

CANADA – BRITISH COLUMBIA

WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Fraser River

AT RED PASS (1984 – 2004)

Prepared by:

L. G. Swain, P. Eng.

B.C. Ministry of Environment

Prepared for:

B.C. Ministry of Environment

and

Environment Canada

March 2007



Environment **Environnement**
Canada **Canada**



Ministry of
Environment

EXECUTIVE SUMMARY

The Fraser River flows through a vast portion of the southern half of British Columbia, from the Rocky Mountains to the Pacific Ocean. The water quality monitoring site at Red Pass (located just below Moose Lake in the headwaters of the Fraser River) is the first of five long-term monitoring stations on the Fraser River. The remaining four monitoring sites are located at Hansard, Stoner, Marguerite, and Hope. This site represents a relatively pristine monitoring station, with no significant anthropogenic activity occurring upstream from this location. The primary purpose of the site is to provide an indication of ambient conditions that can be compared with water quality at downstream sites. The water quality trends identified below have not yet been confirmed by statistical analysis.

CONCLUSIONS

- There was an increasing trend in nickel concentrations since about 1994, although it has been reduced in magnitude in recent years. The cause of this increase is unclear, but concentrations of total nickel remain well below guideline levels for aquatic life.
- There may be slight increases in cobalt, rubidium, and dissolved nitrogen and dissolved sulphate.
- There appears to be a decreasing trend in lead concentrations and a possible increase in manganese. These trends may be related to the elimination of leaded gas and the use of a manganese-based additive.
- Specific conductivity also appeared to be increasing over time, but the levels seem to have remained steady since about 1992. Similar patterns were noted for hardness.
- The Fraser River at Red Pass has a low sensitivity to acid inputs (has a high buffering capacity) based on its relatively high total alkalinity and calcium concentrations.
- Exceedances of water quality guidelines by metals such as total copper, total iron, and total silver, appear to be associated with elevated turbidity levels, indicating

that these metals were bound in particulate matter, and therefore not available to biota and not of concern. Many metals that appeared to have values that exceeded guidelines in the past, have been shown to meet guidelines since lower detection limits have been utilized, and confidence in results have coincidentally improved.

- As there are no major human activities upstream from the Red Pass site, the measured concentrations of all metals would appear to be due to natural erosion processes in the upper watershed. Occasional high turbidity values are also attributed to natural erosion processes.
- All fecal coliform values were very low, indicating little fecal contamination of the Fraser River was occurring upstream from Red Pass.
- True colour has only been measured at Red Pass since 1997, but all values since that time have been below the aesthetic guideline for drinking water quality.
- Another recent evaluation of water quality at the Red Pass site, using the Water Quality Index as an assessment tool, ranked the water quality as Good to Excellent. Benthic populations measured downstream from the site in 1996 also indicated excellent water quality, and the population itself was considered to be a “reference” (i.e. undisturbed) population.

RECOMMENDATIONS

- Continue monitoring at this station for the present suite of water quality indicators, because the Red Pass site provides critical ambient water quality data necessary for interpreting data collected downstream in the Fraser River, as well as elsewhere in the province.
- Initiate monitoring of dissolved aluminum and hexavalent and trivalent chromium to enable the comparison of these metals to existing water quality guidelines.
- Continue to monitor extractable concentrations of all metals, including cadmium, to allow comparisons to total and dissolved concentrations of metals to be made (useful for determining potential impacts on aquatic life and/or drinking water).

TABLE OF CONTENTS

Executive Summary	i
Conclusions	i
Recommendations	ii
Table of Contents	iii
List of Figures	iii
Introduction	1
Water Quality Assessment	4
References	10

LIST OF FIGURES

	Page
Figure 1. Fraser River at Red Pass	3
Figure 2. Water Survey of Canada Flow Data for Fraser River at Red Pass	4
Figure 3. Alkalinity	11
Figure 4. Aluminum	11
Figure 5. Antimony	12
Figure 6. Arsenic	12
Figure 7. Barium	13
Figure 8. Beryllium	13
Figure 9. Bismuth	14
Figure 10. Boron	14
Figure 11. Cadmium	15
Figure 12. Calcium	15
Figure 13. Carbon	16
Figure 14. Chloride	16
Figure 15. Chromium	17

LIST OF FIGURES
(CONTINUED)

	Page
Figure 16. Cobalt	17
Figure 17. Coliforms, Fecal	18
Figure 18. Colour	18
Figure 19. Conductivity, Specific	19
Figure 20. Copper	19
Figure 21. Fluoride	20
Figure 22. Gallium	20
Figure 23. Hardness	21
Figure 24. Iron	21
Figure 25. Lanthanum	22
Figure 26. Lead	22
Figure 27. Lead (1991-2004)	23
Figure 28. Lithium	23
Figure 29. Magnesium	24
Figure 30. Manganese	24
Figure 31. Molybdenum	25
Figure 32. Nickel	25
Figure 33. Nickel (1995-2004)	26
Figure 34. Nitrate and Nitrite	26
Figure 35. Nitrogen	27
Figure 36. pH	27
Figure 37. Phosphorus	28
Figure 38. Potassium	28
Figure 39. Rubidium	29
Figure 40. Selenium	29
Figure 41. Silica and Silicon	30
Figure 42. Silver	30
Figure 43. Sodium	31

LIST OF FIGURES

(CONTINUED)

	Page
Figure 44. Solids – dissolved	31
Figure 45. Solids – suspended	32
Figure 46. Strontium	32
Figure 47. Sulphate	33
Figure 48. Temperature, Water	33
Figure 49. Thallium	34
Figure 50. Tin	34
Figure 51. Turbidity	35
Figure 52. Uranium	35
Figure 53. Vanadium	36
Figure 54. Zinc	36

INTRODUCTION

Since 1985, B.C. Ministry of Environment and Environment Canada have been cooperatively measuring water quality at a number of locations in British Columbia. The express purposes of this joint monitoring program have been to define the quality of the water and to determine whether there are any trends in water quality.

Water quality measurements for the Fraser River at Rd Pass were plotted on a graph over time, along with the relevant water quality objectives or guidelines. The graphs were inspected for "environmentally significant" trends - where the measurements are increasing or decreasing over time and the levels are close to the objectives or guidelines, or are otherwise judged to represent an important change in water quality. These trends are further evaluated to ensure that they were not caused by measurement errors, to identify their causes, and to determine whether they are statistically significant. A confidence level of 95% or better is used to define statistical significance, unless noted otherwise.

The Fraser River basin is one of British Columbia's most valued ecosystems, draining fully one quarter of the province. Its headwaters are located in the Mount Robson Provincial Park near Moose Lake in the Rocky Mountains. The northern part of the river follows a northwest path before heading south, starting just north from Prince George. The Fraser River then flows 1,200 km before turning to the west, near Hope, and continues for about 150 km before entering the Pacific Ocean at Vancouver. The river has two very important tributaries which affect both flow and water quality. They are the Nechako River, which merges with the Fraser River at Prince George, and the Thompson River, which flows into the Fraser River at Lytton.

The Fraser River supports commercial and recreational fisheries of all five salmon species, and salmon runs on the Fraser River are among the largest in the world.

Water Quality Assessment of the Fraser River at Red Pass 1984 - 2004

There are five long-term federal-provincial water quality monitoring sites on the Fraser River (Fraser River at Red Pass, Hansard, Stoner, Marguerite, and Hope). Also, there are long-term sites on both the Nechako and Thompson rivers. This report deals with the site on the Fraser River at Red Pass (Figure 1). Red Pass is located upstream from Hansard in a sparsely populated reach of the river. The drainage area for the site is 1,700 km², and is contained within the Mount Robson Provincial Park. There are no active water licences or permitted waste discharges between the headwaters of the Fraser River and Red Pass. The main potential human influences on water quality are the Yellowhead Highway and the Canadian National Railway, which run alongside the Fraser River and Moose Lake through Mt. Robson Park, recreational activities in the park, and atmospheric deposition of contaminants carried by rain and snow.

Data for the Fraser River at Red Pass have been collected on a frequency of about once every two weeks. As well, twice per year, two additional samples are collected in order to ensure that there are two periods when weekly samples are collected during five consecutive weeks to assess attainment of water quality objectives. In addition, quality assurance samples (blanks and replicates) are collected three times per year. The results for each variable were used in this assessment to identify potential outliers that should be removed from consideration of trends, and to “flag” questionable data in the database (www.waterquality.ec.gc.ca) as to possible or likely errors.

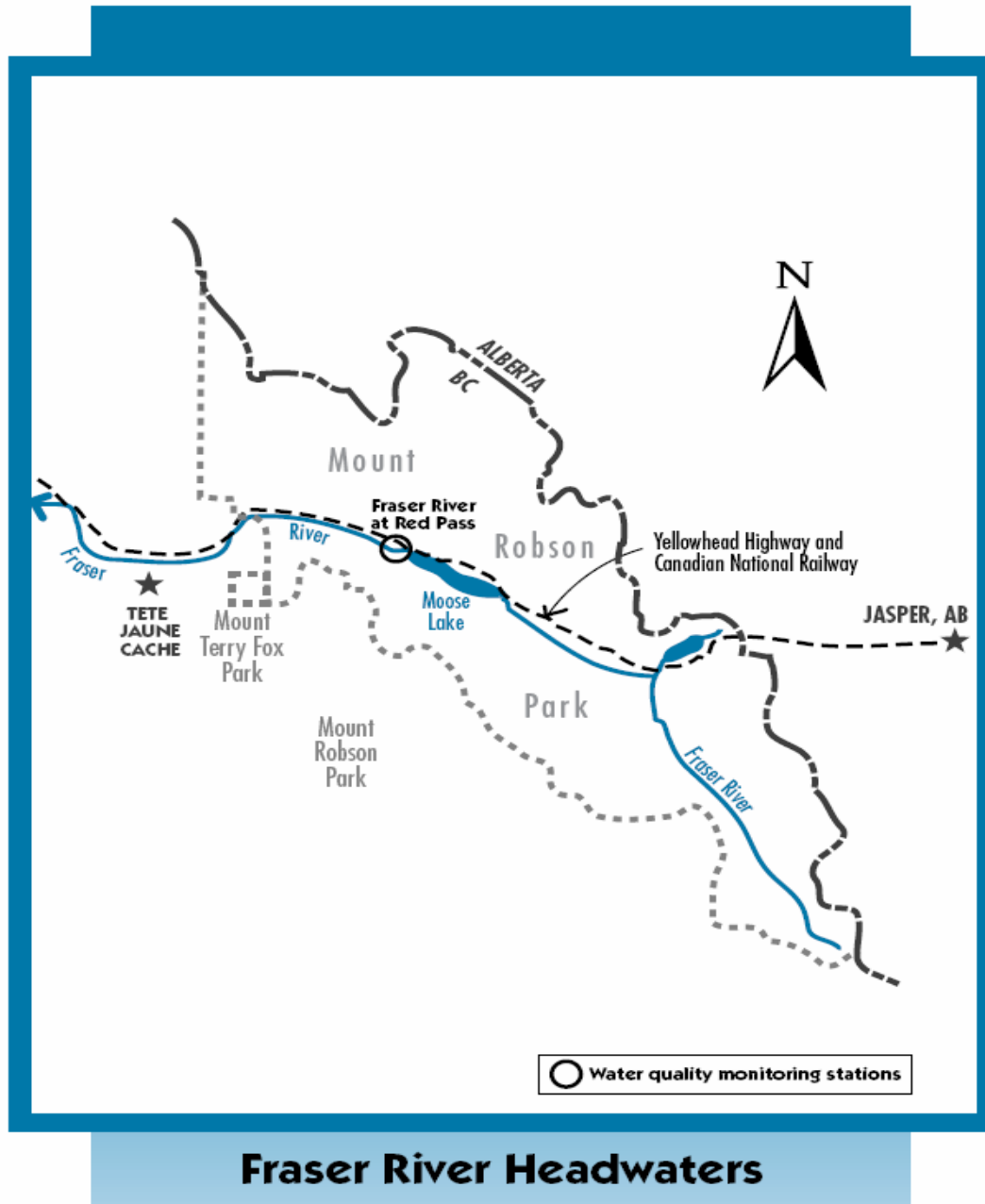
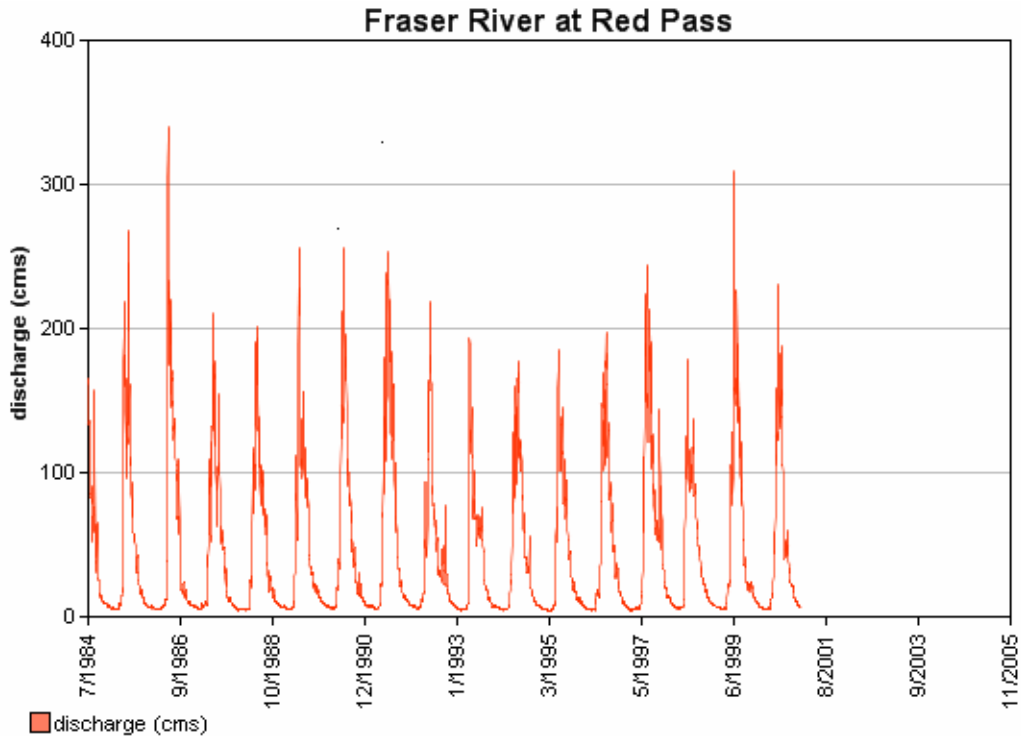


Figure 1: Fraser River at Red Pass

This report assesses twenty-one years (1984 – 2004) of water quality data collected by Environment Canada and B.C Environment. The data, from bi-weekly water samples, are stored in the Environment Canada database under ENVIRODAT station number BC08KA0007 and in the Ministry of Environment database under EMS number E236796. All of the data are available to the public on our web site, located at Canada – British Columbia Water Quality Monitoring Agreement

www.waterquality.ec.gc.ca. Flow data for the Fraser River at Red Pass (station no. BC08KA007), collected by the Water Survey of Canada, are plotted in Figure 2 for 1984-2004. Water quality data are plotted in Figures 3 to 54.



ChartDirector (unregistered) from www.advsofteng.com

Figure 2: Water Survey of Canada Flow Data for Fraser River at Red Pass

WATER QUALITY ASSESSMENT

The status and trends of various water quality indicators were assessed by plotting the indicators over time and comparing the values to the Province’s approved and working water quality guidelines (Ministry of Environment, 2006a & 2006b). Any levels or changes of the indicators over time that may have been harmful to sensitive water uses, such as drinking water, aquatic life, wildlife, recreation, irrigation, and livestock watering, are described below in alphabetical order.

When concentrations of a substance cannot be detected, we have plotted the concentration at the level of detection. We believe this to be a conservative approach to

assessing possible trends. As well, there are times when measurements were not taken for some reason. In these cases, straight lines will join the two consecutive points and may give the illusion on the graph of a trend that does not exist.

In cases where we have used statistical techniques such as linear regression analysis to estimate if a trend is possibly present, a more thorough statistical analysis of the trend is necessary for verification of the trend.

In some cases, testing for the presence of a variable has been terminated after a certain period. In general, this has been because a previous data assessment and review has indicated that collections of these data are not warranted for this station. For other variables, concerns about concentrations may have only arisen in recent years.

Water quality indicators were not discussed if they were in no danger of exceeding water quality guidelines values (if guidelines exist for the variable) and showed no harmful trends. These included: alkalinity, antimony, arsenic, barium, beryllium, bismuth, boron, calcium, carbon, chloride, gallium, lanthanum, lithium, magnesium, molybdenum, pH, phosphorus, selenium, sodium, strontium, solids, thallium, tin, uranium, and vanadium.

Total aluminum (Figure 4) exceeded the water quality guideline for the protection of wildlife, livestock and irrigation (5 mg/L) once. The highest values occurred in August and September of 1998, concurrent with high turbidity values (see Figure 4), which suggests that the majority of the aluminum was associated with particulate matter and not in the dissolved form. Aluminum is the most common metal on the planet, comprising 7-8% of the earth's crust, so it is not surprising to find that levels vary in proportion to the amount of sediment (turbidity) in the water. However, it is recommended that the concentration of dissolved aluminum be measured in the future to allow a useful comparison with the guidelines for aquatic life and drinking water. No change was noted in total aluminum concentrations over the duration of record.

Cadmium concentrations (Figure 11) have been hampered by high levels of detection that have made interpretation of results difficult. Detection limits have improved in 2003

and 2004 to 0.001 µg/L and values usually are less than the guidelines for the protection of aquatic life (0.008 µg/L) at minimum hardness of 20 mg/L and 0.024 µg/L at average hardness of 70 mg/L. No values have exceeded the guideline for the respective hardness since the detection limit has changed. In our analysis, we removed one suspected error/outlier from the data set: a value of 4 µg/L on September 16, 1985 when the level of detection was 1 µg/L.

Total chromium concentrations occasionally exceeded the aquatic life guidelines of 1 µg/L for hexavalent and 9 µg/L for trivalent chromium (Figure). Irrigation guidelines are a maximum of 5 µg/L trivalent and 8 µg/L hexavalent chromium. Measurements of the trivalent and hexavalent forms of chromium with detection limits of 0.1 µg/L or lower should be made when the analytical methods become available.

Total cobalt has shown a slight increase during the period of record (Figure 16), although concentrations have not exceeded the B.C. guidelines for the protection of aquatic life (4 µg/L).

Fecal coliform concentrations have only been measured at Red Pass since early 2000 (Figure 17). All individual values were below the 90th percentile guideline for the protection of drinking water that will receive only disinfection (10 CFU/100 mL). Two suspected errors were removed from the data set: <59 CFU on September 3, 2003 and <13 CFU on November 12, 2003.

True colour values (Figure 18) are below the aesthetic guideline for drinking water of 15 TCU. All apparent colour values were at or below that guideline.

Specific conductivity values (Figure 19) appear to be increasing; however, when the data before 1992 are excluded, there is no increase. All values are well below guidelines values, and this increase is not a cause for concern. Conductivity values generally increase with lower water levels (ions become more concentrated). In our analysis, we removed one suspected error/outlier: 408 µS/cm on April 25, 2001

Total copper (Figure 20). The aquatic life guidelines for copper are hardness-dependent. The guideline corresponding to the average hardness was exceeded on only a couple of occasions by individual samples; however, these were related to high suspended solids concentrations. This suggests that much of the copper present at these times was associated with particulate matter which decreases its availability to biota. There does not appear to be any change in total or extractable copper concentrations over time.

Hardness concentrations (Figure 23) appear to be increasing from the early 1980's; however, when the data before 1992 are excluded from our analysis as we did for specific conductivity, there is no apparent recent trend.

Total iron (Figure 24) concentrations exceeded the aesthetic drinking water and aquatic life guideline of 0.3 mg/L on occasion. These exceedances occurred almost invariably between July and September, when turbidity levels were relatively high. The occasional high concentrations of iron at Red Pass are due to natural sources, as there are no known human sources of iron upstream from this point. There was no apparent change in iron levels over time.

Guidelines for **total lead** (10 µg/L for drinking water and 30-day mean of 3.7 µg/L for aquatic life) were not exceeded by any samples collected between 1984 and 2004 (Figure 26). There appears (Figure 27) to be a trend of lower extractable lead concentrations during the 1991-2004 period. There seems to be some correlation between total lead concentrations and turbidity.

Total manganese concentrations seem to be showing a slight trend of increasing concentrations (Figure 29). This upward trend, in conjunction with the potentially decreasing trend for lead, suggests the possibility that these are related to the removal of leaded gas and the use of the fuel additive containing manganese. These concentrations seem to be correlated with turbidity to some degree. All values were less than the drinking water guideline of 50 µg/L.

Total nickel values measured at Red Pass during 1990-2004 were considerably below the guideline for the protection of aquatic life of 25 µg/L at a hardness of 0 to 60 mg/L. There appears to have been a gradually increasing trend in total nickel concentrations over time at this site (Figure 32), which has been reduced in scope in the period 1995 to 2004 (Figure 33). However, the levels were well below guidelines and are therefore not of environmental concern at this time. Total and extractable nickel values were similar and did not seem to be correlated with turbidity.

Total dissolved nitrogen seems to have increased slightly between 1984 and 2004 (Figure 35). **Nitrate** and **nitrite** concentrations generally were stable (Figure 34) but sampling for these variables was suspended in the late 1990's.

Extractable rubidium (Figure 39) seems to be increasing slightly between 1997 and 2004. There appears to be a correlation between turbidity and rubidium concentrations. We could find no guidelines with which to assess this metal.

Total silver concentrations occasionally exceeded the 30-day average freshwater guideline of 0.05 µg/L but this only occurred when a high detection limit was in use (Figure 42). All values were less than the 1.5 µg/L guideline for maximum concentrations. All individual values have met the 0.05 µg/L guideline since detection limits have been lowered. No change was noted in total silver concentrations over the duration of the record.

Dissolved sulphate concentrations had a definite trend towards increasing values over time (Figure 47). However, all concentrations were well below guideline values (a maximum of 100 mg/L for the protection of aquatic life), and are therefore not a cause for concern at this time.

Turbidity values frequently exceeded both the drinking water guideline for health (1 NTU), and occasionally exceeded the aesthetic drinking water guideline (5 NTU) (Figure

51). This indicates that the water would require partial treatment (*e.g.*, filtration) plus disinfection before use as drinking water.

The aquatic guidelines for **total zinc** are dependent on hardness and zinc concentrations appear to be correlated with turbidity events. The aquatic life guideline is a 30-day average of ≤ 7.5 $\mu\text{g/L}$. No individual zinc values have exceeded this guideline over the period of record (Figure 54). It does not appear that zinc concentrations are changing over time at this site. Concentrations of extractable zinc were similar to those of total zinc. There are no known human sources of zinc in the upper Fraser River watershed.

REFERENCES

- Ministry of Environment. 2006a. British Columbia Approved Water Quality Guidelines (Criteria). , Ministry of Environment, Victoria, B.C.
- Ministry of Environment. 2006b. A Compendium of Working Water Quality Guidelines for British Columbia. Ministry of Environment, Victoria, B.C.
- Water Quality Branch. 1996. State of Water Quality of Fraser River at Red Pass (1984-1995). Water Quality Branch, Environmental Protection Department, Ministry of Environment, Lands and Parks, Victoria, B.C.

