CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF KETTLE RIVER AT CARSON (1980 – 2002)

Prepared by:

Burke Phippen

BWP Consulting

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Environment Canada **Environnement Canada**

BRITISH COLUMBIA Ministry of Environment

EXECUTIVE SUMMARY

This report assesses the long-term water quality trends in the Kettle River, a trans-boundary river which flows from south central B.C. into Washington State crossing the international border at the town of Midway, B.C. and then re-entering B.C. at Carson. Three other related monitoring stations within the B.C. portion of this watershed are the Kettle River at Midway, Boundary Creek at Midway, and the Kettle River at Gilpin sites. The Kettle River at Midway station is located at the international boundary near the town of Midway, B.C. where the Kettle River first enters the U.S. The Boundary Creek at Midway station is located on Boundary Creek very near the town of Midway where this major tributary from the north joins the Kettle River adjacent to the international boundary. The Kettle River at Gilpin station is located downstream from the Carson site but just upstream from where the Kettle River returns to the U.S.

Known errors were removed and the plotted data were compared to B.C. Environment's *Approved and Working Criteria for Water Quality*. Of special interest are water quality levels and trends that are deemed deleterious to sensitive water uses including aquatic life, fish and wildlife, recreation, irrigation and livestock watering. This report focuses on analyzing trends in water quality data, but does not necessarily link these trends to land use or other potential causes for the trends.

CONCLUSIONS

The main conclusions of this assessment are as follows:

- Concentrations of alkalinity and calcium indicate that the water is well buffered and has a low sensitivity to acid inputs.
- The water is naturally high in fluoride and exceeded guidelines for aquatic life on a few occasions. We are not aware of any effects on the local fish populations and expect that fish may be adapted to the higher levels of fluoride. There is no known anthropogenic source of fluoride in the watershed.

- Water quality patterns in this watershed are usually closely matched with flow patterns.
- The increased levels in total phosphorus, dissolved organic carbon, and total metals such as aluminum, chromium, copper, iron, lead and zinc are related to seasonal increased flows due to suspended sediments and thus are likely not biologically unavailable.
- Metals such as beryllium, cobalt, manganese, and selenium showed occasional values in excess of their respective guidelines, but these occasional excursions are not likely a cause for concern.
- Water temperatures frequently exceeded the general fisheries guideline.
- Dissolved chloride may be increasing slightly over time at this site. The cause for this increase is likely a change of analytical techniques with associated detection limits.
- The minimum detection limit used for cadmium analyses was much too high to determine guideline compliance. Tests with much lower analytical limits (maximum 1/10 the guideline, or 0.000003 mg/L) should be used when they become available.

RECOMMENDATIONS

We recommend continued monitoring at this station because there are regional concerns related to resource development within the Kettle River watershed (U.S. and Canada). The potential for impacts from proposed mining in Washington State should be considered. A specific monitoring program to study this impact should be designed and implemented if mining is anticipated. The Kettle River at Carson serves as an excellent "background site" for the collection and assessment of water quality data as the Kettle River re-enters Canada near Grand Forks, B.C. In addition, other water quality indicators such as benthic invertebrates, sediment chemistry and fish tissues could also be examined to determine if long-term trends are occurring.

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INTRODUCTION

The Kettle River at Carson is located just upstream and south west from Grand Forks, B.C. where the Kettle River makes its return into Canada, crossing back into B.C. from Washington State (Figure 1). The drainage area of the Kettle River at Carson watershed is 6730 km². The river flow is monitored at the nearest upstream Environment Canada station number BC08NN013 (Kettle River at the ferry crossing). The flow data are plotted in Figure 2.

Environment Canada has monitored the water quality at this station since 1980, and the data are stored on the federal data base, ENVIRODAT, under station number BC08NN0021. This report assesses the 15 years of data from 1980 through 2001. The water quality parameters are plotted in alphabetical order in Figures 3 to 51 at the end of this report..

Other related monitoring stations are the Kettle River sites at Midway and Kettle River at Gilpin, which are located upstream and downstream respectively, and Boundary Creek at Midway, which joins the Kettle River a short distance downstream from the Kettle River at Midway station. The watershed upstream from Carson is relatively un-impacted, with a small population, and no environmentally significant anthropogenic industrial impacts other than forestry and a small amount of mining. Consumptive water uses for the Kettle River include agricultural and industrial uses.

Substances that met their respective guidelines and showed no environmentally significant trends included: arsenic, barium, boron, bromide, fecal coliforms, colour, specific conductivity, cyanide, gallium, hardness, lanthanum, lithium, magnesium, molybdenum, nickel, nitrate/nitrite, nitrogen, pH, phosphorus, potassium, filterable residue, rubidium, silica, silicon, silver, sodium, strontium, sulphate, thallium, uranium and vanadium.

Figure 1 Map of the Kettle River Basin

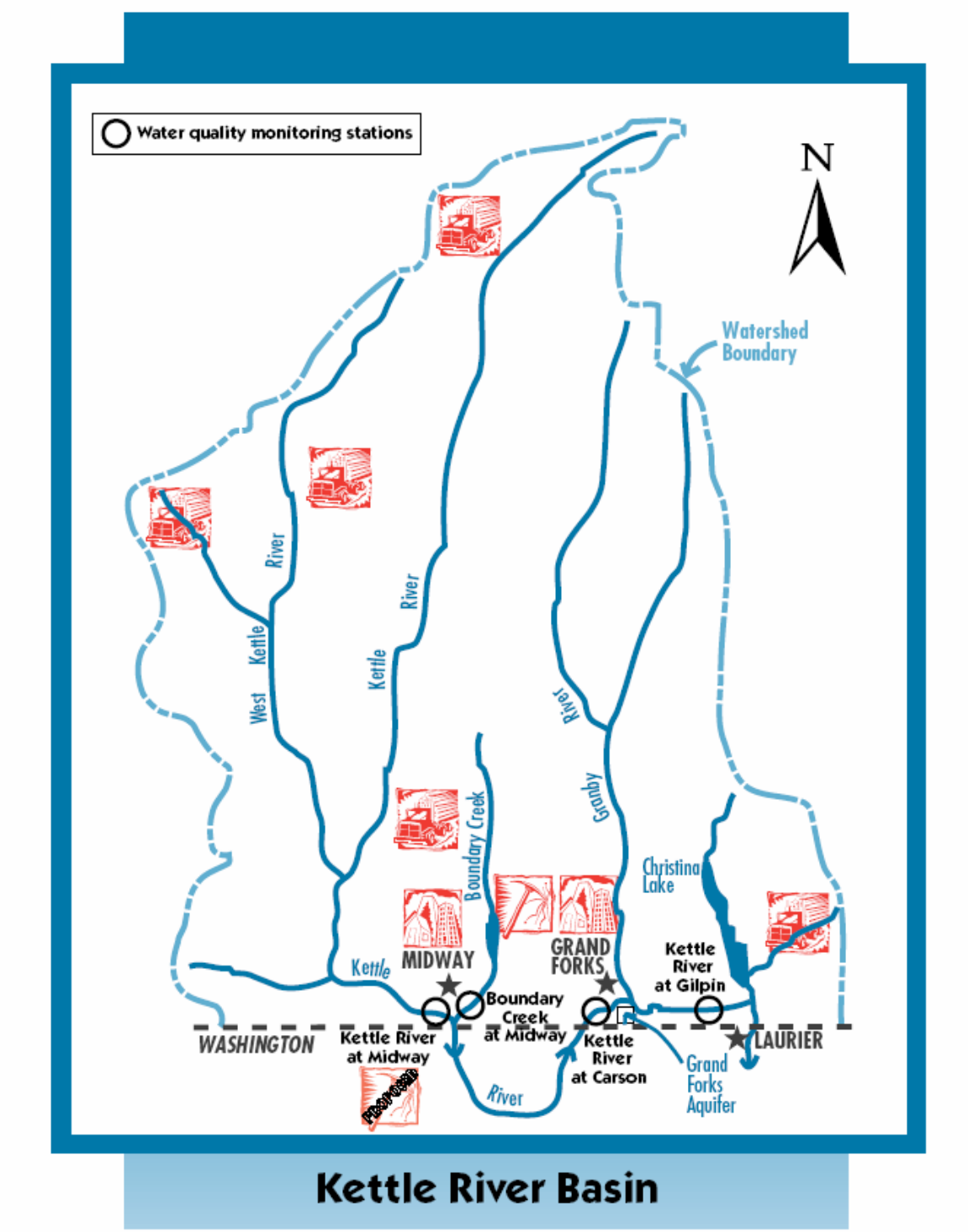
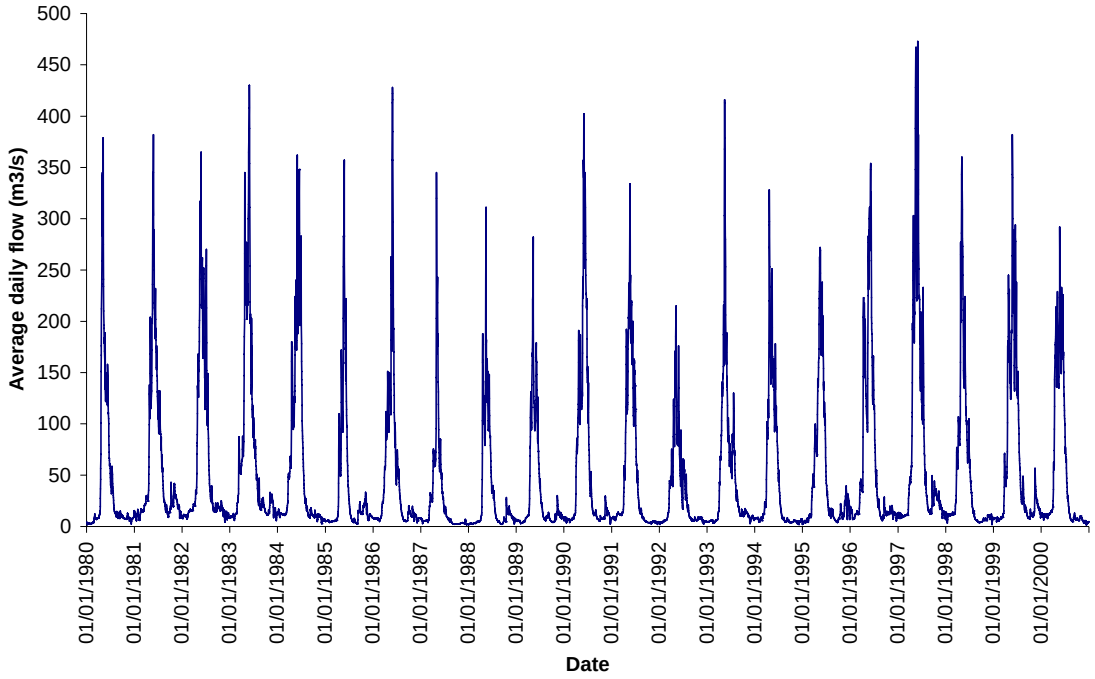


Figure 2. Kettle River at Ferry Flow (1980 - 2000)



QUALITY ASSURANCE

The water quality plots were reviewed, and values that were known to be in error or questionable were removed. The total mercury plot has been removed as it showed many detectable values which were probably errors due to false positives near the minimum detectable limits (MDLs) and artificial contamination due to the sample collection and laboratory measurement method used. Natural mercury levels in pristine areas are typically <1-2 ng/L and are 5-10 ng/L in grossly mercury-polluted waters (Pommen, 1994). These levels are at or below the lowest MDL used for mercury. Mercury monitoring in ambient water was terminated in 1994. Mercury in resident fish tissue should be monitored if there are any mercury concerns upstream in this watershed.

There were known quality assurance problems due to the gradual failure of the re-usable Teflon liners in the bakelite preservative vial caps. Over time, preservatives would leak and leach out contaminates from the bakelite vial caps and contaminate many of the 1986 to 1991 samples. This contamination problem was known to affect federal water quality

data province-wide. The primary variables affected were cadmium, chromium, copper, cyanide, lead, mercury, and zinc during this sampling period.

There were known problems due to pH methodology at the Environment Canada Laboratory in Vancouver from the about the beginning of 1986 to the end of 1988.

STATE OF THE WATER QUALITY

The state of the water quality is assessed by comparing the values to B.C. Environment's *Approved and Working Criteria for Water Quality* (Nagpal, Pommen & Swain, 1995). There are no site-specific water quality objectives for the Kettle River. All comments and observations regarding apparent trends are based solely on the visual examination of the graphically displayed data.

Any levels or trends in water quality that are deleterious to sensitive water uses, including drinking water, aquatic life and wildlife, recreation, irrigation, and livestock watering, are noted. Variables that exhibited no apparent environmental problems have not been discussed although all of these variables have been plotted and included in this report.

Total alkalinity (Figure 3) and **dissolved calcium** (Figure 11) concentrations indicate that the Kettle River at Carson is well buffered and has a low sensitivity to acid inputs.

Total aluminum concentrations often exceeded the aquatic life guideline of 0.1 mg/L dissolved aluminum (36% of 322 samples) as well as the drinking water guideline of 0.2 mg/L dissolved aluminum (28% of samples) (Figure 4). However, as the total fraction of aluminum was measured and the guidelines are expressed in terms of dissolved aluminum, an accurate assessment of attainment cannot be made. The wildlife, livestock and irrigation guideline of 5 mg/L was exceeded by two values, and the maximum recorded value was 10.3 mg/L on May 9, 2000. The strong correlation between total aluminum and turbidity (Figure 4) suggests that the majority of the aluminum was

associated with particulate matter and would therefore be unavailable to biota as well as removed by treatment for turbidity prior to consumption as drinking water.

Total cadmium concentrations invariably appear to exceed the aquatic life guideline of 0.00003 mg/L (Figure 10), but this was due to the fact that the detection limits used in the analyses were between 30 and 300 times higher than the guideline limit. Ninety-one percent of the 461 samples collected between 1981 and 2002 were at or below their respective detection limits. Only 11 of 157 **extractable cadmium** concentrations measured between 1997 and 2002 exceeded the guideline of 0.00003 mg/L. In order to properly assess cadmium concentrations, it is essential that analytical methods with a detection limit of no more than one-tenth the guideline level be employed when such methods become available.

Dissolved organic carbon concentrations showed a strong seasonal trend, typically exceeding the drinking water guideline of 4 mg/L between about March and June of every year (Figure 12). The maximum value measured at this site was 13.6 mg/L on June 22, 1998.

Dissolved chloride concentrations may be increasing slightly in the Kettle River at Carson (Figure 14). There are no guidelines for this parameter, and it is not likely that this trend is cause for concern. It is likely that this apparent trend is a result of the change in methodology in mid-1991 from an automated colorimetric method to ion chromatography.

Total chromium concentrations exceeded the aquatic life guideline of 0.001 mg/L on 54 occasions between 1990 and 2002 (16% of 341 samples), and exceeded the irrigation guideline of 0.005 mg/L on five occasions (1% of all samples) (Figure 15). There was a reasonably strong correlation between total chromium and turbidity (correlation coefficient = 0.50, $p < 0.001$; see Figure 15), suggesting that the majority of the chromium present was associated with suspended particulate matter and therefore not biologically available. Extractable chromium concentrations were well correlated to total

chromium values. If irrigation water is not filtered prior to use, prolonged irrigation may result in an elevation of this metal in soils, although the low level of exceedences suggest that this is not likely.

Total cobalt concentrations were generally low, with only seven values (2% of the 341 samples collected) having concentrations above the aquatic life guideline of 0.0009 mg/L (Figure 16). The maximum value (0.0088 mg/L) was well below the irrigation guideline of 0.05 mg/L.

Specific conductivity values also varied seasonally, with maximum values during winter (low-flow) and minimum values occurring during spring freshet (Figure 20). This reflects the influence of groundwater contributions to baseline flows. Values were generally between 50 and 250 µS/cm, and no values exceeded the drinking water guideline of 700 µS/cm.

Total copper values measured between 1988 and 1991 were suspect due to preservative vial contamination (see Quality Assurance section, above). After this period, 31 values exceeded the hardness-dependent average total copper guideline, and seven values exceeded the maximum total copper guideline (Figure 21). These values were generally strongly correlated with turbidity values (see Figure 21), suggesting copper was associated with particulate matter and therefore not available to biota.

Aquatic life guidelines for **total fluoride** are hardness dependent: at hardness < 50 mg/L, the guideline is a maximum of 0.2 mg/L fluoride, while at hardness 50 mg/L or higher, the guideline is 0.3 mg/L. Eighty-six values (15% of 582 values) exceeded the hardness-dependent guideline for total fluoride (Figure 23). Fluoride and turbidity are negatively correlated (correlation coefficient = -0.29, $p < 0.001$), suggesting that maximum fluoride concentrations occur during low-flow periods

Total iron concentrations ranged from 0.0036 mg/L to 17.6 mg/L, with 101 values (23% of the 442 samples collected) exceeding the aquatic life guideline of 0.3 mg/L (Figure

26). These exceedences typically occurred during periods of elevated turbidity (see Figure 24), suggesting that the iron would not be available to biota.

Total lead concentrations between 1988 and 1991 are suspect due to preservative vial contamination, and therefore will not be considered in this report. After 1991, three samples had total lead concentrations exceeding the hardness-dependent average guideline for the protection of aquatic life (Figure 28). As was typical for other metals, these exceedences showed a strong correlation with turbidity, suggesting that the lead was not toxic to aquatic life. No values exceeded the maximum aquatic life guideline.

Concentrations of **total manganese** ranged from 0.0002 mg/L to a maximum of 0.449 mg/L (Figure 30). Two samples had concentrations exceeding the irrigation guideline of 0.2 mg/L. Total manganese and turbidity concentrations were strongly correlated (correlation coefficient = 0.61, $p < 0.001$), suggesting that elevated levels of manganese were associated with particulate matter.

pH values were generally within the acceptable drinking water range (between 6.5 and 8.5 pH units) over the period of record (Figure 36). Exceptions were one value below 6.5 (6.4, on May 26, 1986), but this was likely due to problems with control in the laboratory, and six values above 8.5 which are not likely a cause for concern. All of these excursions were measured before 1995. The highest recorded pH value was 8.97, on September 6, 1994.

Concentrations of **non-filterable residue** (total suspended solids) ranged from below detectable limits (< 5 mg/L) to a maximum of 426 mg/L on June 10, 1996 (Figure 40). Non-filterable residue values showed a strong seasonal trend, with peak values occurring during the spring freshet (correlation coefficient between NFR and flow = 0.44, $p < 0.001$). Fifty-four values (20% of the 269 samples collected between 1980 and 2002) exceeded the general fisheries guideline of 25 mg/L.

Total selenium concentrations were generally low, with most values near the detection limit of 0.0001 mg/L (Figure 42). The exception to this were two values occurring in 2000 and 2001 of 0.0022 mg/L and 0.0029 mg/L, slightly exceeding the aquatic life guideline of 0.002 mg/L.

Water temperatures in the Kettle River at Carson exceeded the aesthetic drinking water guideline (15°C) almost every summer between 1980 and 2002. During most summers, the general fisheries guideline of 19°C was also exceeded (Figure 48).

As expected, **turbidity** values followed a trend similar to that of non-filterable residue, with maximum values occurring during the spring freshet (Figure 50). One value (84 NTU, on June 4, 1986) exceeded the aesthetic recreation guideline of 50 NTU. There was a good positive correlation between turbidity and flow (correlation coefficient = 0.56, $p < 0.001$).

Five hundred and two samples were analyzed for **total zinc** concentrations between 1981 and 2002 (Figure 53). Of these, 30 (7%) individual values exceeded the hardness-dependent average aquatic life guideline and seven values (2%) exceeded the maximum aquatic life guideline. Total zinc concentrations were not well-correlated with turbidity (correlation coefficient = 0.00, $p = 0.96$) (Figure 51), and so the bio-availability of the zinc is unknown.

Figure 3. Kettle River at Carson - Alkalinity, Total

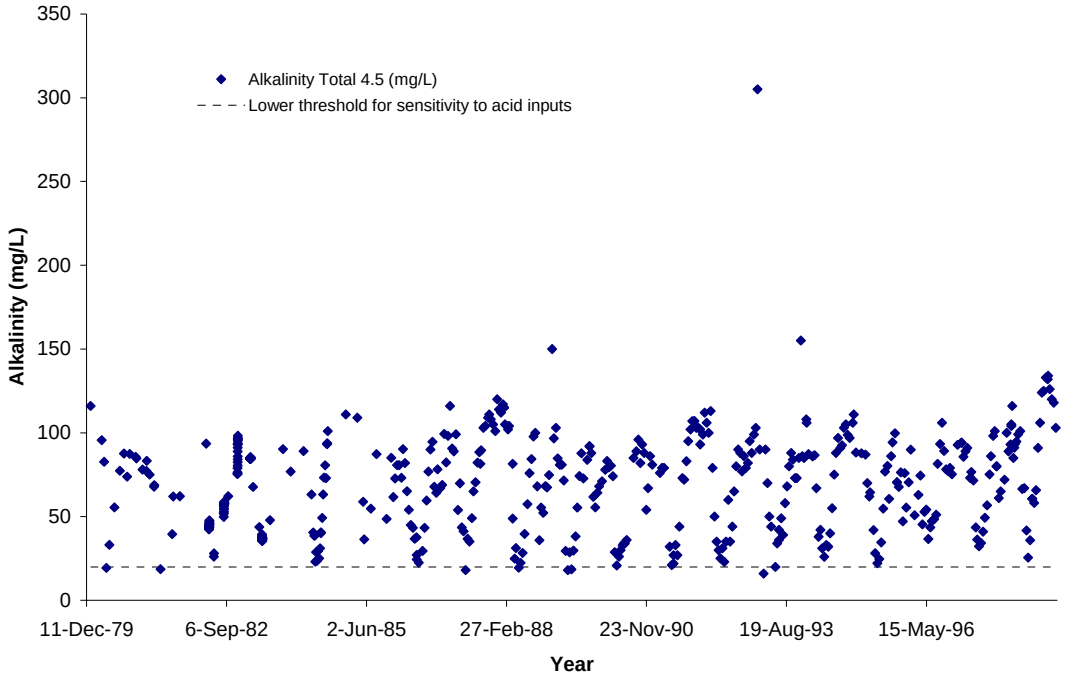


Figure 4. Kettle River at Carson - Aluminum, Total

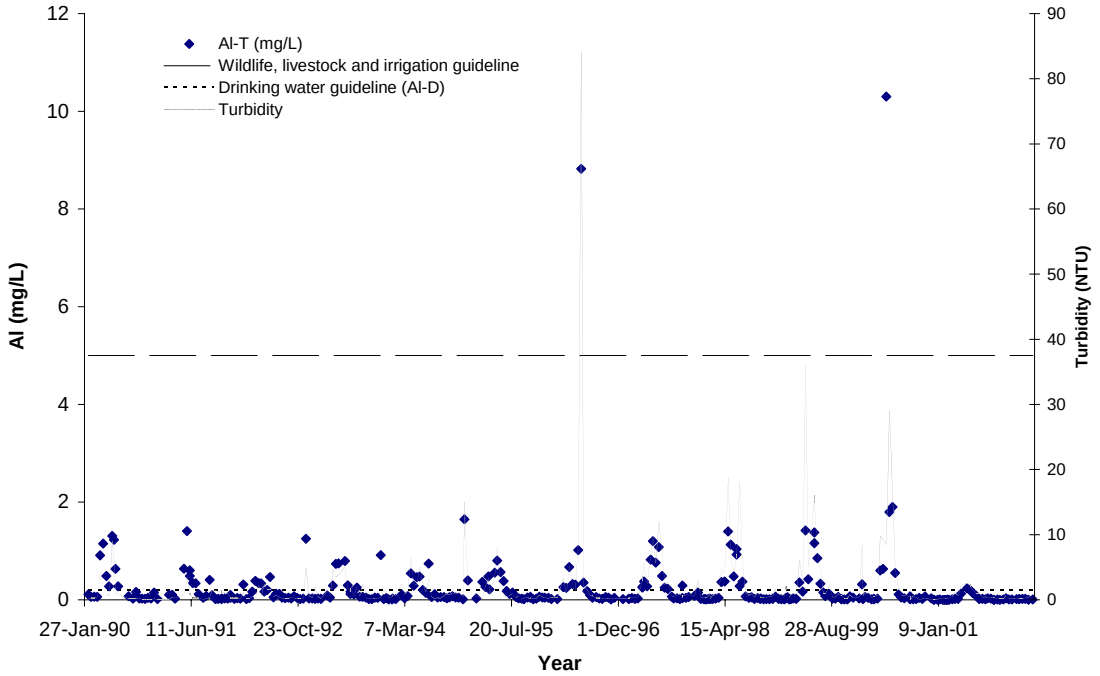


Figure 5. Kettle River at Carson - Arsenic, Total, Dissolved and Extractable

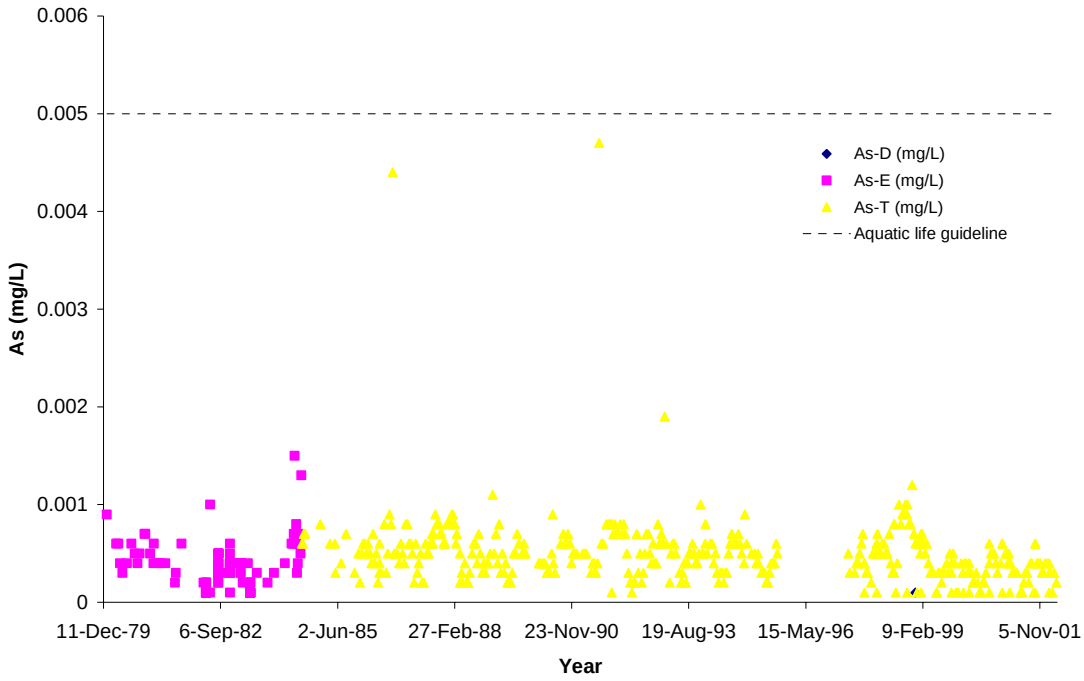


Figure 6. Kettle River at Carson - Barium, Total and Extractable

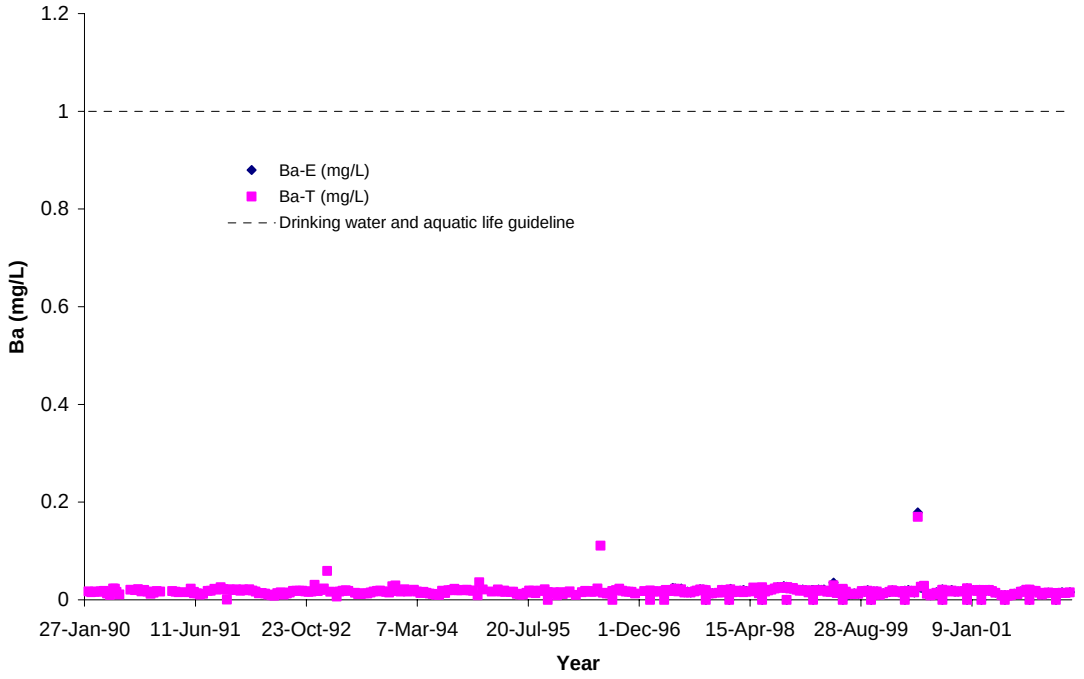


Figure 7. Kettle River at Carson - Beryllium, Total and Extractable

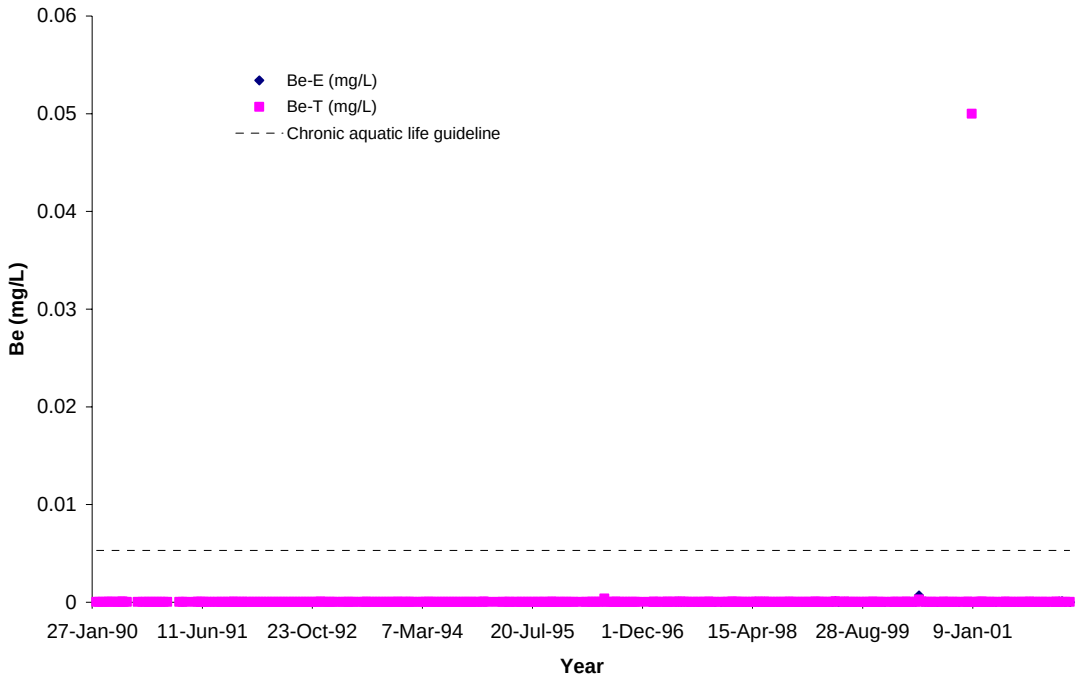


Figure 8. Kettle River at Carson - Boron, Extractable

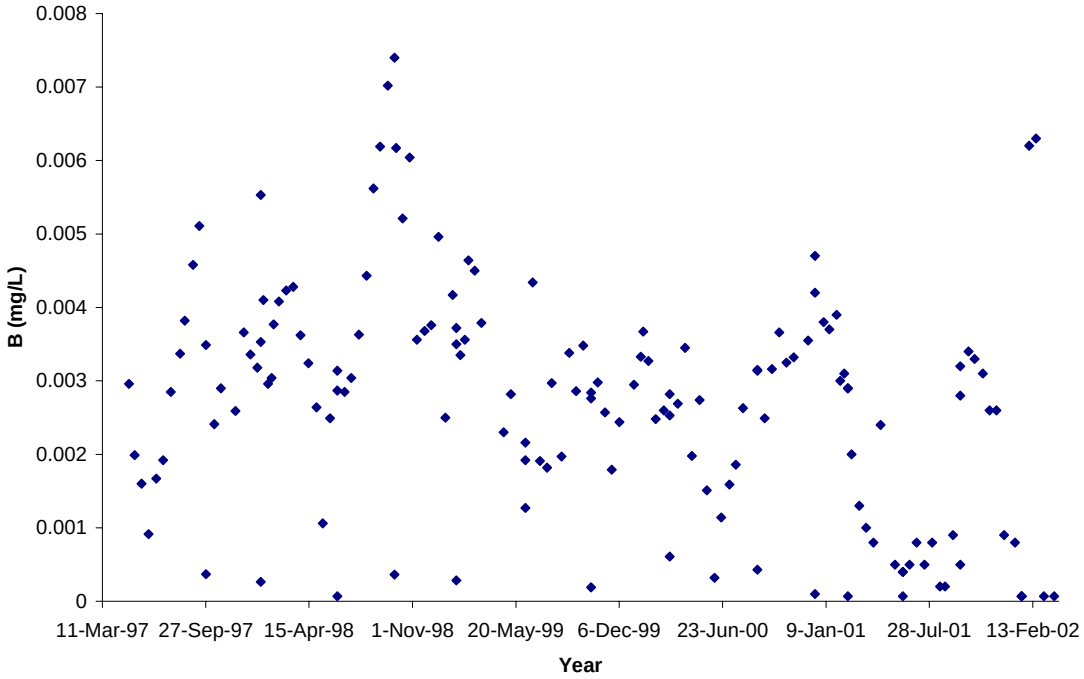


Figure 9. Kettle River at Carson - Bromide, Dissolved

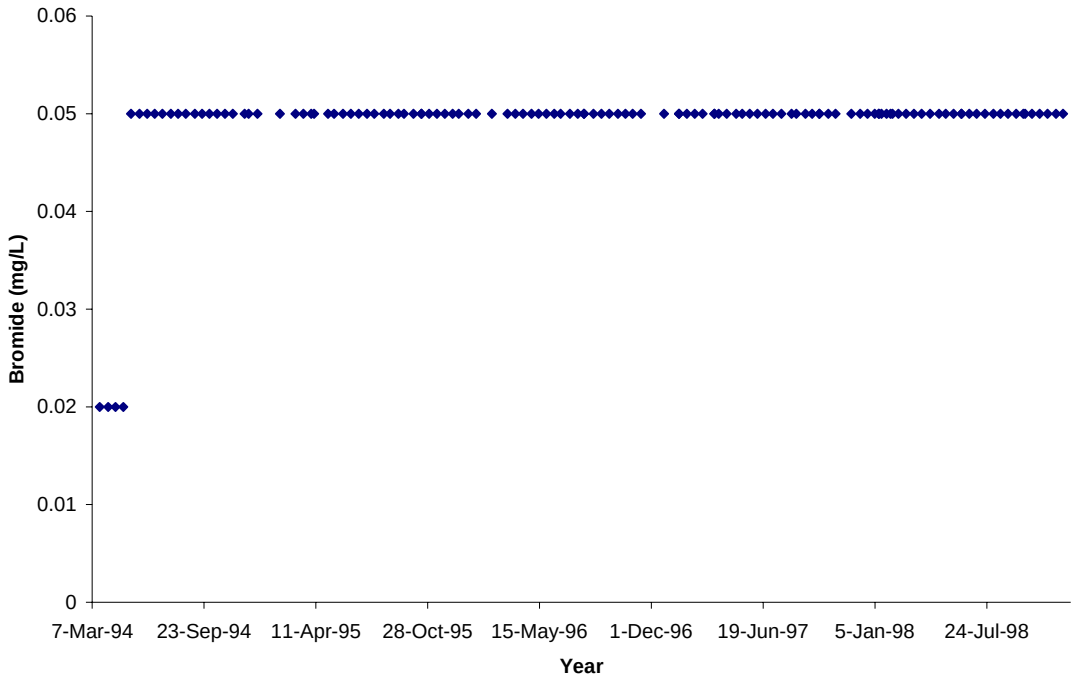


Figure 10. Kettle River at Carson - Cadmium, Total and Extractable

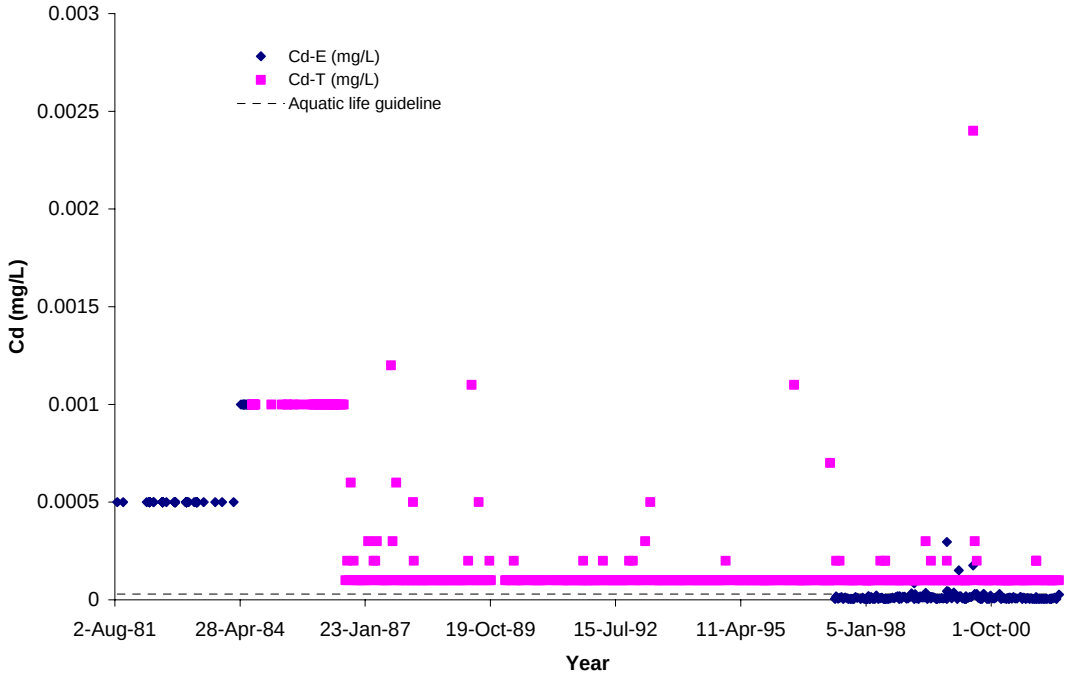


Figure 11. Kettle River at Carson - Calcium, Dissolved and Extractable

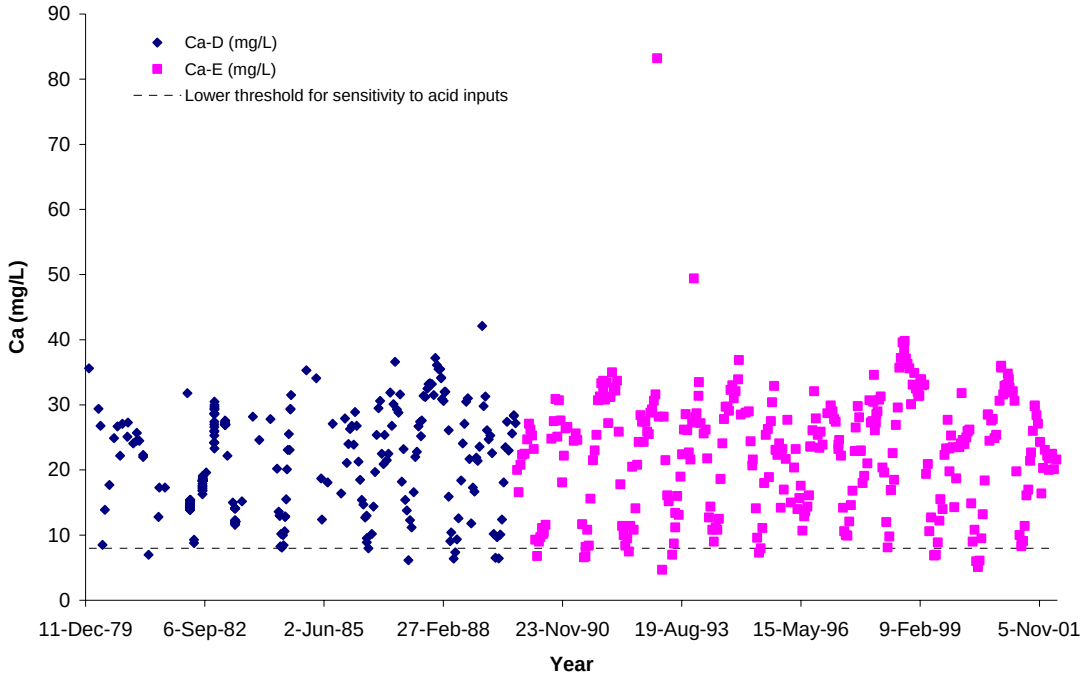


Figure 12. Kettle River at Carson - Carbon, Dissolved Organic

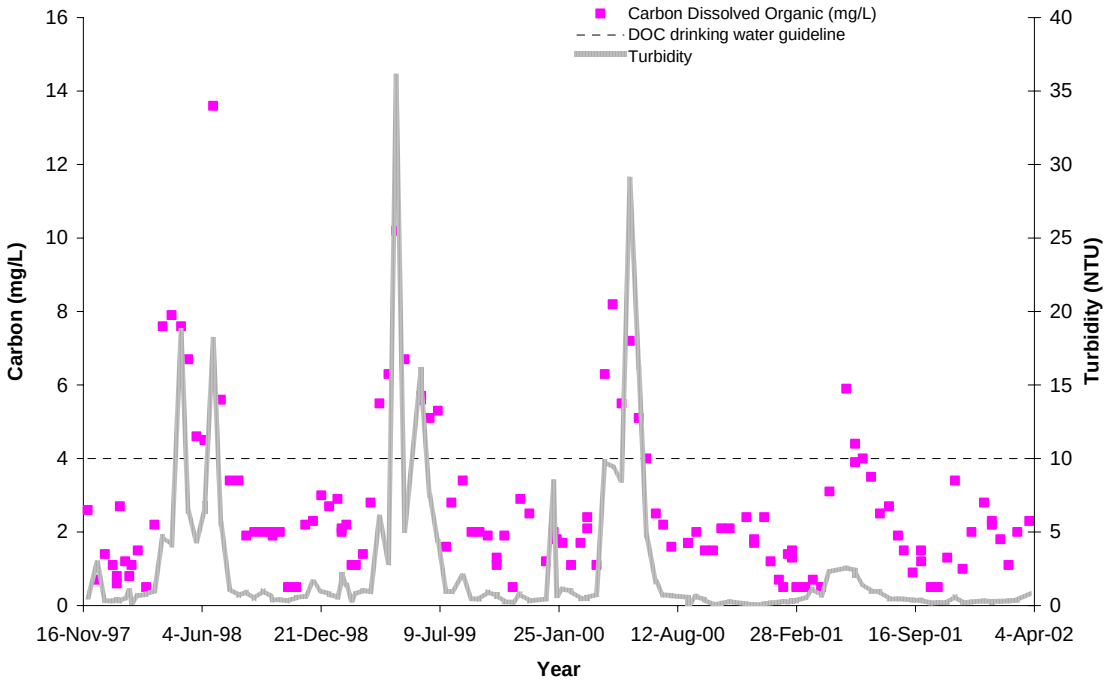


Figure 13. Kettle River at Carson - Carbon, Dissolved Inorganic and Total Dissolved

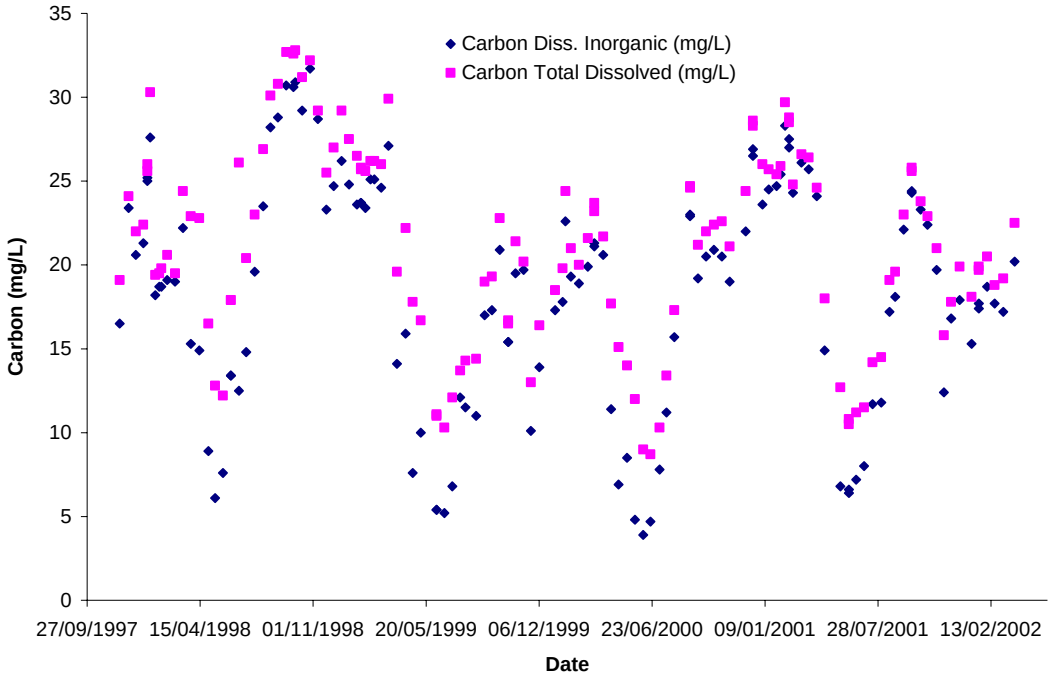


Figure 14. Kettle River at Carson - Chloride, Dissolved

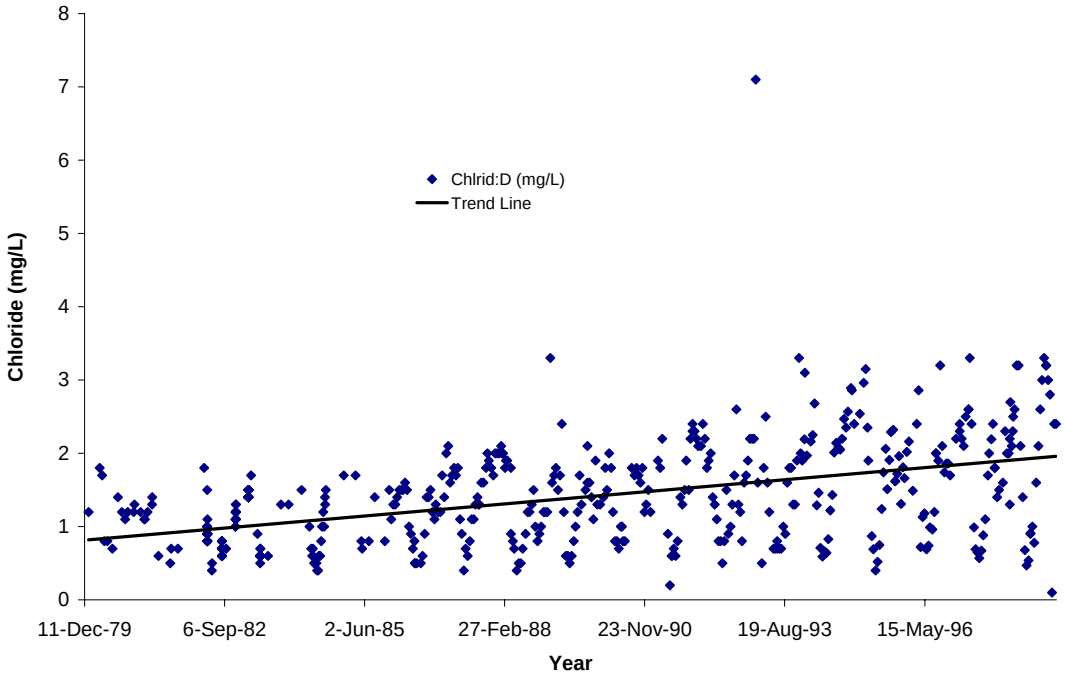


Figure 15. Kettle River at Carson - Chromium, Total and Extractable

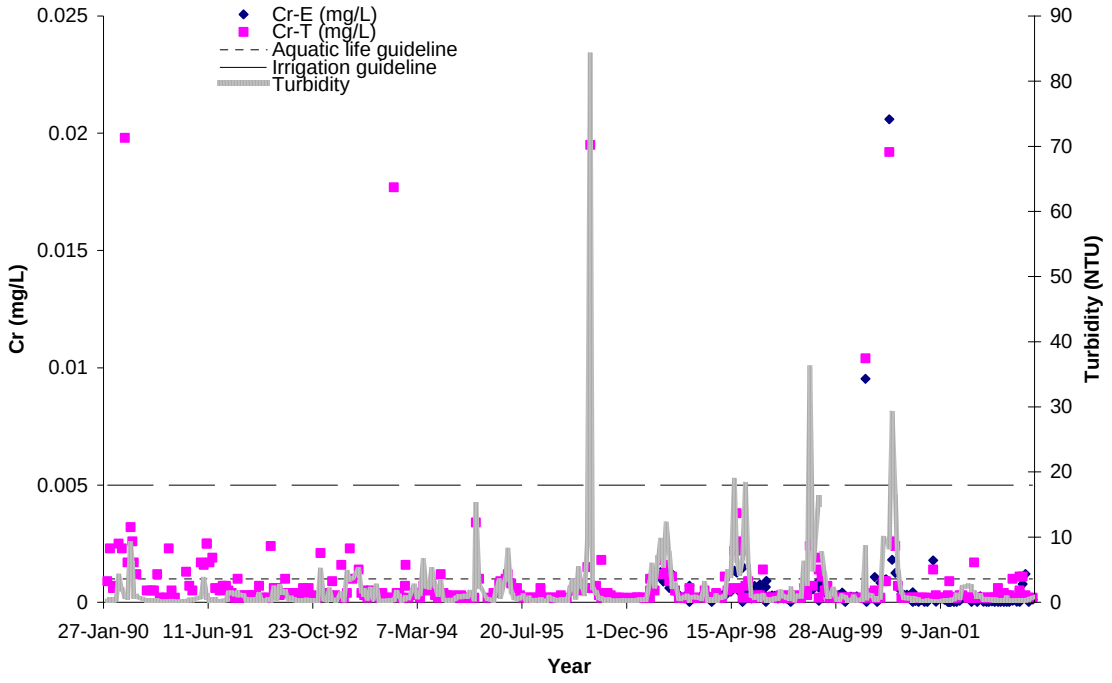


Figure 16. Kettle River at Carson - Cobalt, Total and Extractable

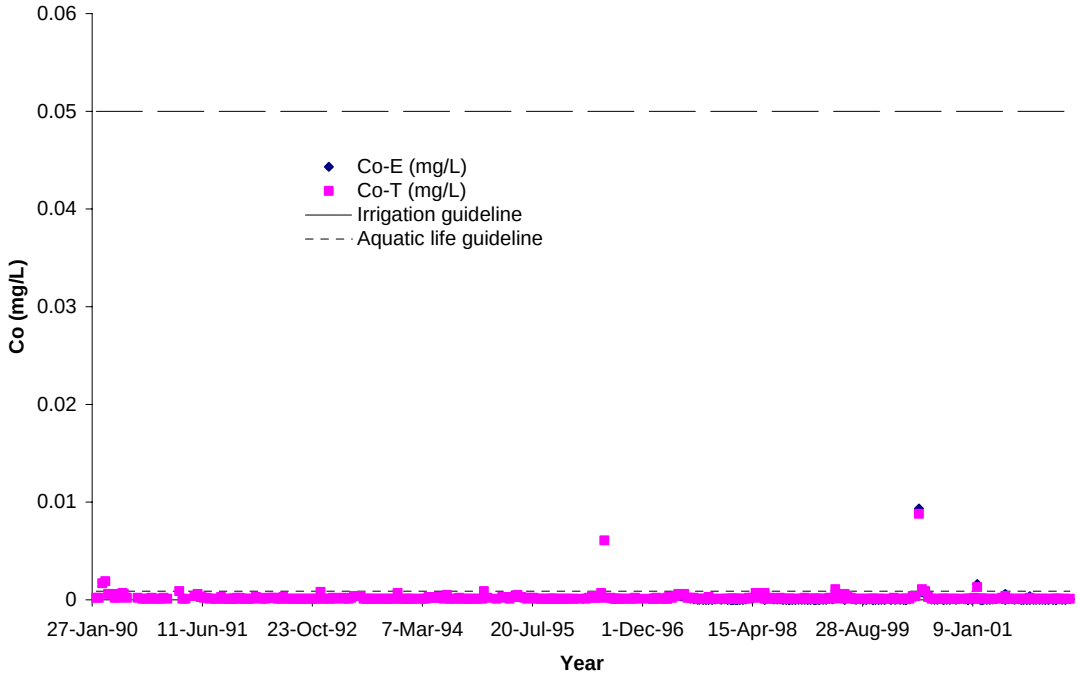


Figure 17. Kettle River at Carson - Fecal Coliforms

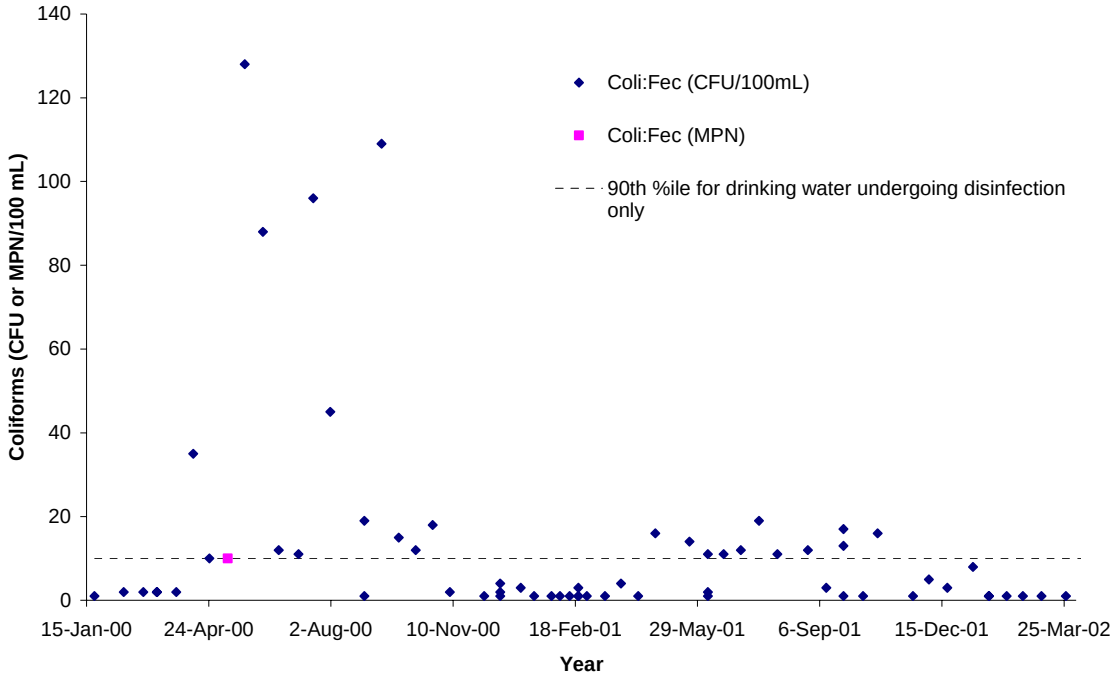


Figure 18. Kettle River at Carson - Colour, True

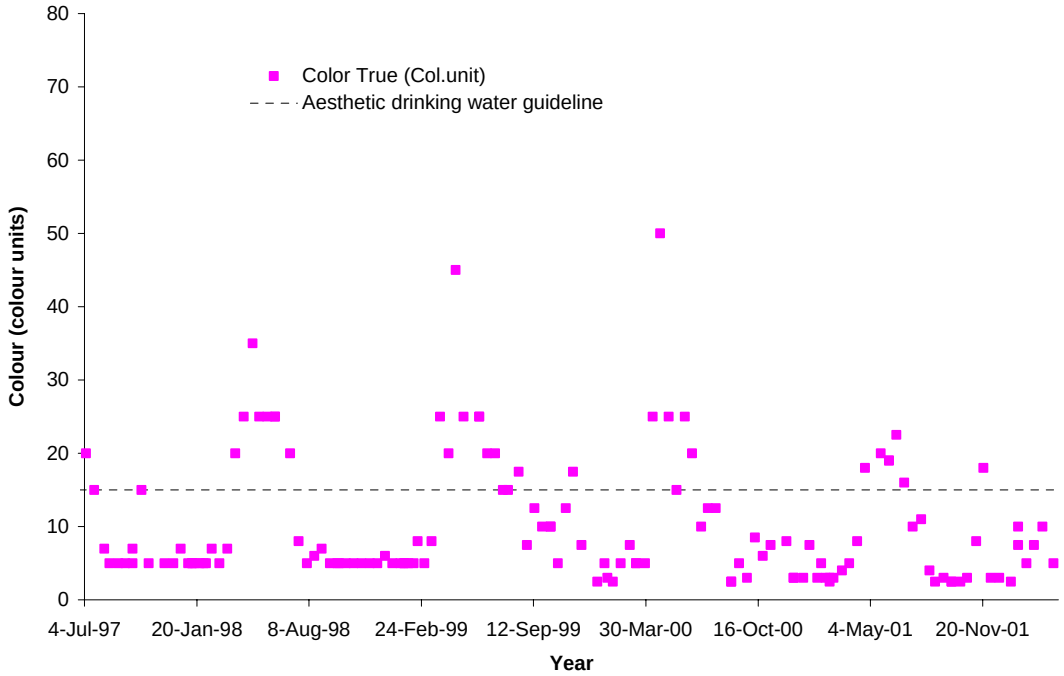


Figure 19. Kettle River at Carson - Colour, Apparent

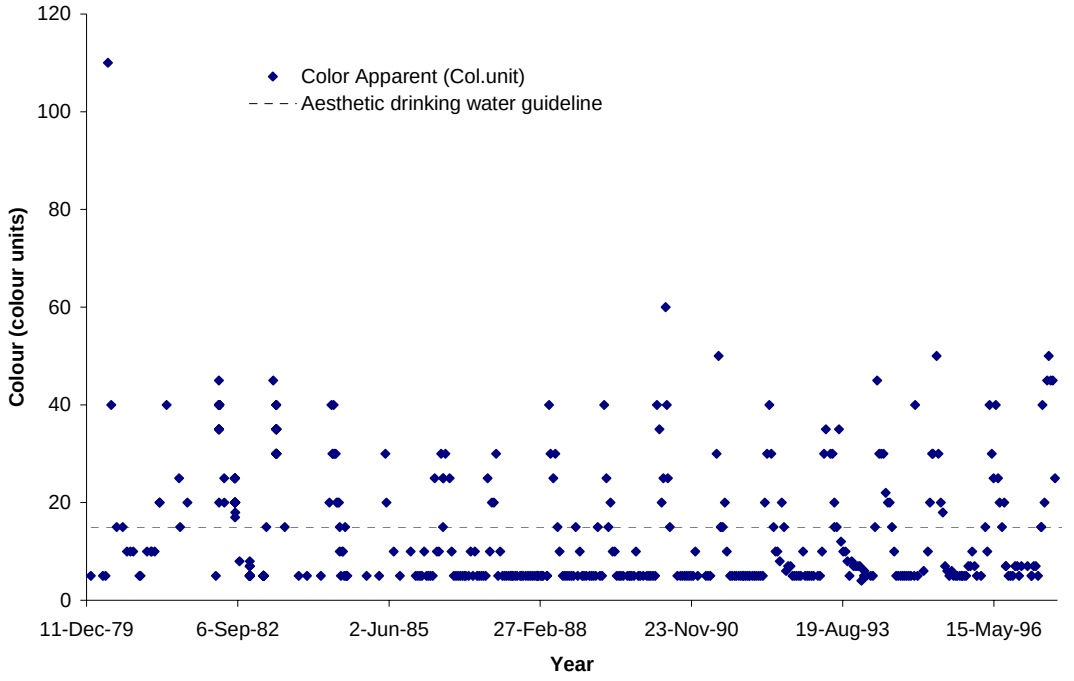


Figure 20. Kettle River at Carson - Conductivity, Specific

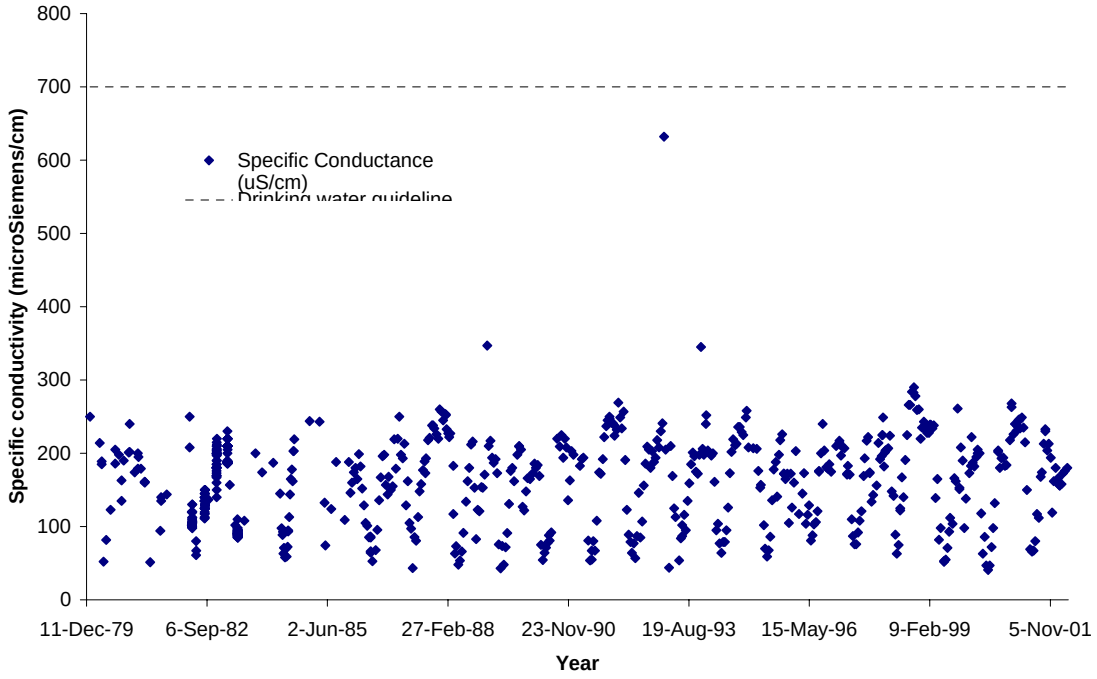


Figure 21. Kettle River at Carson - Copper, Total and Extractable

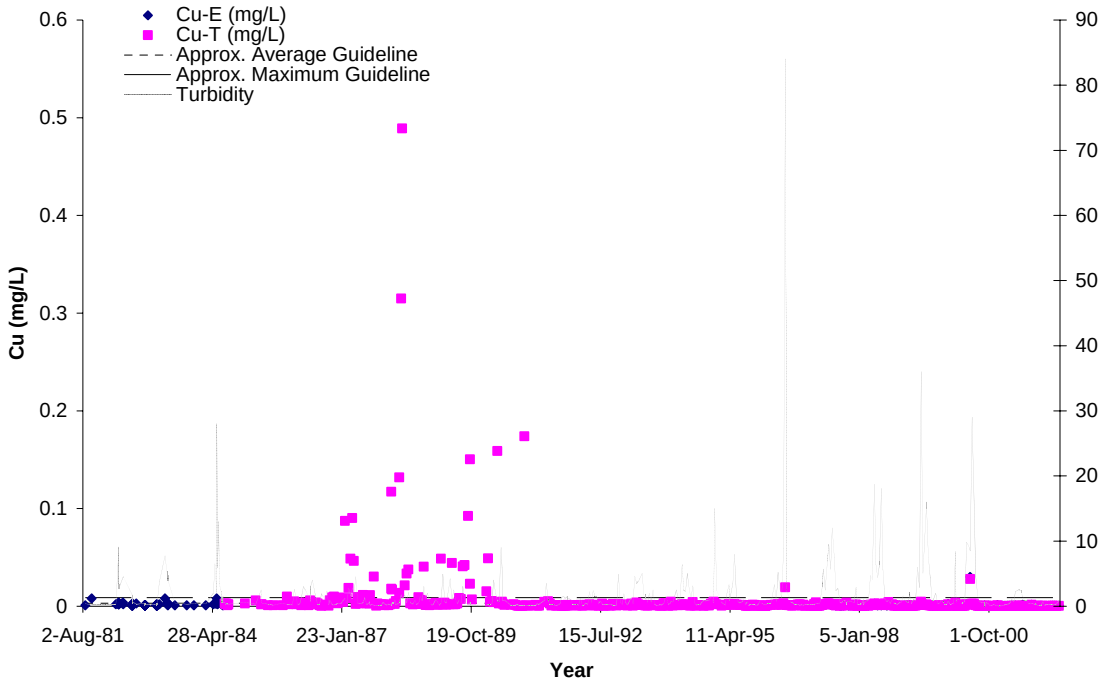


Figure 22. Kettle River at Carson - Cyanide, WAD and SAD+SCN

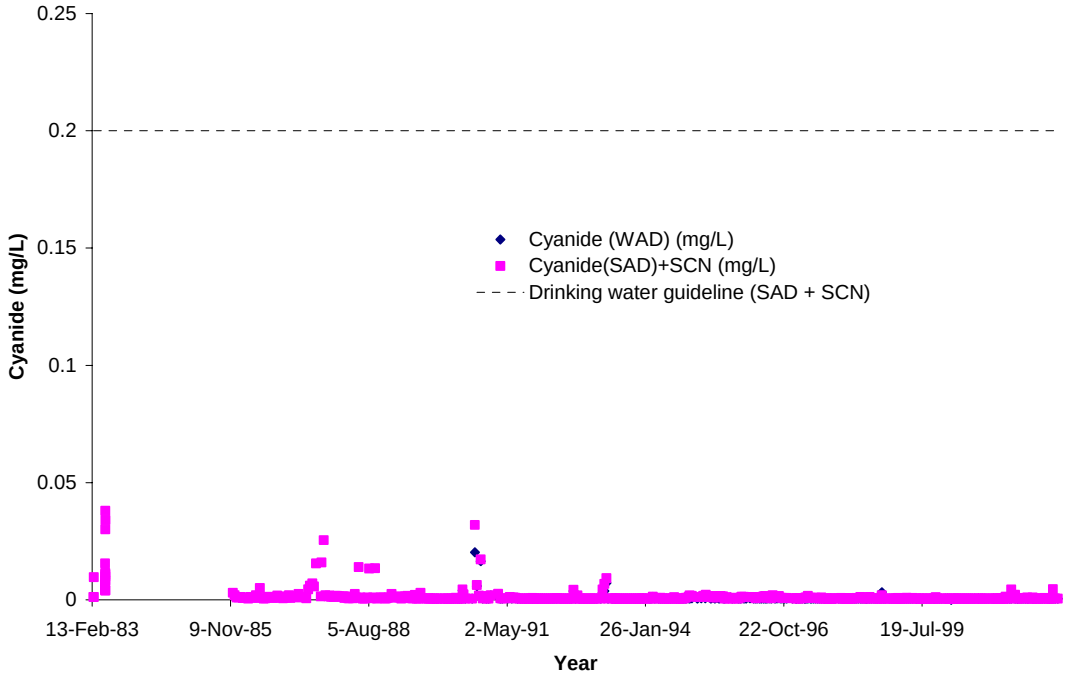


Figure 23. Kettle River at Carson - Fluoride, Total and Dissolved

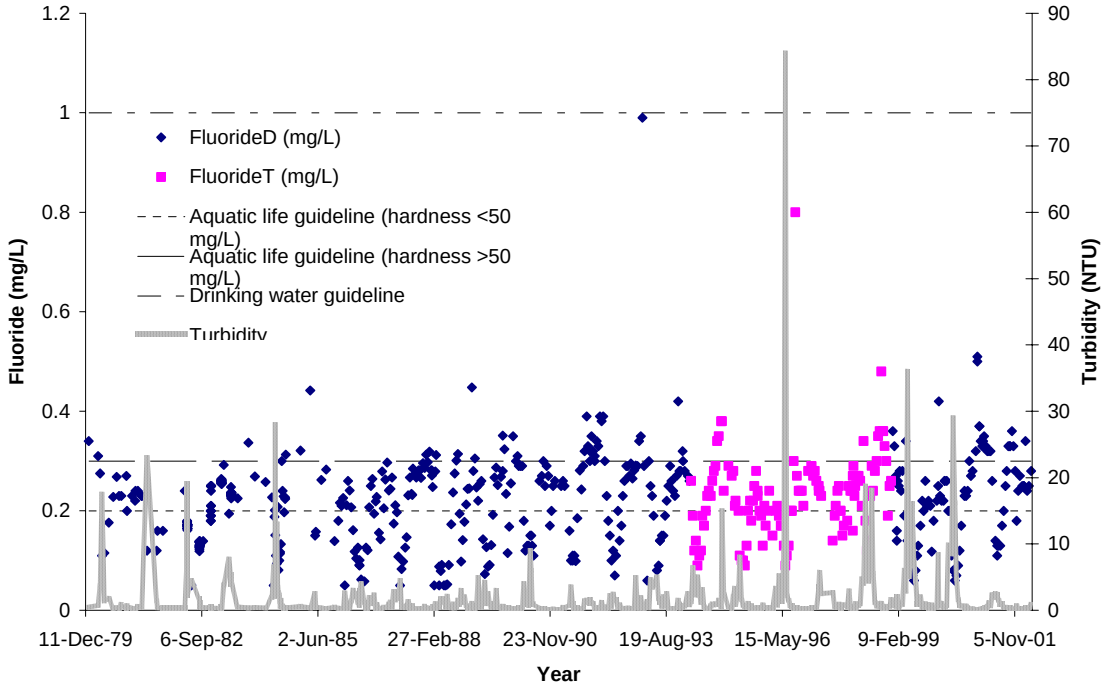


Figure 24. Kettle River at Carson - Gallium, Extractable

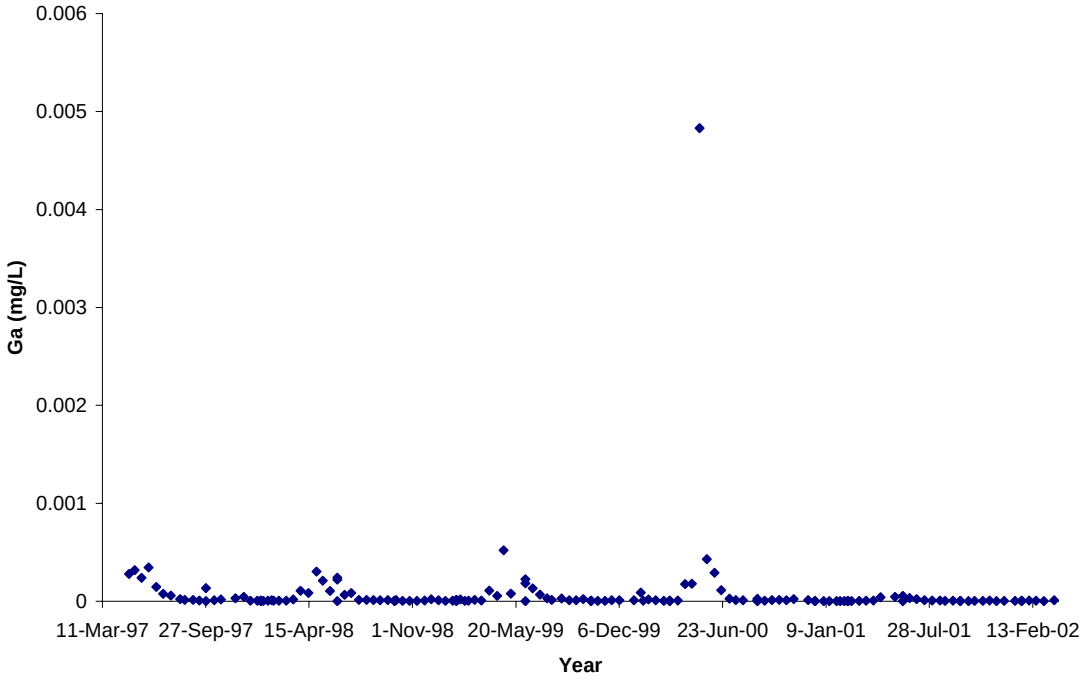


Figure 25. Kettle River at Carson - Hardness, Total

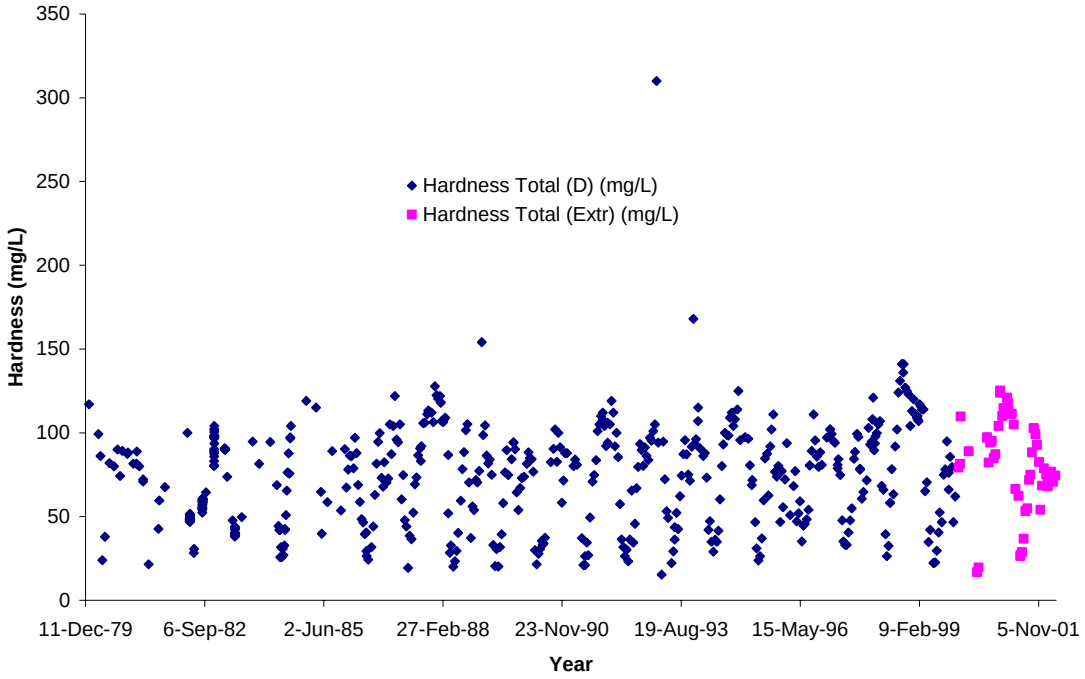


Figure 26. Kettle River at Carson - Iron, Total and Extractable

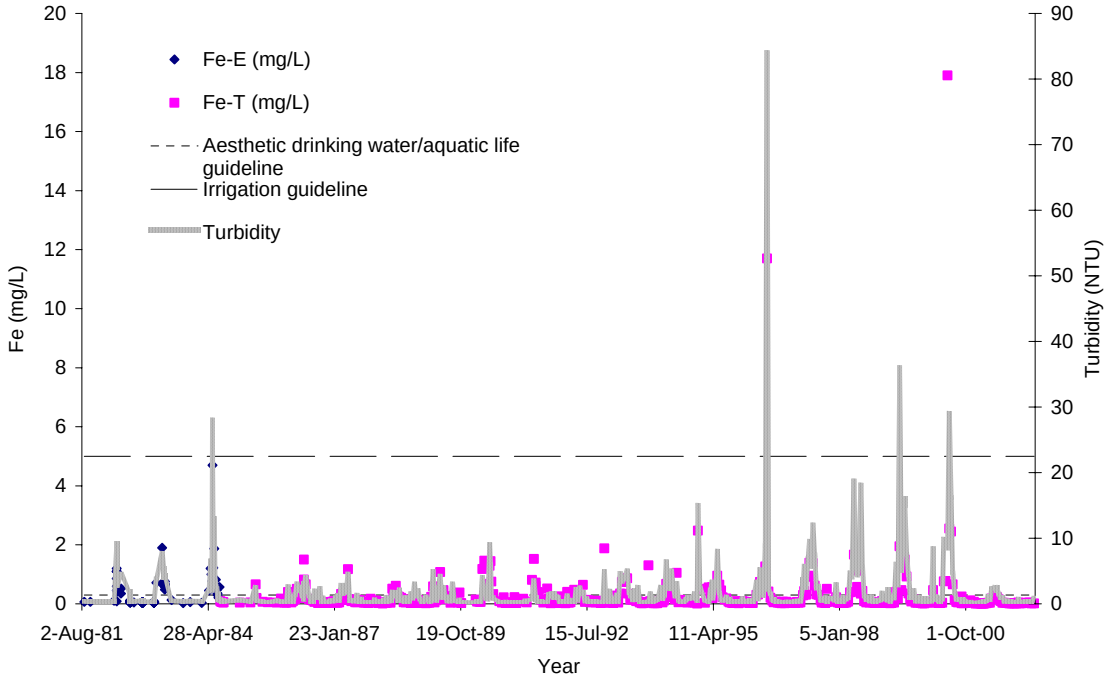


Figure 27. Kettle River at Carson - Lanthanum, Extractable

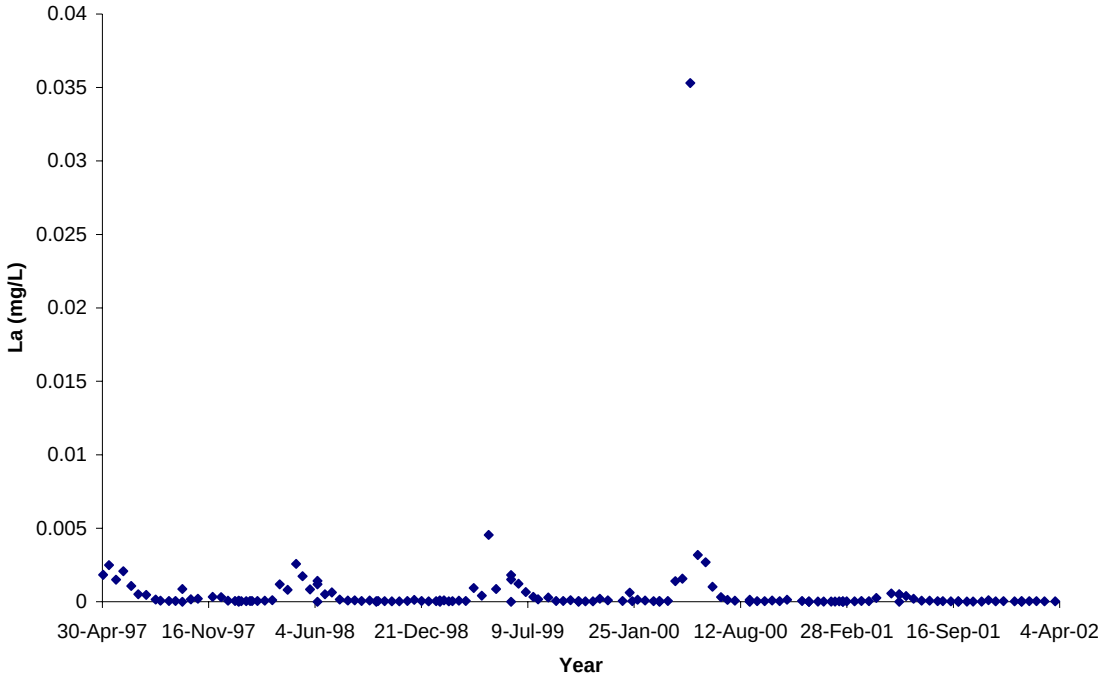


Figure 28. Kettle River at Carson - Lead, Total and Extractable

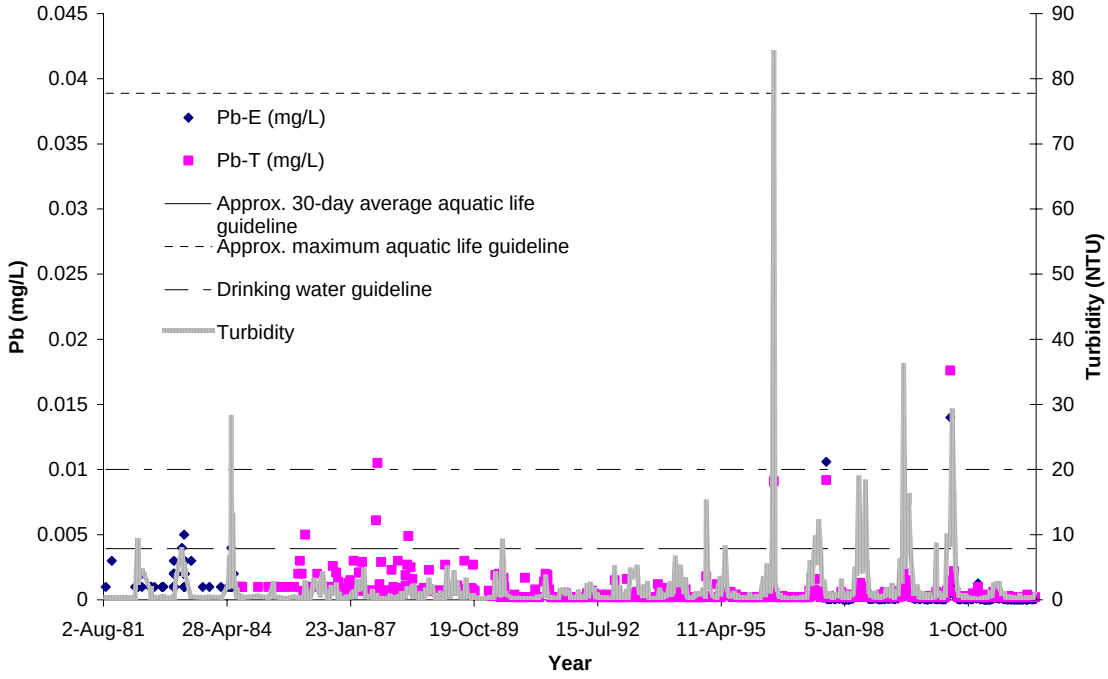


Figure 29. Kettle River at Carson - Lithium, Total and Extractable

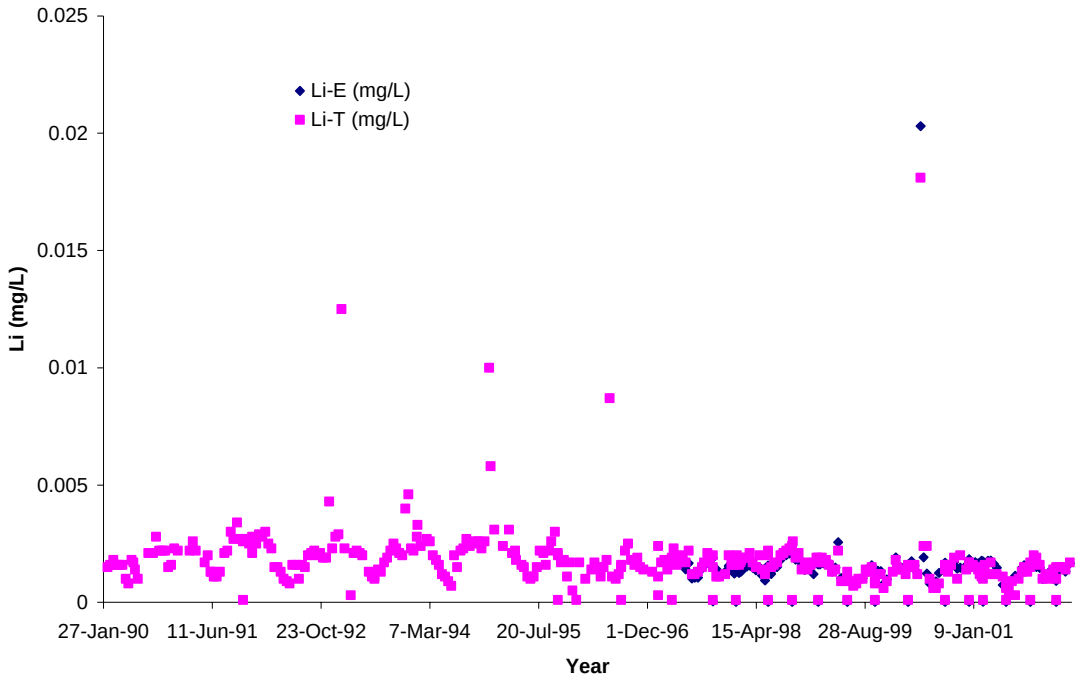


Figure 30. Kettle River at Carson - Magnesium, Dissolved and Extractable

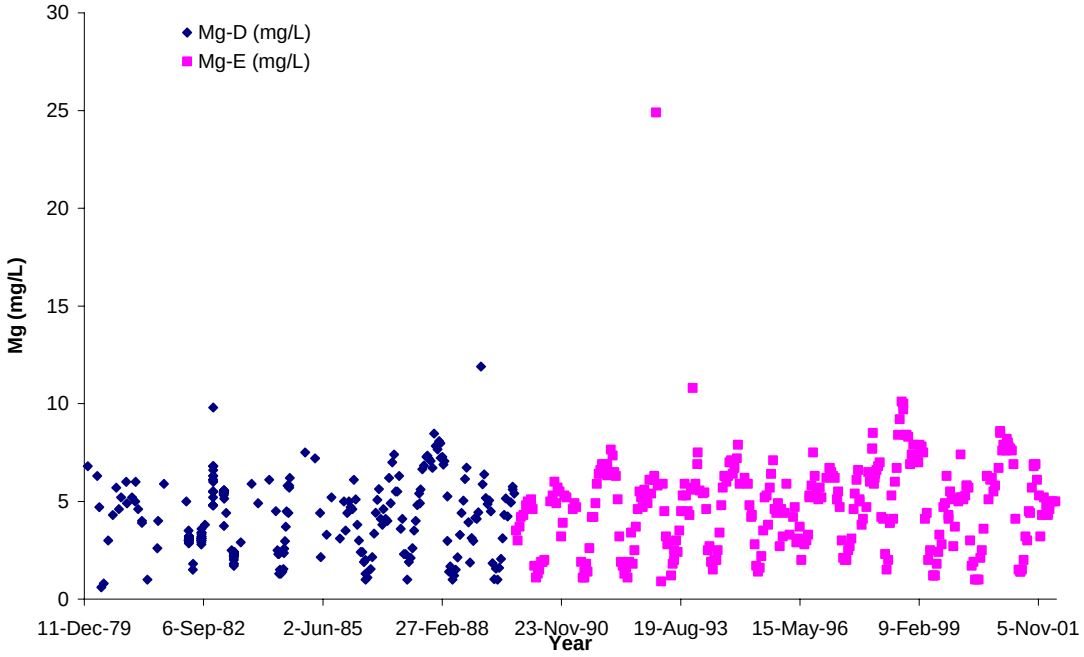


Figure 31. Kettle River at Carson - Manganese, Total and Extractable

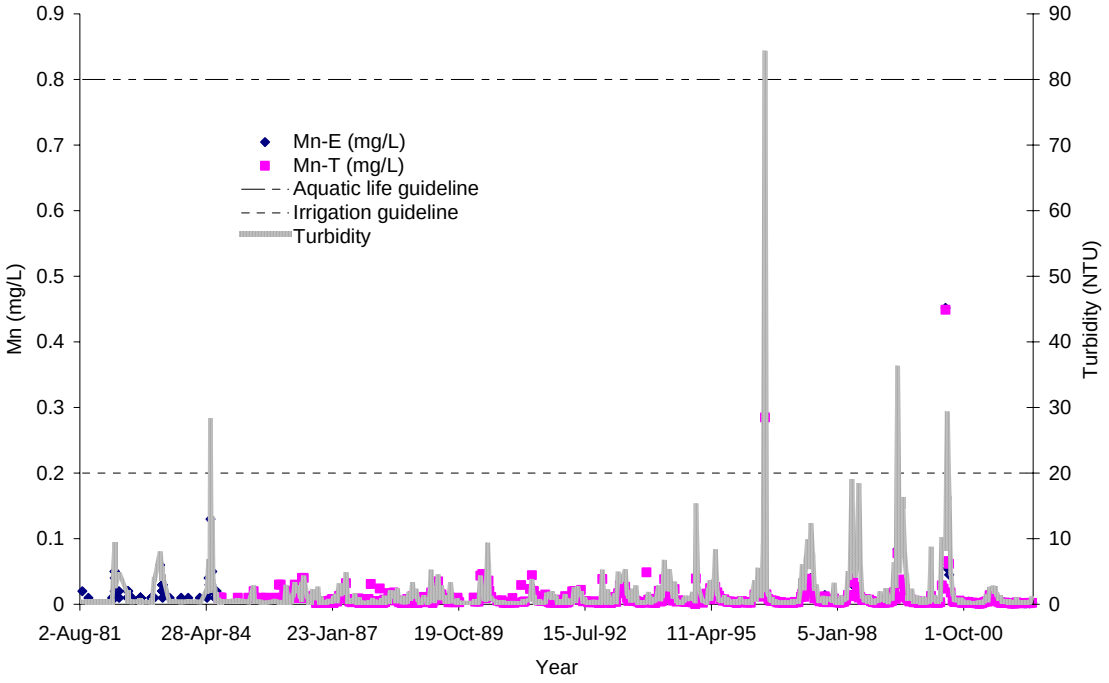


Figure 32. Kettle River at Carson - Molybdenum, Total

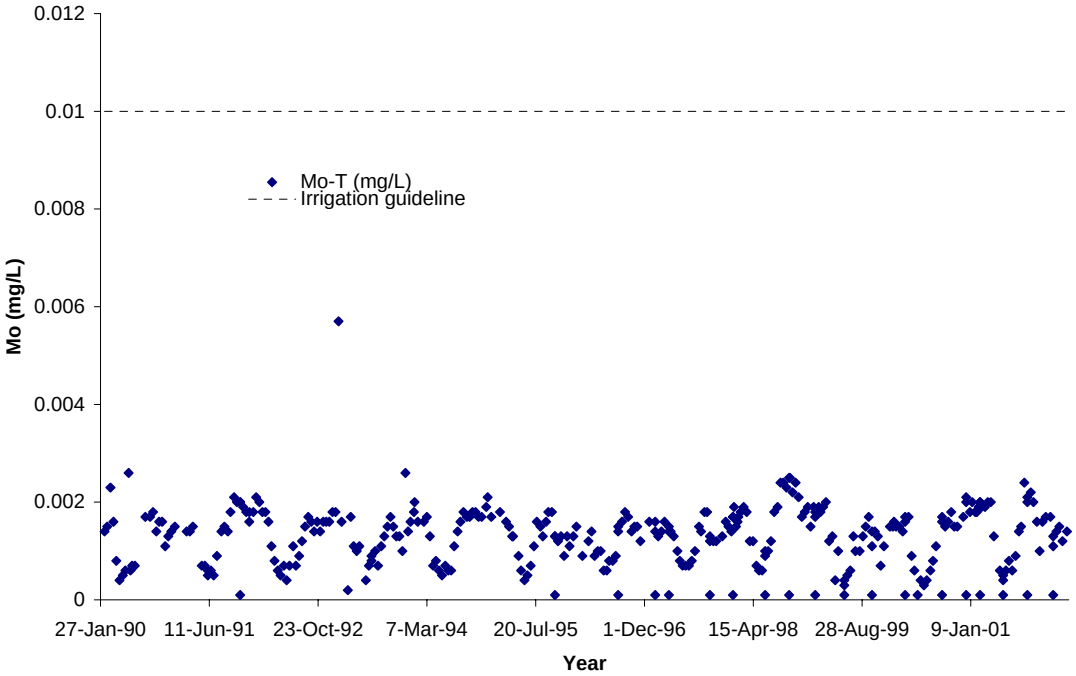


Figure 33. Kettle River at Carson - Nickel, Total and Extractable

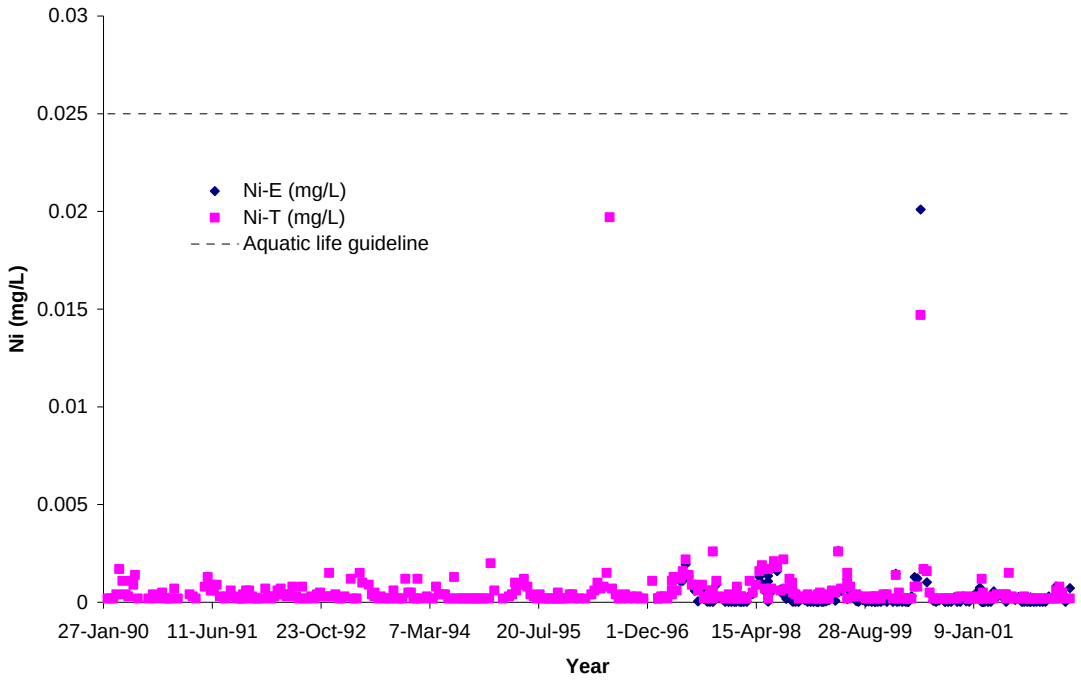


Figure 34. Kettle River at Carson - Nitrate and/or Nitrite

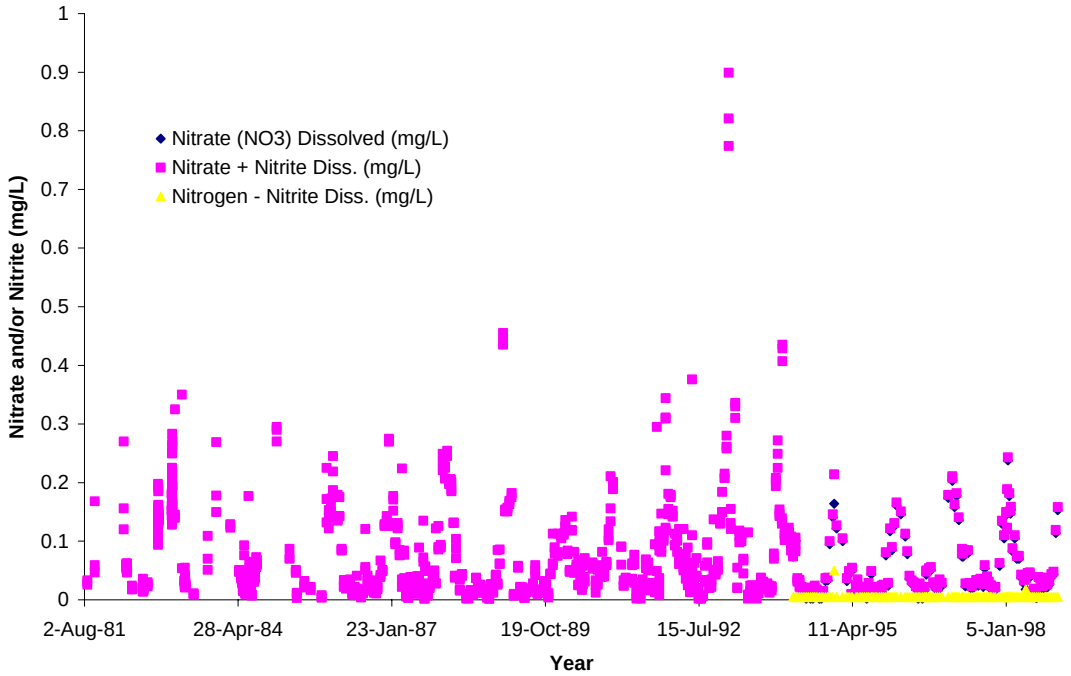


Figure 35. Kettle River at Carson - Nitrogen, Total Dissolved

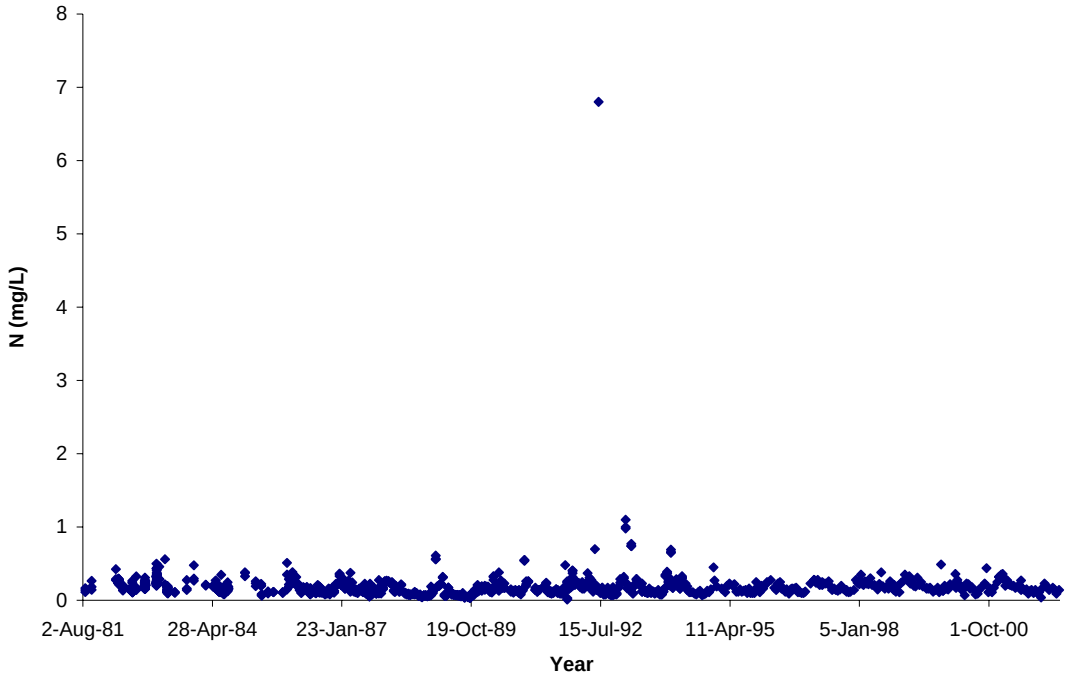


Figure 36. Kettle River at Carson - pH

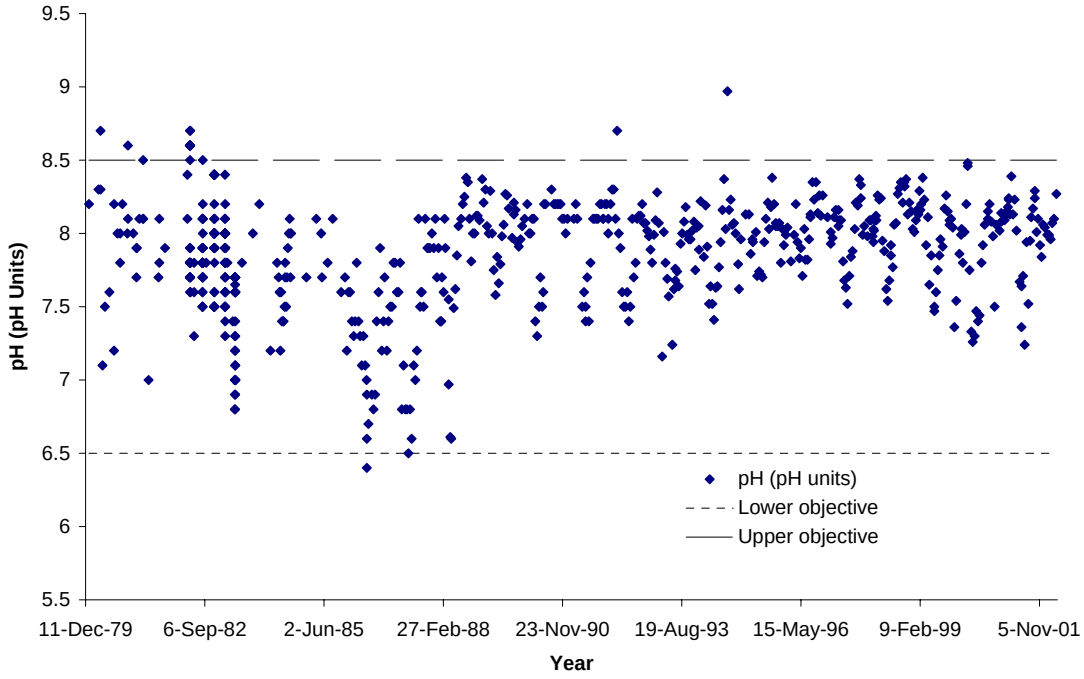


Figure 37. Kettle River at Carson - Phosphorus, Total and Total Dissolved

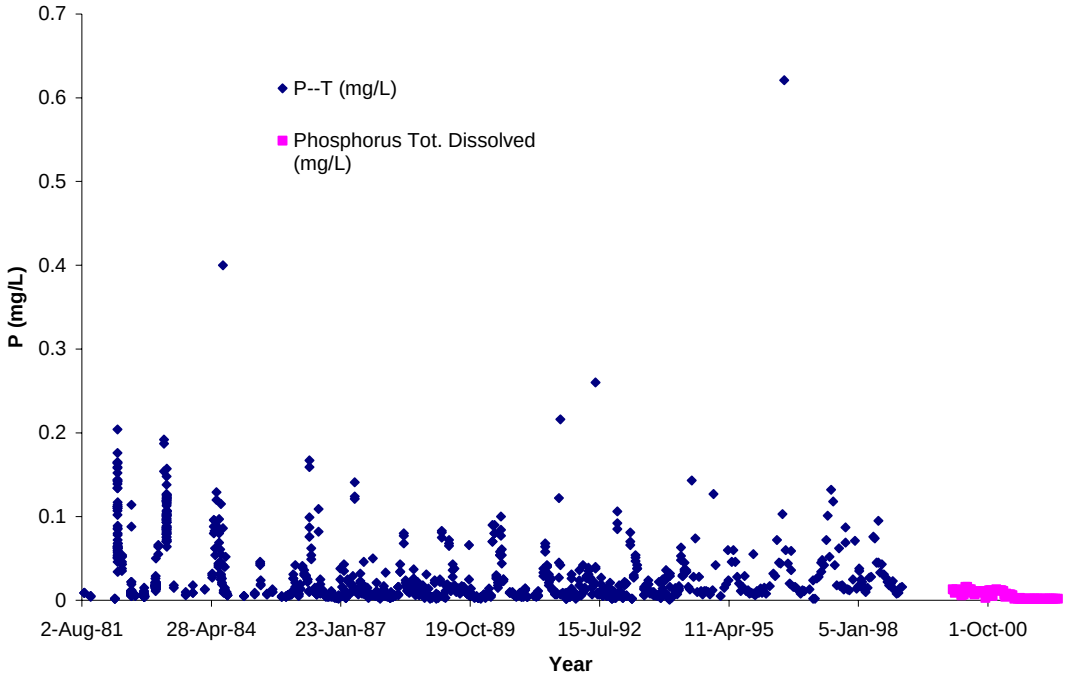


Figure 38. Kettle River at Carson - Potassium, Dissolved and Extractable

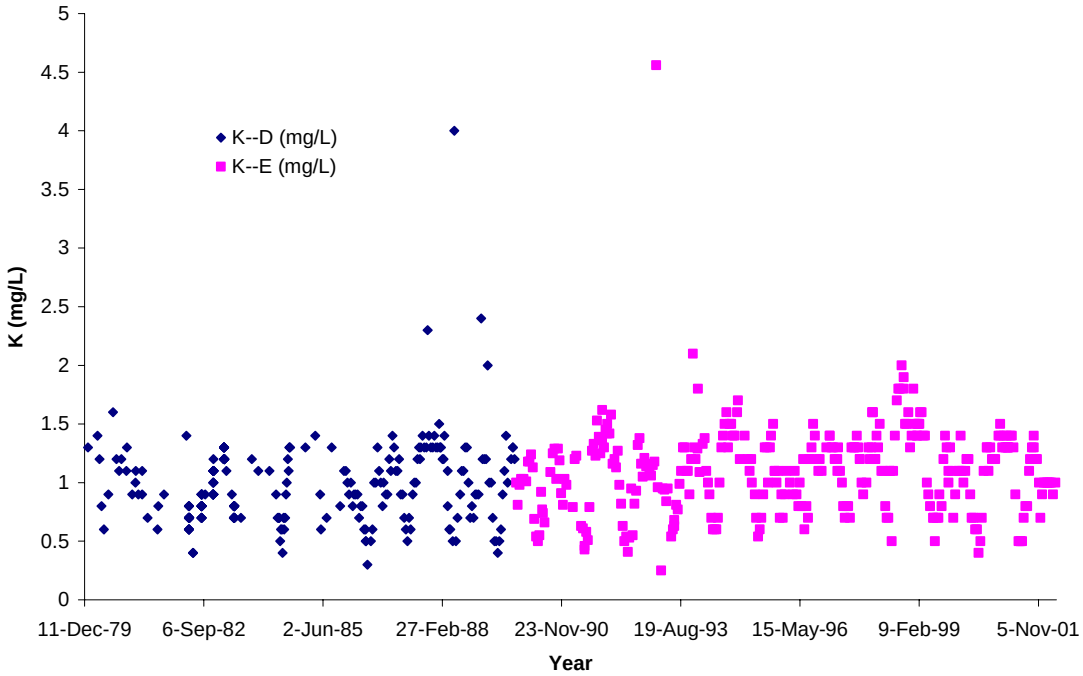


Figure 39. Kettle River at Carson - Residue, Filterable

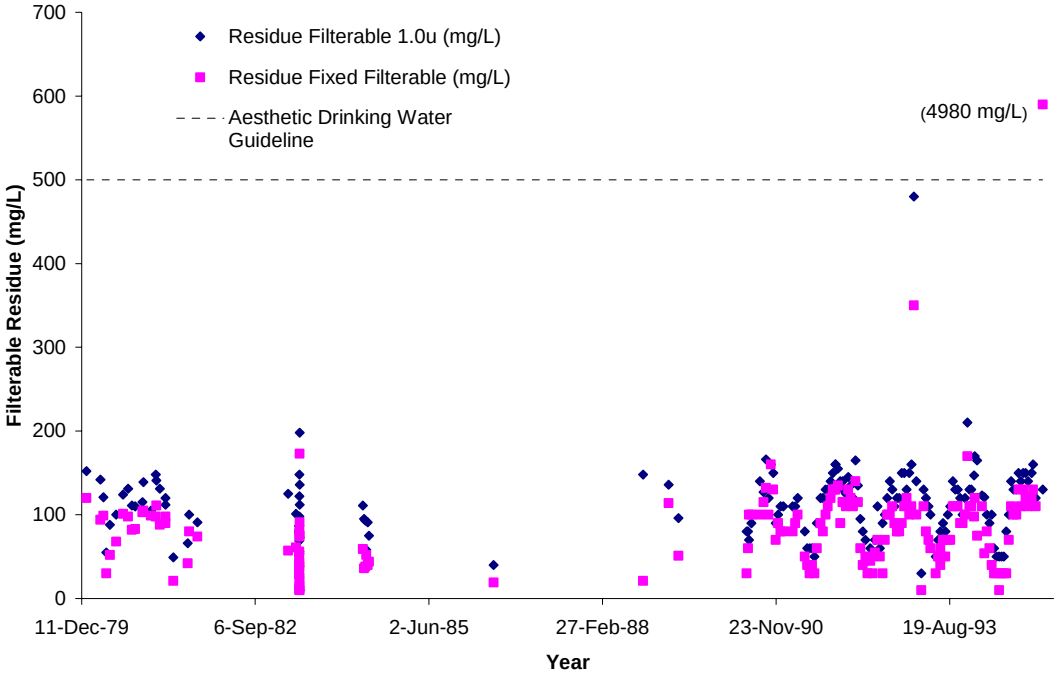


Figure 40. Kettle River at Carson - Residue, Non-Filterable

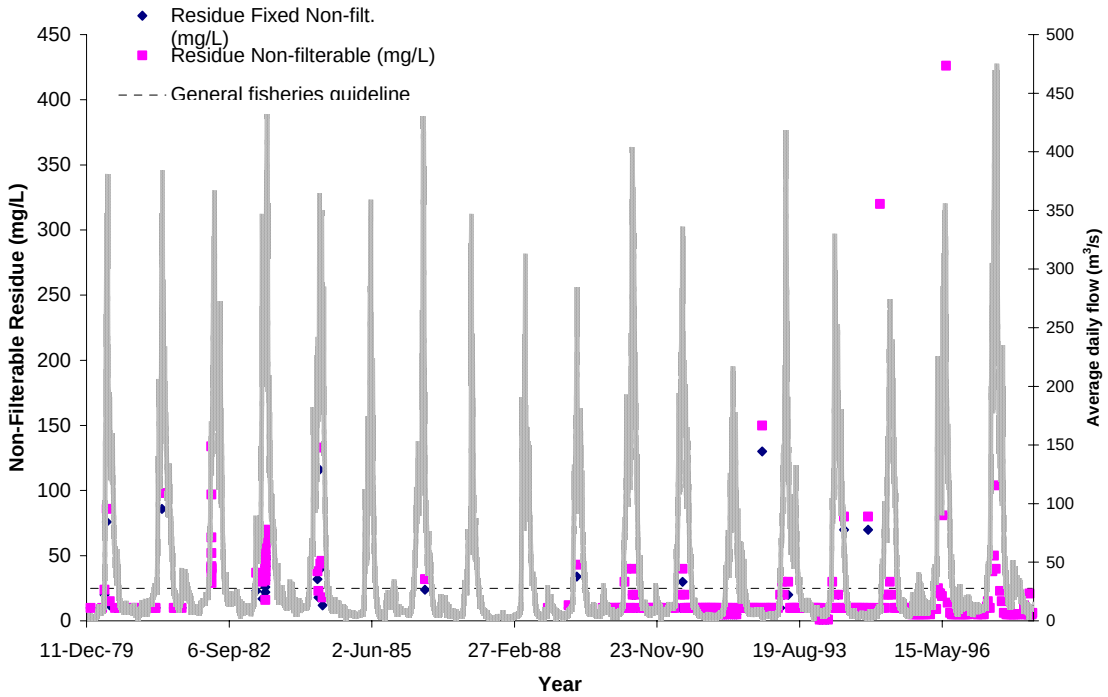


Figure 41. Kettle River at Carson - Rubidium, Extractable

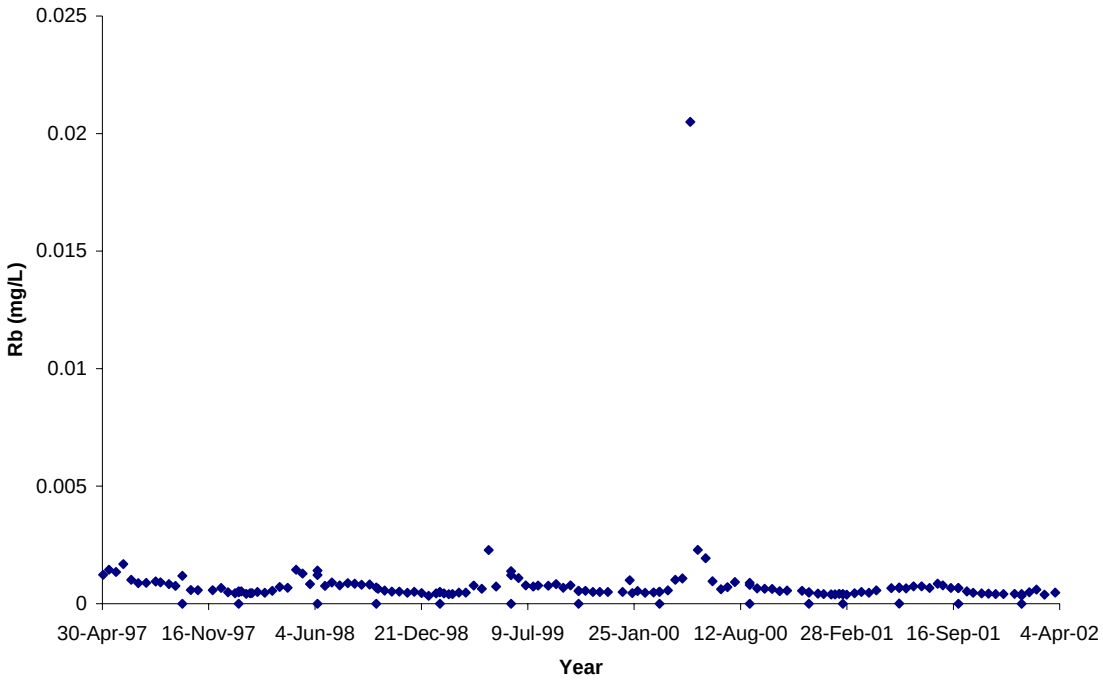


Figure 42. Kettle River at Carson - Selenium, Total, Dissolved and Extractable

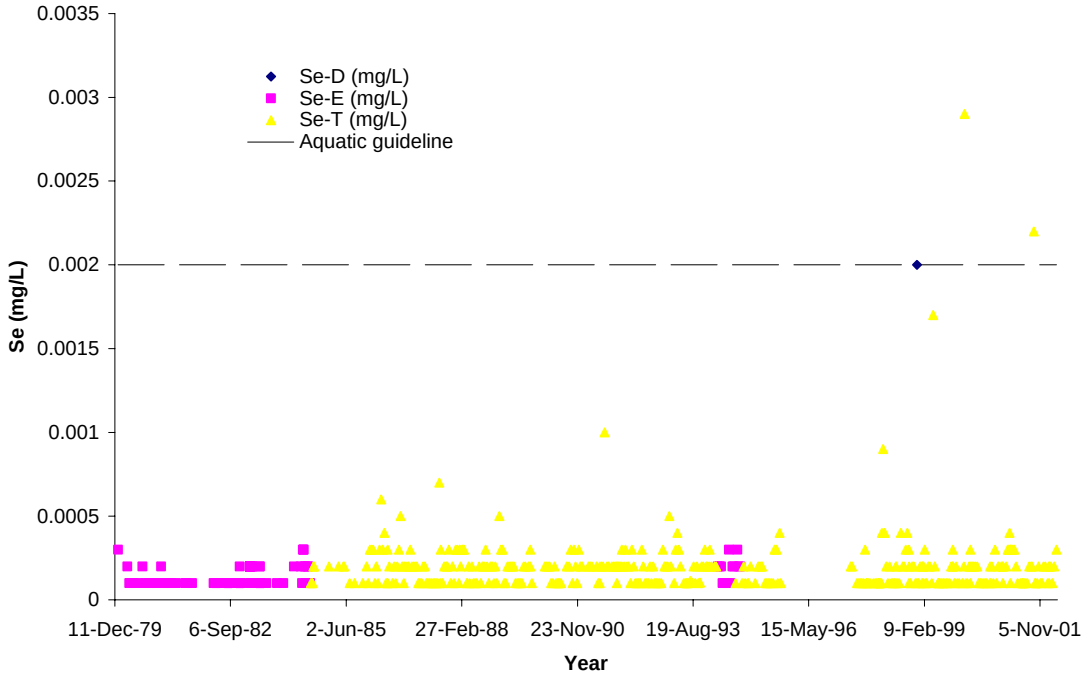


Figure 43. Kettle River at Carson - Silicon, Dissolved and Extractable and Silica, Dissolved

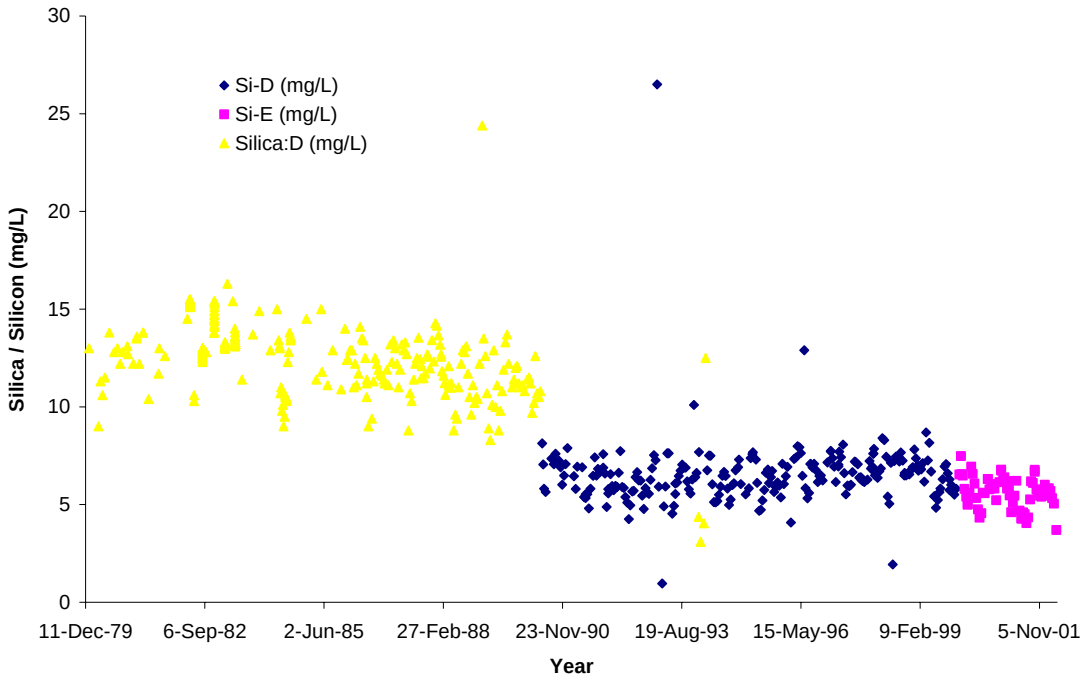


Figure 44. Kettle River at Carson - Silver, Total and Extractable

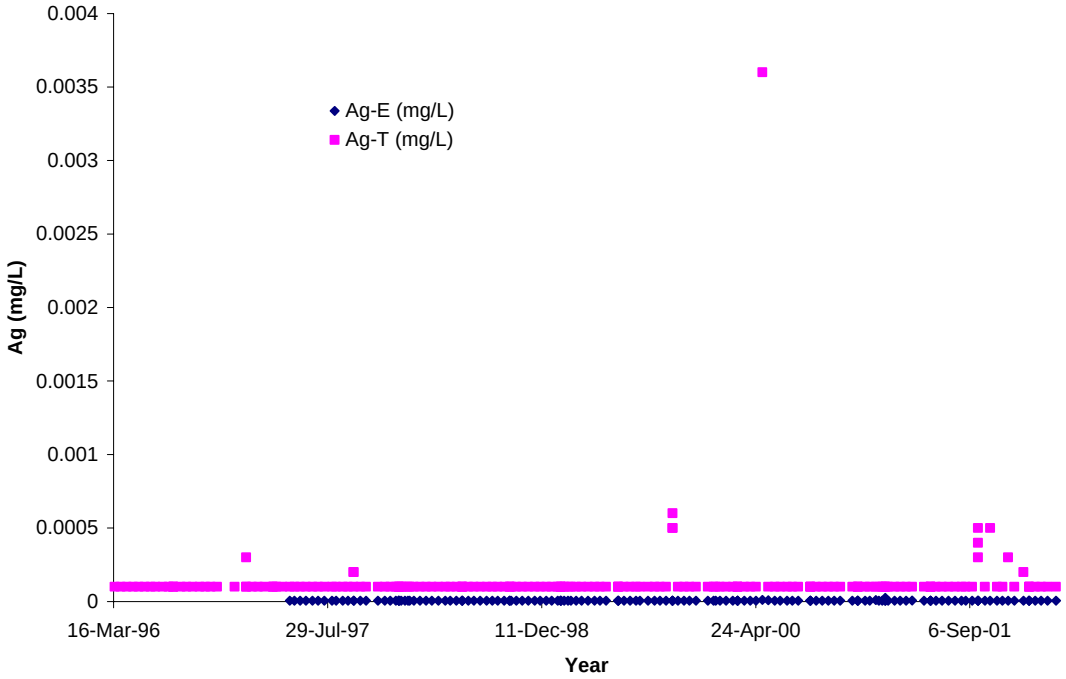


Figure 45. Kettle River at Carson - Sodium, Dissolved and Extractable

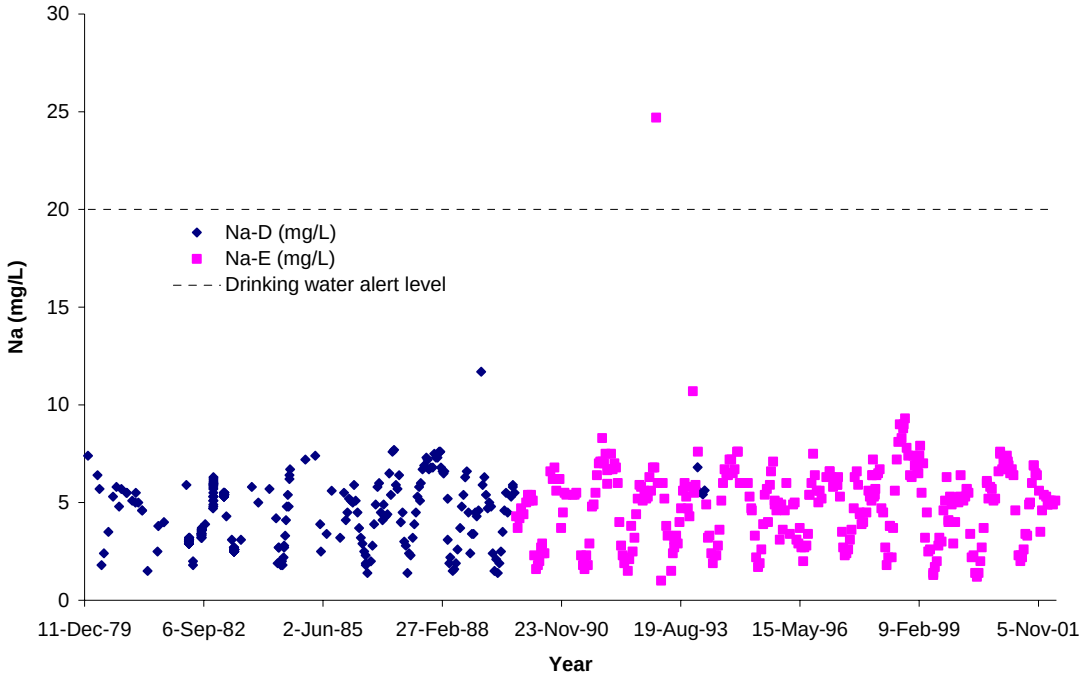


Figure 46. Kettle River at Carson - Strontium, Total and Extractable

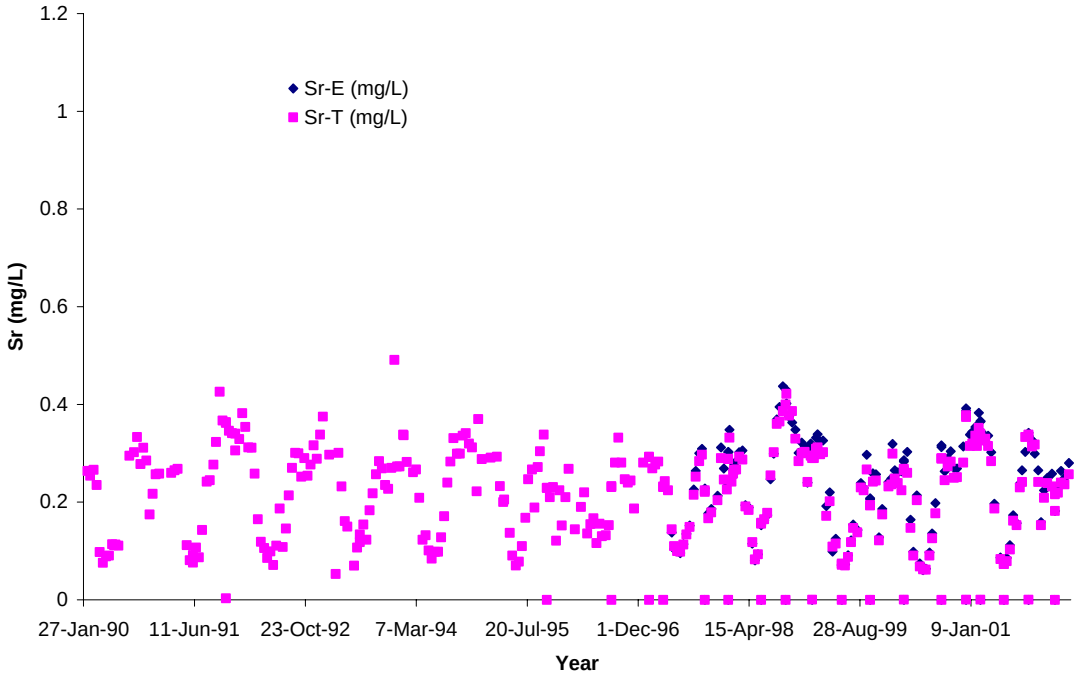


Figure 47. Kettle River at Carson - Sulphate, Dissolved

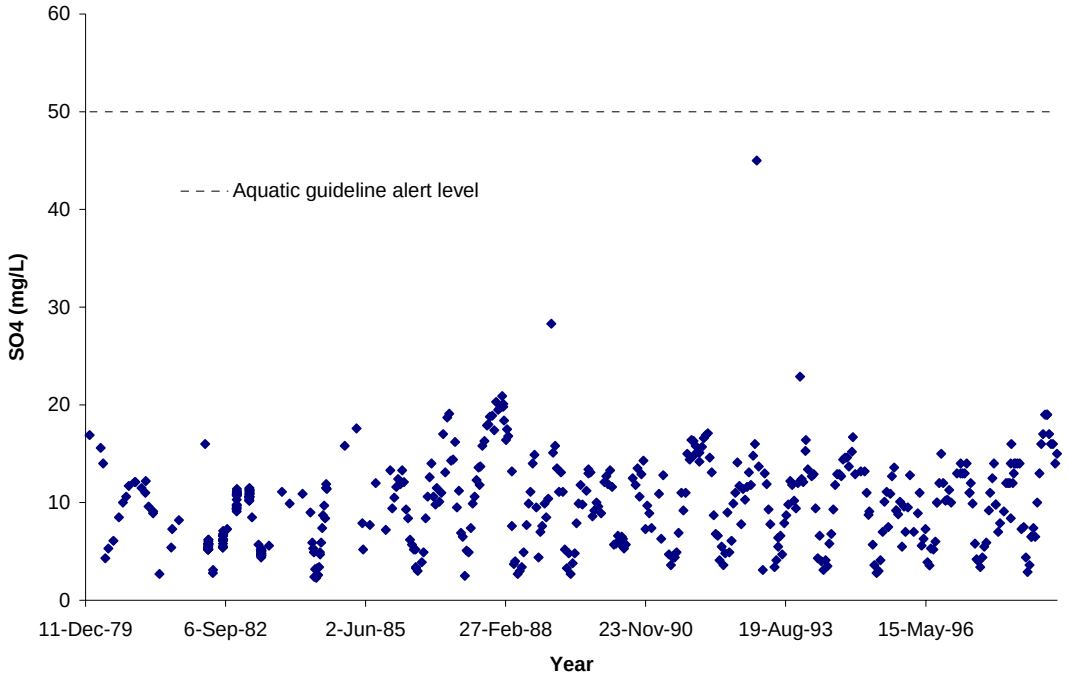


Figure 48. Kettle River at Carson - Temperature, Water

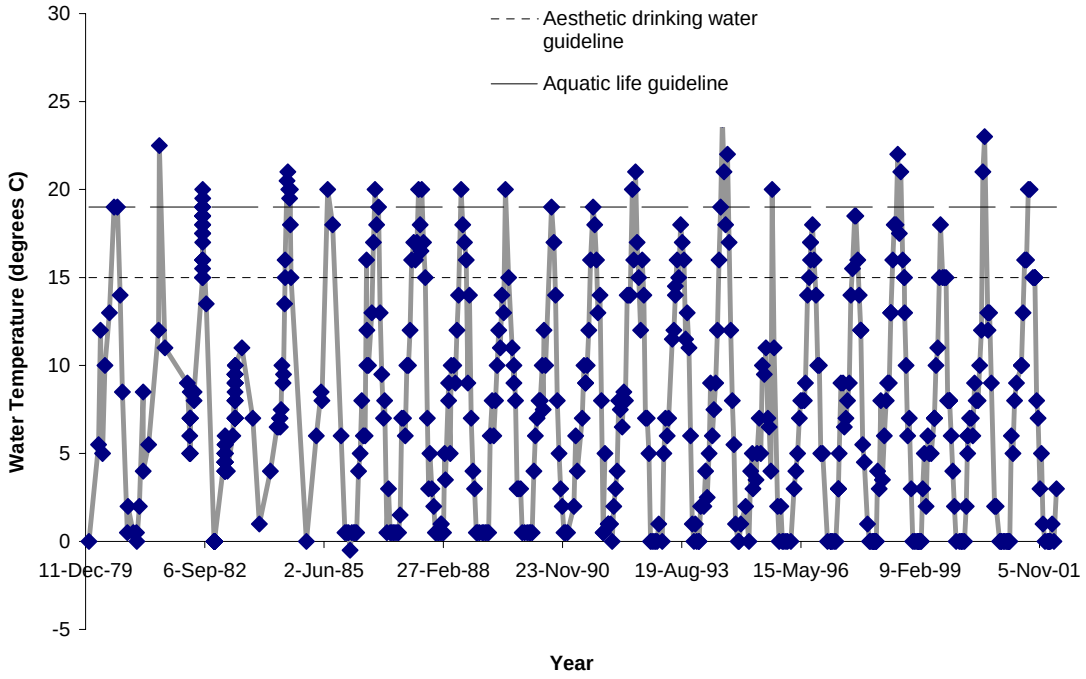


Figure 49. Kettle River at Carson - Thallium, Extractable

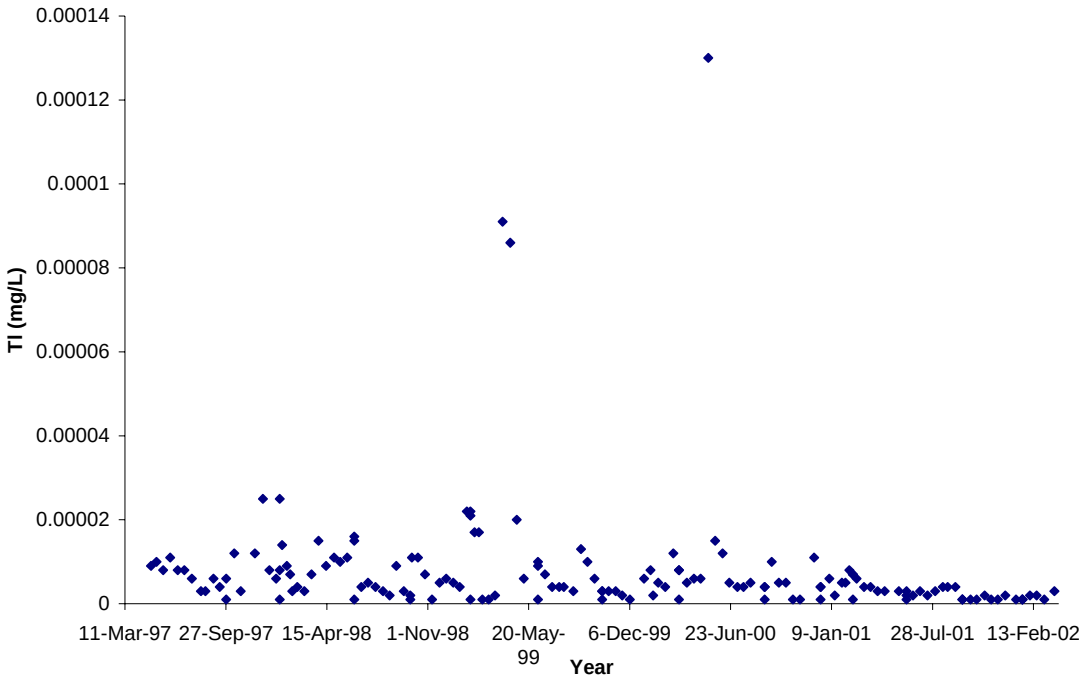


Figure 50. Kettle River at Carson - Turbidity and Flow

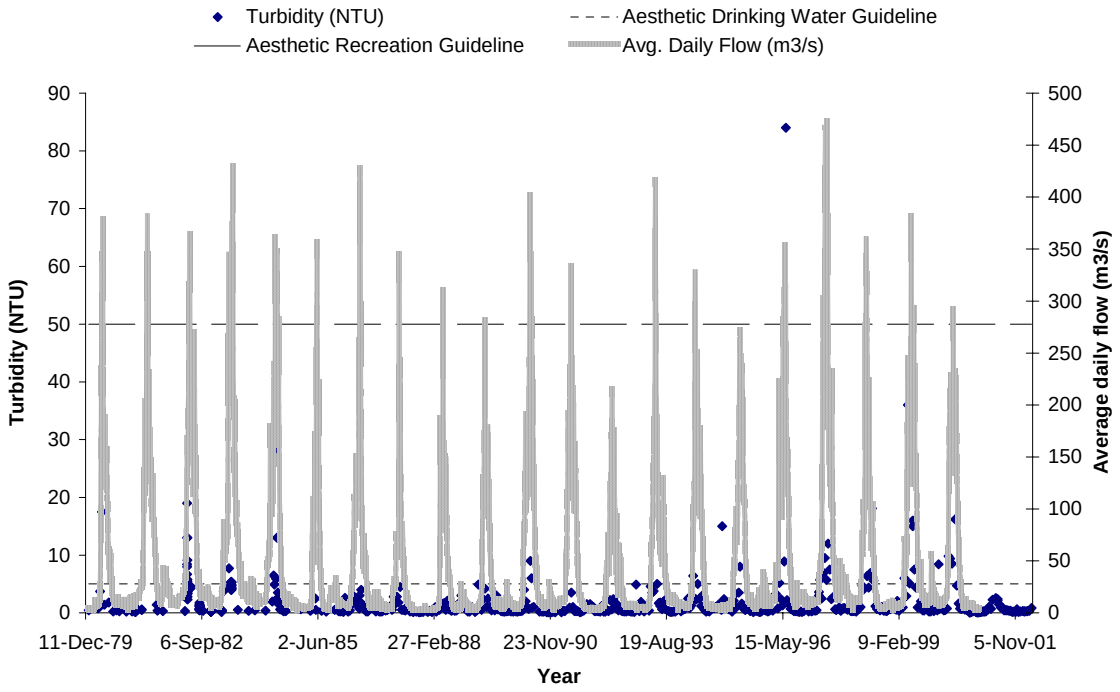


Figure 51. Kettle River at Carson - Uranium, Extractable

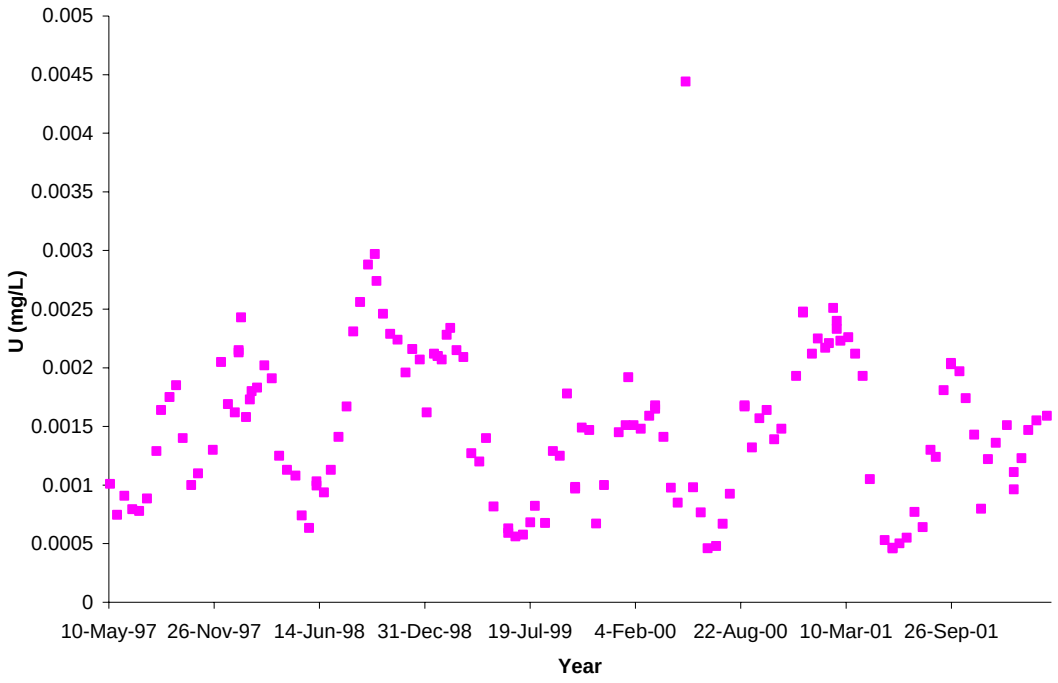


Figure 52. Kettle River at Carson - Vanadium, Total and Extractable

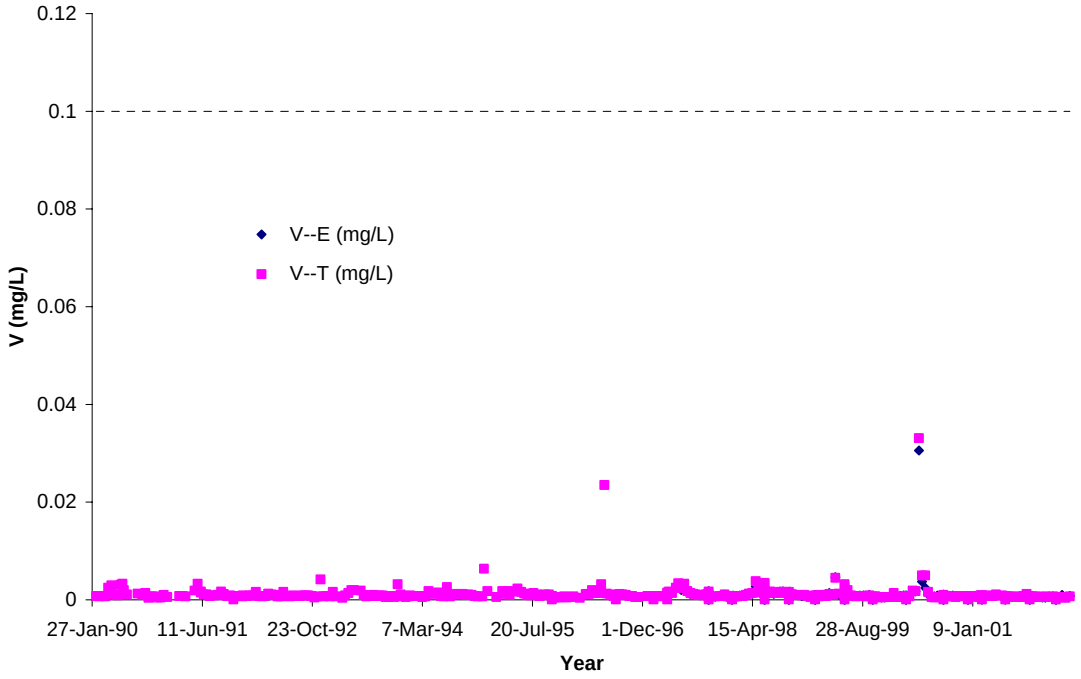


Figure 53. Kettle River at Carson - Zinc, Total and Extractable