Water Quality

State of Water Quality of Kettle River at Gilpin (1980-1994)

Canada - British Columbia Water Quality Monitoring Agreement

Water Quality Section
Water Management Branch
Ministry of Environment, Lands and Parks

Monitoring and Systems Branch
Environment Canada
Pacific and Yukon Region

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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 first crossing the international border at the town of Midway, B.C. and then re-enters B.C. at Carson upstream from Gilpin. Environment Canada has monitored the Kettle River at Gilpin station since 1980 collecting 26 samples per year. 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 Carson sites. The Kettle River at Midway station is located near the town of Midway, B.C. and the international boundary. Boundary Creek, a major tributary from the north, joins the Kettle River a short distance downstream from Midway, B.C. and is also very near the boundary between Canada and the U.S. The Kettle River at Carson station is located downstream of Midway at the point where the Kettle River crosses back into B.C. The Kettle River at Gilpin station, the most easterly of the four stations, is located downstream of the Carson site but just upstream of 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 drinking water, aquatic life, fish and wildlife, recreation, irrigation and livestock watering.

The main conclusions of this assessment are as follows:

- The water quality of the Kettle River at Gilpin site was generally excellent during 1980 to 1994.
- This water is well buffered against acid input and yet soft enough for drinking.
- The water is naturally high in fluoride and exceeds criteria for aquatic life. We are also not aware of any effects on the local fish populations and expect that fish may be adapted to the higher levels of fluoride.

- Water quality patterns in this watershed are usually closely matched with flow patterns. As a result, increased turbidity (i.e., during freshet) makes it necessary to treat the water for drinking purposes.
- The increased levels in total phosphorus and total metals are related to seasonal increased flows due to suspended sediments and thus are largely biologically unavailable.

The main recommendation is:

Monitoring should be suspended at this station.

AUTHORS

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ACKNOWLEDGMENTS (Reviewers)

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1. Introduction

The Kettle River at Gilpin is located downstream and east of Grand Forks, B.C. just north of the B.C. and Washington State boundary (Figure 1). The drainage area of the Kettle River at Gilpin is 9840 km^2. The river flow was monitored at the nearest Environment Canada station number BC08NN012 (Kettle River at Laurier), which is downstream of the sampling site. 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 BC08NN0022. This report assesses the 15 years of data from 1980 through 1994. The water quality data are plotted in alphabetical order in 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 USA. Other related monitoring stations such as the Kettle River at

Carson, Kettle River at Midway and the Boundary Creek at Midway sites are all located upstream of this site. The watershed upstream from Gilpin is relatively pristine, with a small overall population concentrated mainly at Grand Forks, B.C., and no environmentally significant industrial impacts other than forestry and some agriculture. Table 9-3 of the 1977 Kootenay Air and Water Quality Study Report summarizes water licenses on the Kettle River and Boundary Creek.

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2. 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.

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3. 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.

Flow (Figure 2) from the Kettle River at Laurier site appeared stable through early to mid eighties with a slight downward trend after the maximum spring peak flow recorded during the freshet of 1983. The lowest peak spring freshet flow over the 1979 to 1993 period was reported in the spring of 1992.

Total alkalinity (Figure 3) and **calcium** (Figure 9) show that the river at this location has a low sensitivity to acid inputs (well-buffered), except during the majority of spring freshets when a moderate sensitivity occurs.

Total aluminum (Figure 4) had very high peak values during 2 of the 5 spring freshets monitored that were well above drinking water and aquatic life criteria for dissolved aluminum. However, the peak total aluminum was caused by the higher suspended sediment (see residue, non-filterable and turbidity), during freshet, and thus is probably not of concern because dissolved aluminum would be lower. Dissolved aluminum should be monitored for direct comparison to the criteria, if there is any concern about aluminum in the future.

Total cadmium (Figure 8) had MDLs that were 10-100 times above the aquatic life criteria and levels that are typical in pristine waters. We believe that the detectable values are nothing more than artificial contamination and false positives close to the MDLs. There are concerns about the input of cadmium from the slag heaps downstream of Midway, B.C. Any future cadmium monitoring should use an MDL of 1 ng/L or lower.

Total chromium (Figure 11) exceeded the aquatic life criterion at 0.002 mg/L (for phyto and zoo-plankton) in mid-1990 and again in mid-1991 and to a lesser extent, again in 1992 and 1993. These high values were probably due to artificial contamination from preservative vial lids (pre-1991), increased flow and suspended sediment during spring freshet (1991 and 1993), and through-ice sampling contamination (1992). Since mid-1993, total chromium values have remained well below the 0.002 mg/L criterion level.

Apparent colour (Figure 13) exceeded the true colour criteria for drinking water and recreation regularly during spring freshet, probably due to the higher turbidity at this time. True colour would have been lower because the turbidity is removed before this measurement. True colour or total absorbance colour should be measured if there are colour concerns in the future as relevant and current guidelines are geared towards true colour and TAC.

Total copper (Figure 15) results showed widespread artificial contamination due to the failure of preservative vials cap liners during 1986-91. Data assessment after early 1991 when the vials were changed reveals values below the aquatic life criteria of 0.002 to 0.005 mg/L for the river water hardness range to 120 mg/L.

Cyanide (Total & Weak-acid dissociable) (Figures 16 & 17) had widespread contamination of CN up to about 1991 related to the failure of the preservative vial cap liners (Pommen and Ryan, 1992). Cyanide did not exceed the criteria after 1991, although on two occasions, values near the average aquatic life criterion were measured. We are not aware of confirmed cyanide contamination from such sources as placer gold mining affecting either the U.S. or Canadian portion of the Kettle River watershed.

Fluoride (Figure 18) frequently exceeded the tentative aquatic life criteria due to the natural geologic conditions in the watershed. We are not aware of any problems with fish in the Kettle River due to elevated fluoride levels and expect that the fish populations are acclimated and adapted to the naturally higher levels of fluoride. At no time did any values approach the drinking water criterion of 1.0 mg/L.

Hardness (Figure 19) showed that the water was soft, usually below and occasionally slightly above the optimum range for drinking water, but still very acceptable.

Total iron (Figure 20) was frequently above the criterion for drinking water (aesthetics) and aquatic life during spring freshet when flow and suspended sediment were higher. The iron is probably due to the iron content of the suspended sediment and thus of no concern. Drinking water use during freshet would require turbidity removal, which would likely reduce iron below the criterion.

Total lead (Figure 21) exceeded the aquatic life criterion of 0.004 mg/L only twice throughout the 15-year sampling period and this was prior to 1991 when there was probable artificial contamination due to the failure of the preservative vial cap liners. All criteria have been met since early 1990 with a gradual improvement (i.e., downward trend) approaching 1995. This downward trend is associated with a decrease in the detection limits and the use of cleaner methods.

Total manganese (Figure 24) regularly exceeded the aesthetic drinking water criterion of 0.05 mg/L during spring freshet when suspended sediments were naturally elevated. This is not of concern since this was due to the manganese content of the suspended sediment, which would normally be removed by drinking water treatment during turbidity removal. No obvious trends into 1995 were observed.

Nitrogen, total dissolved (Figure 28) and **nitrate/nitrite** (Figure 27) values were well below criteria. There appears to be ample nitrogen available for algal growth except during the summer months.

pH (Figure 29) met all criteria. The lower pH values in 1986-89 were due to a loss of control in pH measurement in the laboratory. The data has been flagged as questionable and unreliable.

Total phosphorus (Figure 30) showed peak values during spring freshet when suspended sediments were naturally elevated. 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 show peaks during spring freshet when suspended sediments were naturally elevated. NFR was below the general fisheries criterion of 25 mg/L (Newcombe, 1986), except during freshet. The turbidity criterion for swimming was always met, but the raw drinking water criterion at 1 NTU for water without turbidity removal was usually exceeded especially during freshet. Turbidity, on the other hand, has demonstrated a slight increasing trend from the mid-80's into mid 1993. Turbidity responds similarly to NFR but is more sensitive (lower MDL & fewer non-detects), cheaper, has better criteria 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.

Filterable residue (FR) (dissolved solids) (Figure 32) values were well below criteria. Specific conductivity is a more precise and cheaper variable to monitor and it has a reasonably constant relationship to filterable residue. We recommend that conductivity be used as a surrogate for FR in future monitoring.

Silicon as Si (Figure 37) showed a stable trend throughout the 15 year sampling period. The very low value in early 1994 is probably a blank. This plot has been corrected to reflect the 1990 method change, which changed the mode of expression from SiO2 to Si, thus reducing the values by a factor of 2 (i.e., SiO2 = 28 + (16)2 = 60, and Si = 28; 60/28 = 2.14). A minor step change in level is apparent when the method changed. There are no criteria for silica in ambient fresh waters.

Water temperature (Figure 42) met the drinking water criterion (aesthetics) except during most summers, when it was warm enough for water-contact recreation such as swimming, but somewhat less appealing as drinking water.

Total zinc (Figure 45) occasionally exceeded aquatic life criteria (for fish, invertebrates and algae) prior to 1988, in part due to the preservative vial cap liner failures experienced in the late 1980s, and possibly due to elevated suspended sediment during spring freshet. Dissolved zinc is largely bio-available and thus of concern, whereas particulate zinc is not. The lower aquatic (algae) criterion has been exceeded only once since mid 1987. We are observing a downward trend in zinc values since the early 1990's, which is consistent with the low zinc values in this relatively pristine (for zinc sources) watershed, due to declining detection limits and the use of cleaner methods.

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

Conclusions - State of Water Quality

- Water quality patterns in this watershed are closely related to seasonal and annual flow patterns.
- The water quality at the Kettle River at Gilpin was generally very good from 1980 to 1994 as would be expected from a watershed with a low population, little industry and mining and a small amount of forestry upstream of this location.
- The water was well-buffered against acid inputs throughout the year although soft for drinking purposes.
- The water was cool or cold except during most summers, when it warms enough to permit water-contact recreation such as swimming, but was then less aesthetically pleasing for drinking.
- The water is naturally high in fluoride due to the geology of the watershed, making it possibly less than ideal for fish although we are not aware of any affects on fish which may have adapted to the higher levels of fluoride.
- The water is clear, except during spring 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 makes it necessary to treat drinking water to remove turbidity prior to use during freshet.
- Freshet also brings increased levels of metals, phosphorus, and possibly colour, but these are not of concern because they are due to the increased suspended sediment in the water, and the total metals and phosphorus are largely biologically unavailable.

Comparison to other Kettle River watershed water quality reports:

Please refer to the three Water Quality Branch Kettle River basin companion reports; Kettle River at Midway, Kettle River at Carson and Boundary Creek at Midway (Webber and Pommen, 1996) for additional data assessment conclusions and recommendations.

4. Recommendations for Water Quality Management

4.1 Remediation

- There are no water quality remediation measures needed at this time.

4.2 Monitoring

- We recommend that monitoring be suspended at this station.

Some general monitoring recommendations for this station and other stations are:

- Measure dissolved aluminum at all times for direct comparison to current drinking water and aquatic life criteria.
- Measure dissolved metals when waters are turbid to estimate the bio-available fraction. A standardized, simple, easy to use and contamination-free, field-filtration unit needs to be developed.
- Measure true or TAC colour where colour is of concern. Apparent colour is confounded by turbidity.
- Use lower minimum detectable limits for cadmium. The MDL should be at least 10 times below the lowest relevant criterion.
- Do not attempt to measure mercury in water unless ultra-clean sampling and analytical methods are used. Analysis of mercury in resident fish tissue is a better indicator of mercury contamination and much less prone to artificial contamination.
- Measure turbidity as a surrogate for non-filterable residue.
- Measure specific conductivity as a surrogate for filterable residue.
- Do not measure fixed filterable and non-filterable residues; more specific, relevant indicators are available.

Figure 1 Map of the Kettle River Basin

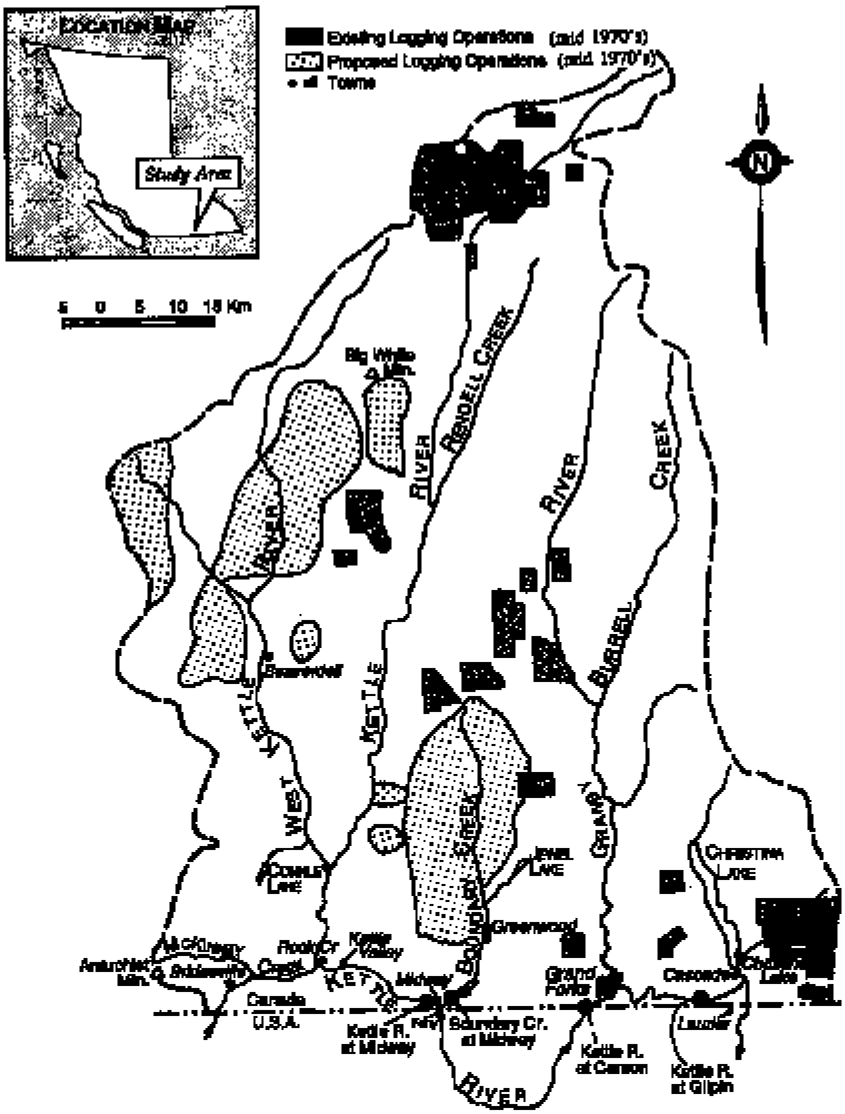


Figure 2 Flow

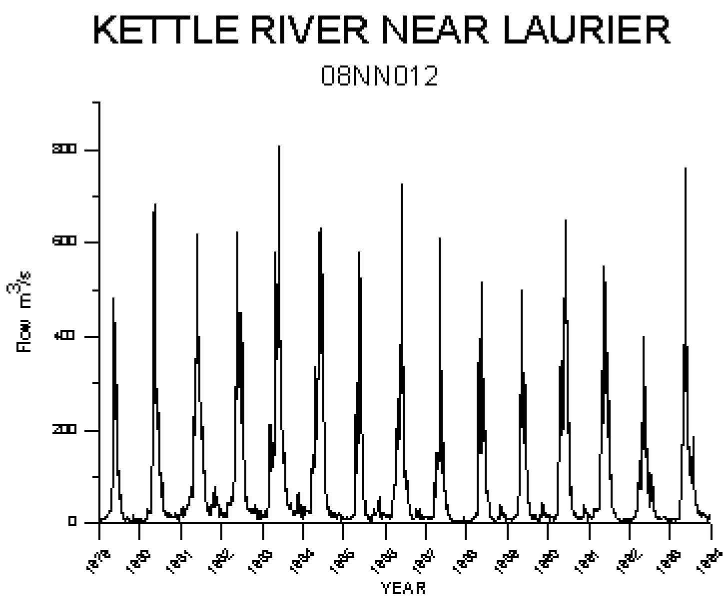


Figure 3 Total Alkalinity

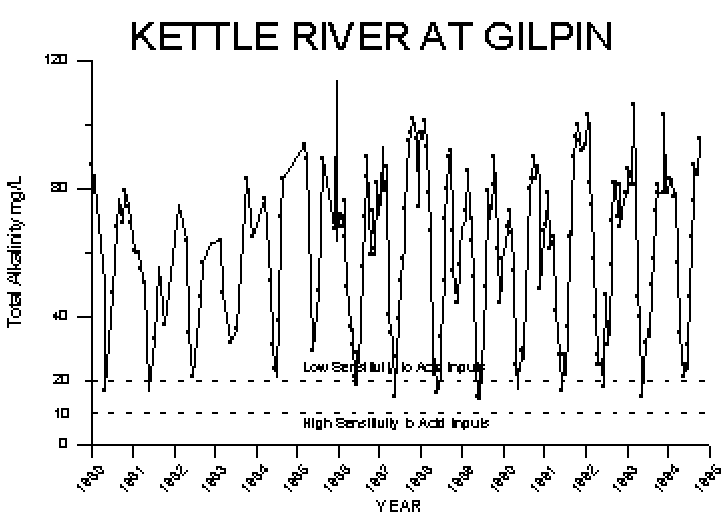


Figure 4 Total Aluminum

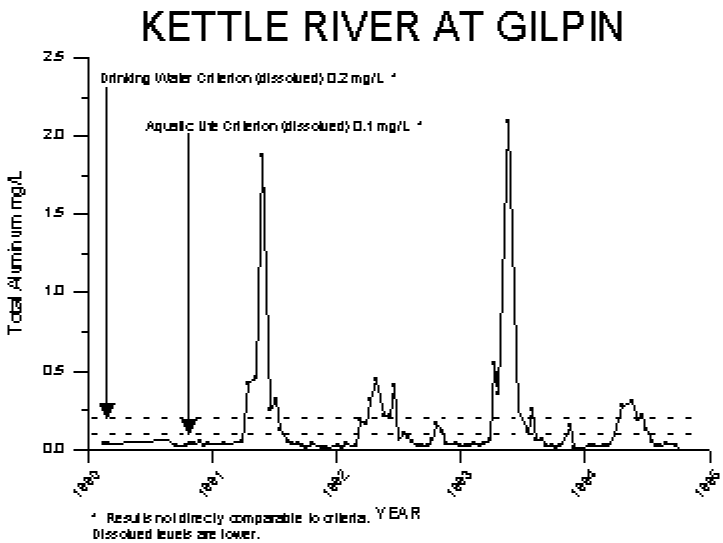


Figure 5 Total Arsenic

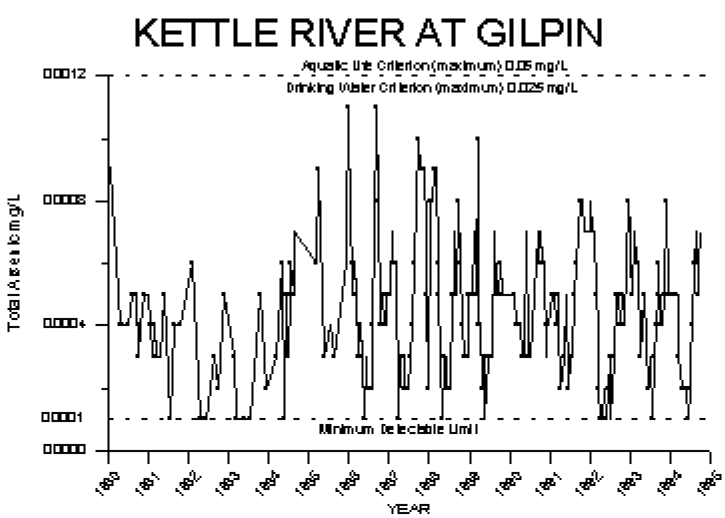


Figure 6 Total Barium

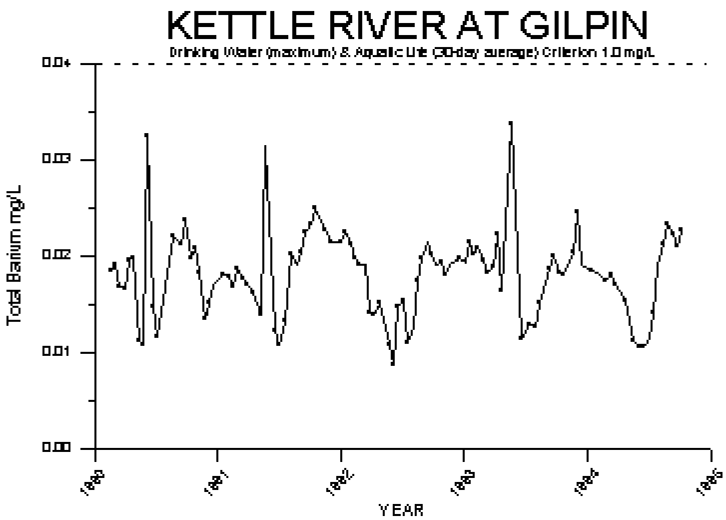


Figure 7 Total Beryllium

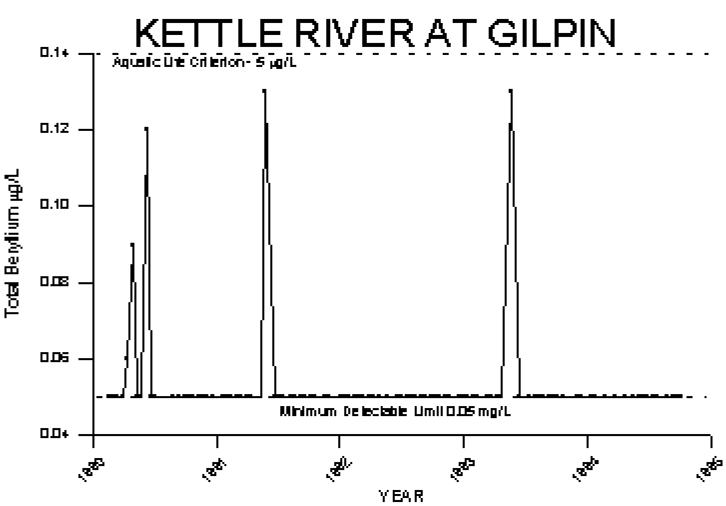


Figure 8 Total Cadmium

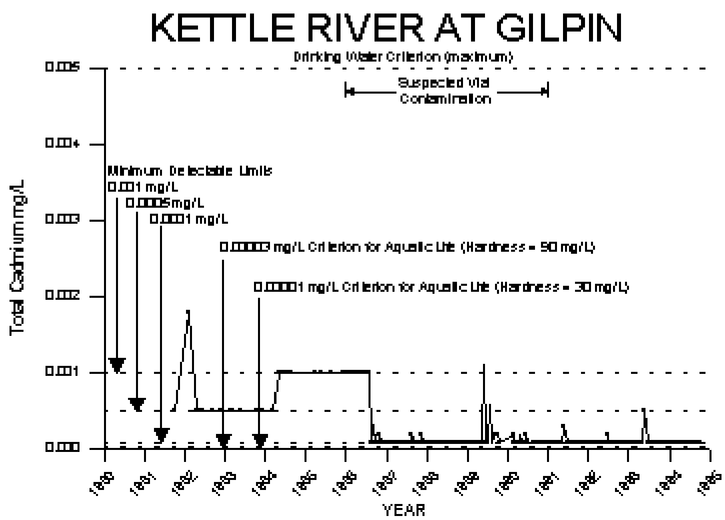


Figure 9 Calcium

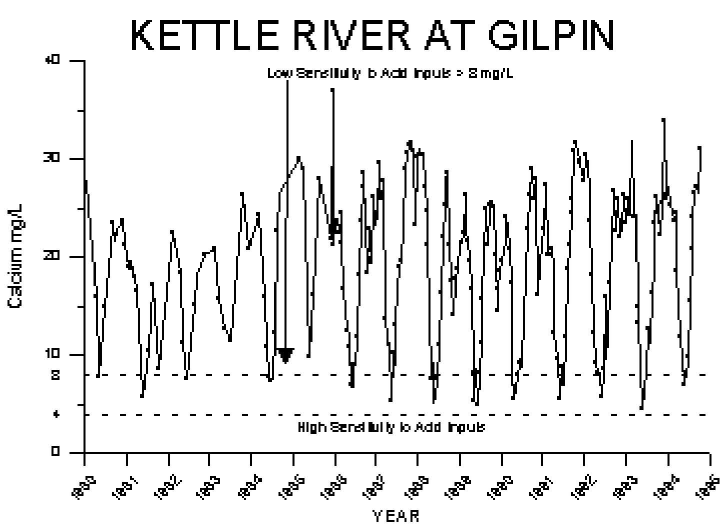


Figure 10 Dissolved Chloride

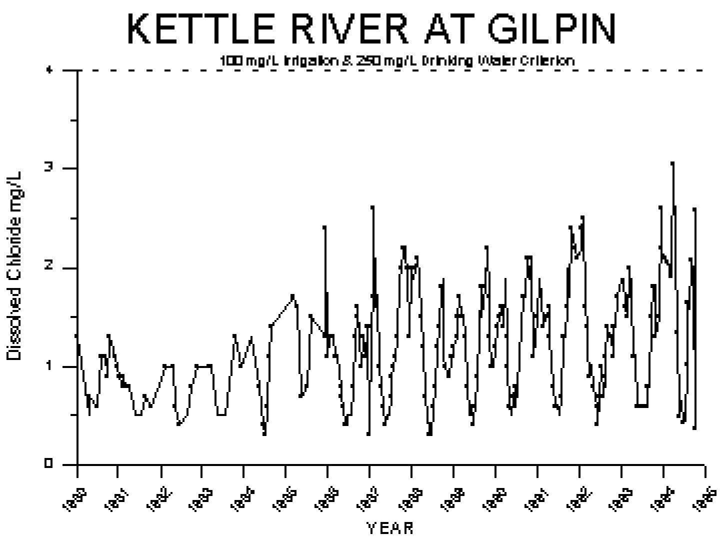


Figure 11 Total Chromium

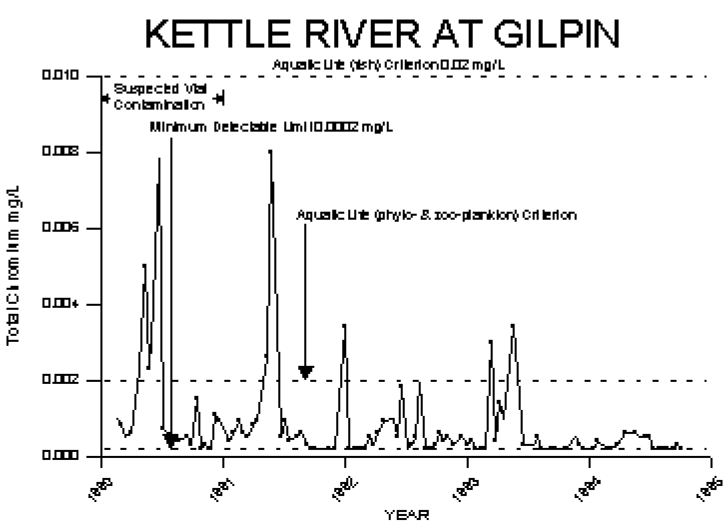


Figure 12 Total Cobalt

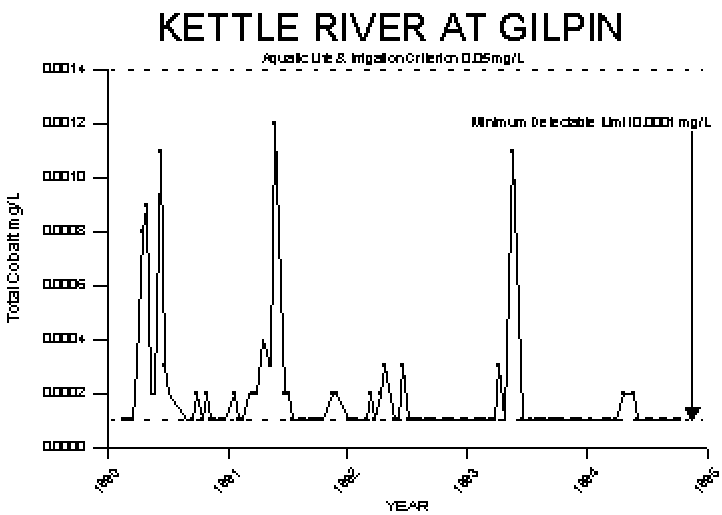


Figure 13 Apparent Colour

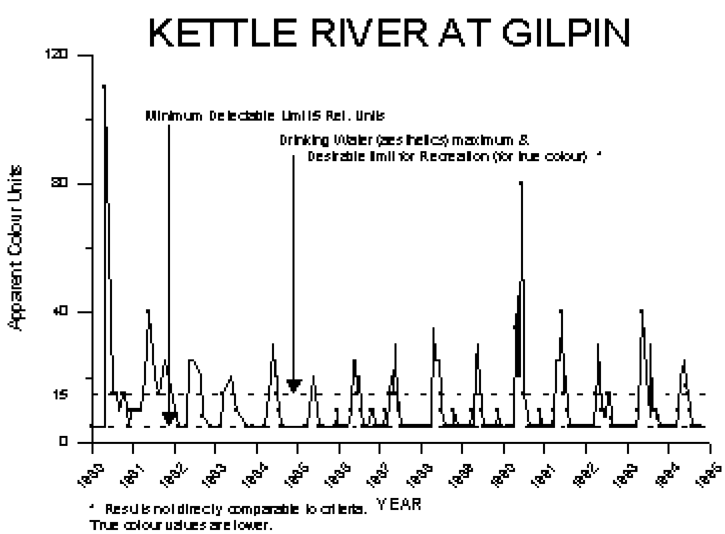


Figure 14 Specific Conductivity

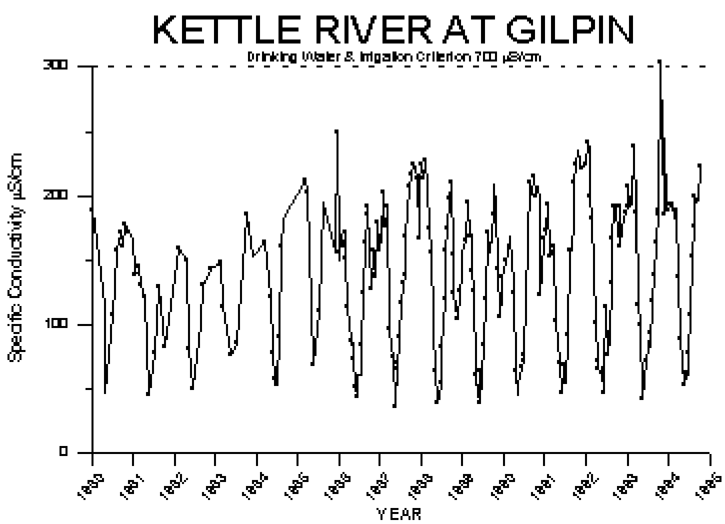


Figure 15 Total Copper

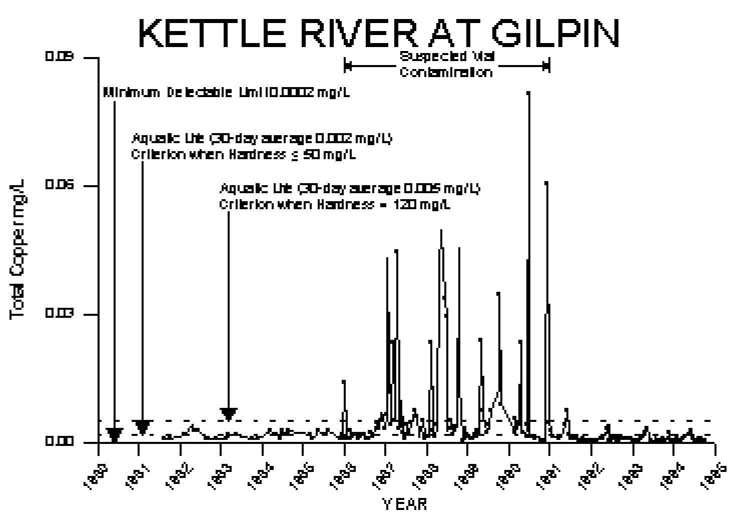


Figure 16 Total Cyanide

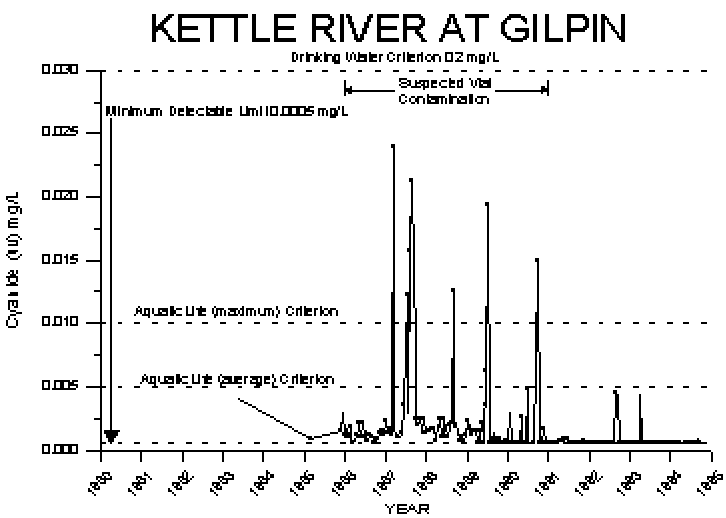


Figure 17 Cyanide (Weak-acid dissociable)

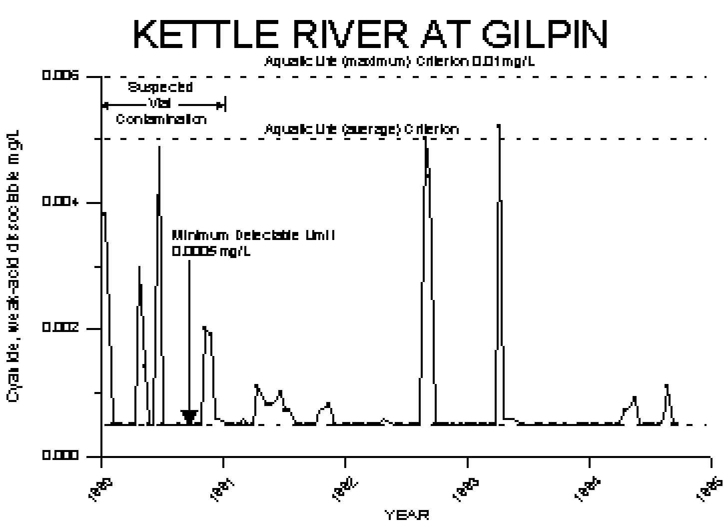


Figure 18 Dissolved Fluoride

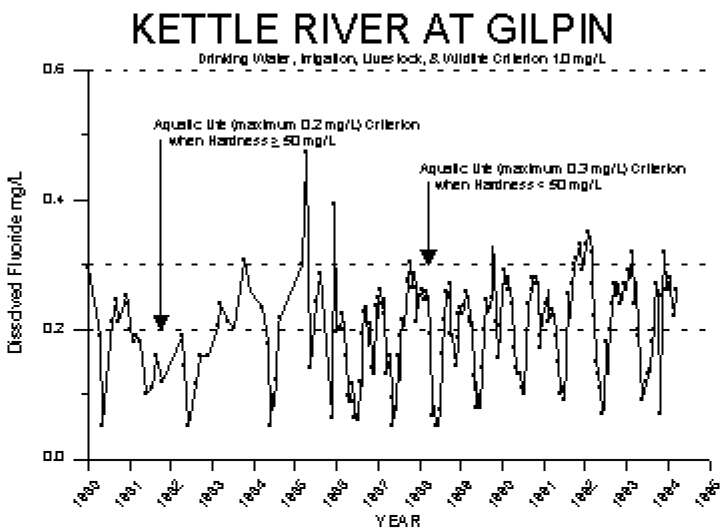


Figure 19 Hardness

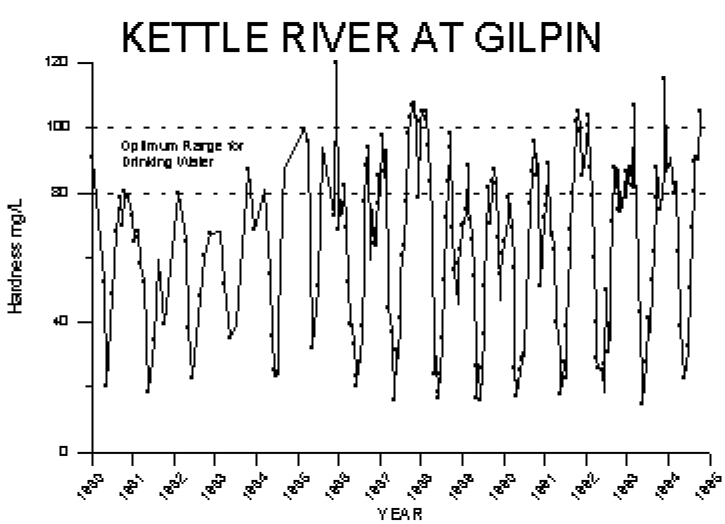


Figure 20 Total Iron

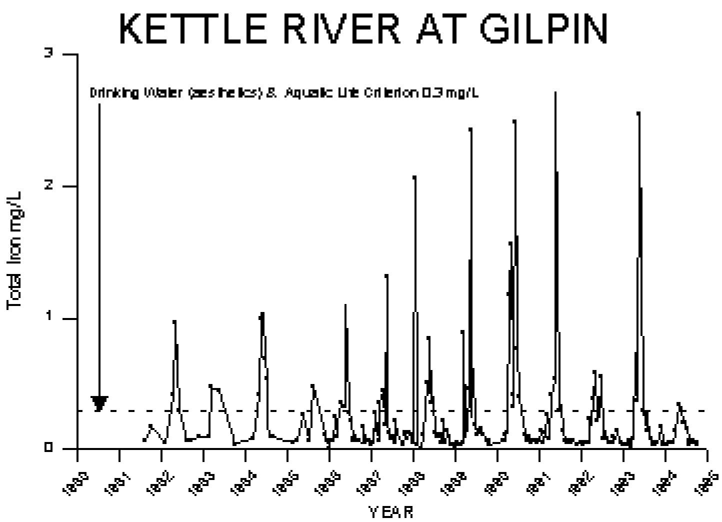


Figure 21 Total Lead

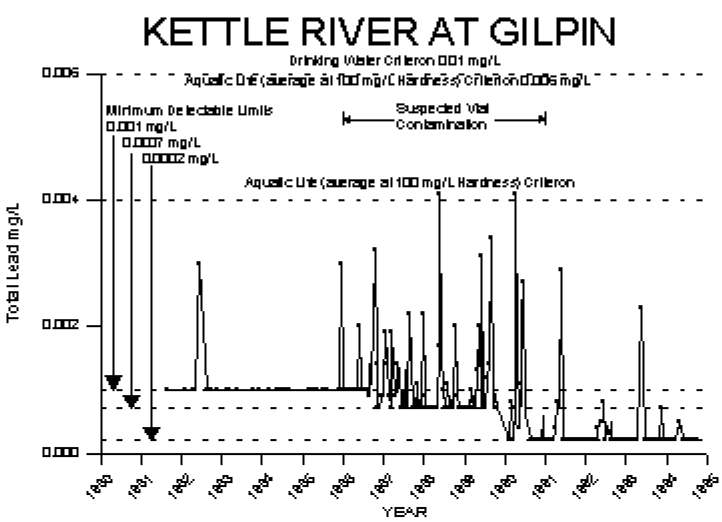


Figure 22 Total Lithium

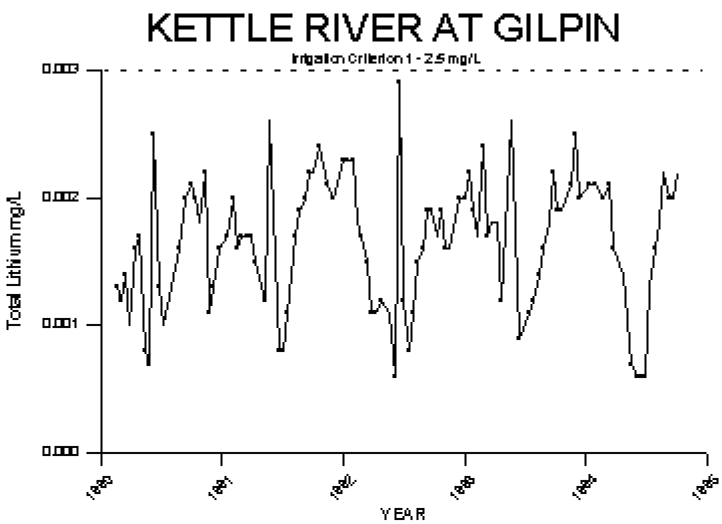


Figure 23 Magnesium

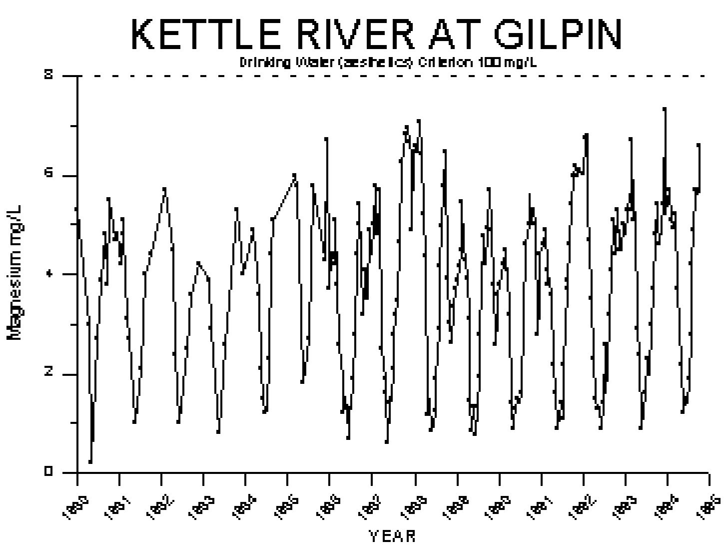


Figure 24 Total Manganese

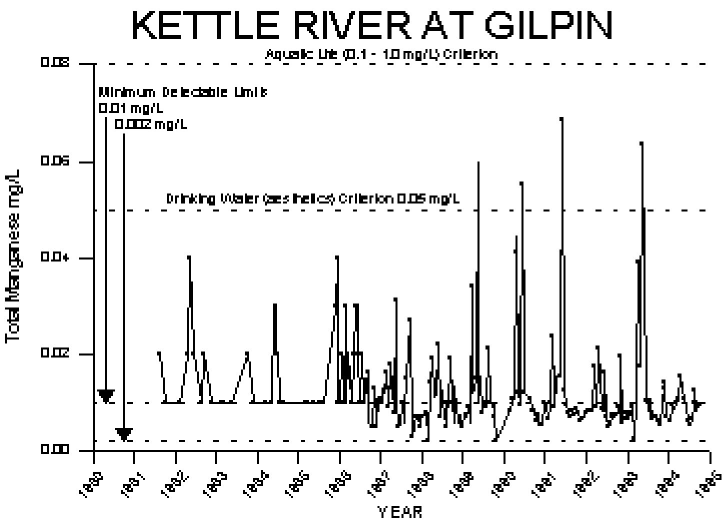


Figure 25 Total Molybdenum

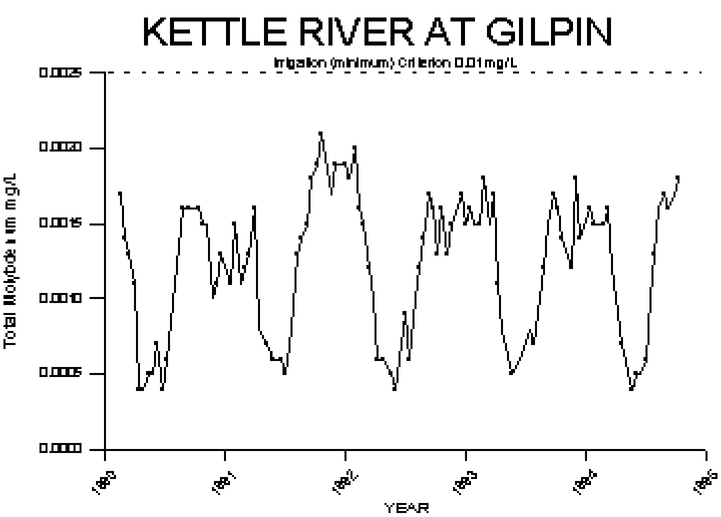


Figure 26 Total Nickel

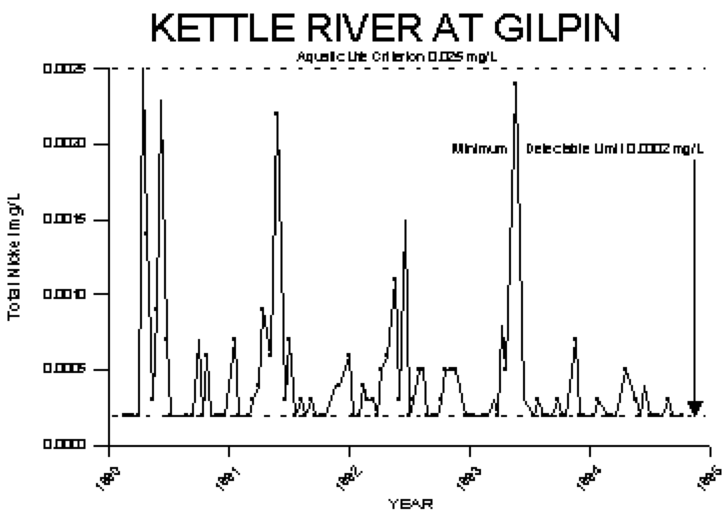


Figure 27 Nitrogen (Nitrate/Nitrite)

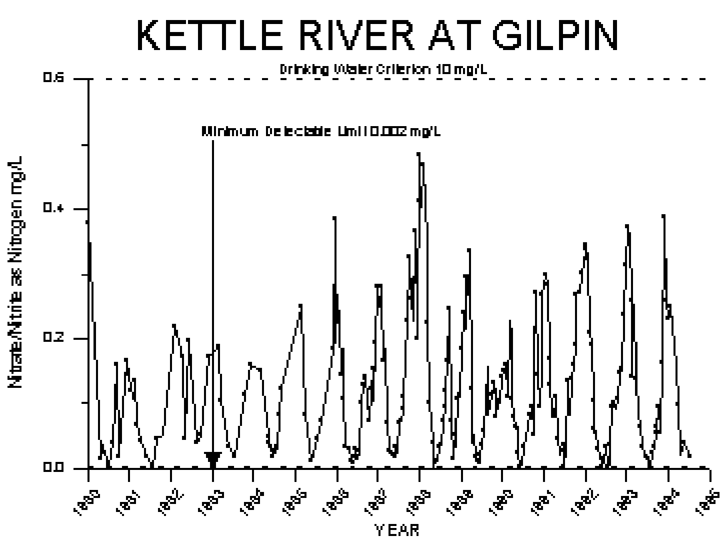


Figure 28 Total Dissolved Nitrogen

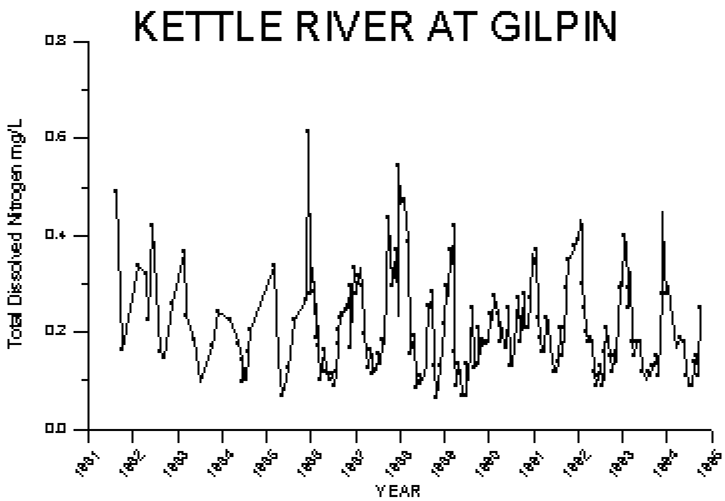


Figure 29 pH

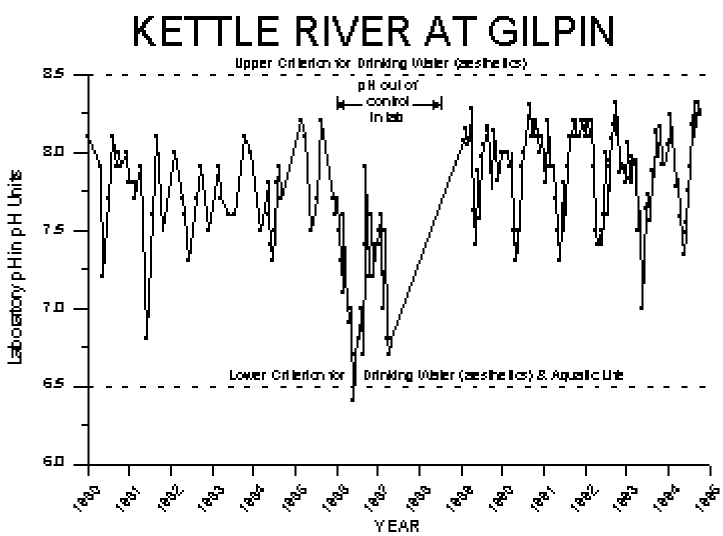


Figure 30 Total Phosphorus

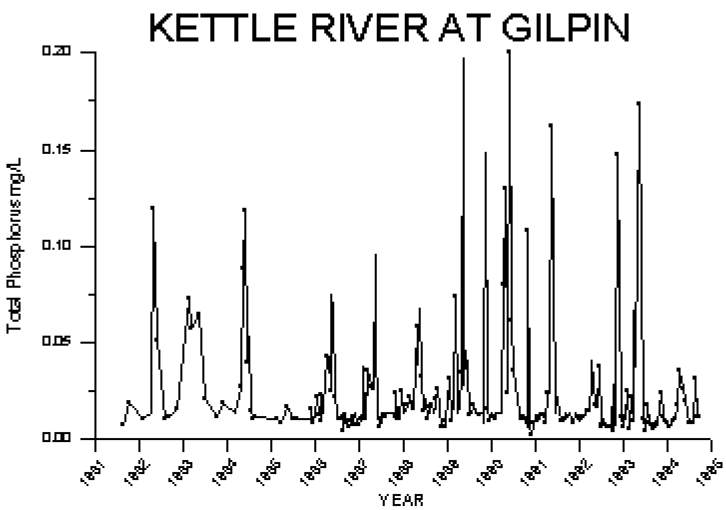


Figure 31 Potassium

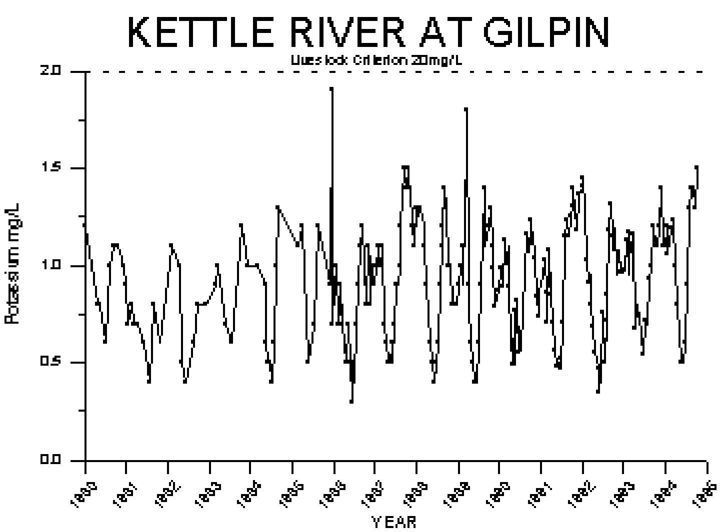


Figure 32 Filterable Residue

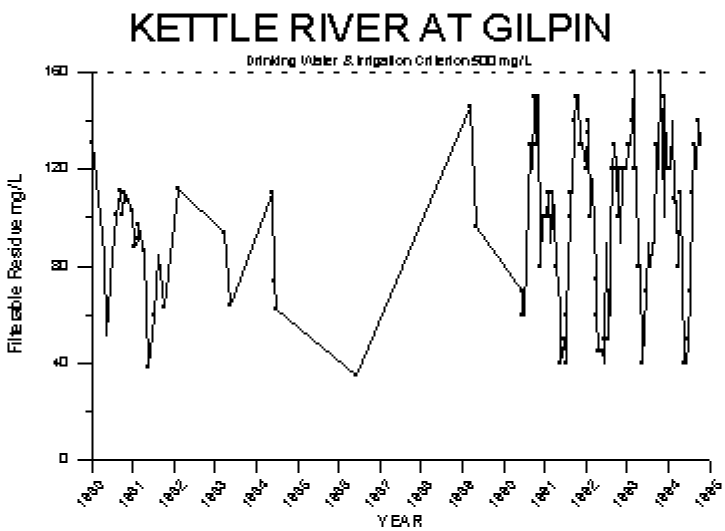


Figure 33 Fixed Filterable Residue

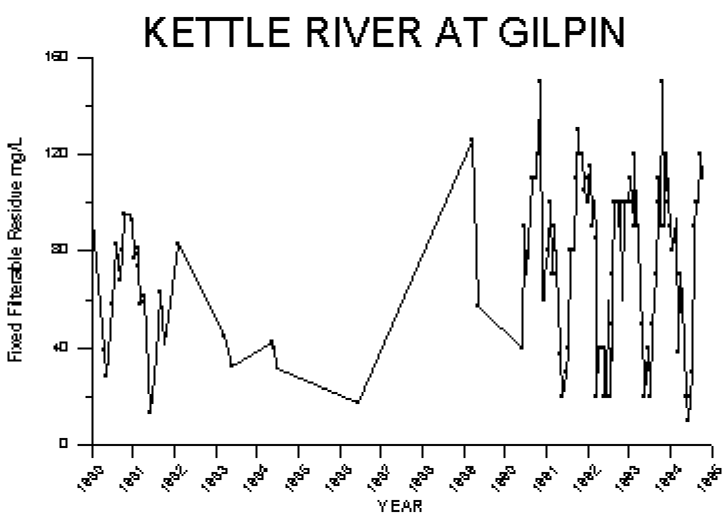


Figure 34 Non-Filterable Residue

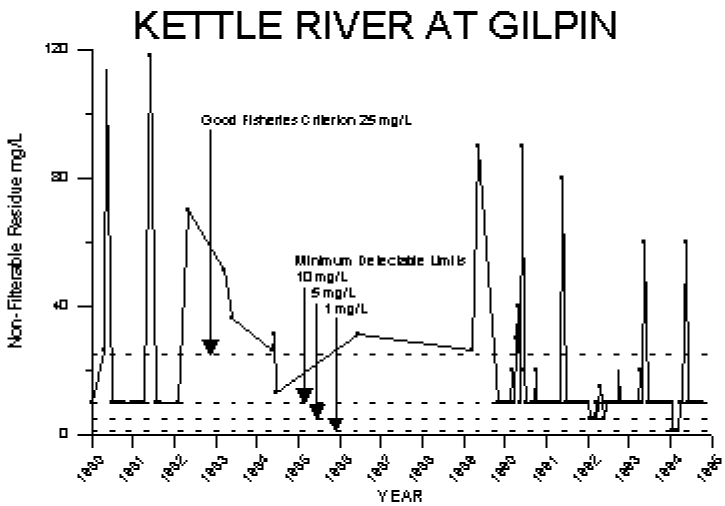


Figure 35 Fixed Non-Filterable Residue

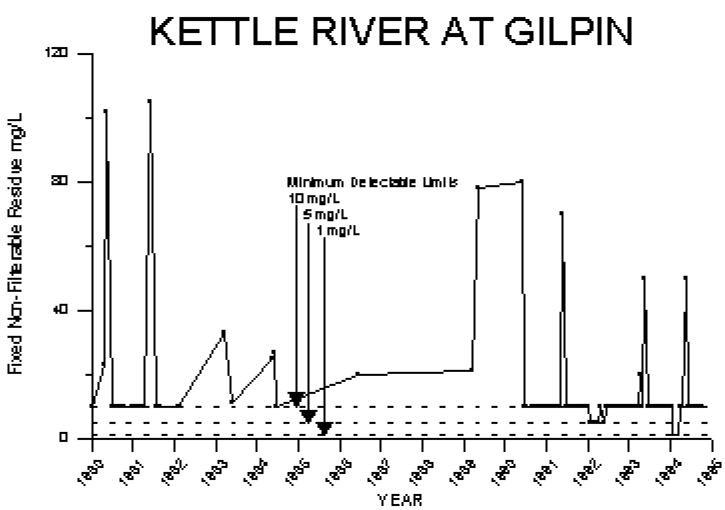


Figure 36 Total Selenium

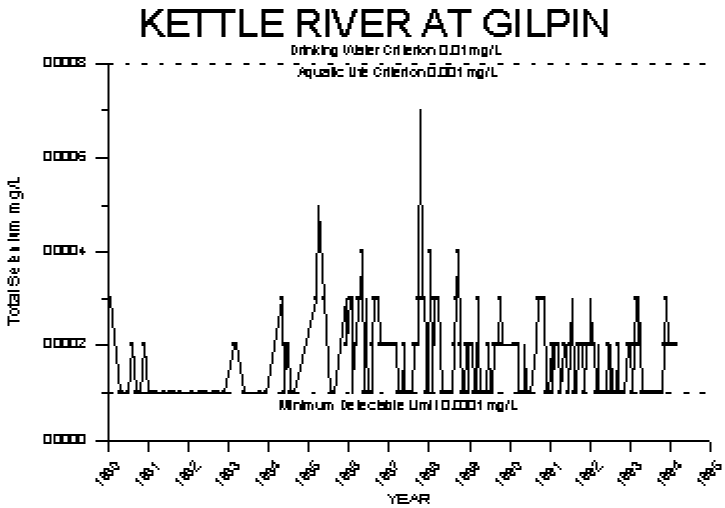


Figure 37 Silica

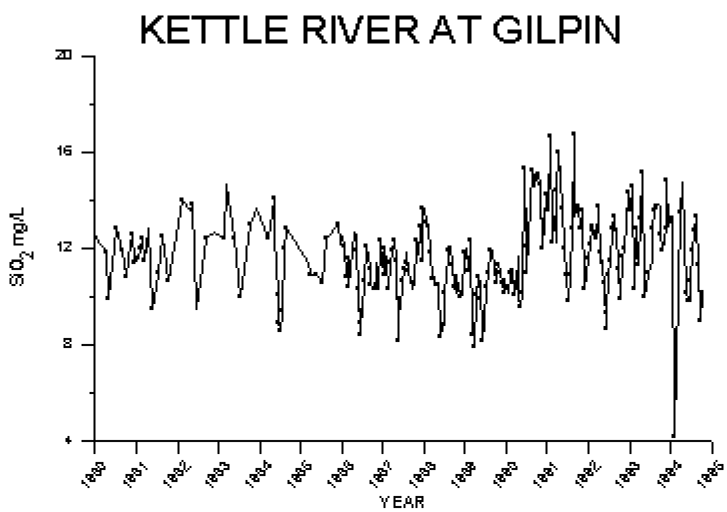


Figure 38 Sodium

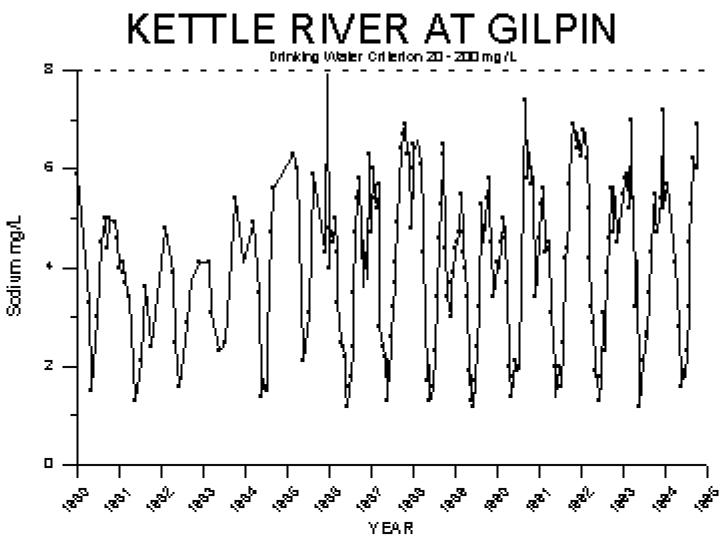


Figure 39 Total Strontium

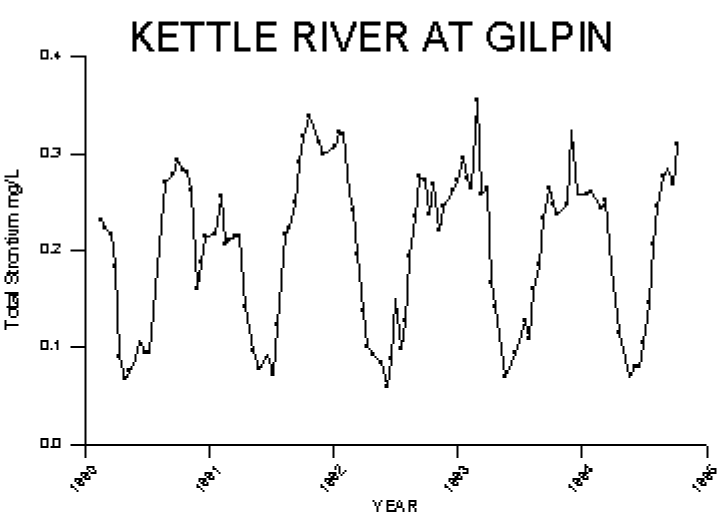


Figure 40 Dissolved Sulphate

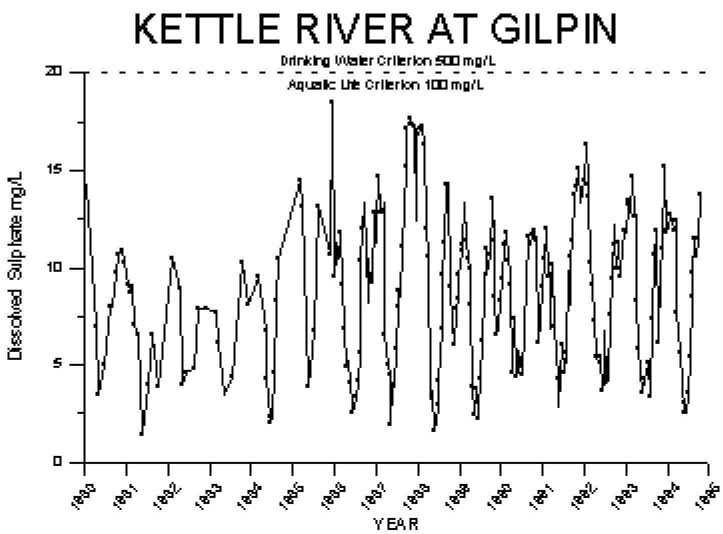


Figure 41 Air Temperature

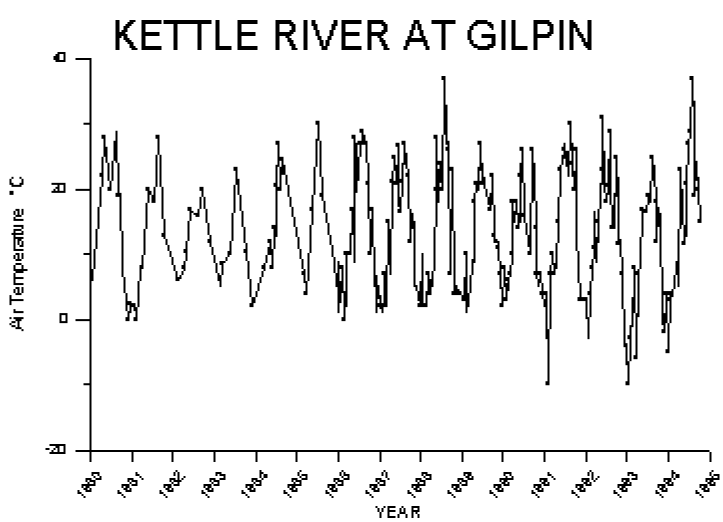


Figure 42 Water Temperature

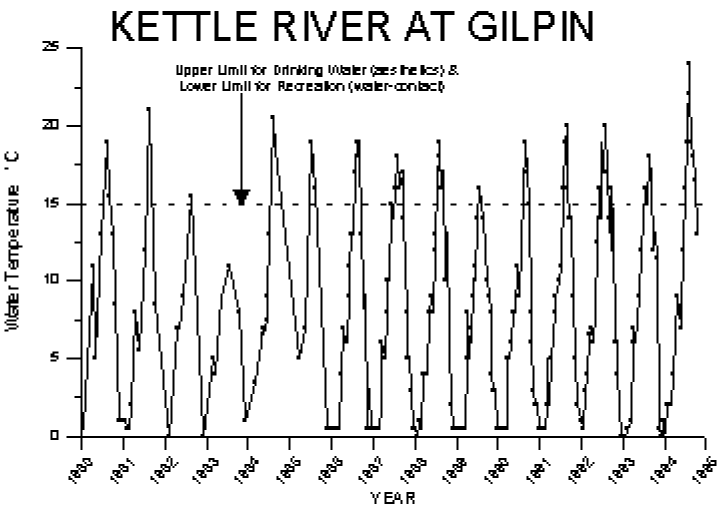


Figure 43 Turbidity

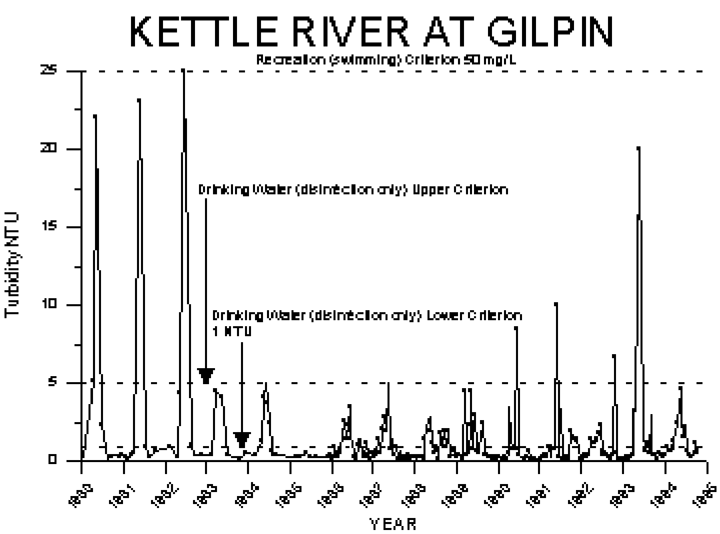


Figure 44 Total Vanadium

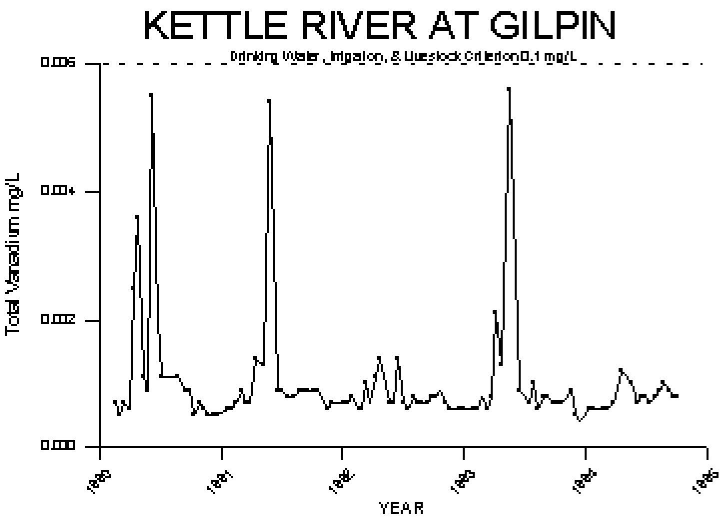
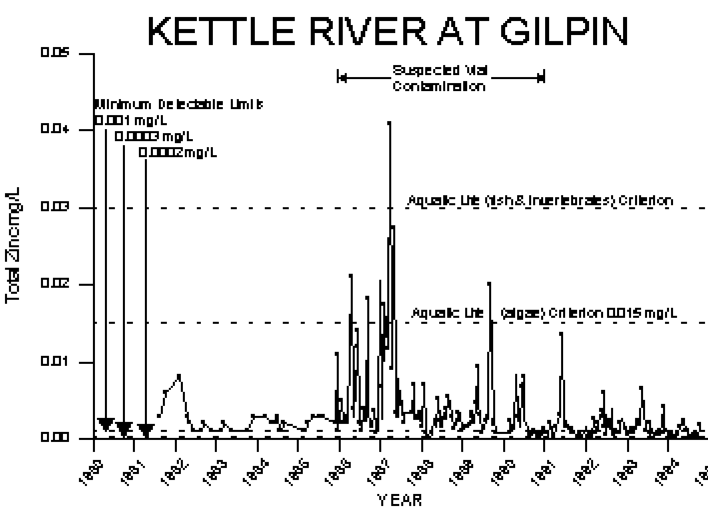


Figure 45 Total Zinc



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