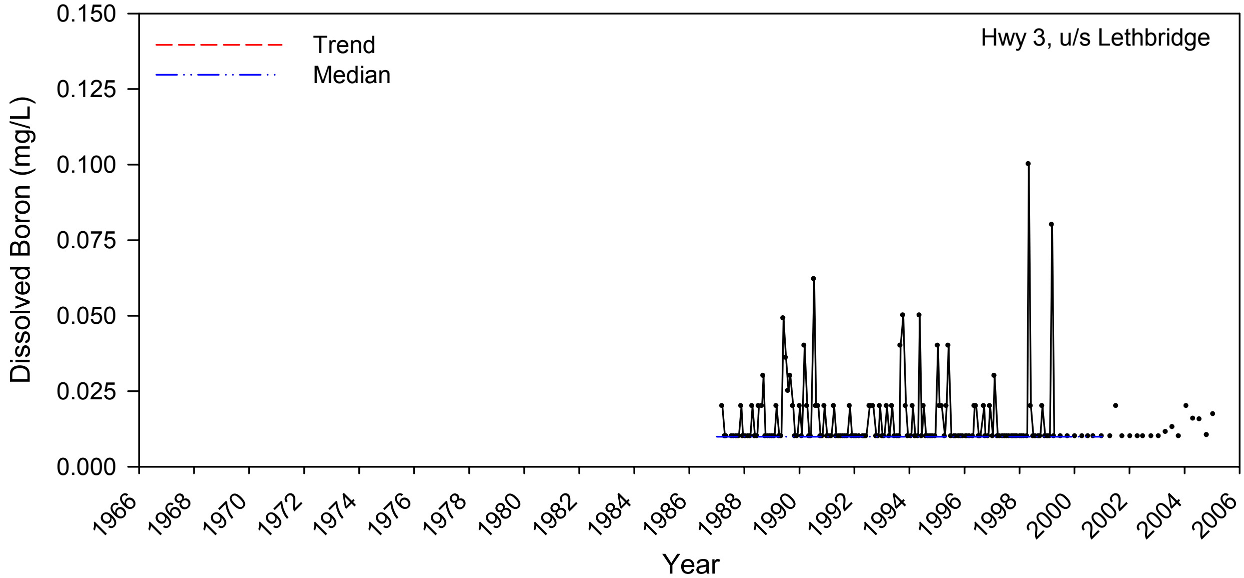
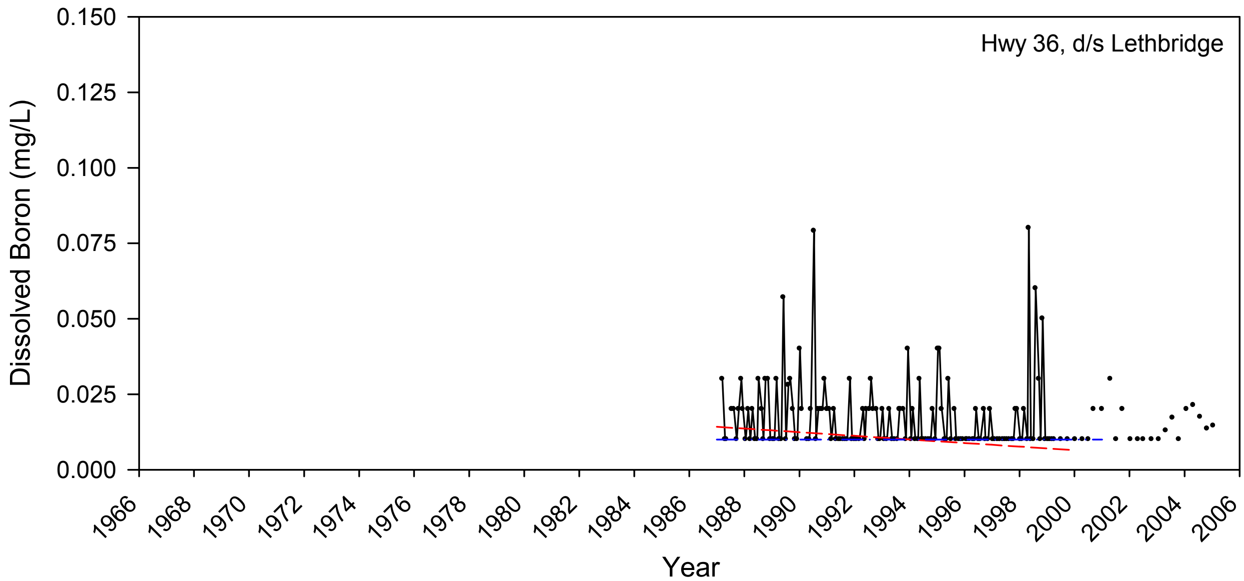


Figure 87 Seasonality of Dissolved Arsenic concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.01	-2.90%	NS
Flow Adjusted								
							-2.45%	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.01	-5.98%	Down
Flow Adjusted								
							-5.50%	Down

Figure 88 Dissolved Boron in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

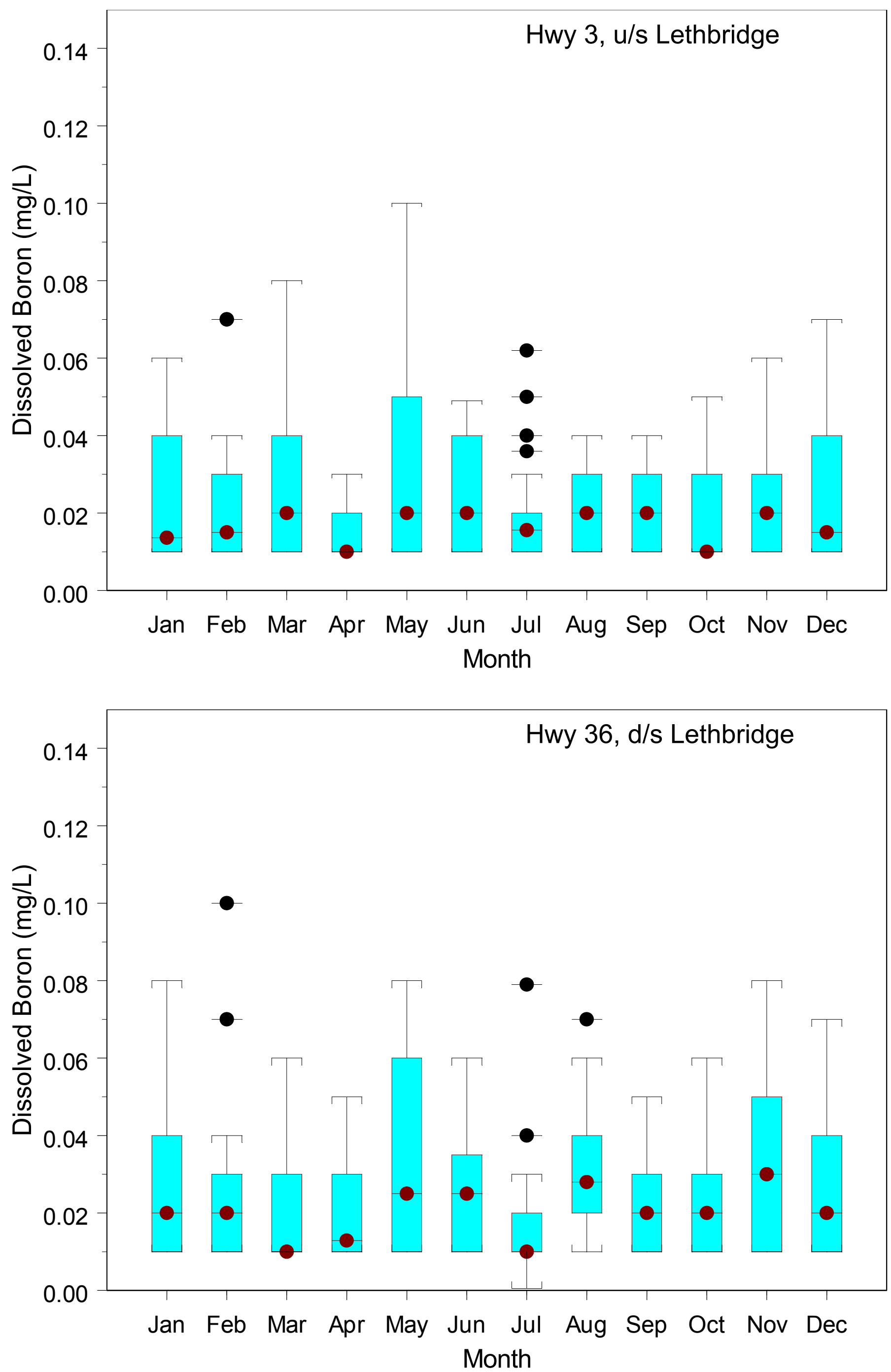
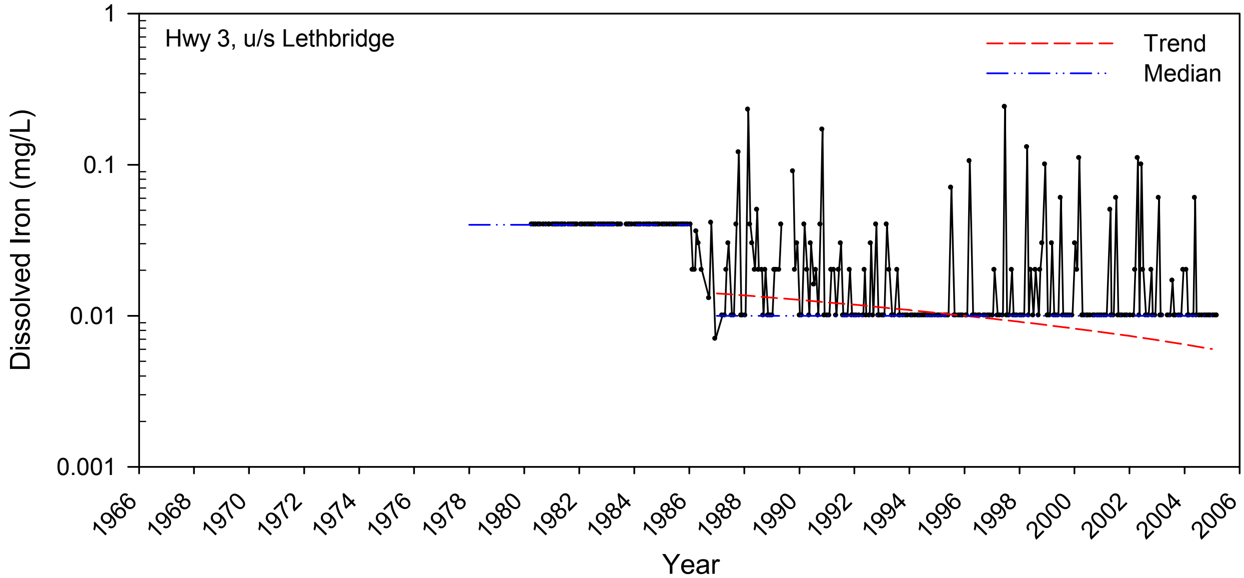
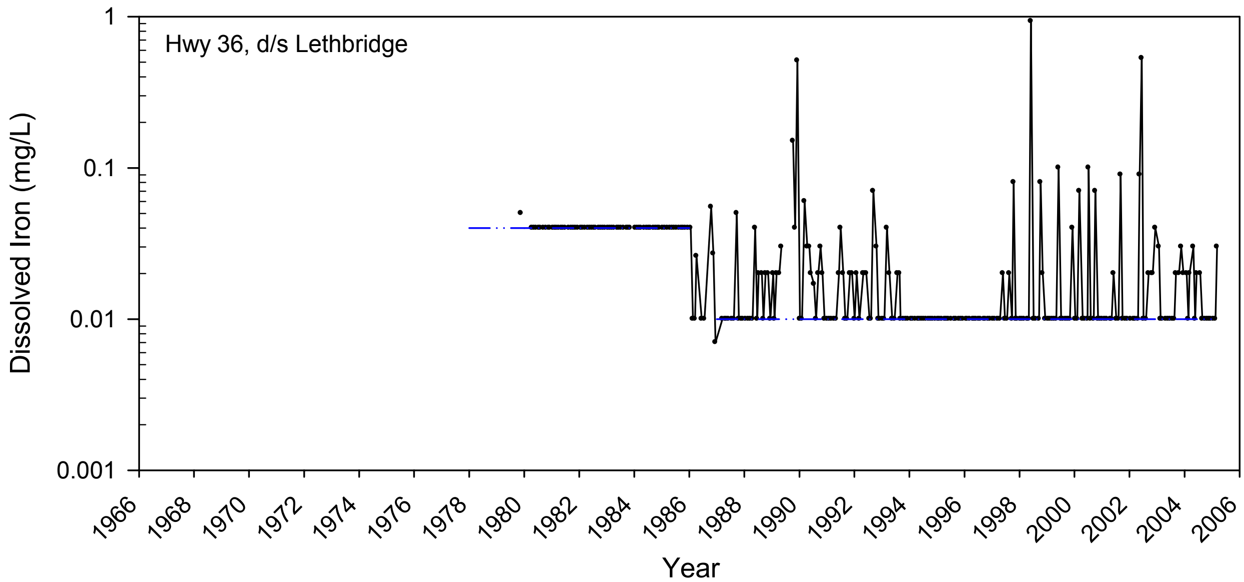


Figure 89 Seasonality of Dissolved Boron concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
		***	0.04	ID	ID	0.01	-4.52%	Down
Flow Adjusted								
				ID	ID		-4.56%	Down



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
		***	0.04	ID	ID	0.01	-0.18%	NS
				ID	ID		-0.13%	NS

Figure 90 Dissolved Iron in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

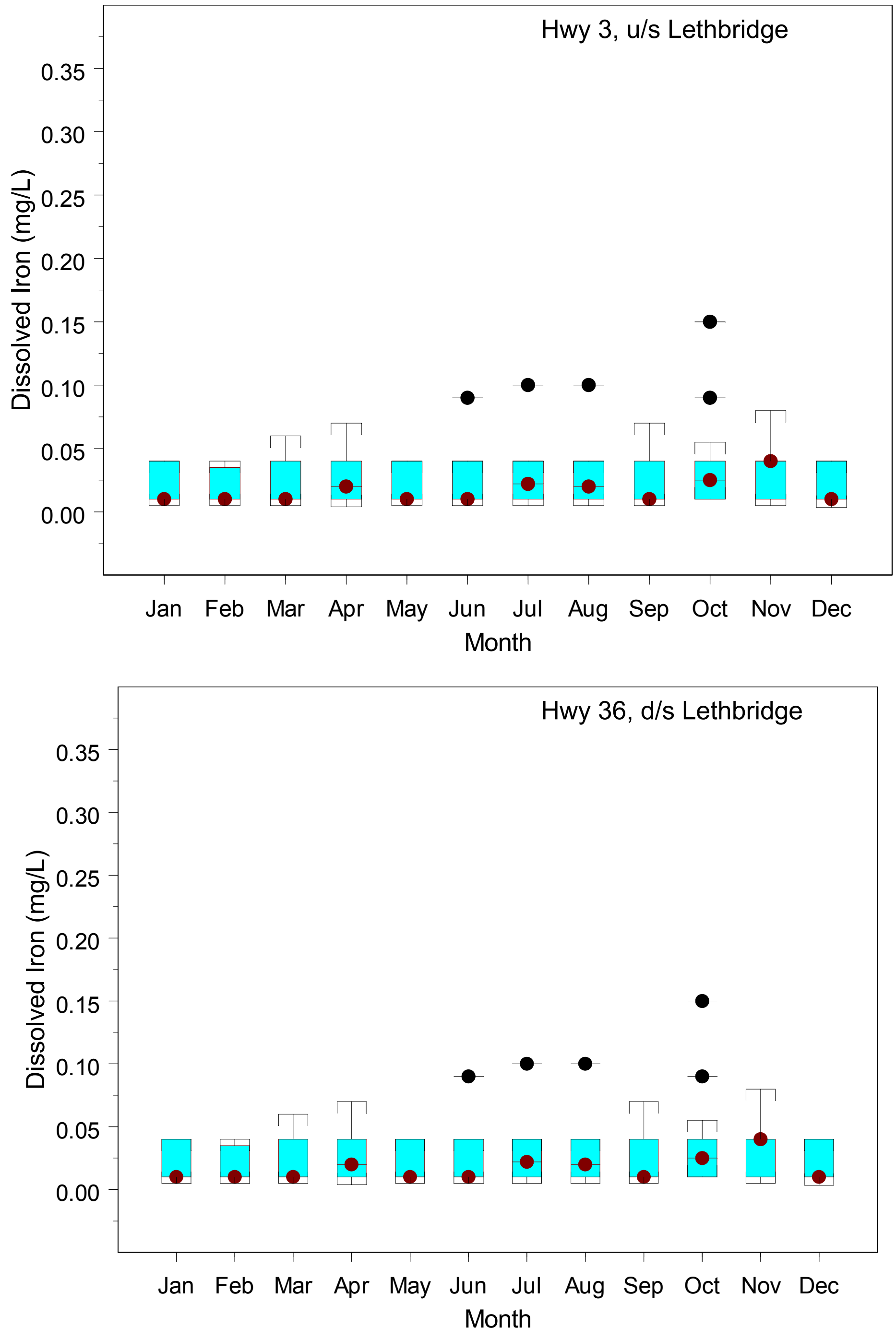
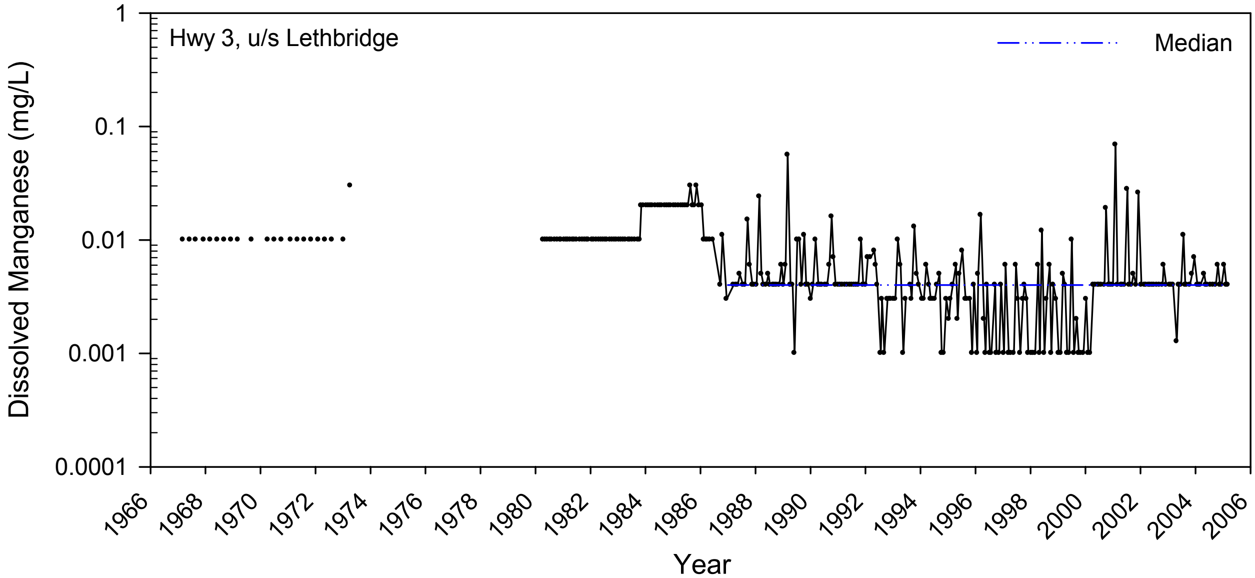
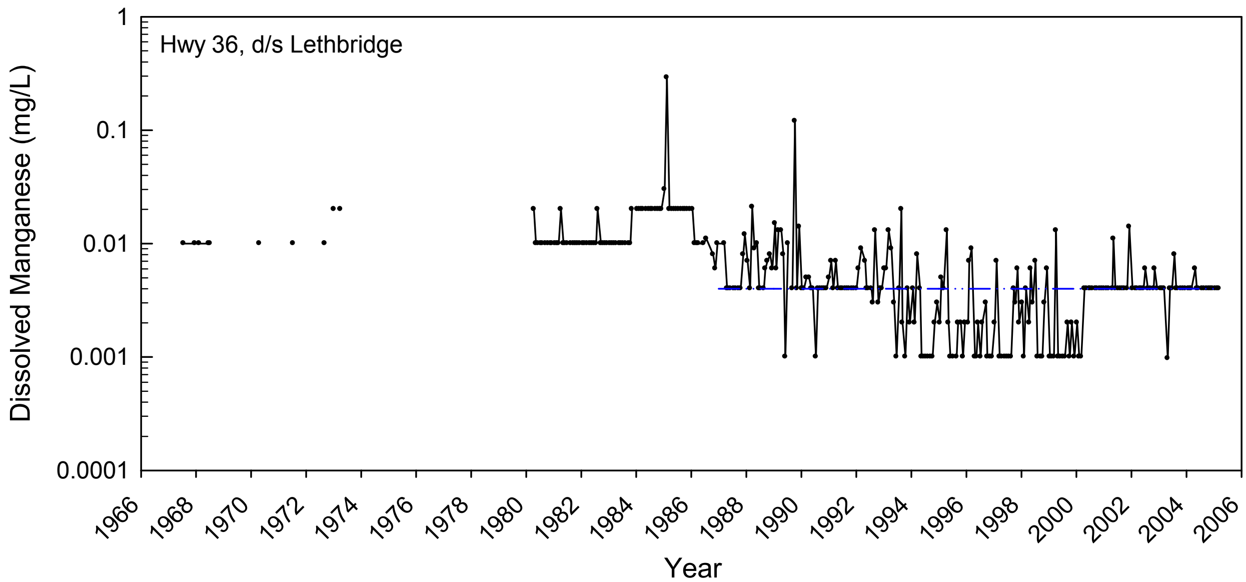


Figure 91 Seasonality of Dissolved Iron concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
		***	0.010	ID	ID	0.004	-4.67%	Down*
Flow Adjusted								
				ID	ID		-4.36%	Down*



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
		***	0.0100	ID	ID	0.0040	-8.04%	Down*
				ID	ID		-7.75%	Down*

Figure 92 Dissolved Manganese in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant. *Negative trends driven by changes in MDL are not plotted.

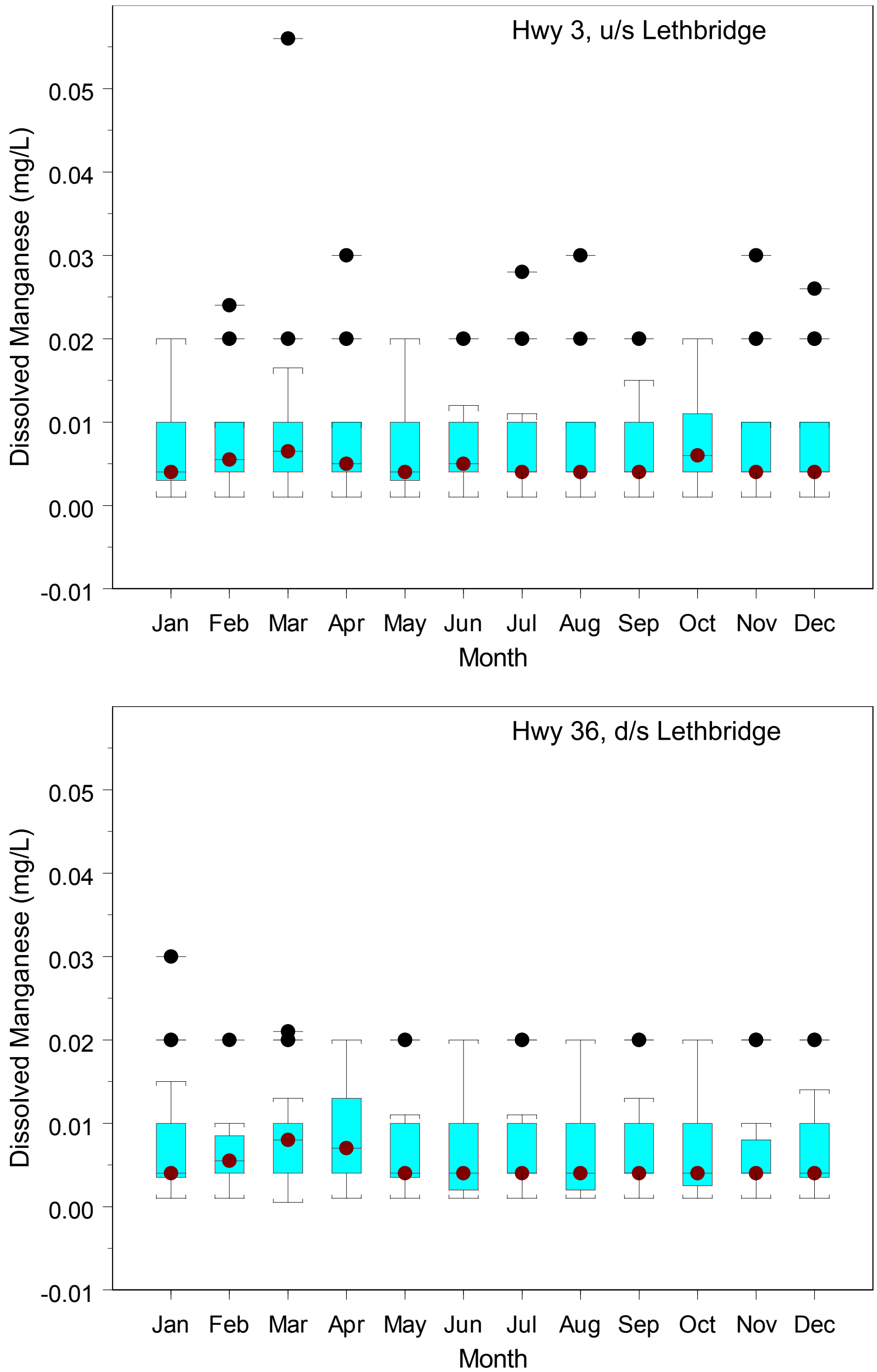
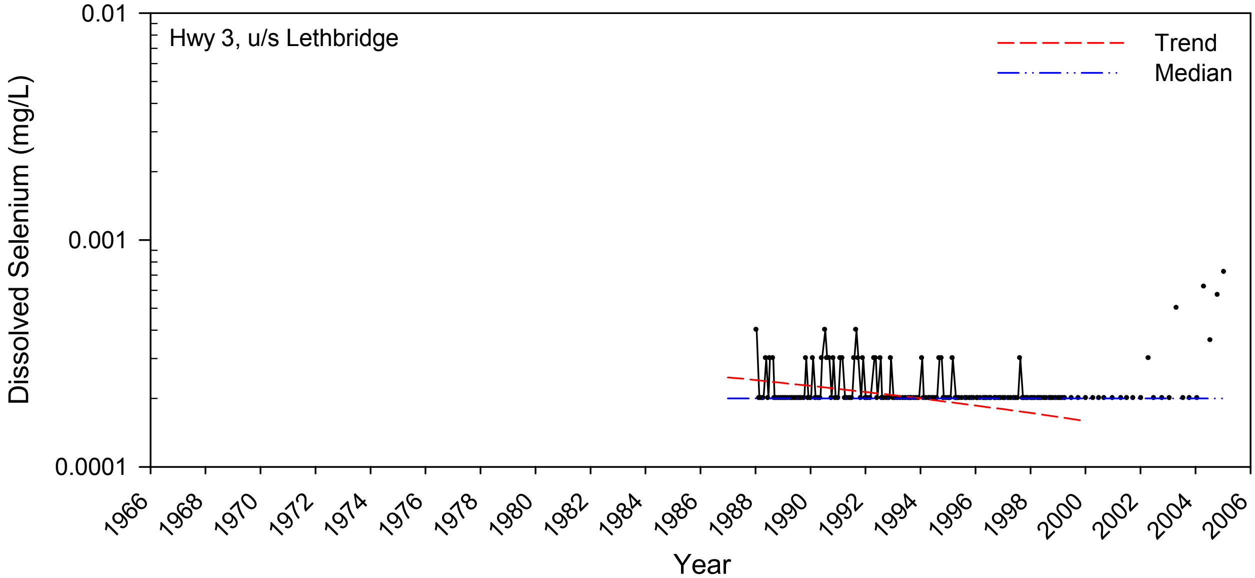
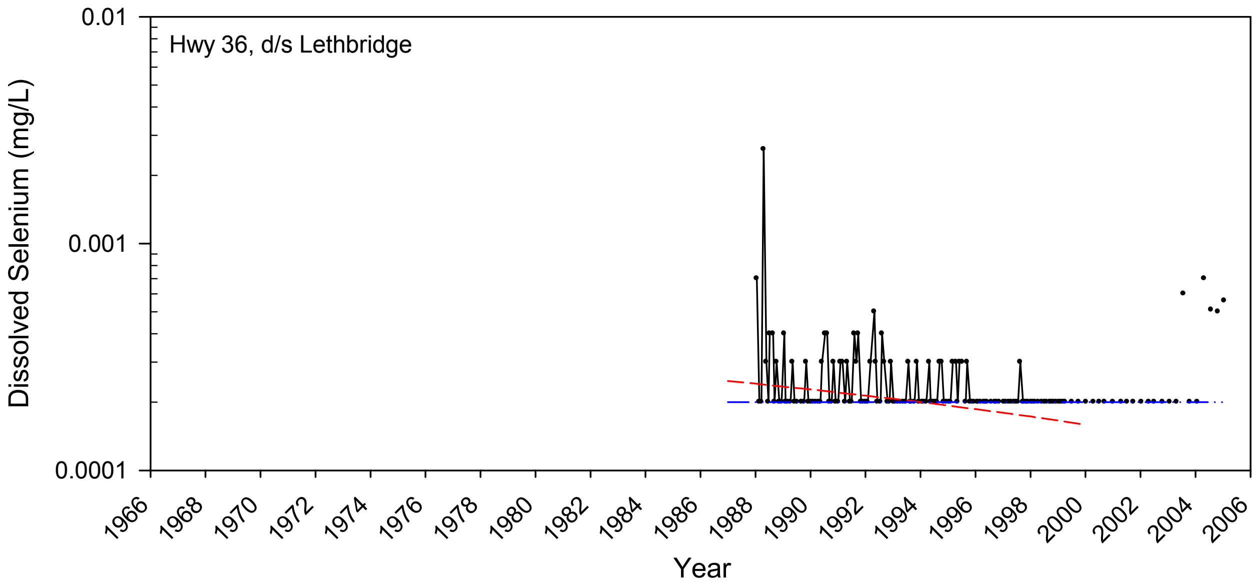


Figure 93 Seasonality of Dissolved Manganese concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.0002	-3.42%	Down
Flow Adjusted								
							-3.18%	Down



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
						0.0002	-0.0573	Down
							-0.0474	Down

Figure 94 Dissolved Selenium in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge), 1966 to 2005. Significance of the step trend is depicted at 90% (*), 95% (**), or 99% (***). NS = Not Significant.

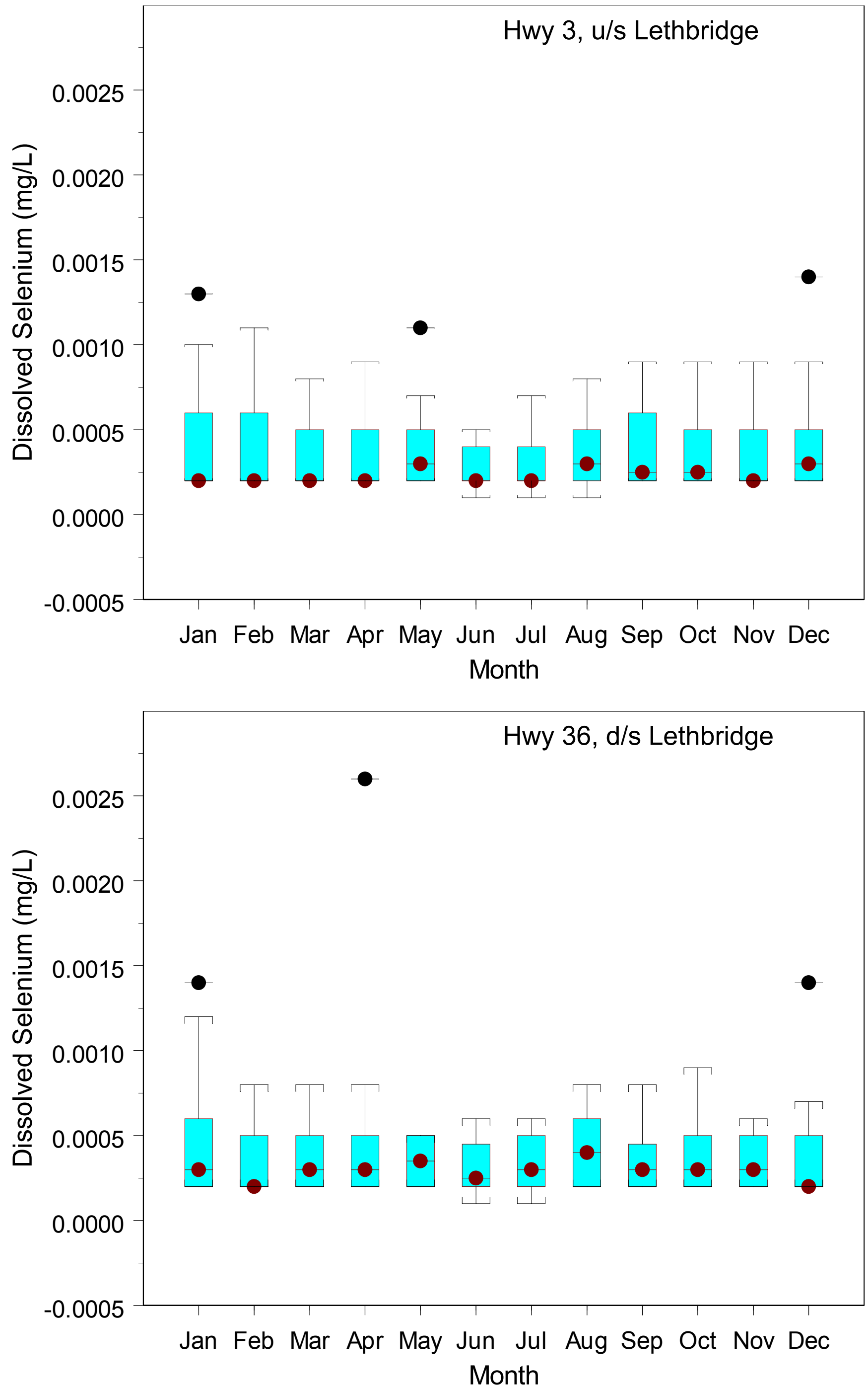
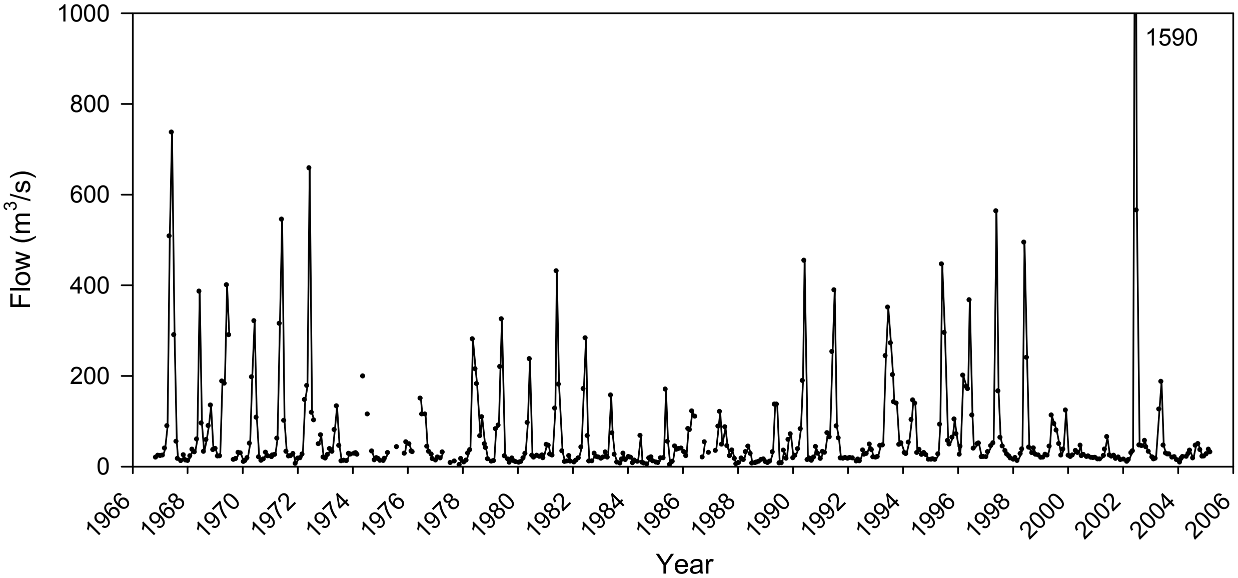


Figure 95 Seasonality of Dissolved Selenium concentration in the Oldman River at Highway 3 (upstream of Lethbridge) and Highway 36 (downstream of Lethbridge) from 1966 to 2005. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.08	NS	NS	28.10	-0.8700	**Down**	29.50	0.0519	NS
Flow Adjusted								

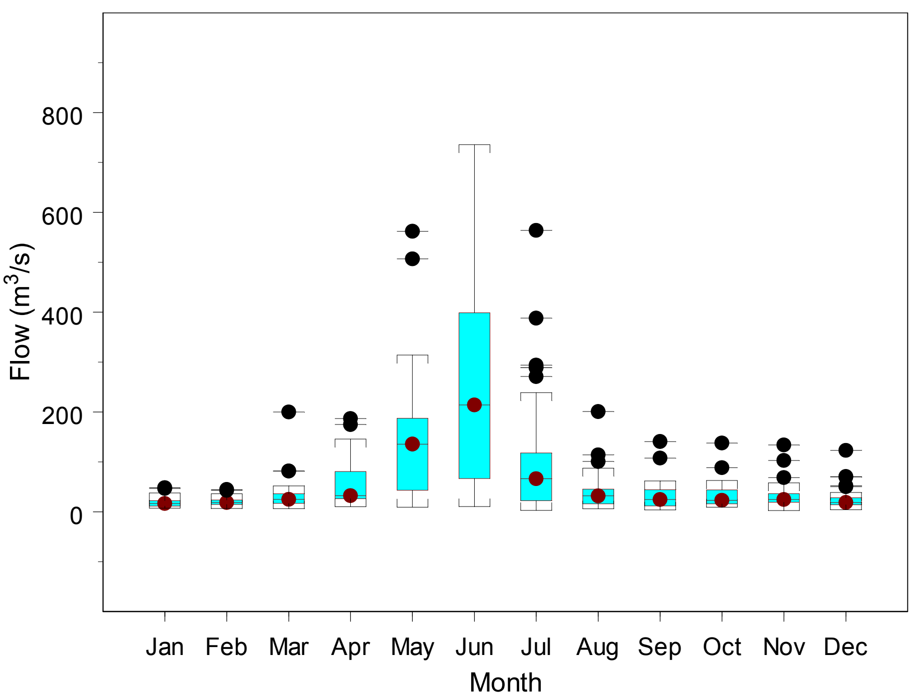


Figure 96 Flow (A) and seasonality of Flow (B) in the Oldman River at Lethbridge, 1966-2005. Data points on the upper graph represent daily means corresponding to sampling dates at the Highway 3 site.

Appendix I Step trend analysis of routine water quality data collected at the Highway **3** (upstream of Lethbridge) site since 1966. Significance of the step is depicted at 90% (*), 95% (**), and 99% (***). NS = Not Significant, ID = Insufficient Data.

Variable	Est. Diff. Btwn Time Periods	Median 1	Median 2	sig.
Temperature	-0.5000	5.6000	8.4300	***
pH	-0.1000	8.2000	8.1000	***
Conductivity	-12.0000	360.0000	343.0000	**
Total Alkalinity	6.0000	140.0000	145.0000	***
Hardness	ID	-	-	-
DO	-0.1000	11.1000	10.7800	NS
Turbidity	1.0000	8.0000	8.5000	*
Colour	0.0000	5.0000	5.0000	NS
Non-Filterable Residue	-3.0000	12.0000	8.0000	***
TDS/Filterable Residue	0.5000	209.5000	203.0000	NS
Potassium	0.0000	1.1000	1.1150	NS
Sodium	-0.5000	13.0000	12.1000	NS
Calcium	-0.7000	40.7000	39.6500	NS
Magnesium	-0.4000	15.5500	14.6000	NS
Bicarbonate	13.0000	163.0000	175.2500	**
Carbonate	0.2500	0.0000	0.2500	***
Chloride	0.1000	1.7000	1.7000	**
Fluoride	0.0000	0.1200	0.1250	NS
Sulphate	-4.0500	46.2000	39.2000	***
Reactive Silica	0.0000	2.7000	2.6200	NS
Total Organic Carbon	-0.1400	2.3200	2.3000	NS
Particulate Organic Carbon	-0.2400	0.4300	0.1000	***
Dissolved Organic Carbon	0.3000	2.0000	2.1000	***
Particulate Nitrogen	0.0000	0.0700	0.0600	NS
Dissolved Nitrogen	ID	-	-	-
Dissolved Kjeldahl Nitrogen	ID	-	-	-
Total Ammonia	-0.0400	0.0500	0.0100	***
Total Kjeldahl Nitrogen	-0.0100	0.2000	0.2200	NS
Nitrite and Nitrate	-0.0035	0.0500	0.0610	NS
Total Nitrogen	0.0580	0.2600	0.3205	***
Total Phosphorus	-0.0090	0.0250	0.0140	***
Total Dissolved Phosphorus	0.0000	0.0040	0.0030	*
Chlorophyll a	0.0000	0.0010	0.0010	NS
Total Coliforms	15.2500	49.0000	123.5000	**
Fecal Coliforms	3.0000	6.1000	13.0000	***
Escherichia coli	ID	-	-	-

Appendix II Results of trend analyses for routine data at Highway **3** (upstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1967	38	12	417	-0.022222	-0.316556	0.000145	**down**
pH	Seaken	1968	37	12	416	-0.001053	-0.012837	0.334881	none
Conductivity	Seaken	1968	37	12	413	-0.628571	-0.180106	0.149666	none
Alkalinity	Seaken	1967	37	12	415	0.222222	0.155400	0.085609	none
DO	Seaken	1978	27	12	310	0.000000	0.000000	0.931406	none
Turbidity	Seaken	1967	38	12	414	0.038613	0.482661	0.168195	none
True Colour	Seaken	1980	25	12	271	0.000000	0.000000	0.299868	none
Non-Filterable Reside	Tobit	1978	27	NA	314	NA	-4.255566	0.000230	**down**
TDS/FR	Seaken	1985	20	12	226	0.104167	0.051314	0.893363	none
Potassium	Seaken	1967	38	12	426	0.000000	0.000000	0.920504	none
Sodium	Seaken	1967	38	12	425	-0.019293	-0.153117	0.509835	none
Calcium	Seaken	1967	38	12	404	-0.063485	-0.158712	0.133259	none
Magnesium	Seaken	1975	30	12	341	-0.057143	-0.383509	0.044676	**down**
Bicarbonate	Seaken	1985	20	12	228	-0.064465	-0.036837	0.835939	none
Carbonate	Tobit	1985	20	NA	233	NA	5.908976	0.115674	none
Chloride	Seaken	1967	38	12	427	0.004545	0.267380	0.222787	none
Fluoride	Seaken	1987	31	12	342	0.0005555	0.462963	0.104002	none
Sulphate	Seaken	1967	38	12	426	-0.173684	-0.413534	0.067136	none
Silica	Seaken	1967	32	12	330	0.000000	0.000000	0.837699	none
Total Organic Carbon	Seaken	1977	28	12	313	-0.008571	-0.379267	0.360539	none
Particulate Organic Carbon	Tobit	1978	21	NA	231	NA	-8.852265	0.000000	**down**
Dissolved Organic Carbon	Seaken	1978	27	12	310	0.005556	0.277778	0.506213	none
Particulate Nitrogen	Tobit	1978	21	NA	231	NA	-1.723231	0.218497	none
Dissolved Nitrogen	Seaken	1978	8	12	93	-0.015000	-9.999998	0.022848	**down**
Dissolved Kjeldahl Nitrogen	Seaken	1987	12	12	136	-0.004000	-2.222222	0.190925	none
Total Ammonia Nitrogen	Tobit	1977	28	NA	317	NA	-7.421032	0.000000	**down**
Total Kjeldahl Nitrogen	Seaken	1987	18	12	207	-0.005455	-2.479339	0.004778	**down**
Nitrite and Nitrate Nitrogen	Tobit	1977	28	NA	327	NA	2.279809	0.035210	**up**
Total Nitrogen	Seaken	1976	29	12	326	0.000642	0.211786	0.607515	none
Total Phosphorus	Seaken	1976	29	12	330	-0.000421	-2.631579	0.002325	**down**
Total Dissolved Phosphorus	Tobit	1978	27	NA	313	NA	-2.677863	0.000403	**down**
Chlorophyll *a*	Seaken	1980	25	12	281	0.000000	0.000000	0.822099	none
Total Coliforms	Seaken	1972	24	1	23	0.500000	1.666667	0.525889	none
Fecal Coliforms	Tobit	1972	34	NA	359	NA	3.041121	0.007484	**up**
E. coli	Tobit	1994	11	NA	126	NA	-9.340989	0.078265	none

Appendix III Results of trend analyses on flow adjusted data for routine variables at Highway **3** (upstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1967	38	12	417	-0.014843	-0.212049	0.361785	none
pH	Seaken	1967	38	12	428	-0.001961	-0.023912	0.352913	none
Conductivity	Seaken	1967	38	12	425	-0.826548	-0.236156	0.039834	**down**
Alkalinity	Seaken	1967	38	12	421	0.091495	0.063982	0.493307	none
DO	Seaken	1978	27	12	310	0.000792	0.007262	0.907046	none
Turbidity	Seaken	1967	38	12	414	0.086666	1.083329	0.007337	**up**
Non-Filterable Reside	Tobit	1978	27	NA	314	NA	-5.645629	0.000000	**down**
TDS/FR	Seaken	1985	20	12	226	-0.026593	-0.013100	0.971350	none
Potassium	Seaken	1967	38	12	426	-0.000014	-0.001280	0.804776	none
Sodium	Seaken	1967	38	12	425	-0.043052	-0.341684	0.157547	none
Calcium	Seaken	1967	38	12	404	-0.097275	-0.243188	0.056666	none
Magnesium	Seaken	1975	20	12	228	-0.036493	-0.236200	0.606077	none
Bicarbonate	Seaken	1985	20	12	228	-0.195885	-0.111934	0.718304	none
Carbonate	Tobit	1985	20	NA	233	NA	5.884434	0.118727	none
Chloride	Seaken	1967	38	12	427	0.002978	0.175205	0.447879	none
Fluoride	Seaken	1974	31	12	342	0.000553	0.460578	0.099601	none
Sulphate	Seaken	1967	38	12	426	-0.228638	-0.544376	0.004960	**down**
Silica	Tobit	1977	18	NA	205	NA	-0.622499	0.312006	none
Total Organic Carbon	Seaken	1977	28	12	313	-0.012755	-0.564363	0.079780	none
Particulate Organic Carbon	Tobit	1978	21	NA	231	NA	-9.936242	0.000000	**down**
Dissolved Organic Carbon	Seaken	1978	27	12	310	0.007117	0.355859	0.396902	none
Particulate Nitrogen	Tobit	1978	21	NA	231	NA	-3.512603	0.007799	**down**
Dissolved Nitrogen	Seaken	1978	8	12	93	-0.013408	-8.938342	0.033802	**down**
Dissolved Kjeldahl Nitrogen	Seaken	1987	12	12	136	-0.004686	-2.603444	0.182545	none
Total Ammonia Nitrogen	Tobit	1977	28	NA	317	NA	-7.559710	0.000000	**down**
Total Kjeldahl Nitrogen	Seaken	1987	18	12	207	-0.005913	-2.687761	0.033925	**down**
Nitrite and Nitrate Nitrogen	Tobit	1977	28	NA	326	NA	1.315883	0.190719	none
Total Nitrogen	Seaken	1976	29	12	326	0.001499	0.494728	0.348889	none
Total Phosphorus	Seaken	1976	29	12	330	-0.000369	-2.303721	0.000753	**down**
Total Dissolved Phosphorus	Tobit	1978	27	NA	313	NA	-2.843173	0.000141	**down**
Chlorophyll a	Seaken	1980	25	12	281	-0.000006	-0.591815	0.590717	none
Total Coliforms	Seaken	1972	24	1	23	1.619653	5.398844	0.711571	none
Fecal Coliforms	Tobit	1972	34	NA	359	NA	2.700513	0.015100	**up**
E. coli	Tobit	1994	11	NA	126	NA	-0.497793	0.918466	none

Appendix IV Results of trend analyses for routine data at Highway **3** (upstream of Lethbridge), **1966-1987**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1966	20	12	209	0.000000	0.000000	0.594987	none
pH	Seaken	1966	20	12	220	0.009091	0.110864	0.042880	**up**
Conductivity	Seaken	1967	19	12	207	-1.000000	-0.277778	0.389763	none
Alkalinity	Seaken	1967	19	12	203	-0.142857	-0.102041	0.540548	none
Hardness	Seaken	1967	11	12	113	-0.750000	-0.449102	0.389185	none
Non-filterable Reside	Tobit	1977	9	NA	94	NA	-6.338638	0.297715	none
Sodium	Seaken	1966	20	12	217	-0.080000	-0.615384	0.184528	none
Magnesium	Seaken	1966	20	12	160	-0.028571	-0.183150	0.684840	none
Fluoride	Seaken	1974	12	12	125	-0.002000	-1.818183	0.129132	none
Sulphate	Seaken	1966	20	12	219	-0.200000	-0.431965	0.355958	none
Particulate Organic Carbon	Tobit	1978	9	NA	96	NA	-3.765234	0.393357	**none**
Total Ammonia Nitrogen	Tobit	1977	9	NA	97	NA	-4.368486	0.000006	**down**
Total Nitrogen	Seaken	1976	10	12	110	-0.021667	-8.333334	0.019528	**down**
Total Phosphorus	Seaken	1976	10	12	112	-0.002000	-7.999999	0.040301	**down**
Total Dissolved Phosphorus	Tobit	1978	8	NA	91	NA	-2.093759	0.604458	none
Total Coliforms	Seaken	1972	14	1	14	-1.000000	-8.000000	0.511220	none
Fecal Coliforms	Tobit	1972	14	NA	137	NA	-2.186162	0.602092	none

Appendix V Results of trend analyses on flow-adjusted data for routine variables at Highway **3** (upstream of Lethbridge), **1966-1987**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1966	20	12	209	0.066512	1.187716	0.105704	none
pH	Seaken	1966	20	12	220	0.011807	0.143989	0.016890	**up**
Conductivity	Seaken	1966	20	12	217	-2.369700	-0.658250	0.011949	**down**
Alkalinity	Seaken	1966	20	12	212	-0.560579	-0.400414	0.055434	none
Hardness	Seaken	1966	11	12	113	-1.050496	-0.629040	0.056181	none
Non-filterable Reside	Tobit	1977	9	NA	94	NA	2.670935	0.601980	none
Sodium	Seaken	1966	20	12	217	-0.184369	-1.418227	0.003412	**down**
Magnesium	Seaken	1966	20	12	160	-0.110132	-0.705976	0.160084	none
Fluoride	Seaken	1974	12	12	125	-0.002021	-1.836874	0.113435	none
Sulphate	Seaken	1966	20	12	219	-0.580833	-1.254498	0.005502	**down**
Particulate Organic Carbon	Tobit	1978	9	NA	96	NA	0.532846	0.895532	none
Total Ammonia Nitrogen	Tobit	1977	9	NA	97	NA	-4.294097	0.000017	**down**
Total Nitrogen	Seaken	1976	10	12	110	-0.016959	-6.522577	0.065210	none
Total Phosphorus	Seaken	1976	10	12	112	-0.000927	-3.709669	0.253049	none
Total Dissolved Phosphorus	Tobit	1978	8	NA	91	NA	-2.888867	0.496195	none
Total Coliforms	Seaken	1972	14	1	14	8.557453	68.459625	0.154629	none
Fecal Coliforms	Tobit	1972	14	NA	137	NA	8.576791	0.120407	none

Appendix VI Results of trend analyses for routine data at Highway **3** (upstream of Lethbridge), **1987-2005**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1987	18	12	209	-0.022967	-0.284598	0.012357	**down**
pH	Seaken	1987	18	12	209	0.010000	0.123153	0.074127	none
Conductivity	Seaken	1987	18	12	209	-1.207143	-0.350914	0.329846	none
Alkalinity	Seaken	1987	18	12	209	-0.174242	-0.119344	0.680066	none
Hardness	Seaken	1987	18	12	209	-0.345128	-0.215705	0.367164	none
Non-filterable Reside	Tobit	1987	18	NA	213	NA	-4.083524	0.069503	none
Sodium	Seaken	1987	18	12	209	0.000000	0.000000	0.948238	none
Magnesium	Seaken	1987	18	12	209	-0.066667	-0.456623	0.245853	none
Fluoride	Seaken	1987	18	12	208	-0.000625	-0.480770	0.290484	none
Sulphate	Seaken	1987	18	12	208	-0.075000	-0.189874	0.799793	none
Particulate Organic Carbon	Tobit	1987	12	NA	135	NA	3.737534	0.160165	none
Total Ammonia Nitrogen	Tobit	1987	18	NA	211	NA	-2.030573	0.159297	none
Total Nitrogen	Seaken	1987	18	12	207	-0.003583	-1.116303	0.143240	none
Total Phosphorus	Seaken	1987	18	12	209	-0.000449	-3.210678	0.034092	**down**
Total Dissolved Phosphorus	Tobit	1987	18	NA	213	-0.000850	-4.652241	0.000862	**down**
Total Coliforms	Seaken	1987	18	1	10	-1.200000	-0.761905	1.000000	none
Fecal Coliforms	Tobit	1987	18	NA	210	-20.218770	-7.064558	0.001284	down
E. coli	Tobit	1994	11	NA	126	NA	-9.340989	0.078265	none

Appendix VII Results of trend analyses on flow-adjusted data for routine variables at Highway **3** (upstream of Lethbridge), **1987-2005**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1987	18	12	209	-0.033621	-0.416618	0.436667	none
pH	Seaken	1987	18	12	209	0.011028	0.135807	0.061663	none
Conductivity	Seaken	1987	18	12	209	-0.978731	-0.284515	0.476591	none
Alkalinity	Seaken	1987	18	12	209	-0.328503	-0.225002	0.579413	none
Hardness	Seaken	1987	18	12	209	-0.348913	-0.218070	0.579429	none
Non-filterable Reside	Tobit	1987	18	NA	213	NA	-4.657284	0.005482	**down**
Sodium	Seaken	1987	18	12	209	0.008602	0.070506	0.946396	none
Magnesium	Seaken	1987	18	12	209	-0.044973	-0.308032	0.355732	none
Fluoride	Seaken	1987	18	12	208	-0.000654	-0.502723	0.321405	none
Sulphate	Seaken	1987	18	12	208	-0.041686	-0.105535	0.859089	none
Particulate Organic Carbon	Tobit	1987	12	NA	135	NA	1.368480	0.562514	none
Total Ammonia Nitrogen	Tobit	1987	18	NA	211	NA	-2.123427	0.125289	none
Total Nitrogen	Seaken	1987	18	12	207	-0.003023	-0.941885	0.293626	none
Total Phosphorus	Seaken	1987	18	12	209	-0.000229	-1.635533	0.567318	none
Total Dissolved Phosphorus	Tobit	1987	18	NA	213	NA	-4.800220	0.000523	**down**
Total Coliforms	Seaken	1987	18	1	10	-1.816216	-1.153153	1.000000	none
Fecal Coliforms	Tobit	1987	18	NA	210	NA	-7.522882	0.001077	**down**
E. coli	Tobit	1994	11	NA	126	NA	-8.279978	0.081838	none

Appendix VIII Step trend analysis of metals data collected at the Highway **3** (upstream of Lethbridge) site since 1966. Significance of the step is depicted at 90% (*), 95% (**), and 99% (***). NS = Not Significant, ID = Insufficient Data.

Variable	Est. Diff. Btwn Time Periods	Median 1	Median 2	sig.
Dissolved Aluminum	ID	-	-	-
Dissolved Arsenic	-0.0001	0.0005	0.0004	***
Dissolved Boron	ID	-	-	-
Dissolved Iron	-0.0300	0.0400	0.0100	***
Dissolved Manganese	-0.0060	0.0100	0.0040	***
Dissolved Selenium	ID	-	-	-

Appendix IX Results of trend analyses for metals data at Highway **3** (upstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data), ID = Insufficient Data.

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	20	NA	227	NA	-4.5054E-01	4.8286E-01	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-
Dissolved Selenium	ID	-	-	-	-	-	-	-	-

Appendix X Results of trend analyses on flow-adjusted data for metals at Highway **3** (upstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data). ID = Insufficient Data.

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	20	NA	227	NA	-5.7059E-02	9.3219E-01	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-
Dissolved Selenium	ID	-	-	-	-	-	-	-	-

Appendix XI Results of trend analyses for metals data at Highway **3** (upstream of Lethbridge), **1966-1987**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data), ID = Insufficient Data.

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	8	NA	89	NA	2.0975E+00	5.3400E-01	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-

Appendix XII Results of trend analyses on flow-adjusted data for metals at Highway **3** (upstream of Lethbridge), **1966-1987**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	8	NA	89	NA	2.2516E+00	4.8438E-01	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-
Dissolved Selenium	ID	-	-	-	-	-	-	-	-

Appendix XIII Results of trend analyses for metals data at Highway **3** (upstream of Lethbridge), **1987-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	Tobit	1987	13	NA	136	NA	-3.2814E+00	2.2466E-01	none
Dissolved Arsenic	Tobit	1987	13	NA	148	NA	-1.9714E+00	6.2427E-02	none
Dissolved Boron	Tobit	1987	13	NA	147	NA	-2.8976E+00	1.5732E-01	none
Dissolved Iron	Tobit	1987	19	NA	213	NA	-4.5214E+00	1.1242E-02	**down**
Dissolved Manganese	Tobit	1987	19	NA	216	NA	-4.6724E+00	5.3206E-03	**down**
Dissolved Selenium	Tobit	1987	13	NA	148	NA	-3.4154E+00	2.0307E-03	**down**

Appendix XIV Results of trend analyses on flow-adjusted data for metals at Highway **3** (upstream of Lethbridge), **1987-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	Tobit	1987	13	NA	136	NA	-8.1139E-01	7.6893E-01	none
Dissolved Arsenic	Tobit	1987	13	NA	148	NA	-1.9309E+00	8.0714E-02	none
Dissolved Boron	Tobit	1987	13	NA	147	NA	-2.4534E+00	2.5149E-01	none
Dissolved Iron	Tobit	1987	19	NA	213	NA	-4.5597E+00	1.0536E-02	**down**
Dissolved Manganese	Tobit	1987	19	NA	216	NA	-4.3674E+00	8.4539E-03	**down**
Dissolved Selenium	Tobit	1987	13	NA	148	NA	-3.1796E+00	5.7564E-03	**down**

Appendix XV Step trend analysis of routine water quality data collected at the Highway **36** (downstream of Lethbridge) site since 1966. Significance of the step is depicted at 90% (*), 95% (**), and 99% (***). NS = Not Significant, ID = Insufficient Data.

Variable	Est. Diff. Btwn Time Periods	Median 1	Median 2	sig.
Temperature	-0.2000	7.7500	8.9800	NS
pH	0.0000	8.3000	8.2600	NS
Conductivity	-20.0000	386.5000	363.5000	***
Total Alkalinity	5.0000	138.5000	147.0000	***
Hardness	ID	-	-	-
DO	0.5000	10.6000	11.1800	***
Turbidity	0.0000	8.0000	7.2000	NS
Colour	0.0000	10.0000	9.0000	**
Non-Filterable Residue	-1.0000	9.5000	7.0000	*
TDS/Filterable Residue	17.0000	201.5000	218.7500	*
Potassium	0.0000	1.6000	1.5800	NS
Sodium	-0.8000	18.0000	15.7000	NS
Calcium	-1.6000	41.4000	39.9500	***
Magnesium	-0.6500	16.3000	15.4000	*
Bicarbonate	13.4000	162.1000	175.5000	***
Carbonate	0.2500	0.0000	0.2500	***
Chloride	-0.2000	4.5000	4.0000	NS
Fluoride	0.0200	0.1200	0.1400	***
Sulphate	-3.8500	51.6500	46.4000	**
Reactive Silica	-0.1075	1.3000	1.0000	NS
Total Organic Carbon	-0.5600	3.2000	2.7000	***
Particulate Organic Carbon	-0.4600	0.6700	0.1000	***
Dissolved Organic Carbon	0.3000	2.1000	2.5000	***
Particulate Nitrogen	-0.0400	0.1100	0.0700	***
Dissolved Nitrogen	ID	-	-	-
Dissolved Kjeldahl Nitrogen	ID	-	-	-
Total Ammonia	-0.0400	0.0500	0.0200	***
Total Kjeldahl Nitrogen	-0.2050	0.5000	0.3050	***
Nitrite and Nitrate	-0.0035	0.0500	0.0650	NS
Total Nitrogen	-0.0370	0.4300	0.4130	NS
Total Phosphorus	-0.0310	0.0880	0.0420	***
Total Dissolved Phosphorus	-0.0195	0.0400	0.0120	***
Chlorophyll a	-0.0010	0.0040	0.0021	**
Total Coliforms	-55.5000	242.5000	148.0000	*
Fecal Coliforms	-3.0000	23.0000	18.0000	NS
Escherichia coli	ID	-	-	-

Appendix XVI Results of trend analyses for routine data at Highway **36** (downstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Temperature	Seaken	1973	32	12	337	-0.017500	-0.205882	0.009196	**down**
pH	Seaken	1973	32	12	341	0.000909	0.010966	0.437868	none
Conductivity	Seaken	1973	32	12	340	-1.063508	-0.286660	0.083919	none
Alkalinity	Seaken	1973	32	12	335	0.235294	0.163399	0.137365	none
DO	Seaken	1978	27	12	310	0.030465	0.278732	0.036155	**up**
Turbidity	Seaken	1973	32	12	335	-0.020000	-0.266667	0.618403	none
True Colour	Seaken	1980	25	12	271	0.000000	0.000000	0.077727	none
Non-Filterable Reside	Tobit	1978	27	NA	316	NA	-4.776925	0.000084	**down**
TDS/FR	Seaken	1985	20	12	226	0.000000	0.000000	1.000000	none
Potassium	Seaken	1973	32	12	341	0.003846	0.240385	0.381556	none
Sodium	Seaken	1973	32	12	341	-0.028571	-0.175285	0.539260	none
Calcium	Seaken	1973	32	12	341	-0.104674	-0.261685	0.046752	**down**
Magnesium	Seaken	1975	30	12	330	-0.063636	-0.405327	0.060174	none
Bicarbonate	Seaken	1985	20	12	228	0.246000	0.141379	0.618863	none
Carbonate	Tobit	1985	20	NA	232	NA	3.725915	0.260442	none
Chloride	Seaken	1973	32	12	341	-0.016667	-0.396825	0.505393	none
Fluoride	Seaken	1974	31	12	327	0.000714	0.510204	0.043876	**up**
Sulphate	Seaken	1973	32	12	340	-0.177778	-0.370370	0.292913	none
Silica	Tobit	1973	32	NA	294	NA	-4.055522	0.000347	**down**
Total Organic Carbon	Seaken	1977	28	12	316	-0.025000	-0.892856	0.024521	**down**
Particulate Organic Carbon	Tobit	1978	21	NA	233	NA	-9.874248	0.000000	**down**
Dissolved Organic Carbon	Seaken	1978	27	12	310	0.005263	0.219298	0.514820	none
Particulate Nitrogen	Tobit	1978	21	NA	233	NA	-3.608940	0.002802	**down**
Dissolved Nitrogen	Seaken	1978	8	12	92	-0.010000	-4.444445	0.127813	none
Dissolved Kjeldahl Nitrogen	Seaken	1987	12	12	132	-0.010000	-3.846153	0.047843	**down**
Total Ammonia Nitrogen	Tobit	1977	28	NA	317	NA	-6.829817	0.000000	**down**
Total Kjeldahl Nitrogen	Seaken	1987	18	12	204	-0.010000	-3.333333	0.002554	**down**
Nitrite and Nitrate Nitrogen	Tobit	1973	32	NA	344	NA	-1.699797	0.083048	none
Total Nitrogen	Seaken	1976	29	12	321	-0.004833	-1.150794	0.014652	**down**
Total Phosphorus	Seaken	1976	29	12	326	-0.002857	-4.722549	0.000187	**down**
Total Dissolved Phosphorus	Tobit	1978	27	NA	315	NA	-10.179248	0.000000	**down**
Chlorophyll *a*	Seaken	1980	25	12	281	-0.000045	-2.043159	0.056284	none
Total Coliforms	Seaken	1979	15	1	15	0.000000	0.000000	0.920706	none
Fecal Coliforms	Tobit	1977	28	NA	309	NA	-3.059188	0.022016	**down**
E. coli	Tobit	1994	11	NA	125	NA	-17.128610	0.000927	**down**

Appendix XVII Results of trend analyses on flow-adjusted data for routine variables at Highway **36** (downstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	**Trend Test**	**Start Year**	**# Years**	**# Seasons**	**N**	**Trend**	**Trend Percent**	**p-value**	**Sig.**
Temperature	Seaken	1973	32	12	337	-0.037686	-0.443362	0.141757	none
pH	Seaken	1973	32	12	341	0.001335	0.016102	0.432925	none
Conductivity	Seaken	1973	32	12	340	-1.061966	-0.286244	0.153869	none
Alkalinity	Seaken	1973	32	12	335	0.202812	0.140841	0.285627	none
DO	Seaken	1978	27	12	310	0.029897	0.273534	0.034088	**up**
Turbidity	Seaken	1973	32	12	335	-0.103625	-1.381668	0.596381	none
Non-Filterable Reside	Tobit	1978	27	NA	316	NA	-6.060551	0.000000	**down**
TDS/FR	Seaken	1985	20	12	226	0.148516	0.068283	0.850442	none
Potassium	Seaken	1973	32	12	341	0.008133	0.508296	0.134969	none
Sodium	Seaken	1973	32	12	341	-0.006910	-0.042391	0.878707	none
Calcium	Seaken	1973	32	12	341	-0.093785	-0.234463	0.176080	none
Magnesium	Seaken	1975	20	12	216	-0.022635	-0.139294	0.746093	none
Bicarbonate	Seaken	1985	20	12	228	-0.075772	-0.043547	0.893172	none
Carbonate	Tobit	1985	20	NA	232	NA	4.336194	0.179150	none
Chloride	Seaken	1973	32	12	341	-0.015525	-0.369651	0.260172	none
Fluoride	Seaken	1974	31	12	327	0.000953	0.681017	0.011072	**up**
Sulphate	Seaken	1973	32	12	340	-0.042851	-0.089272	0.737124	none
Silica	Tobit	1973	26	NA	272	NA	-5.865158	0.000000	**down**
Total Organic Carbon	Seaken	1977	28	12	316	-0.028758	-1.027066	0.009137	**down**
Particulate Organic Carbon	Tobit	1978	21	NA	233	NA	-10.758111	0.000000	**down**
Dissolved Organic Carbon	Seaken	1978	27	12	310	0.006205	0.258521	0.502984	none
Particulate Nitrogen	Tobit	1978	21	NA	233	NA	-4.677335	0.000072	**down**
Dissolved Nitrogen	Seaken	1978	8	12	92	-0.017079	-7.590647	0.105569	none
Dissolved Kjeldahl Nitrogen	Seaken	1987	12	12	132	-0.007234	-2.782197	0.108959	none
Total Ammonia Nitrogen	Tobit	1977	28	NA	317	NA	-7.044358	0.000000	**down**
Total Kjeldahl Nitrogen	Seaken	1987	18	12	204	-0.007352	-2.450650	0.022895	**down**
Nitrite and Nitrate Nitrogen	Tobit	1973	32	NA	344	NA	-2.346939	0.008988	**down**
Total Nitrogen	Seaken	1976	29	12	321	-0.003457	-0.823003	0.113539	none
Total Phosphorus	Seaken	1976	29	12	326	-0.002588	-4.277059	0.000292	**down**
Total Dissolved Phosphorus	Tobit	1978	27	NA	315	NA	-10.098452	0.000000	**down**
Chlorophyll a	Seaken	1980	25	12	281	-0.000054	-2.440890	0.025678	**down**
Total Coliforms	Tobit	1979	15	NA	145	NA	-1.348744	0.734447	none
Fecal Coliforms	Tobit	1977	28	NA	309	NA	-3.939980	0.001234	**down**
E. coli	Tobit	1994	11	NA	125	NA	-8.301392	0.068292	none

Appendix XVIII Results of trend analyses for routine data at Highway **36** (downstream of Lethbridge), **1966-1987**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Conductivity	Seaken	1978	9	12	102	-7.000000	-1.794872	0.115088	none
Alkalinity	Seaken	1978	9	12	102	0.000000	0.000000	0.817317	none
Dissolved Oxygen	Seaken	1978	9	12	102	0.025000	0.233646	0.754247	none
Non-filterable Residue	Tobit	1978	9	NA	103	NA	5.182782	0.179978	none
Dissolved Calcium	Seaken	1978	9	12	103	-0.570833	-1.419983	0.021681	**down**
Dissolved Magnesium	Seaken	1978	9	12	103	-0.383333	-2.351738	0.013529	**down**
Dissolved Fluoride	Seaken	1977	10	12	109	0.000000	0.000000	0.543419	none
Sulphate	Seaken	1978	9	12	103	-1.350000	-2.547170	0.153394	none
Total Organic Carbon	Seaken	1978	9	12	99	-0.080000	-2.749141	0.174664	none
Particulate Organic Carbon	Tobit	1978	9	NA	97	NA	0.873571	0.749536	none
Dissolved Organic Carbon	Seaken	1978	9	12	102	-0.050000	-2.325582	0.192029	none
Particulate Nitrogen	Tobit	1978	9	NA	100	NA	0.027867	0.993591	none
Total Ammonia Nitrogen	Tobit	1978	9	NA	104	NA	-5.622999	0.039355	**down**
Total Phosphorus	Seaken	1978	9	12	102	0.002583	2.690973	0.337096	none
Total Dissolved Phosphorus	Tobit	1978	9	NA	101	NA	6.727220	0.039326	**up**

Appendix XIX Results of trend analyses on flow-adjusted data for routine variables at Highway **36** (downstream of Lethbridge), **1966-1987**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Conductivity	Seaken	1978	9	12	102	-9.277988	-2.378971	0.035647	**down**
Alkalinity	Seaken	1978	9	12	102	-0.023919	-0.017587	0.936606	none
Dissolved Oxygen	Seaken	1978	9	12	102	-0.034147	-0.319127	0.675882	none
Non-filterable Residue	Tobit	1978	9	NA	103	NA	5.438670	0.232093	none
Dissolved Calcium	Seaken	1978	9	12	103	-0.541241	-1.346371	0.135972	none
Dissolved Magnesium	Seaken	1978	9	12	103	-0.458158	-2.810783	0.017760	**down**
Dissolved Fluoride	Seaken	1977	10	12	99	0.001304	1.086940	0.117240	none
Sulphate	Seaken	1978	9	12	103	-1.066383	-2.012043	0.018542	**down**
Total Organic Carbon	Seaken	1978	9	12	99	-0.064070	-2.201715	0.361338	none
Particulate Organic Carbon	Tobit	1978	9	NA	97	NA	0.998251	0.727883	none
Dissolved Organic Carbon	Seaken	1978	9	12	102	-0.049231	-2.289802	0.242653	none
Particulate Nitrogen	Tobit	1978	9	NA	100	NA	-0.354420	0.921525	none
Total Ammonia Nitrogen	Tobit	1978	9	NA	104	NA	-5.038686	0.067072	none
Total Phosphorus	Seaken	1978	9	12	102	0.007144	7.441802	0.219065	none
Total Dissolved Phosphorus	Tobit	1978	9	NA	101	NA	6.528371	0.047796	**up**

Appendix XX Results of trend analyses for routine data at Highway **36** (downstream of Lethbridge), **1987-2005**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Conductivity	Seaken	1987	18	12	209	-0.714286	-0.195695	0.587311	none
Alkalinity	Seaken	1987	18	12	209	-0.042858	-0.029155	0.847360	none
Hardness	Seaken	1987	18	12	209	-0.350666	-0.216461	0.408279	none
Dissolved Oxygen	Seaken	1987	18	12	208	0.000000	0.000000	0.987095	none
Non-filterable Residue	Tobit	1987	18	NA	213	NA	-7.776552	0.001130	**down**
Dissolved Calcium	Seaken	1987	18	12	209	-0.084615	-0.211538	0.521939	none
Dissolved Magnesium	Seaken	1987	18	12	209	-0.070000	-0.454545	0.297895	none
Bicarbonate	Seaken	1987	18	12	209	-0.084616	-0.048077	0.874032	none
Carbonate	Tobit	1987	18	NA	213	NA	6.658765	0.105279	none
Fluoride	Seaken	1987	18	12	208	-0.001000	-0.714286	0.119444	none
Sulphate	Seaken	1987	18	12	208	0.066667	0.143062	0.889964	none
Total Organic Carbon	Seaken	1987	18	12	206	-0.033333	-1.234567	0.087521	none
Particulate Organic Carbon	Tobit	1987	12	NA	136	NA	5.862915	0.085100	none
Dissolved Organic Carbon	Seaken	1987	18	12	208	-0.033333	-1.307191	0.060990	none
Particulate Nitrogen	Tobit	1987	18	NA	136	NA	-1.738469	0.576425	none
Total Ammonia Nitrogne	Tobit	1987	18	NA	211	NA	-4.771608	0.008726	**down**
Total Kjeldahl Nitrogen	Seaken	1987	18	12	204	-0.010000	-3.333333	0.002554	**down**
Total Phosphorus	Seaken	1987	18	12	209	-0.003583	-8.958333	0.004014	**down**
Total Dissolved Phosphorus	Tobit	1987	18	NA	214	NA	-16.511570	0.000000	**down**
Chlorophyll *a*	Seaken	1987	18	12	204	-0.000030	-1.449068	0.108036	none
Total Coliforms	Seaken	1987	18	1	10	-2.882353	-5.288721	0.529599	none
E. coli	Tobit	1994	11	NA	125	NA	-17.128610	0.000927	**down**

Appendix XXI Results of trend analyses on flow-adjusted data for routine variables at Highway **36** (downstream of Lethbridge), **1987-2005**. Pre- and post-1987 trend tests were only performed on variables demonstrating a significant step trend in 1987. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Conductivity	Seaken	1987	18	12	209	-0.884613	-0.242360	0.578567	none
Alkalinity	Seaken	1987	18	12	209	-0.280519	-0.190829	0.555898	none
Hardness	Seaken	1987	18	12	209	-0.463882	-0.286347	0.392746	none
Dissolved Oxygen	Seaken	1987	18	12	208	-0.020212	-0.180063	0.346680	none
Non-filterable Residue	Tobit	1987	18	NA	213	NA	-8.103465	0.000014	**down**
Dissolved Calcium	Seaken	1987	18	12	209	-0.124003	-0.310007	0.431601	none
Dissolved Magnesium	Seaken	1987	18	12	209	-0.048171	-0.312800	0.395890	none
Bicarbonate	Tobit	1987	18	NA	214	NA	0.118822	0.457254	none
Carbonate	Tobit	1987	18	NA	213	NA	6.923933	0.083518	none
Fluoride	Seaken	1987	18	12	208	-0.001056	-0.754199	0.216397	none
Sulphate	Seaken	1987	18	12	208	0.148323	0.318290	0.563826	none
Total Organic Carbon	Seaken	1987	18	12	206	-0.024576	-0.910218	0.176302	none
Particulate Organic Carbon	Tobit	1987	12	NA	136	NA	4.337289	0.201983	none
Dissolved Organic Carbon	Seaken	1987	18	12	208	-0.033663	-1.320122	0.063105	none
Particulate Nitrogen	Tobit	1987	18	NA	136	NA	-4.462828	0.157532	none
Total Ammonia Nitrogne	Tobit	1987	18	NA	211	NA	-4.896216	0.005718	**down**
Total Kjeldahl Nitrogen	Seaken	1987	18	12	204	-0.007352	-2.450650	0.022895	**down**
Total Phosphorus	Seaken	1987	18	12	209	-0.003084	-7.709029	0.011767	**down**
Total Dissolved Phosphorus	Tobit	1987	18	NA	214	NA	-16.619440	0.000000	**down**
Chlorophyll *a*	Seaken	1987	18	12	204	-0.000029	-1.406512	0.139186	none
Total Coliforms	Seaken	1987	18	1	10	-5.219946	-9.577883	0.474275	none
E. coli	Tobit	1994	11	NA	125	NA	-15.768995	0.000659	**down**

Appendix XXII Step trend analysis of metals data collected at the Highway **36** (downstream of Lethbridge) site since 1966. Significance of the step is depicted at 90% (*), 95% (**), and 99% (***). NS = Not Significant, ID = Insufficient Data.

Variable	Est. Diff. Btwn Time Periods	Median 1	Median 2	Sig.
Dissolved Aluminum	ID	-	-	-
Dissolved Arsenic	-0.0001	0.0005	0.0005	***
Dissolved Boron	ID	-	-	-
Dissolved Iron	-0.0300	0.0400	0.0100	***
Dissolved Manganese	-0.0008	0.0100	0.0040	***
Dissolved Selenium	ID	-	-	-

Appendix XXIII Results of trend analyses for metals data at Highway **36** (downstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data), ID = Insufficient Data..

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	20	NA	225	NA	-1.9885E+00	1.3540E-03	**down**
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-
Dissolved Selenium	ID	-	-	-	-	-	-	-	-

Appendix XXIV Results of trend analyses on flow-adjusted data for metals at Highway **36** (downstream of Lethbridge), **1966-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data), ID = Insufficient Data.

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	20	NA	225	NA	-1.1656E+00	6.2671E-02	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-
Dissolved Selenium	ID	-	-	-	-	-	-	-	-

Appendix XXV Results of trend analyses for metals data at Highway **36** (downstream of Lethbridge), **1966-1987**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	8	NA	88	NA	3.6976E+00	1.6769E-01	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-

Appendix XXVI Results of trend analyses on flow-adjusted data for metals at Highway **36** (downstream of Lethbridge), **1966-1987**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	ID	-	-	-	-	-	-	-	-
Dissolved Arsenic	Tobit	1980	8	NA	89	NA	2.2516E+00	4.8438E-01	none
Dissolved Boron	ID	-	-	-	-	-	-	-	-
Dissolved Iron	ID	-	-	-	-	-	-	-	-
Dissolved Manganese	ID	-	-	-	-	-	-	-	-
Dissolved Selenium	ID	-	-	-	-	-	-	-	-

Appendix XXVII Results of trend analyses for metals data at Highway **36** (downstream of Lethbridge), **1987-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	Tobit	1987	13	NA	137	NA	3.7735E+00	3.9273E-01	none
Dissolved Arsenic	Tobit	1987	13	NA	147	NA	-5.3084E+00	4.3825E-06	**down**
Dissolved Boron	Tobit	1987	13	NA	147	NA	-5.9779E+00	1.0247E-02	**down**
Dissolved Iron	Tobit	1987	19	NA	213	NA	-1.7904E-01	9.2242E-01	none
Dissolved Manganese	Tobit	1987	19	NA	216	NA	-8.0439E+00	5.6651E-07	**down**
Dissolved Selenium	Tobit	1987	13	NA	145	NA	-5.7315E+00	2.4883E-04	**down**

Appendix XXVIII Results of trend analyses on flow-adjusted data for metals at Highway **36** (downstream of Lethbridge), **1987-2005**. Seaken = Seasonal Kendall Analysis, Tobit = Tobit regression (for censored data).

Variable	Trend Test	Start Year	# Years	# Seasons	N	Trend	Trend Percent	p-value	Sig.
Dissolved Aluminum	Tobit	1987	13	NA	137	NA	4.1201E+00	3.7221E-01	none
Dissolved Arsenic	Tobit	1987	13	NA	147	NA	-4.8687E+00	4.7975E-05	**down**
Dissolved Boron	Tobit	1987	13	NA	147	NA	-5.5012E+00	2.3525E-02	**down**
Dissolved Iron	Tobit	1987	19	NA	213	NA	-1.2745E-01	9.4429E-01	none
Dissolved Manganese	Tobit	1987	19	NA	216	NA	-7.7510E+00	9.3519E-07	**down**
Dissolved Selenium	Tobit	1987	13	NA	145	NA	-4.7386E+00	3.3119E-03	**down**