CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF ELK RIVER AT HIGHWAY 93 (1968 – 2000)

Water Quality Section
Water Protection Branch
Ministry of Water, Land and Air Protection

Aquatic Sciences Section
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Environment Canada
Pacific and Yukon Region

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Environment Canada **Environnement Canada**

BRITISH COLUMBIA Ministry of Environment

Executive Summary

The Elk River watershed is located in the southeast corner of British Columbia, and drains 4450 km^2 of the Rocky Mountains to the Kootenay River/Lake Koocanusa about 20 km upstream from the border with the United States. The water quality sampling station on the Elk River is located just upstream from the confluence with the Kootenay River/Lake Koocanusa at Highway 93. This assessment is based on up to 33 years of water quality data during 1968-2000. The main human activities in the Elk River watershed are open pit coal mining, forestry, outdoor tourism, and residential and commercial development. The water quality trends identified below have not yet been confirmed by statistical analysis.

Conclusions

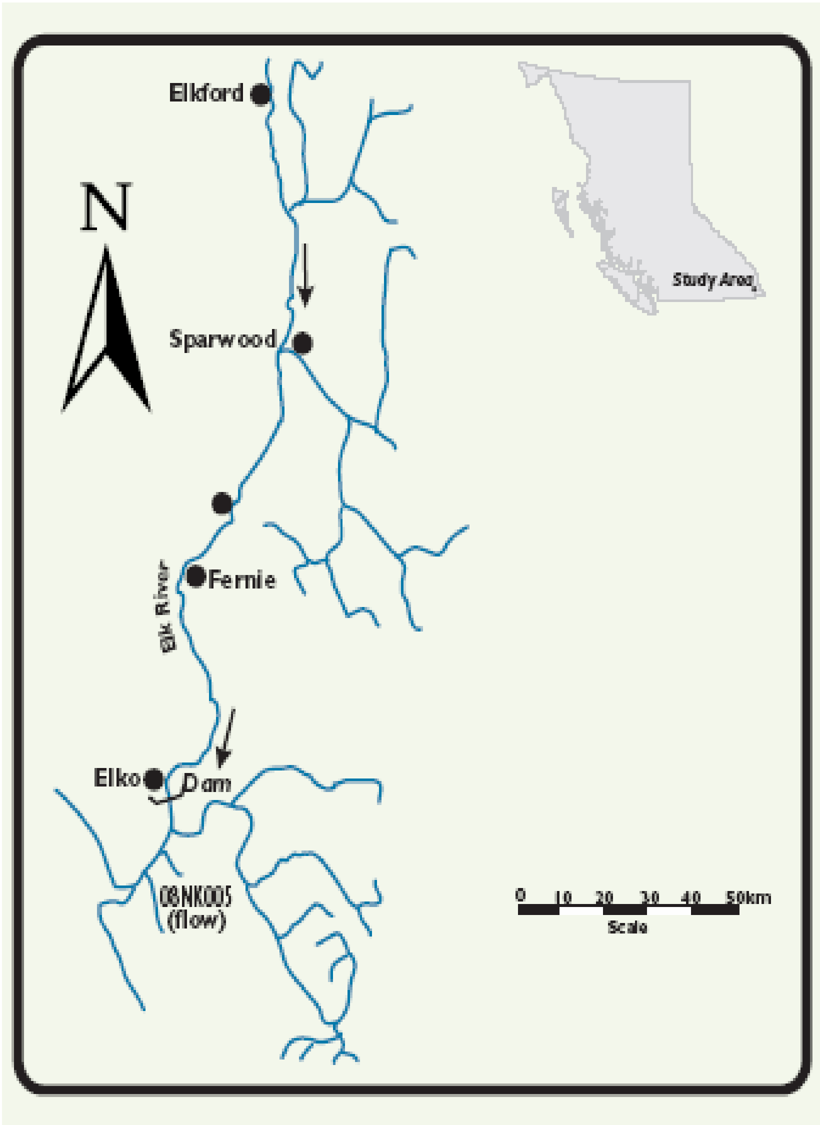
- There was an increasing trend in selenium, although the rate of increase slowed during 1995-2000. The cause of the increasing trend appears to have been the increased disturbance of selenium-bearing strata during surface coal mining. The increasing trend caused guidelines for aquatic life and wildlife to be exceeded often, but no harmful effects have been detected to date.
- There was an increasing trend in nitrogen, although the rate of increase slowed during 1995-2000. The cause of the increasing trend was the increased use of nitrogen-based explosives during coal mining. The increasing concentrations removed any nitrogen limitation to undesirable algal growth, but algal growth was in any case limited by the availability of phosphorus.
- There were increasing trends in calcium, chloride, magnesium, hardness and conductivity. The cause of the increasing trends was probably due to increased mineral weathering due to coal mining. The chloride trend might also have been due to the use of salt for highway de-icing. The increasing trend has caused the hardness of the water to exceed the poor (but tolerable) aesthetic guideline for drinking water during the winter. The Elk River is not currently used for drinking water.
- There was a decreasing trend in dissolved ortho Phosphorus. It is not clear whether the trend is real due to improved municipal sewage and coal mine effluent management, or artificial due to the use of more sensitive laboratory methods and better quality control. The decreasing trend would make the river less susceptible to undesirable algal growth.
- Fecal coliforms declined between 1975-76 and 2000, probably due to improved management of municipal sewage. In 2000, the water was suitable for swimming, livestock water, irrigation and drinking water after partial treatment (e.g., filtration) and disinfection.
- pH did not change over time, but occasionally exceeded the upper aesthetic limit for drinking water. The Elk River is not currently used for drinking water.
- Suspended sediment, as measured by non-filterable residue and turbidity, did not change over time. Annual peak levels occurred during the spring snowmelt freshet and caused several water quality indicators (aluminum, arsenic, cadmium, chromium, cobalt, colour, copper, iron, lead, manganese, phosphorus and zinc) to exceed water

quality guidelines. These exceedances are of little significance because the substances are bound to suspended sediment, and thus not readily bio-available. Additionally, they would be removed by water treatment (e.g., filtration) needed before using the Elk River as a drinking water source.

Recommendations

- Continue monitoring at this station for the present suite of water quality indicators, because the Elk River discharges into transboundary waters (Koocanusa Lake) and has exhibited trends and levels that are potentially harmful.
- Initiate monitoring of dissolved aluminum, dissolved or extractable cadmium with a detection limit of at least 0.000005 mg/L, and dissolved or extractable chromium, or preferably hexavalent and trivalent chromium, to establish the levels of these substances relative to water quality guidelines.

Figure 1 Map of Elk River Basin



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1. Introduction

The Elk River at Highway 93 water quality monitoring station is located south of Elko, B.C., just before the river enters Lake Koocanusa (Figure 1). This site, also known as Phillips Canyon, is in the hotter, southern part of the Elk River basin. The drainage area of the river is 4450 km^2 and its major tributaries are the Fording River in the north, Michel Creek in the east, and the Wigwam River in the south. There is widespread coal mining in the upper Elk basin. The output of coal from the Elk Valley nearly doubled during the 1980's. Forestry and outdoor tourism are other major economic contributors. The primary contaminants discharged in the basin are nitrogen (explosives residuals from mining), non-filterable residues and turbidity, and selenium from mining seleniferous geologic formations.

The Elk River is the mostly heavily fished river in the Kootenays. It has some of the largest populations of westslope cutthroat trout, bull trout, and whitefish in the Kootenay Region. The Wigwam River has the largest spawning population of adfluvial bull trout in B.C. (Adfluvial bull trout spend their first 1-2 years in the river, the next 2-4 years in Lake Koocanusa, and then return to the river to spawn.) The Elk basin fishery is thus regionally and provincially significant, and has been given a "high" rating by the regional Fisheries Branch. There is domestic water use from 36 streams and lakes in the basin, with four designated community watersheds and 112 licences. Water licences for the Elk River mainstem include domestic (1), irrigation (3), industrial (6), and power generation (2). Municipal drinking water within the watershed is taken from tributaries of the Elk River (Ministry of Environment, Lands and Parks and Environment Canada, 1997). The power generation licences are for B.C. Hydro’s Elko Dam above the Wigwam River, which is a barrier to fish movement between the upper Elk River and Koocanusa Lake (McDonald, L.E. 2001).

Environment Canada monitored flow on the Elk River at Phillips Bridge, about 5 km upstream from Highway 93, during 1924-96. The flow data are stored on the Water Survey of Canada database under station number BC08NK005. Twenty-nine years (1968-96) of flow data are plotted in Figure 2. The Province began collecting water quality data about monthly at Phillips Bridge in 1968 and the data are stored on the Environmental Monitoring System (EMS) under site number 0200016. Environment Canada began monitoring water quality at Highway 93 in 1984 and since 1986 Canada and B.C have jointly operated the station. Water quality data have been collected every two weeks since 1986 and are stored on the ENVIRODAT database under station number BC08NK0003 and on EMS under site number 0200016. Up to thirty-three years (1968-2000) of water quality data were used in this report. The data for the current suite of water quality indicators are plotted in Figures 3 to 38. These are the water quality indicators that were recommended by a previous assessment (Ministry of Environment, Lands and Parks and Environment Canada, 1997) and that have been monitored up to the present. There are also many other upstream stations on the Elk River and some of its main tributaries that have been monitored by the Province.

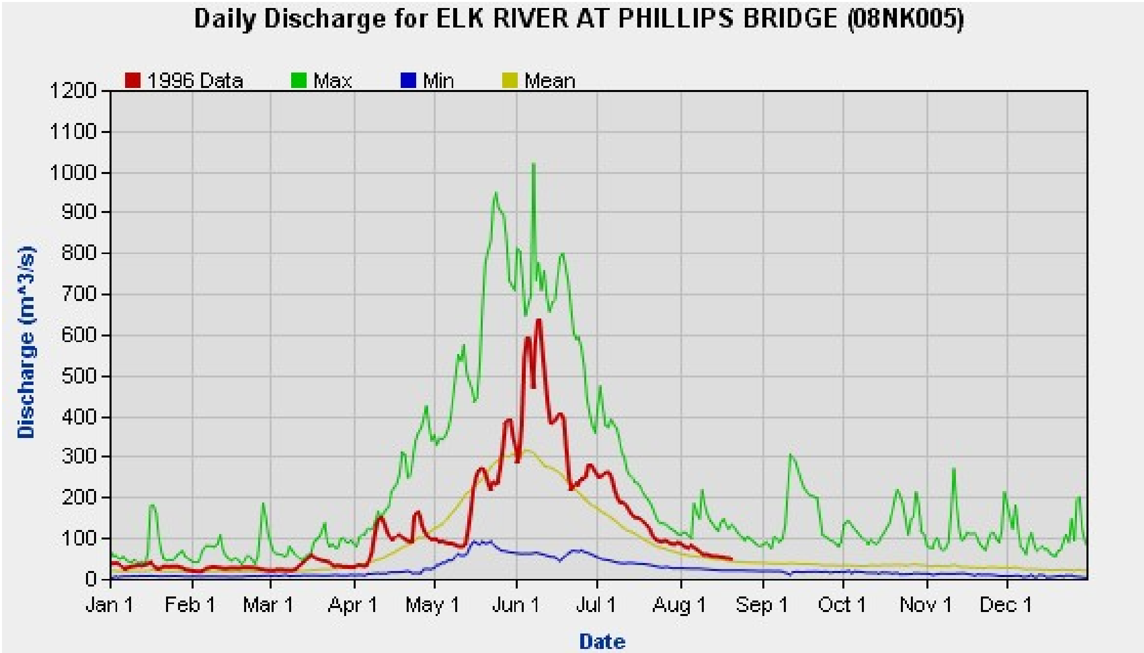

Figure 2 Flow at the Elk River at Phillips Bridge, 1924-1996

2. Water Quality Assessment

The status and trends of water quality were assessed by plotting the water quality indicators over time and comparing the values to the Province's approved and working water quality guidelines (Ministry of Environment, Lands and Parks, 2001a & 2001b). Any levels or changes of the indicators over time that may have been harmful to sensitive water uses, such as drinking water, aquatic life, wildlife, recreation, irrigation and livestock, are described below in alphabetical order. Water quality indicators were not discussed if they easily met all water quality guidelines and showed no harmful trends. These include: total barium, total beryllium, dissolved organic carbon, total molybdenum, total nickel, sodium, total strontium, and total vanadium.

Aluminum, total (Figure 3) was monitored during 1982-2000 and had only two values (9.46 and 9.78 mg/L) above the 5 mg/L guideline for wildlife, livestock and irrigation. These peak values occurred during spring freshet in 1996 and 1999, when turbidity levels were very high (240 and 560 NTU). Aluminum is the third most abundant element in the Earth's crust and the large amount of suspended sediment present at these times accounts for the high total aluminum levels. There were no apparent changes over time. Dissolved aluminum should be measured for comparison to the drinking water, aquatic life, and recreation guidelines.

Arsenic, total was monitored during 1984-2000 and **extractable arsenic** was monitored during early 1984, and the data have been plotted in Figure 4. There was no apparent change over 1984-2000.Only one of 367 values exceeded the 0.005 mg/L guideline for aquatic life. The maximum total arsenic value of 0.012 mg/L occurred during spring freshet in 1996, when the turbidity was very high (240 NTU) and accounts for the elevated arsenic. **Dissolved arsenic** was also monitored during 1998-2000 and the values were similar to the total arsenic values. The maximum dissolved arsenic value of 0.0059 mg/L on August 15, 2000 appears to be an error, since total arsenic was 0.0001 mg/L and turbidity was low (0.92 NTU).

Cadmium, total (Figure 7) was monitored during 1982-2000, but the data were excluded prior to 1991, owing to high detection limits and contamination from preservative vials in 1986-90. The 1991-2000 detection limit was 0.0001 mg/L, which is above the aquatic life guidelines (0.00003-0.00006 mg/L). Nevertheless, there were 30 values above the detection limit during 1991-2000, all occurring in freshet due to elevated turbidity. The cadmium was probably particulate-bound and thus unlikely to have been bio-available. The maximum value of 0.003 mg/L was still below the drinking water guideline of 0.005 mg/L. There were no apparent changes over time. Dissolved or extractable cadmium with a detection limit of at least 0.000005 mg/L should be measured to permit comparison of the data to aquatic life guidelines.

Calcium (Figure 8) was monitored during 1968-2000. Dissolved, total and extractable calcium data were combined in Figure 5, since there was little difference in paired values. There has been an increasing trend in calcium values over time. Calcium and magnesium are the two main components of water hardness, and increasing levels make the water less aesthetically desirable for drinking water, as discussed under hardness below. The increasing calcium trend is similar to the increasing magnesium, nitrogen and selenium trends, and was also probably due to increased coal mining in the Elk basin. Mining increases the natural rate of weathering of minerals such as calcium by exposing large amounts of fine rock to weathering processes.

Chloride, dissolved (Figure 10) was monitored during 1972-2000. There was an increasing trend in chloride levels over this time, but the levels were too far below guidelines to be of environmental significance. Increased weathering due to coal mining and the use of road salt for highway de-icing are the probable sources of the increased chloride.

Chromium, total (Figure 11) was monitored during 1982-2000, but the data prior to 1991 were excluded due to high detection limits and contamination from preservative vials in 1986-90. During 1991-2000, three values (0.01-0.014 mg/L) exceeded the 0.009 mg/L aquatic life guideline for trivalent chromium. Two of the peaks occurred during freshet when turbidity was high, and one happened in winter when turbidity was very low. The aquatic life guideline of 0.001 mg/L for hexavalent chromium was often exceeded, mainly during freshet when turbidity was high. There was no apparent change over time. Measuring dissolved or extractable chromium and preferably measuring the trivalent and hexavalent forms of chromium are needed to evaluate the significance of the elevated total chromium values to aquatic life.

Cobalt, total (Figure 12) was monitored during 1991-2000 and 18 values exceeded the 0.0009 mg/L aquatic life guideline. These peaks occurred during spring freshet due to elevated turbidity and thus the cobalt was probably not bioavailable. There were no apparent changes over time.

Coliforms, fecal (Figure 13) were monitored during 1975-76 and 2000. The levels in 2000 (maximum of 30/100 mL) were much lower than in 1975-76 (maximum of 280/100 mL), probably due to improved sewage treatment. The 2000 levels suggest that the water met the guidelines for swimming, livestock and irrigation (200/100 mL) and raw drinking water that receives partial treatment and disinfection (10-100/100 mL).

Colour, true (Figure 14) was monitored during 1972-77 and 1997-2000. The aesthetic guideline for drinking water (15 true colour units) was exceeded four times, all during spring freshet. There was no apparent change over time.

Conductivity, specific (Figure 15) was monitored during 1968-2000. There was an apparent increasing trend over time, although the maximum (416 microSiemans/cm) was well below the lowest guidelines for drinking water and irrigation (700 microSiemans/cm). Conductivity is a measure of the dissolved ions in water and thus the increasing trend is a reflection of the increasing levels of calcium, chloride and magnesium ions due to coal mining and road salting.

Copper, total (Figure 16) was monitored during 1977-2000, but data prior to 1991 were excluded due to high detection limits and contamination from preservative vials in 1986-90. During 1991-2000, seven values exceeded the 0.004-0.006 mg/L average guideline for aquatic life. All of these peaks occurred during spring freshet when turbidity was high, and thus the copper was likely particulate-bound and not bio-available. There was no apparent change over time.

Fluoride (Figure 17) was monitored during 1972-2000. Two values exceeded the 0.3 mg/L aquatic life guideline for hardness >50 mg/L, with a maximum of 0.8 mg/L, which was well below the 1.5 mg/L drinking water guideline. There was no apparent change over time.

Hardness (Figure 18) was monitored during 1972-2000 and exhibited an increasing trend over time. Increasing trends in calcium and magnesium caused this trend, since they are the main components of water hardness. The environmental significance of this trend is that drinking water becomes less desirable aesthetically as hardness increases. During 1972-88, hardness did not exceed 200 mg/L, which is the poor, but tolerable level. During 1989-2000, hardness often exceeded 200 mg/L during winter low flows. The Elk River is not currently used for drinking water.

Iron, total (Figure 19) was monitored during 1974-2000. Twelve values exceeded the 5 mg/L guideline for irrigation, with a maximum of 21 mg/L. These peak values occurred during spring freshet when turbidity was high. Iron is the fourth most abundant element in the Earth's crust and the large amount of suspended sediment present during freshet accounts for the high total iron levels. The 0.3 mg/L guideline for drinking water and aquatic life was exceeded on numerous occasions whenever turbidity was elevated due to the particulate-bound iron in the suspended sediment. Particulate-bound iron is unlikely to be bioavailable and would be removed by the water treatment needed to remove turbidity prior to use as drinking water. There was no apparent change over time.

Lead, total (Figure 20) was monitored during 1978-2000, but the values prior to 1991 were excluded due to high detection limits and contamination from preservative vials during 1986-90. There was no apparent change during 1991-2000. Two values exceeded the drinking water guideline of 0.01 mg/L and three values exceeded the average aquatic life guideline, which varied from 0.007 to 0.012 mg/L, depending on water hardness. These maximum values ranged from 0.0137 to 0.0155 mg/L. Two of these values occurred during spring freshet when non-filterable residue and turbidity (240-560 NTU) were high. In these cases, the lead was probably particulate-bound, and would not be bio-available. The particulate matter would be removed by the treatment needed to remove turbidity from the water prior to its use as drinking water. One of the three values occurred in the spring before freshet when turbidity was low (0.92 NTU), suggesting that the lead may have been bio-available, but the frequency of this occurrence (0.4 % of values) was too low to be of concern.

Magnesium (Figure 21) was monitored during 1968-2000. Dissolved, total and extractable magnesium data were combined in Figure 21, since there was little difference in paired values. There has been an increasing trend in magnesium values over time. Calcium and magnesium are the two main components of water hardness, and increasing levels make the water less aesthetically desirable for drinking water, as discussed under hardness above. The increasing magnesium trend is similar to the increasing calcium, nitrogen and selenium trends, and is also probably due to increased coal mining in the Elk basin. Mining increases the natural rate of weathering of minerals such as magnesium by exposing large amounts of fine rock to weathering processes.

Manganese, total (Figure 22) was monitored during 1978-2000, but the data prior to 1986 were excluded since many values were produced using methods with high detection limits (i.e., 0.01 and 0.02 mg/L). During 1986-2000, 7.6 % of values exceeded the aesthetic guideline for drinking water of 0.05 mg/L when turbidity was elevated, mainly during spring freshet. The manganese was probably associated with particulate matter and would be removed by the water treatment needed prior to use as drinking water. The maximum of 0.87 mg/L was below the average aquatic life guideline of 1.0 mg/L at a hardness of 100 mg/L. There was no apparent change over time.

Nitrogen, nitrate + nitrite (Figure 25) was monitored during 1975-2000 and **nitrogen, total dissolved** (Figure 26) was monitored during 1984-2000. Both figures show increasing trends, although the upward slope of the trends appears to have flattened since the mid-1990's. The source of the increased nitrogen is from the use of nitrogen-based explosives at the coal mines in the Elk basin. Losses of 0.2 to 6% of the nitrogen in the explosives used at the coal mines has been documented (Ferguson and Leask, 1988). The nitrogen levels were well below guidelines for drinking water and aquatic life. The increasing trend has resulted in an ample supply of nitrogen for algal growth at all times of the year, but algal growth in the Elk River is limited by the availability of phosphorus, which may have declined over time (see phosphorus, dissolved ortho).

pH (Figure 27) was monitored during 1968-2000 and ranged from 6.5 to 9.2 pH units. Two values exceeded the aquatic life guideline of 9 units and 46 values exceeded the aesthetic drinking water guideline of 8.5 units. The majority (83%) of the values >8.5 were field measurements. In 35 pairs of field and laboratory pH measurements where at least one of the pair was >8.5, the field value was the highest in 32 pairs. Field values are expected to be higher than laboratory values because of lower temperatures and lower carbon dioxide concentrations during measurement. Because of pH instability due to CO_2 diffusion enroute to the laboratory, field measurement of pH is desirable, but high quality field pH measurements are difficult to obtain due to increased operator error and poor equipment performance (McKean and Huggins, 1989). There were no apparent changes over time.

Phosphorus, dissolved ortho (Figure 28) was monitored during 1968-2000. There was an apparent downward trend over this time, due in part to the decline in the detection limit from 0.003 to 0.001 mg/L in 1996. However, there was still an apparent downward trend from 1968-95. The cause of the trend may have been improved sewage treatment and disposal and improved coal mine effluent control. On the other hand, the trend may have been caused by the use of more sensitive measurement methods and improved quality control over time. In addition, most of the data was below the limit of quantitation (e.g., 3-20 times the detection limit), and thus must be used with caution (Clark and Whitfield 1994).

Phosphorus, total (Figure 29) was monitored during 1971-2000. Unlike dissolved ortho Phosphorus, there was no apparent change over time. Total phosphorus levels were much higher than dissolved ortho Phosphorus levels due to the phosphorus associated with suspended sediment. Total phosphorus was highly correlated (R^2 = 0.96) with non-filterable residue (a measure of suspended sediment), and peak total phosphorus levels occurred when non-filterable residue was high. Total phosphorus is not a sensitive indicator of trends in bioavailable phosphorus, but it should continue to be monitored to track loadings to Koocanusa Lake.

Residue, non-filterable (Figure 30) is also known as suspended solids or sediment, and was monitored during 1982-2000. The peak values (e.g., >200 mg/L) all occurred in May or June during the spring snowmelt freshet, when the flows were the highest of the year and had their maximum erosive force and carrying capacity for sediment. There was no apparent change over time.

Selenium, total (Figure 31) was monitored during 1984-2000. **Extractable selenium** was monitored for short periods in 1984 and 1994 instead of total selenium, and these data were included in Figure 31 to fill in gaps in the total selenium record. There was an increasing trend in selenium over 1984-2000, although the slope of the upward trend has flattened during 1995-2000 in comparison to 1986-94. Nevertheless, the maximum value of 0.0033 mg/L was recorded in May 1999. The cause of the increasing trend appears to have been the large-scale exposure of selenium-bearing strata to weathering and erosion during surface coal mining (McDonald and Strosher 1998). **Total and dissolved selenium** were measured during 1998-2000, and the paired data show that most of the total selenium was in the dissolved form.

The recently revised aquatic life and wildlife guideline (0.002 mg/L) was exceeded by 24% of the values, but the values were well below guidelines for drinking water, livestock and irrigation. Although the aquatic life and wildlife guideline was often exceeded, no toxic effects have been reported. Studies to date indicate that selenium has been bioaccumulating in fish, but have found no reproductive failures, which are symptomatic of selenium toxicosis mining (McDonald and Strosher 1998, Kennedy *et al.* 2000). Further studies on bioaccumulation in food-chain organisms, fish and aquatic birds in various aquatic habitats in the vicinity of the coal mines are underway (McDonald, L.E. 2001).

Silver, total (Figure 32) was monitored during 1996-2000. All 115 values were below the aquatic life guidelines of 0.0015 mg/L average and 0.003 mg/L maximum (at hardness >100 mg/L), with the exception of one value of 0.0431 mg/L on April 27, 1998. This value is two orders of magnitude above all the other values and may well be an error. Total silver values were not correlated with non-filterable residue or turbidity values, and thus the modest levels (33 mg/L and 18 NTU) of these indicators on this day do not provide an explanation for the high total silver value.

Temperature, water (Figure 35) was monitored during 1968-2000. Water temperatures met the guideline for aquatic life (maximum of 19 degrees Celsius), with the exception of eight values (1.5% of values) of 20 to 30 degrees in the summers of 1986, 1987 and 1988. The two highest values of 29 and 30 degrees appear to be outliers, because although air temperatures were high at the time (32 and 40 degrees), the water temperatures 8 to 14 days before and after were in the 15.5 to 21 degree range. This magnitude of temperature change over such short periods of time is unlikely for a river of this size. In addition, the next highest water temperature is only 21 degrees and thus there is a lack of continuity in the range of water temperatures, bolstering the conclusion that the highest values are spurious. Water temperatures exceeded 15 degrees during about one summer in three (5.5% of all values). Fifteen degrees is the aesthetic guideline for drinking water, but the lower limit for swimming. There was no apparent change over time.

Turbidity (Figure 36) was monitored during 1968-2000 and is an optical measure of the amount of suspended sediment in water. The peak values (e.g., >50 NTU) all occurred during the spring snowmelt freshet in late April to early July. The recreation guideline of 50 NTU was exceeded almost every year during the freshet, and the drinking water guidelines of 1-5 NTU were often exceeded, indicating that water treatment to remove turbidity (e.g., filtration) would be needed before using the river for drinking water. There was no apparent change over time.

Zinc, total (Figure 38) was monitored during 1978-2000, but the data prior to 1991 were excluded due to high detection limits (e.g., 0.005 mg/L) and contamination from preservative vials during 1986-90. No change over time is apparent for 1991-2000, when a detection limit of 0.0002 mg/L was used. Five or 2.1% of values (0.023-0.096 mg/L) exceeded the average aquatic life guidelines, which are hardness-dependent, including two values (0.085 and 0.096 mg/L) that also exceeded the maximum aquatic life guidelines. However, all of these exceedances occurred during spring freshet when turbidity was high (140-560 NTU), suggesting that the zinc was particulate-bound and not bio-available.

References

Clark, M.J.R. and P.H. Whitfield. 1994. Conflicting Perspectives About Detection Limits and About Censoring of Environmental Data. Water Resources Bulletin 30(6):1063-1079.

Ferguson, K.D. and S.M. Leask. 1988. The Export of Nutrients From Surface Coal Mines. Regional Program Report 87-12. Environment Canada, West Vancouver, B.C.

Kennedy, C.J., L.E. McDonald, R. Loveridge, and M.M. Strosher. 2000. The Effect of Bioaccumulated Selenium on Mortalities and Deformities in the Eggs, Larvae and Fry of a Wild Population of Cutthroat Trout (*Oncorhyncus clarki lewisi*). Arch. Env. Cont. Toxicol. 39: 46-52.

McDonald, L.E. 2001. Personal communication. Pollution Prevention, Ministry of Water, Land and Air Protection, Cranbrook, B.C.

McDonald, L.E. and M.M. Strosher. 1998. Selenium Mobilization From Surface Coal Mining in the Elk River Basin, British Columbia: A Survey of Water, Sediment and Biota. Ministry of Environment, Lands and Parks, Pollution Prevention, Cranbrook, B.C. 56 p.

McKean, C.J.P. and B.W. Huggins. 1989. pH Determination and Measurement. Ministry of Environment, Water Management Branch, B.C.

Ministry of Environment, Lands and Parks. 2001a. British Columbia Water Quality Guidelines (Criteria). Updated January 17, 2001.

Ministry of Environment, Lands and Parks. 2001b. A Compendium of Working Water Quality Guidelines for British Columbia. Updated April 24, 2001.

Ministry of Environment, Lands and Parks and Environment Canada. 1997. State of Water Quality of Elk River at Highway 93 (Phillips Bridge) 1984-1995. Canada – British Columbia Water Quality Monitoring Agreement.

Ministry of Environment, Lands and Parks and Environment Canada. 2000. Water Quality Trends in Selected British Columbia Waterbodies.

Figure 3 Elk River at Highway 93 - Total Aluminum

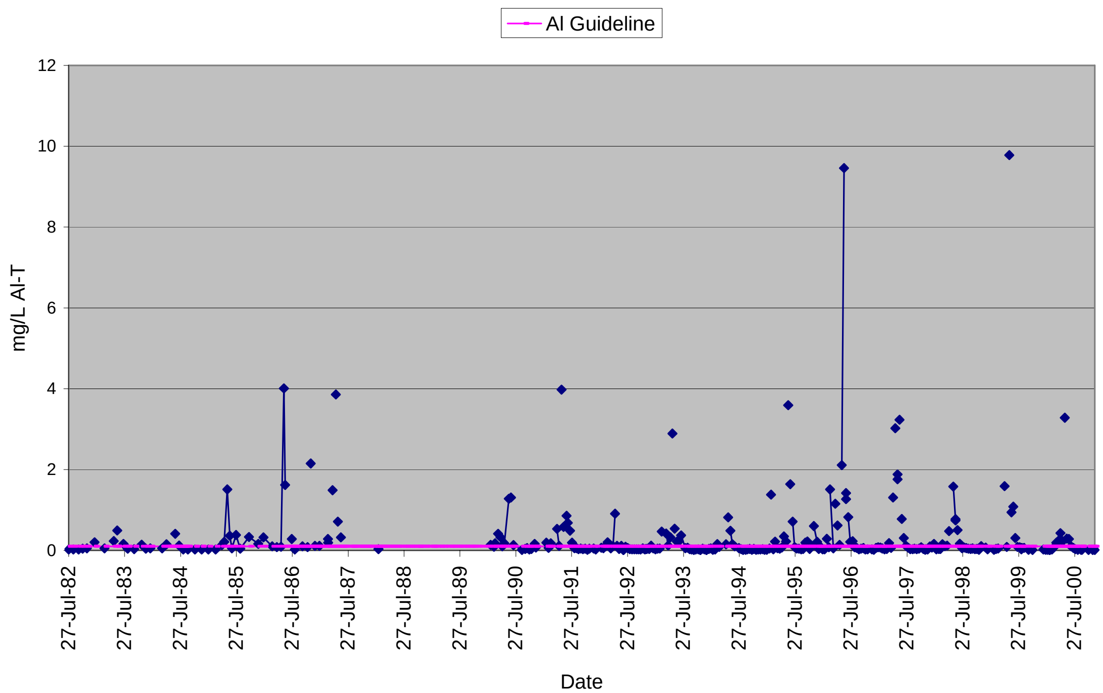

Figure 4 Elk River at Highway 93 -Total and Dissolved

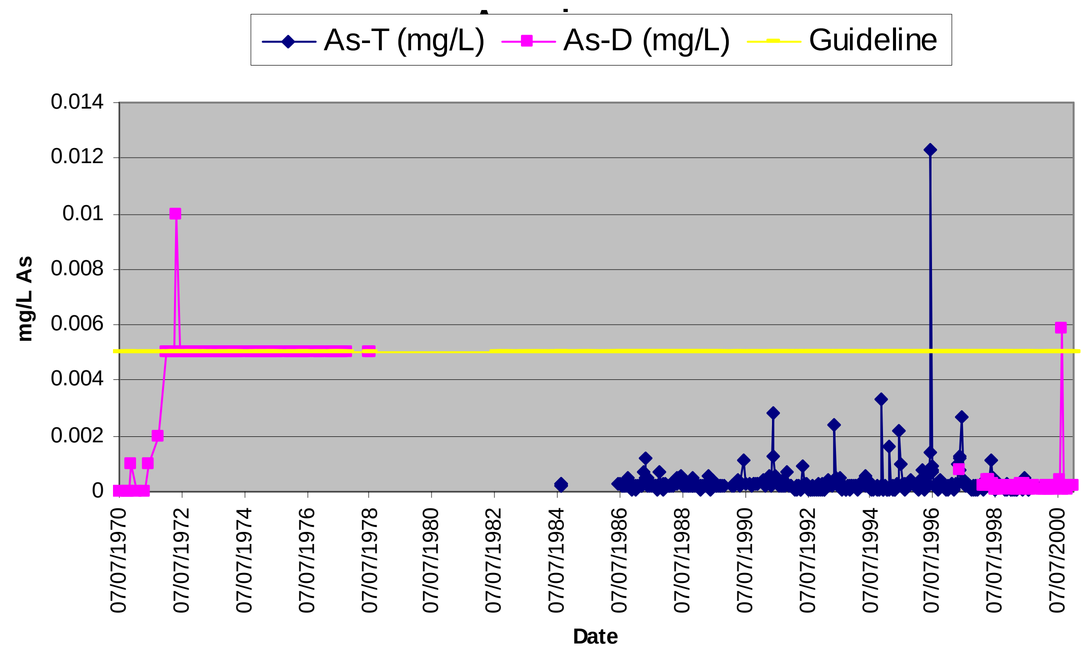

Figure 5 Elk River at Highway 93 - Total Barium

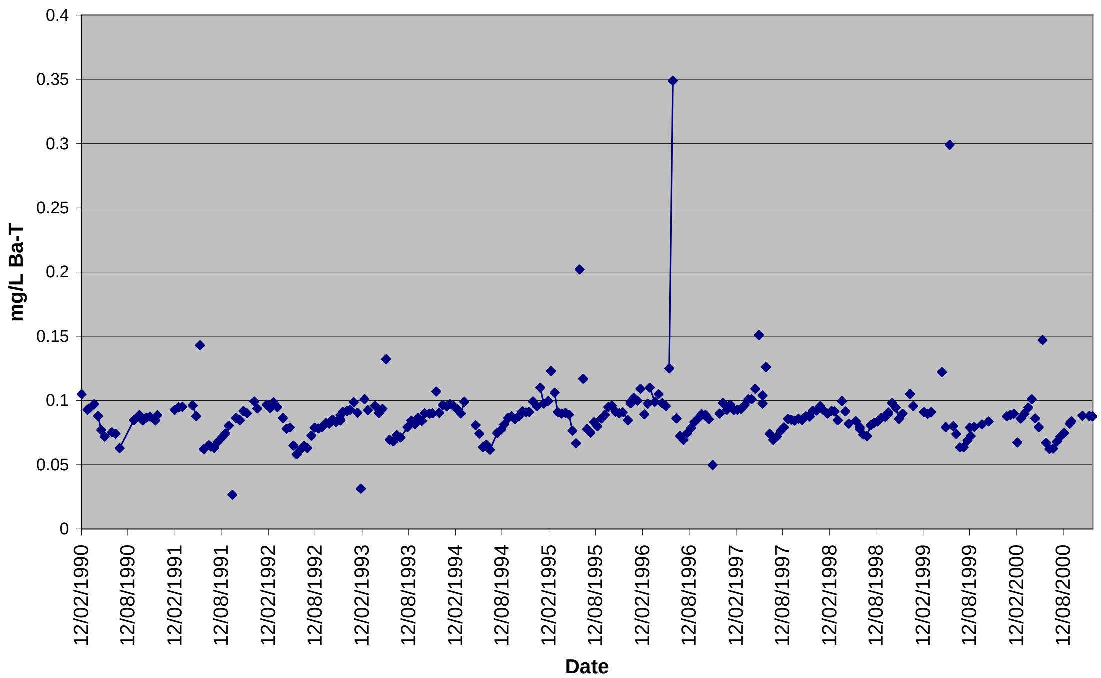

Figure 6 Elk River at Highway 93 - Total Beryllium

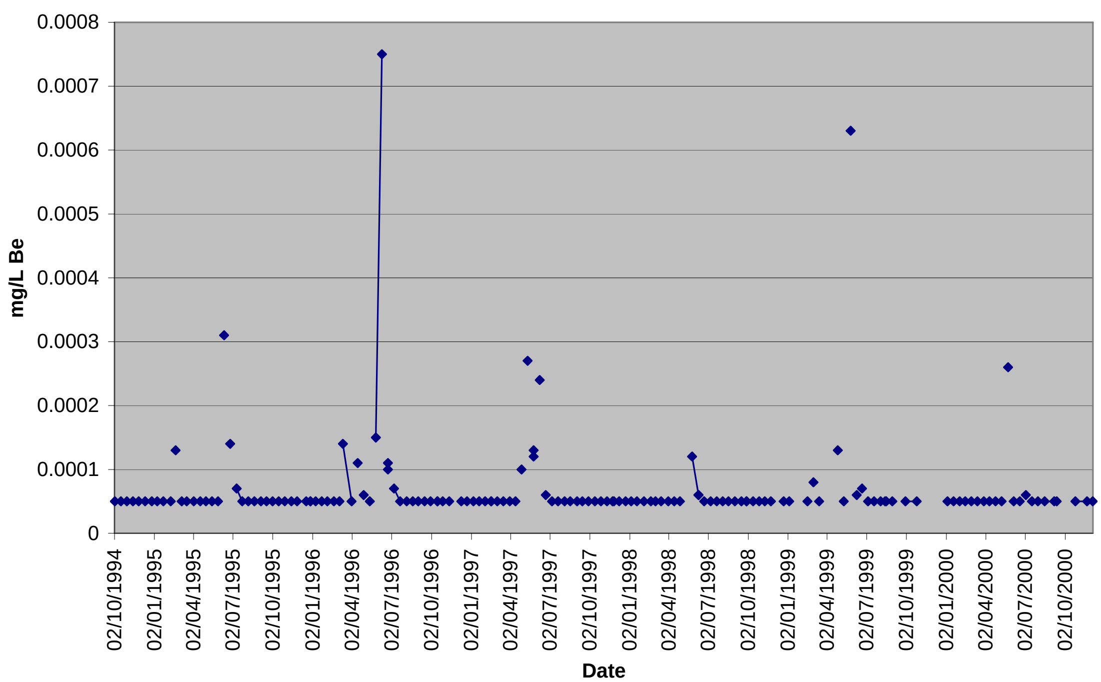

Figure 7 Elk River at Highway 93 - Total Cadmium

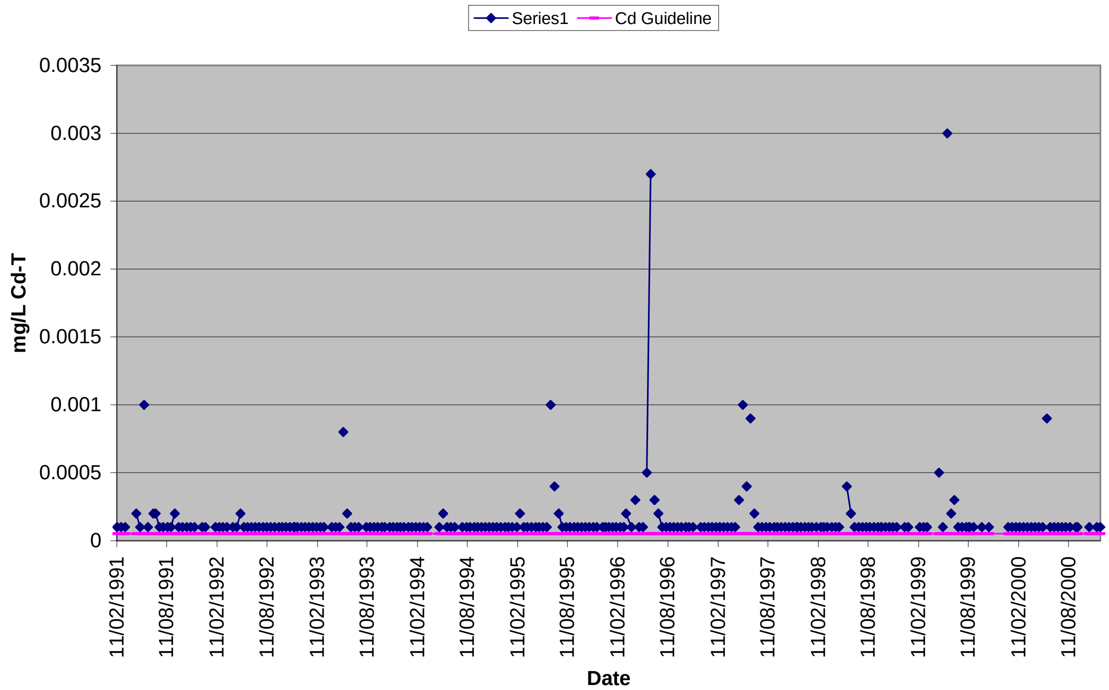

Figure 8 Elk River at Highway 93 - Calcium

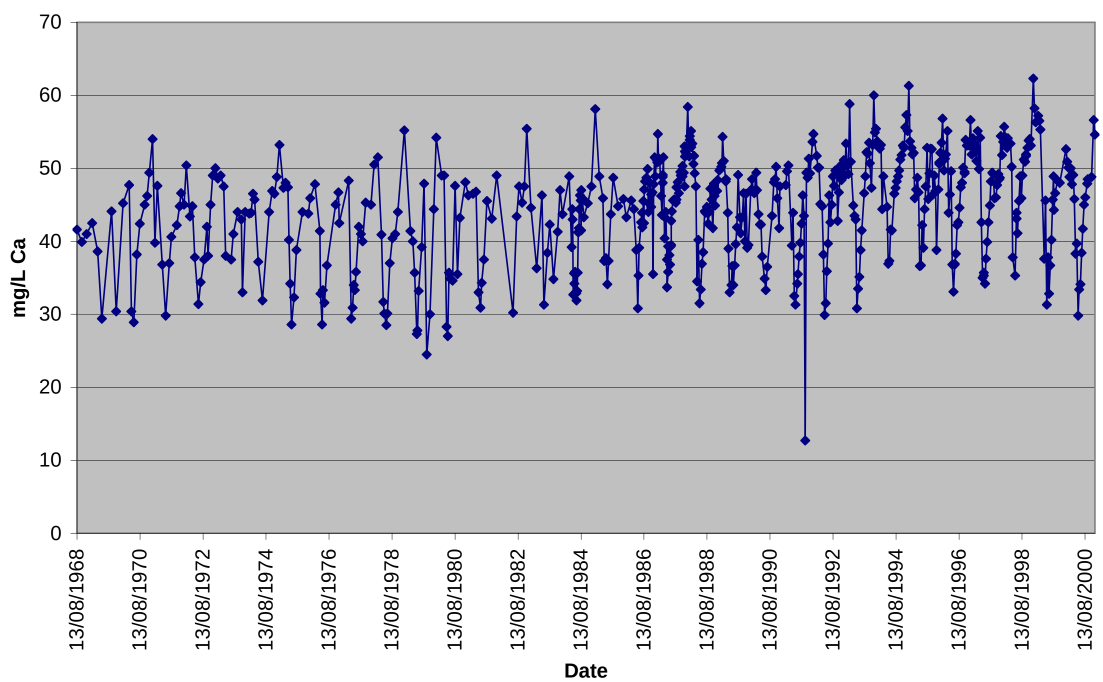

Figure 9 Elk River at Highway 93 - Dissolved Organic Carbon

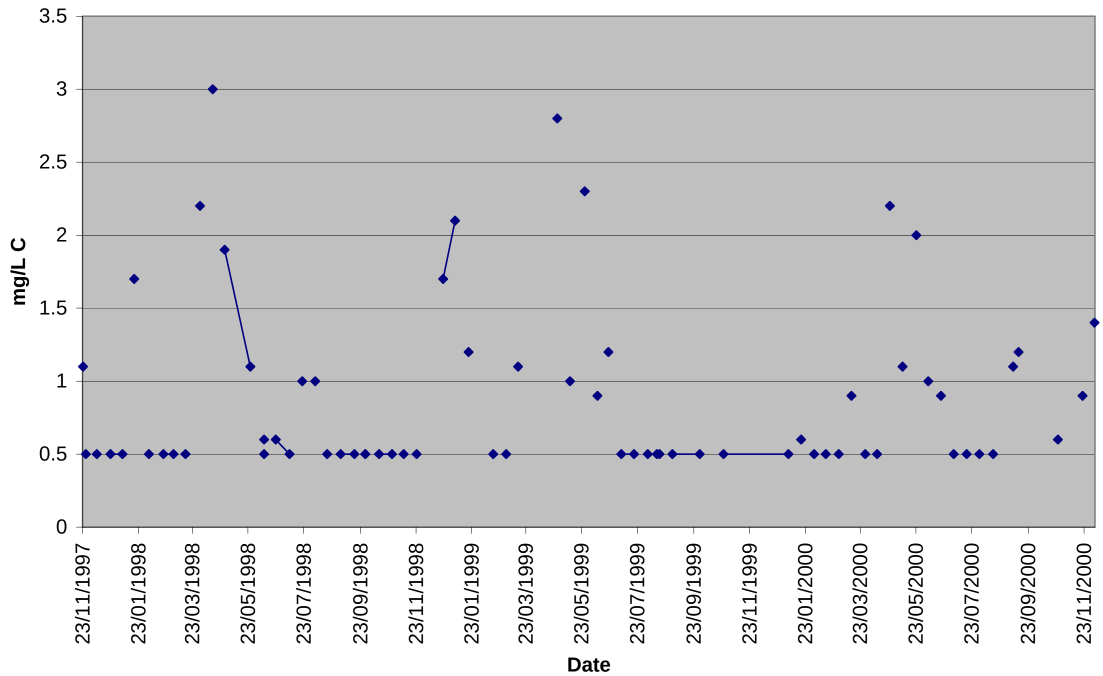

Figure 10 Elk River at Highway 93 - Chloride

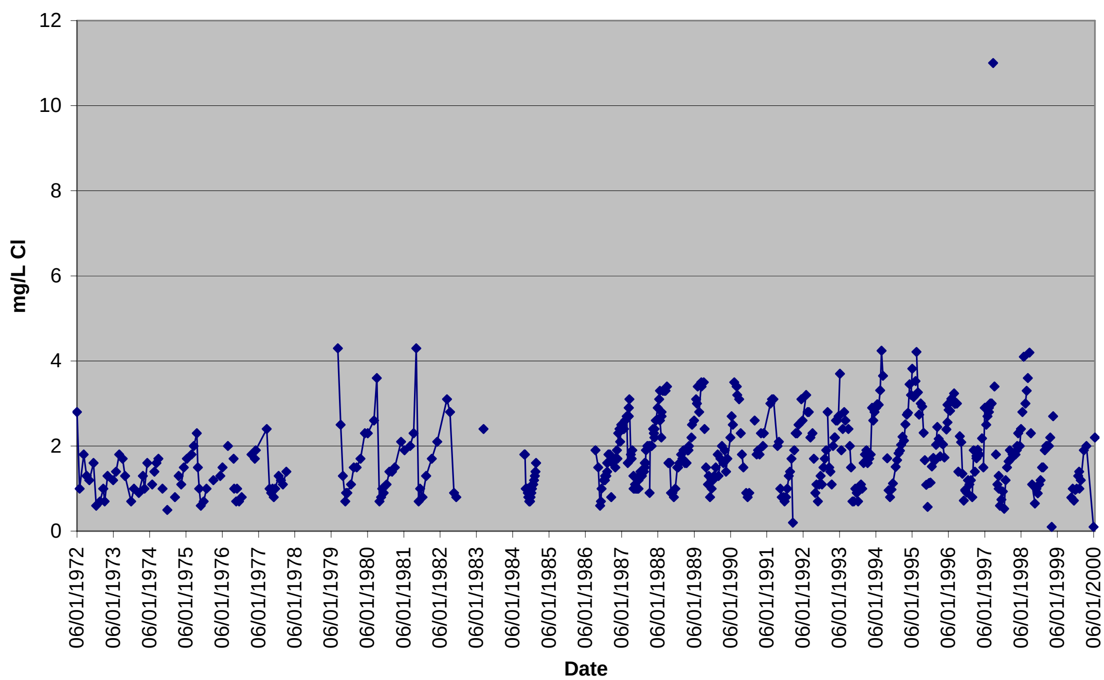

Figure 11 Elk River at Highway 93 - Total Chromium

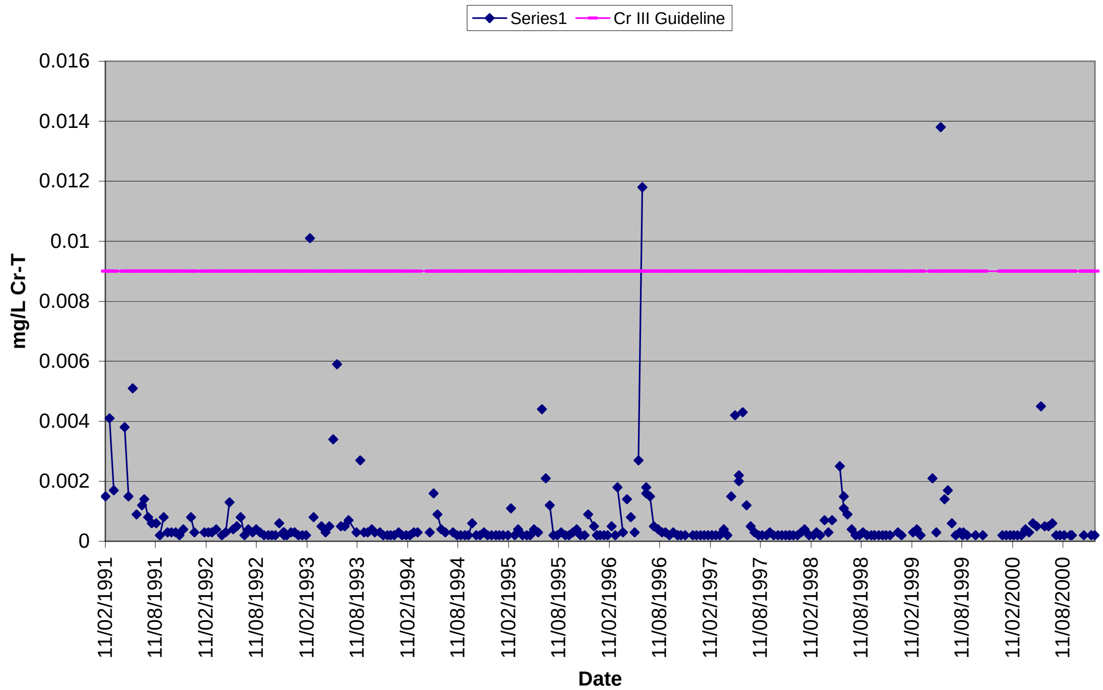

Figure 12 Elk River at Highway 93 - Total Cobalt

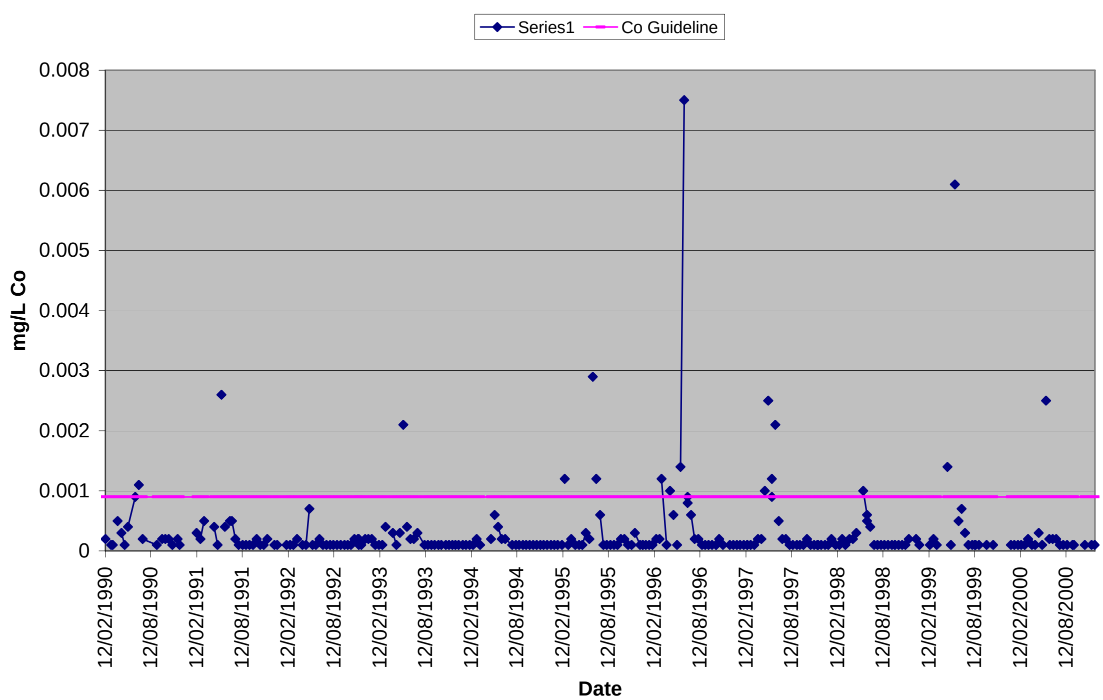

Figure 13 Elk River at Highway 93 - Fecal Coliforms

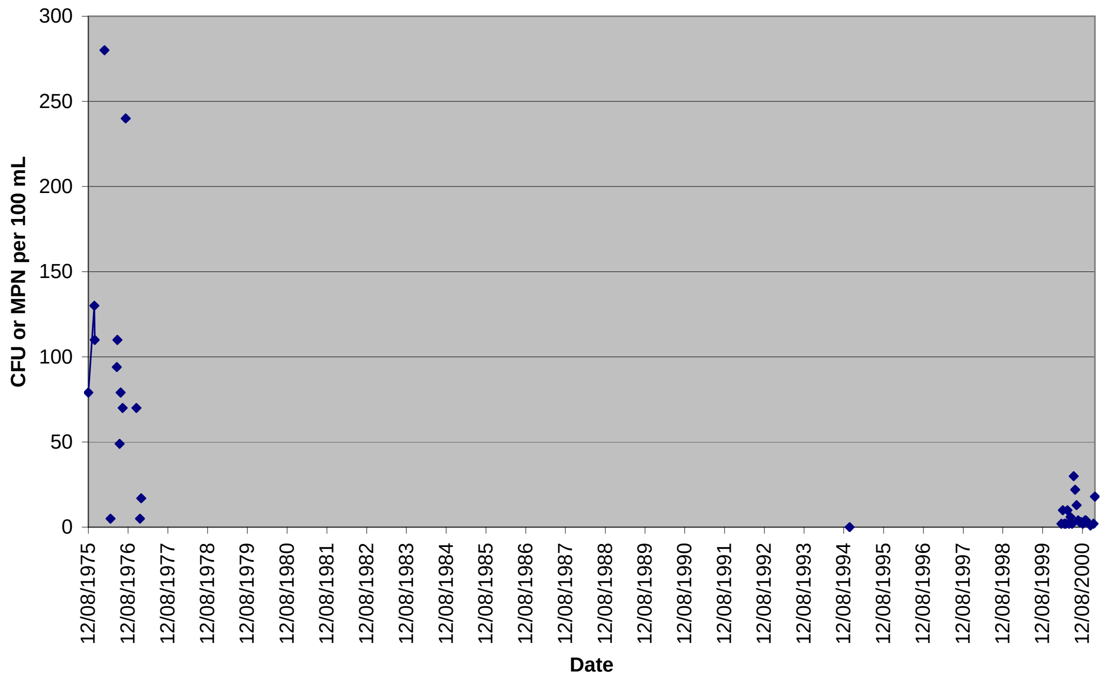

Figure 14 Elk River at Highway 93 - True Colour

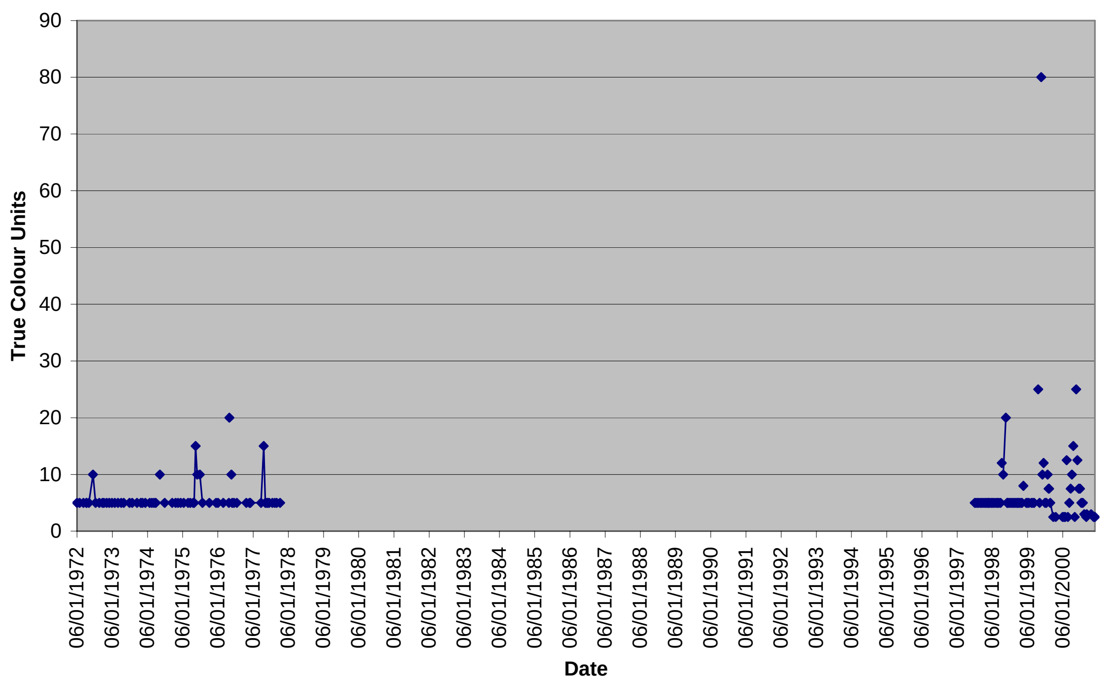

Figure 15 Elk River at Highway 93 - Conductance, Specific

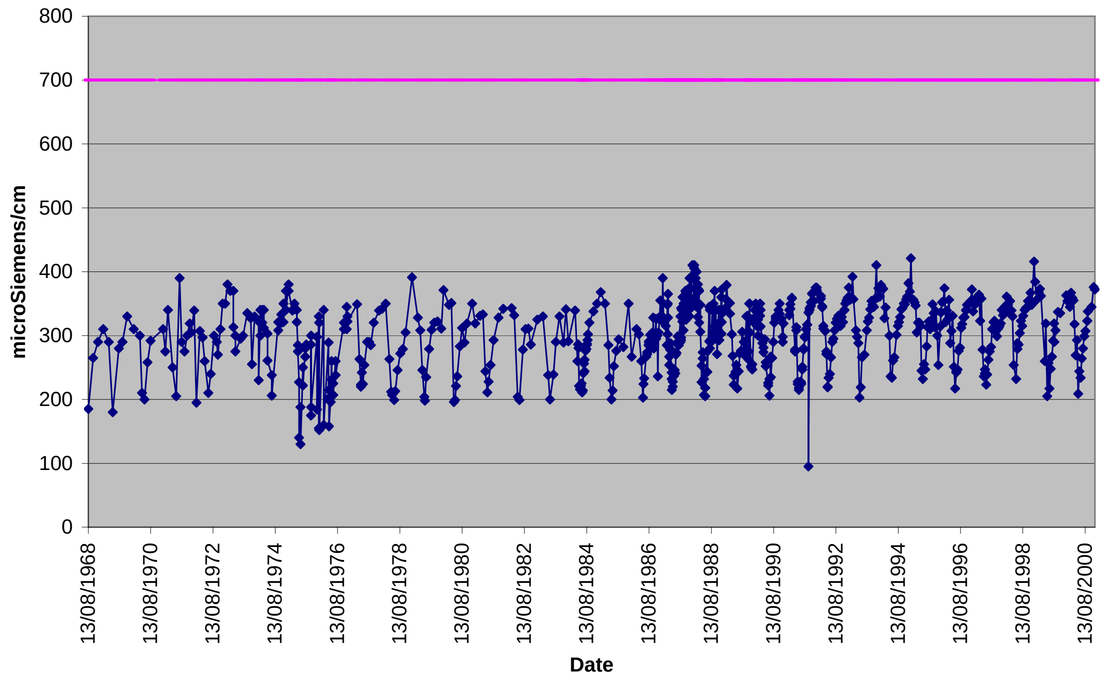

Figure 16 Elk River at Highway 93 - Total Copper

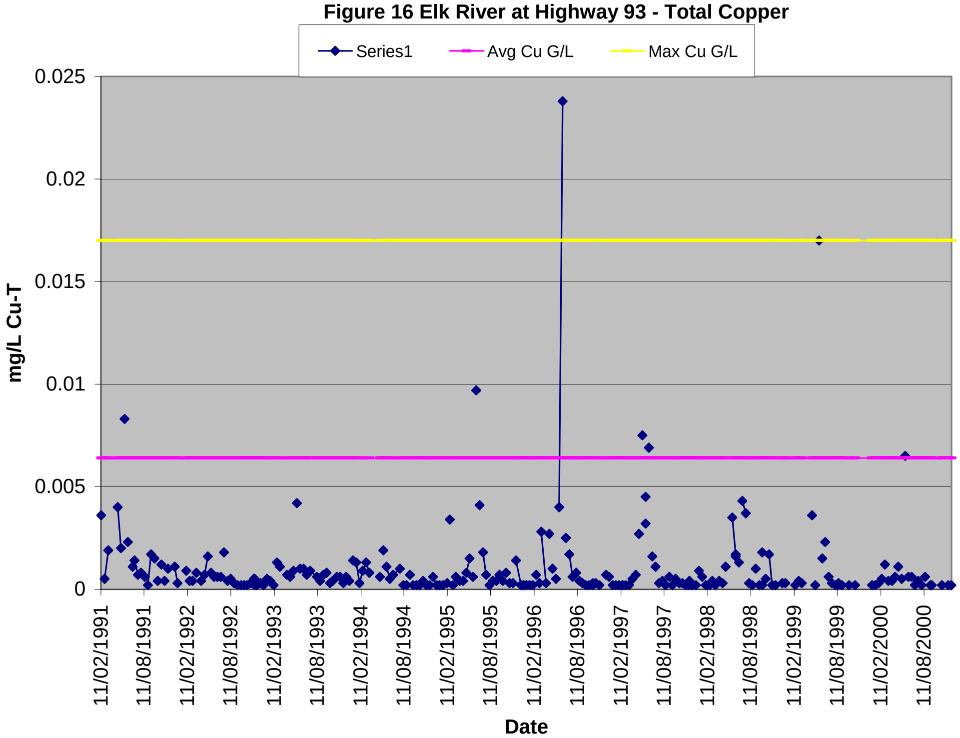

Figure 17 Elk River at Highway 93 - Fluoride

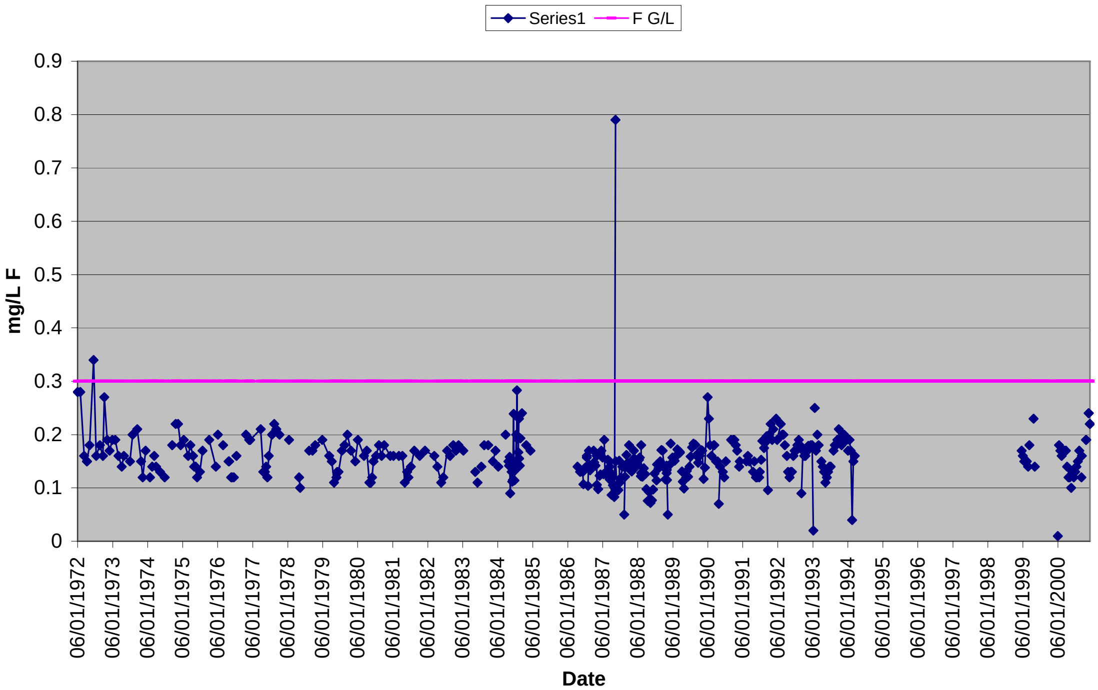

Figure 18 Elk River at Highway 93 - Hardness

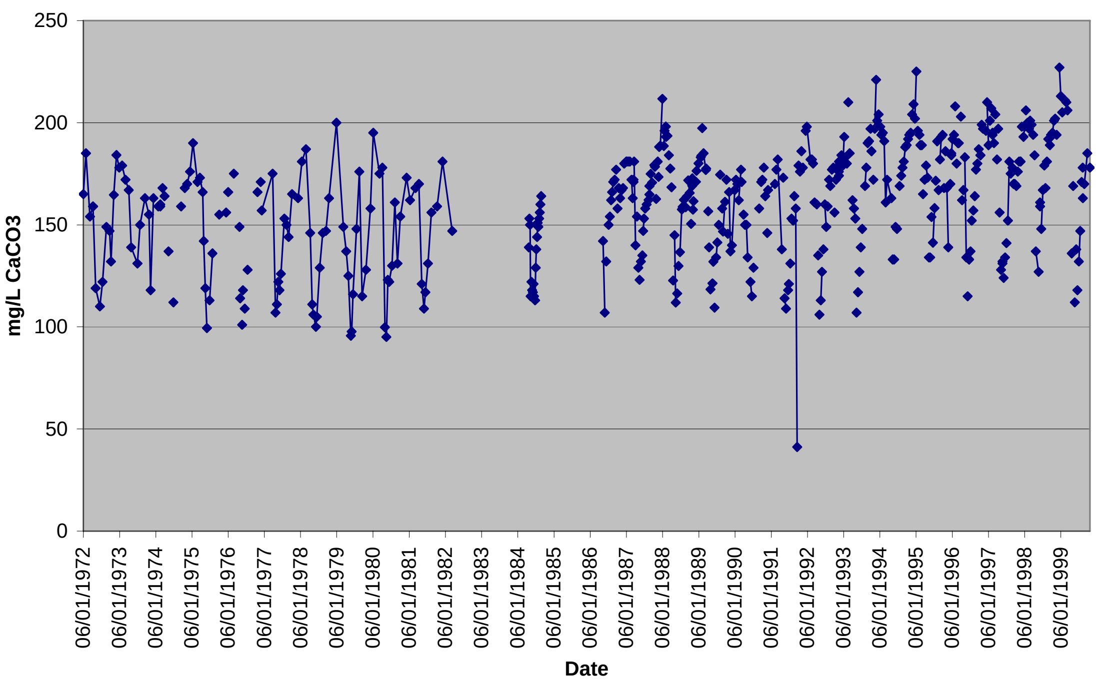

Figure 19 Elk River at Highway 93 - Total Iron

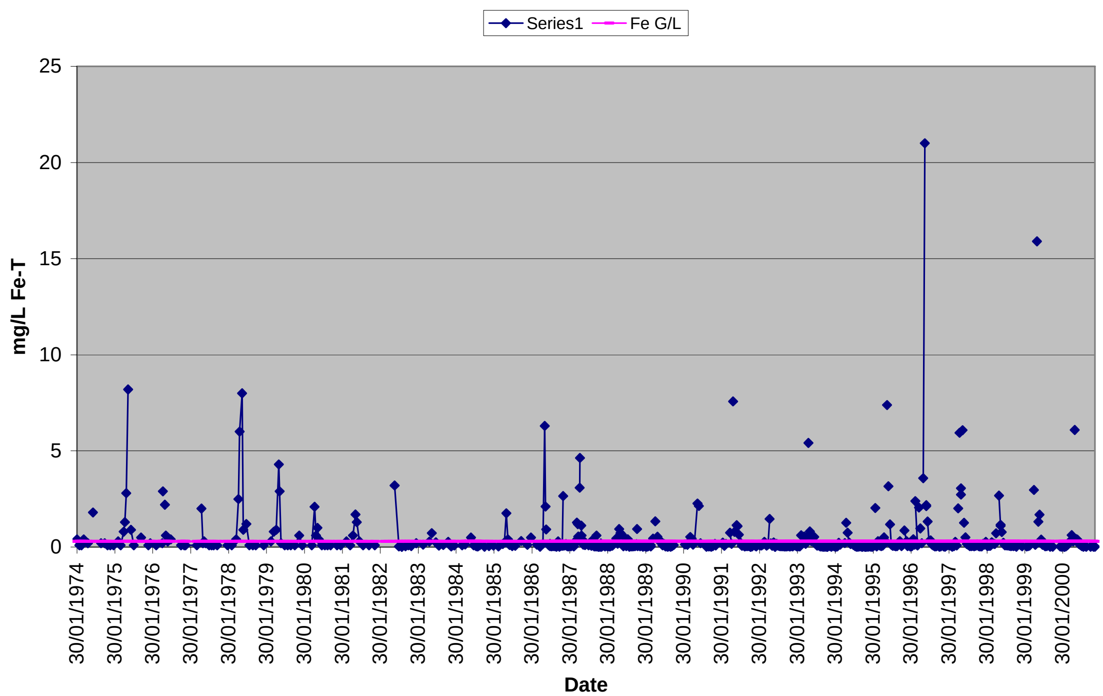

Figure 20 Elk River at Highway 93 - Lead, Total

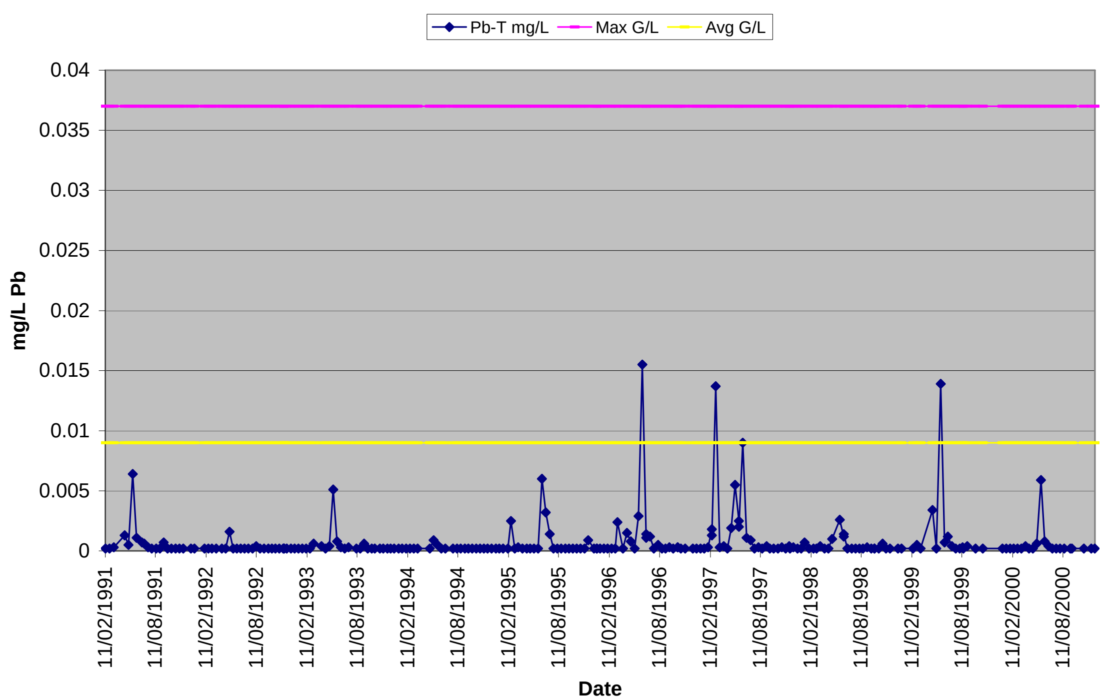

Figure 21 Elk River at Highway 93 - Magnesium

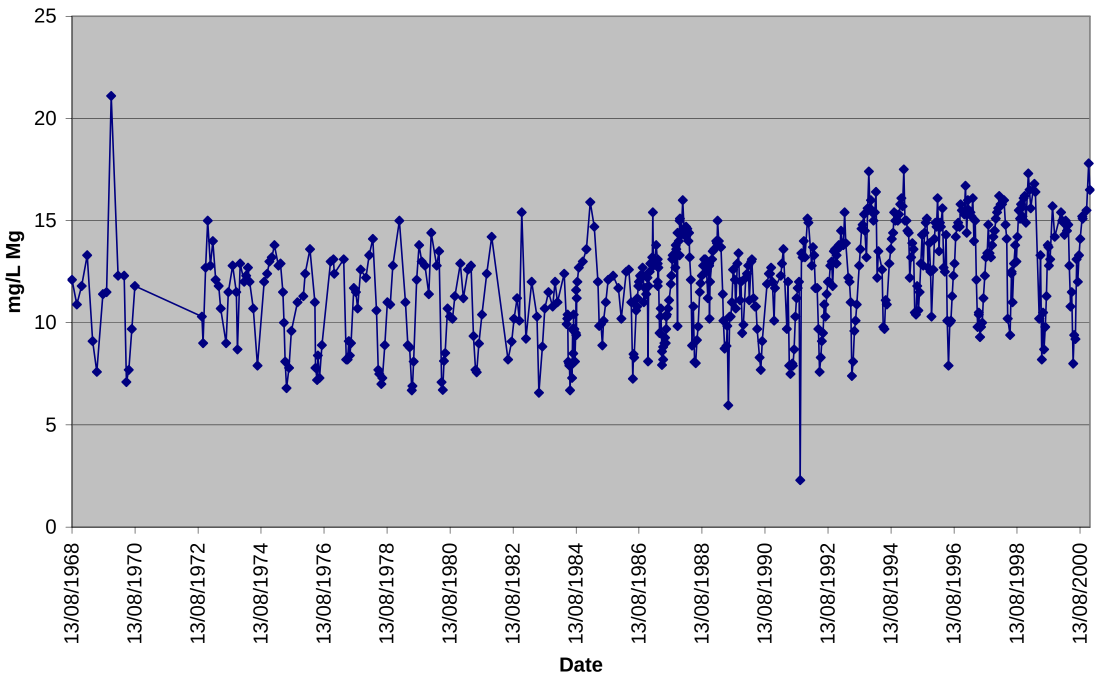

Figure 22 Elk River at Highway 93 - Manganese, Total

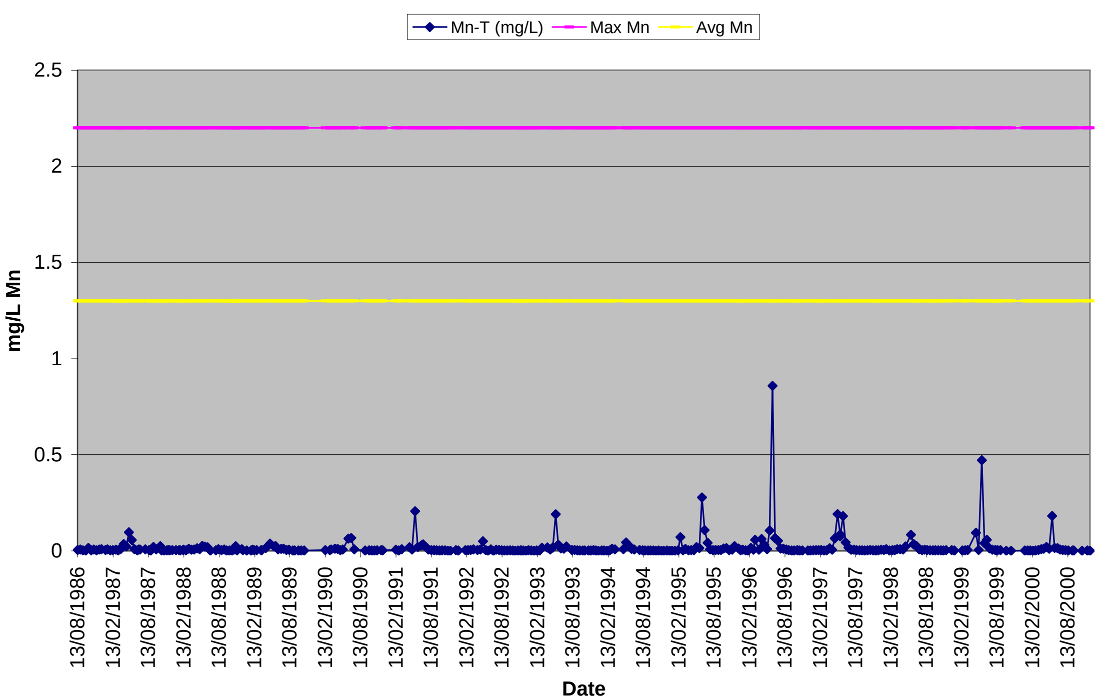

Figure 23 Elk River at Highway 93 - Total Molybdenum

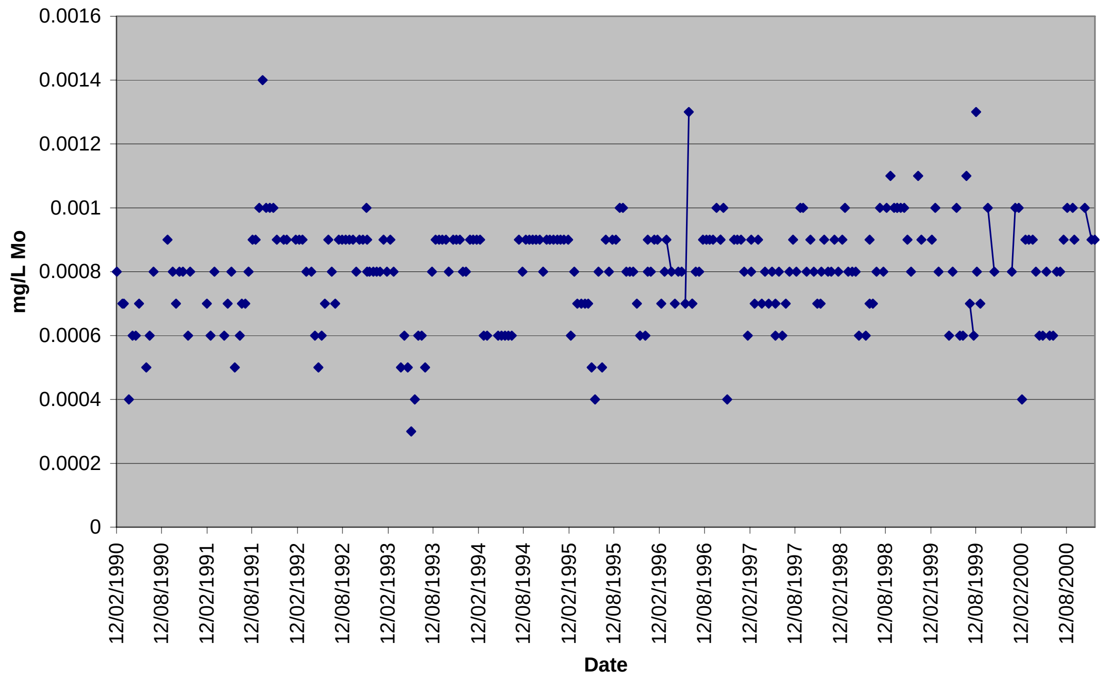

Figure 24 Elk River at Highway 93 - Total Nickel

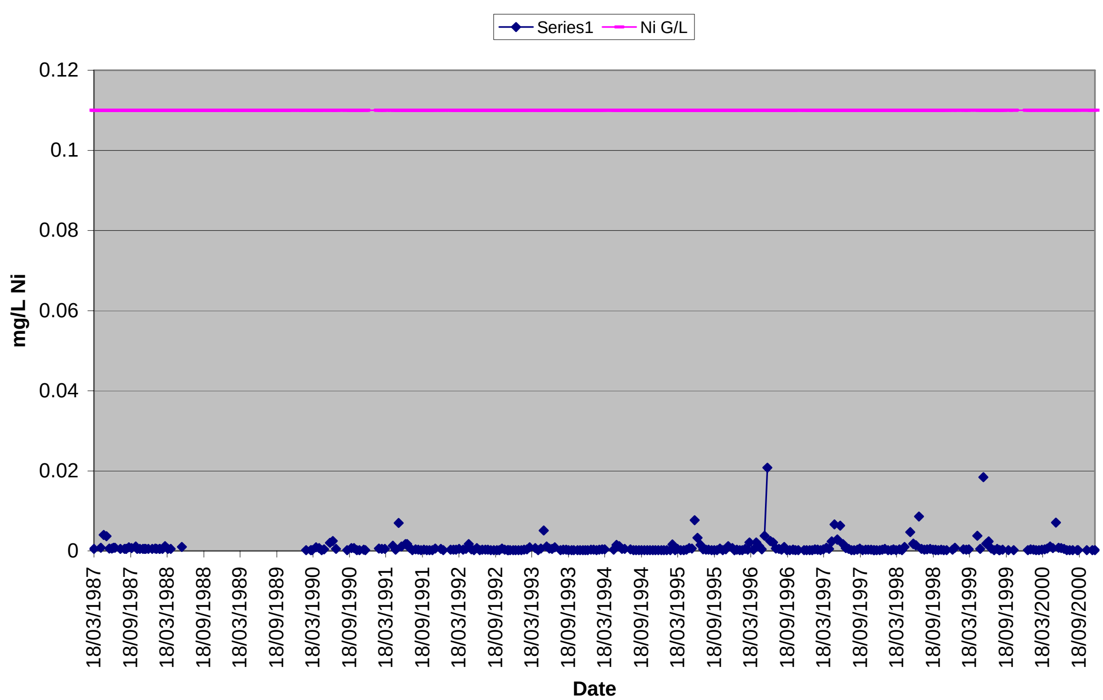

Figure 25 Elk River at Highway 93 - Nitrate+Nitrite-N

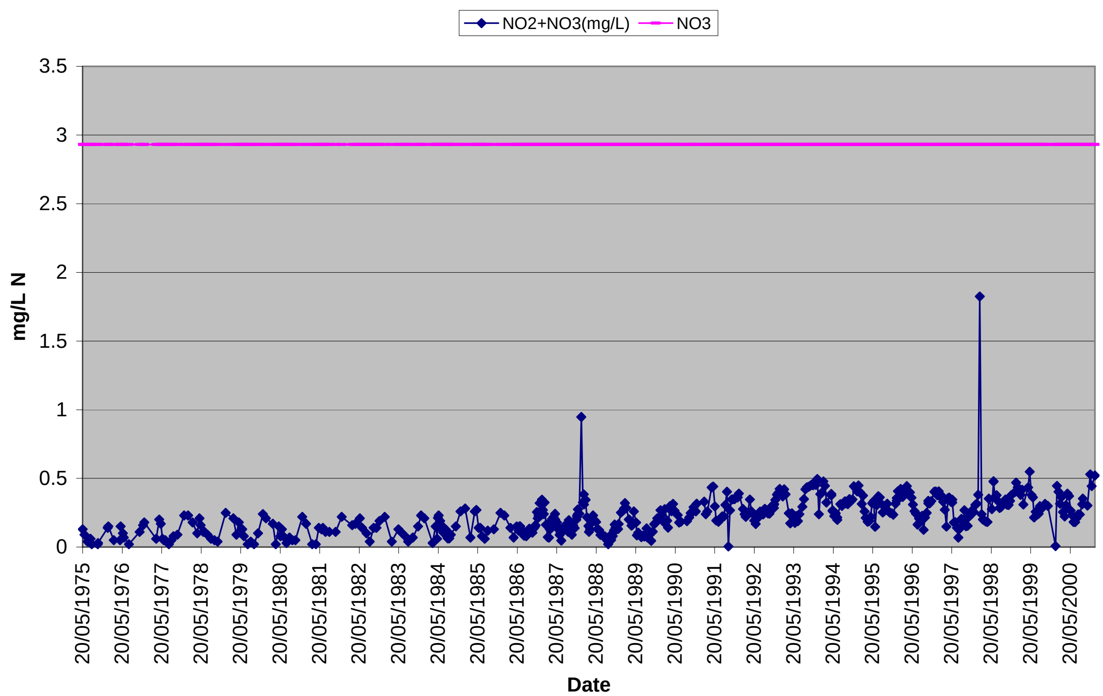

Figure 26 Elk River at Highway 93 - Total Dissolved Nitrogen

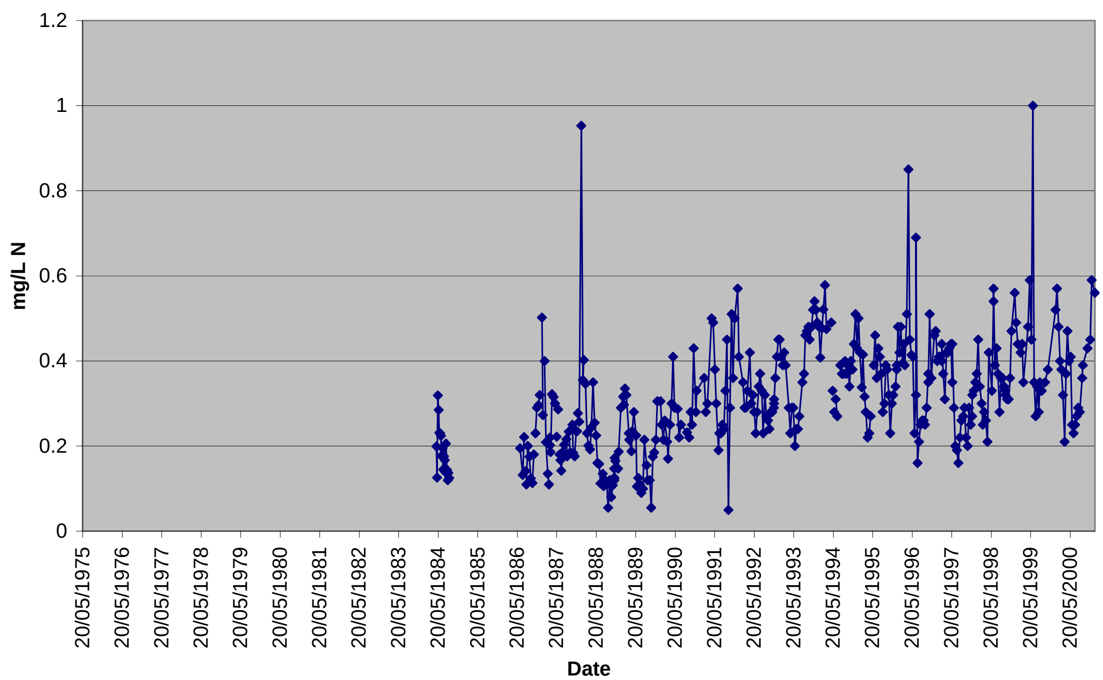

Figure 27 Elk River at Highway 93 - pH

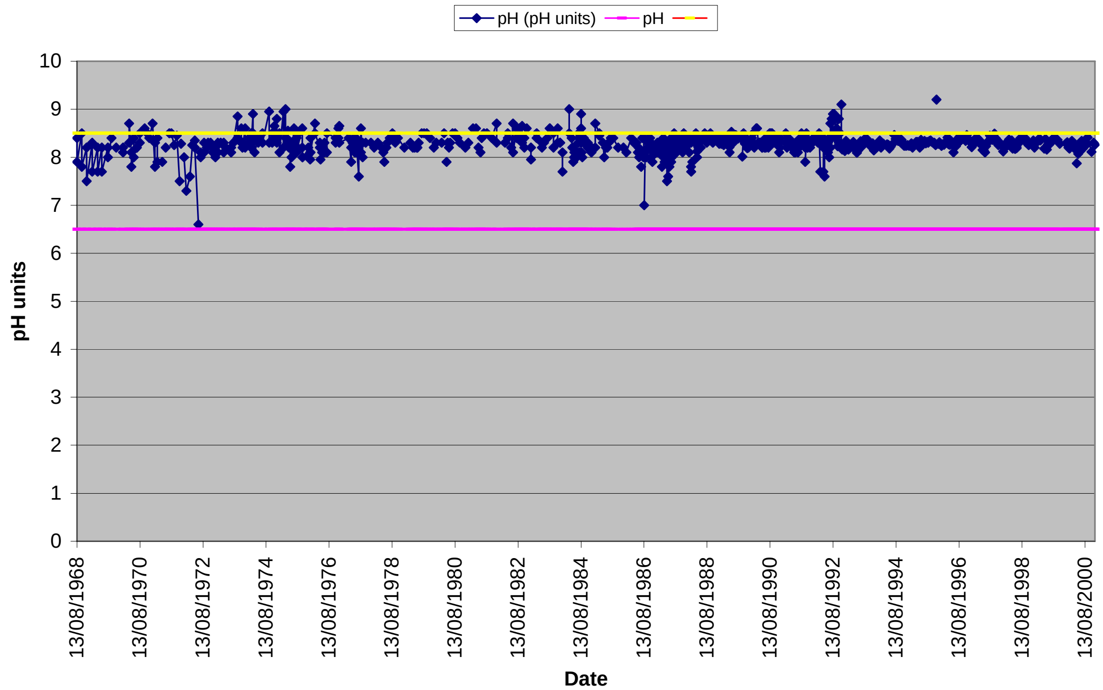

Figure 28 Elk River at Highway 93 - Dissolved Orthophosphorus

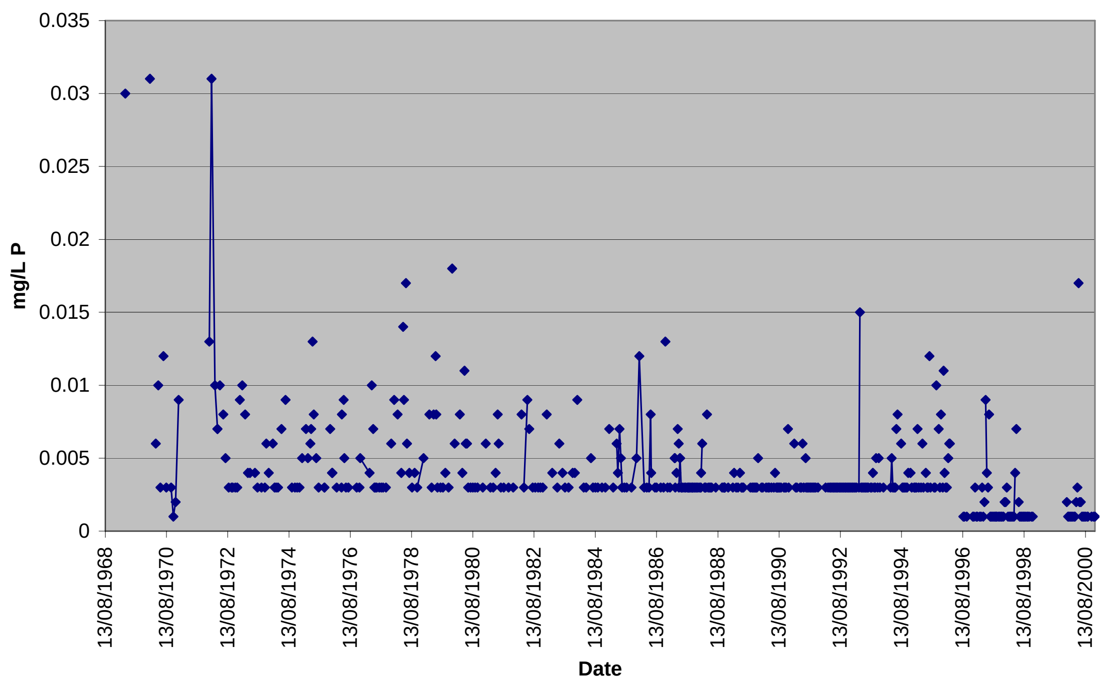

Figure 29 Elk River at Highway 93 - Total Phosphorus

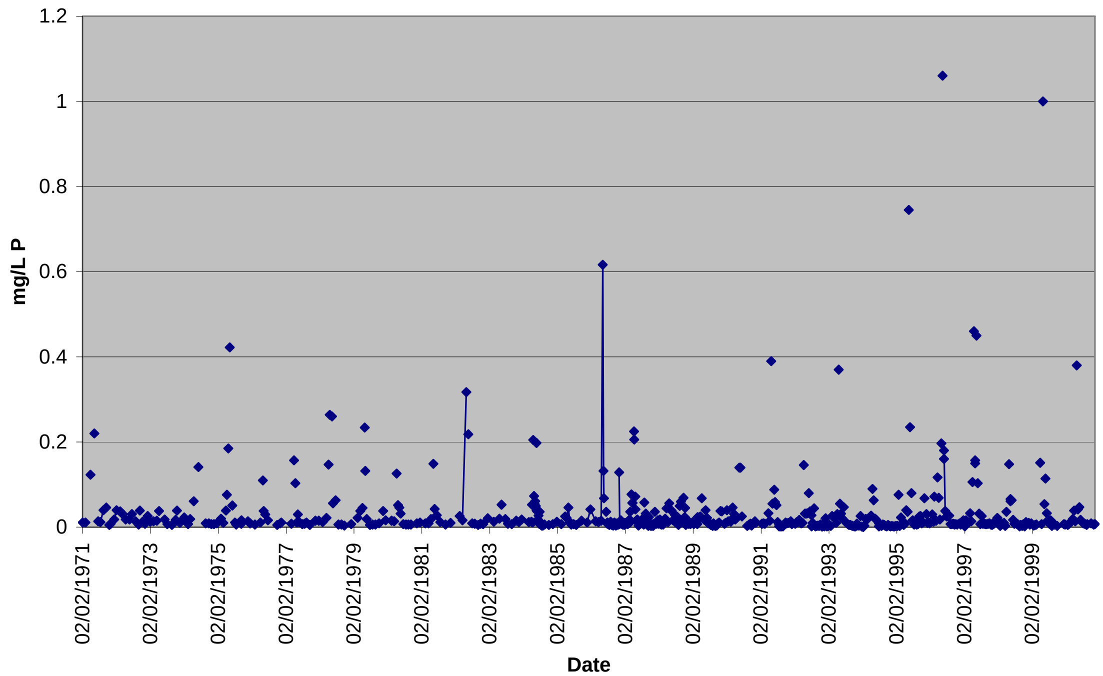

Figure 30 Elk River at Highway 93 - Non-Filterable Residue

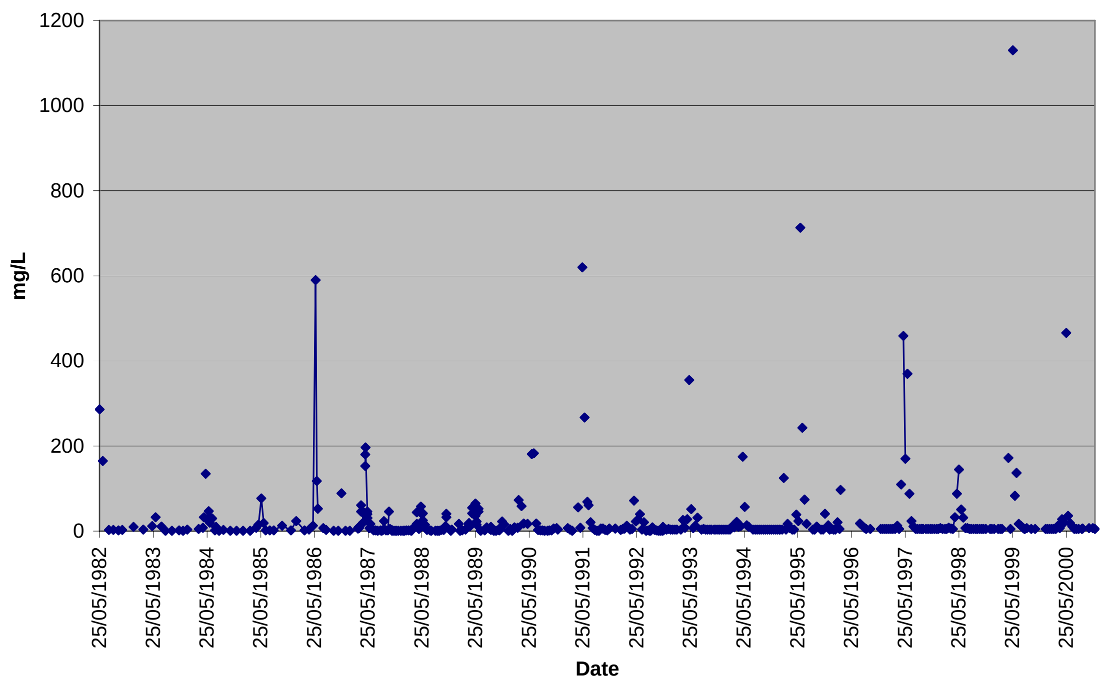

Figure 31 Elk River at Highway 93 - Selenium, Total and Extractable

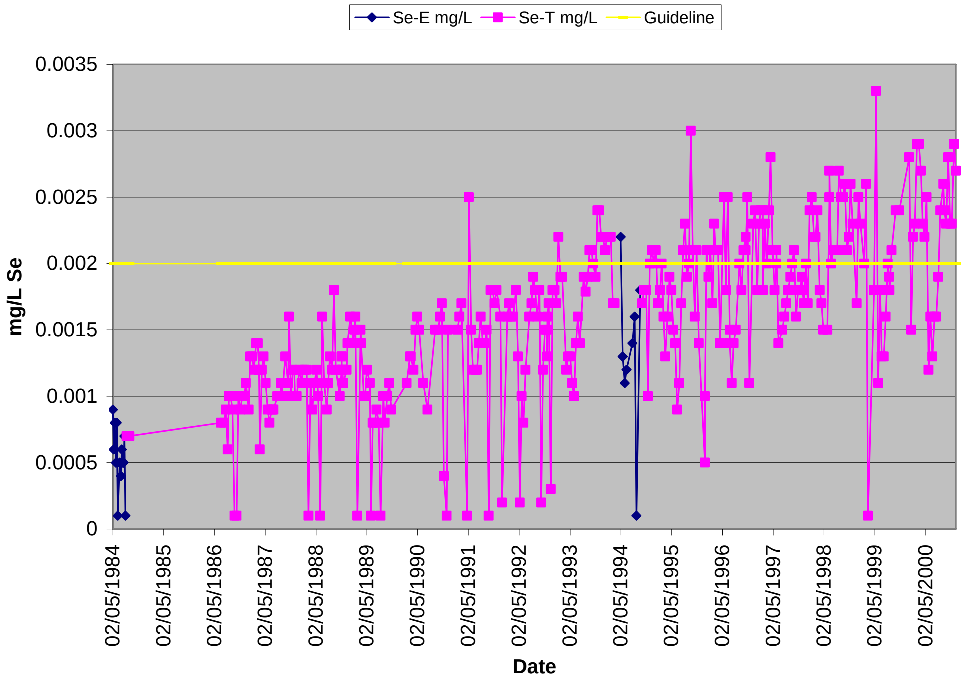

Figure 32 Elk River at Highway 93 - Total Silver

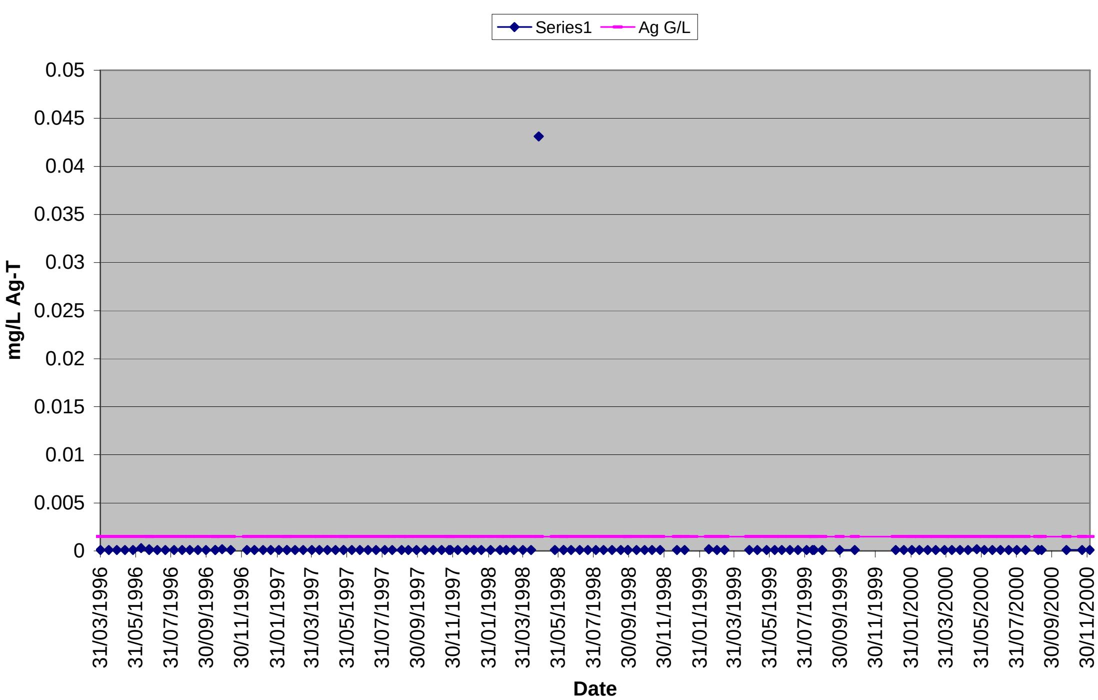

Figure 33 Elk River at Highway 93 - Sodium

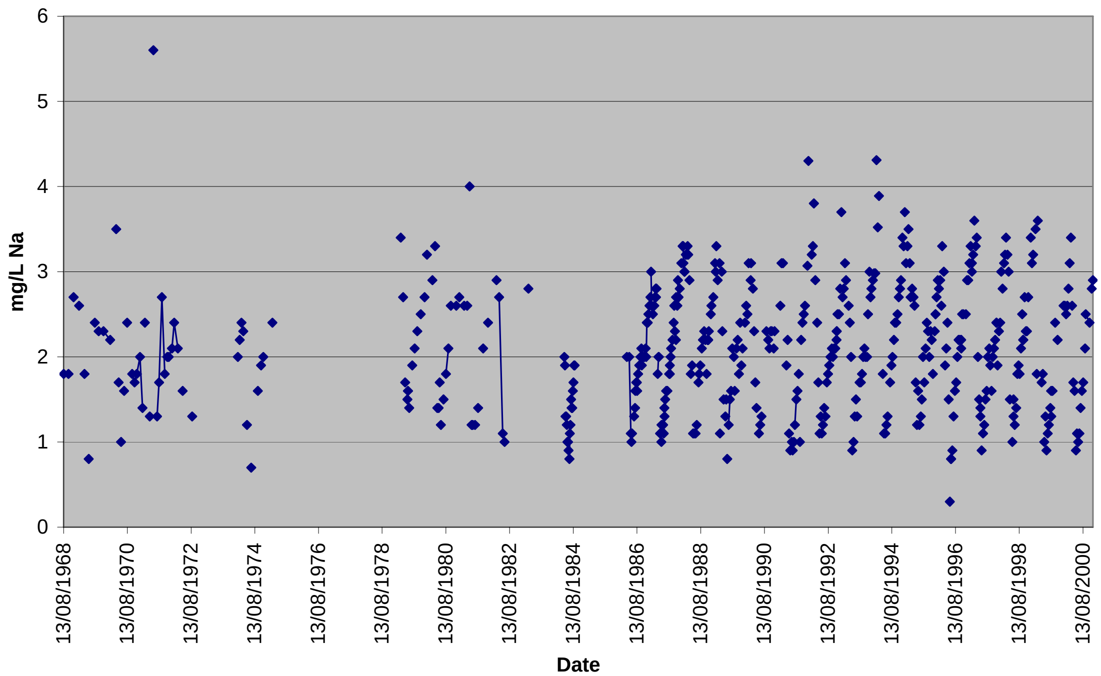

Figure 34 Elk River at Highway 93 - Total Strontium

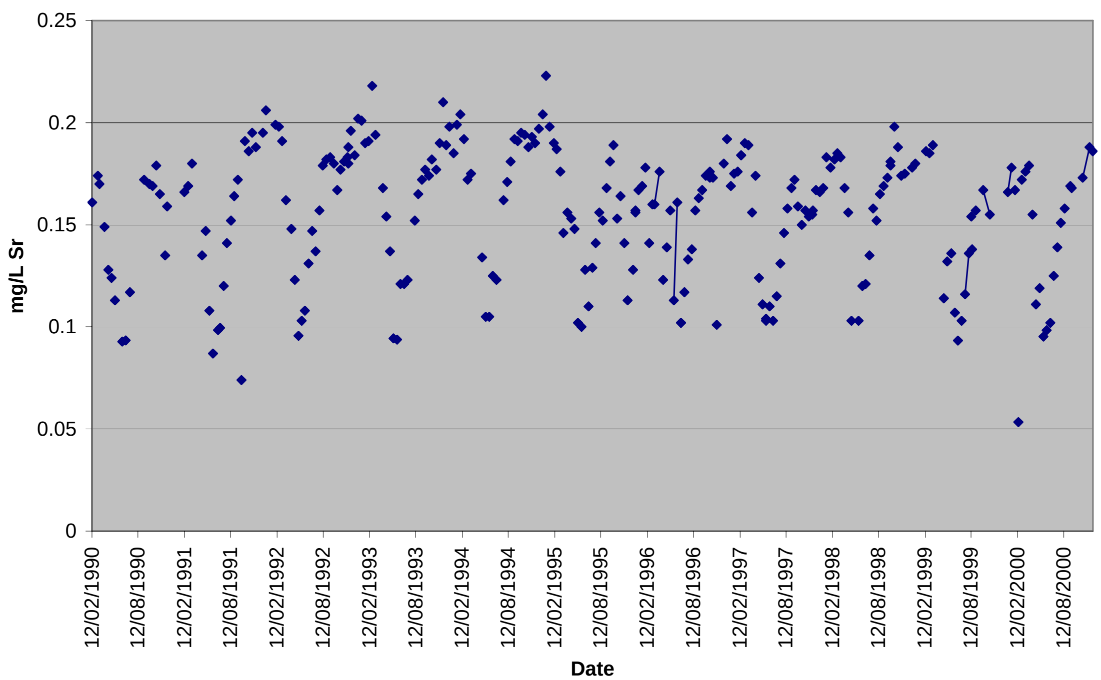

Figure 35 Elk River at Highway 93 - Temperature, Water

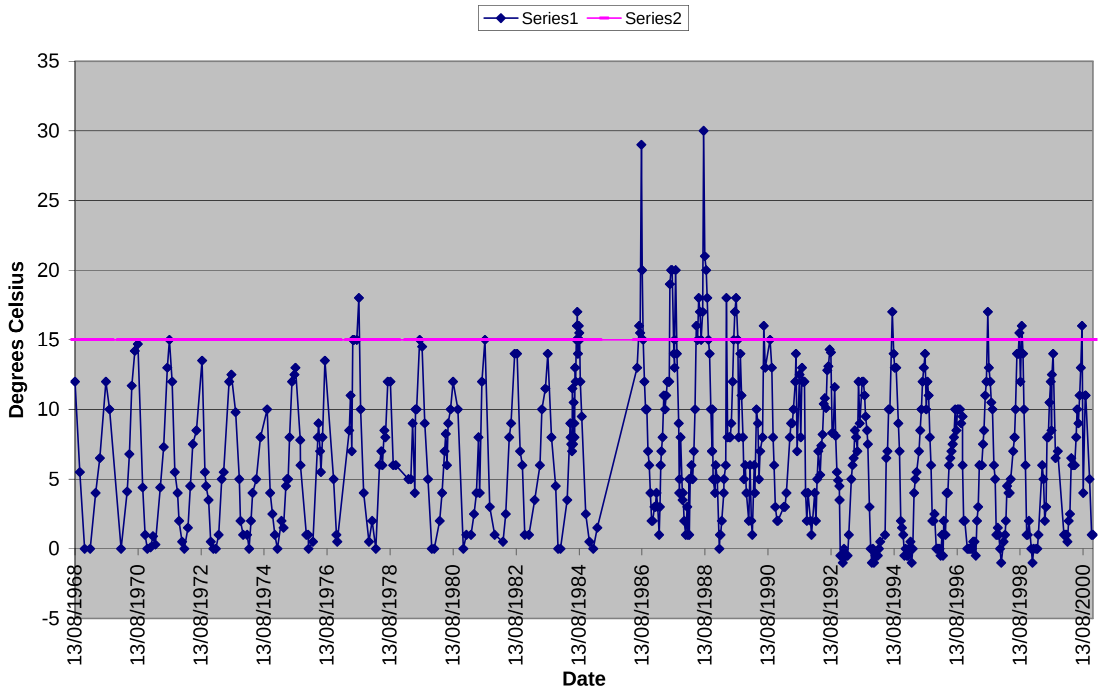

Figure 36 Elk River at Highway 93 - Turbidity

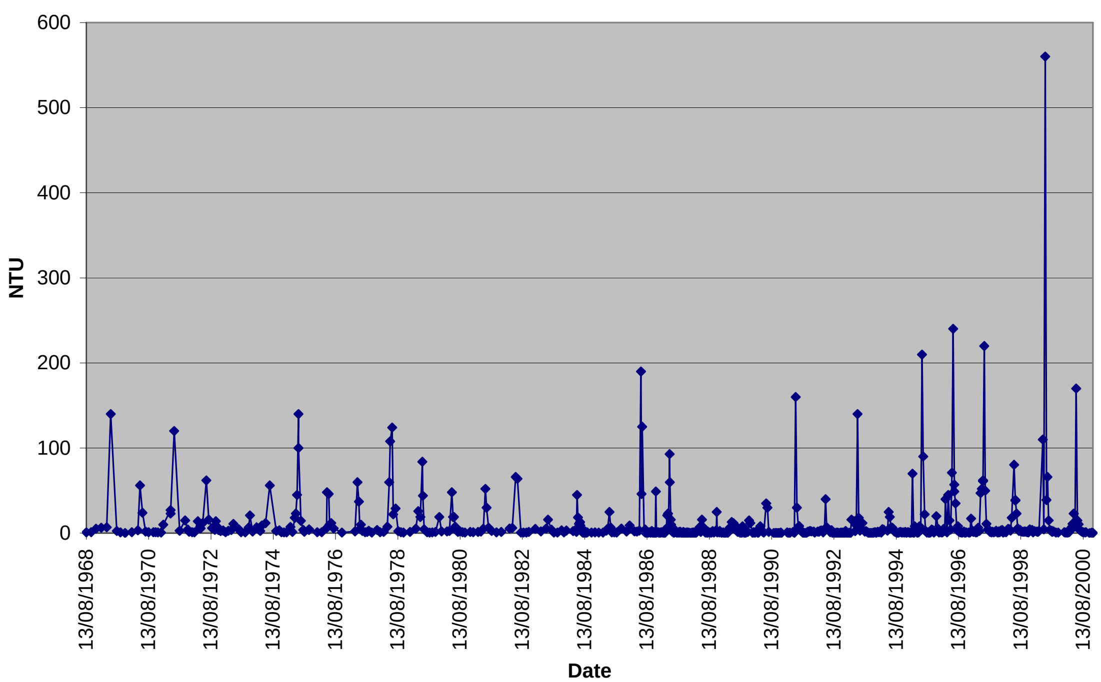

Figure 37 Elk River at Highway 93 - Total Vanadium

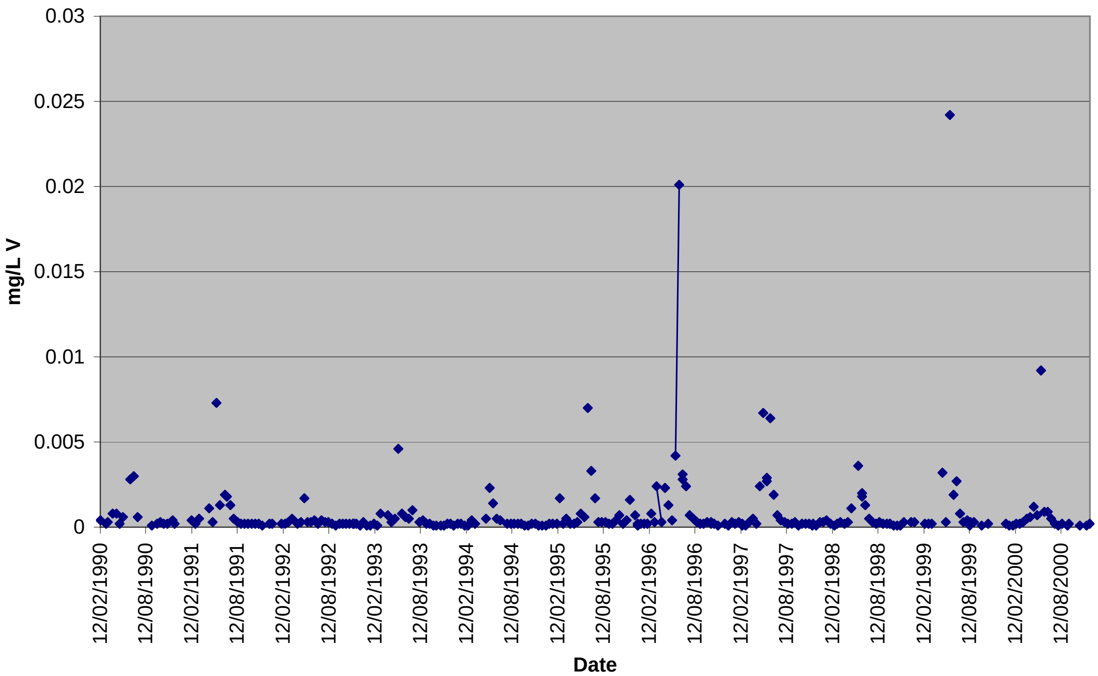

Figure 38 Elk River at Highway 93 - Zinc, Total