Water Quality

Environmental Protection

State of Water Quality of the Bear River at Stewart, B.C. 1987-1994

Canada - British Columbia Water Quality Monitoring Agreement

Water Quality Branch
Environmental Protection Department
Ministry of Environment, Lands and Parks

Monitoring and Systems Branch

Environment Canada

Pacific and Yukon Region

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Executive Summary

This report assesses eight years of water quality data from the Bear River. The Bear River flows in a southerly direction from the north central coastal area of the province, emptying into the top end of the Portland Canal near Stewart, B.C. (Figure 1). The Portland Canal separates the southern portion of the state of Alaska and the north central B.C. coast. Environment Canada has monitored the Bear River since 1987 collecting 26 samples per year. One other related monitoring station within this area is the Salmon River near Hyder, Alaska.

Known errors were removed and the plotted data were compared to BC 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, wildlife, recreation, irrigation and livestock watering.

The main conclusions of this assessment are:

- No environmentally significant trends in water quality were detected by visual inspection of the plotted data.
- The water quality of the Bear River at Stewart during 1987 to 1994 is believed to be in a state of natural origin. It is influenced by glacial erosion, snow melt and mineralization. The watershed is sparsely populated and relatively unimpacted by resource development.

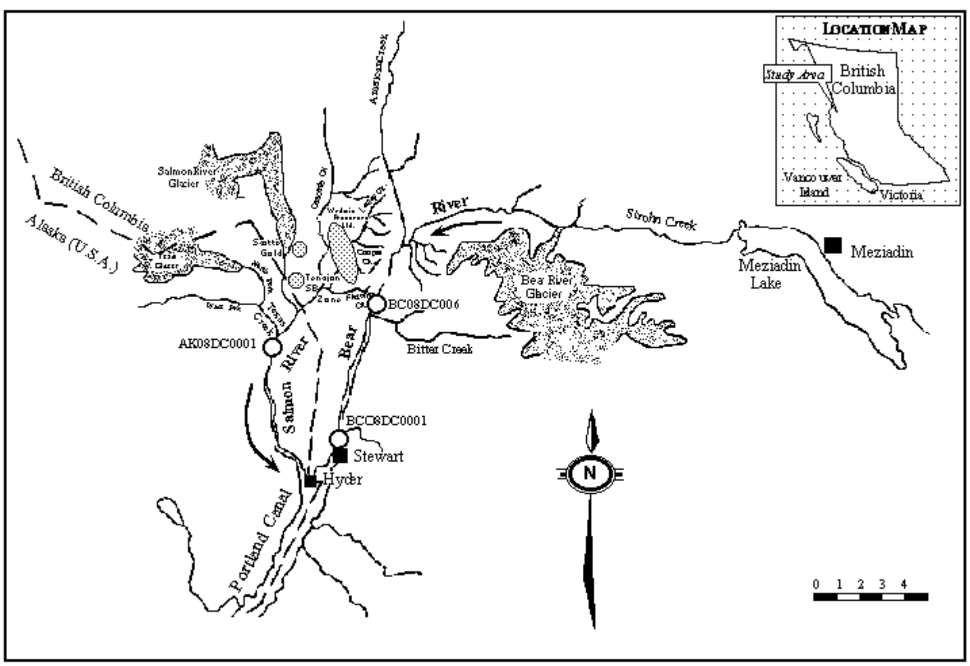
- The water was cool or cold throughout the year and not warm enough during the summer months to permit water-contact recreation such as swimming. This is due, in part, to the fact that a large volume of the water is glacier fed.
- The water was high in selenium due to the geology of the watershed and possibly historical mining activities, and often exceeded the selenium criterion for aquatic life.
- Because of the impact of glaciers, the water was often very turbid especially during annual freshet when higher flows resulted in increased erosion, suspended sediment, and turbidity. The extent to which human land use activities contribute to this natural phenomenon is unknown.
- The increased turbidity makes it necessary to treat drinking water to remove high levels of turbidity prior to use during freshet.
- Freshet also brings increased levels of total metals, total phosphorus, total organic carbon and apparent colour. Most of these may not be of concern as they are due to the increased suspended sediment in the water, and thus are probably largely biologically unavailable or would be removed by the treatment needed prior to drinking.
- Turbidity and suspended solids have remained stable or decreased slightly over the last 8 years.

Our main recommendations are:

- Suspend trend monitoring at this station.
- Identify the sources of the elevated selenium in the watershed for possible remediation.

Figure 1 Map of The Bear River Basin

STATE OF WATER QUALITY OF THEBEAR RIVER AT STEWART



AUTHOR

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CONTRIBUTORS

Collection of the water samples for this site over the 1987 to 1994 period was carried out by local sample collectors hired under the Canada-British Columbia Water Quality Monitoring Agreement. Preliminary drafts of this document were distributed to representatives of Environment Protection Department (EPD), and Environment Canada for their consideration and input. The author would like to acknowledge the editorial contributions and extend his appreciation to the following people; Larry Pommen and Roland Rocchini of Water Quality Branch, Victoria, B.C.; Mr. Philip Ross, Environmental Impact Assessment Section, Smithers, B.C.; Dr. Malcolm Clark, Senior Science Officer, EPD, Victoria, B.C.; and Andrea Ryan, Environment Canada, Vancouver, B.C. The author would also like to extend his appreciation to the three co-op students, Brant Wipperman and Leon Jang of Water Quality Branch and Robin Regnier of Environment Canada whose efforts in preparing the entire set of graphical plots made the data assessment of the very large data base possible.

Introduction

The Bear River at Stewart is located in the north central coast area of B.C. (Figure 1). The drainage area of the Bear River at Stewart, B.C. upstream from the water quality station is about 708 km2 (Fisheries Branch). The flow data from gauging station BC08DC006, which is located about 8 km upstream from the water quality station, are plotted on Figure 2. This gauging station is also upstream from the confluence with Bitter Creek, a major tributary with a glacier in the headwaters, and known for its high turbidity and silt content as well as high volume (up to 50% of the Bear River). The drainage area of the Bear River at Stewart, B.C. upstream from the gauging station is about 330 km2 (Fisheries Branch).

Environment Canada has monitored the water quality at this station about every two weeks since 1987, and the data are stored on the federal data base, ENVIRODAT, under station number BC08DC0001 (latitude 55° 57' 15" by longitude 129° 58' 23" on map sheet NTS 103-P13). This report assesses the 8 years of data from 1987 through 1994. The water quality data are plotted in alphabetical order from Figures 3 to 45. 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). The watershed upstream from Stewart is relatively pristine, with almost no human habitation or impacts. The Bear River glacier is located within the watershed. The Bear River is used as a control for the Salmon River near Hyder, Alaska. The Salmon River enters the west side of Portland Canal south-west of Stewart, B.C. (Figure 1).

Quality Assurance

The water quality plots were reviewed, and values that were known outliers were removed. Certain peak values were plotted off-scale using an asterisk, the value, and the sample date to facilitate better viewing and interpretation of the other values around criteria and minimum detectable limits (MDLs). There were known quality assurance problems for cadmium, chromium, copper, lead, mercury, pH, and zinc at various times during the period of record. Several of these metals (e.g., cadmium, chromium, copper, lead and zinc) were affected by contamination from the preservative vial lids from 1986-91. Mercury monitoring in water was discontinued in 1994 and the data have been excluded because all detectable values were probably a result of contamination (Pommen, 1994). Mercury in fish tissue should be monitored if there are any mercury concerns. Samples collected from 1986 to 1988 revealed low pH values due to a loss of control in measurements at the federal laboratory. There were no winter air temperatures below 0° C prior to the beginning of 1990, indicating an error in the temperature measurement or recording.

State of Water Quality

The state of the water quality is assessed by comparing the values to BC Environment's Approved and Working Criteria for Water Quality (Nagpal et al., 1995). There are no site-specific water quality objectives for the Bear River. Any levels or trends in water quality that may have been deleterious to sensitive water uses, including drinking water, aquatic life, wildlife, recreation, irrigation, and livestock watering are noted in the following discussion. The following 20 water quality indicators were not discussed as they easily met all water quality criteria and showed no clearly visible trends: Ba, Be, Ca, C (inorganic), Cl-, Co, conductivity, F-, Li, Mg, Mo, N03/N02-N, N2-N, pH, P, Si, Na, Sr, S04--, and V.

Flow (Figure 2) reveals a general pattern of very low flow in winter with high flows in mid to late summer due to snow and glacier melt. The highest flows often occurred in the fall due to rainstorms. The data were taken from flow station BC08DC006 which is located on the mainstem a short distance upstream from Bitter Creek and about 8 km upstream from the water quality site. Bitter Creek is a major glacier-headed tributary to the Bear River.

Total alkalinity (Figure 3) and calcium (Figure 9) show that the river at this location has a low sensitivity to acid inputs (well-buffered).

Total aluminum (Figure 4) had regular very high peak values throughout the mid-summer and fall freshets that were well above the 5 mg/L total aluminum criterion for wildlife, irrigation and livestock. Peak values were also above the drinking water and aquatic life criteria for dissolved aluminum. However, peak total aluminum was caused by the higher suspended sediment (see residue, non-filterable and turbidity) in freshet, and thus is probably not of concern because the dissolved aluminum fraction is suspected to be quite low. There appears to be no trend in peak total aluminum levels over this 5-year sampling period. Dissolved aluminum should be monitored for direct comparison to the criteria, if there is any concern about aluminum in the future.

Total arsenic (Figure 5) had occasional peak values that exceeded the drinking water criterion of 0.025 mg/L, and regularly exceeded the proposed aquatic life criterion of 0.005 mg/L. All of the peak values were related to high non-filterable residue (NFR) and turbidity due to high suspended sediment and thus are probably not bio-available. High levels would be reduced by the treatment to remove turbidity for use as drinking water. The adjacent Salmon River watershed had similar arsenic levels (Webber, 1996) indicating that the arsenic levels are probably a natural occurrence. Dissolved and total arsenic should be monitored if there is any concern about this variable in the future.

Total cadmium (Figure 8) had MDLs that were 2-10 times above the proposed Canadian Council of Ministers of the Environment (CCME) aquatic life criteria and above levels that are typical in pristine waters. Some of the detectable values prior to 1991 may be unreliable because of suspected contamination from the failure of preservative vial cap liners during 1986-91. The contamination was indicated by poor correlation with some turbidity peaks. Since 1991, cadmium and turbidity levels correlate well, indicating that cadmium peaks were due to elevated suspended sediment and the cadmium may not be biologically available. An MDL at least 10 times below the lowest relevant criterion is required to determine if criteria are being met and both dissolved and total cadmium should be measured.

Total organic carbon (Figure 10) had one value above the drinking water criterion when turbidity and non-filterable residue levels were high. The elevated total organic carbon (TOC) was probably due to particulate matter in the water which would be removed by the settling and/or filtration needed prior to use for drinking water. Further evaluation of organic carbon and the potential for trihalomethane formation should be done if the Bear River is ever used as a chlorinated drinking water supply.

Total chromium (Figure 13) regularly exceeded the criterion to protect phyto- and zoo-plankton of 0.002 mg/L and occasionally exceeded the criterion for fish criterion of 0.02 mg/L throughout the 5-year sampling period. This was mainly due to increased flow and subsequent elevated particulate levels during mid-summer freshets. The chromium was therefore probably not bio-available.

Apparent color (Figure 15) occasionally exceeded the 100-unit true colour maximum criterion for recreation and regularly exceeded the 15-unit true color criterion for drinking water (aesthetics) and recreation during periods of high mid-summer flow, due to the higher turbidity at that time. True color would have been lower because the turbidity is removed before measurement. True color should be measured if there are color concerns in the future.

Total copper (Figure 17) was influenced by widespread artificial contamination due to the failure of preservative vial cap liners during 1986-91. Data assessment after early 1991, when the vials were changed, reveals lower values compared to the aquatic life criteria of 0.002 to 0.006 mg/L for the river water hardness range of <50-150 mg/L, and better correlation with peak flows and high turbidity. Although the vials were changed, copper still regularly exceeded the aquatic life criteria during freshet due to elevated levels of NFR and turbidity. This should be of little concern as the elevated copper is unlikely to be bio-available. The adjacent Salmon River had similar total copper levels.

Hardness (Figure 19) showed that the water ranged from soft to hard, alternating above, within, and below the optimum range for drinking water in response to the peak and low flow periods of this watershed. The lowest values corresponded well with the peak flows during mid-summer.

Total Iron (Figure 20) was usually well above the criterion for drinking water (aesthetics) and aquatic life during summer freshet when flow and suspended sediment were usually very high. As most of the iron and turbidity peaks coincide, the high iron is probably due to the iron content of the suspended sediment and thus, unlikely to be bio-available. Drinking water use during freshet would require turbidity removal, which would probably reduce iron below the criterion. There appears to be no particular trend in the total iron peaks during summer freshets throughout the 8-year sampling period.

Total lead (Figure 21) frequently exceeded aquatic life criteria of 0.004 mg/L to 0.008 mg/L throughout the 8-year sampling period although, prior to 1991, artificial contamination may have occurred due to preservative vial cap liner failures and false positives near the old MDL (0.001 mg/L). Peak lead levels were well correlated with peak turbidity, indicating that the lead was due to suspended sediment and was probably not bio-available. The drinking water criterion of 0.01 mg/L was also exceeded during periods of high flow when most of the lead and turbidity peaks coincide. Drinking water use during freshet would require turbidity removal, which would reduce the lead content below the criterion. Total lead levels were also high in the adjacent Salmon River watershed.

Total manganese (Figure 24) frequently exceeded the drinking water criterion at 0.05 mg/L, the aquatic life criterion at 0.1 mg/L and the irrigation criterion at 0.20 mg/L, particularly during the mid-summer high flow periods when nearly all manganese and turbidity peaks coincide. This indicates that the elevated manganese was due to suspended sediment, and was probably not bio-available. The manganese would therefore be removed by the treatment needed to remove turbidity before use for drinking water.

Total nickel (Figure 26) showed only one exceedence of the aquatic life criterion at 0.025 mg/L (hardness = 0 to 60 mg/L), on September 25, 1991, when very high NFR, flow and turbidity values were also recorded. This indicates that the nickel was probably due to suspended sediment and was probably not bio-available.

Total phosphorus (Figure 30) showed peak values during mid-summer freshet when suspended sediments were naturally elevated (i.e., coincides with high NFR and turbidity). There was a slight downward trend in peak phosphorus levels towards 1995, similar to the declining pattern in NFR. There are no criteria for phosphorus in B.C. rivers.

Non-filterable residue (NFR) (i.e., suspended solids or sediment) (Figure 34) and Turbidity (Figure 43) both showed peaks during summer and fall freshet when suspended sediments were greatly elevated. NFR was regularly below the general fisheries criterion of 25 mg/L (Newcombe, 1986) during the winter and early spring periods of low flow. The turbidity criterion for swimming was not met during the summer, but the water was too cold for contact recreation such as swimming. The raw drinking water criterion at 5 NTU for water without treatment for turbidity removal was usually exceeded especially during mid summer-fall freshet. NFR showed an overall declining trend in peak values from 1989 onward, although a decreasing trend in flow and turbidity is not apparent. Turbidity is more sensitive (lower MDL, fewer non-detects), cheaper, has better criteria, and responds similarly to NFR, and thus we recommend that it be used as a surrogate for NFR in any future monitoring.

Fixed filterable and fixed non-filterable residue (Figures 33 and 35) have no criteria, and are generally uninterpretable, with little value for water quality assessment. We recommend that they be replaced with more relevant and specific measures of organic or inorganic constituents.

Selenium (Figure 36) often exceeded the aquatic life criterion of 0.001 mg/L. The highest value was recorded in mid-1987 corresponding to very high flow, turbidity and NFR at that time, although peak Se levels also occurred in winter low flows. The local geology is highly mineralized and may be naturally rich in selenium. Selenium levels in the adjacent Salmon River are similar (Webber, 1996). The levels in the Bear and Salmon Rivers, along with the Elk River in the east Kootenays (Wipperman and Webber, 1996), were the highest levels measured by Environment Canada in B.C. rivers (Pommen, 1996). Many of the old mines in the Bear and Salmon River area may contribute to the mobilization of selenium. We recommend that a survey be conducted to identify the sources of selenium in the Bear River watershed and the potential for remediation. 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.

Water temperature (Figure 42) always met the drinking water criterion (aesthetics) throughout the 8-year sampling period but, as expected from a glacier-fed system, failed to reach the lower limit for recreation (i.e., too cold for contact use such as swimming).

Total zinc (Figure 45) usually exceeded aquatic life criteria throughout the 8-year sampling period during the summer-fall periods of high flow, in part due to the preservative vial cap liner failures experienced in the late 1980s, and the elevated suspended sediment during summer-fall freshet. Peak total zinc, non-filterable residue and turbidity values coincided, indicating that the zinc was due to particulate matter and thus unlikely to be bio-available. The aquatic life criteria continued to be exceeded during peak flows after early 1991, when preservative vials were changed, in this apparently highly mineralized watershed. Total zinc levels were similar in the adjacent Salmon River watershed.

Other variables were well below all water quality criteria for the sensitive water uses and showed no environmentally significant trends.

Conclusions - State of Water Quality

- No environmentally significant trends in water quality were detected by visual inspection of the plotted data.
- The water quality of the Bear River at Stewart during 1987 to 1994 is believed to be in a natural state and is influenced by glacial erosion and mineralization. The watershed is sparsely populated and relatively unimpacted by humans.
- The water was well buffered against acid inputs throughout the year, yet acceptably soft enough for drinking water.
- The water was cool or cold throughout the year and not warm enough during the summer months to permit water-contact recreation such as swimming. This is due, in part, to the fact that a large volume of the water is glacier-fed.
- The water was high in selenium due to the geology of the watershed and possibly historical mining activities, and often exceeded the selenium criterion for aquatic life.
- Because of the impact of glaciers, the water is often very turbid especially during annual freshet when higher flows result in increased erosion, suspended sediment, and turbidity. The extent to which human land use activities contribute to this natural phenomenon is unknown.
- The increased turbidity make it necessary to treat drinking water to remove high levels of turbidity prior to use during freshet.
- Freshet also brings increased levels of total metals, total phosphorus, total organic carbon and apparent colour. Most of these may not be of concern as they are due to the increased suspended sediment in the water, and thus are probably largely biologically unavailable or would be removed by the treatment needed prior to drinking.

- Turbidity and suspended solids have remained stable or decreased slightly over the last 8 years.

Comparison to other rivers in the area:

Please refer to the Salmon River near Hyder, Alaska report (Webber, 1996).

Recommendations for Water Quality Management

Remediation

The sources of the elevated selenium in the watershed should be identified for possible remediation.

Monitoring

We recommend that monitoring be discontinued at this station.

<u>Figure 1 Map of The Bear River Basin</u>

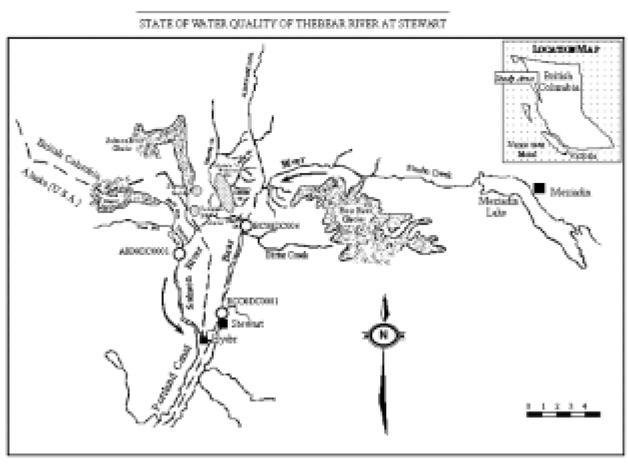


Figure 2 Flow, in m3/s

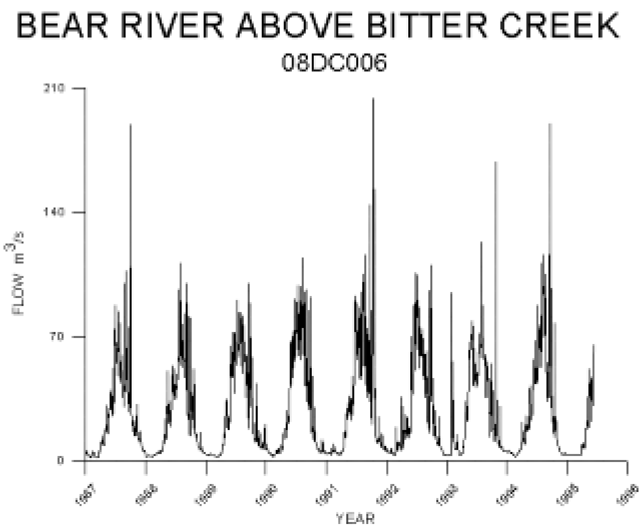


Figure 3 Alkalinity, Total in mg/L as CaC03

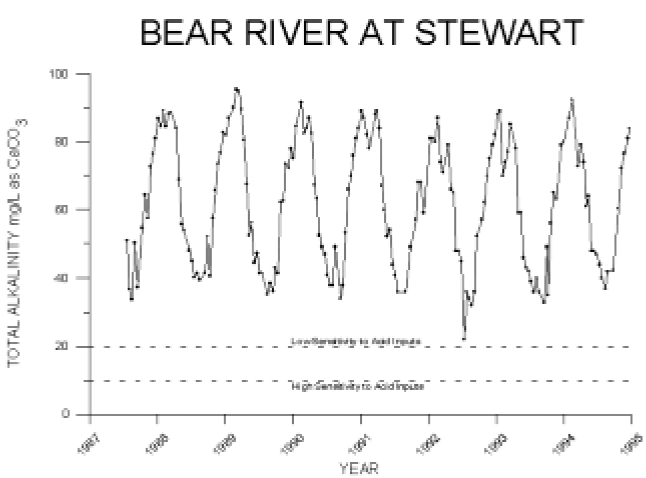


Figure 4 Aluminum, Total in mg/L

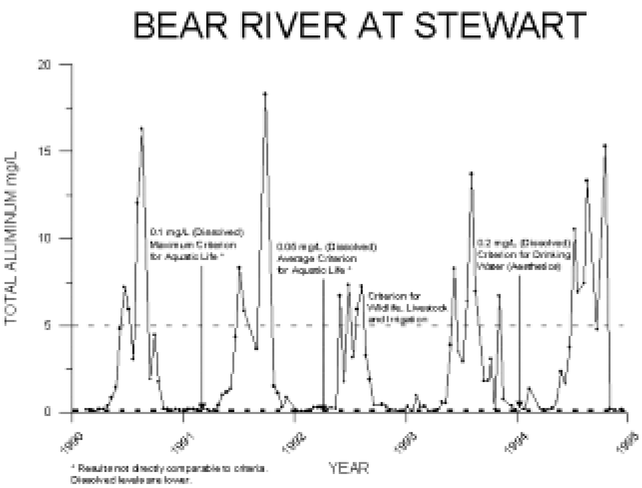


Figure 5 Arsenic, Total in mg/L

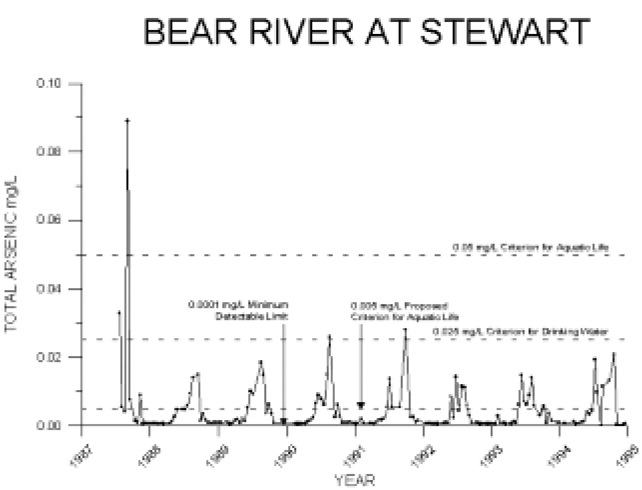


Figure 6 Barium, Total in mg/L

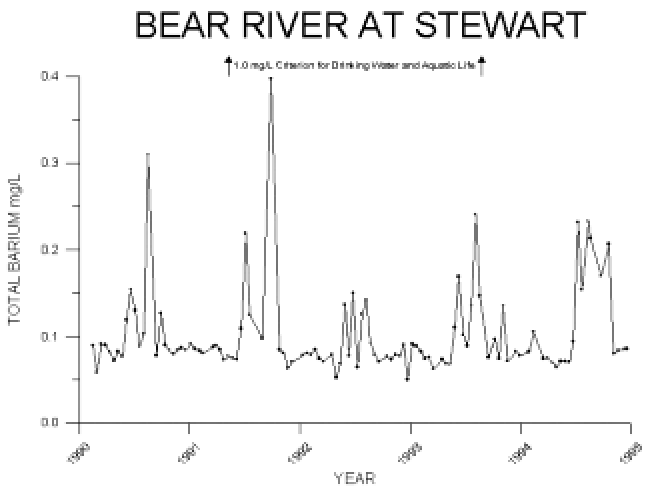


Figure 7 Beryllium, Total in mg/L

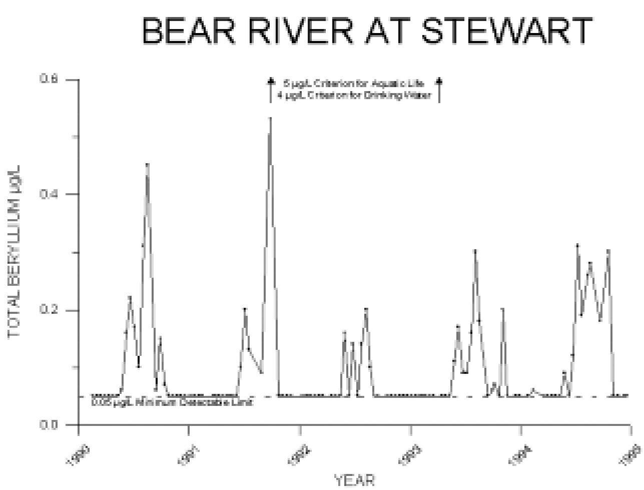


Figure 8 Cadmium, Total in mg/L

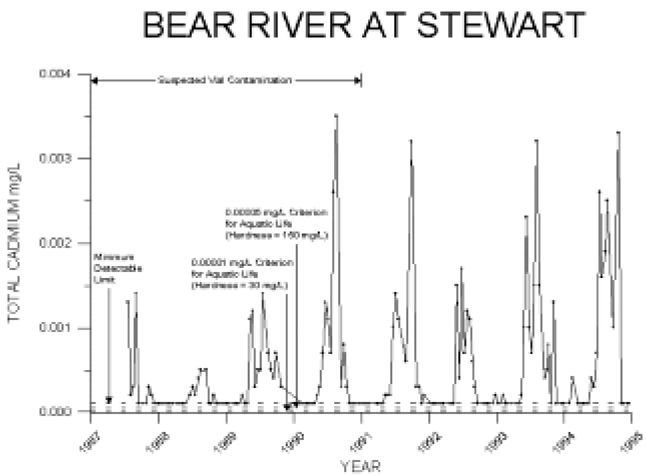


Figure 9 Calcium in mg/L

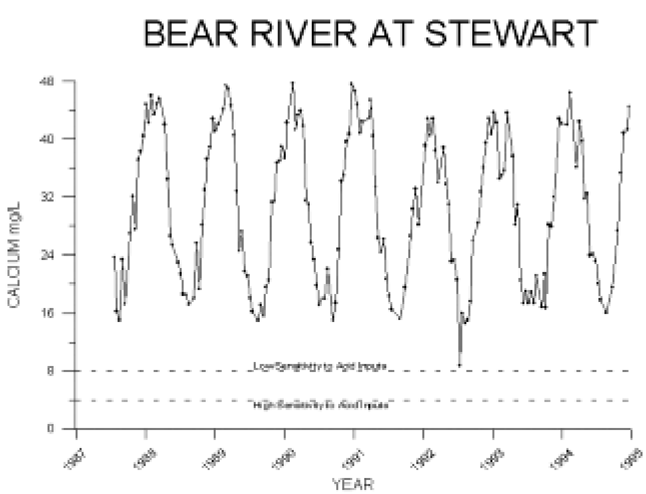


Figure 10 Carbon, Total Organic in mg/L

Figure 11 Carbon, Total Inorganic in mg/L

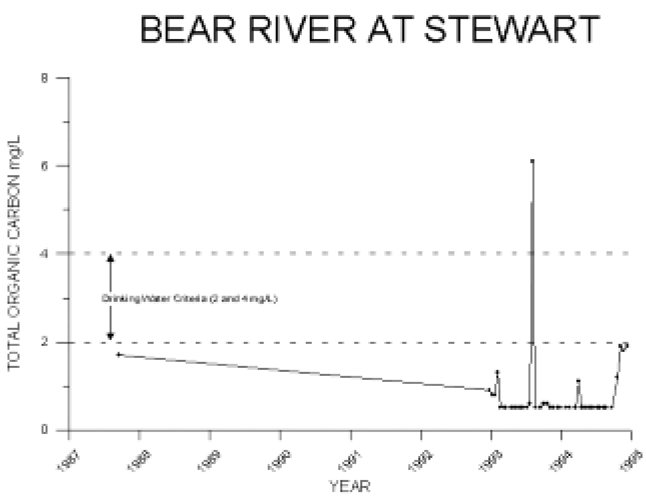


Figure 12 Chloride, Dissolved in mg/L

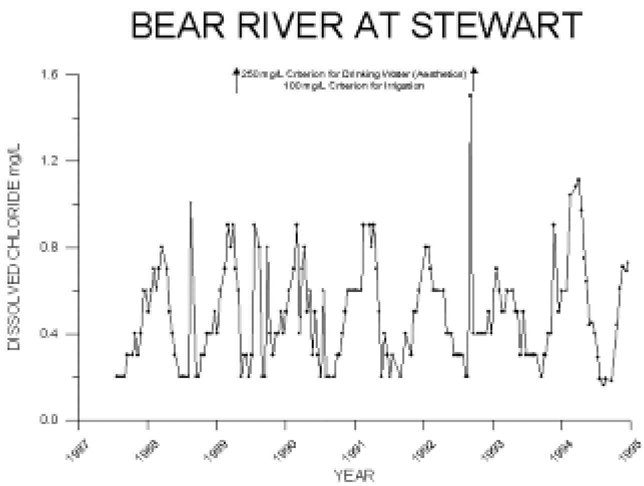


Figure 13 Chromium, Total in mg/L

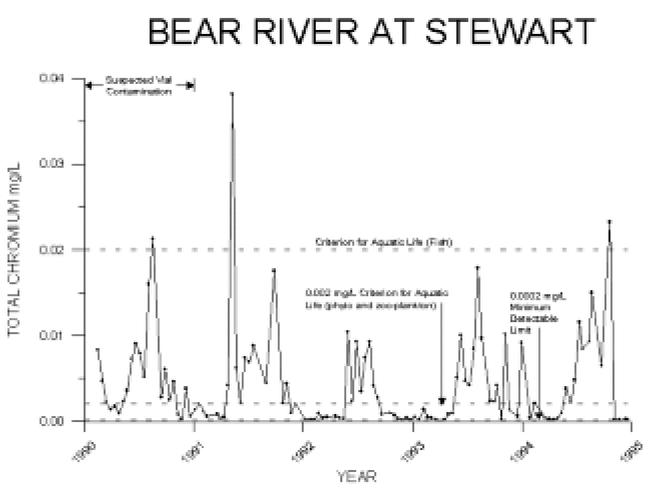


Figure 14 Cobalt, Total in mg/L

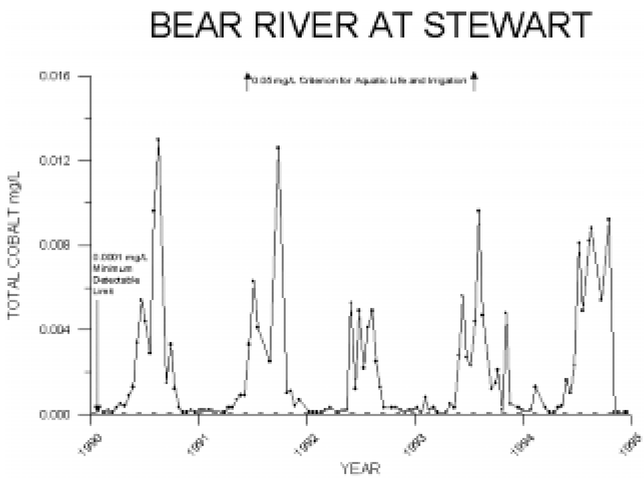


Figure 15 Colour, Apparent Units

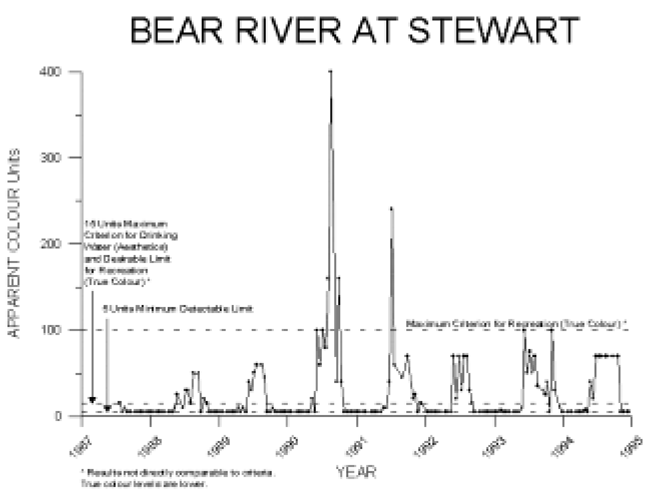


Figure 16 Conductivity, Specific in μS/cm

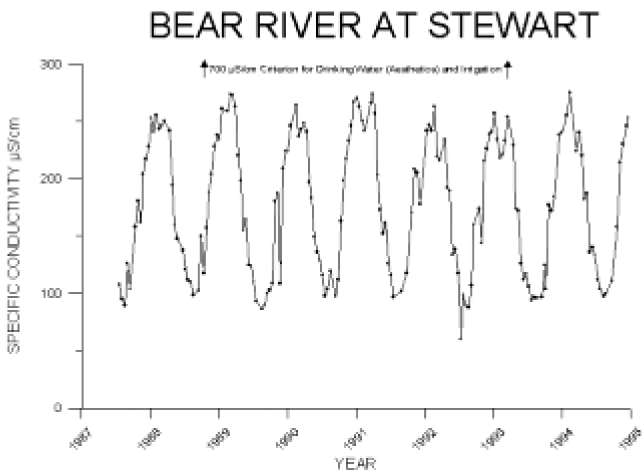


Figure 17 Copper, Total in mg/L

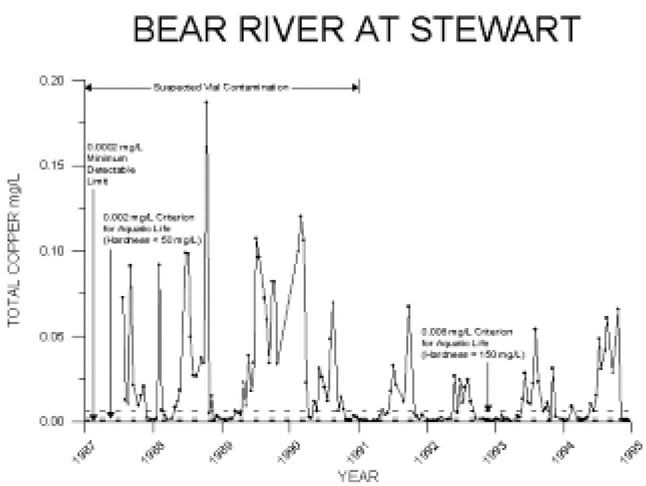


Figure 18 Fluoride, Dissolved in mg/L

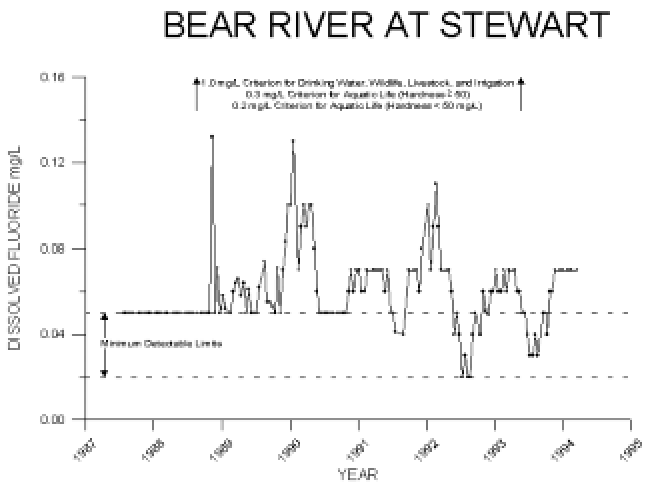


Figure 19 Hardness in mg/L

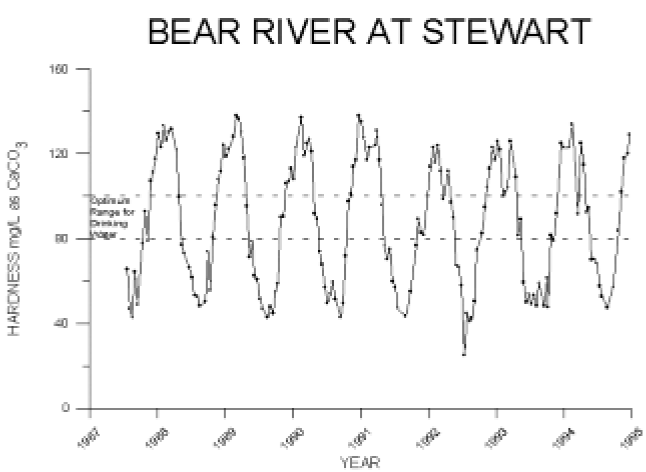


Figure 20 Iron, Total in mg/L

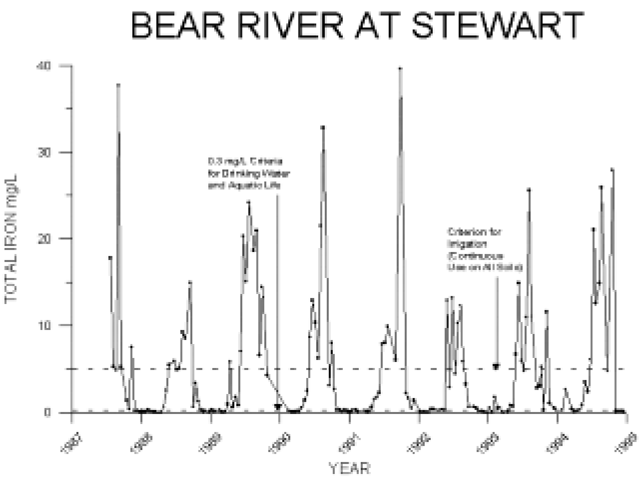


Figure 21 Lead, Total in mg/L

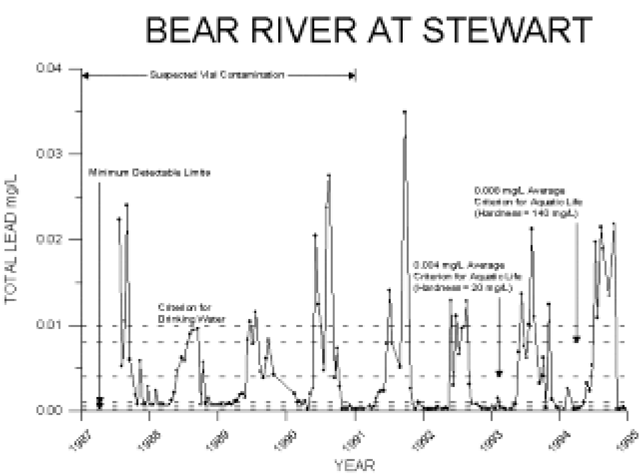


Figure 22 Lithium, Total in mg/L

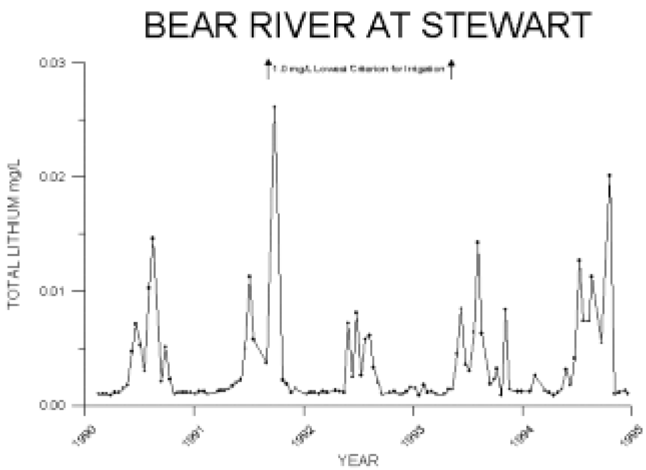


Figure 23 Magnesium, Total in mg/L

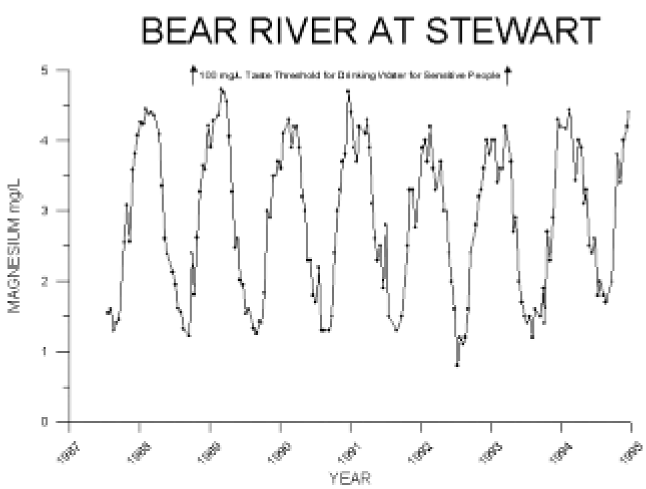


Figure 24 Manganese, Total in mg/L

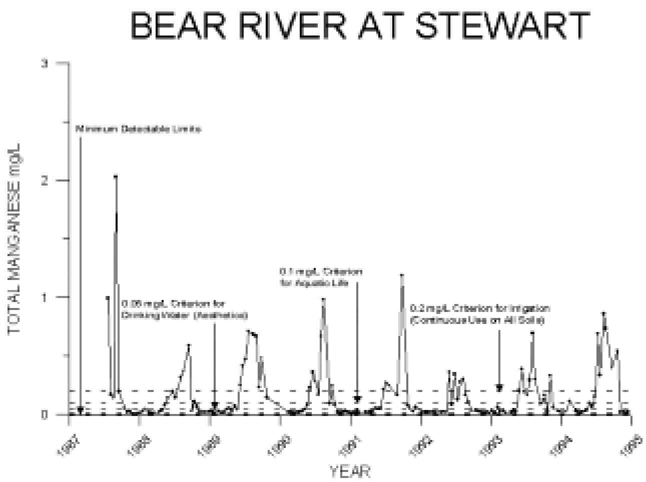


Figure 25 Molybdenum, Total in mg/L

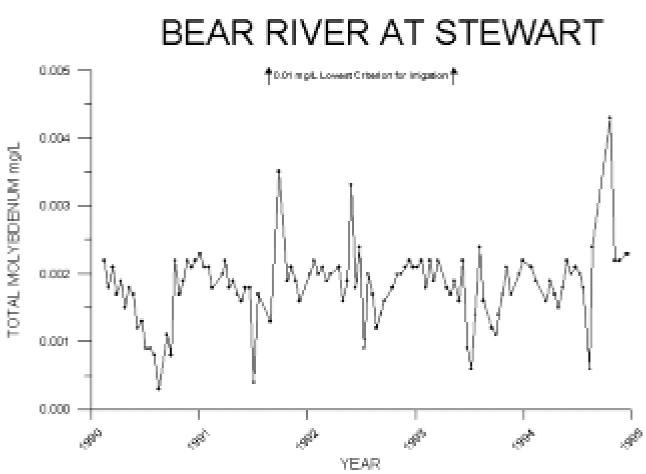


Figure 26 Nickel, Total in mg/L

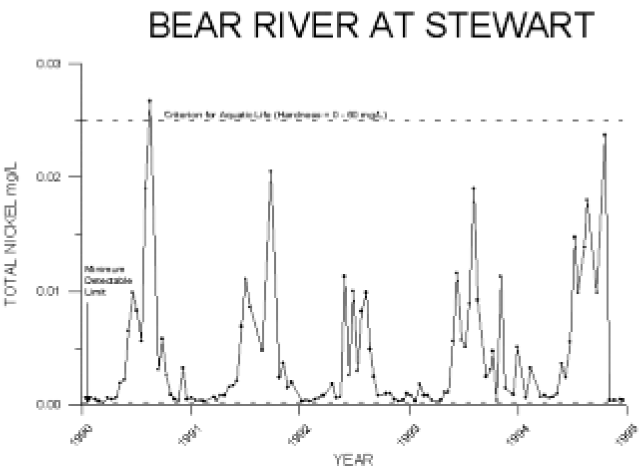


Figure 27 Nitrate/Nitrite as N in mg/L

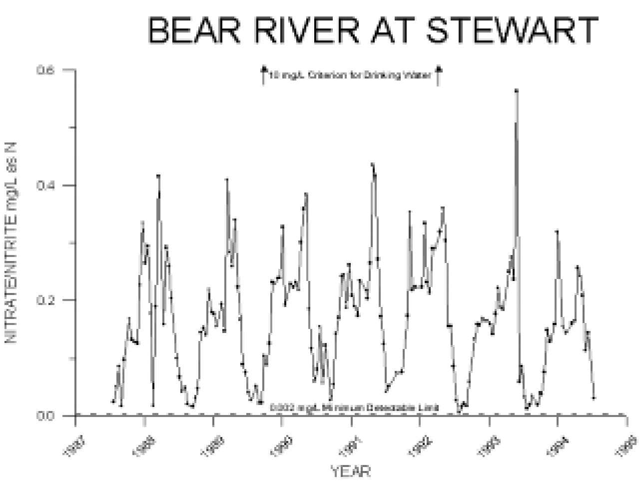


Figure 28 Nitrogen, Total Dissolved in mg/L

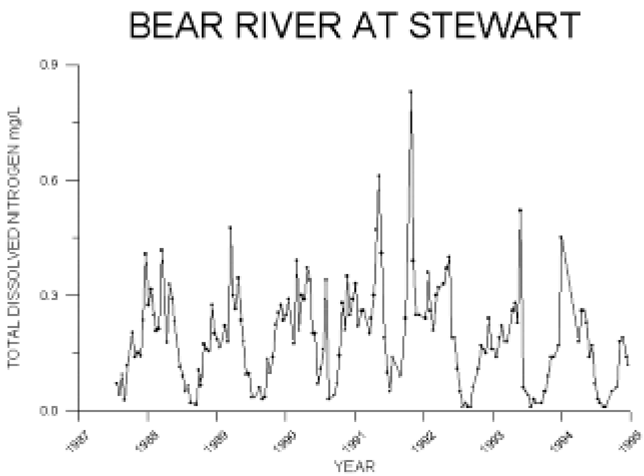


Figure 29 pH, Laboratory in pH Units

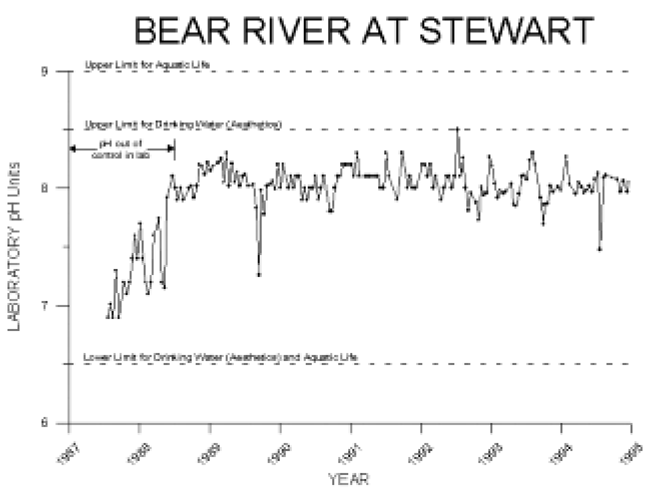


Figure 30 Phosphorus, Total in mg/L

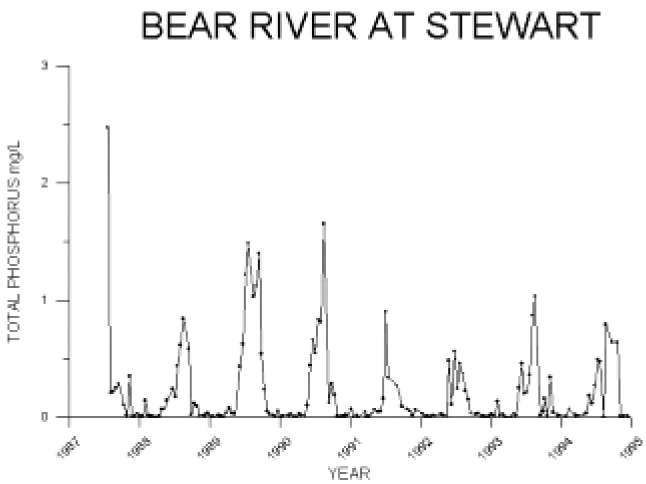


Figure 31 Potassium in mg/L

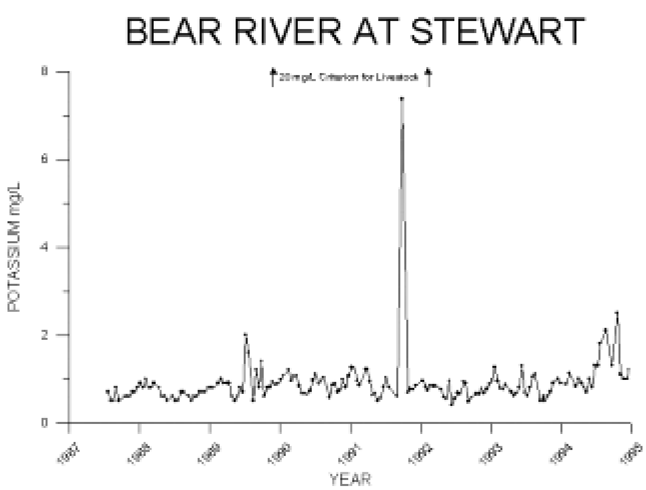


Figure 32 Residue, Filterable in mg/L

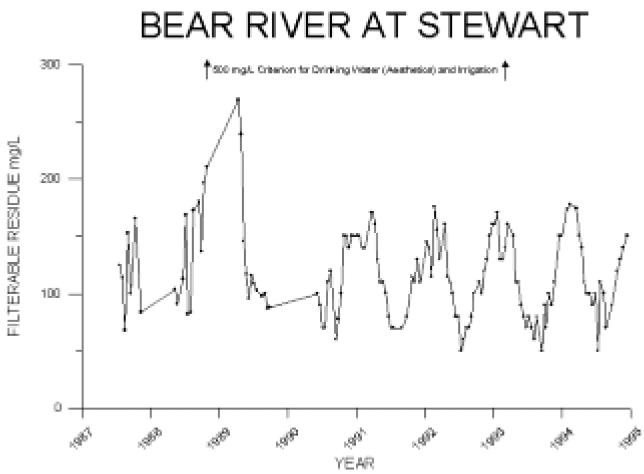


Figure 33 Residue, Fixed Filterable in mg/L

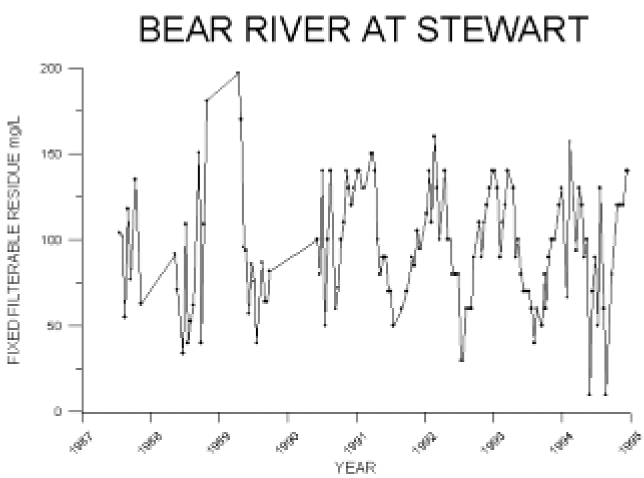


Figure 34 Residue, Non-Filterable (NFR) in mg/L

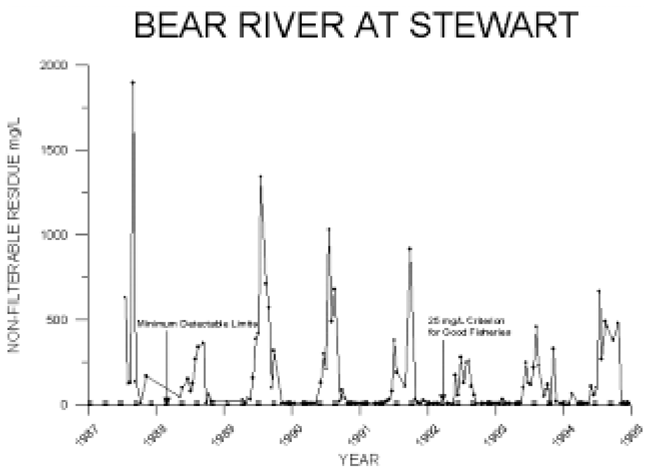


Figure 35 Residue, Fixed Non-Filterable in mg/L

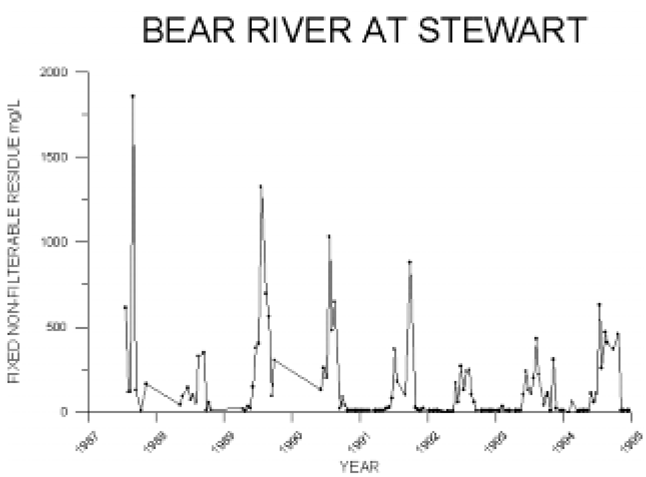


Figure 36 Selenium, Total in mg/L

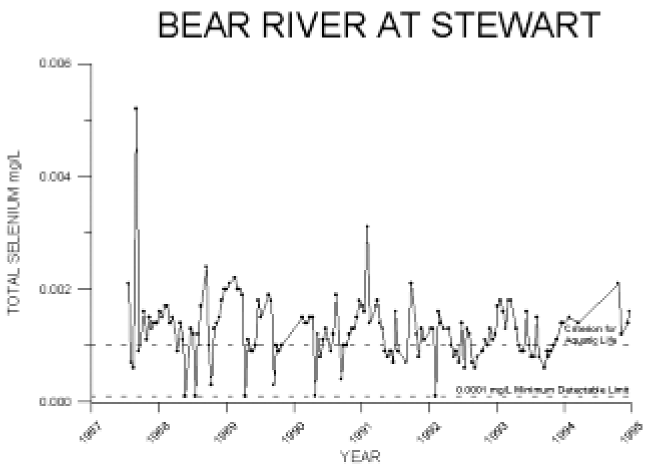


Figure 37 Silica in mg/L Si

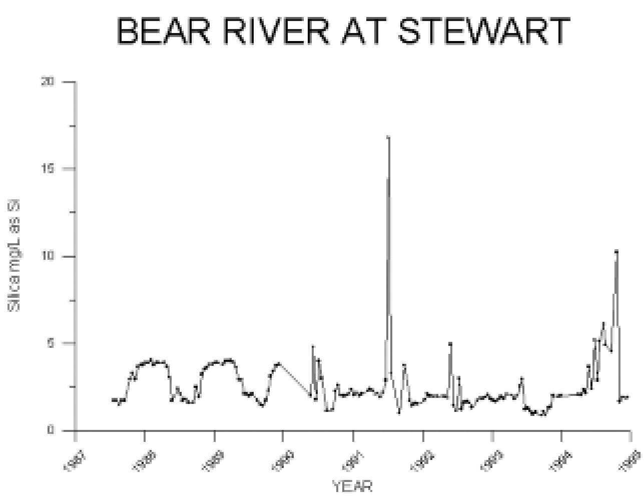


Figure 38 Sodium in mg/L

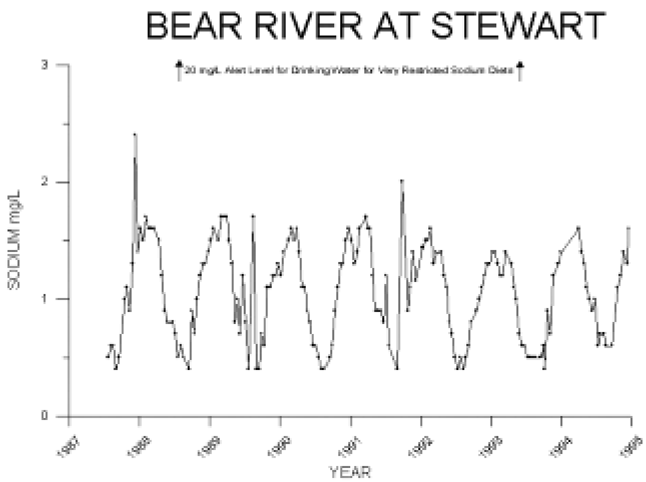


Figure 39 Strontium, Total in mg/L

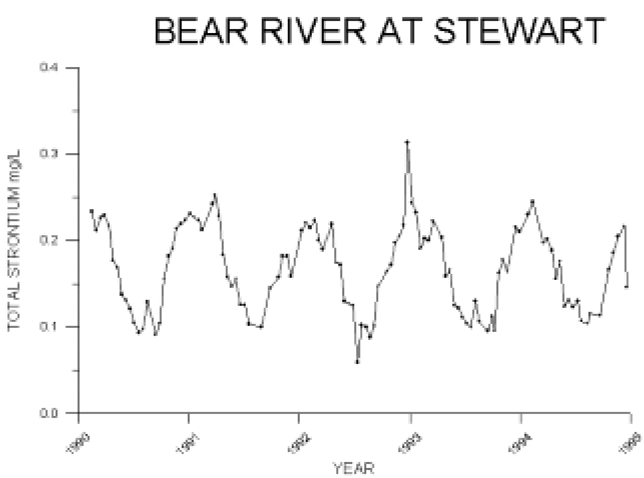


Figure 40 Sulphate, Dissolved in mg/L S04

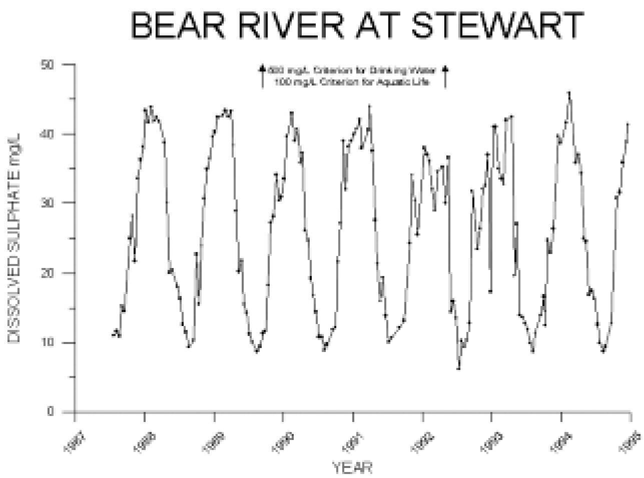


Figure 41 Temperature, Air in ° C

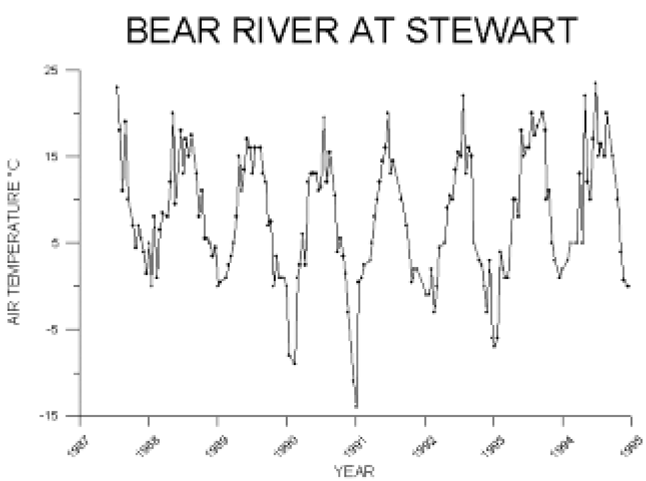


Figure 42 Temperature, Water in ° C

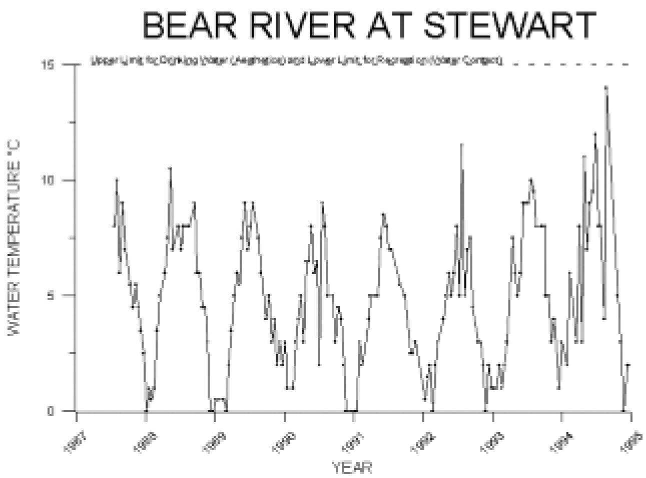


Figure 43 Turbidity in NTU

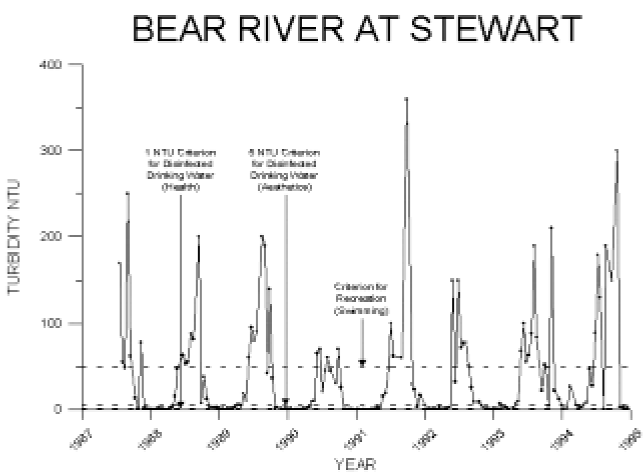


Figure 44 Vanadium, Total in mg/L

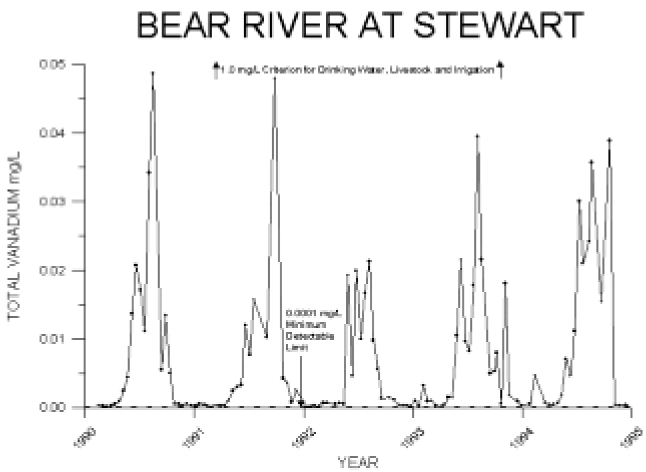
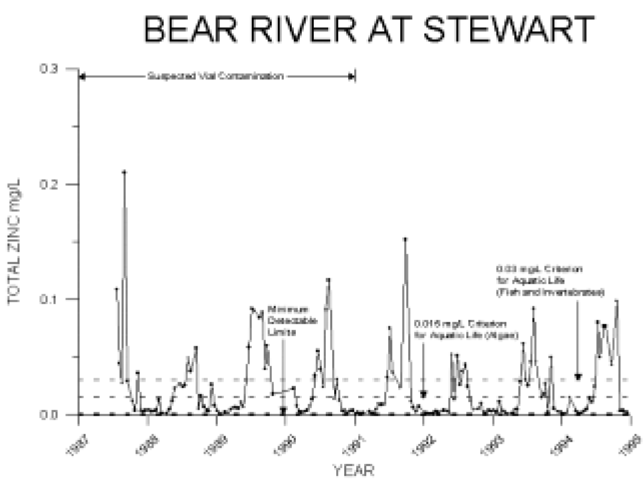


Figure 45 Zinc, Total in mg/L



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