CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF SALMON RIVER NEAR HYDER, ALASKA (1981 – 2002)

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Environment Canada **Environnement Canada**

BRITISH COLUMBIA Ministry of Environment

EXECUTIVE SUMMARY

This report assesses twenty-one years of water quality data from the Salmon River near Hyder Alaska. The Salmon River is a trans-boundary river which flows in a southerly direction from the north central coast of the province, emptying into the north end of the Portland Canal near Hyder, Alaska (USA). The Portland Canal separates the southern portion of the state of Alaska and the north central B.C. coast (Figure 1). Environment Canada has monitored the Salmon River since 1982, collecting approximately 52 samples per year. One other related water quality monitoring station within this area is the Bear River at Stewart, B.C.

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 were water quality levels and trends that are deemed deleterious to sensitive water uses including drinking water, aquatic life, fish and wildlife, recreation, irrigation and livestock watering.

CONCLUSIONS

We concluded that:

- The water quality of the Salmon River near Hyder over the 1981 to 2002 sampling period is believed to be largely influenced by natural phenomena such as glacial erosion and mineralization. The watershed is sparsely populated and relatively un-impacted by humans except for some mining.
- Variables such as dissolved organic carbon, true colour, fluoride, molybdenum, selenium and sulphate occasionally exceeded their respective guidelines.
- A number of metals, including aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel and zinc, were closely correlated with turbidity and increased significantly during spring freshet. Guidelines were generally exceeded by these metals during spring freshet. Since the metals were associated with particulate matter, they would not be available to biota (and therefore would not be toxic) and would be removed by treatment necessary to remove turbidity prior to use as drinking water, should this ever be the case.

- pH values were generally high, and occasionally exceeded the upper threshold for acceptable drinking water.
- The water was often turbid because this is a glacier-fed river, especially during annual freshet when higher flows resulted in increased erosion, suspended sediment, and turbidity.
- The increased turbidity during freshet would make it necessary to treat the water to remove turbidity prior to use as a drinking water supply.

RECOMMENDATIONS

We recommend monitoring of water quality and flow for the Salmon River near Hyder, Alaska be continued because the site is being used to determine trans-boundary effects between British Columbia and Alaska, and assess the environmental impacts of upstream activities such as mining.

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INTRODUCTION

The Salmon River near Hyder, Alaska, is located in the north central coast area of B.C. (Figure 1). The drainage area of the Salmon River near Hyder is not known, but estimated at 300 km^2. The river flow has not been monitored in this watershed (Edgar Link, Water Survey office in Terrace).

The purpose of the water quality monitoring has been long-term trend assessment for a trans-boundary river flowing from Canada to the Portland Canal, USA (Alaska). This report assesses the 21 years of data from 1981 through 2002. Environment Canada has monitored the water quality at this station since 1982, and the data are stored on the federal data base, ENVIRODAT, under station number AK08DC0001 (latitude 56° 01' 18" by longitude 130° 04' 17" on NTS map sheet # 104B1). The water quality data are plotted in alphabetical order from Figures 2 to 53. A related monitoring station is the Bear River at Stewart, B.C. which is located upstream from the Salmon River at the head of the Portland Canal.

The watershed upstream from Hyder is relatively pristine, with almost no human habitation, but there are some mining operations that may be environmentally significant. Scottie Gold and Tenajon Resources SB Zone, both located near the headwaters of this watershed, have small mine water discharges. The Westmin Premier mine operated from 1989 to 1995, and is still discharging effluents and tailings pond supernatant from old mine workings and a mine water treatment into the Cascade Creek just above the U.S. border. There are two other small tributaries to Cascade Creek, Cooper and Fletcher creeks, which experience metals loading from old mine workings, as well as disturbances from more recent operations. There are two glaciers, the Texas Glacier and the Salmon River Glacier, within this watershed.

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

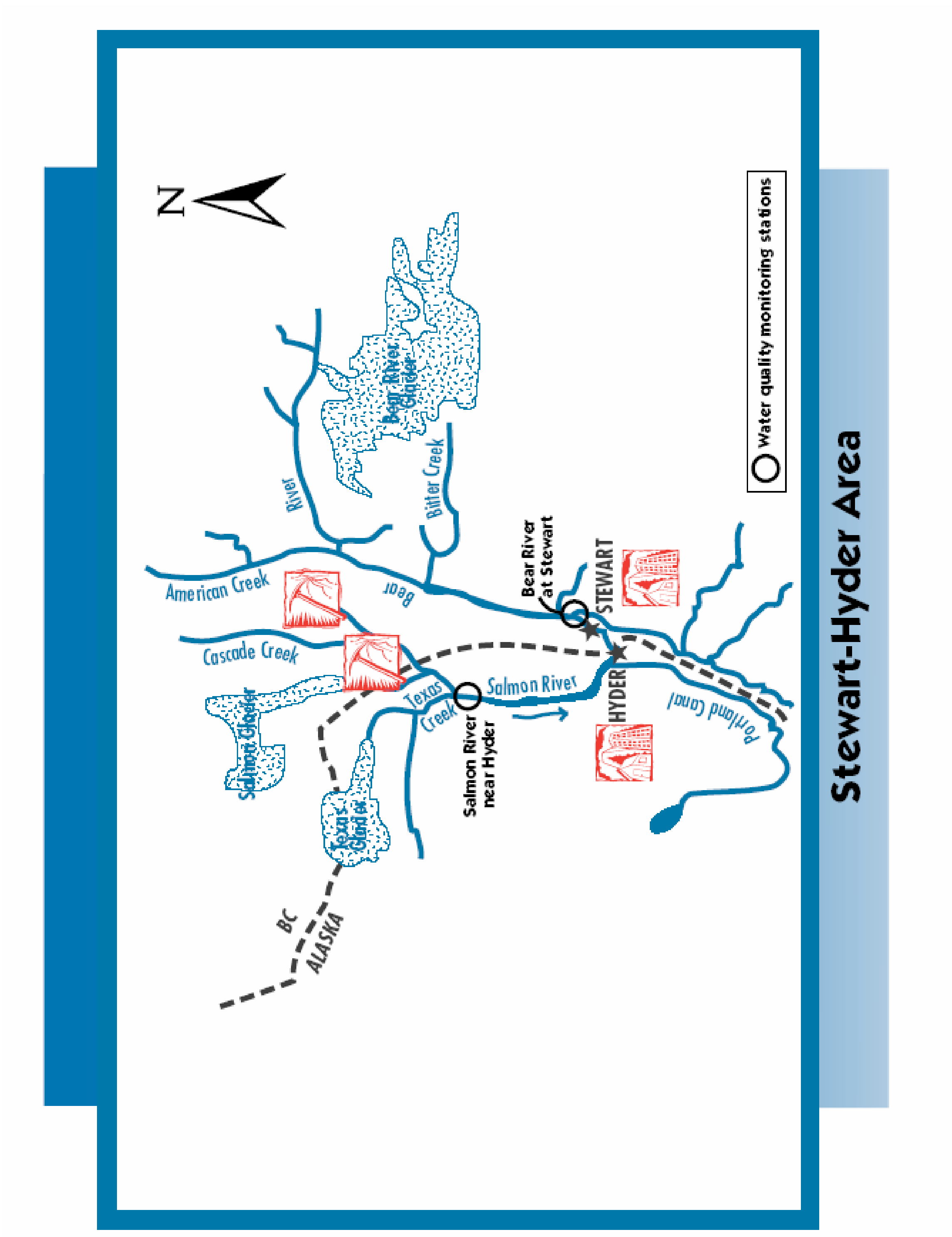

Figure 1. Salmon River near Hyder, Alaska

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 was determined by comparing the values to B.C. Environment's *Approved and Working Criteria for Water Quality* (Nagpal *et al*., 2001a, 2001b). No site-specific water quality objectives have been developed for the Salmon River. Substances not discussed below met guidelines and displayed no environmentally significant trends. They include: ammonia, barium, beryllium, boron, bromide, total, dissolved and inorganic carbon, specific conductivity, cyanide, lithium, magnesium, mercury, nitrogen, phosphorus, potassium, filterable residue, rubidium, selenium, silicon, silica, silver, sodium, strontium, sulphate, and uranium.

Total alkalinity (Figure 2) and **dissolved calcium** (Figure 10) concentrations indicate that the Salmon River has a relatively low sensitivity to acidic inputs (is fairly well buffered), although occasionally during the summer months this sensitivity can increase somewhat.

Total aluminum concentrations were typically high, ranging from 0.01 mg/L to 79.9 mg/L. Seventy percent (217 of 310 samples) exceeded the aquatic life guideline of 0.1 mg/L, and 60% (185 of 310 samples) also exceeded the drinking water guideline of 0.2 mg/L (Figure 3). However, as these guidelines apply to the dissolved form only of aluminum and that form was not measured in this study, an accurate assessment of the guidelines cannot be made. The guideline for wildlife, irrigation and livestock watering of 5 mg/L total aluminum was exceeded by 9% of samples (28 of the 310 samples collected). There was a strong correlation between elevated aluminum levels and higher turbidity values (see Figure 3), suggesting that higher aluminum levels were associated with particulate matter and may not be biologically available. The strong seasonality evident in aluminum concentrations is due in part to contributions of various metals from glacial till – the majority of these metals would be in particulate form.

Total arsenic concentrations exceeded the aquatic life guideline of 0.005 mg/L on 33 occasions (8% of 391 samples collected) (Figure 5). Arsenic concentrations were closely correlated with turbidity values (see Figure 5), suggesting that the arsenic was bound to particulate matter and not likely toxic to biota.

Total cadmium concentrations appeared to exceed the aquatic life guideline of 0.0003 mg/L (Figure 10), but this was due largely in part to the fact that the detection limits used in the analyses were too high (between 30 and 300 times the guideline limit). 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. Cadmium concentrations were well correlated with turbidity, suggesting that higher levels of total cadmium were associated with particulate matter and therefore not likely a threat to biota.

Dissolved organic carbon concentrations were generally below the drinking water guideline, with only one value (4.1 mg/L) of 87 samples collected between 1997 and 2002 slightly exceeding the guideline of 4.0 mg/L (Figure 14). As drinking water is not currently a use for the Salmon River, this is not a concern.

Total chromium concentrations measured prior to 1991 may have been elevated due to suspected preservative vial contamination (Figure 16). Since that time, 112 values (42% of 267 values collected) exceeded the aquatic life guideline of 0.001 mg/L, and 38 of these values (14%) also exceeded the irrigation guideline of 0.005 mg/L. The maximum recorded concentration after 1991 was 0.161 mg/L. Elevated levels of total chromium were associated with elevated turbidity levels (see Figure 16), suggesting that the chromium was associated with particulate matter and therefore not likely available to biota.

Total cobalt levels exceeded the aquatic life guideline of 0.0009 mg/L in 97 of 310 samples collected (31%) (Figure 17), and the irrigation guideline of 0.05 mg/L was exceeded by one sample. The close relationship between cobalt and turbidity (see Figure 17) suggests that the majority of the cobalt present was in particulate form and not likely biologically available.

The drinking water quality objective for **colour** is expressed in terms of true colour. This method of measurement has been used only since 1997 for the Salmon River. Of the 99 samples collected between 1997 and 2002 and analyzed for true colour, 23 (or 23%) exceeded the drinking water guideline (Figure 18). These exceedences invariably occurred between April and October, when the river wasn't covered with ice and when glacial runoff was contributing particulate matter. As the Salmon River isn't currently used as a drinking water source, these exceedences are not a cause for concern.

Total copper levels were elevated between 1986 and 1991 due to suspected preservative vial contamination (Figure 20). Outside of that period, 56% of individual values (159 of 282 samples) exceeded the 30-day average aquatic life guideline, and 30% of values

(85 of 282 samples) also exceeded the maximum aquatic life guideline. The strong relationship between total copper and turbidity suggests that elevated levels of copper are associated with particulate matter and therefore not likely toxic to biota.

The guideline for the protection of aquatic life from **dissolved fluoride** is hardness-dependent. As hardness concentrations in the Salmon River during the summer (when fluoride concentrations were the highest) were generally lower than 50 mg/L (see Figure 24), the applicable aquatic-life guideline is usually 0.2 mg/L. Eleven samples (about 3% of 370 samples) exceeded this guideline, and all exceedences occurred in 1981 and 1982 (Figure 22). The drinking water guideline (1 mg/L) was not exceeded by any samples.

Total hardness concentrations ranged from 19 mg/L to 163 mg/L, with values fluctuating seasonally (Figure 24). Peak hardness was measured during the winter when flows were lowest, while lower hardness values were recorded during spring freshet.

Total iron concentrations were measured 400 times between 1981 and 2002, with 247 values (62% of samples) exceeding the aquatic life and aesthetic drinking water guideline of 0.3 mg/L (Figure 25). The irrigation guideline of 5 mg/L was exceeded by 66 samples (17% of all values measured). The exceedences occurred primarily during spring freshet, and the strong correlation between total iron and turbidity indicates that higher levels of iron are associated with particulate matter. This would mean that they were not likely biologically available.

Concentrations of **total lead** measured between 1988 and 1991 are suspected to be contaminated as a result of faulty preservative vial seals. Outside of this period, 91 individual values (32% of 282 samples) exceeded the average hardness-dependent aquatic life guideline of approximately 0.0037 mg/L and 33 samples also exceeded the drinking water guideline of 0.01 mg/L. The maximum guideline of approximately 0.024 mg/L was exceeded by 11 of 282 values (4%) (Figure 27). All exceedences of the average guideline occurred during periods of elevated turbidity (see Figure 27), suggesting that the lead was associated with particulate matter and would not likely be bio-available.

Total manganese was measured 400 times between 1981 and 2002. One hundred and sixty eight of the 113 values (42%) exceeded the drinking water guideline of 0.05 mg/L, 39 values exceeded the irrigation guideline of 0.2 mg/L (10%), and four values (1%) exceeded the aquatic life guideline of 0.8 mg/L (Figure 30). Elevated manganese concentrations occurred concurrently with elevated turbidity levels, suggesting that the manganese was bound to particulate matter and therefore not likely biologically available.

One of 311 **total molybdenum** samples measured between 1981 and 2002 slightly exceeded the irrigation guideline of 0.01 mg/L, with a value of 0.0103 mg/L (Figure 32). As Salmon River water is not currently licensed for irrigation purposes, this single exceedence is not a concern.

Total nickel concentrations exceeded the aquatic life guideline of 0.025 mg/L on two occasions (less than one percent of the 310 samples collected) (Figure 33). These exceedences coincided with periods of elevated turbidity, suggesting that the nickel was likely not available to biota.

pH values in the Salmon River were generally slightly basic, with values typically between 7.5 and 8.0 pH units. One of the 565 samples collected had a pH value below this range, with a value of 6.3 pH units, and five values were above this range (between 8.53 and 8.7 pH units) (Figure 36). The highest pH values occurred at the same time as maximum turbidity values, suggesting that the elevated pH is caused by glacial till contributions, which tend to be alkaline. These occasional slight exceedences are likely a natural phenomenon and not likely a cause for concern. Values reported between 1986 and 1988 were artificially low due to a problem with control in the laboratory.

Non-filterable residue (total suspended solids) concentrations frequently exceeded the general fisheries guideline of 25 mg/L (Figure 40), with 157 values lying between the guideline and a maximum of 1820 mg/L. While flow data is not available to confirm this hypothesis, the increases in NFR during spring and summer indicate that the suspended solids are likely due to increased flows as well as glacial melt contributing glacial till.

Water temperatures in the Salmon River regularly were generally low and only exceeded the aesthetic drinking water guideline of 15°C on one occasion (Figure 48). The general fisheries guideline of 19°C was not exceeded. Temperatures seldom exceeded 10°C, and therefore waters were generally not warm enough for recreational use (< 15°C).

Turbidity levels in the Salmon River were strongly seasonally correlated, with peak values generally occurring during spring freshet (Figure 50). Sixty-six percent of values (357 of 537 values collected between 1981 and 2002) exceeded the drinking water guideline of 1 NTU, while 48% also exceeded the aesthetic drinking water guideline of 5 NTU. Eighty-one values (15% of samples) exceeded the recreation guideline of 50 NTU. Turbidity values were typically quite low during the winter, when ice covered the river.

Total and extractable selenium concentrations were typically high in the Salmon River. The aquatic life guideline of 0.002 mg/L was exceeded by both extractable selenium (4% of samples) and total selenium (1% of samples). There was a slight negative correlation between both extractable and total selenium with turbidity (correlation coefficients were -0.13 and -0.22. respectively, with $p = 0.10$ and $p < 0.001$, respectively). A negative correlation suggests that peak concentrations of selenium tended to occur during periods when turbidity was lower. The local geology is highly mineralized and may be naturally rich in selenium. However, there are several old mines and a few operating mines that may be contributing to the mobilization of selenium. The selenium levels in the adjacent Bear River watershed were similar (Webber, 1996). The levels in the Salmon and Bear rivers, and the Elk River in the east Kootenays, are the highest levels that Environment Canada has measured in B.C. (Pommen, 1996). Selenium is now being measured at the Westmin Premier mine (Sharpe, 1996). The water quality criteria for selenium are under review and investigations are underway in the Elk River to determine the sources and environmental impacts of selenium. Both of these studies will contribute to an understanding of the selenium situation in the Bear and Salmon rivers. We recommend that a survey be conducted to determine the source of selenium and its potential effects on the environment, and recommend that both total and dissolved selenium be monitored in the Salmon River.

Dissolved sulphate concentrations ranged from below detectable limits (< 0.5 mg/L) to a maximum of 114 mg/L for 472 samples measured between 1981 and 1998 (Figure 47). The aquatic guideline alert level for dissolved sulphate of 50 mg/L was exceeded by the maximum value, but as the next highest concentration was 49 mg/L, the alert level was exceeded on only the one occasion. As the alert level signifies only that aquatic moss populations should be monitored on occasion (Singleton, 1981), this single exceedence is not likely a cause for concern.

The drinking water, livestock watering and irrigation guideline of 0.1 mg/L for **total vanadium** was exceeded by one value (0.308 mg/L) (Figure 50). This exceedence occurred when turbidity levels were extremely high (3940 NTU, see Figure 50), suggesting that the vanadium was associated with particulate matter. This single exceedence is not a concern since none of these uses apply to the Salmon River.
Total zinc concentrations were artificially elevated between 1986 and 1991 due to preservative vial contamination. Outside of that period, 184 individual samples (46% of 400 samples collected) exceeded the hardness-dependent average aquatic life guideline (approximately 0.0077 mg/L) and 42 of these (11%) also exceeded the hardness-dependent maximum guideline (0.033 mg/L) (Figure 51). The strong correlation between elevated zinc concentrations and higher turbidity levels suggests that the zinc was bound to particulate matter and therefore not likely toxic to aquatic life.

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Figure 2. Salmon River near Hyder, Alaska - Alkalinity, Total

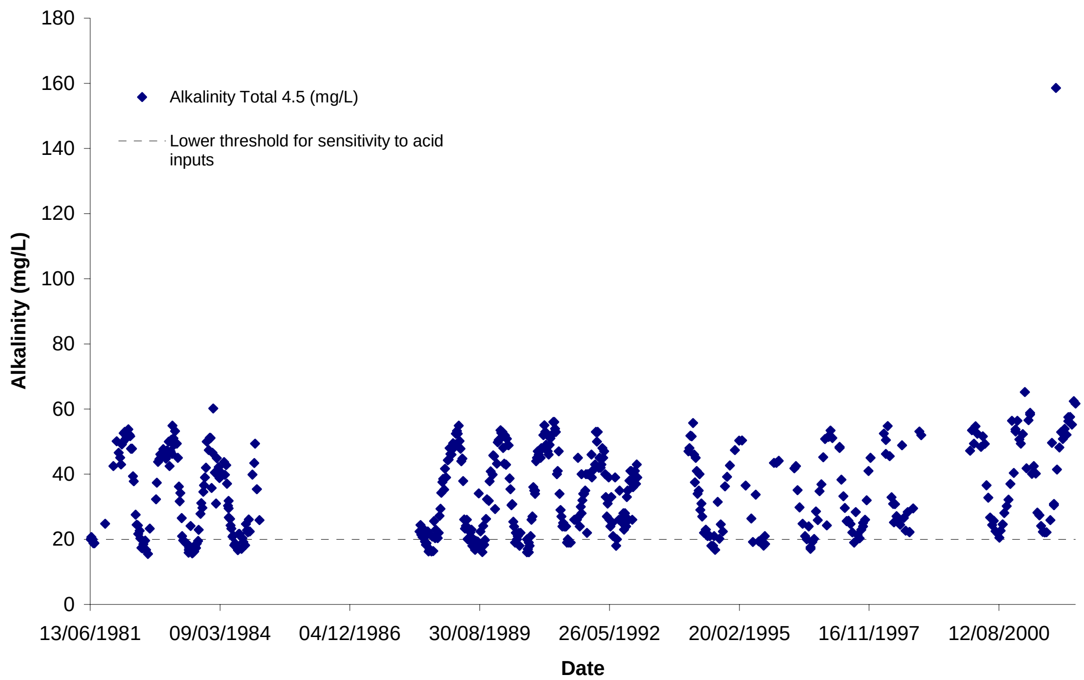


Figure 3. Salmon River near Hyder, Alaska - Aluminum, Total

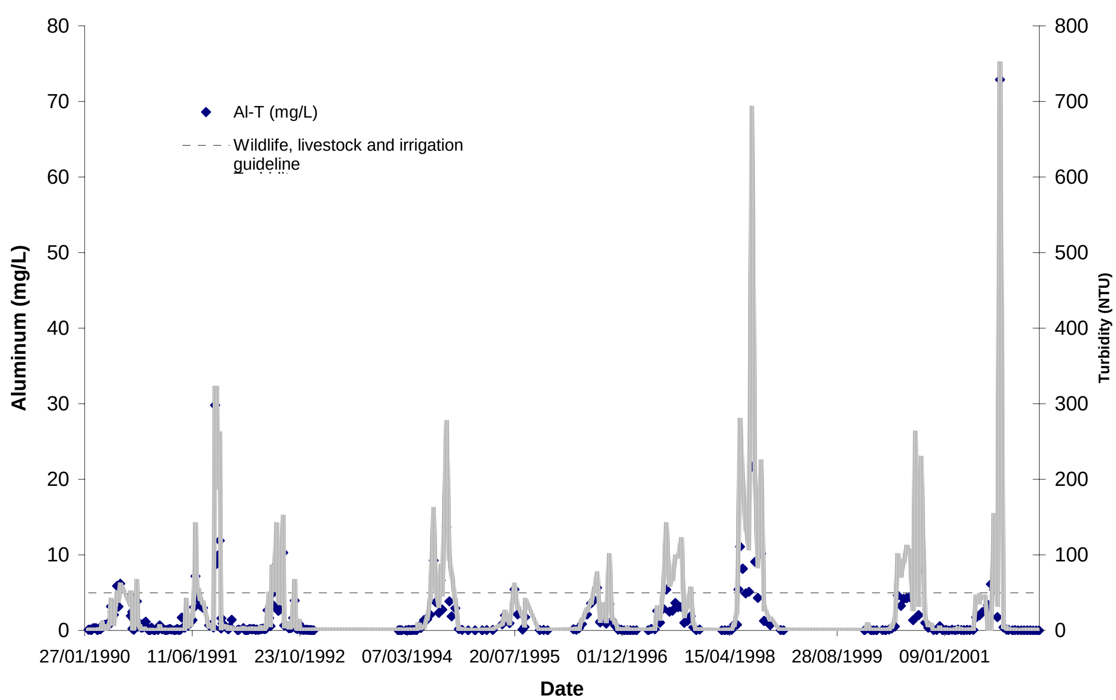


Figure 4. Salmon River near Hyder, Alaska - Ammonia, Dissolved

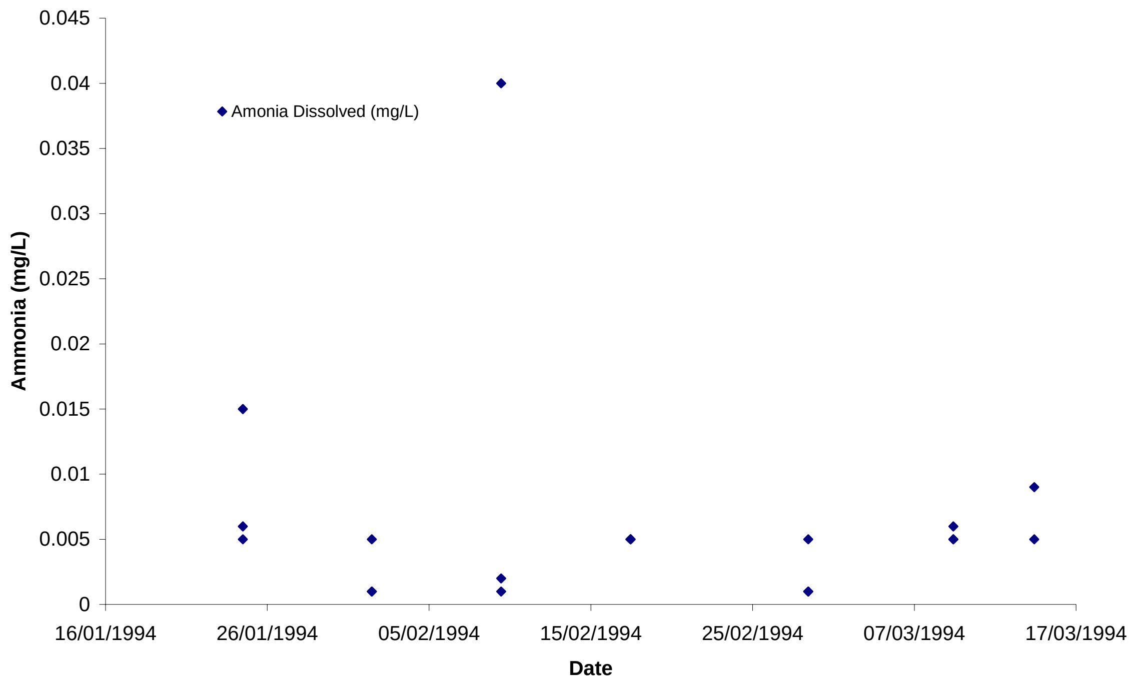


Figure 5. Salmon River near Hyder, Alaska - Arsenic, Total, Dissolved and Extractable

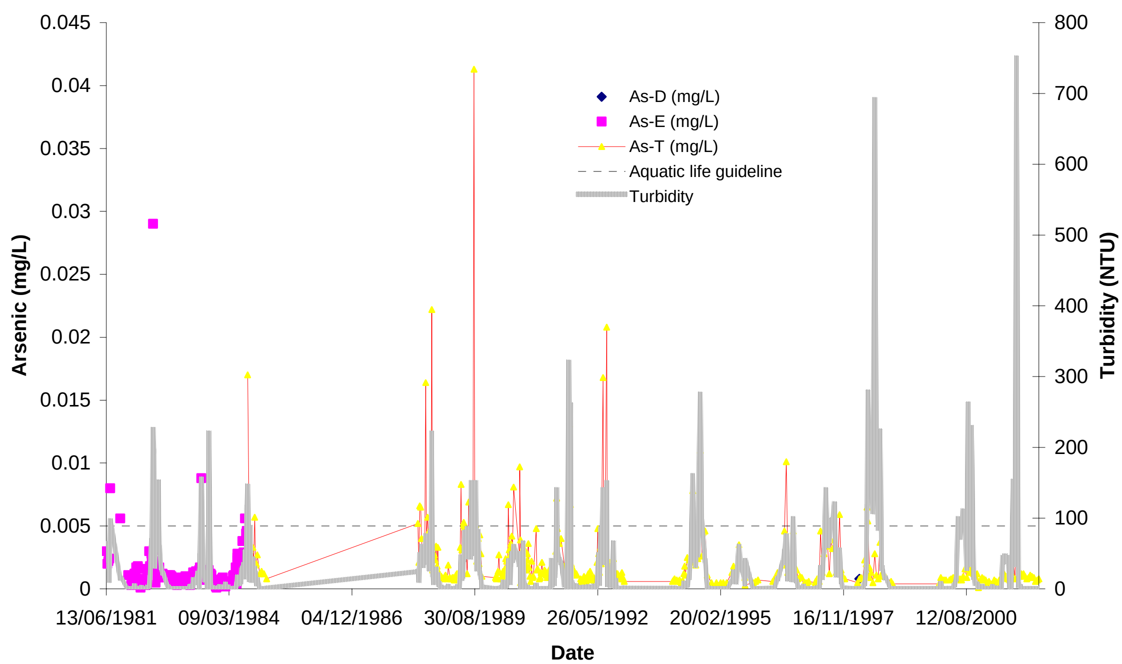


Figure 6. Salmon River near Hyder, Alaska - Barium, Total and Extractable

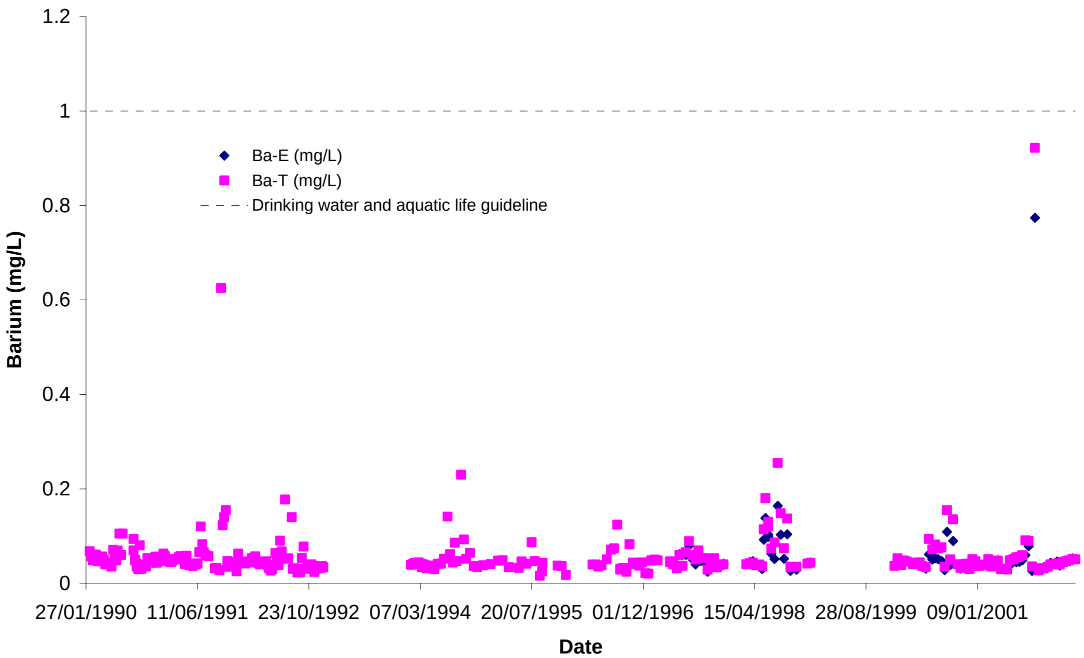


Figure 7. Salmon River near Hyder, Alaska - Beryllium, Total and Extractable

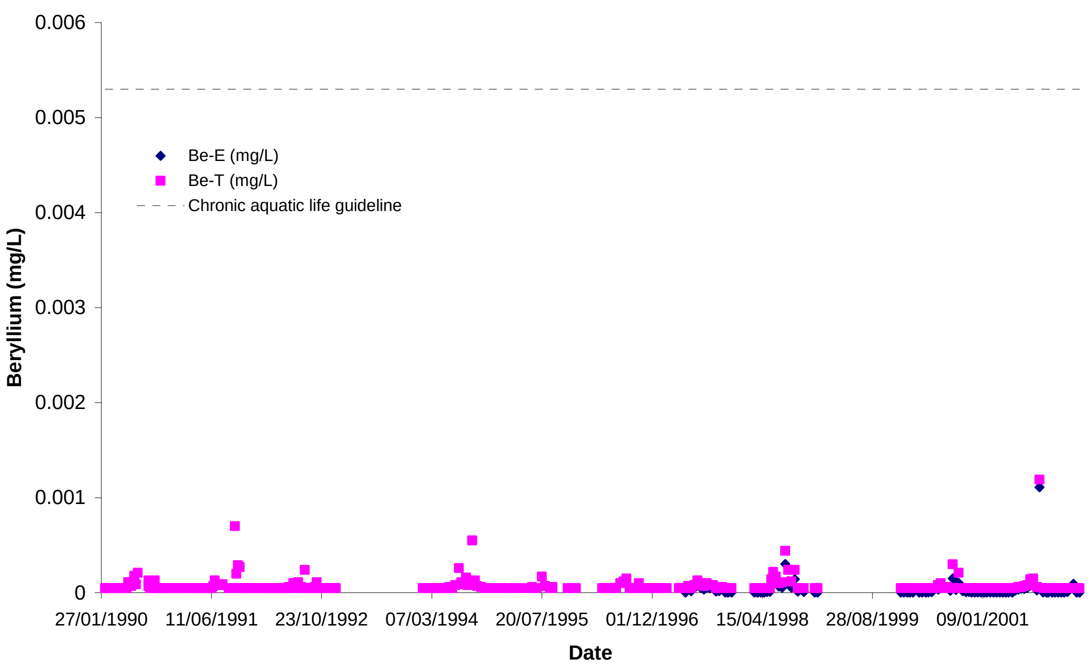


Figure 8. Salmon River near Hyder, Alaska - Boron, Extractable

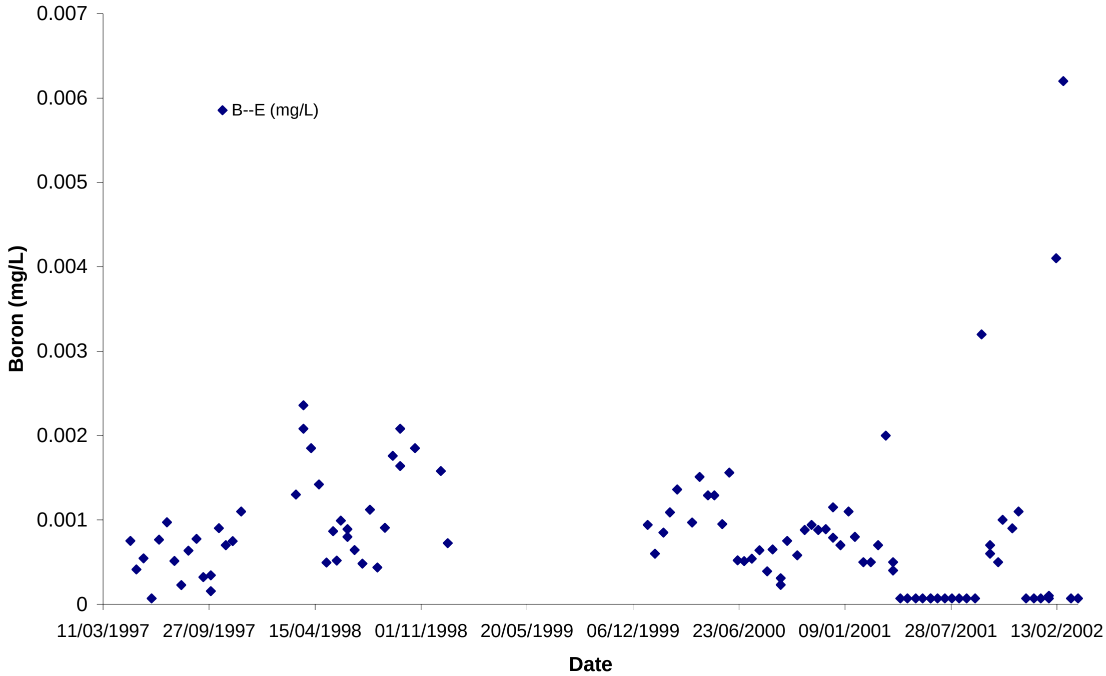


Figure 9. Salmon River near Hyder, Alaska - Bromide, Dissolved

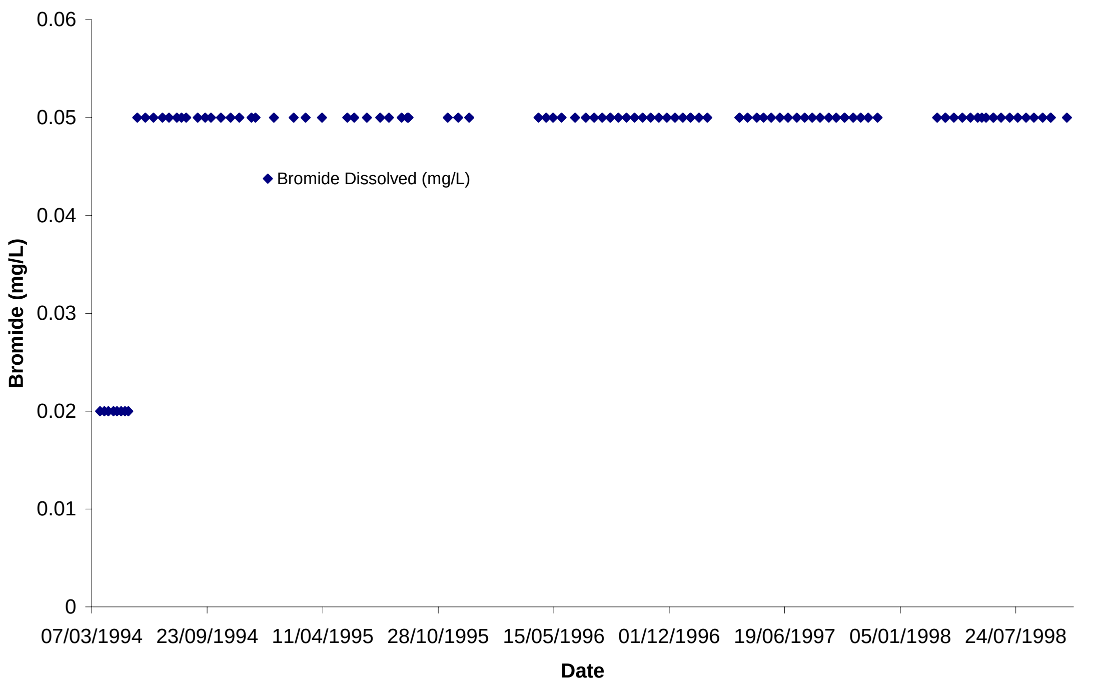


Figure 10. Salmon River near Hyder, Alaska - Cadmium, Total and Extractable and Turbidity

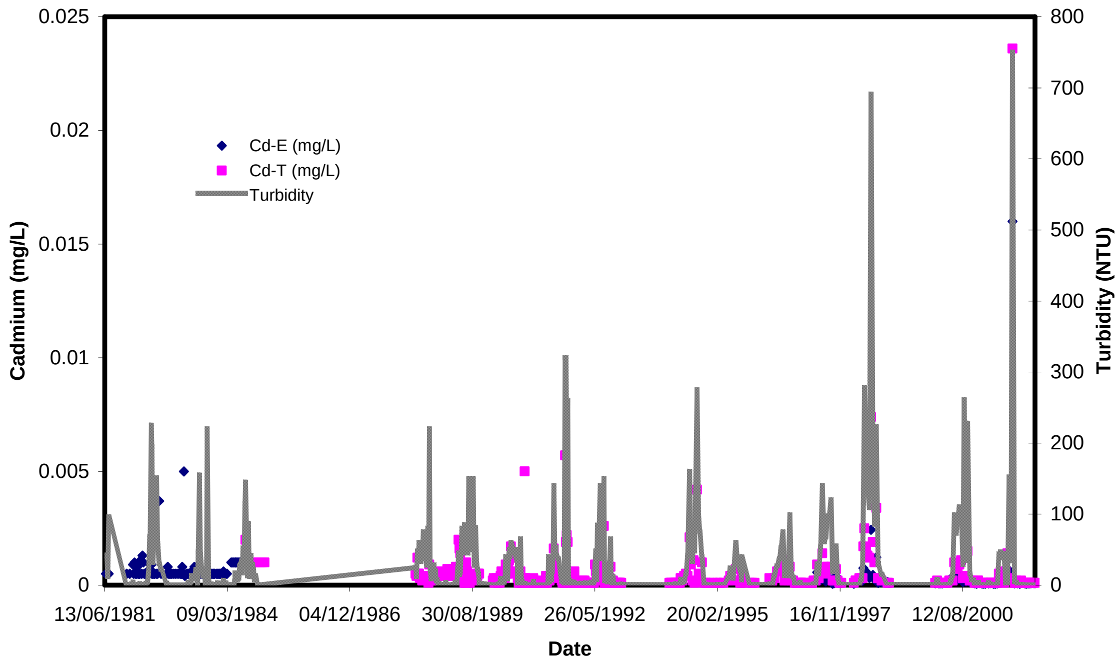


Figure 11. Salmon River near Hyder, Alaska - Calcium, Dissolved and Extractable

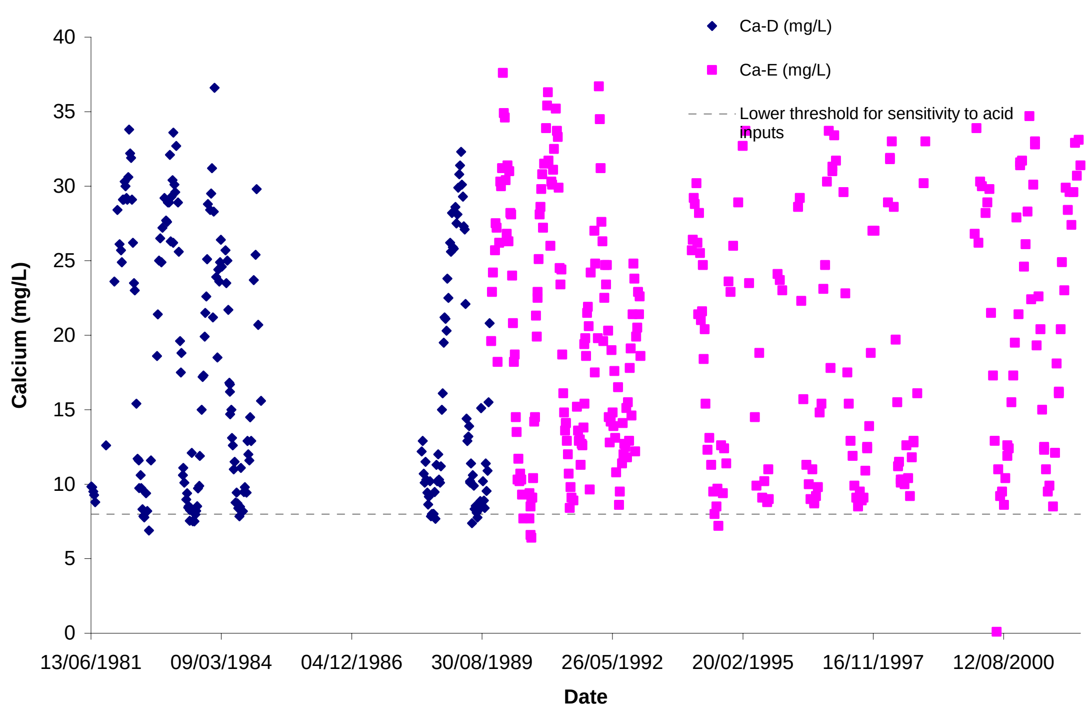


Figure 12. Salmon River near Hyder, Alaska - Carbon, Total and Total Dissolved

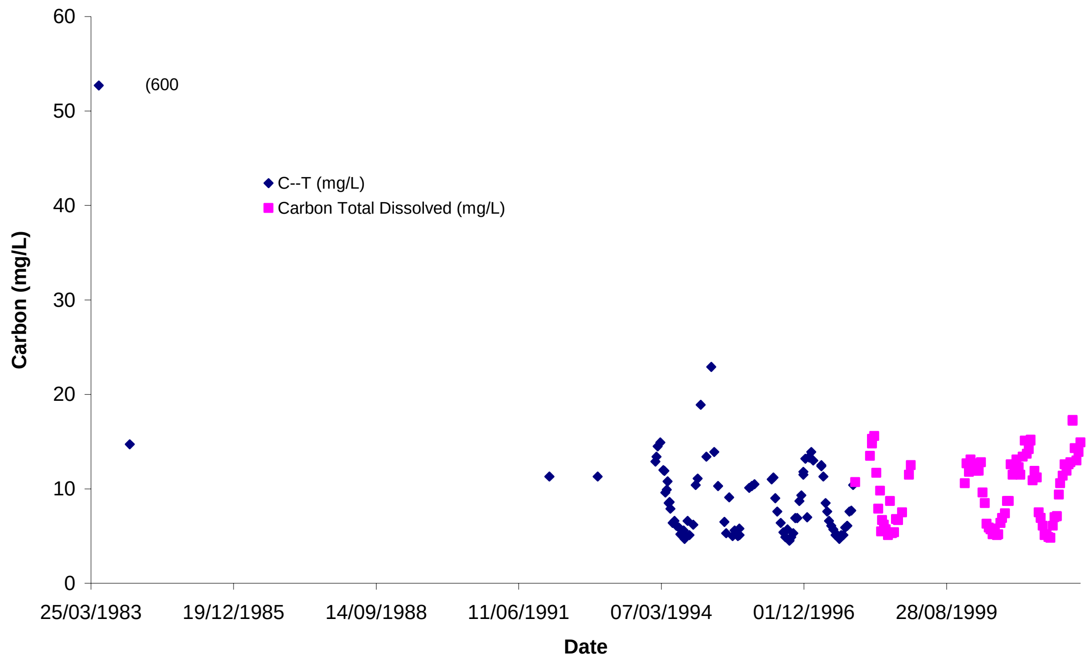


Figure 13. Salmon River near Hyder, Alaska - Carbon, Inorganic

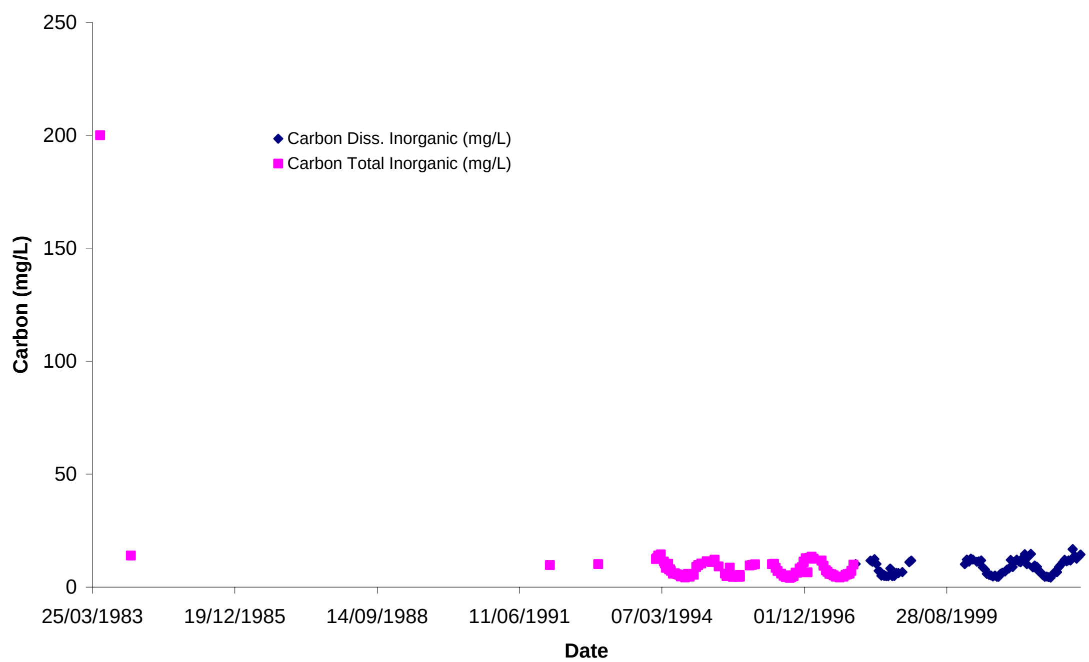


Figure 14. Salmon River near Hyder, Alaska - Carbon, Organic

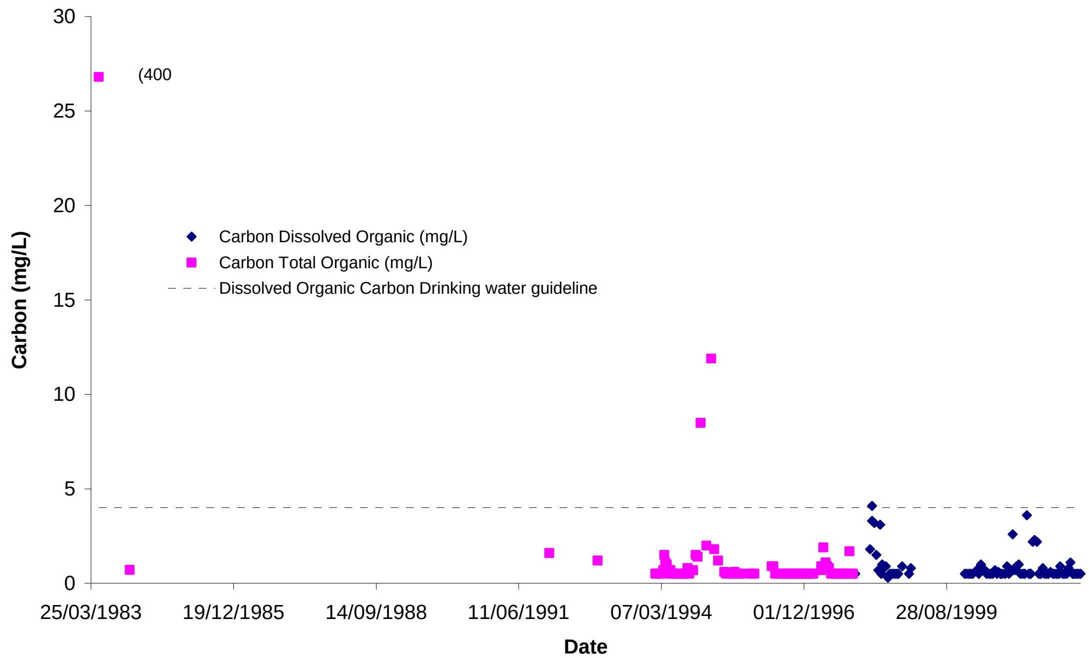


Figure 15. Salmon River near Hyder, Alaska - Chloride, Dissolved

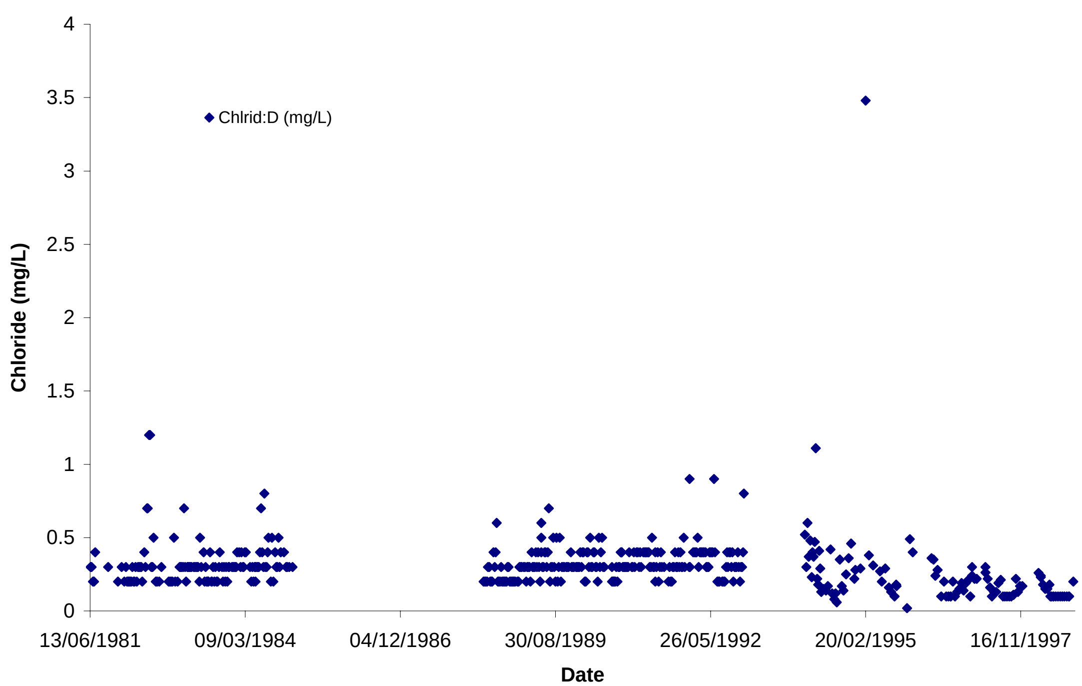


Figure 16. Salmon River near Hyder, Alaska - Chromium, Total and Extractable and Turbidity

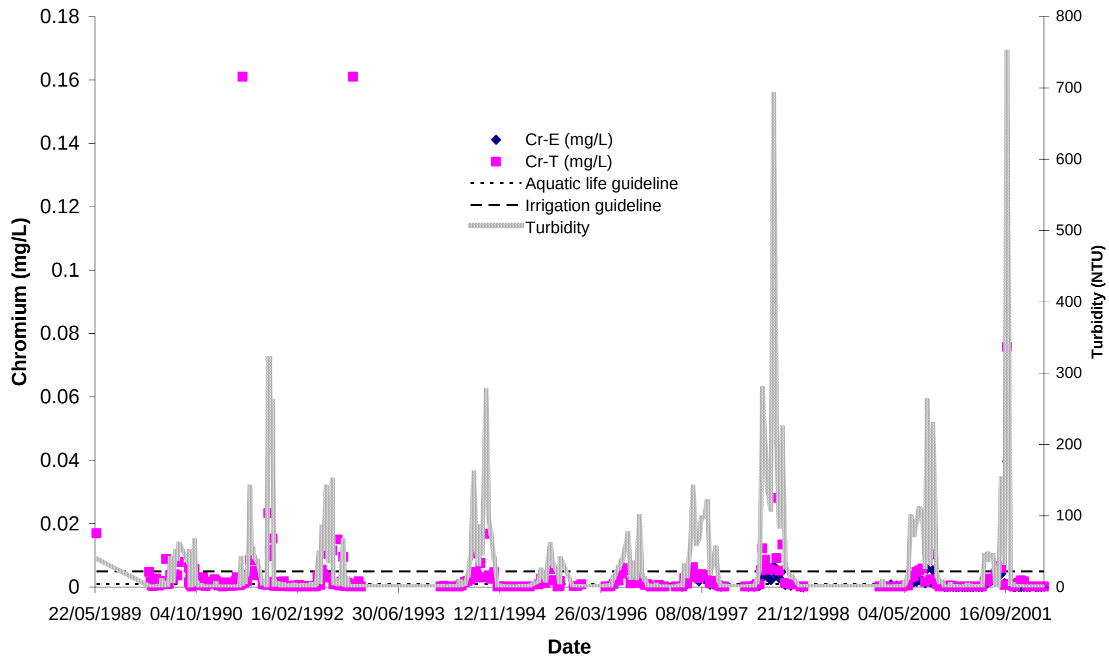


Figure 17. Salmon River near Hyder, Alaska - Cobalt, Total and Extractable and Turbidity

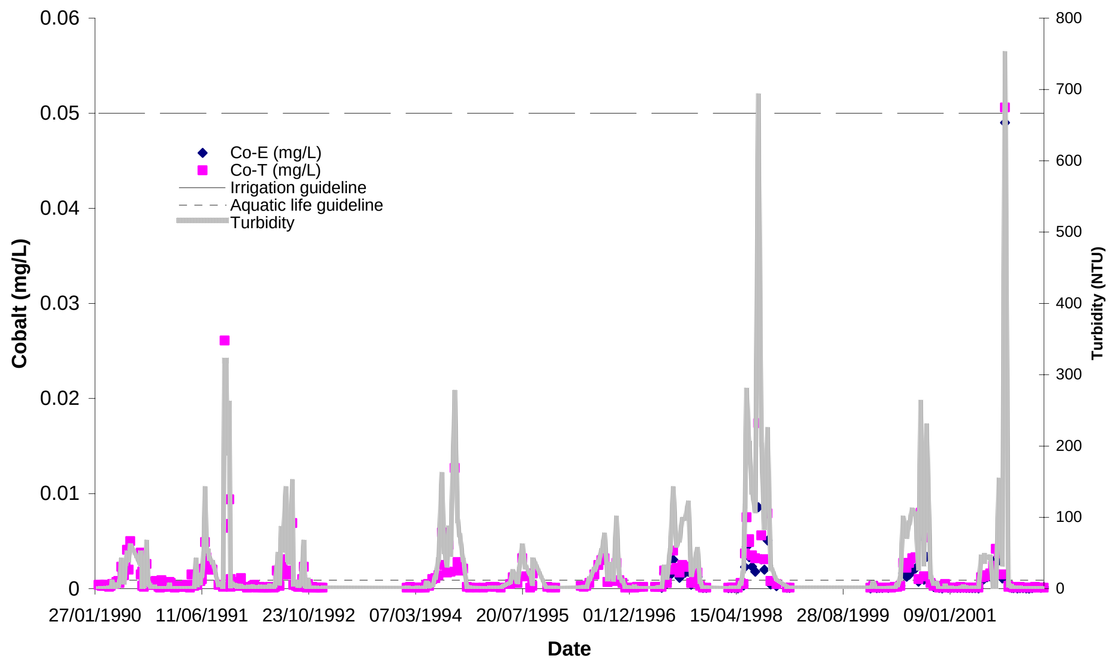
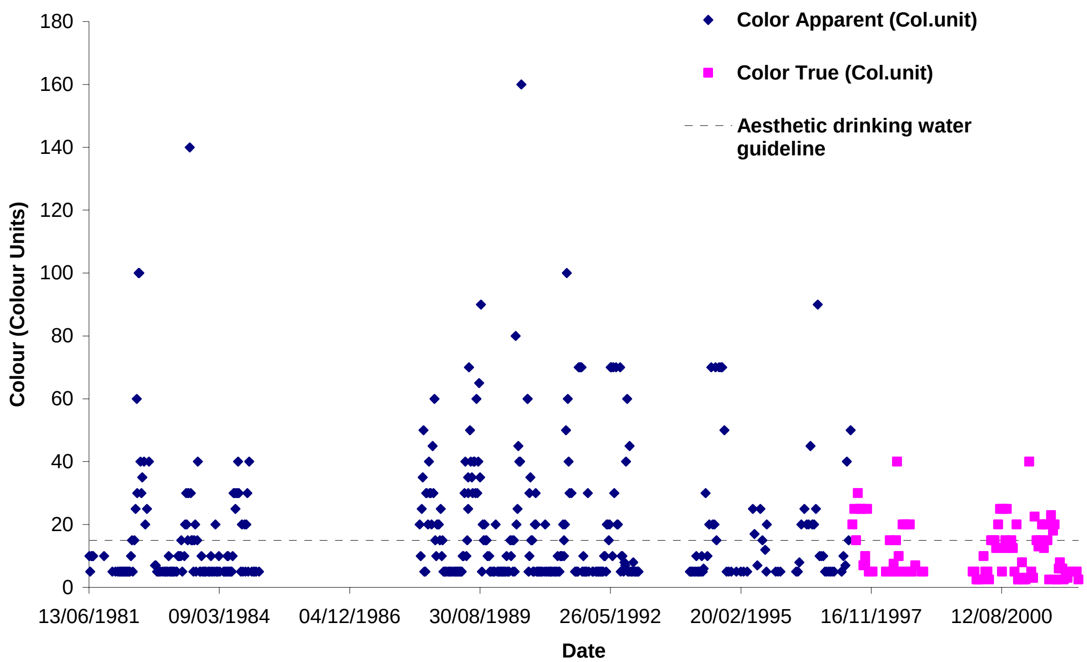


Figure 18. Salmon River near Hyder, Alaska - Colour, Apparent and True



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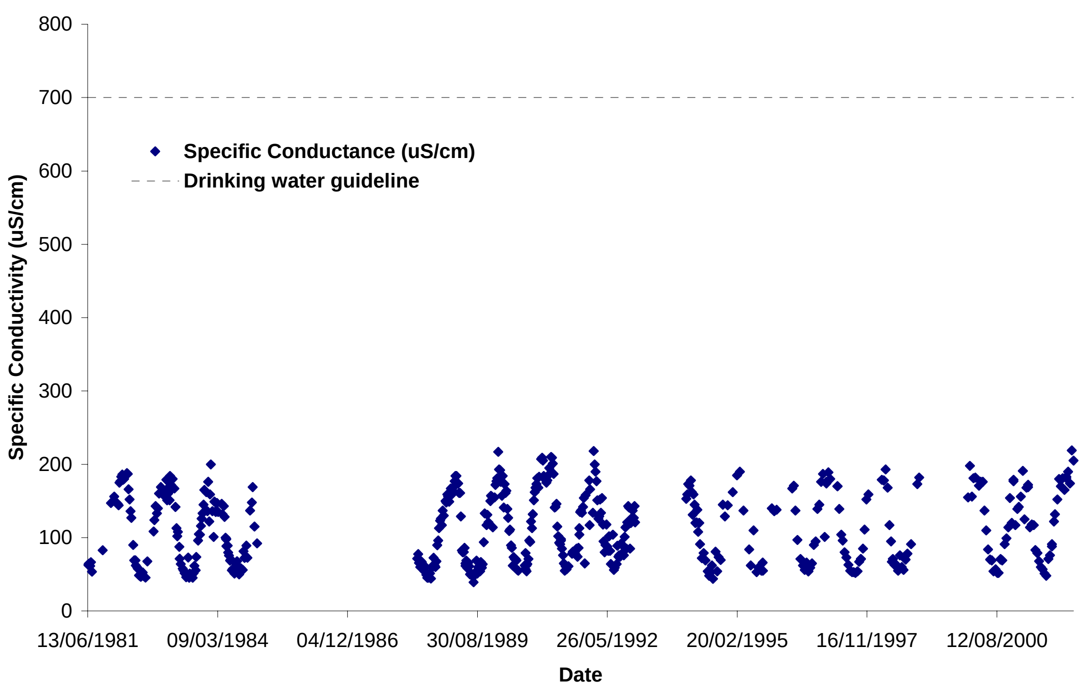

Figure 20. Salmon River near Hyder, Alaska - Copper, Total and Extractable and Turbidity

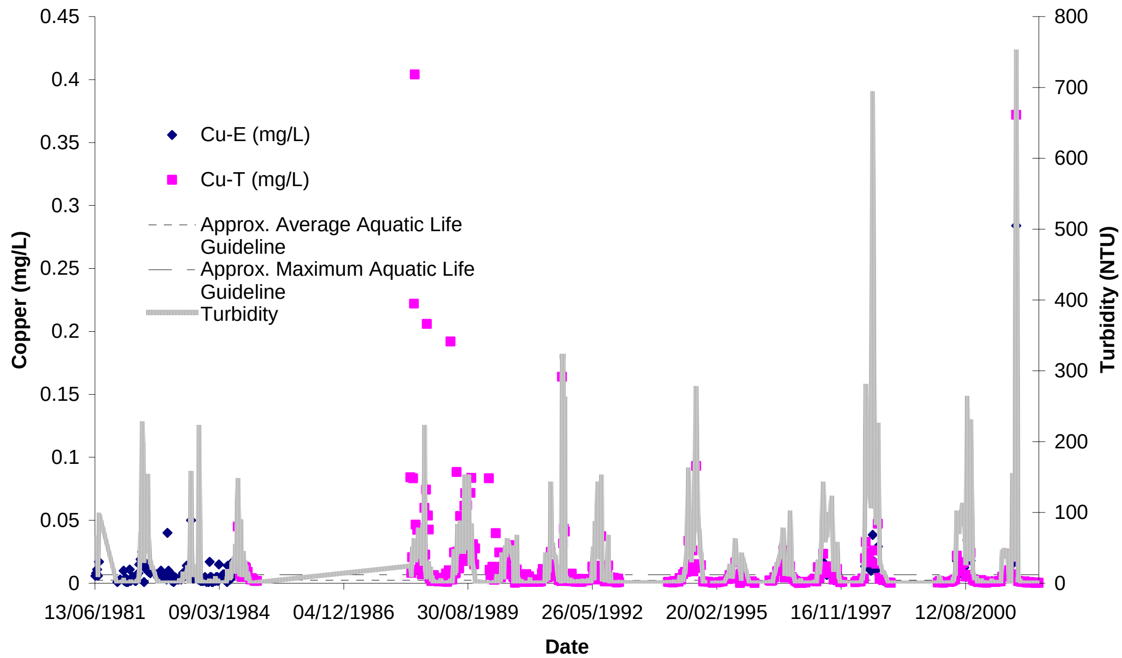

Figure 21. Salmon River near Hyder, Alaska - Cyanide WAD and SAD+SCN

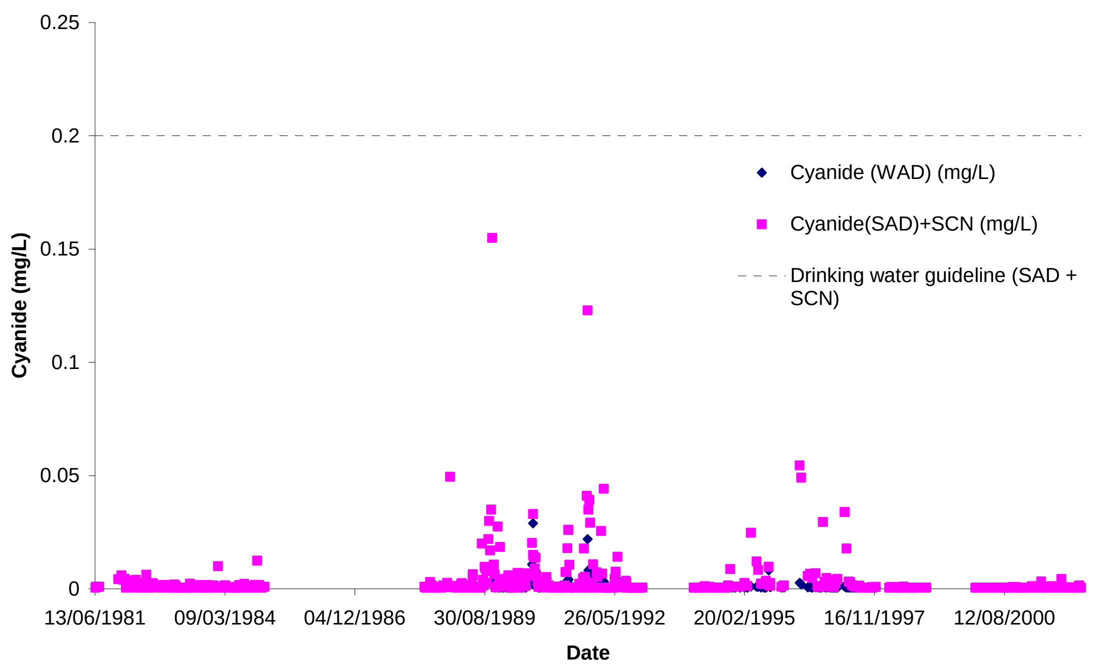

Figure 22. Salmon River near Hyder, Alaska - Fluoride, Total and Dissolved

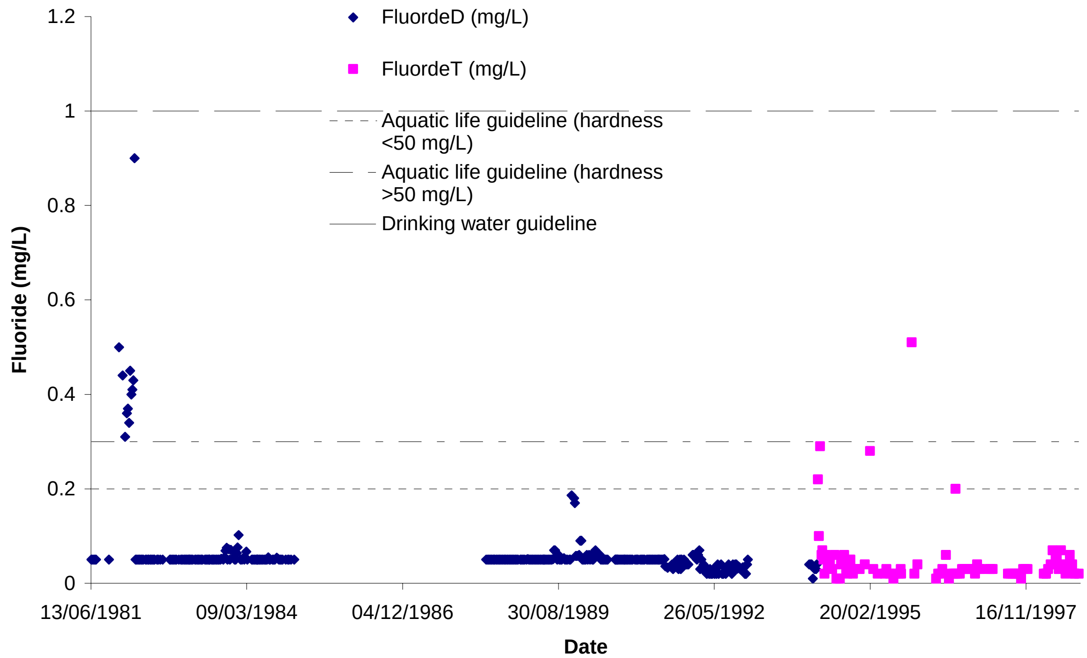

Figure 23. Salmon River near Hyder, Alaska - Gallium, Extractable

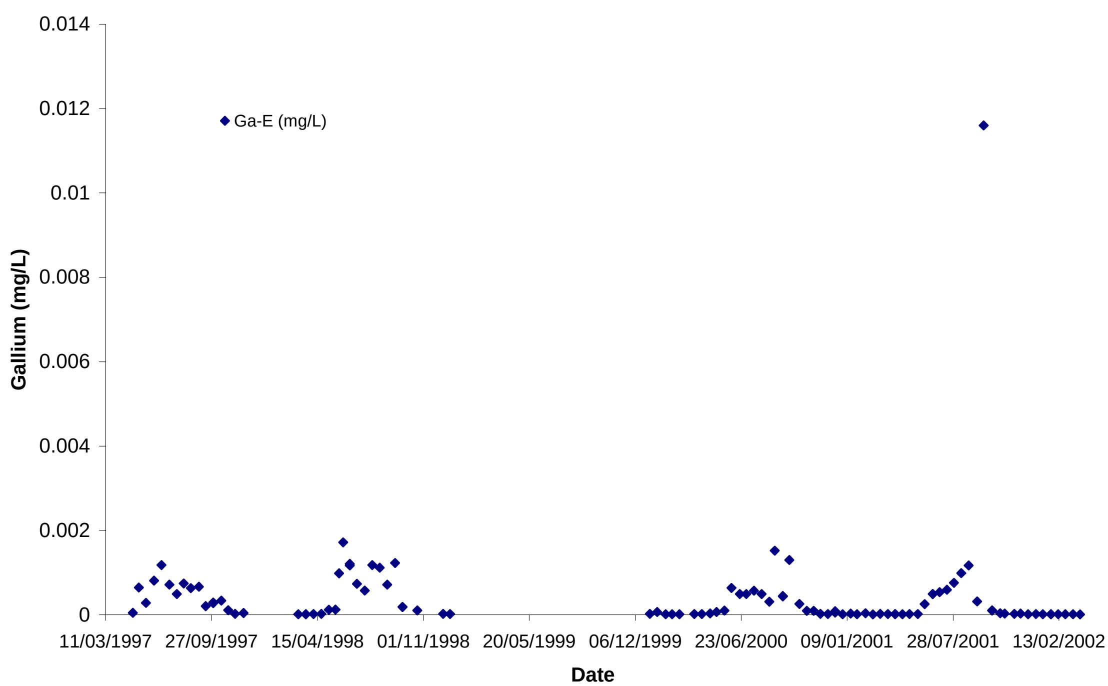

Figure 24. Salmon River near Hyder, Alaska - Hardness, Dissolved and Extractable

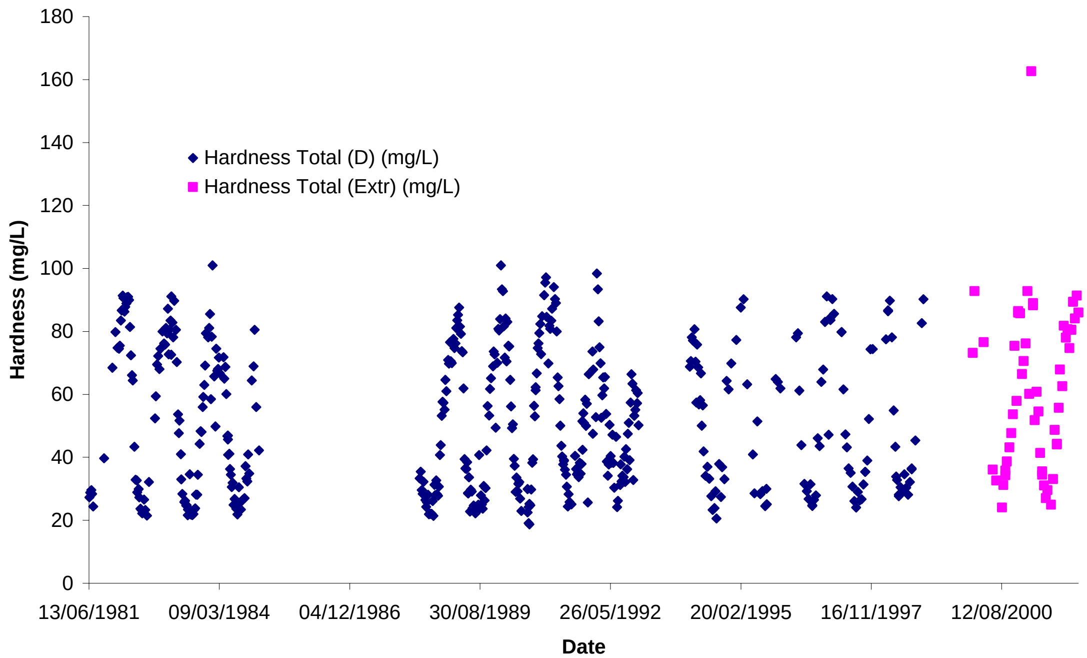

Figure 25. Salmon River near Hyder, Alaska - Iron, Total and Extractable and Turbidity

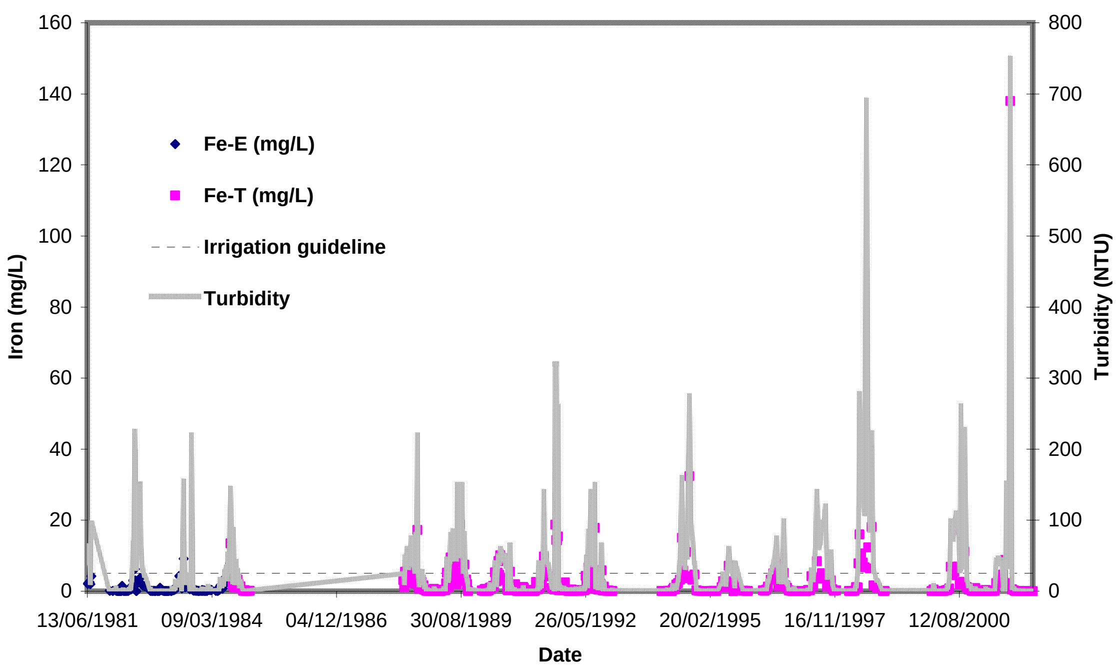

Figure 26. Salmon River near Hyder, Alaska - Lanthanum, Extractable

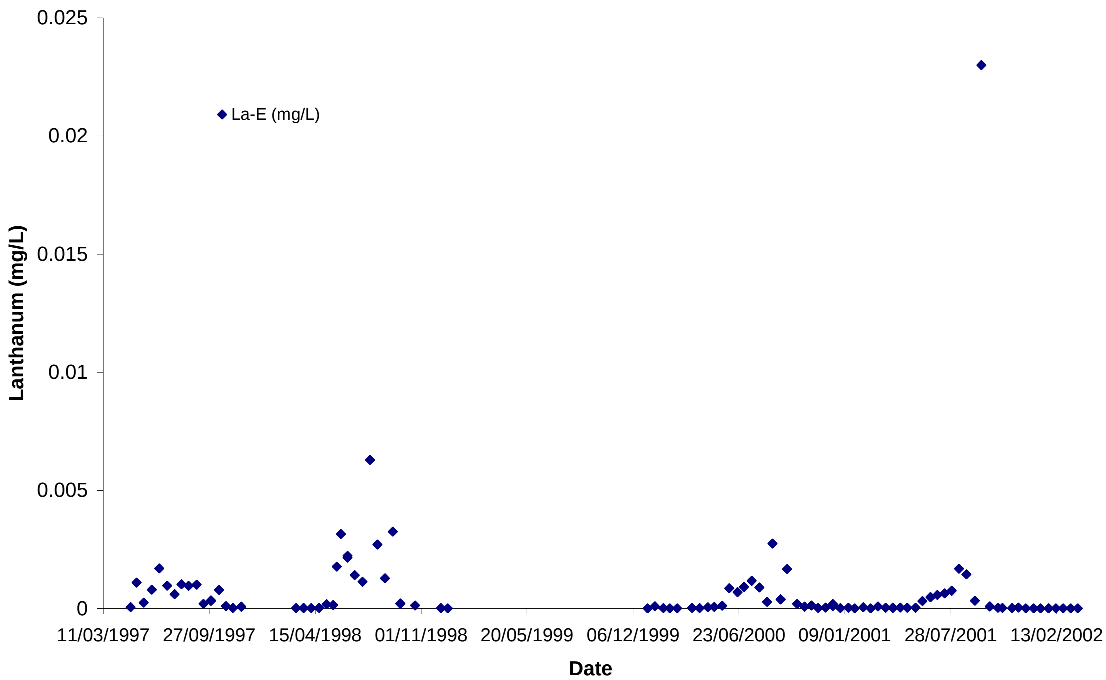

Figure 27. Salmon River near Hyder, Alaska - Lead, Total and Extractable and Turbidity

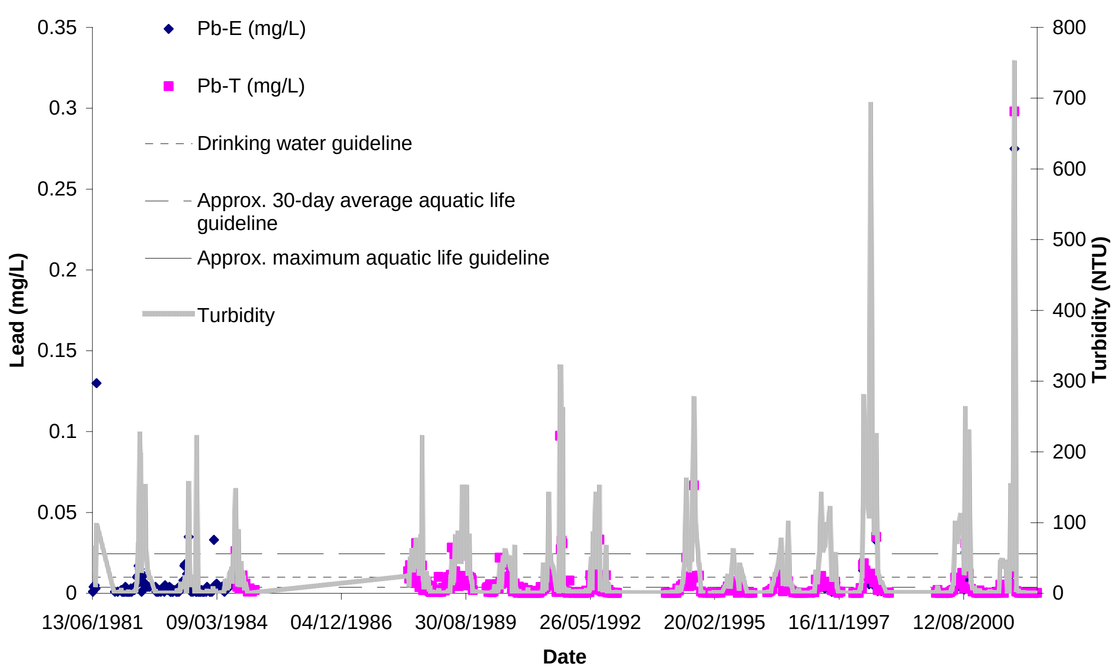

Figure 28. Salmon River near Hyder, Alaska - Lithium, Total and Extractable

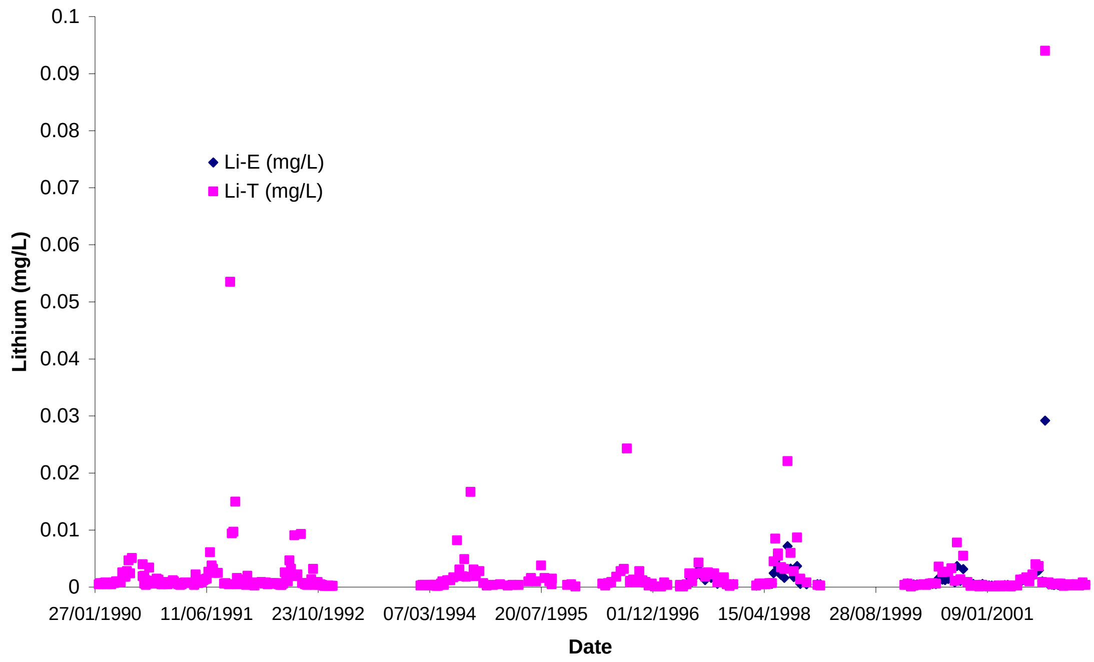

Figure 29. Salmon River near Hyder, Alaska - Magnesium, Dissolved and Extractable

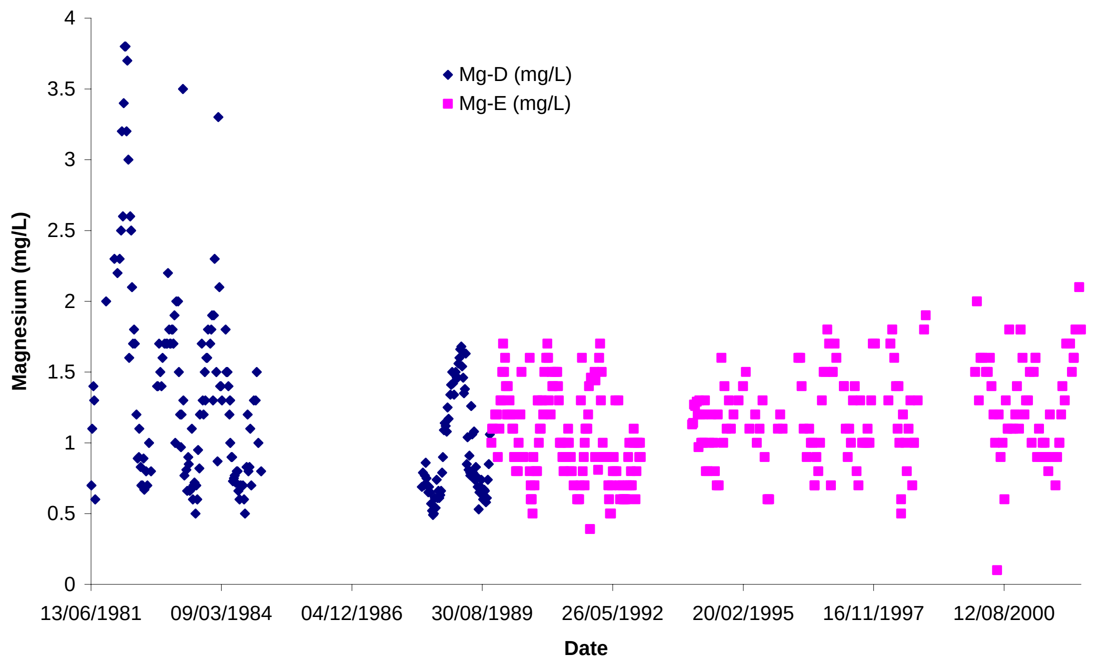

Figure 30. Salmon River near Hyder, Alaska - Manganese, Total and Extractable and Turbidity

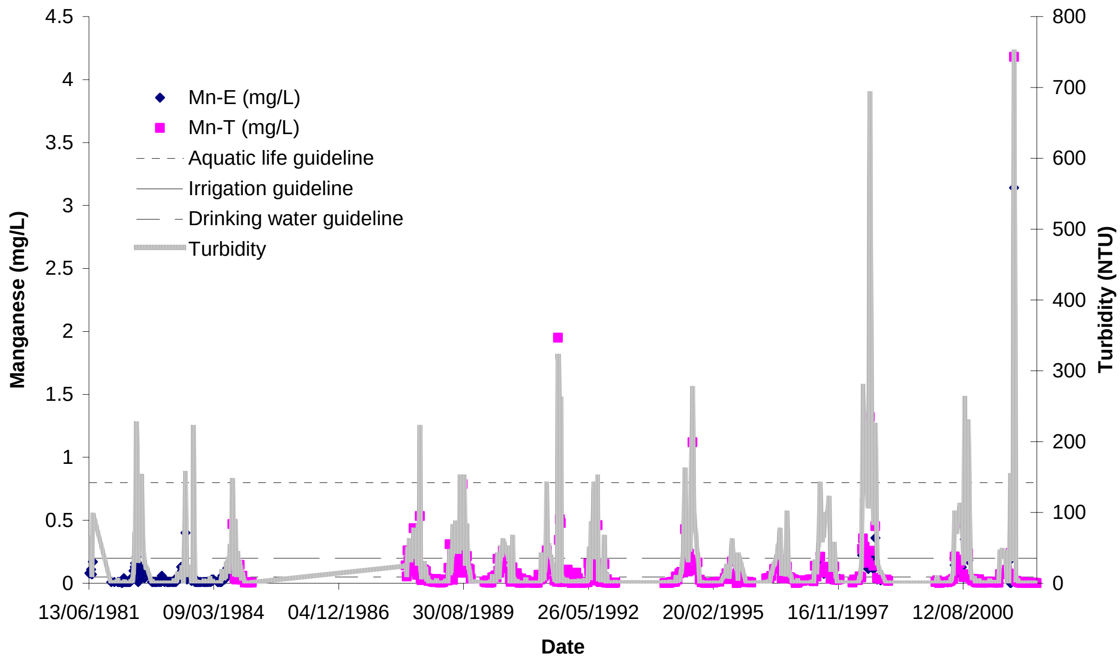

Figure 31. Salmon River near Hyder, Alaska - Mercury, Total and Extractable

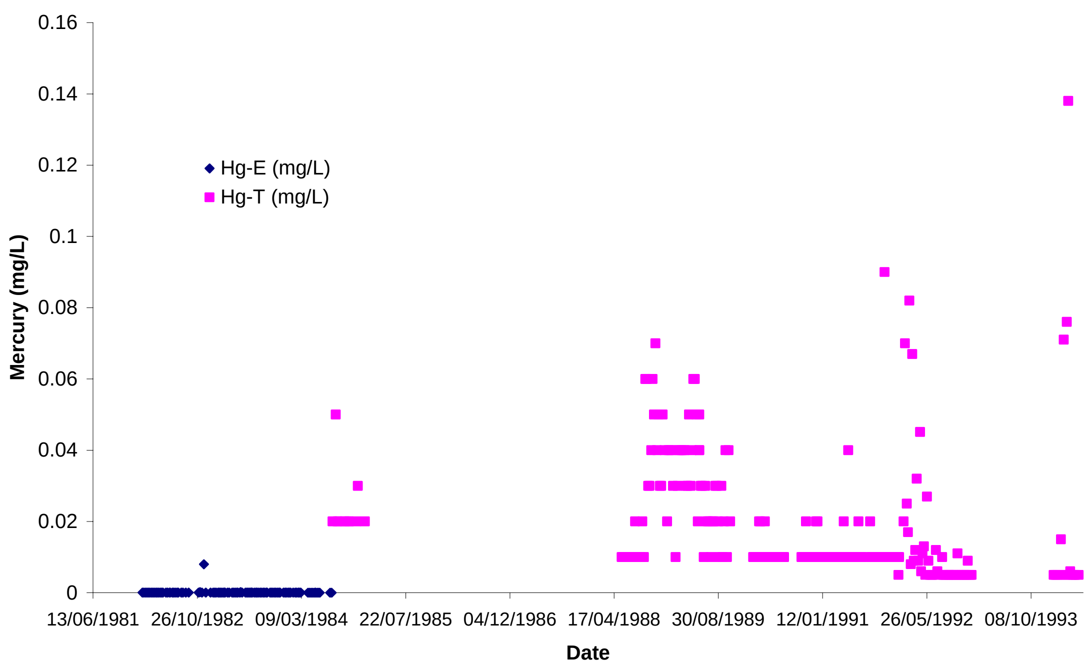

Figure 32. Salmon River near Hyder, Alaska - Molybdenum, Total

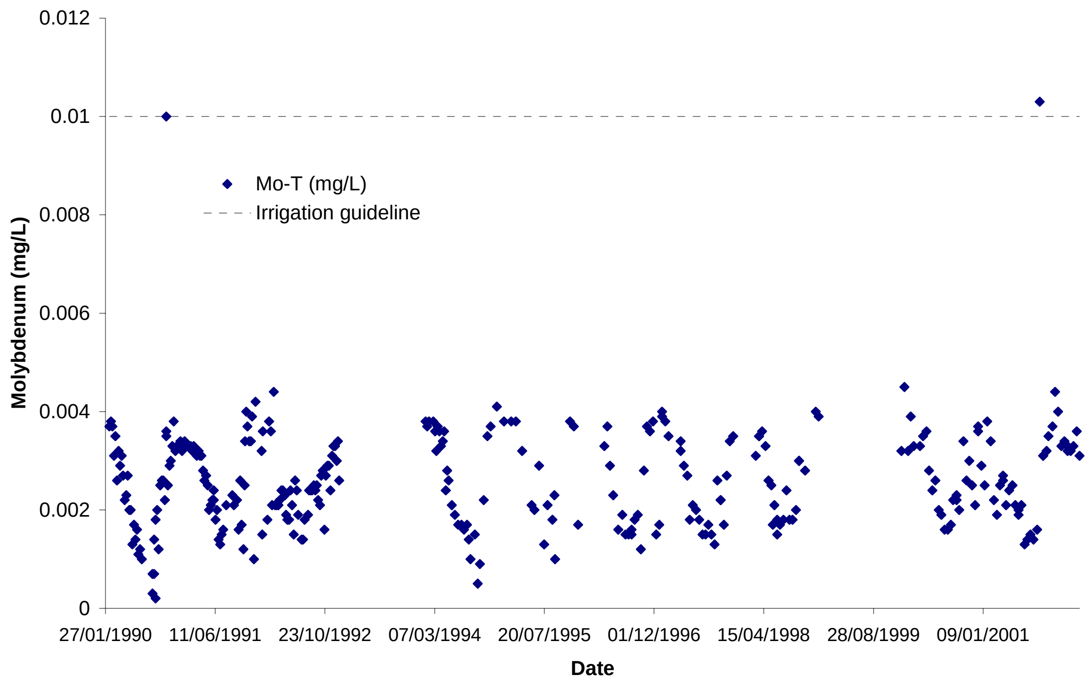

Figure 33. Salmon River near Hyder, Alaska - Nickel, Total and Extractable

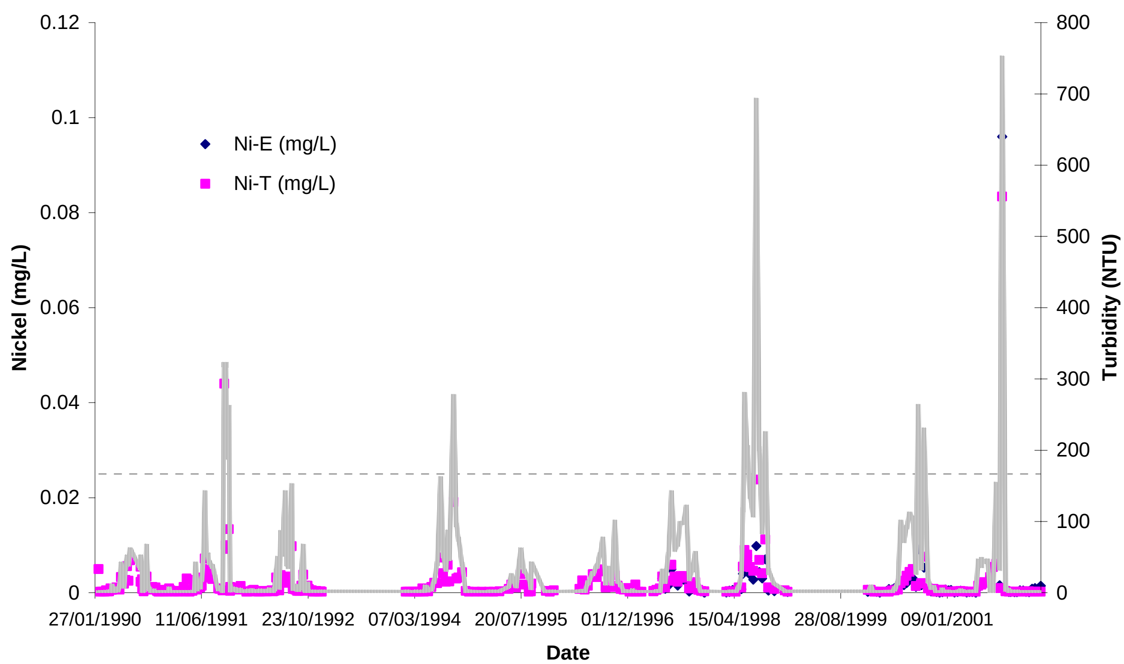

Figure 34. Salmon River near Hyder, Alaska - Nitrogen, Nitrate and Nitrite

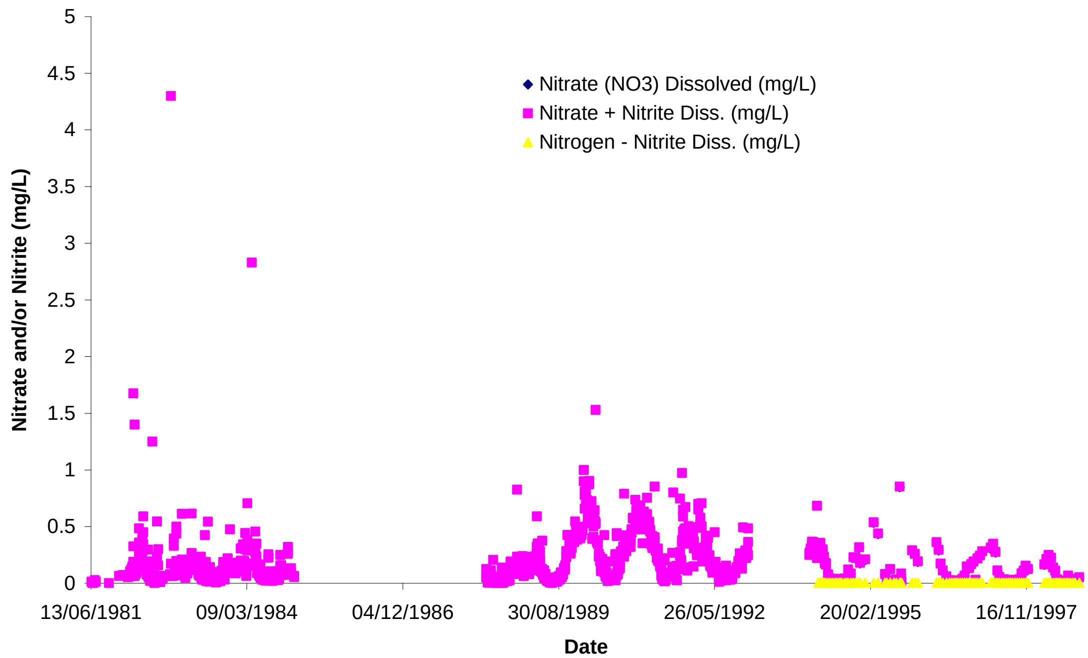

Figure 35. Salmon River near Hyder, Alaska - Nitrogen, Total Dissolved and Kjeldahl

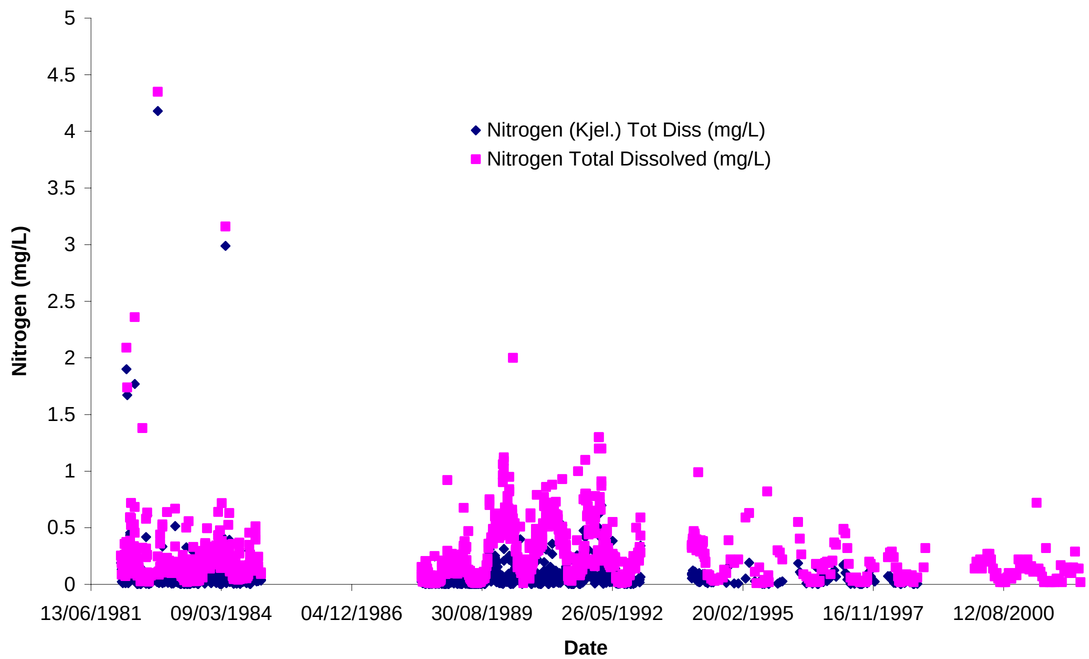

Figure 36. Salmon River near Hyder, Alaska - pH and Tubidity

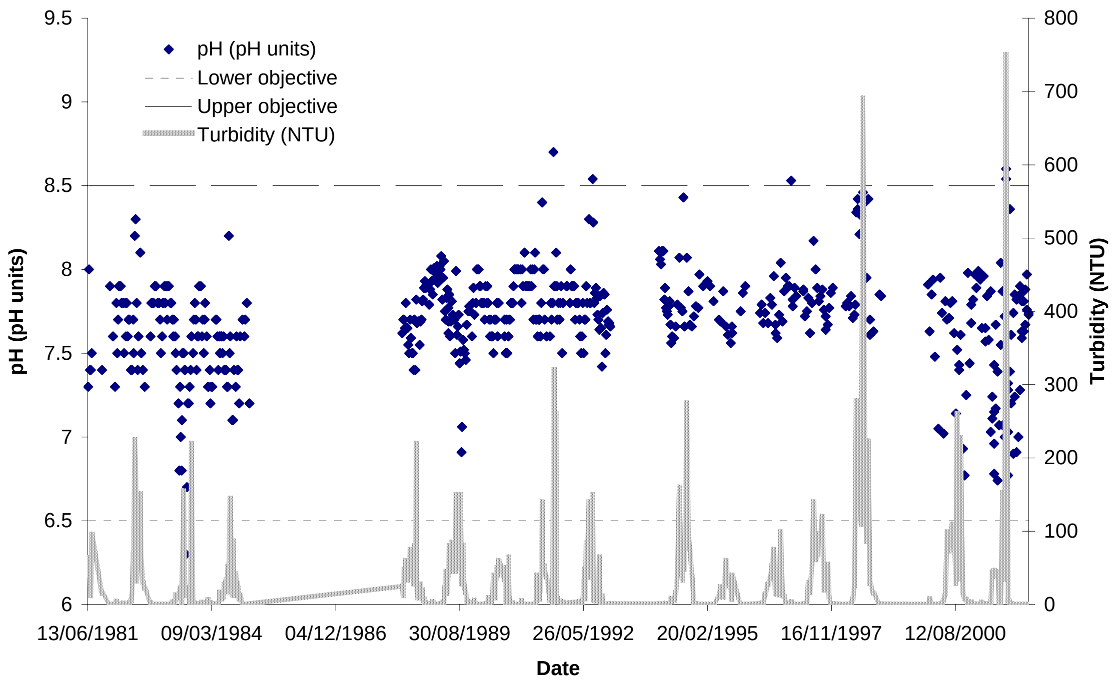

Figure 37. Salmon River near Hyder, Alaska - Phosphorus, Total and Ortho-Phosphate

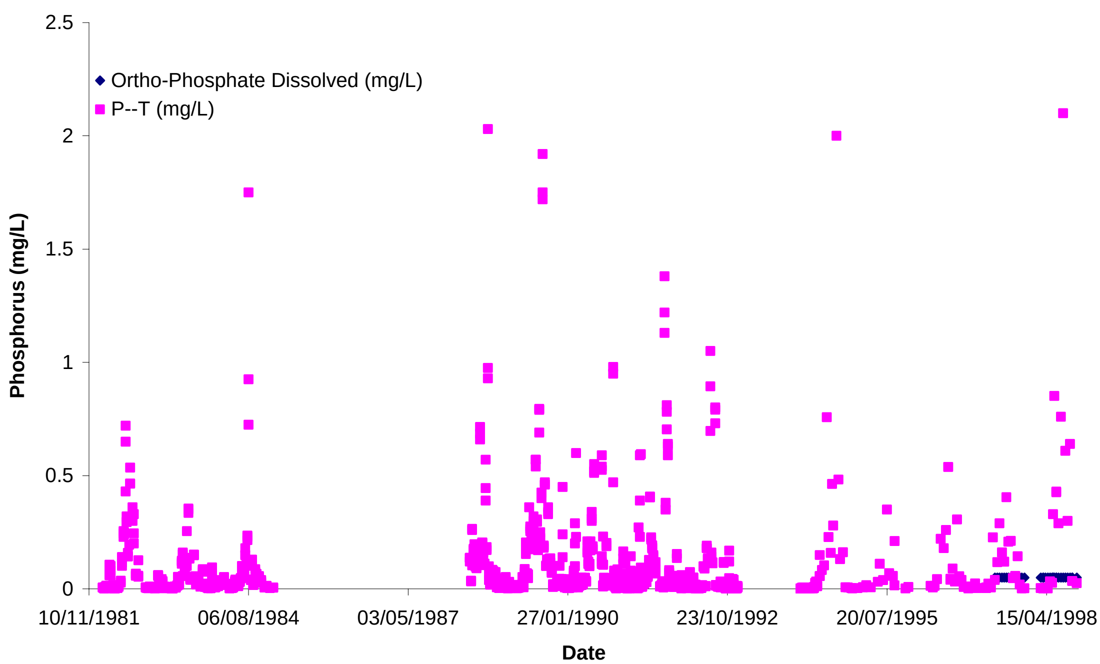

Figure 38. Salmon River near Hyder, Alaska - Potassium, Dissolved and Extractable

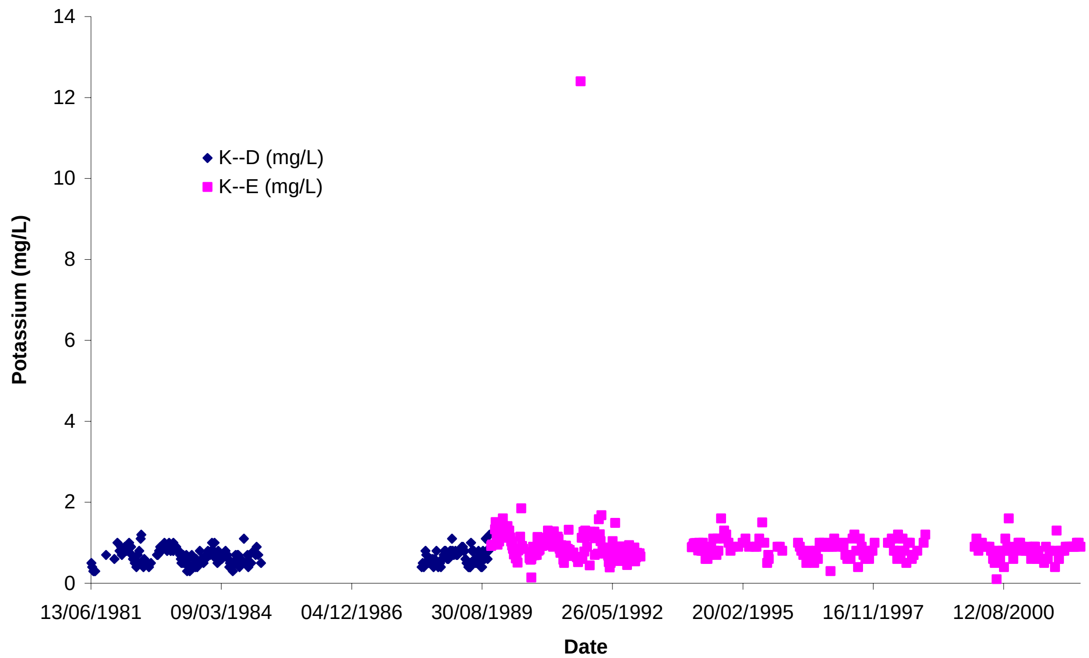

Figure 39. Salmon River near Hyder, Alaska - Residue, Filterable

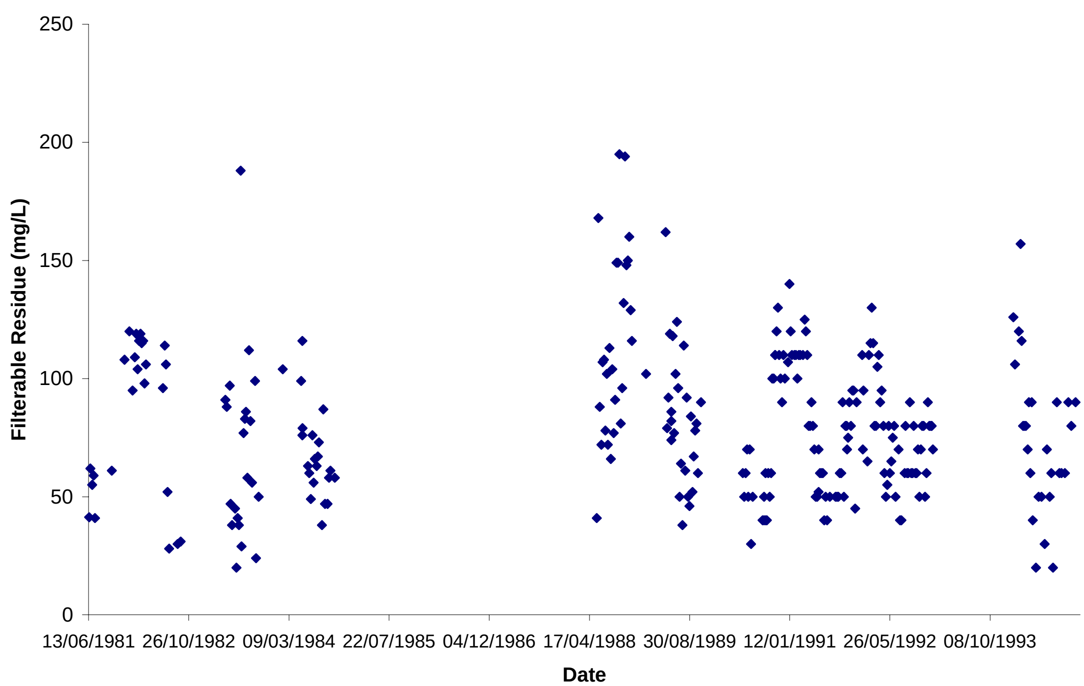

Figure 40. Salmon River near Hyder, Alaska - Residue, Non-Filterable

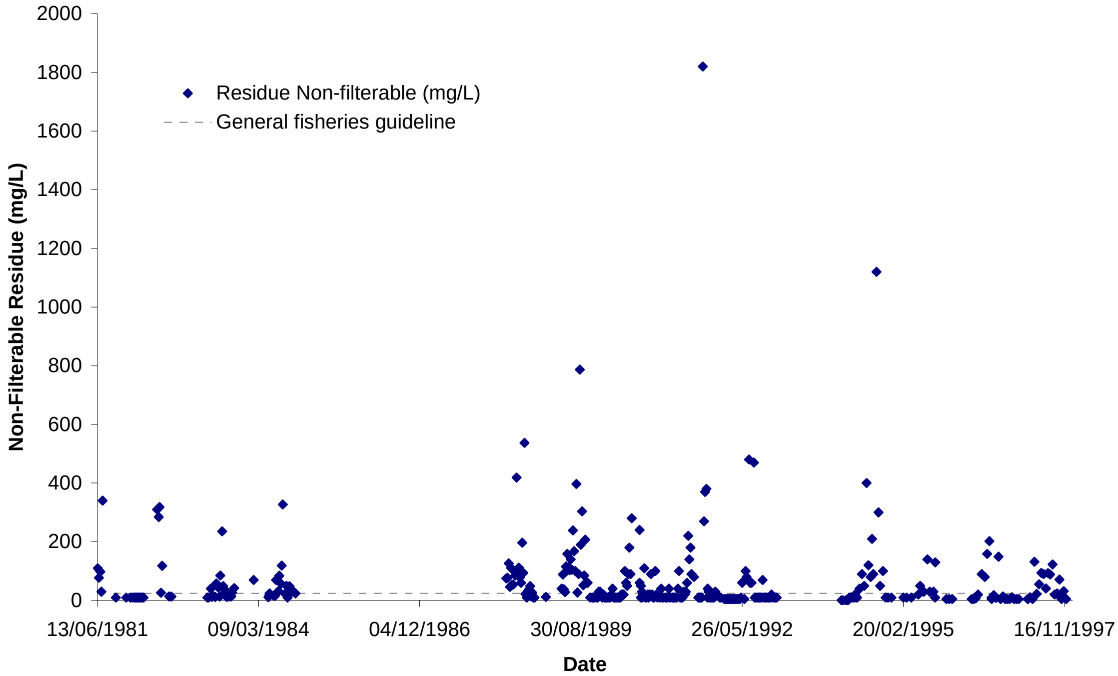

Figure 41. Salmon River near Hyder, Alaska - Rubidium, Extractable

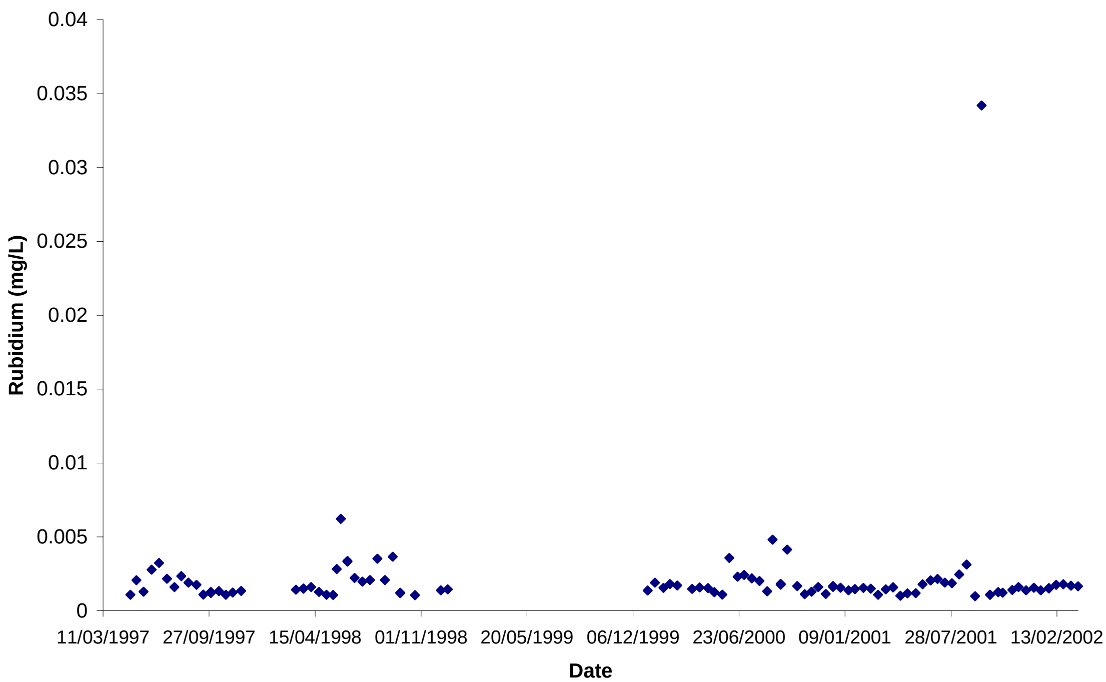

Figure 42. Salmon River near Hyder, Alaska - Selenium, Total, Dissolved and Extractable and Turbidity

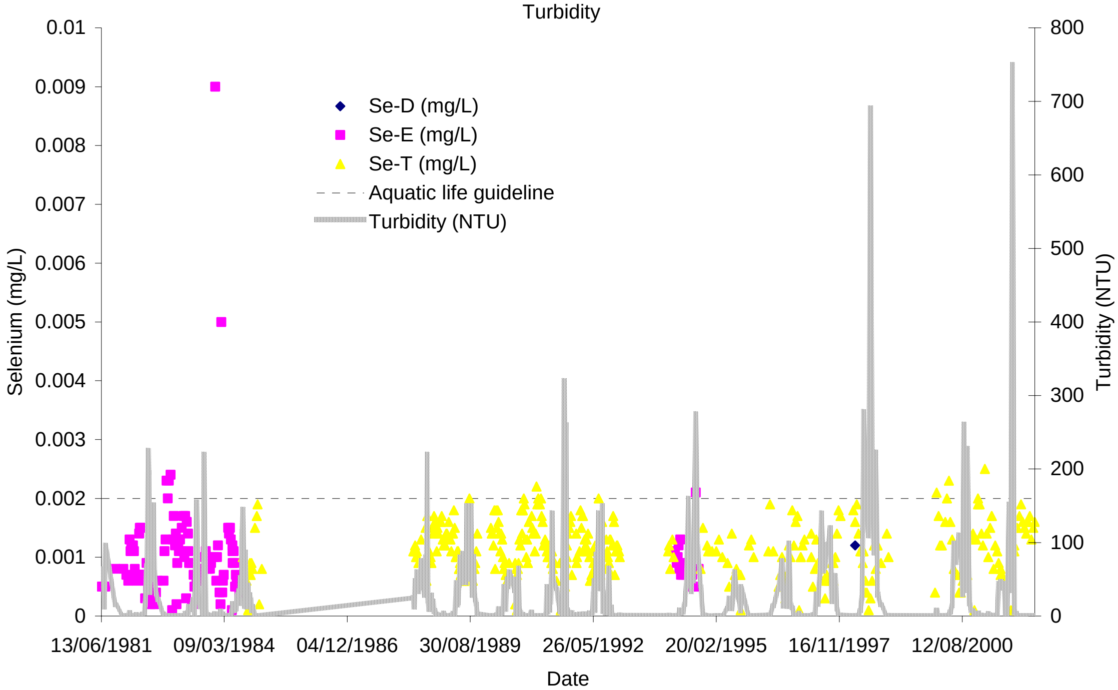

Figure 43. Salmon River near Hyder, Alaska - Silicon, Dissolved and Extractable and Silica, Dissolved

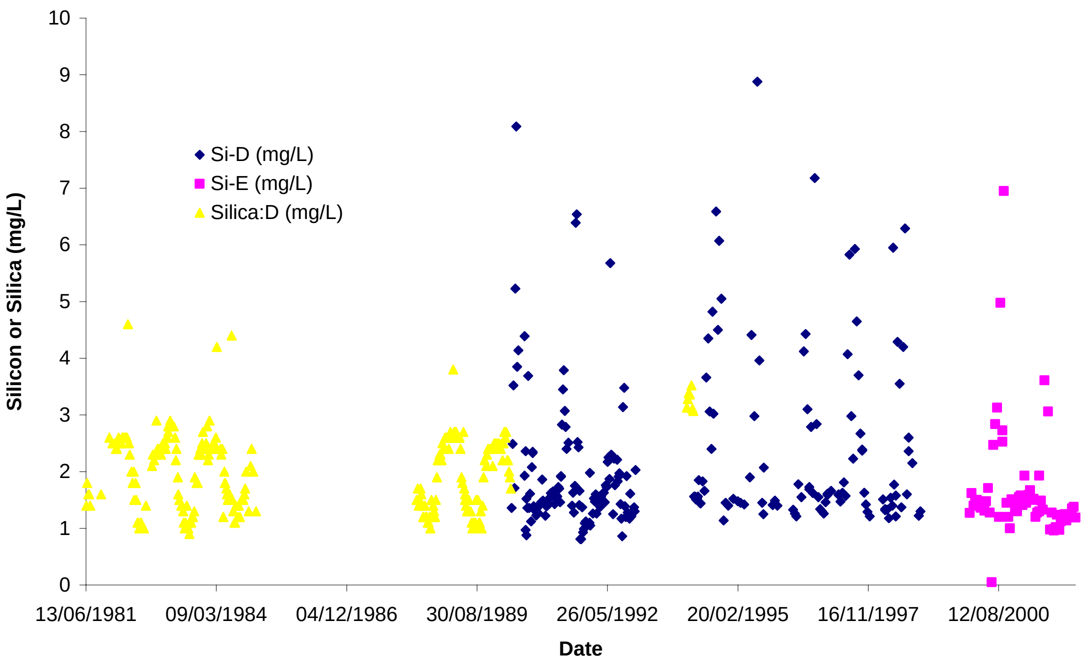

Figure 44. Salmon River near Hyder, Alaska - Silver, Total and Extractable

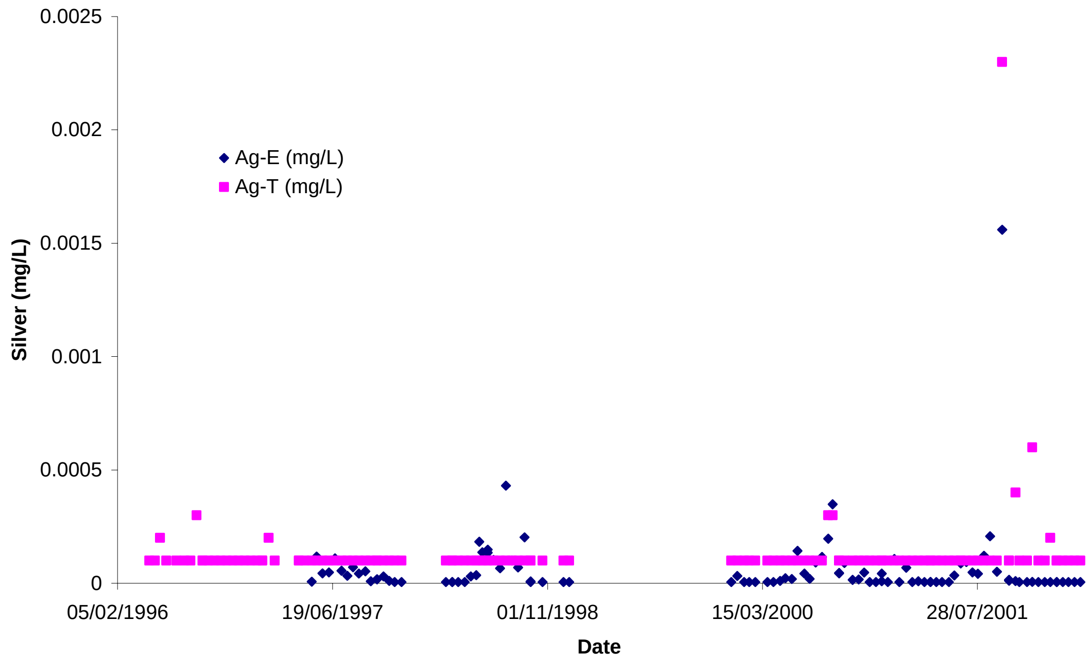

Figure 45. Salmon River near Hyder, Alaska - Sodium, Dissolved and Extractable

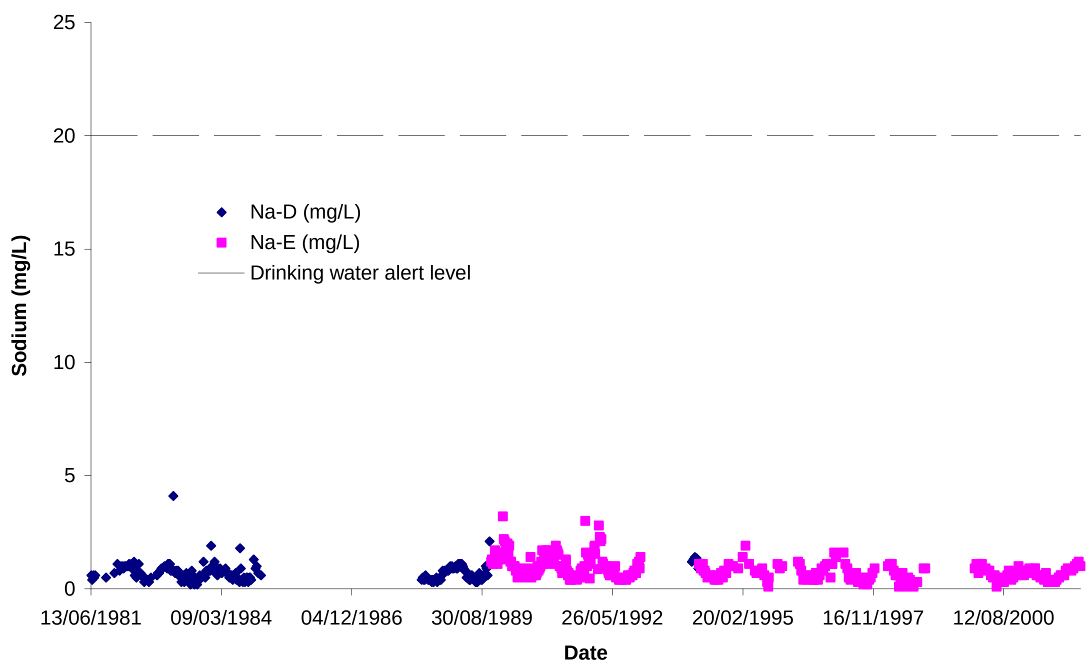

Figure 46. Salmon River near Hyder, Alaska - Strontium, Total and Extractable

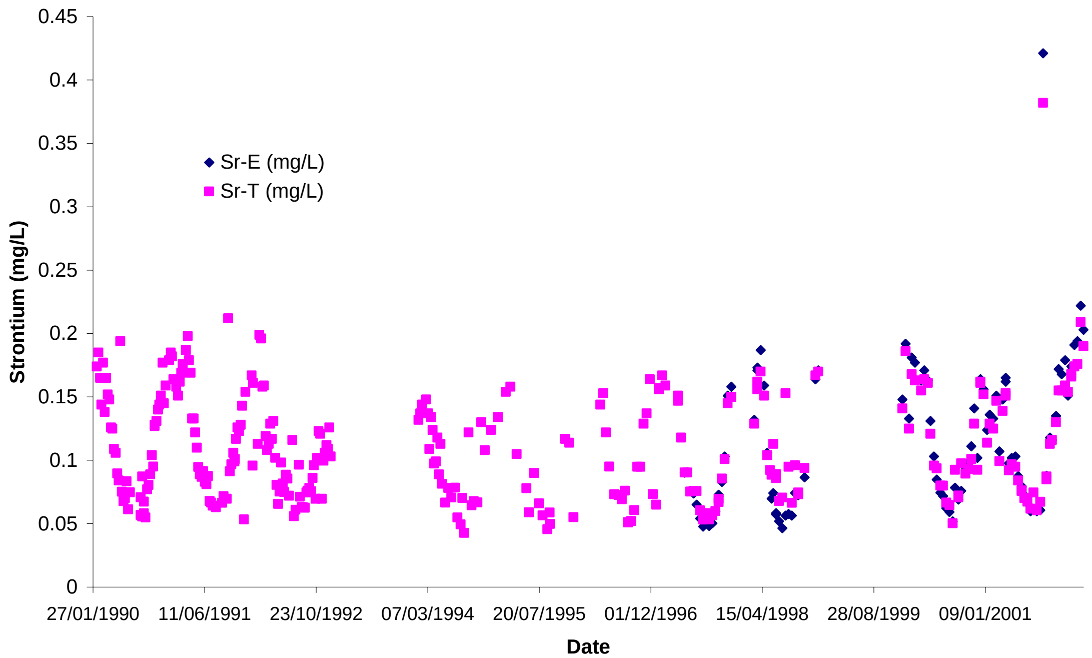

Figure 47. Salmon River near Hyder, Alaska - Sulphate, Dissolved and Turbidity

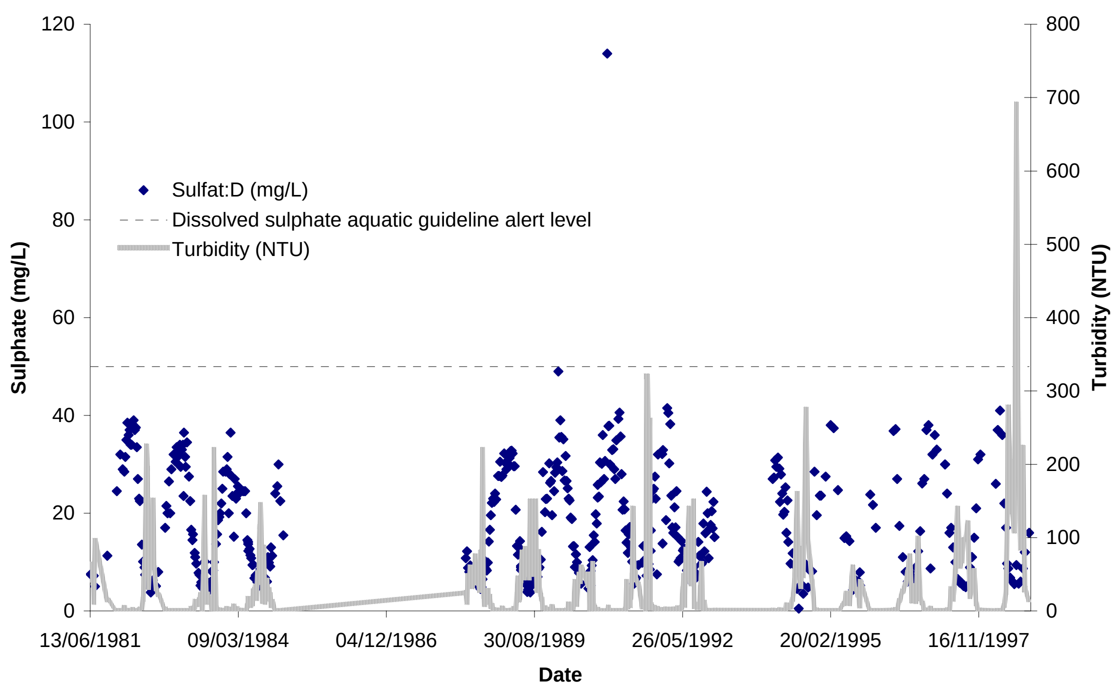

Figure 48. Salmon River near Hyder, Alaska - Temperature, Water

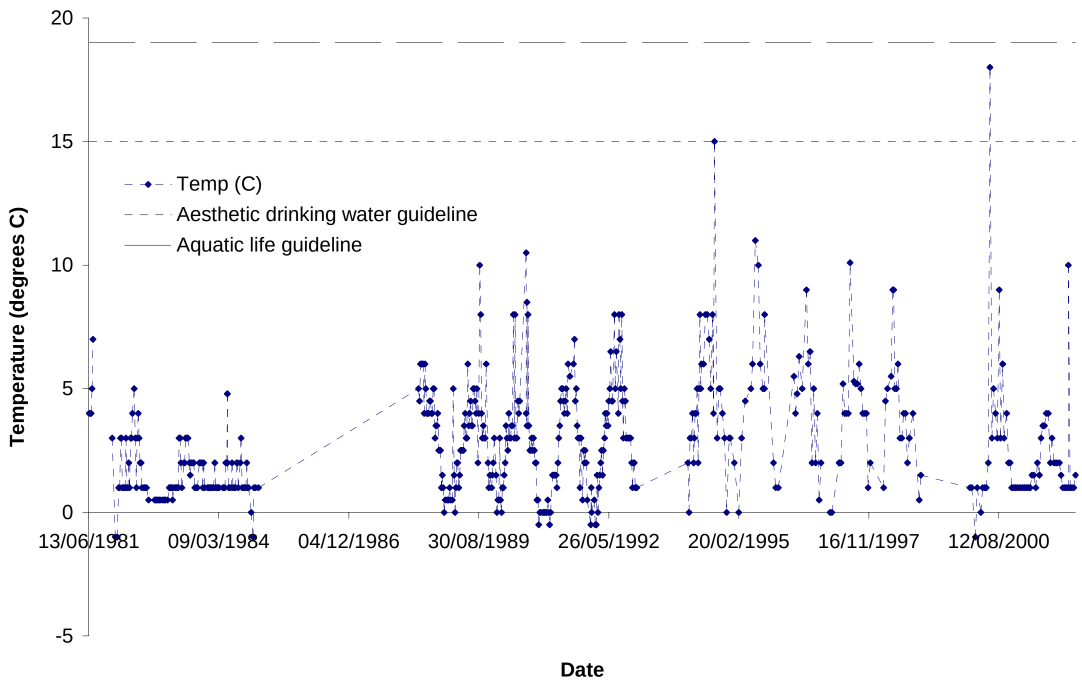

Figure 49. Salmon River near Hyder, Alaska - Thallium, Extractable

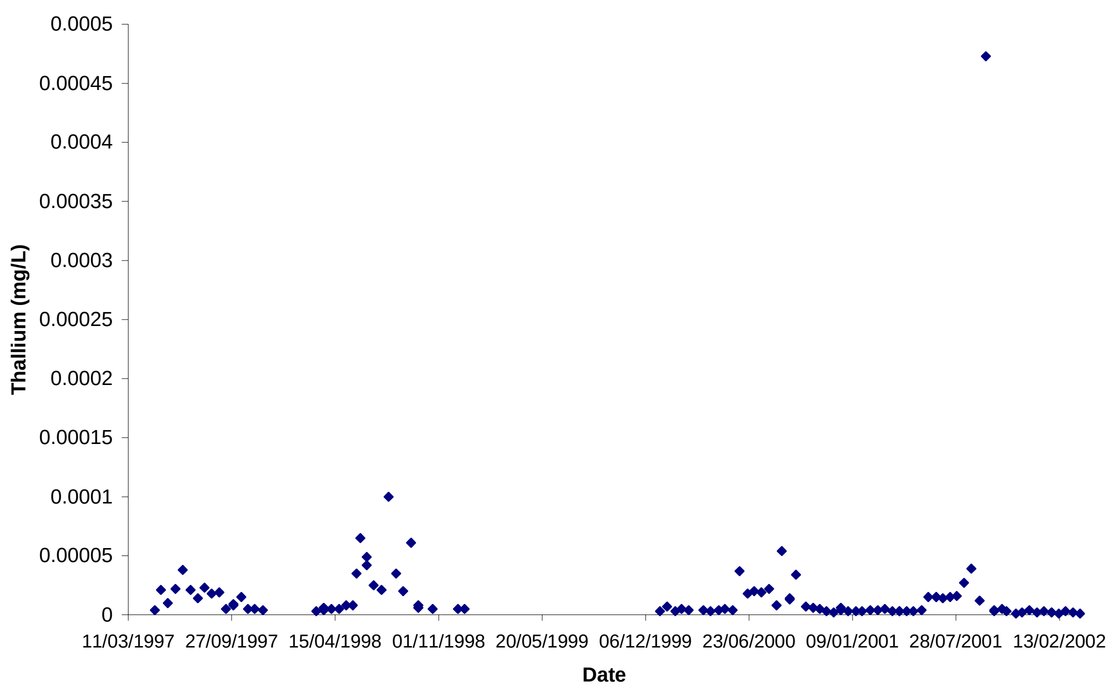

Figure 50. Salmon River near Hyder, Alaska - Turbidity

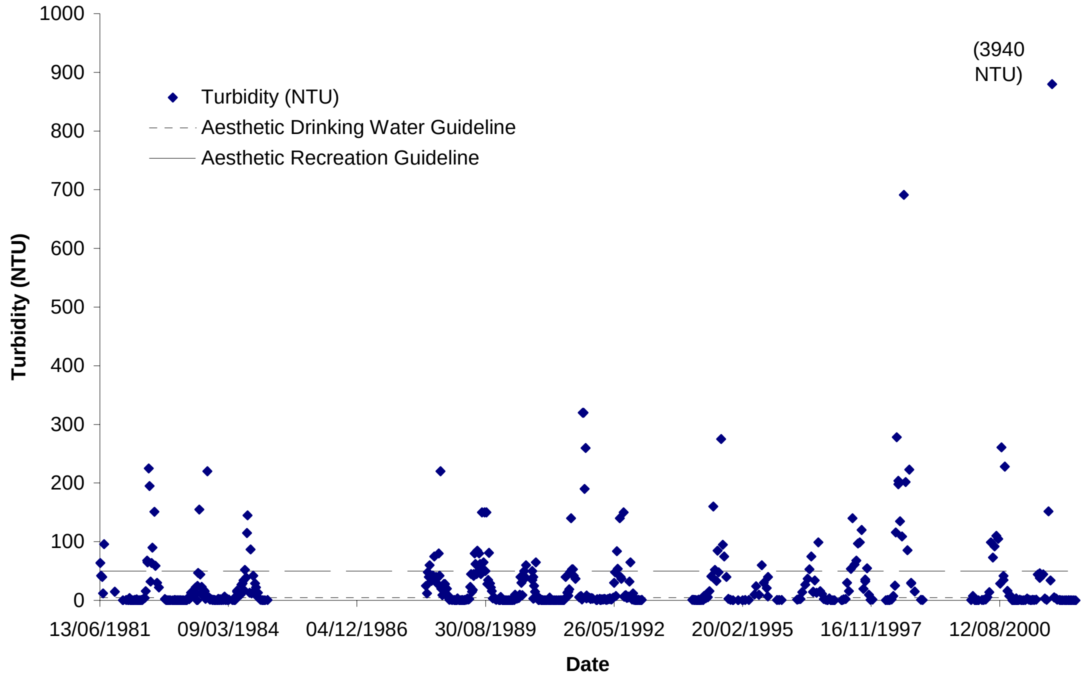

Figure 51. Salmon River near Hyder, Alaska - Uranium, Extractable

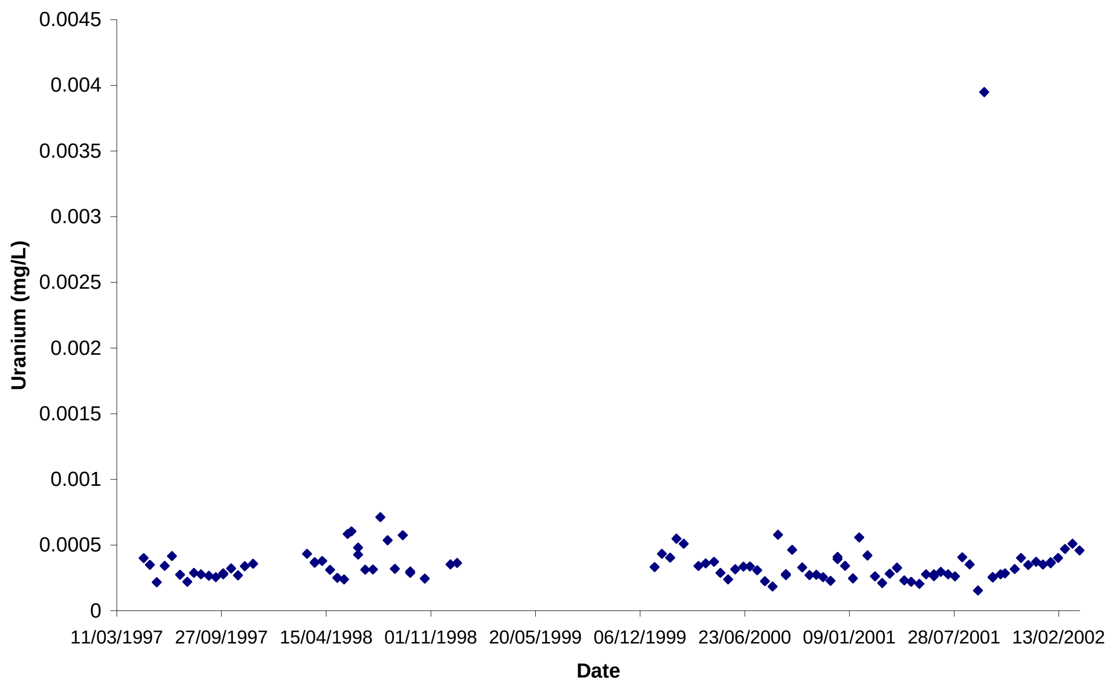

Figure 52. Salmon River near Hyder, Alaska - Vanadium, Total and Extractable

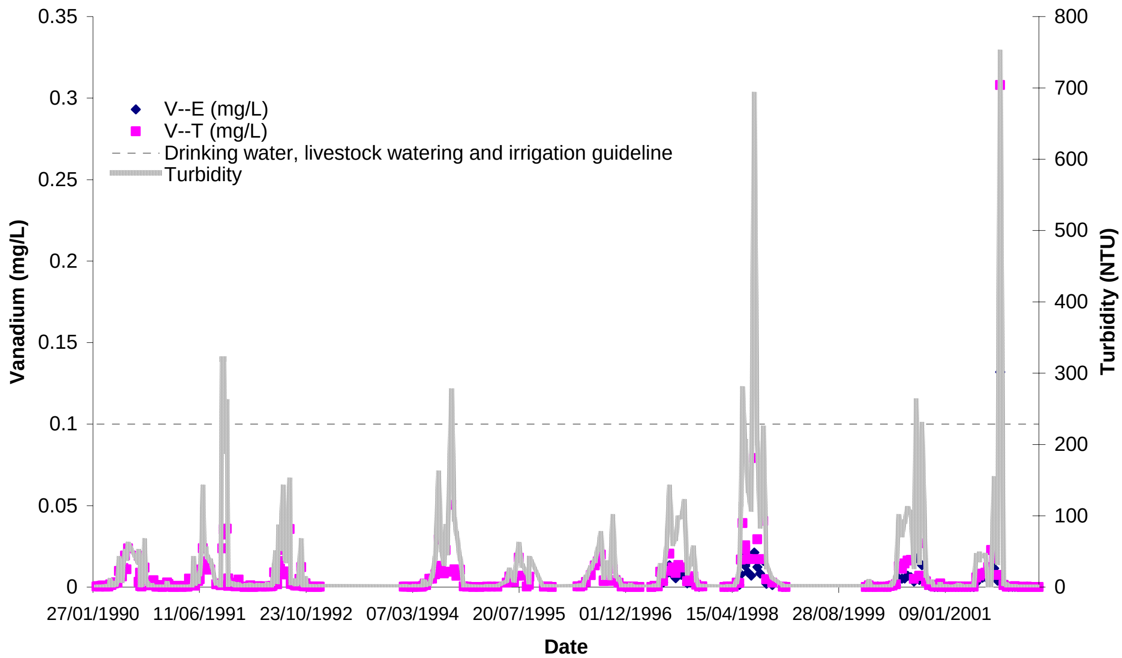

Figure 53. Salmon River near Hyder, Alaska - Zinc, Total and Extractable and Turbidity