CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Fraser River AT HOPE (1979 – 2004)

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B.C. Ministry of Environment
and
Environment Canada

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Environment Canada **Environnement Canada**

BRITISH COLUMBIA
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EXECUTIVE SUMMARY

The Fraser River basin drains about one-quarter of British Columbia and is an extremely important migratory route for spawning salmon. The Fraser River at Hope monitoring station is the station furthest downstream measured in the river itself. As such, it is upstream from the influence from the Greater Vancouver area and the agricultural inputs from the lower Fraser Valley.

As monitoring techniques are developed, it would be advantageous to incorporate a new Fraser River station at a location within the lower Fraser River Estuary. Such a station would be problematic to operate, but would provide increasingly crucial information on the health of the Fraser River Estuary. Such a station would ideally be operated under the Federal-Provincial Water Quality Monitoring Agreement

Several potential trends identified in this report should be verified by a statistician using appropriate statistical techniques. Such trends were possible increasing potassium and turbidity levels, and possible stability of chloride concentrations since 1992. Neither of the former possible trends are environmentally significant at his time; however, the possible stability of chloride concentrations is likely directly related to the elimination of chlorine dioxide as a bleaching compound at pulp and paper mills.

The forms of some variables and the guidelines do not correspond and if possible, should be modified in order that direct comparisons to guideline values can be made. Examples of this include aluminum which should be measured in the dissolved form, and chromium with guidelines expressed as hexavalent and trivalent chromium.

Although some metals concentrations appear to exceed guideline and objectives on occasion, these appear to fluctuate with turbidity and are likely not biologically available. As well, the analytical detection limits for many of these metals have been lowered considerably since 2002, and concentrations have correspondingly been reduced. This will be interesting to review after 2009 when a full seven years of data using lower analytical detection limits is available for analysis.

CONCLUSIONS

- Flows are typical of interior rivers, with peaks occurring during the spring to early summer period and low flow taking place during the late autumn through winter periods.

- Turbidity levels seem to fluctuate with flows as is to be expected. Although there appears to be a possible increase in turbidity through time ($R^2 = 0.028$), this needs to be assessed by a statistician and verified. Based on our assessment, this possible increasing trend is weaker than found at the upstream stations. Related to this is a possible increase in potassium ($R^2 = 0.036$) which also needs to be verified by a statistician but is at about the same level as we found at the upstream stations. The statistician should also test whether these possible increases are dependent on each other.

- Although there continues to be an apparent decline in chloride concentrations, we believe that this decrease has been stable since some time in early 1992. The decline in chloride concentrations is about the same as we noted at the upstream stations. Both these conclusions should be tested by a statistician.

- The forms of some variables and the guidelines do not correspond and if possible, should be modified in order that direct comparisons to guideline values can be made. Examples of this include aluminum which should be measured in the dissolved form, and chromium with guidelines expressed as hexavalent and trivalent chromium.

- Several variables, including most metals, fluctuated with turbidity levels which in turn corresponded to increased flows. High metal concentrations at those times that exceeded guidelines or site-specific water quality objectives would not be biologically available and therefore of little concern. Concentrations of many metals such as cadmium, copper, silver, and zinc showed considerable decreases in concentrations after 2002 when considerably lower analytical detection limits were available and were used for analyses. This leads one to speculate that many of the higher apparent concentrations in earlier years may have been related as much to analytical variability at concentrations closer to those higher analytical detection limits as to true environmental concentrations. This pattern will be interesting to observe in the next several years and will be much more definitive when results to the end of 2009 are reported.

- Many variables appeared to fluctuate with conductivity levels, particularly variables measured as dissolved concentrations. This is not unexpected.

RECOMMENDATIONS

- We recommend monitoring be continued for the Fraser River at Hope to track the possible increases in variables that have been identified in this report. As well, dissolved aluminum should be measured, and either trivalent and hexavalent forms of chromium should be measured in the future, or alternately, guidelines be developed for total chromium values.
- A statistician should verify the possible trends identified in this report using appropriate statistical techniques.
- As monitoring techniques are developed, it would be advantageous to incorporate a new Fraser River station at a location within the lower Fraser River Estuary. Such a station would be problematic to operate, but would provide increasingly crucial information on the health of the Fraser River Estuary. Such a station would ideally be operated under the Federal-Provincial Water Quality Monitoring Agreement.

Water quality indicators that are important for future monitoring are:

- Flow because of its importance in interpreting many water quality indicators.

- water temperature, specific conductivity, pH, turbidity, and dissolved oxygen,
- appropriate forms of metals for comparison to their respective guidelines, and
- other variables related to drinking water such as colour and dissolved organic carbon.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

(CONTINUED)

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 Marguerite 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 one-quarter of the province (Fraser River Action Plan, 1995). Its headwaters are located near Moose Lake in the Rocky Mountains. The northern part of the river follows a north-west path before heading south starting just north from Prince George. The Fraser River then flows 600 km before turning to the west, near Hope, B.C., and flowing in a south-westerly direction to the Pacific Ocean. The river has two major tributaries which affect its flow and water quality: the Nechako River (which merges with the Fraser River at Prince George); and the Thompson River (which flows into the Fraser River at Lytton, B.C. -approximately 95 km north from Hope). These two tributaries contribute 41% of the total Fraser River flow at Hope: the Thompson River contributes 30% and the Nechako River contributes 11%.

There are four long-term water quality monitoring sites on the Fraser River (Red Pass, Hansard, Marguerite, and Hope), as well as sites on both the Nechako and Thompson rivers. This report deals with the site on the Fraser River at Marguerite (Figure 1). Marguerite is in central B.C., roughly halfway between Quesnel and Williams Lake. The Fraser River at Marguerite has a drainage area of 114 000 km^2. Water quality at this site is affected by five upstream mills producing pulp and/or paper: three in Prince George and two in Quesnel. The designated water uses for this reach of the Fraser River are aquatic life, wildlife, drinking water (with partial treatment and disinfection), livestock, irrigation, and secondary-contact recreation (e.g., boating).

This report assesses eighteen years of data from the Ministry of Environment (1987 – 2004) and twenty years of Environment Canada data (1985 – 2004). The provincial station number in EMS is E206581 and the federal site number in ENVIRODAT is BC08MF0001. The station is located at the highway 1 bridge in Hope. Flow is plotted in Figure 2, showing 1985-2004 data from Water Survey of Canada station BC08MF005 at Hope. Water quality data are plotted in Figures 3 to 60. All of the data are available to the public on our web site, located at www.waterquality.ec.gc.ca.

Data for the Fraser River at Hope 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. In addition, quality assurance samples (blanks and replicates) are collected six times per year. The results for each variable were used in this assessment to identify potential outliers that should be removed form 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 Hope

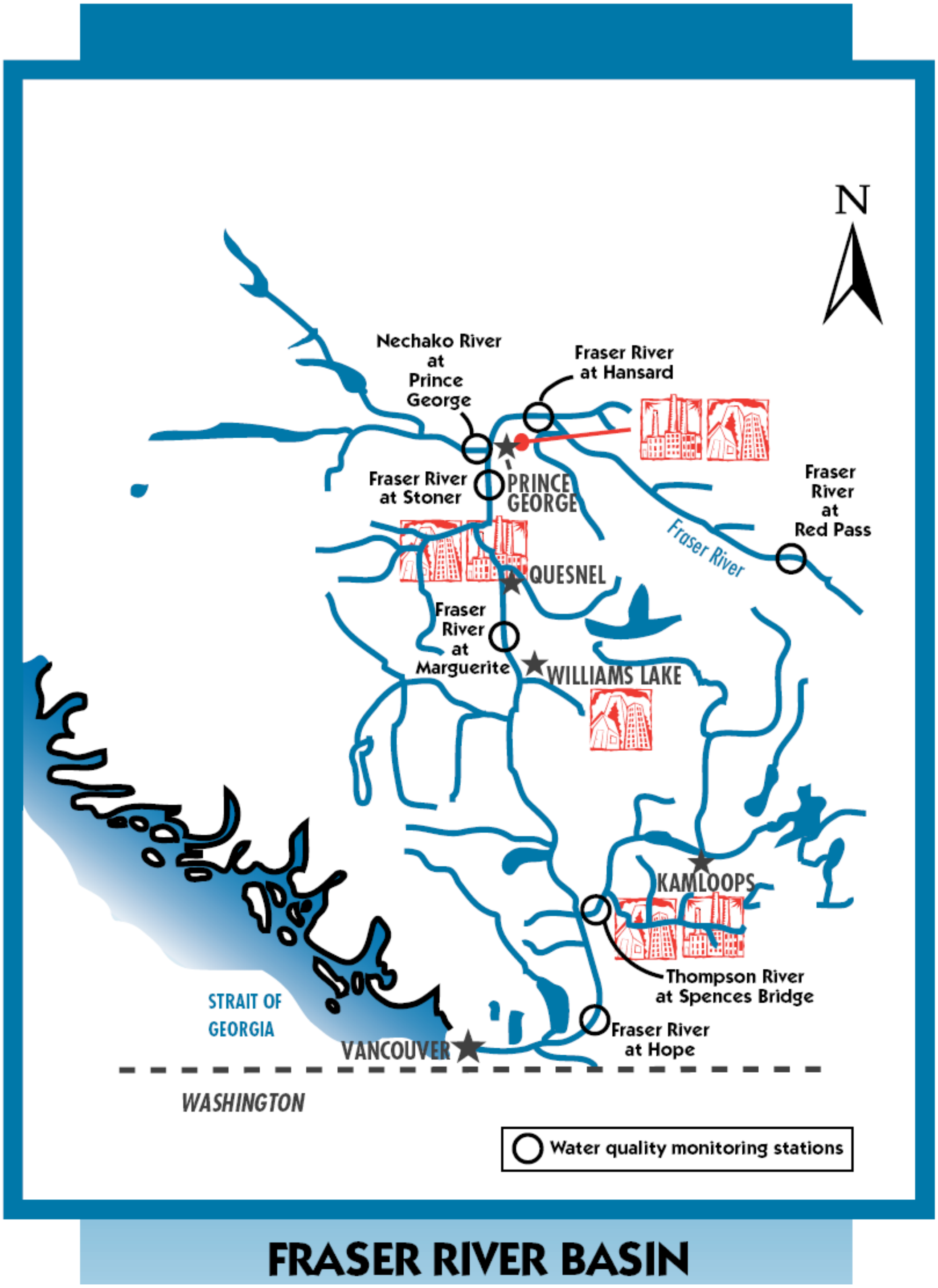
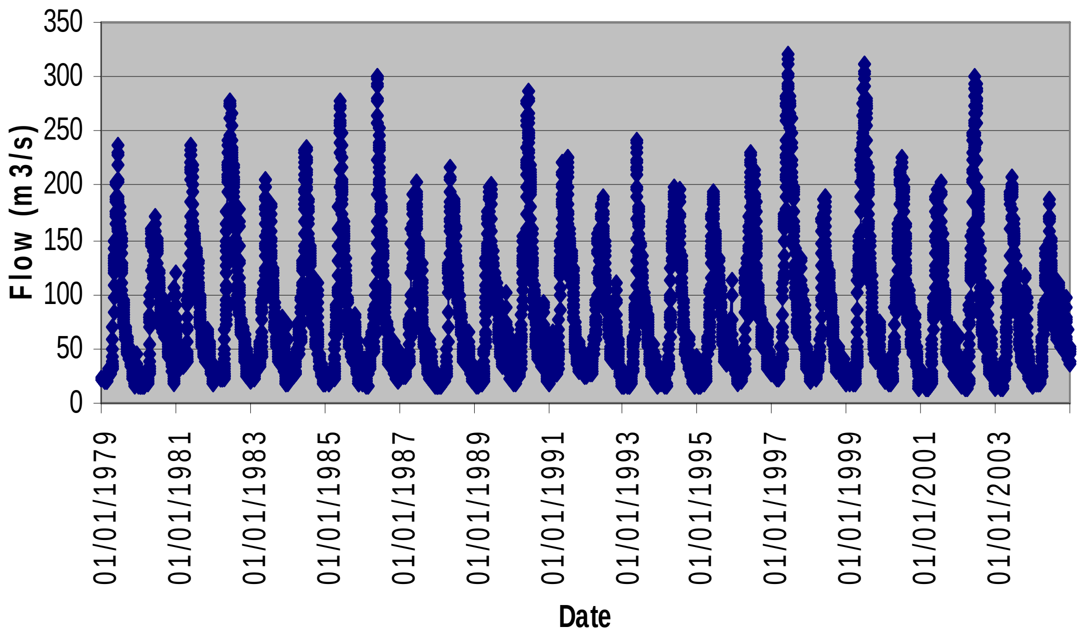


FIGURE 2: Water Survey of Canada Flow Data for Fraser River at Hope



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 objectives for this reach of the Fraser River (Swain *et al.* 1997) or its 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 objectives or guidelines and showed no harmful trends. These included fluoride (dissolved and total), total molybdenum, nitrite, total nitrogen, pH, fixed filterable residue, and extractable silicon.

The following water quality indicators seemed to fluctuate through the year according to turbidity concentrations, but were below guideline values (if these exist) and had no other trends. These included total aluminum, total beryllium, dissolved organic carbon, total chromium, total gallium, total lanthanum, total lithium, total nickel, total rubidium, total antimony, total thallium, and total uranium.

Other water quality indicators seemed to fluctuate through the year according to the specific conductivity of the water, but were below guideline values (if these exist) and had no other trends. For dissolved forms of many of these indicators, they would be a part of the measured conductivity, and this is to be expected. These types of indicators that were not measured above guideline values included alkalinity, total boron, total hardness, magnesium, dissolved nitrate, total dissolved nitrogen, dissolved and extractable sodium, dissolved nitrate plus nitrite, filterable residue, fixed non-filterable residue, non-filterable residue, dissolved and reactive silica, total strontium, dissolved sulphate, and total vanadium.

Flow (Figure 2) values are typical of interior rivers, with peaks ($\simeq$ 300 m^3/s) occurring during the spring to early summer period and low flows ($\simeq$ 25 m^3/s) taking place during the late autumn through winter periods. Flow monitoring should continue because of its importance in interpreting many water quality indicators.

Aluminum (Figure 5): values fluctuate with turbidity and exceed the guidelines for the dissolved form of the metal. Values seem to fluctuate with turbidity values, meaning that the aluminum is in particulate form and not likely biologically available.

Arsenic (Figure 6): values fluctuate with turbidity. Occasional values exceed the guideline of 5 µg/L to protect aquatic life. During these periods when guidelines are exceeded, the cadmium will likely be in particulate form and not biologically available.

Cadmium (Figures 9 and 10): values fluctuate with turbidity levels and are in excess of guidelines on a regular basis. This is especially apparent for 2003 and 2004 (Figure 10) when the detection limit was reduced to 0.02 µg/L. We would consider values within about five times the detection limit (up to 0.10 µg/L) with caution due to inherent variability at levels so close to the detection limit. During these periods when guidelines are exceeded, especially at five times the detection limit, that the cadmium will likely be in particulate form and not biologically available.

Chloride (Figure 11): values seem to have decreased since the mid-1980's, due to the elimination of chlorine dioxide as a bleaching compound at the pulp and paper mills. The reduction was most noticeable in early 1992. A linear regression analysis showed a decline (R^2 = 0.20) in that period. This compares to a decline at the upstream site at Marguerite (R^2 = 0.25) which may have been stronger since Marguerite is closer to the sources of the decline than is Hope. When the data from 1992 until 2004 were plotted, there is no trend. Therefore, we can say that the decreasing trend in chloride is now stable. Dissolved chloride values also varied according to specific conductivity as would be expected.

Dissolved Organic Carbon (Figure 13): values seem to fluctuate with turbidity concentrations. High values in excess of the drinking water guideline of 4 mg/L as total organic carbon occur when solids removal would be required for water treatment.

Cobalt (Figure 14): values (individual) have exceeded the 30-day mean guideline value for the protection of aquatic life of 4 μg/L on occasion. Individual cobalt concentrations varied with turbidity, and all values that exceeded the guideline (30-d mean value) took place when turbidity was high. No individual values exceeded the guideline for a maximum concentration of 110 μg/L. These higher values would be associated with particulate matter and would likely not be biologically available.

Fecal Coliforms: (Figure 15) exceeded the guideline (individual values) of 10 CFU/100 mL (90^{th} percentile) for source waters for drinking receiving no treatment other than disinfection, and the guideline of 100 CFU/100 mL (90^{th} percentile) for source waters receiving partial treatment. Individual values varied with turbidity, so that if the waters were being withdrawn for consumption, treatment would be required to remove the turbidity. This would improve the effectiveness of the disinfection process.

Colour: (Figures 16 and 17) values regularly exceeded the guidelines for true colour of 15 mg/L Pt. for drinking water supplies; however, the colour was related to turbidity in the river. Colour would be reduced with turbidity removal if the water was used as a source water supply.

Copper: (Figure 19) values (individual) regularly exceeded the B.C. guidelines to protect aquatic life both as maximum concentrations and in comparison to the 30-d mean. The Ministry of Environment does not have a site-specific water quality objective for copper at Hope, likely due to the fact that copper at this site is generally natural and .fluctuates with turbidity. This means that the copper would not be biologically available.

Iron: (Figure 20) values regularly exceeded the guideline to protect aquatic life and aesthetics of drinking water supplies (300 μg/L); however, concentrations are directly correlated with turbidity levels and would not be biologically available. It would also be removed in treatment of turbidity for use as a drinking water supply.

Potassium (Figure): values apparently increased during the period pf record. The increase was tested using a linear regression analysis ($R^2 = 0.036$) which is virtually identical to that measured at Marguerite. As at Marguerite, we suspect that this increase is related to increases in turbidity during the same period (see below). At Marguerite, extractable potassium was found (Swain 2006b) to be showing a slightly increasing trend through time when a linear regression of the data was used ($R^2 = 0.0392$).

Lead: (Figure 26) values occasionally exceeded guidelines for the protection of aquatic life; however, since the analytical detection limit was lowered in 2003, no values have exceeded the guideline. Since lead fluctuates in parallel with turbidity, any values that may have exceeded the guideline in the past were likely associated with suspended solids and were not biologically available.

Phosphorus: (Figure 39) values fluctuated with turbidity levels and frequently exceeded the B.C. guideline for the protection of source waters for drinking in lakes of 10 µg/L. This guideline is based on development of algal growths which will not occur in the Fraser River die to turbidity levels. Total dissolved phosphorus values (Figure 40) seemed to fluctuate with specific conductivity levels.

Silver: (Figures 47 and 48) values seemed to exceed the B.C. guidelines for the protection of aquatic life; however, when the analytical detection limit was lowered in 2003, no individual values exceeded either the 30-d mean of 0.05 µg/L or the maximum value of 0.10 µg/L when hardness is less than 100 mg/L. Since silver concentrations seem to fluctuate with turbidity levels, any values that truly exceeded the guidelines in the past were likely associated with suspended solids and not biologically available.

Selenium: One (Figure 49) value exceeded the B.C. guideline of 1 µg/L for the protection of aquatic life in 1985; however, no other values have exceeded the guideline. Selenium concentrations seem to fluctuate with turbidity, meaning that if this one value that exceeded the guideline was valid, the selenium would not likely be biologically available.

Water Temperature (Figure 55): tend to peak during the hot summer months and on occasion exceed guidelines for the protection of aquatic life. This is not a regular occurrence but could reduce the energy levels of salmon that might be migrating upstream during these periods. Other than expected seasonal variation in temperatures, there were no other long-term trends apparent.

Turbidity (Figure 57): values seemed to increase during the period of record. We tested the possible increase using a linear regression analysis ($R^2 = 0.0277$). At Marguerite and Hansard, the R^2 value was about 0.07 (Swain 2006a; 2006b), indicating that the influence of the possible upstream source of solids is diminished by the time flows reach the Hope monitoring station.

Zinc (Figure 60) values increase with increasing turbidity levels, and on occasion exceed hardness-dependent guidelines for the protection of aquatic life. Because the high zinc concentrations coincide with high turbidity levels, the metals are likely in particulate form and not biologically available.

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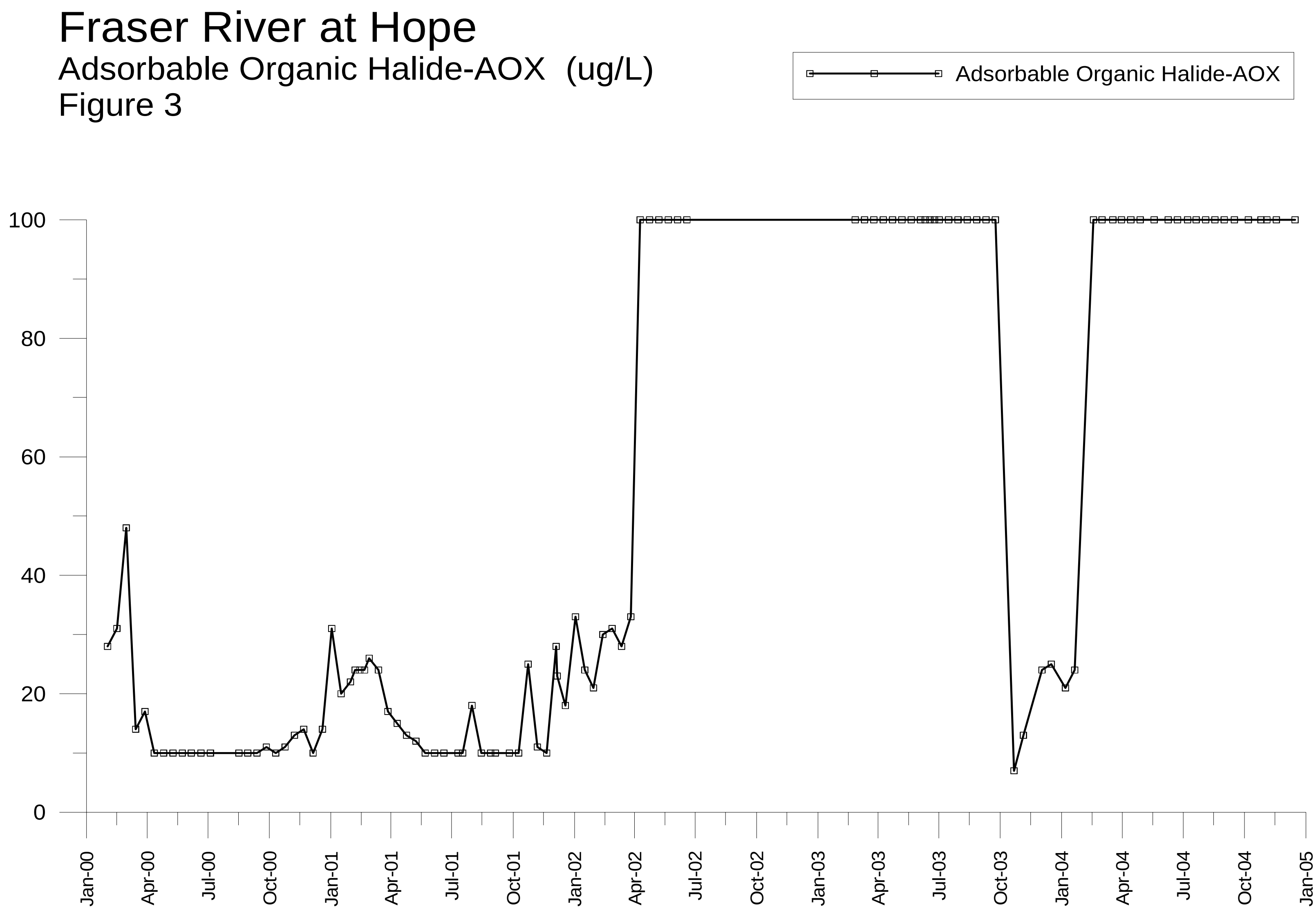
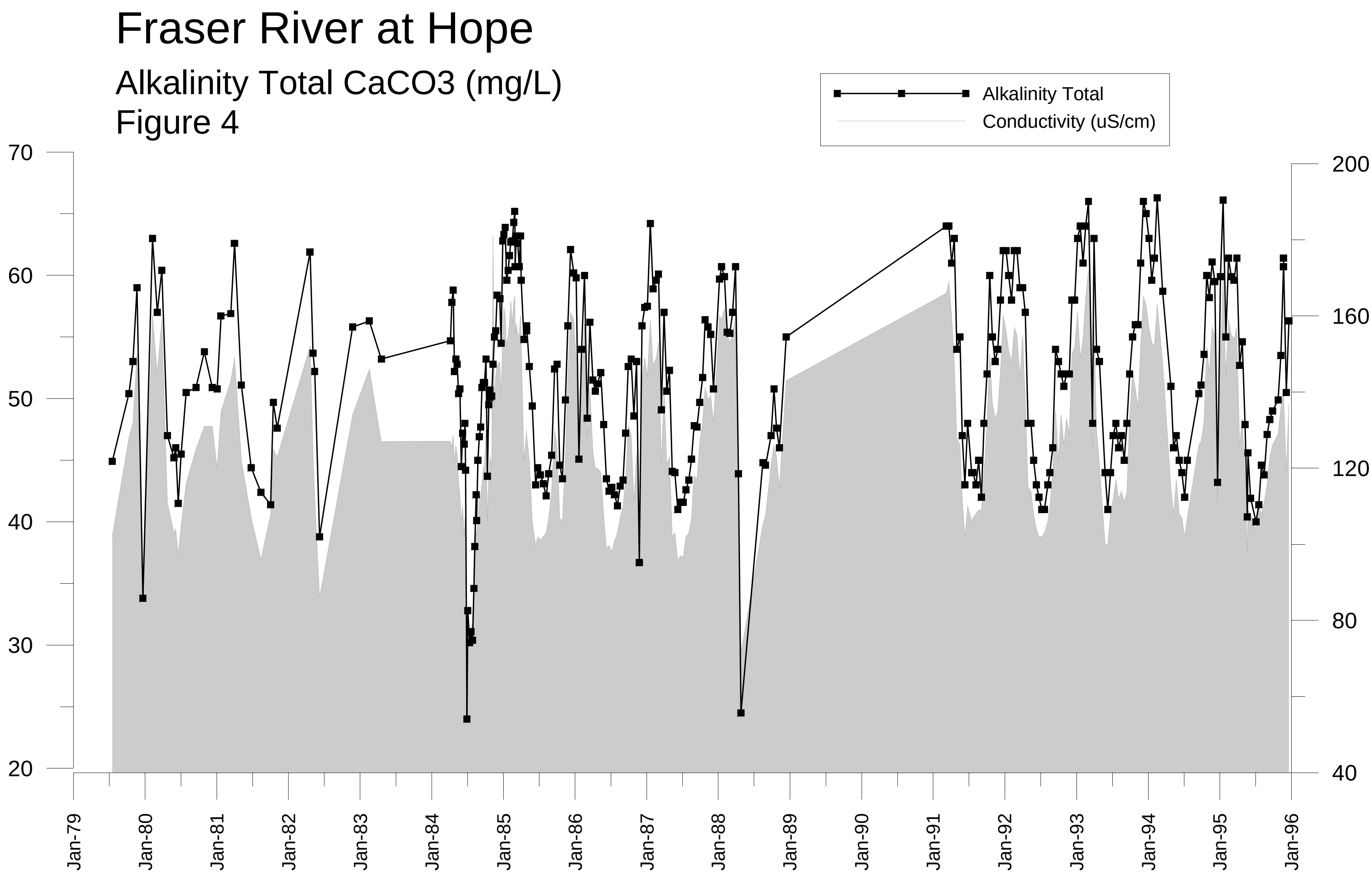
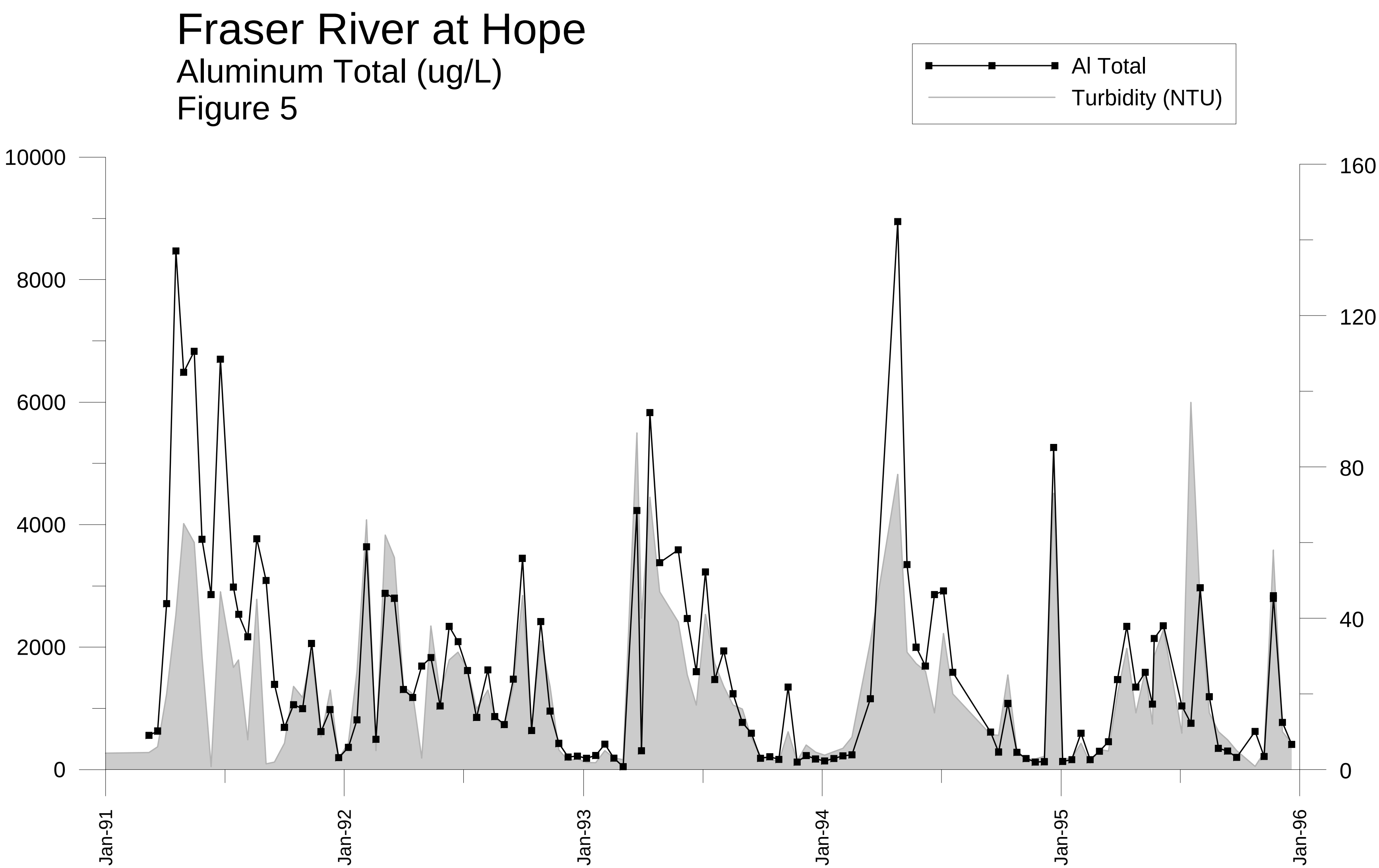
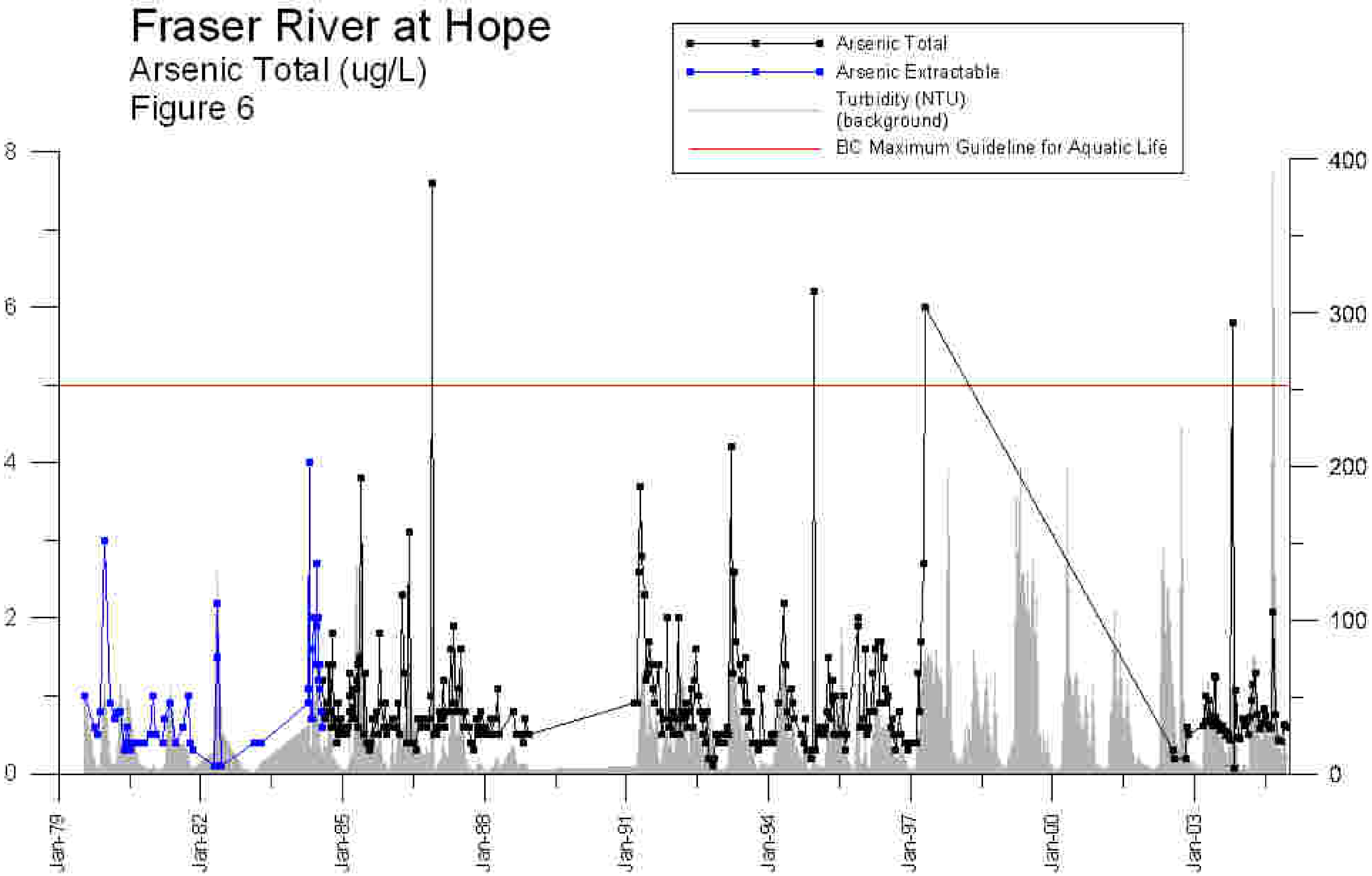
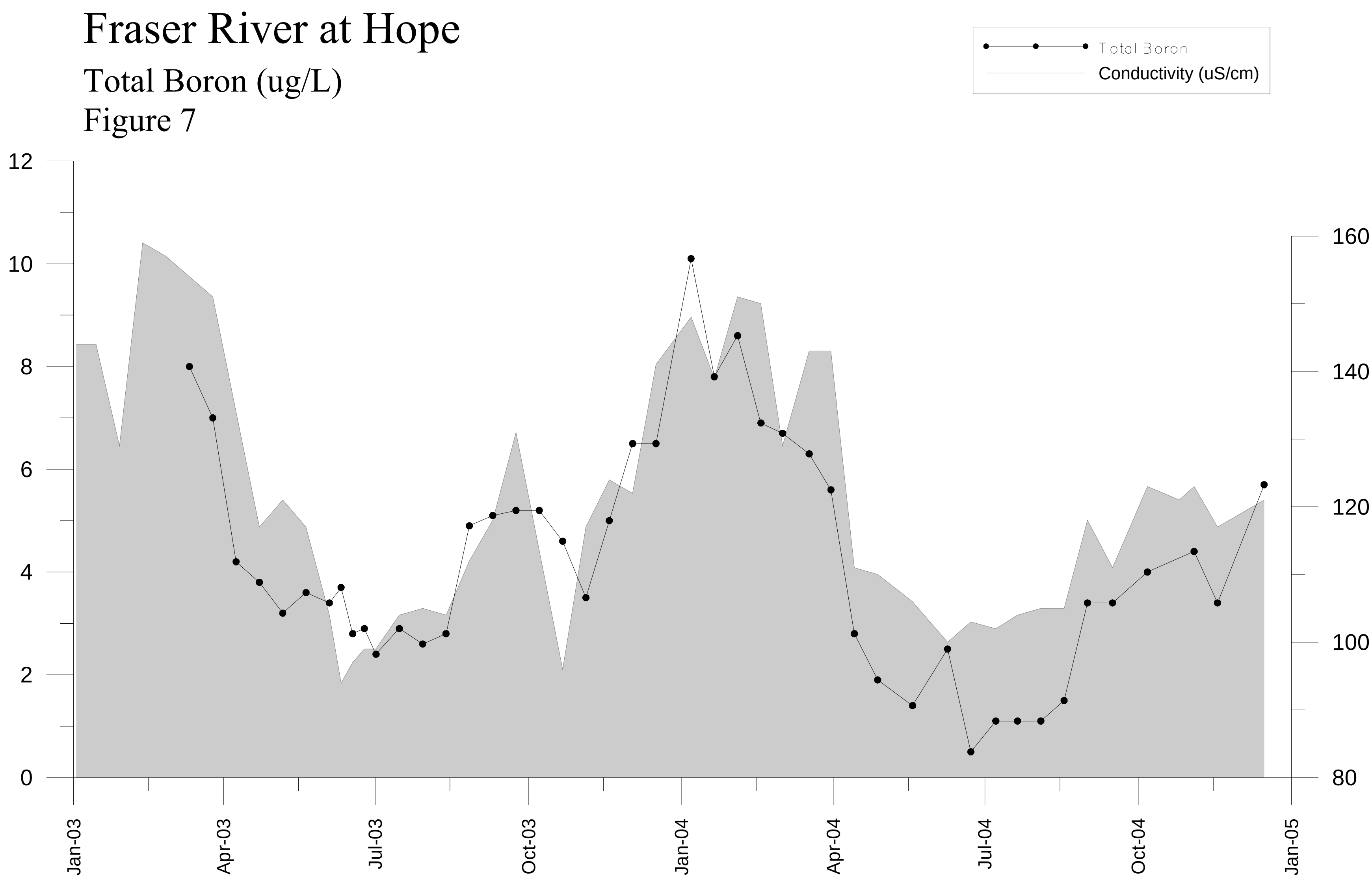
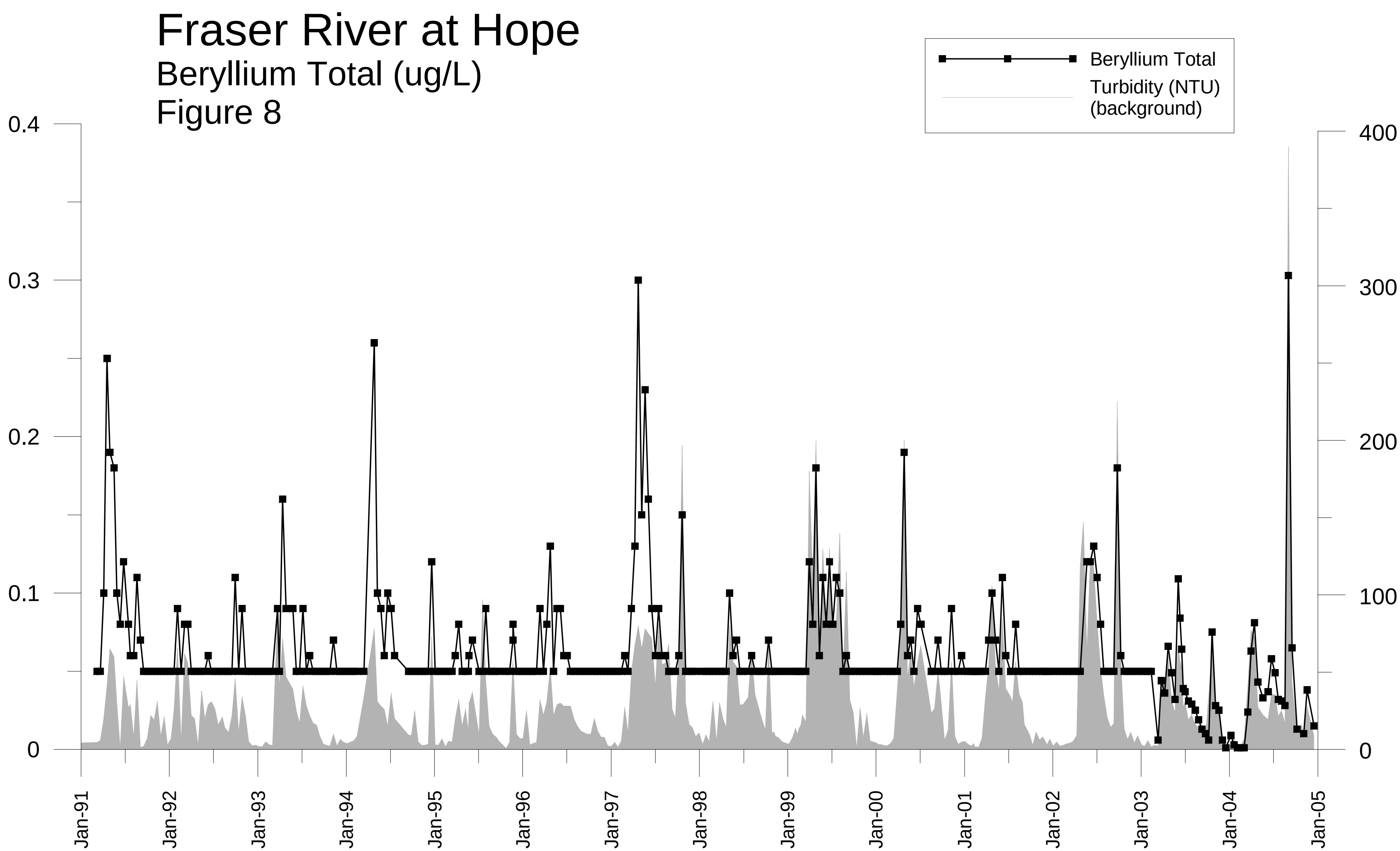

Fraser River at Hope
Adsorbable Organic Halide-AOX (ug/L)
Figure 3
Adsorbable Organic Halide-AOX
100
80
60
40
20
0
Jan-00
Apr-00
Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

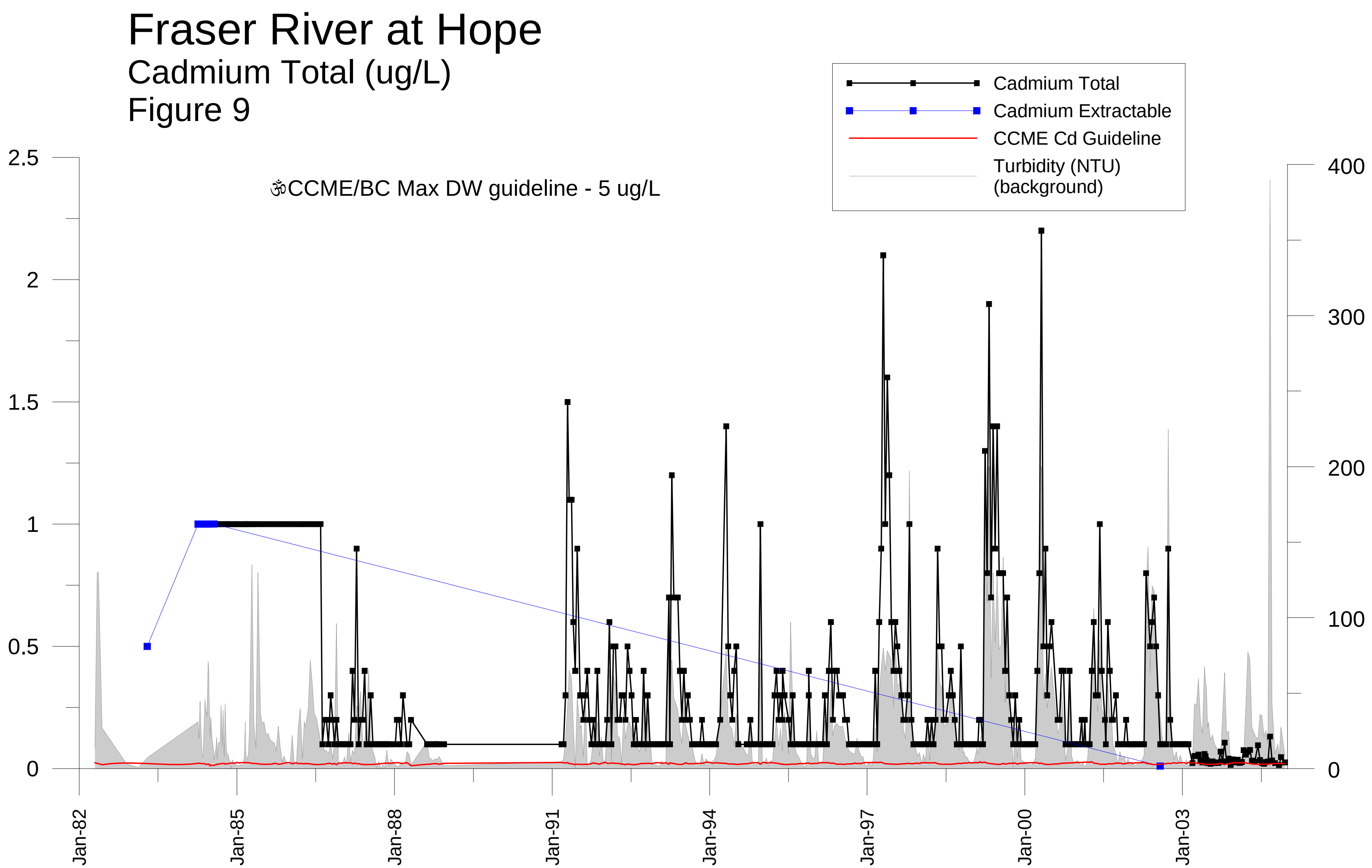

Fraser River at Hope
Alkalinity Total CaCO3 (mg/L)
Figure 4
Alkalinity Total
Conductivity (uS/cm)
70
60
50
40
30
20
200
160
120
80
40
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96

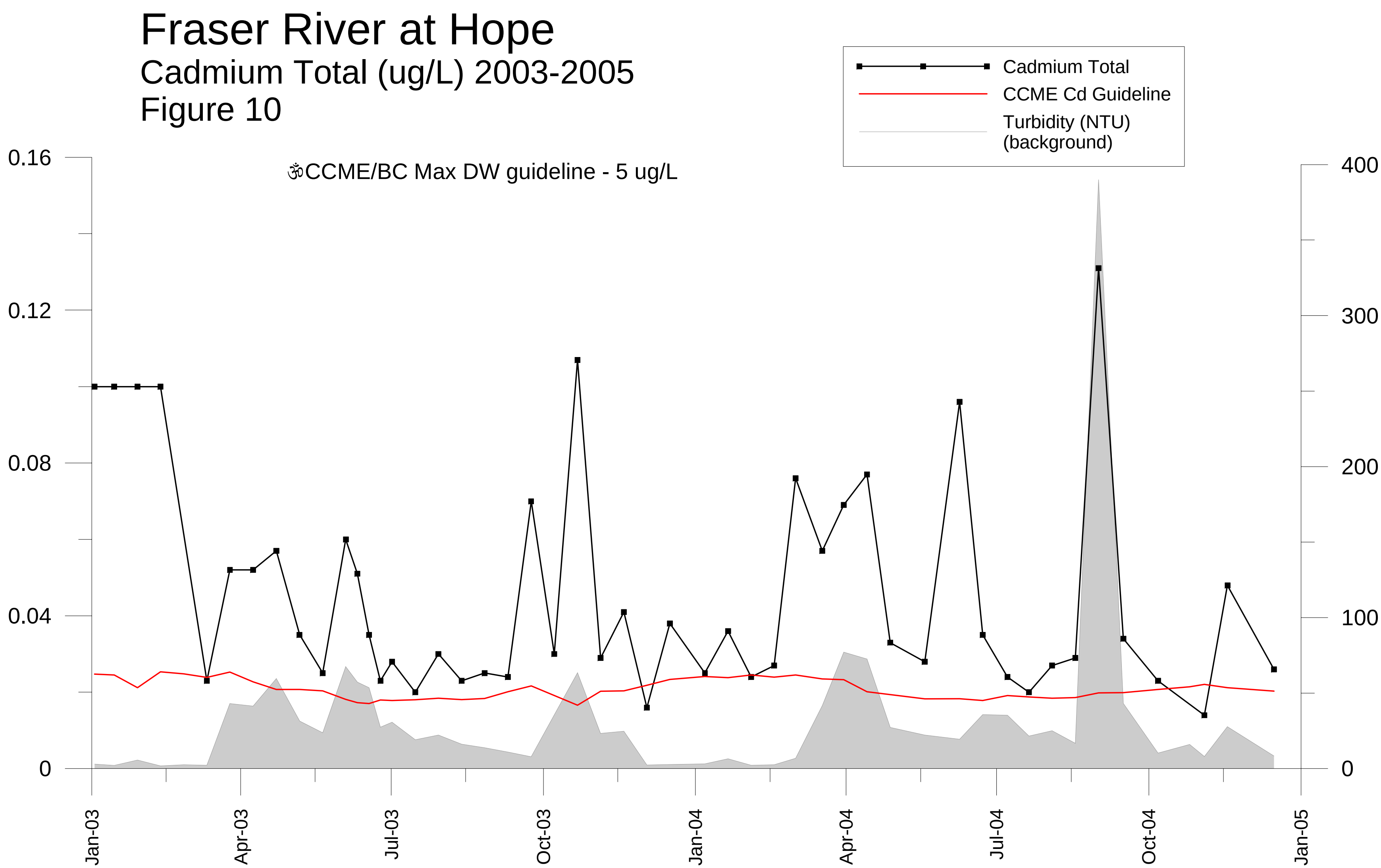

Fraser River at Hope
Aluminum Total (ug/L)
Figure 5
Al Total
Turbidity (NTU)
10000
8000
6000
4000
2000
0
160
120
80
40
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96


Fraser River at Hope
Arsenic Total (ug/L)
Figure 6
Arsenic Total
Arsenic Extractable
Turbidity (NTU)
(background)
BC Maximum Guideline for Aquatic Life
8
6
4
2
0
400
300
200
100
0
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

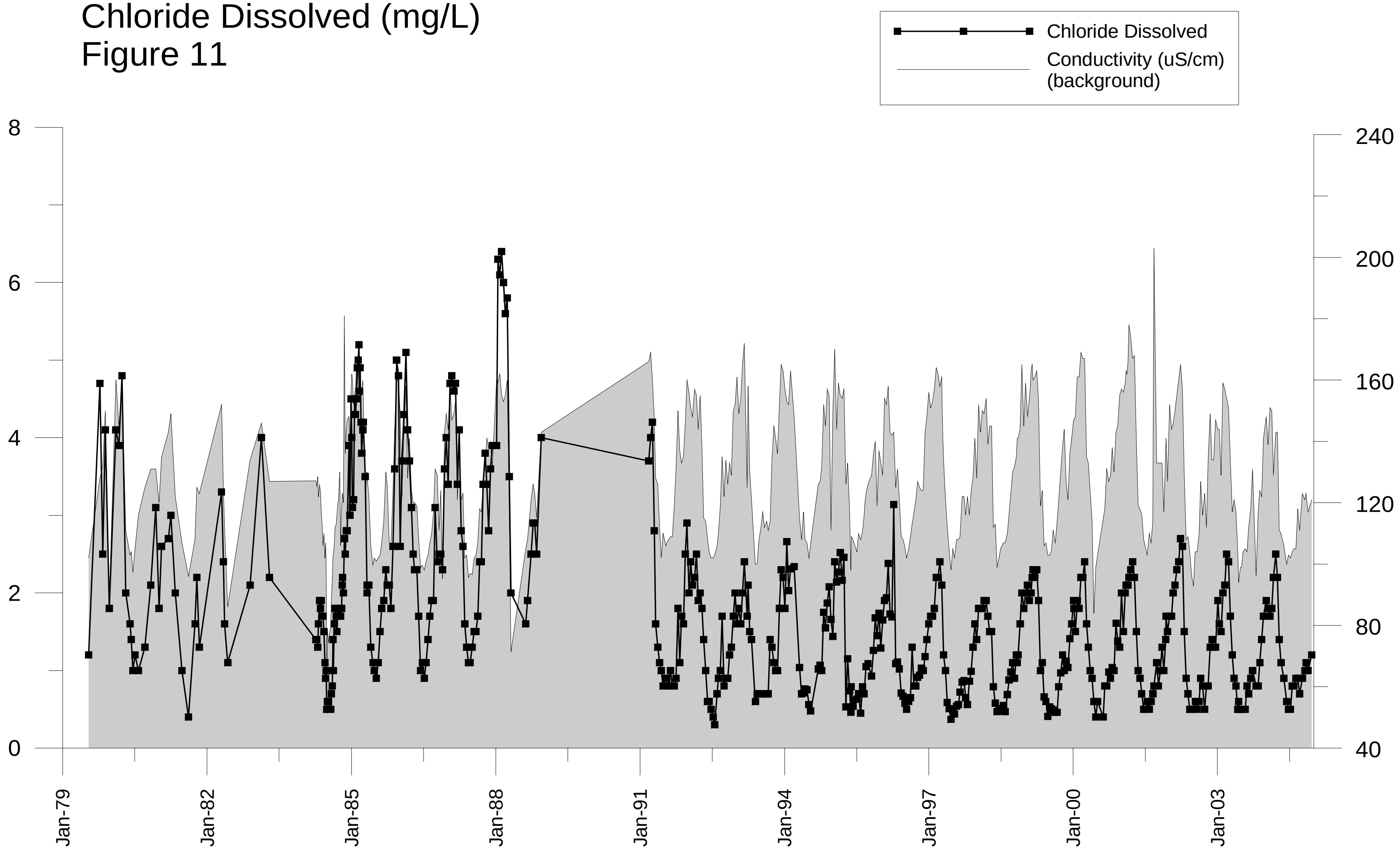

Fraser River at Hope
Total Boron (ug/L)
Figure 7
Total Boron
Conductivity (uS/cm)
12
10
8
6
4
2
0
160
140
120
100
80
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

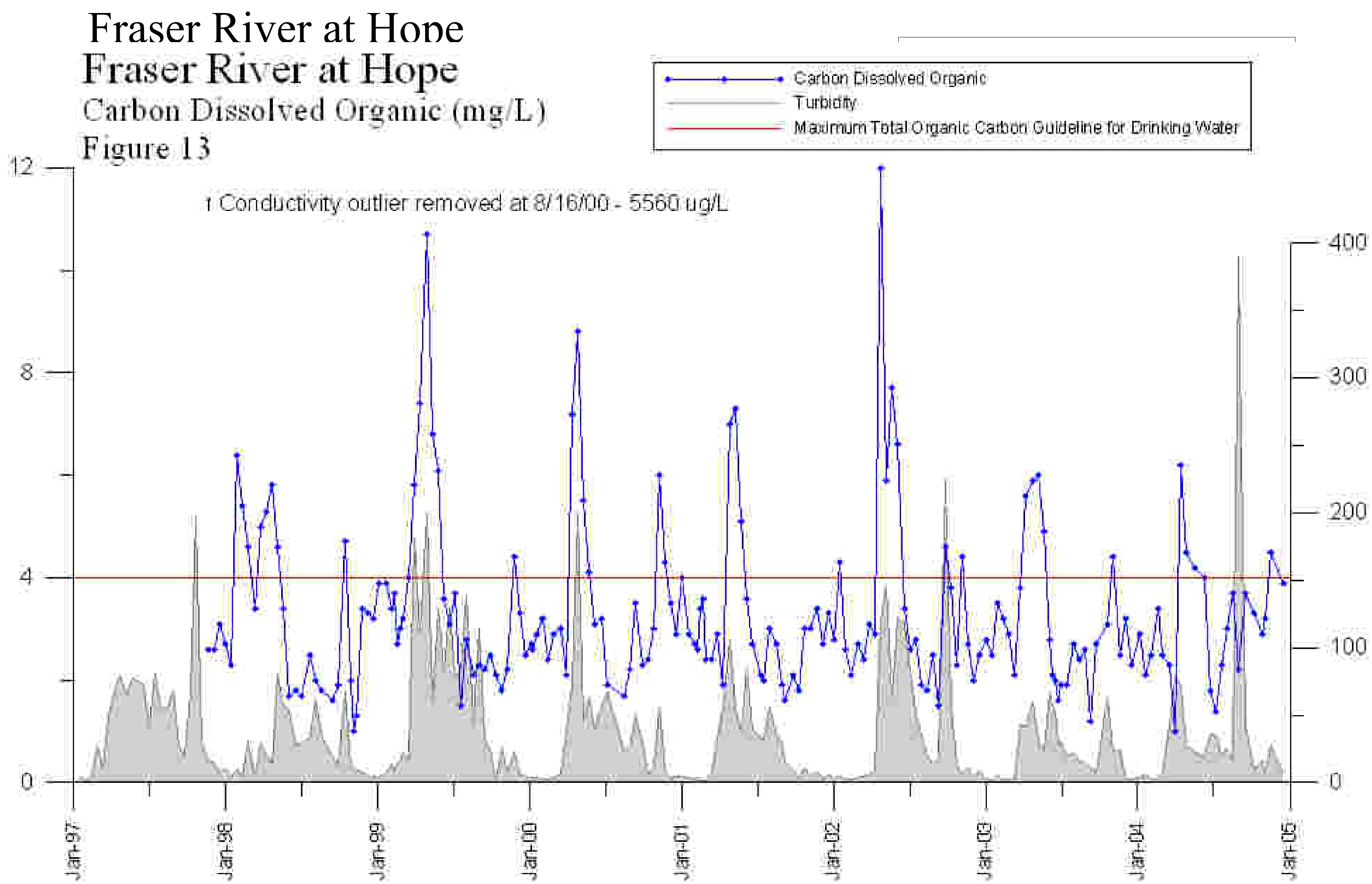

Fraser River at Hope
Beryllium Total (ug/L)
Figure 8
Beryllium Total
Turbidity (NTU)
(background)
0.4
0.3
0.2
0.1
0
400
300
200
100
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

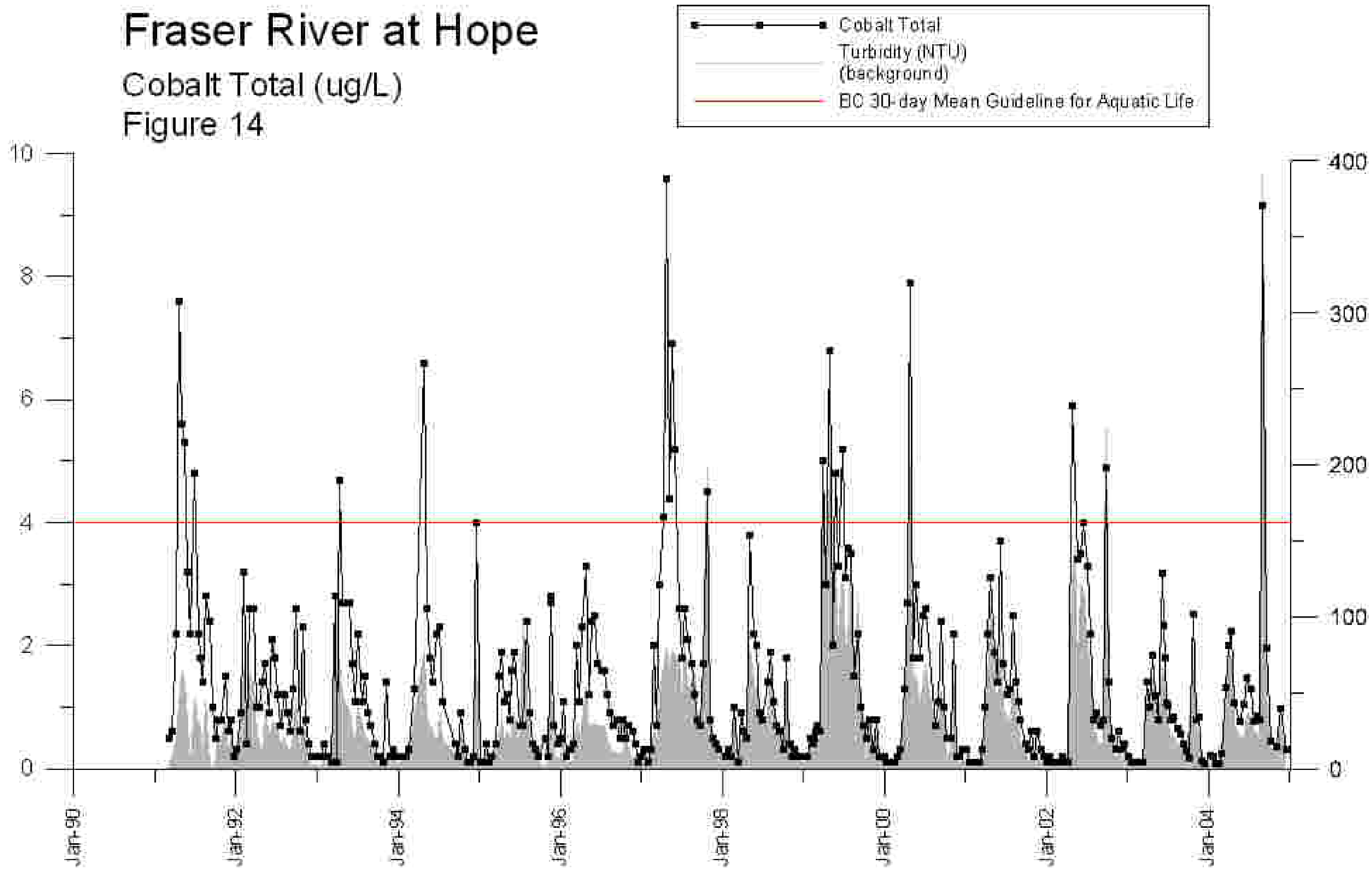

Fraser River at Hope
Cadmium Total (ug/L)
Figure 9
ॐCCME/BC Max DW guideline - 5 ug/L
Cadmium Total
Cadmium Extractable
CCME Cd Guideline
Turbidity (NTU) (background)
2.5
2
1.5
1
0.5
0
400
300
200
100
0
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

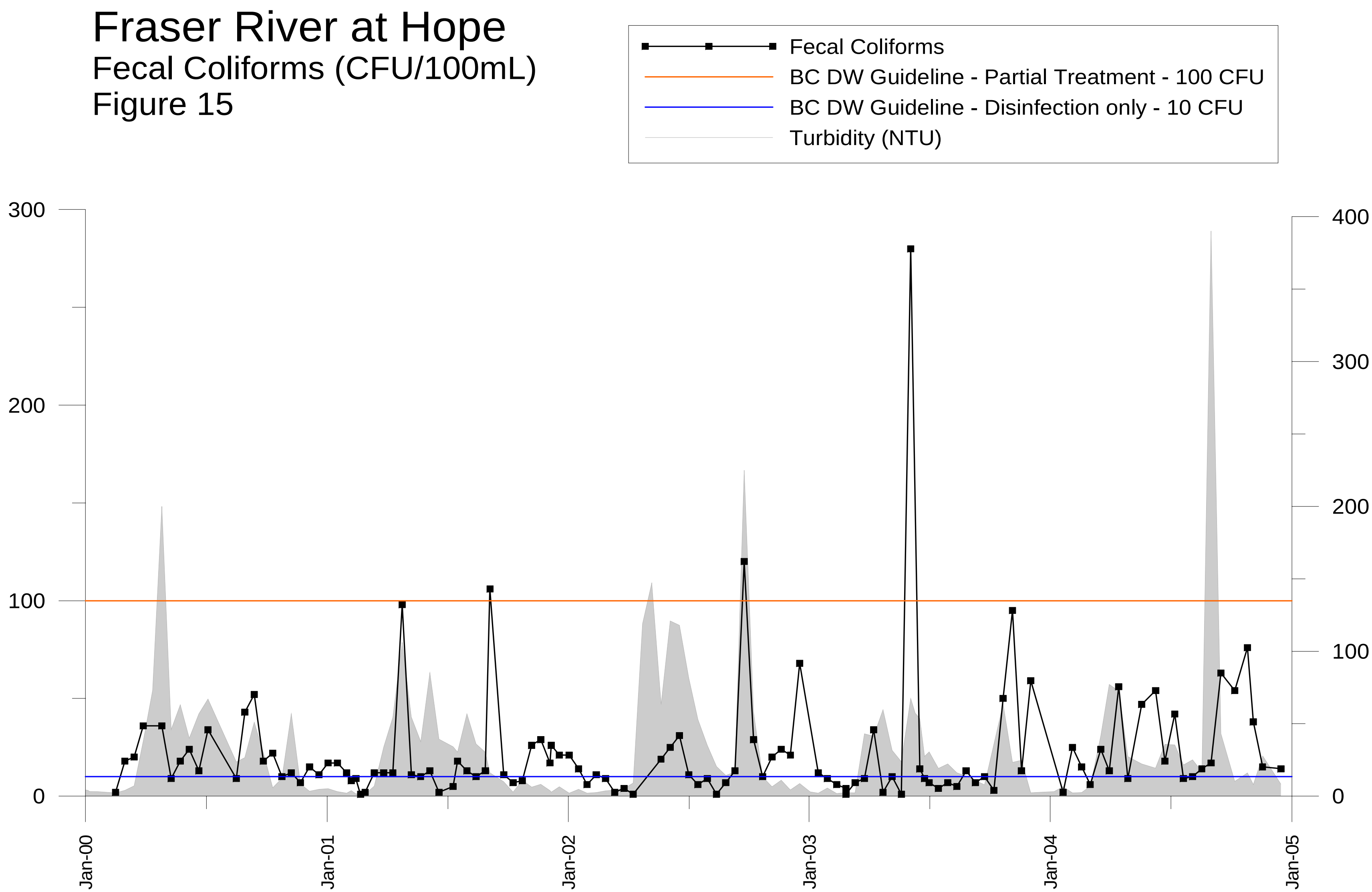

Fraser River at Hope
Cadmium Total (ug/L) 2003-2005
Figure 10
CCME/BC Max DW guideline - 5 ug/L
Cadmium Total
CCME Cd Guideline
Turbidity (NTU)
(background)
0.16
0.12
0.08
0.04
0
400
300
200
100
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

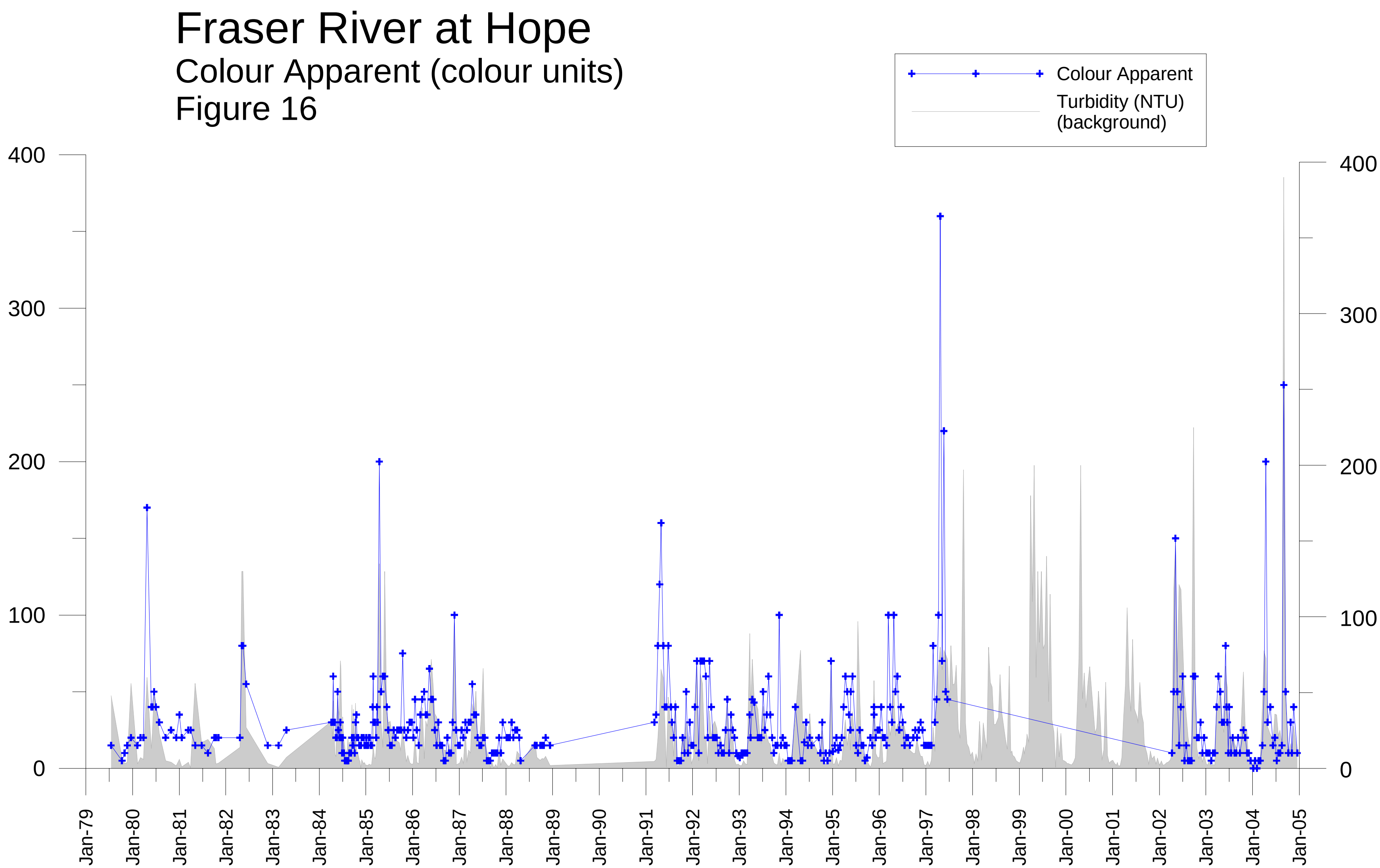
Fraser River at Hope
Chloride Dissolved (mg/L)
Figure 11




Fraser River at Hope
Fraser River at Hope
Carbon Dissolved Organic (mg/L)
Figure 13
Carbon Dissolved Organic
Turbidity
Maximum Total Organic Carbon Guideline for Drinking Water
↑ Conductivity outlier removed at 8/16/00 - 5560 ug/L
12
8
4
0
400
300
200
100
0
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Fraser River at Hope
Cobalt Total (ug/L)
Figure 14
Cobalt Total
Turbidity (NTU)
(background)
BC 30-day Mean Guideline for Aquatic Life
10
8
6
4
2
0
400
300
200
100
0
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04


Fraser River at Hope
Fecal Coliforms (CFU/100mL)
Figure 15
Fecal Coliforms
BC DW Guideline - Partial Treatment - 100 CFU
BC DW Guideline - Disinfection only - 10 CFU
Turbidity (NTU)
300
200
100
0
400
300
200
100
0
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05



Fraser River at Hope
Colour Apparent (colour units)
Figure 16
Colour Apparent
Turbidity (NTU)
(background)
400
300
200
100
0
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
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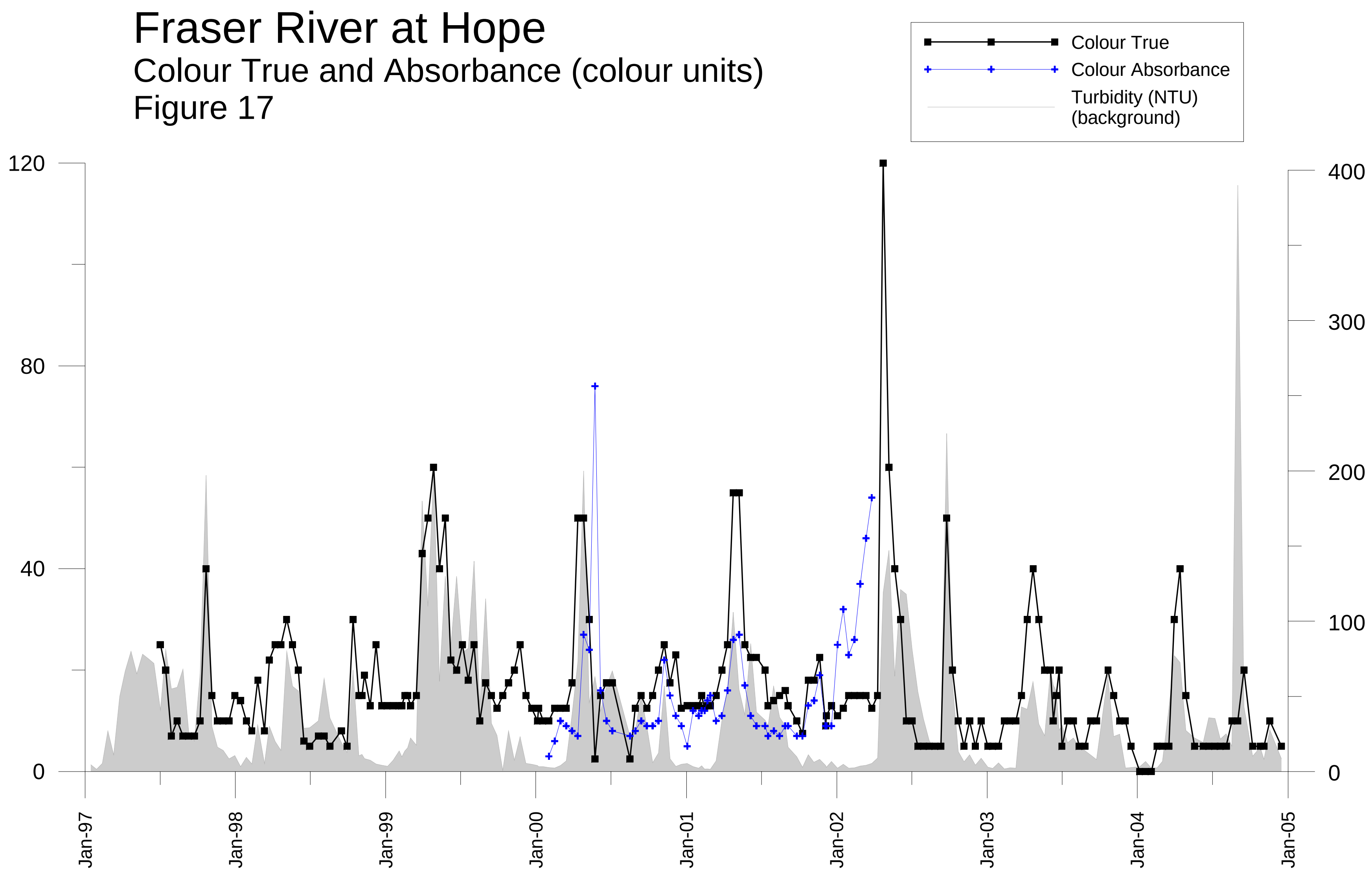
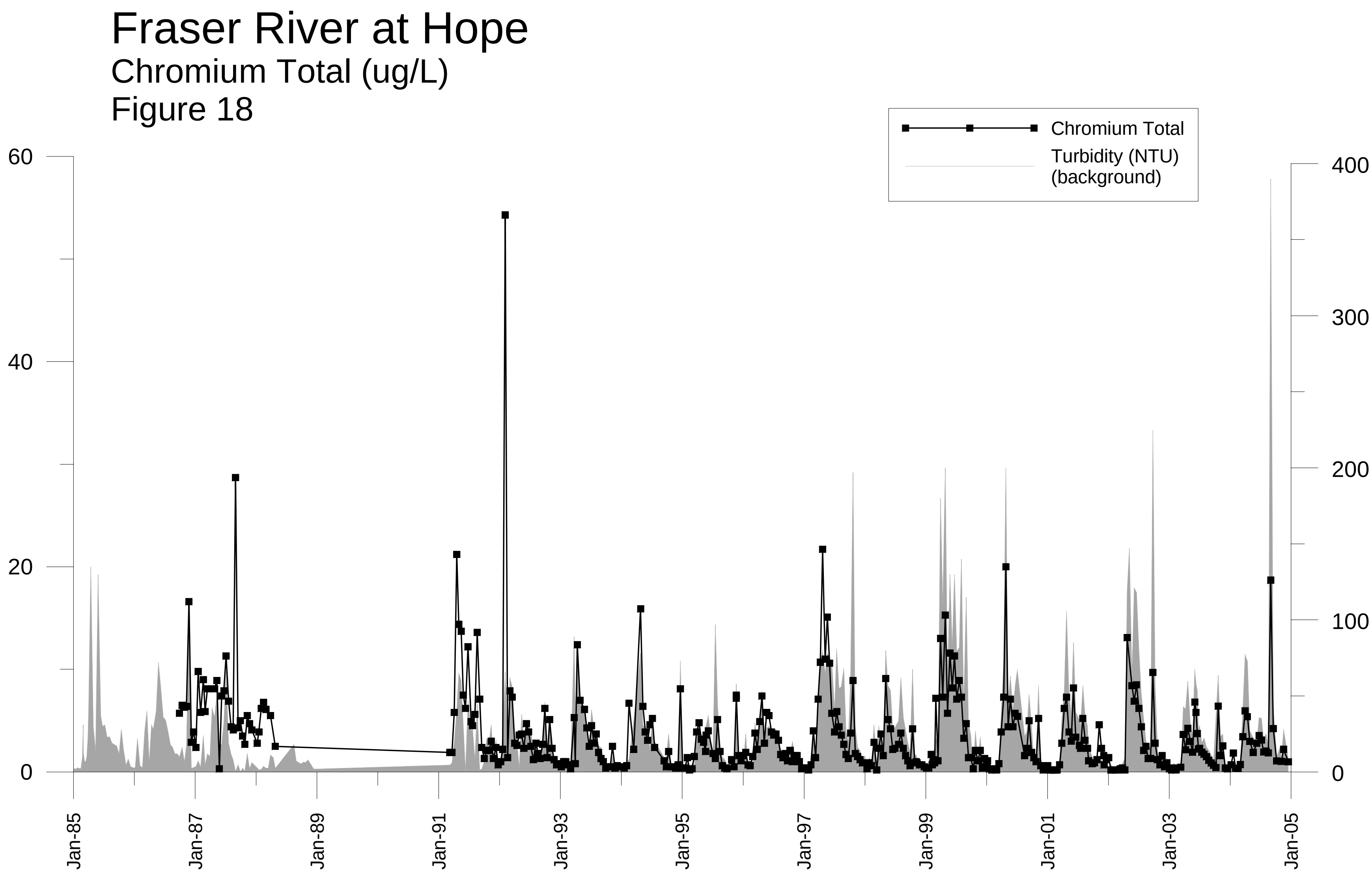
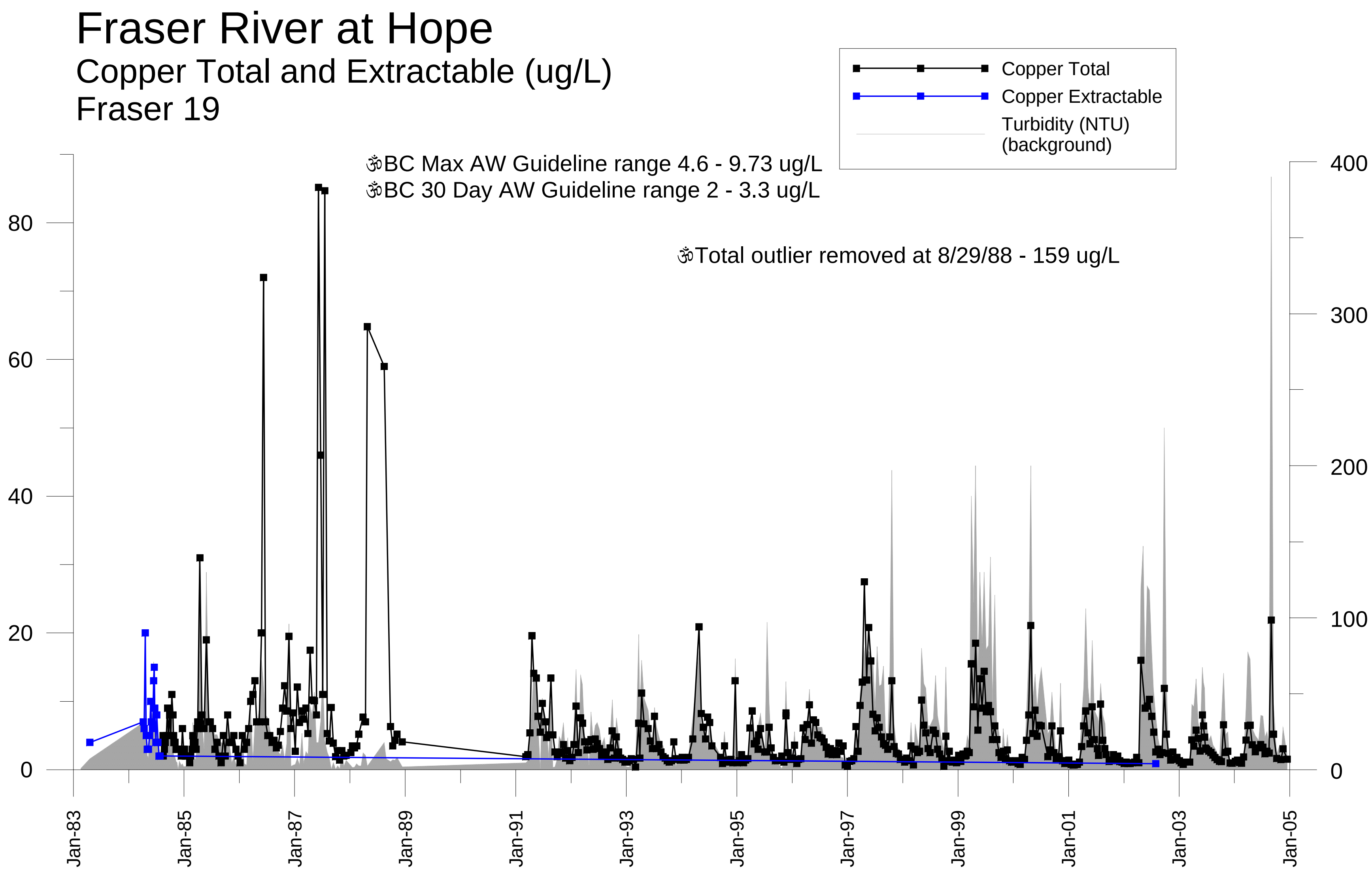
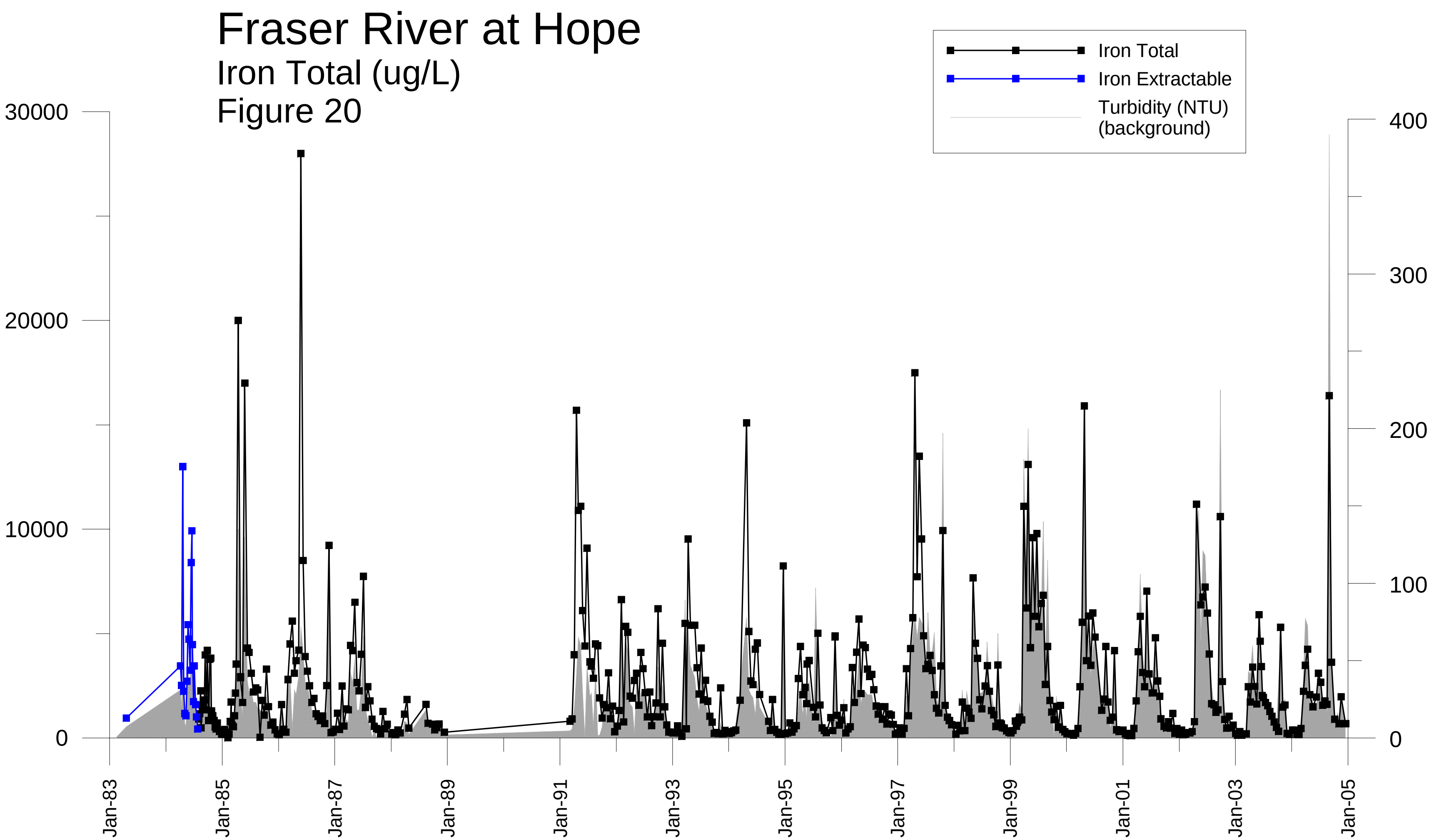
Jan-03
Jan-04
Jan-05

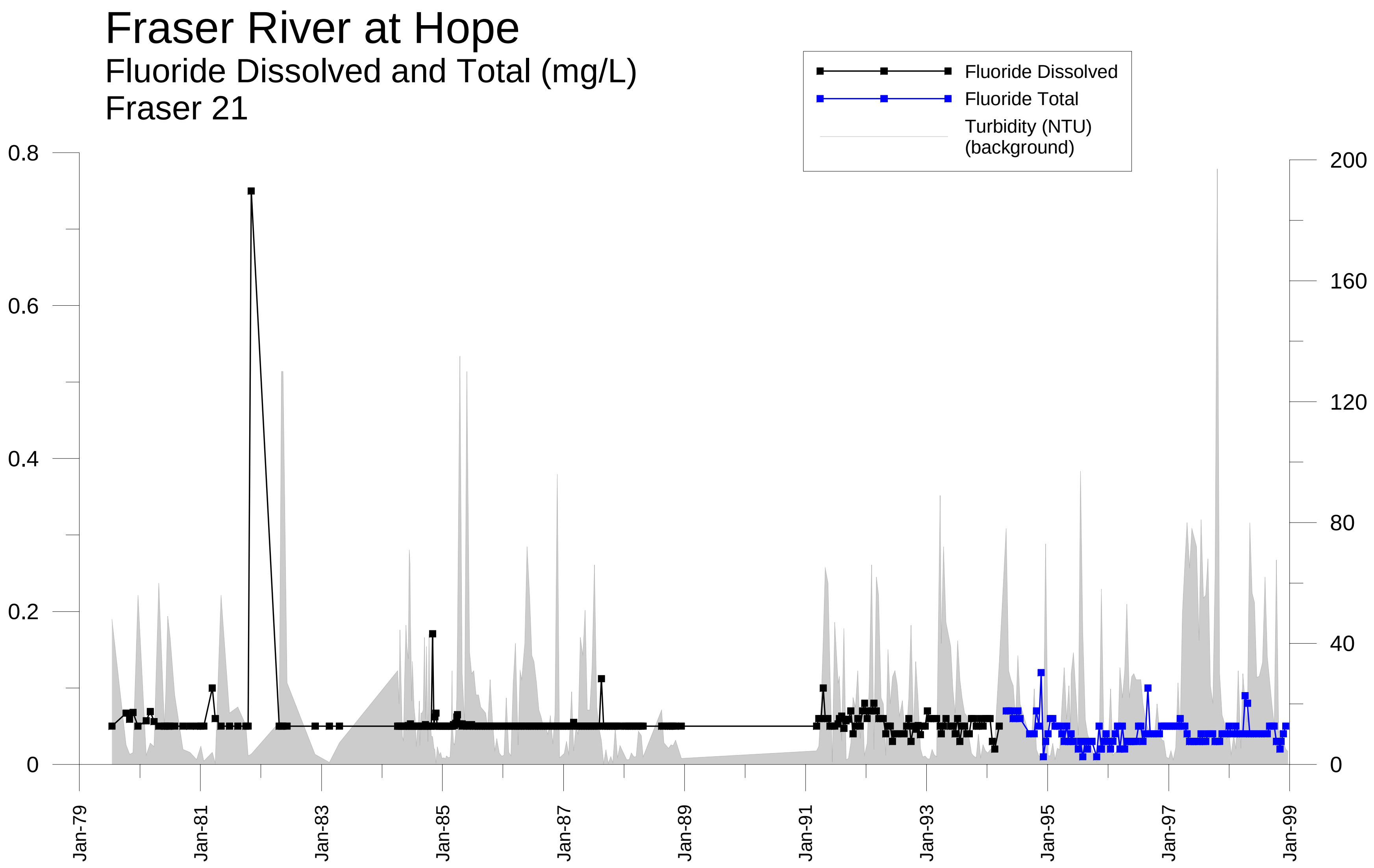


Fraser River at Hope
Colour True and Absorbance (colour units)
Figure 17
Colour True
Colour Absorbance
Turbidity (NTU)
(background)
120
80
40
0
400
300
200
100
0
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Fraser River at Hope
Chromium Total (ug/L)
Figure 18
Chromium Total
Turbidity (NTU)
(background)
60
40
20
0
400
300
200
100
0
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05


Fraser River at Hope
Copper Total and Extractable (ug/L)
Fraser 19
Copper Total
Copper Extractable
Turbidity (NTU)
(background)
ॐBC Max AW Guideline range 4.6 - 9.73 ug/L
ॐBC 30 Day AW Guideline range 2 - 3.3 ug/L
ॐTotal outlier removed at 8/29/88 - 159 ug/L
0
20
40
60
80
0
100
200
300
400
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

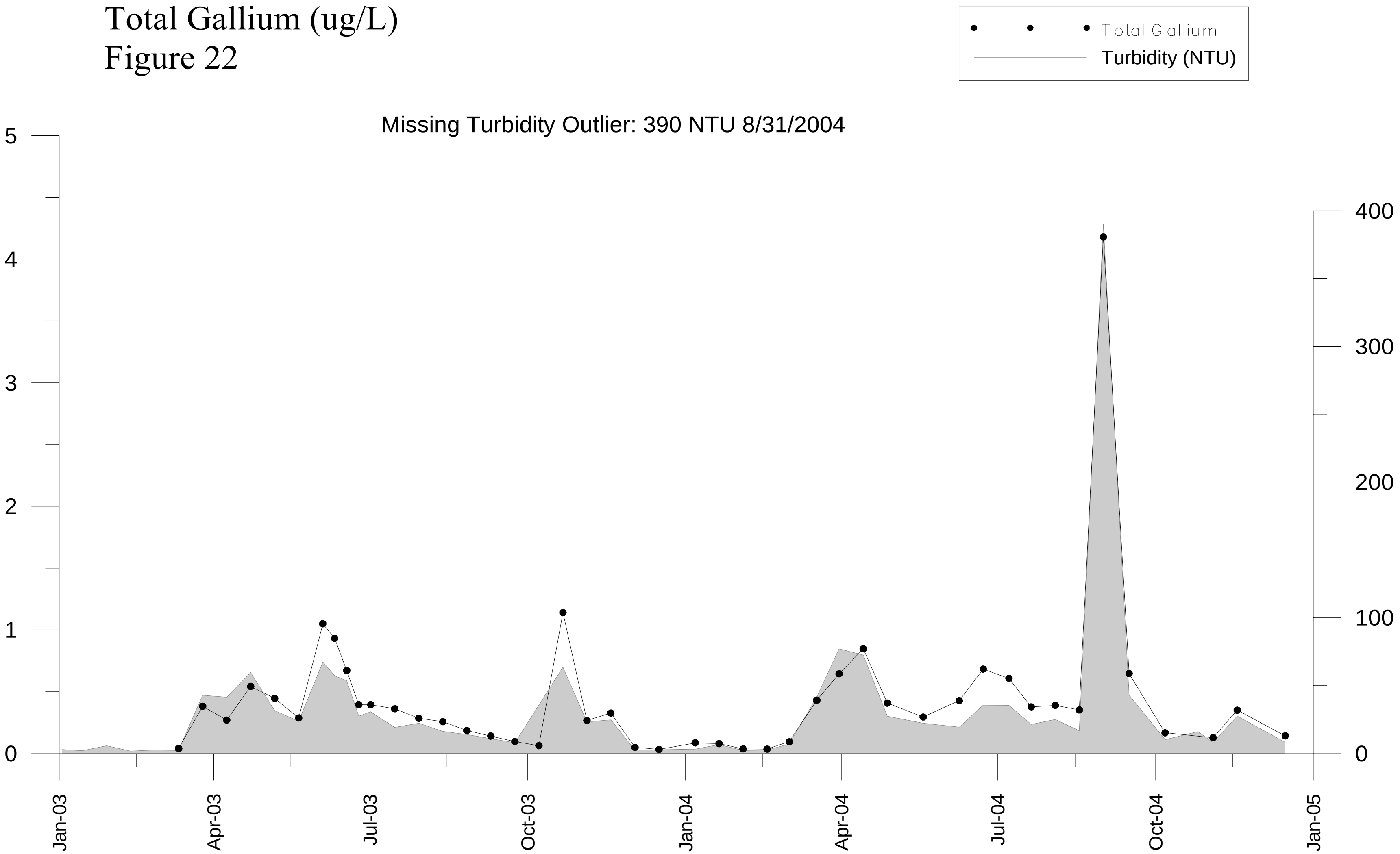

Fraser River at Hope
Iron Total (ug/L)
Figure 20
Iron Total
Iron Extractable
Turbidity (NTU)
(background)
30000
20000
10000
0
400
300
200
100
0
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05


Fraser River at Hope
Fluoride Dissolved and Total (mg/L)
Fraser 21
Fluoride Dissolved
Fluoride Total
Turbidity (NTU)
(background)
0.8
0.6
0.4
0.2
0
200
160
120
80
40
0
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99

Fraser River at Hope

Total Gallium (ug/L)

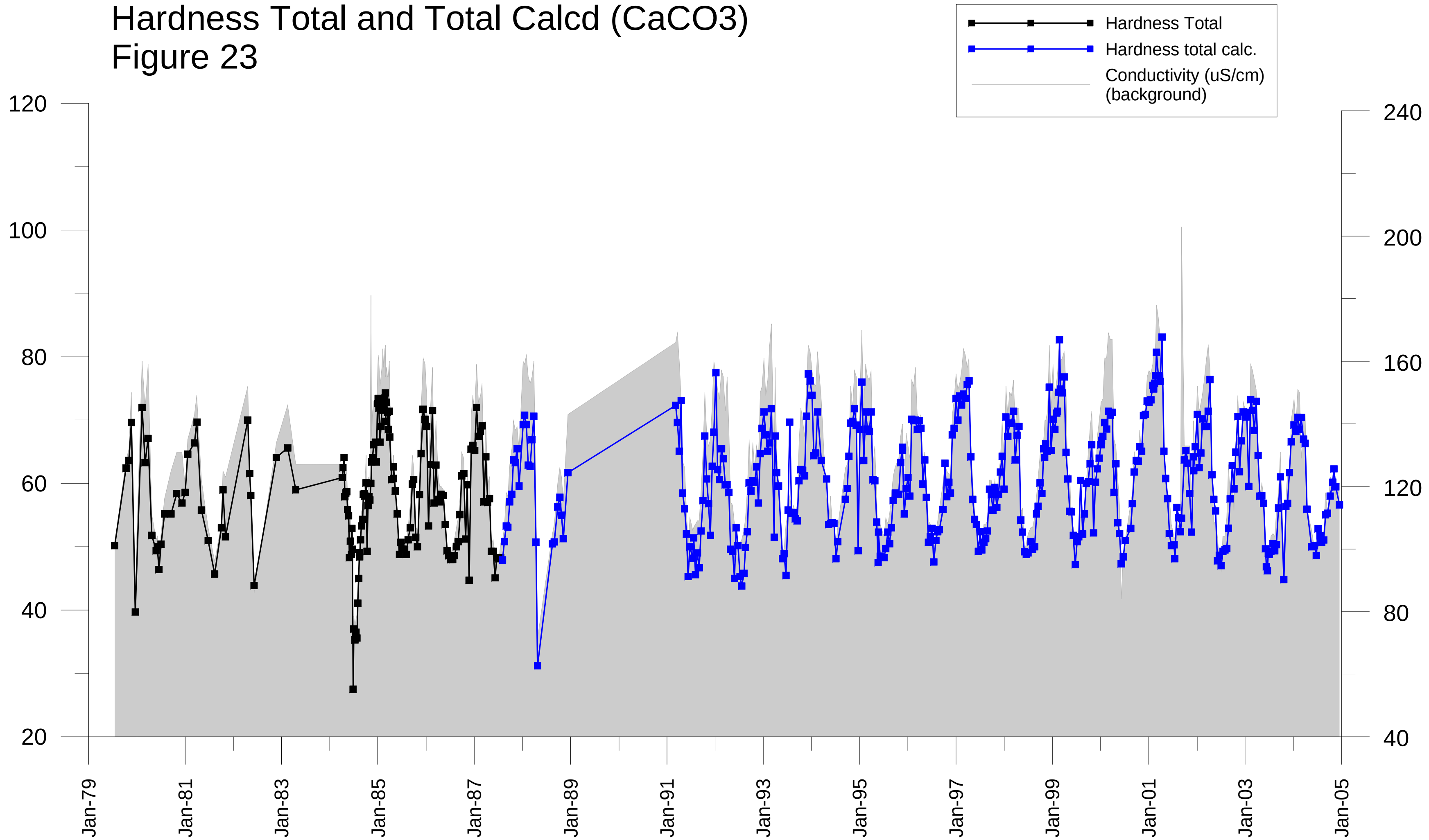
Figure 22

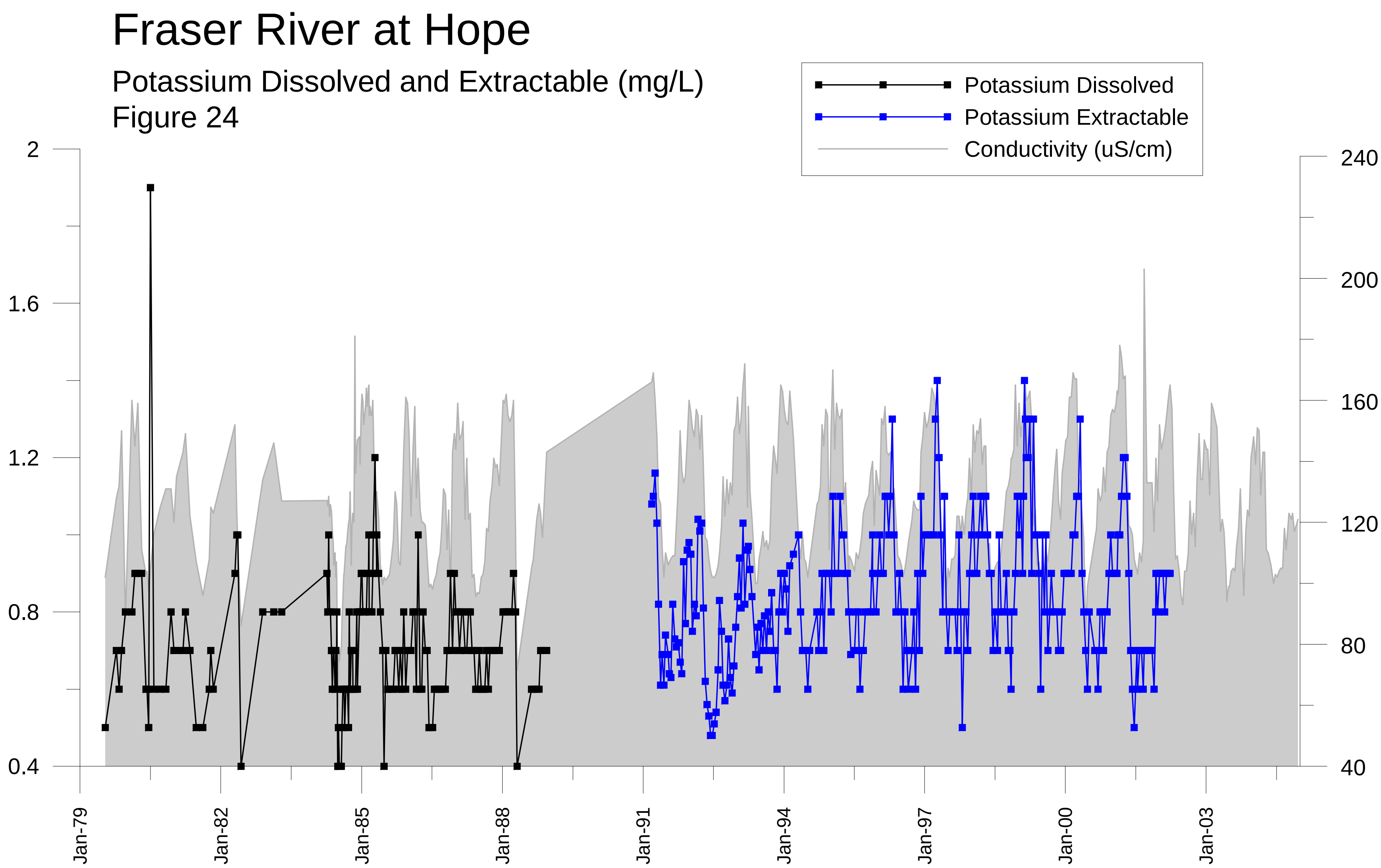


Fraser River at Hope

Hardness Total and Total Calcd (CaCO3)

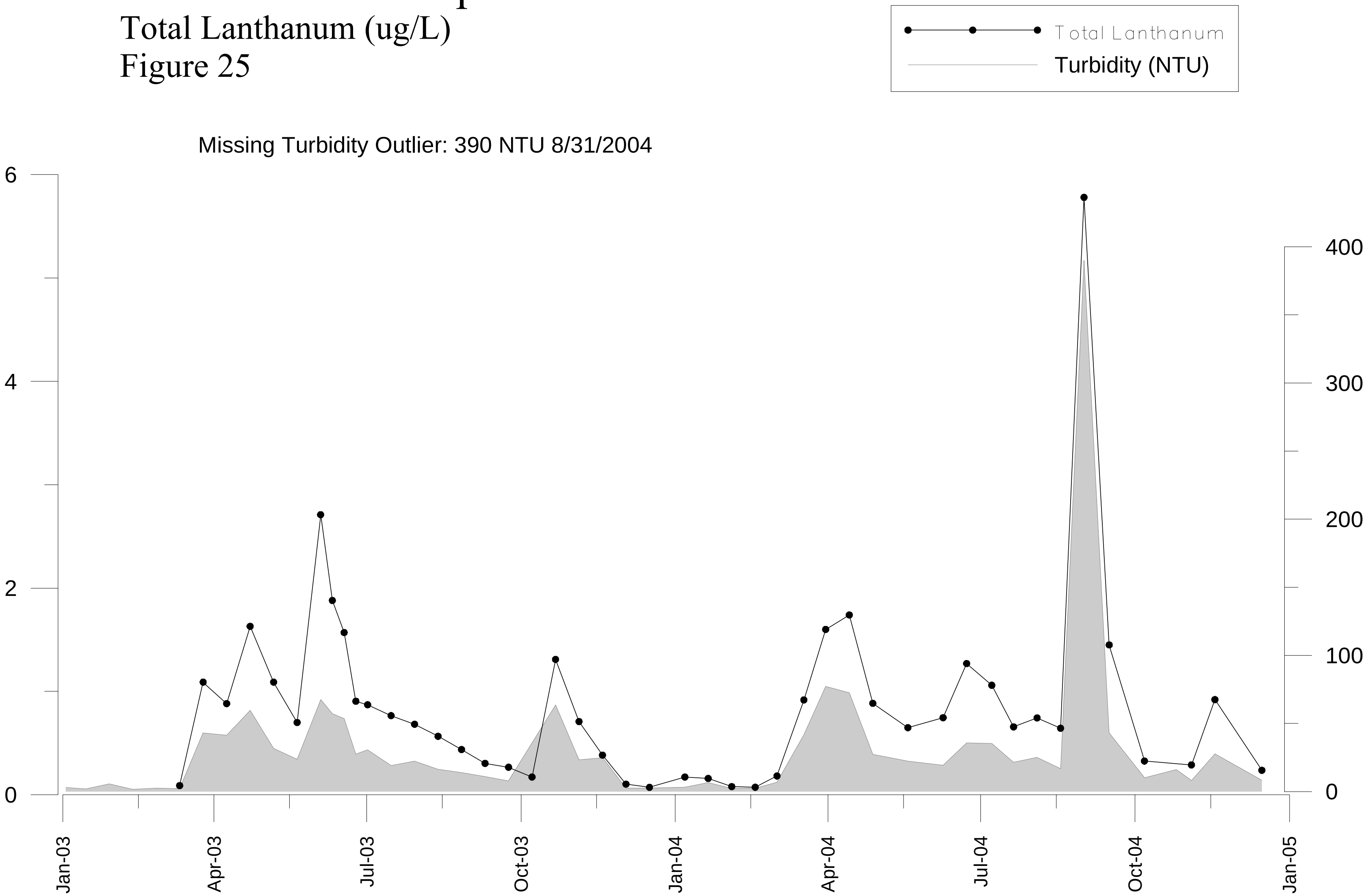
Figure 23

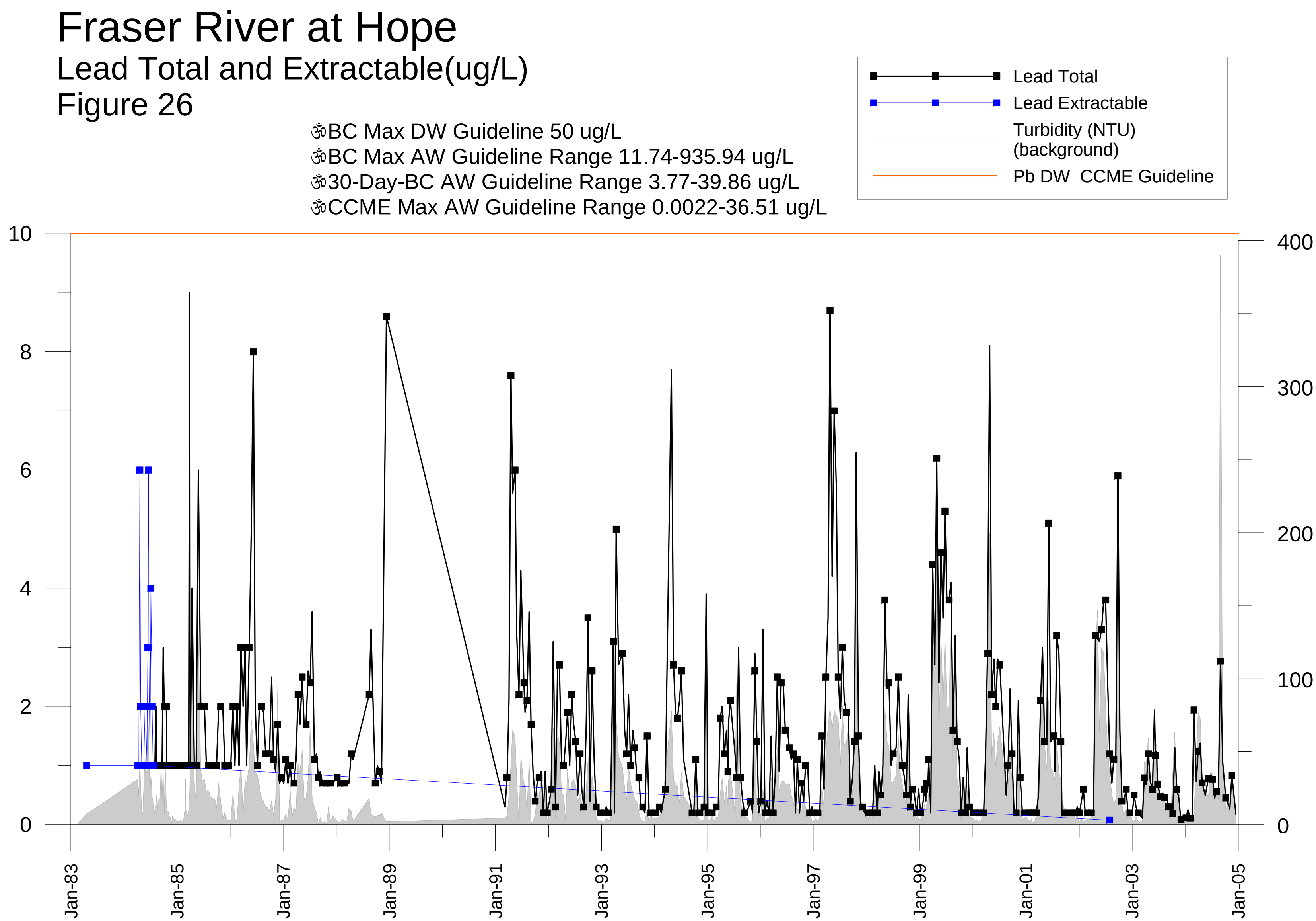


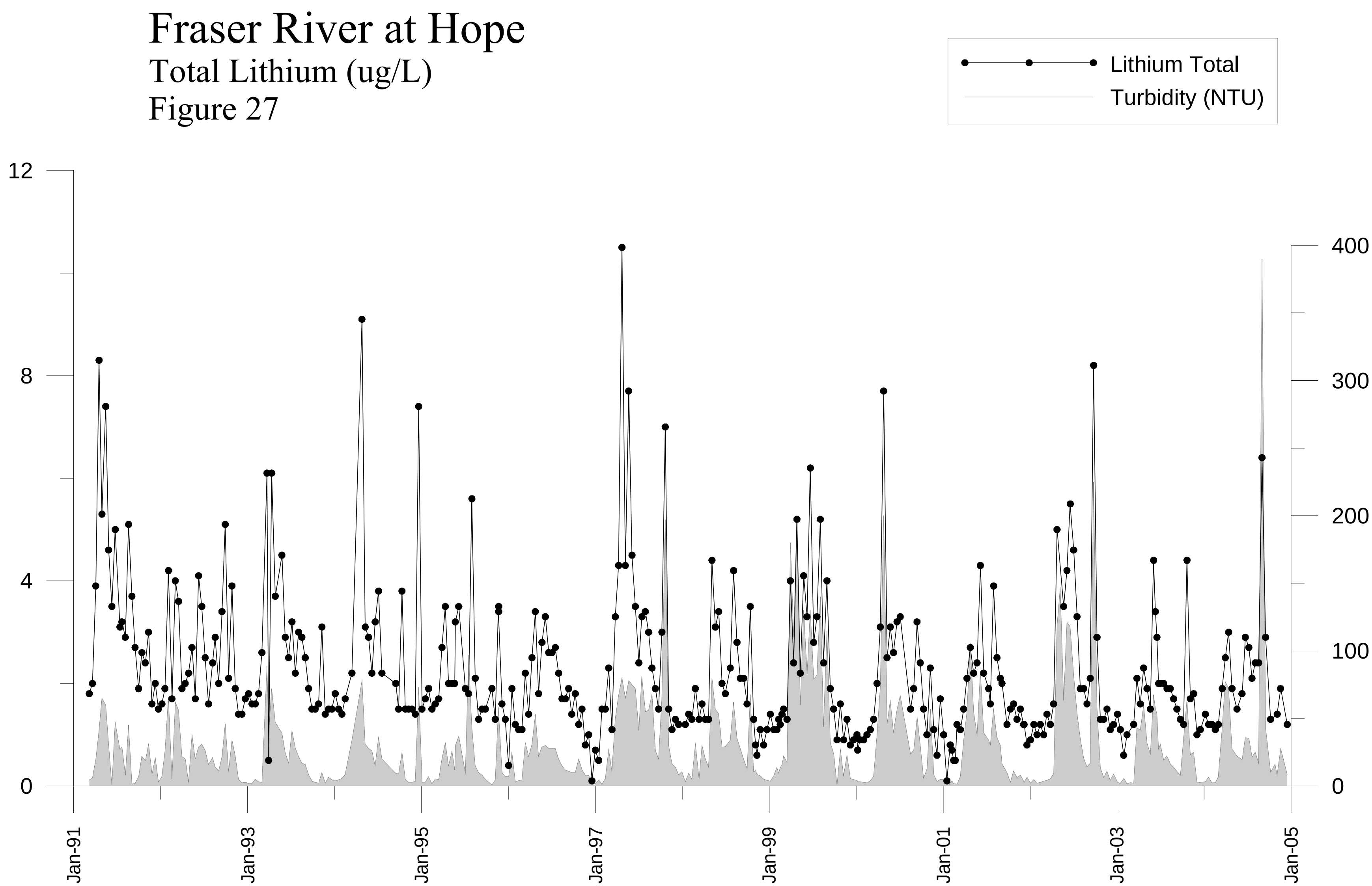


Fraser River at Hope
Potassium Dissolved and Extractable (mg/L)
Figure 24
Potassium Dissolved
Potassium Extractable
Conductivity (uS/cm)
2
1.6
1.2
0.8
0.4
240
200
160
120
80
40
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

Fraser River at Hope
Total Lanthanum (ug/L)
Figure 25



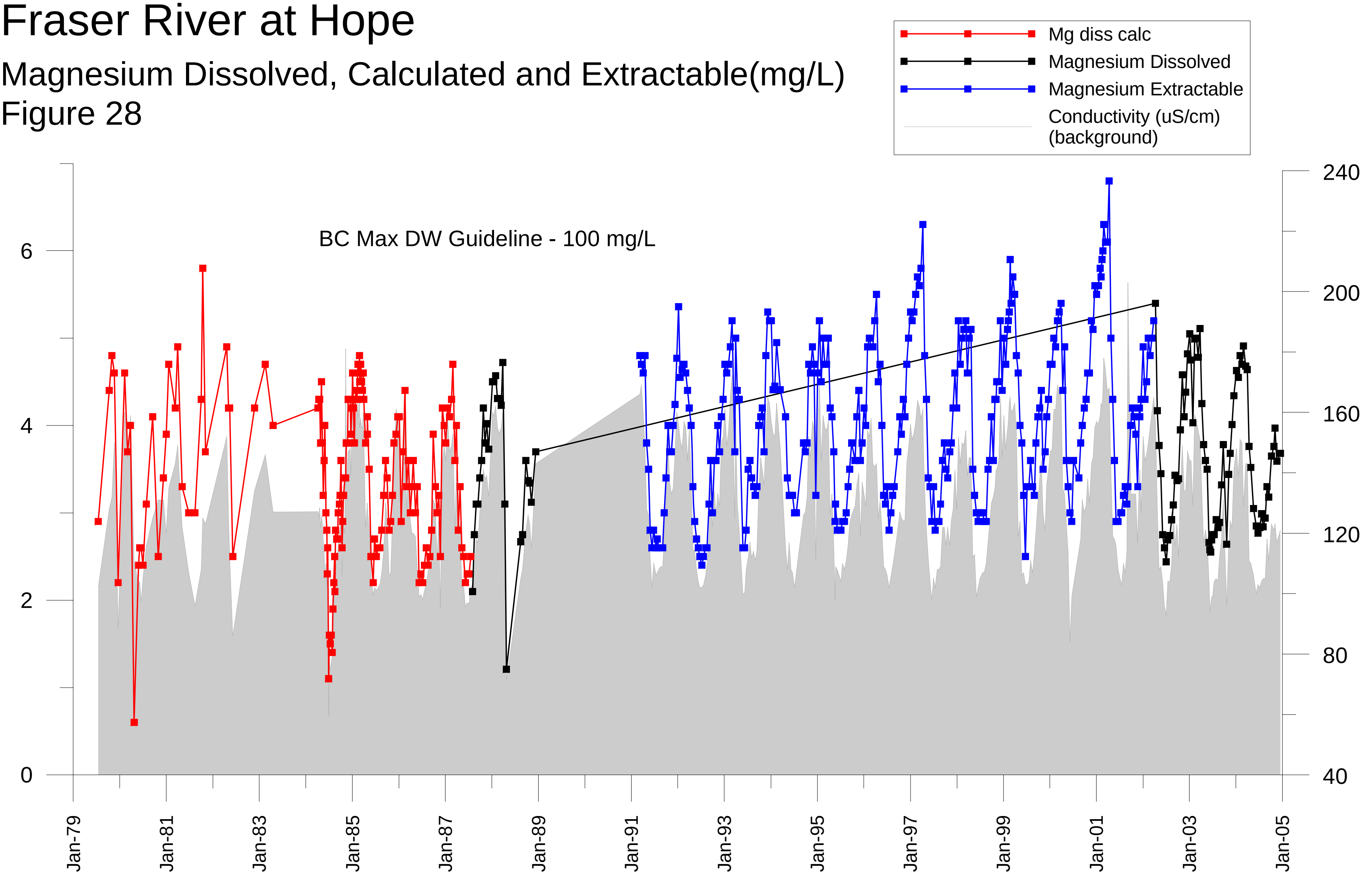

Fraser River at Hope
Lead Total and Extractable(ug/L)
Figure 26
ॐBC Max DW Guideline 50 ug/L
ॐBC Max AW Guideline Range 11.74-935.94 ug/L
ॐ30-Day-BC AW Guideline Range 3.77-39.86 ug/L
ॐCCME Max AW Guideline Range 0.0022-36.51 ug/L
Lead Total
Lead Extractable
Turbidity (NTU) (background)
Pb DW CCME Guideline
0
2
4
6
8
10
0
100
200
300
400
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

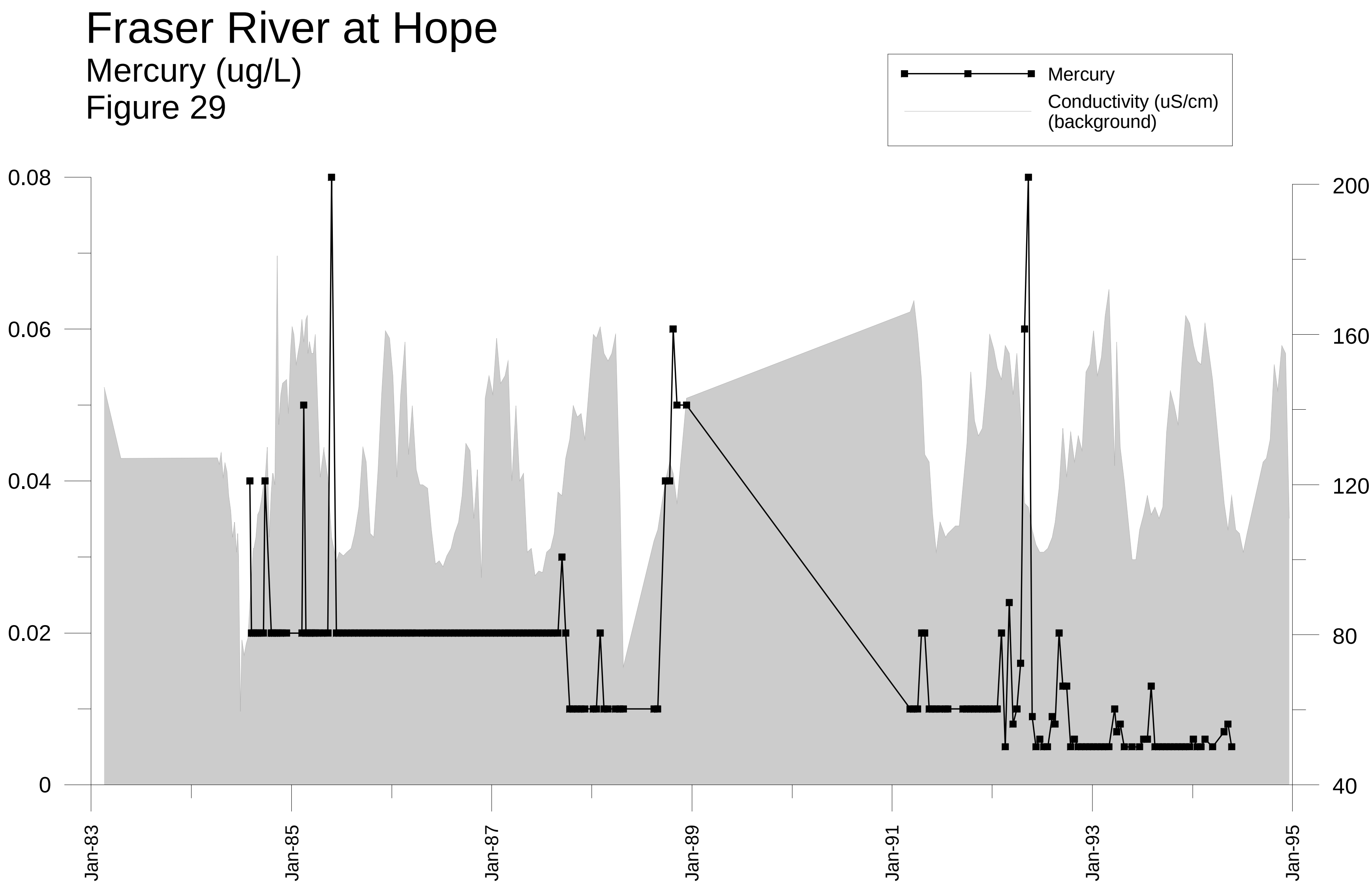

Fraser River at Hope
Total Lithium (ug/L)
Figure 27
Lithium Total
Turbidity (NTU)
12
8
4
0
400
300
200
100
0
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

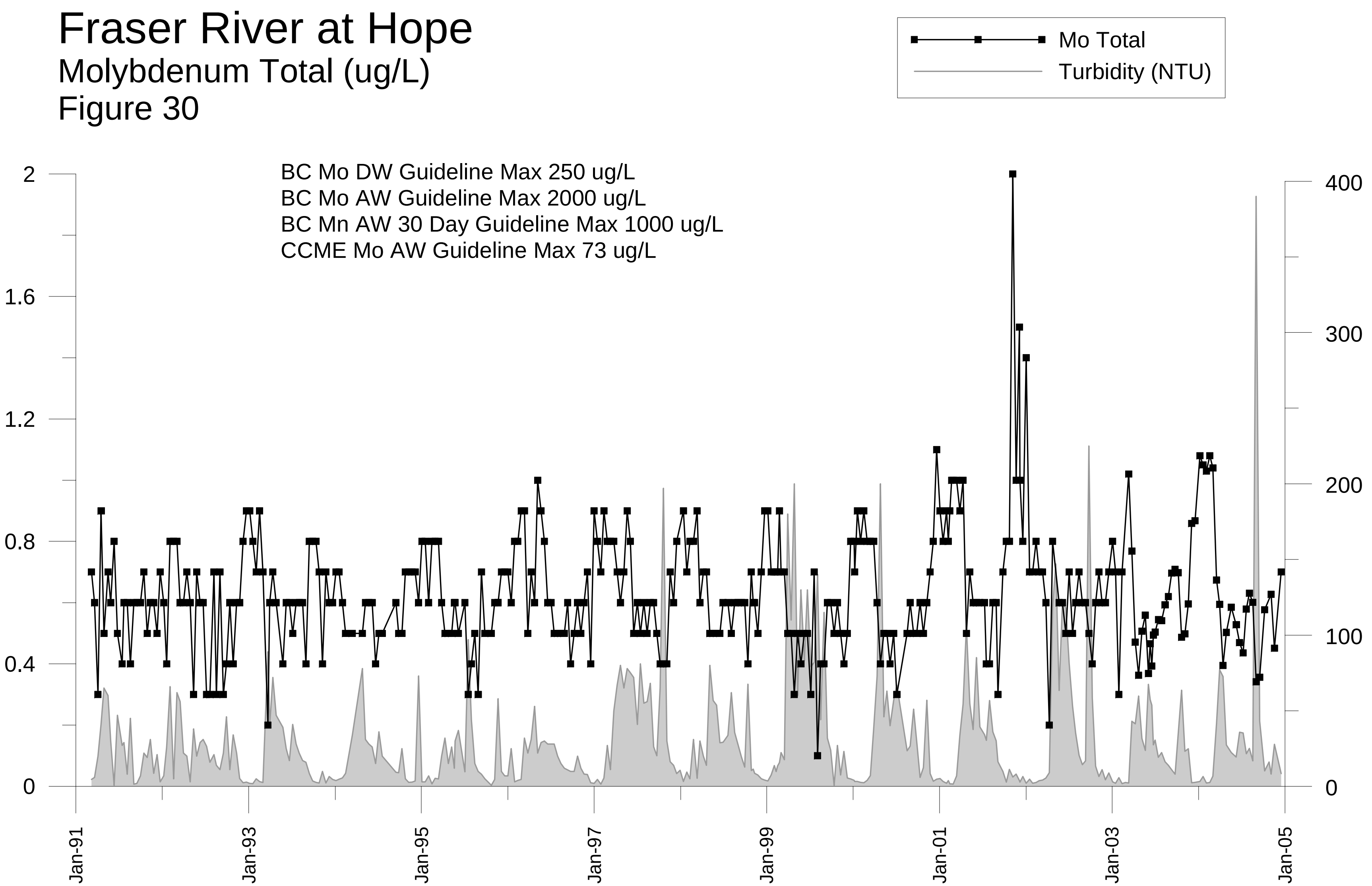
Fraser River at Hope

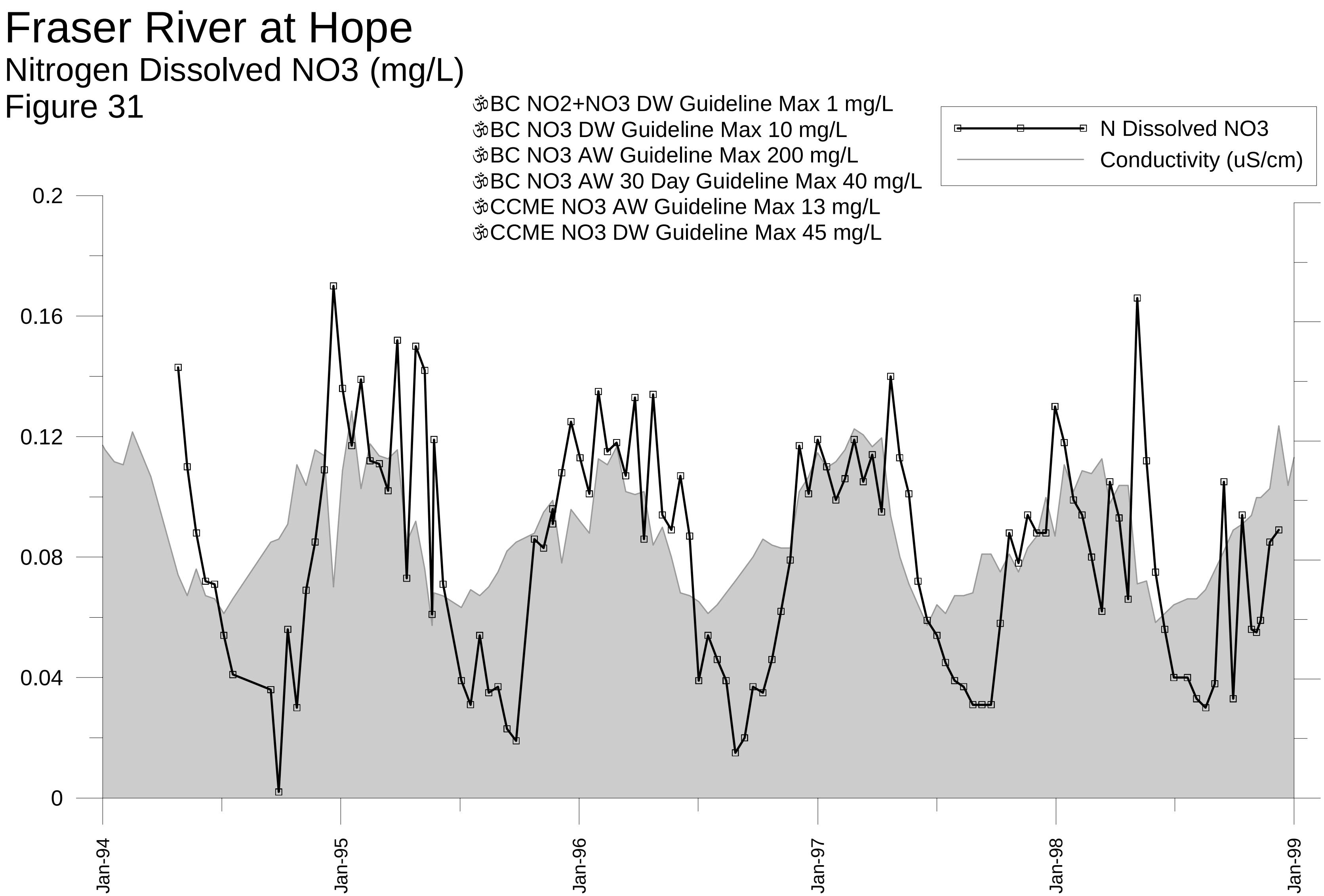
Magnesium Dissolved, Calculated and Extractable(mg/L)

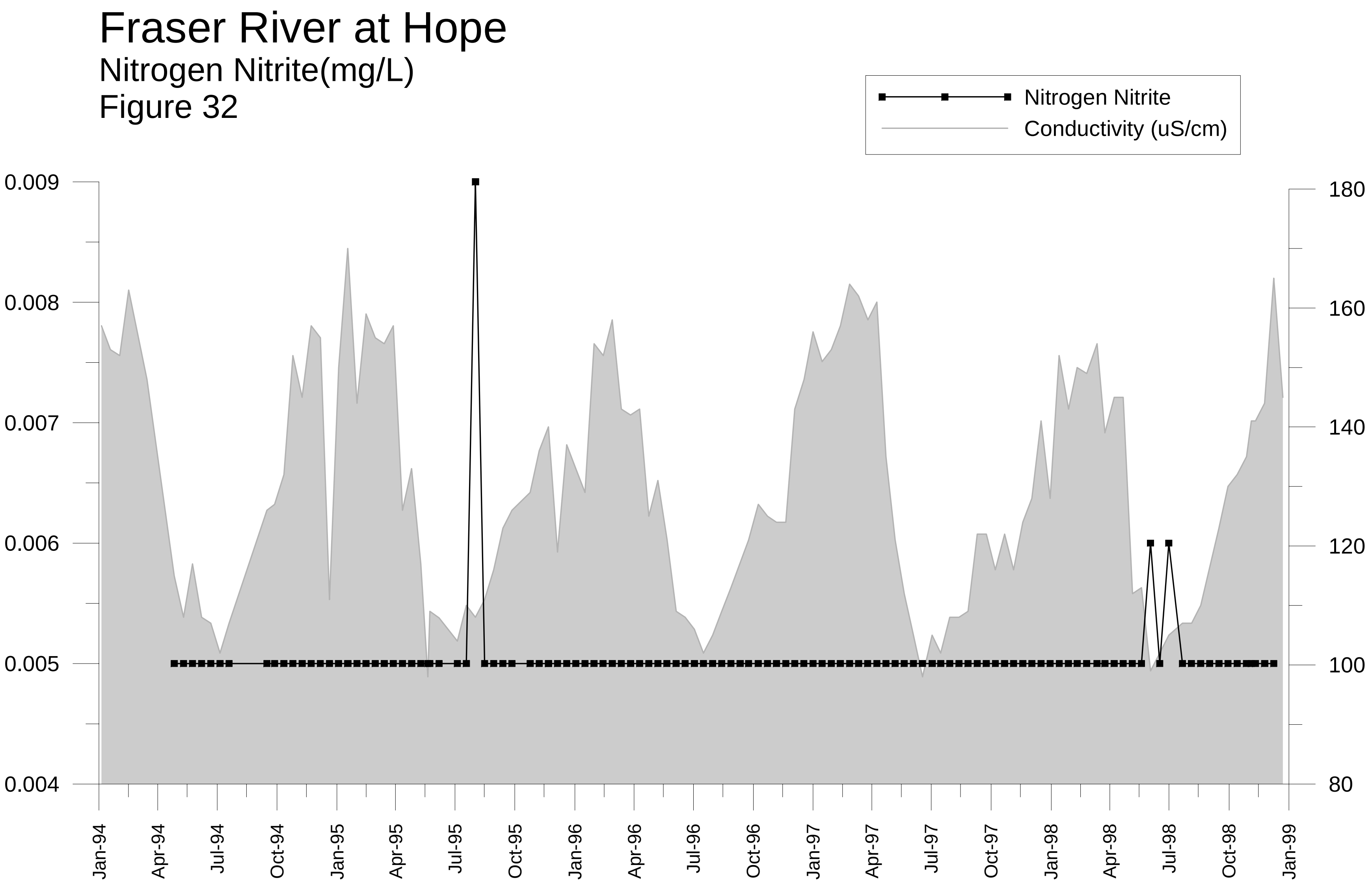
Figure 28

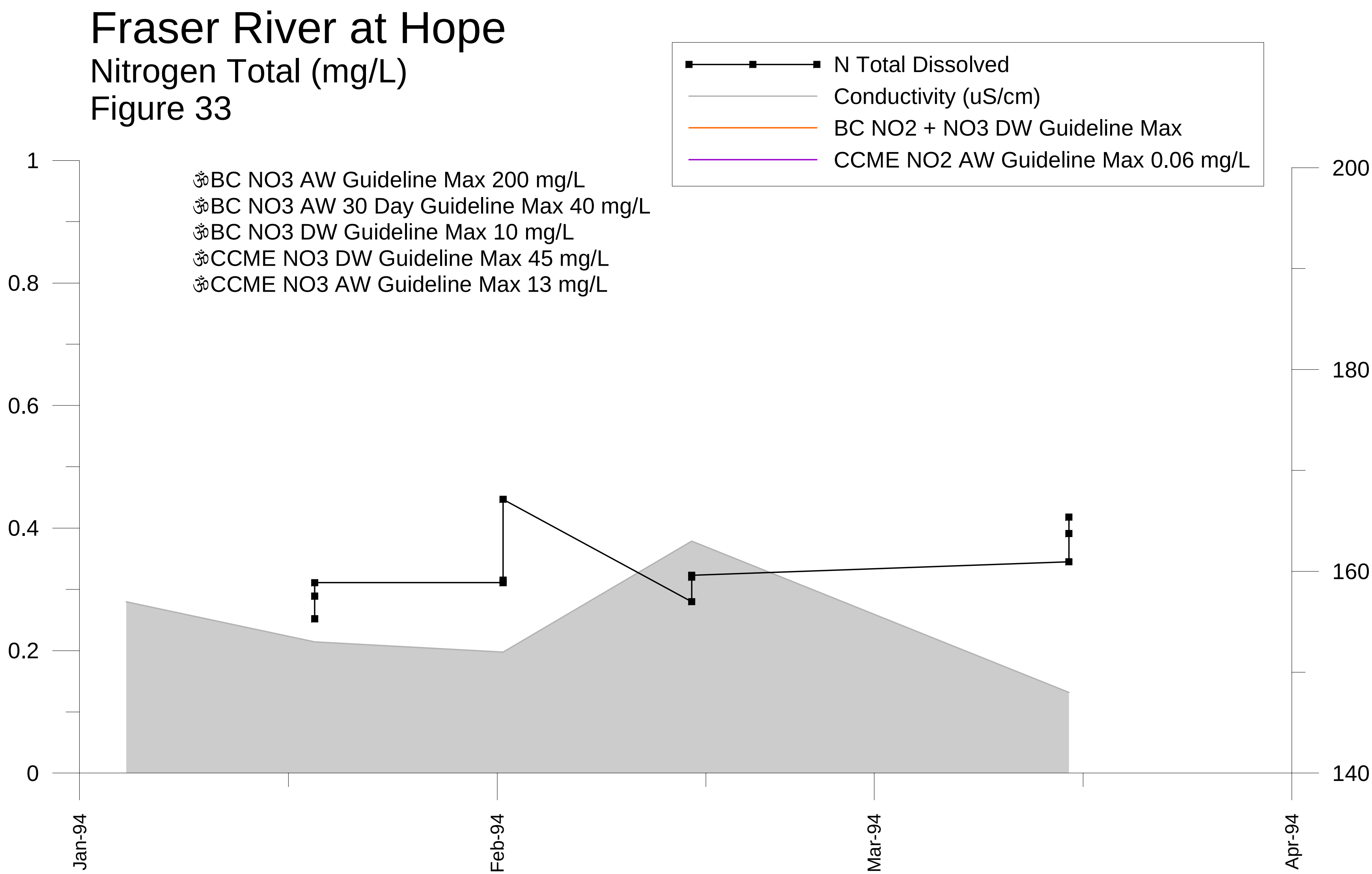



Fraser River at Hope
Mercury (ug/L)
Figure 29
Mercury
Conductivity (uS/cm) (background)
0.08
0.06
0.04
0.02
0
200
160
120
80
40
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95


Fraser River at Hope
Molybdenum Total (ug/L)
Figure 30
Mo Total
Turbidity (NTU)
BC Mo DW Guideline Max 250 ug/L
BC Mo AW Guideline Max 2000 ug/L
BC Mn AW 30 Day Guideline Max 1000 ug/L
CCME Mo AW Guideline Max 73 ug/L
2
1.6
1.2
0.8
0.4
0
400
300
200
100
0
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

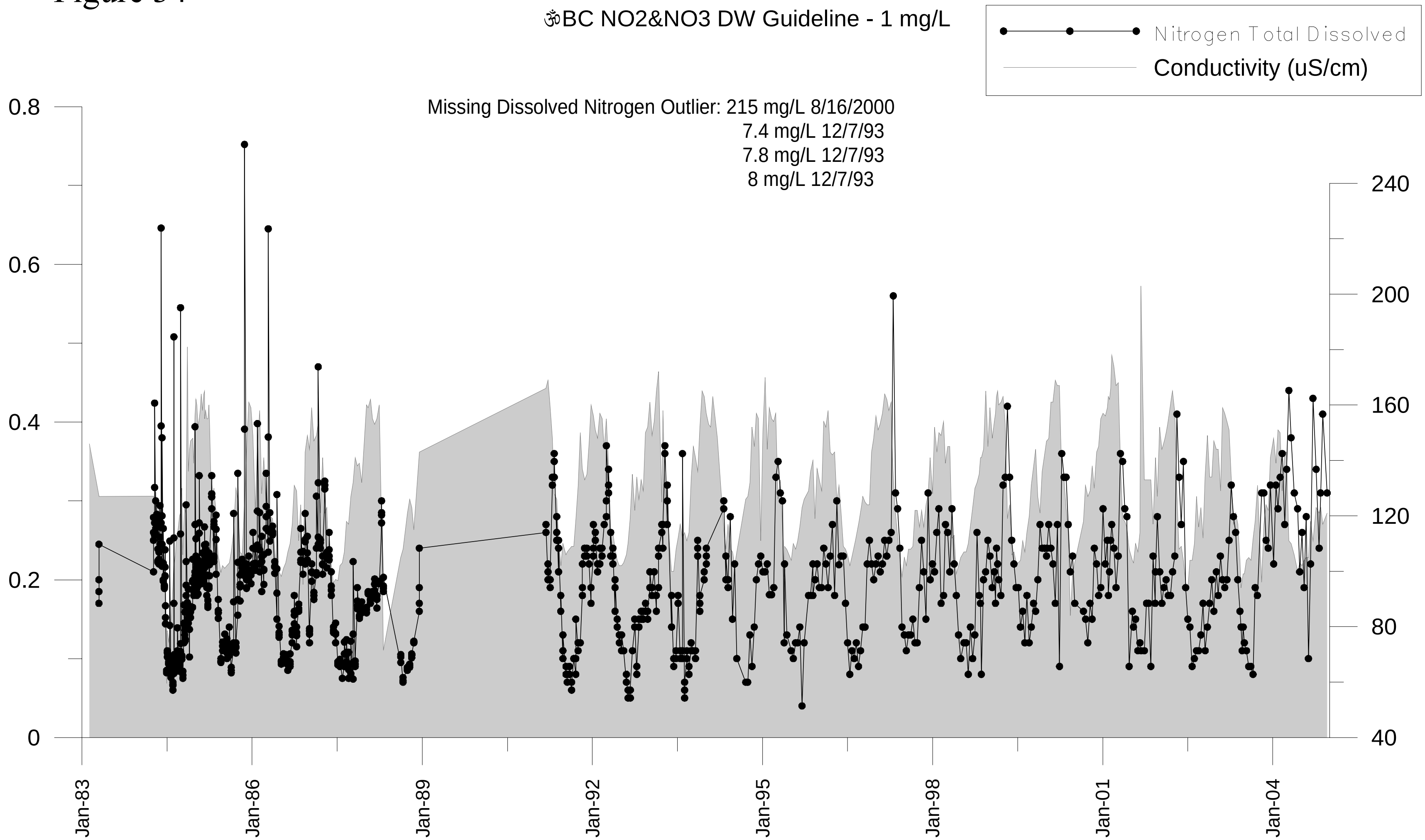

Fraser River at Hope
Nitrogen Dissolved NO3 (mg/L)
Figure 31
ॐBC NO2+NO3 DW Guideline Max 1 mg/L
ॐBC NO3 DW Guideline Max 10 mg/L
ॐBC NO3 AW Guideline Max 200 mg/L
ॐBC NO3 AW 30 Day Guideline Max 40 mg/L
ॐCCME NO3 AW Guideline Max 13 mg/L
ॐCCME NO3 DW Guideline Max 45 mg/L
N Dissolved NO3
Conductivity (uS/cm)
0.2
0.16
0.12
0.08
0.04
0
240
200
160
120
80
40
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99

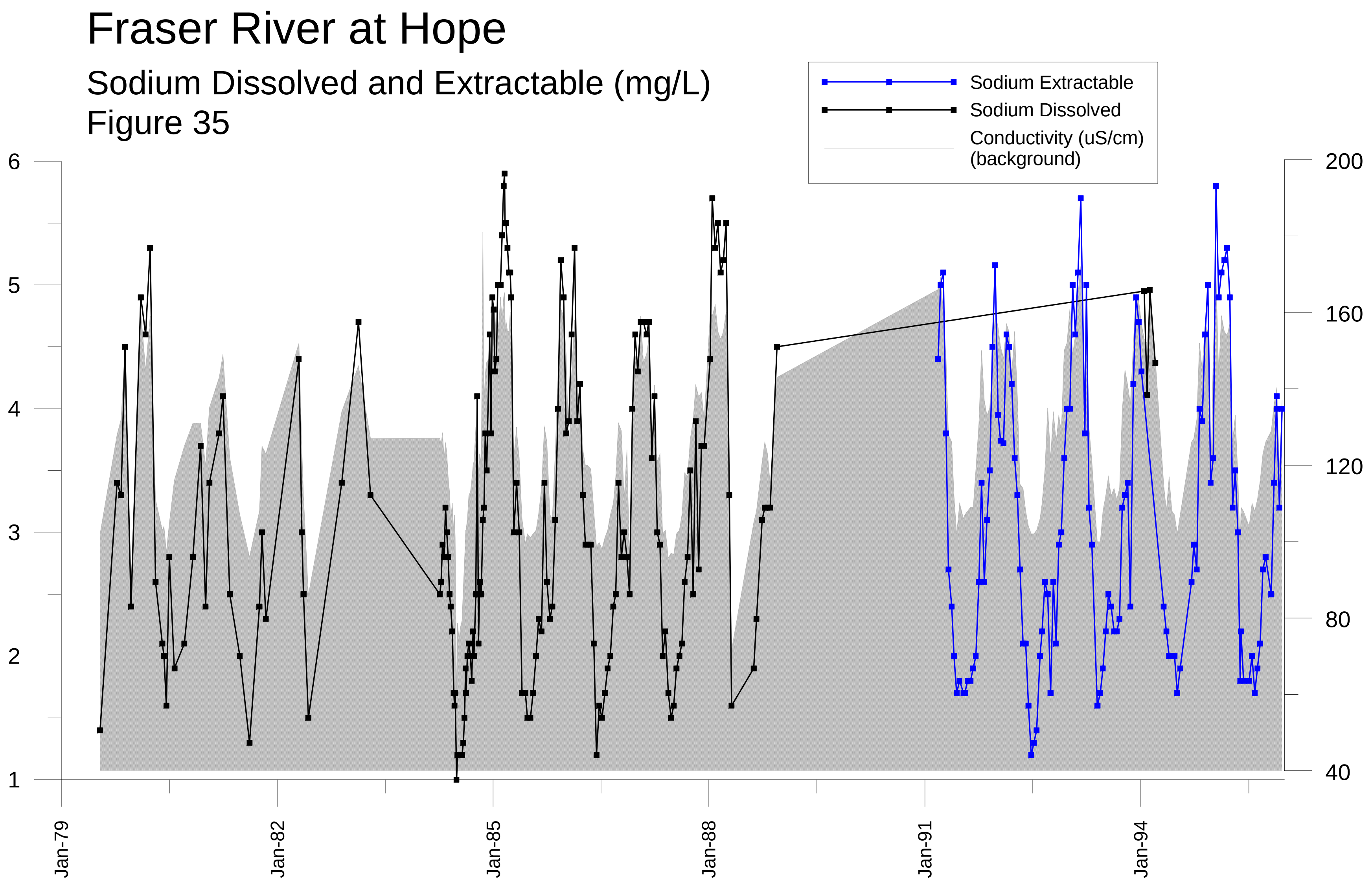

Fraser River at Hope
Nitrogen Nitrite(mg/L)
Figure 32
Nitrogen Nitrite
Conductivity (uS/cm)
0.009
0.008
0.007
0.006
0.005
0.004
180
160
140
120
100
80
Jan-94
Apr-94
Jul-94
Oct-94
Jan-95
Apr-95
Jul-95
Oct-95
Jan-96
Apr-96
Jul-96
Oct-96
Jan-97
Apr-97
Jul-97
Oct-97
Jan-98
Apr-98
Jul-98
Oct-98
Jan-99



Fraser River at Hope
Nitrogen Total (mg/L)
Figure 33
N Total Dissolved
Conductivity (uS/cm)
BC NO2 + NO3 DW Guideline Max
CCME NO2 AW Guideline Max 0.06 mg/L
ॐBC NO3 AW Guideline Max 200 mg/L
ॐBC NO3 AW 30 Day Guideline Max 40 mg/L
ॐBC NO3 DW Guideline Max 10 mg/L
ॐCCME NO3 DW Guideline Max 45 mg/L
ॐCCME NO3 AW Guideline Max 13 mg/L
1
0.8
0.6
0.4
0.2
0
200
180
160
140
Jan-94
Feb-94
Mar-94
Apr-94

Fraser River at Hope
Nitrogen Total Dissolved (mg/L)
Figure 34



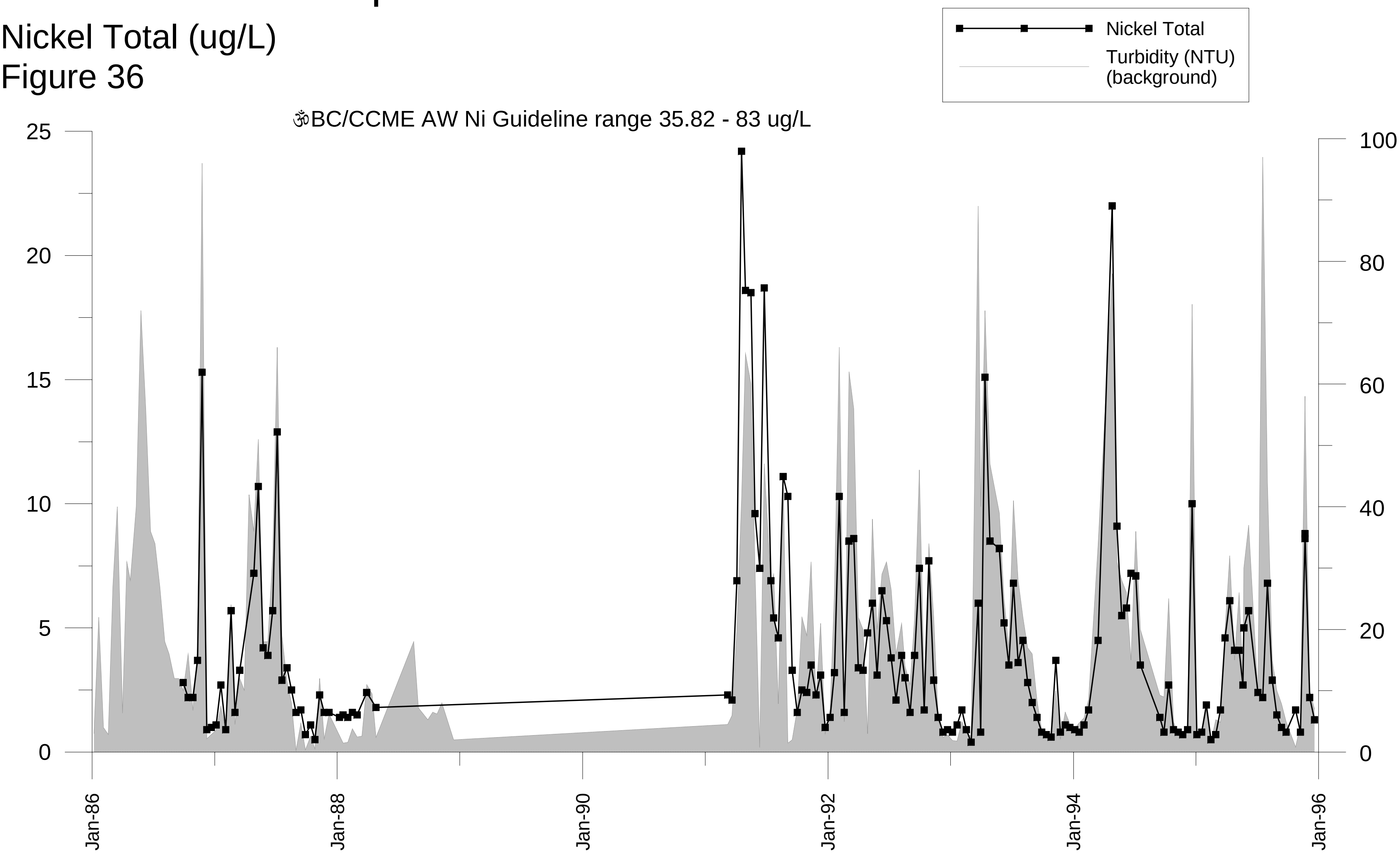


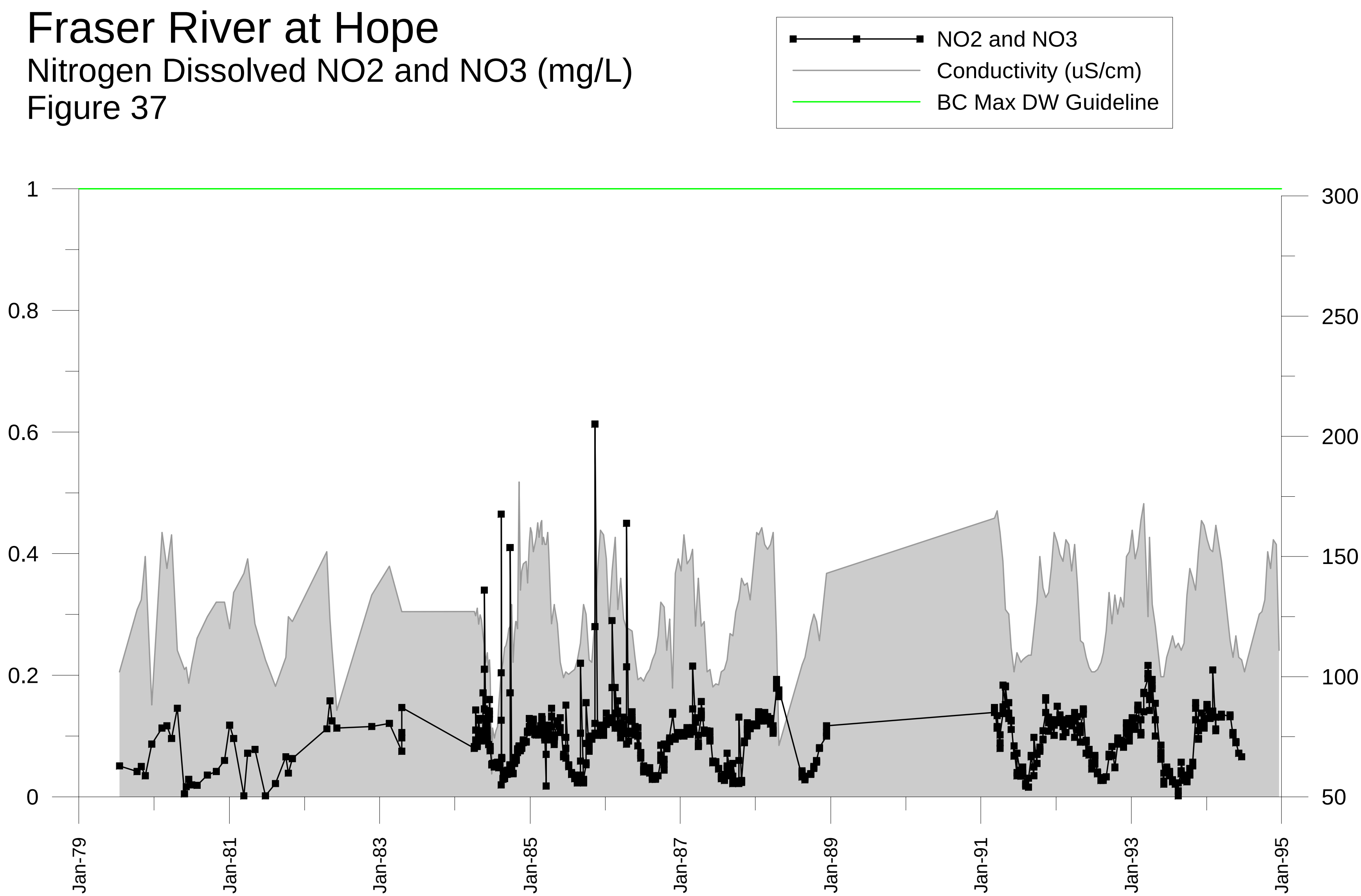
Fraser River at Hope
Sodium Dissolved and Extractable (mg/L)
Figure 35
Sodium Extractable
Sodium Dissolved
Conductivity (uS/cm)
(background)
6
5
4
3
2
1
200
160
120
80
40
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94

Fraser River at Hope

Nickel Total (ug/L)

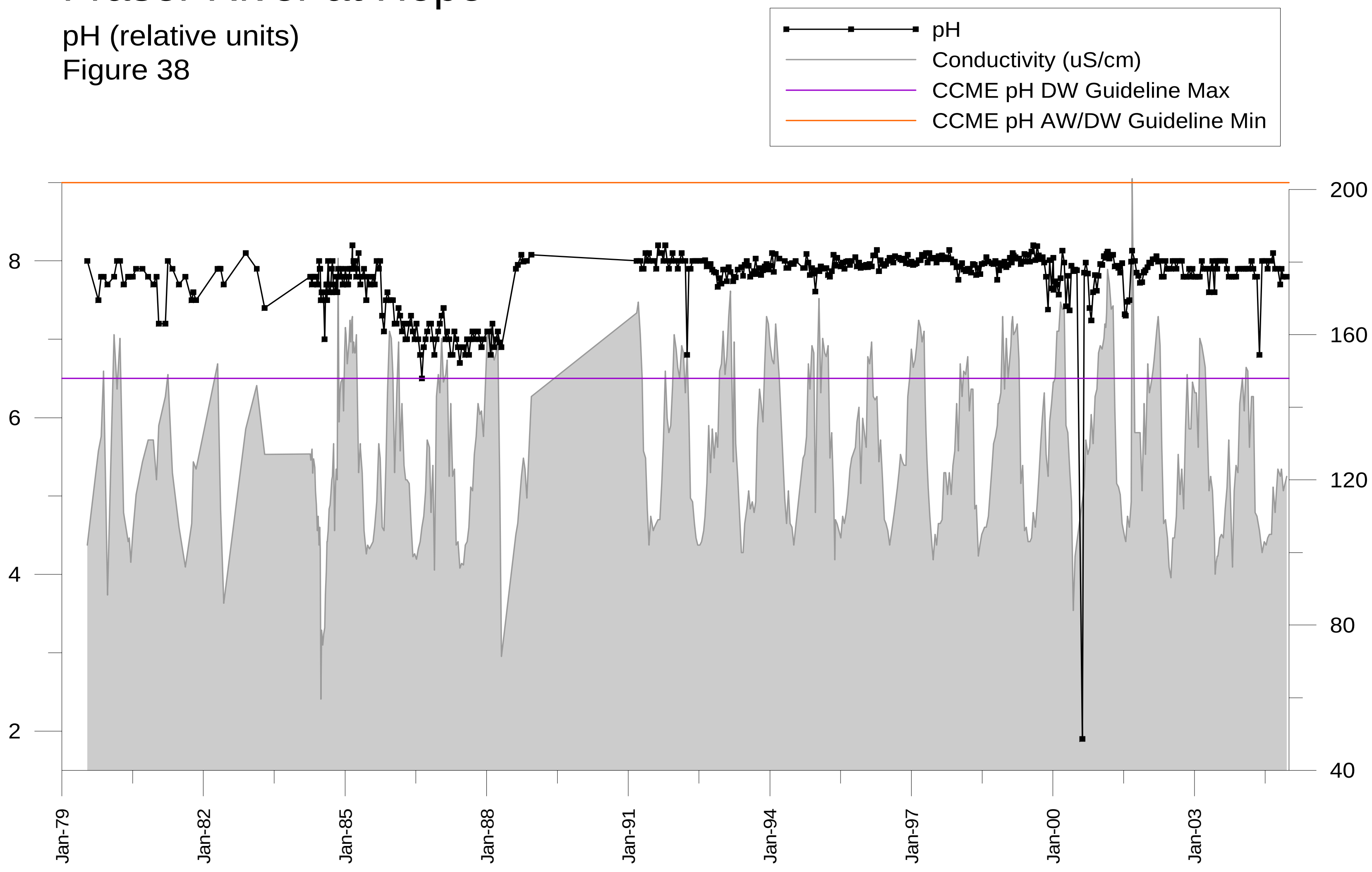
Figure 36

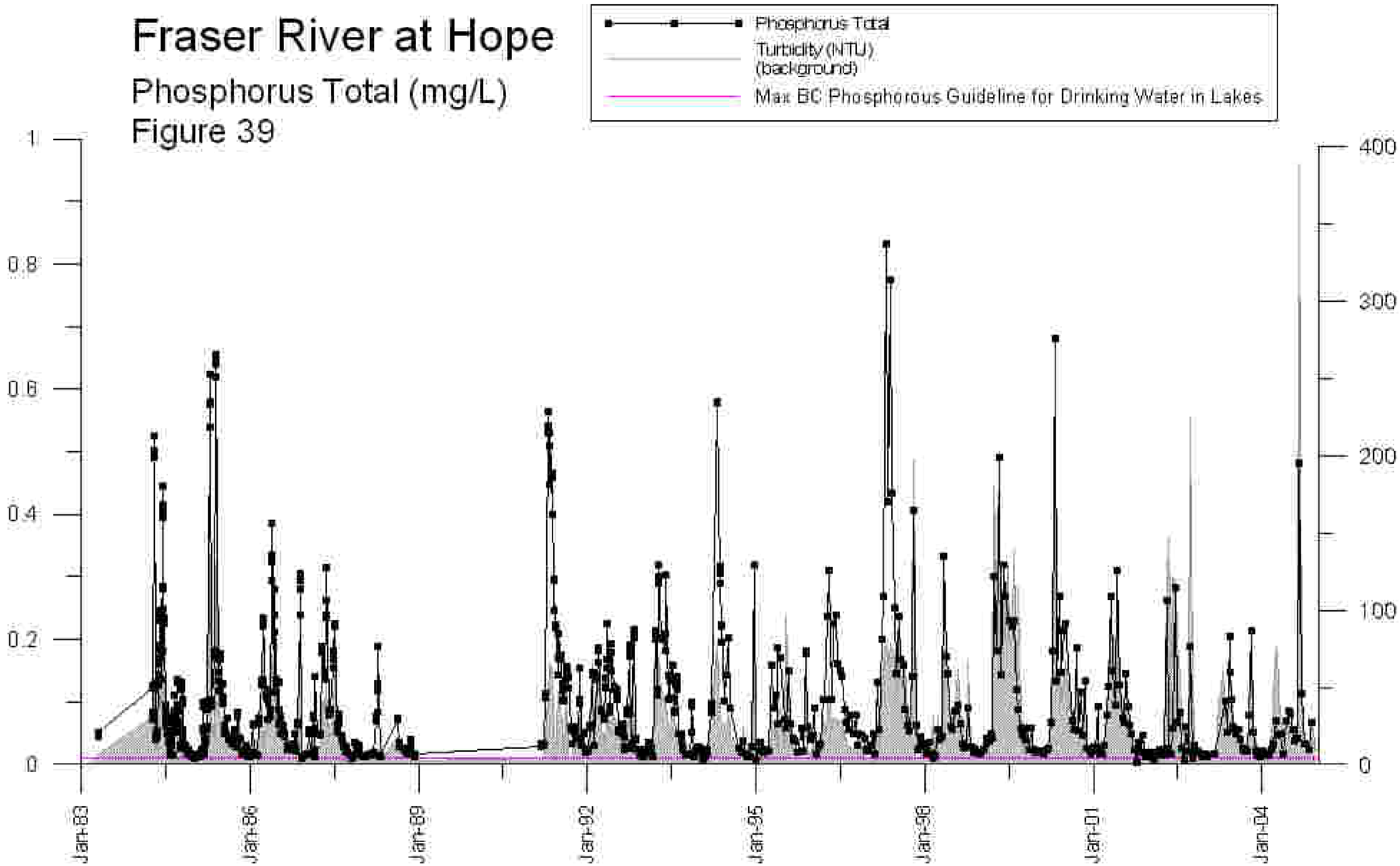



Fraser River at Hope
Nitrogen Dissolved NO2 and NO3 (mg/L)
Figure 37
NO2 and NO3
Conductivity (uS/cm)
BC Max DW Guideline
1
0.8
0.6
0.4
0.2
0
300
250
200
150
100
50
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95

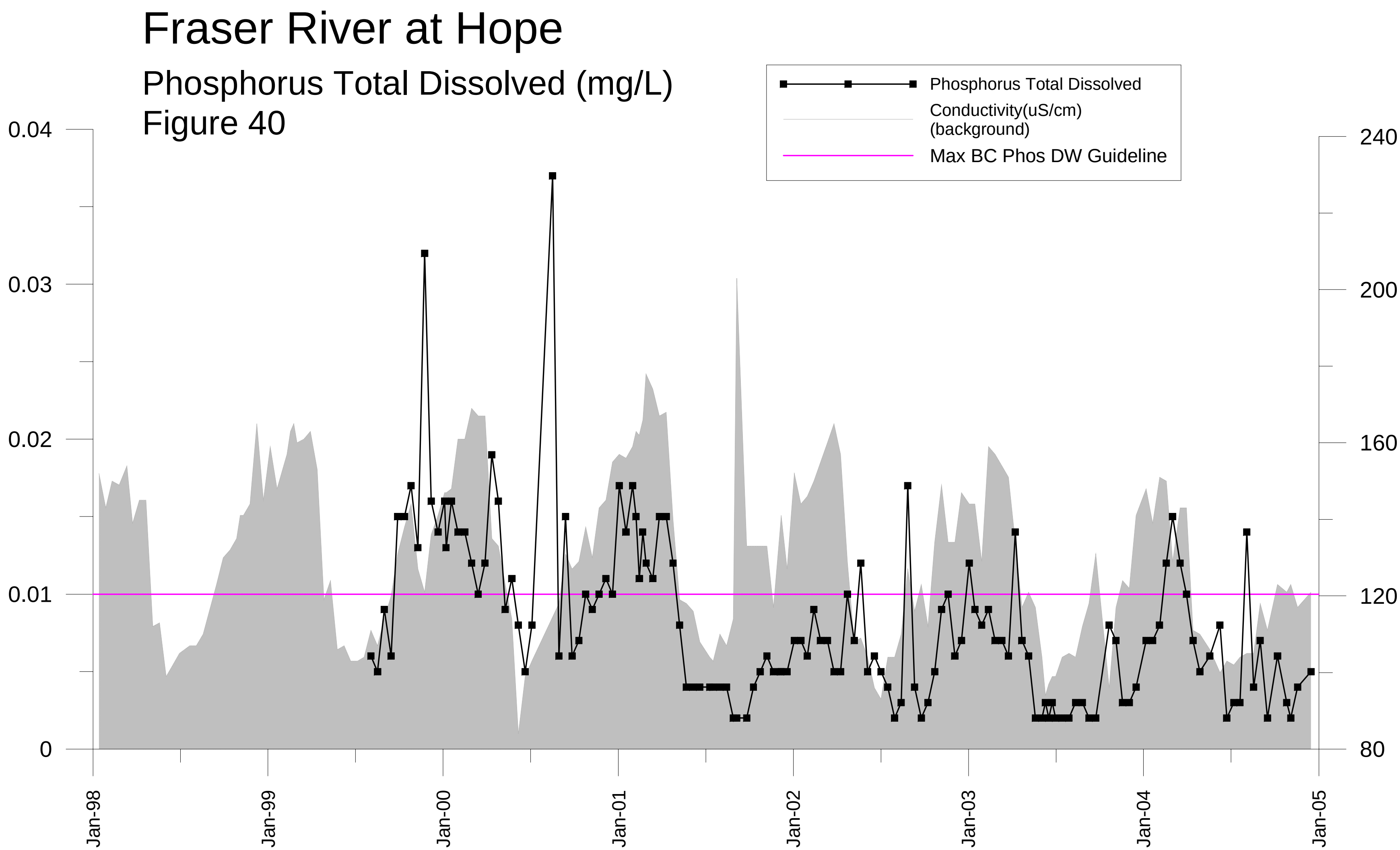
Fraser River at Hope

pH (relative units)
Figure 38

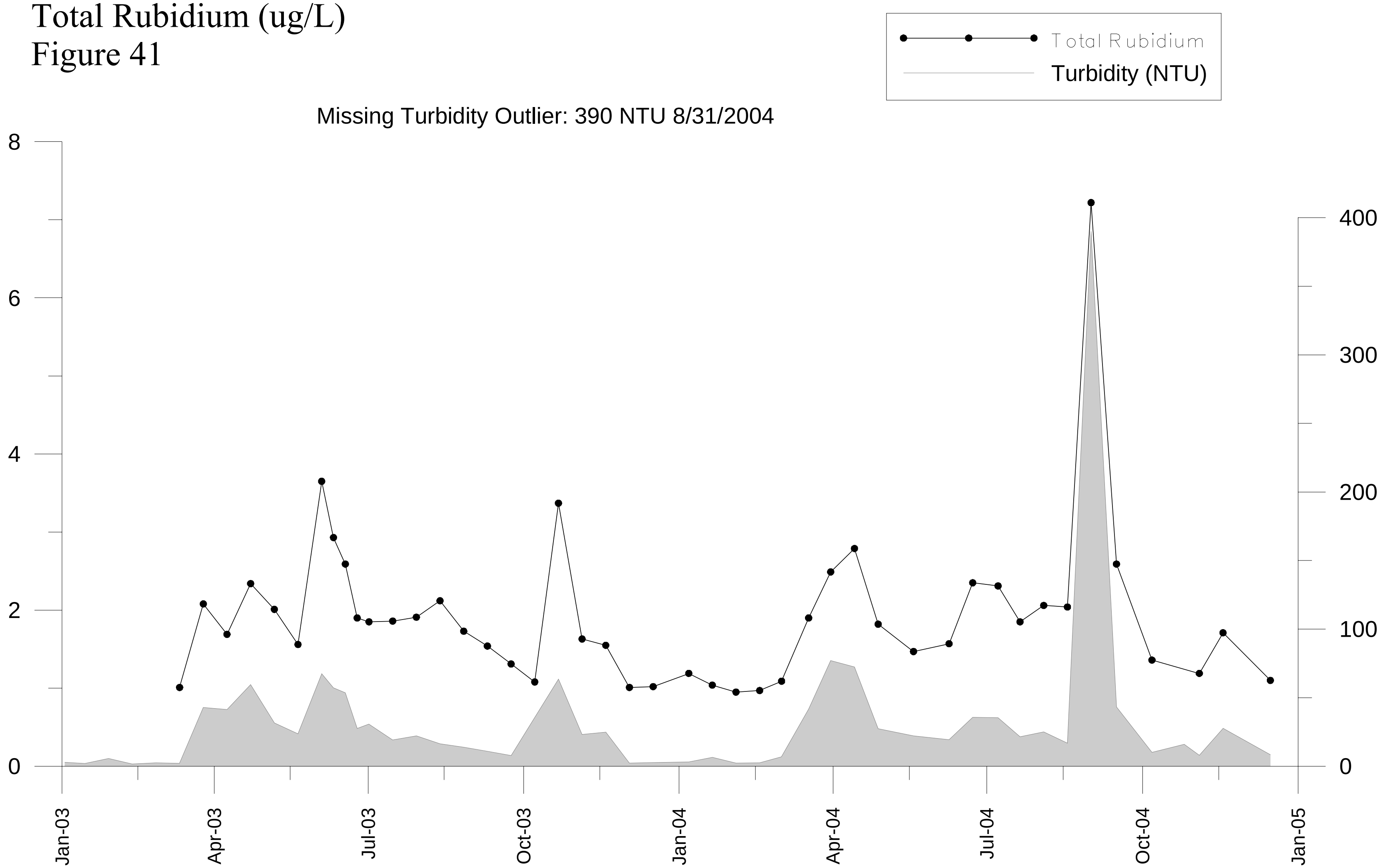


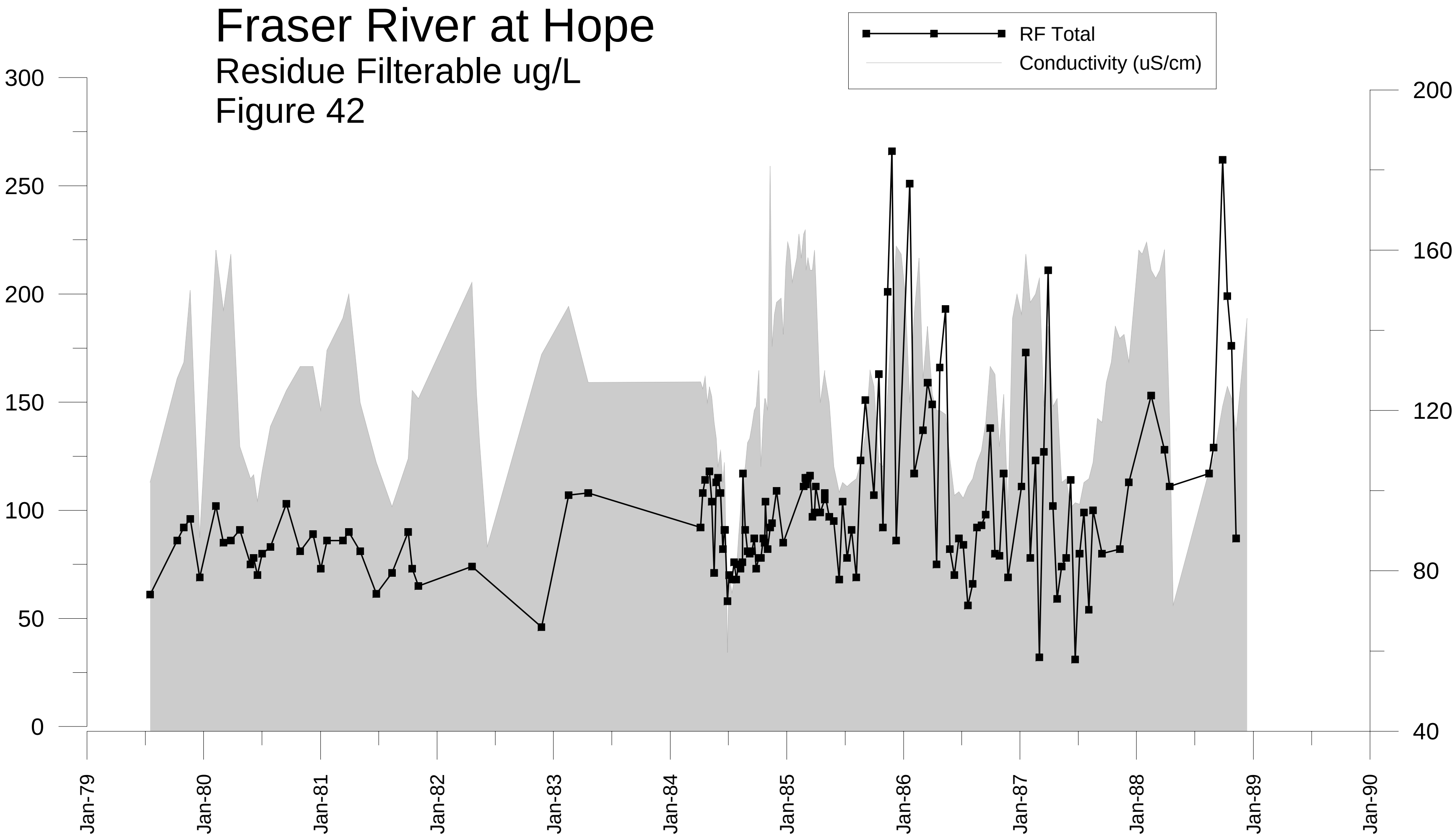


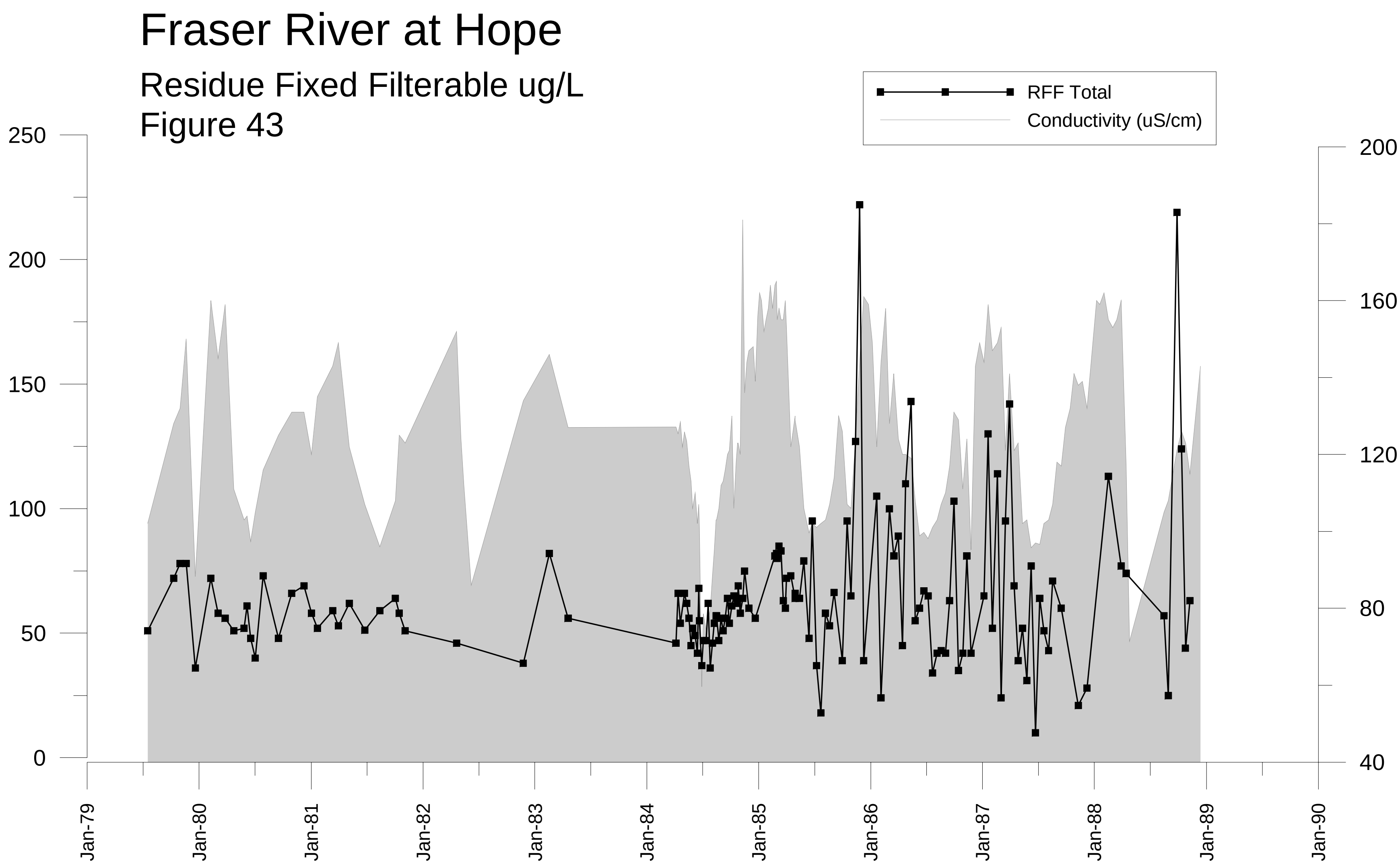
Fraser River at Hope
Phosphorus Total (mg/L)
Figure 39
Phosphorus Total
Turbidity (NTU)
(background)
Max BC Phosphorous Guideline for Drinking Water in Lakes
1
0.8
0.6
0.4
0.2
0
400
300
200
100
0
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Jan-01
Jan-04

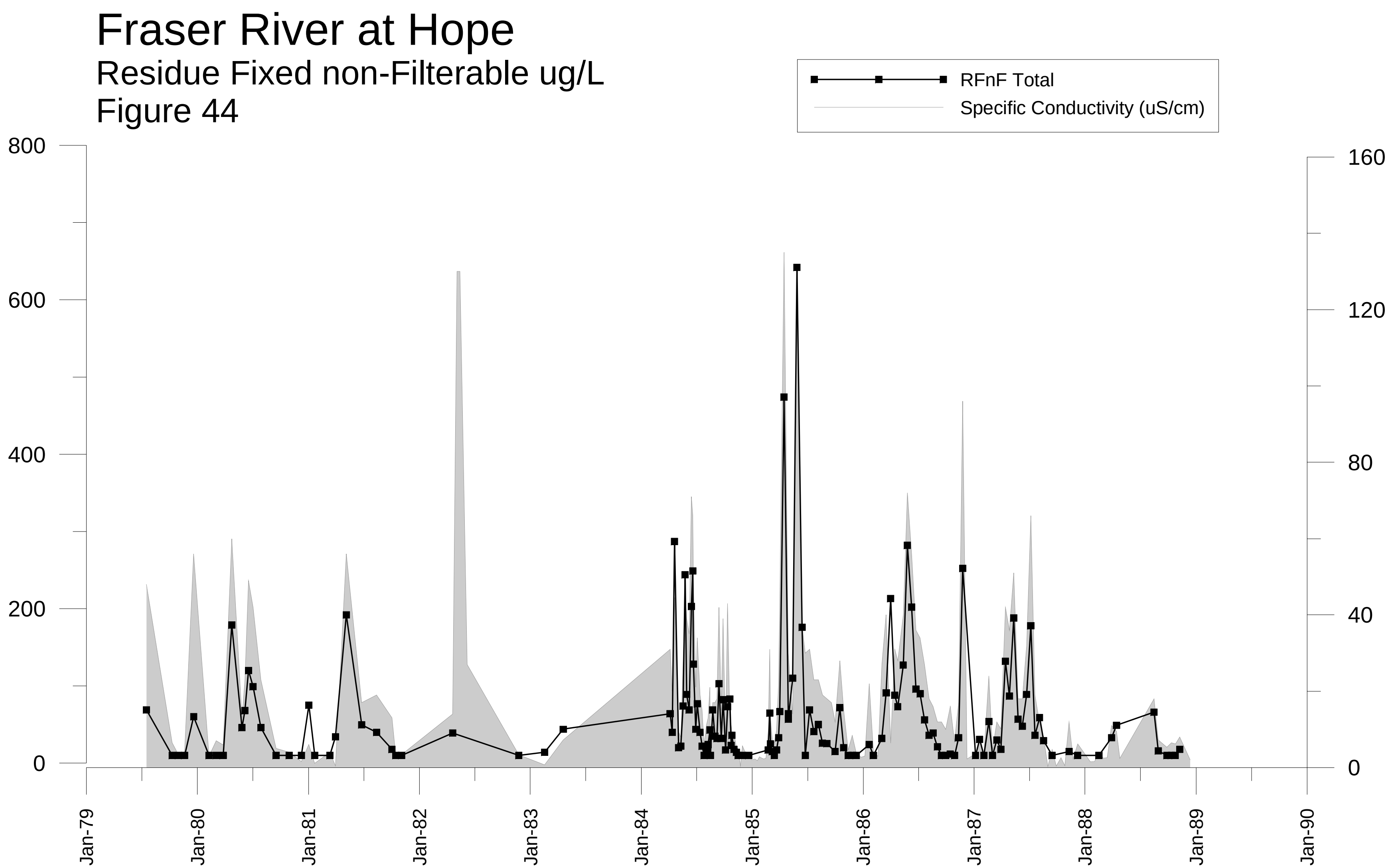

Fraser River at Hope
Phosphorus Total Dissolved (mg/L)
Figure 40
Phosphorus Total Dissolved
Conductivity(uS/cm)
(background)
Max BC Phos DW Guideline
0.04
0.03
0.02
0.01
0
240
200
160
120
80
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

Fraser River at Hope
Total Rubidium (ug/L)
Figure 41

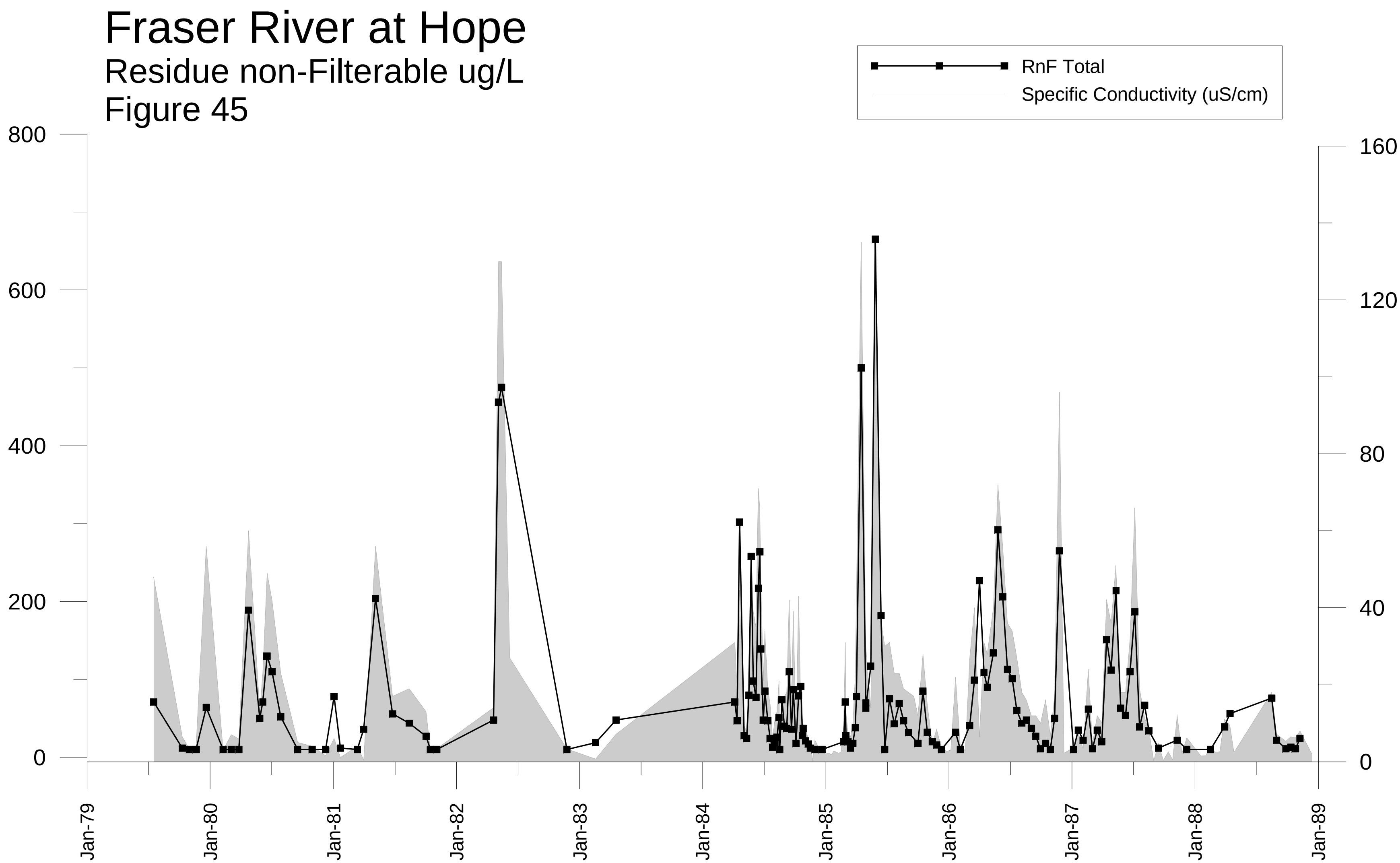



Fraser River at Hope
Residue Filterable ug/L
Figure 42
RF Total
Conductivity (uS/cm)
300
250
200
150
100
50
0
200
160
120
80
40
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90


Fraser River at Hope
Residue Fixed Filterable ug/L
Figure 43
RFF Total
Conductivity (uS/cm)
250
200
150
100
50
0
200
160
120
80
40
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90



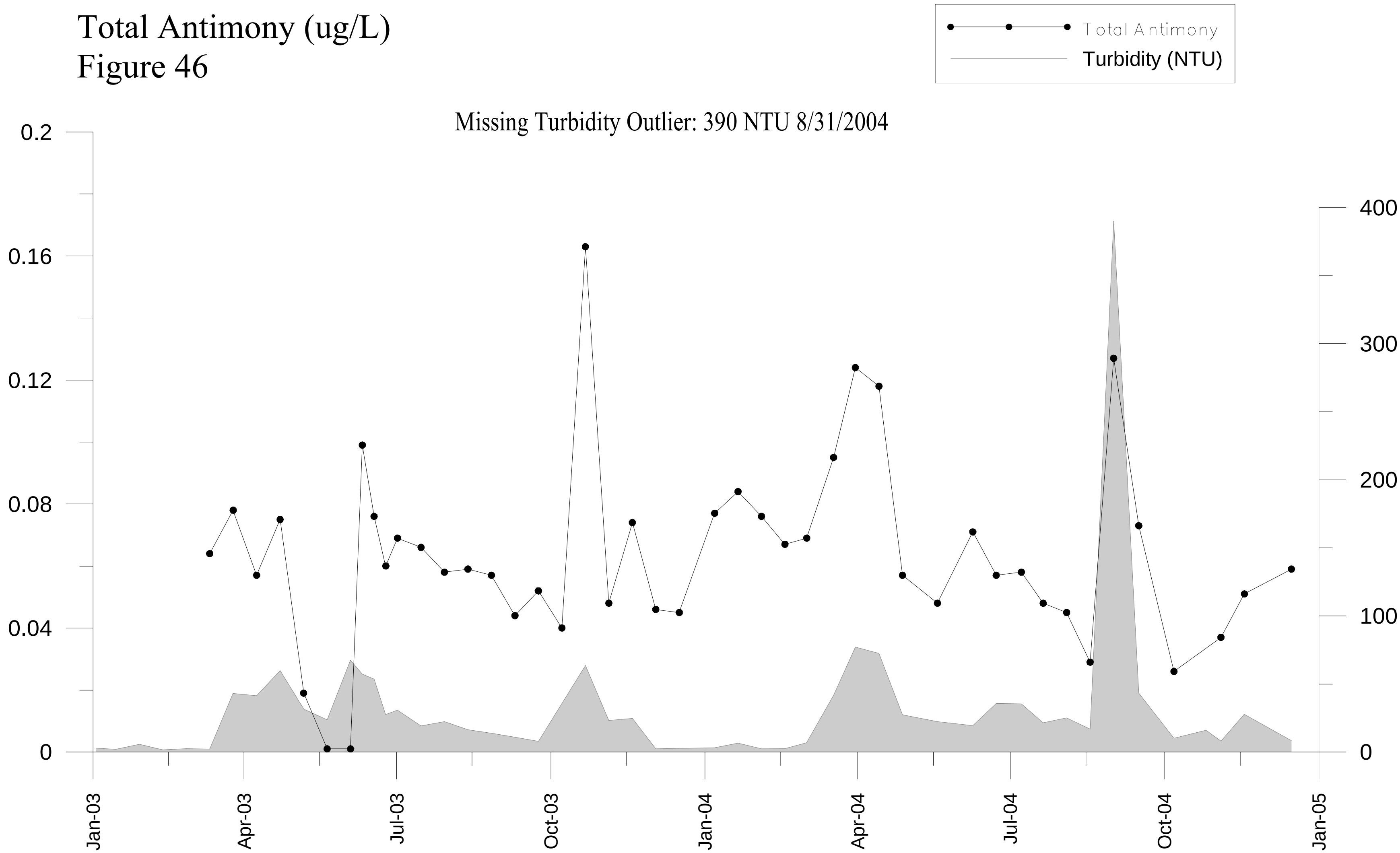
Fraser River at Hope
Residue Fixed non-Filterable ug/L
Figure 44
RFnF Total
Specific Conductivity (uS/cm)
800
600
400
200
0
160
120
80
40
0
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90

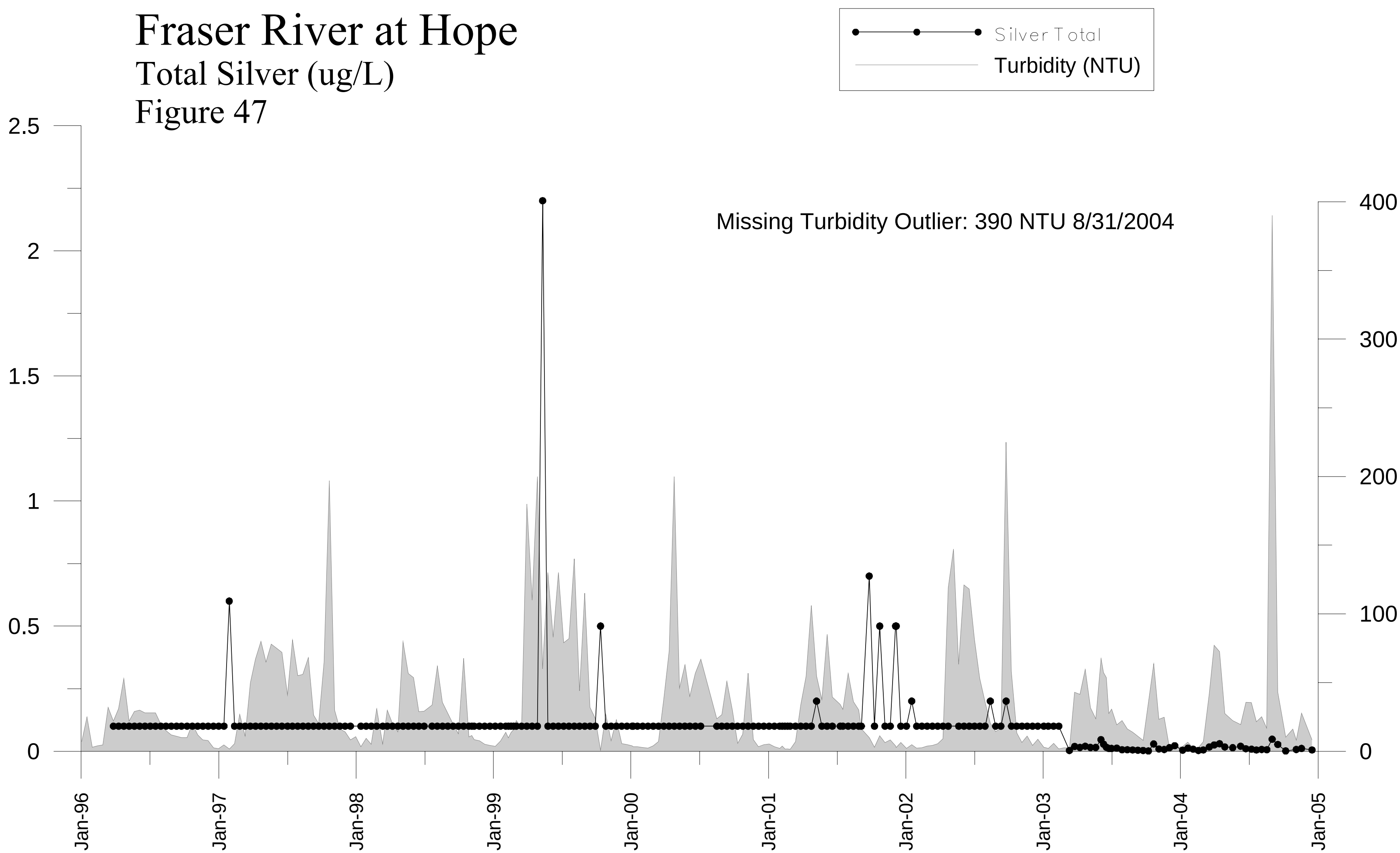

Fraser River at Hope
Residue non-Filterable ug/L
Figure 45
RnF Total
Specific Conductivity (uS/cm)
800
600
400
200
0
160
120
80
40
0
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89

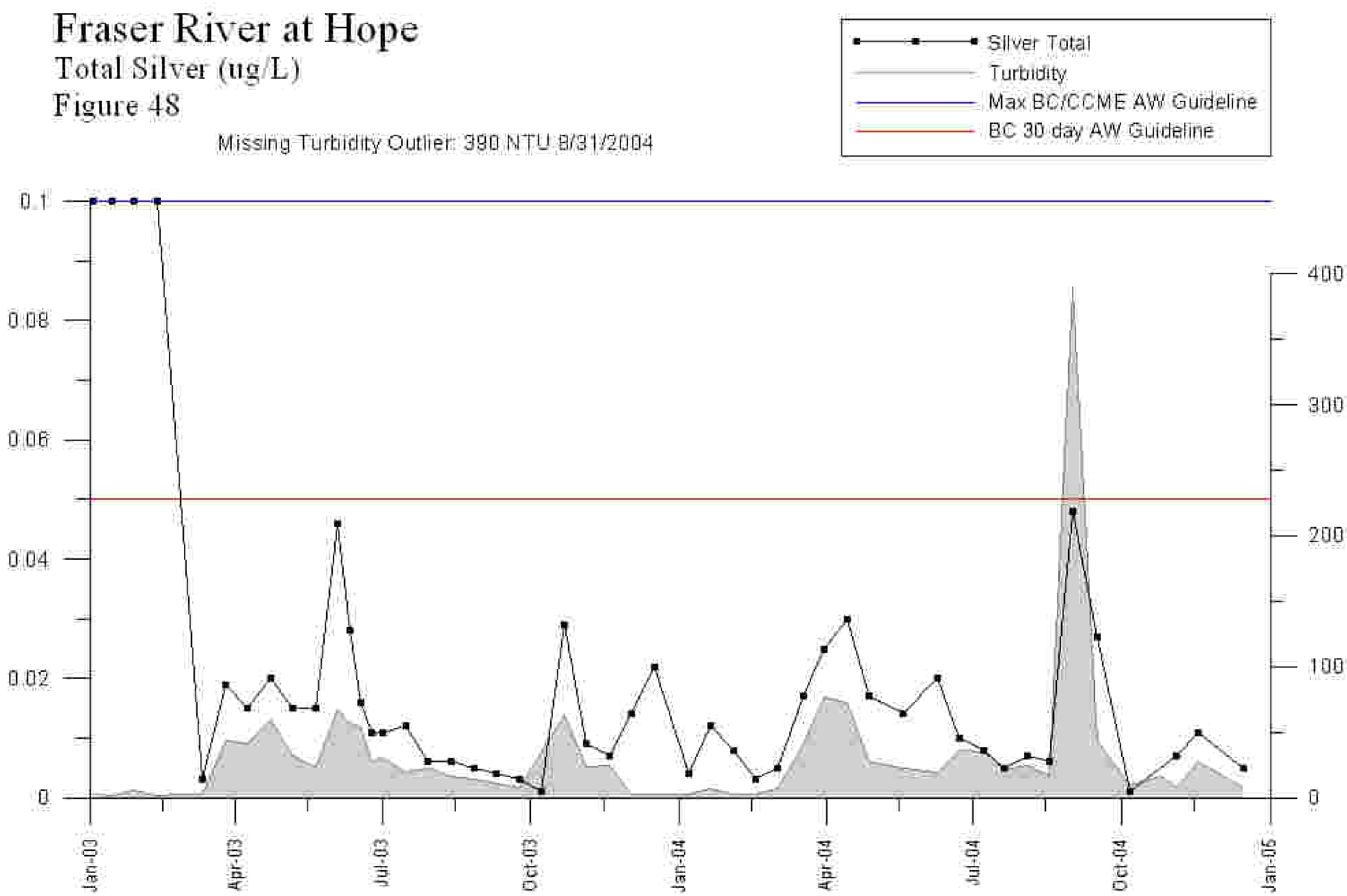
Fraser River at Hope

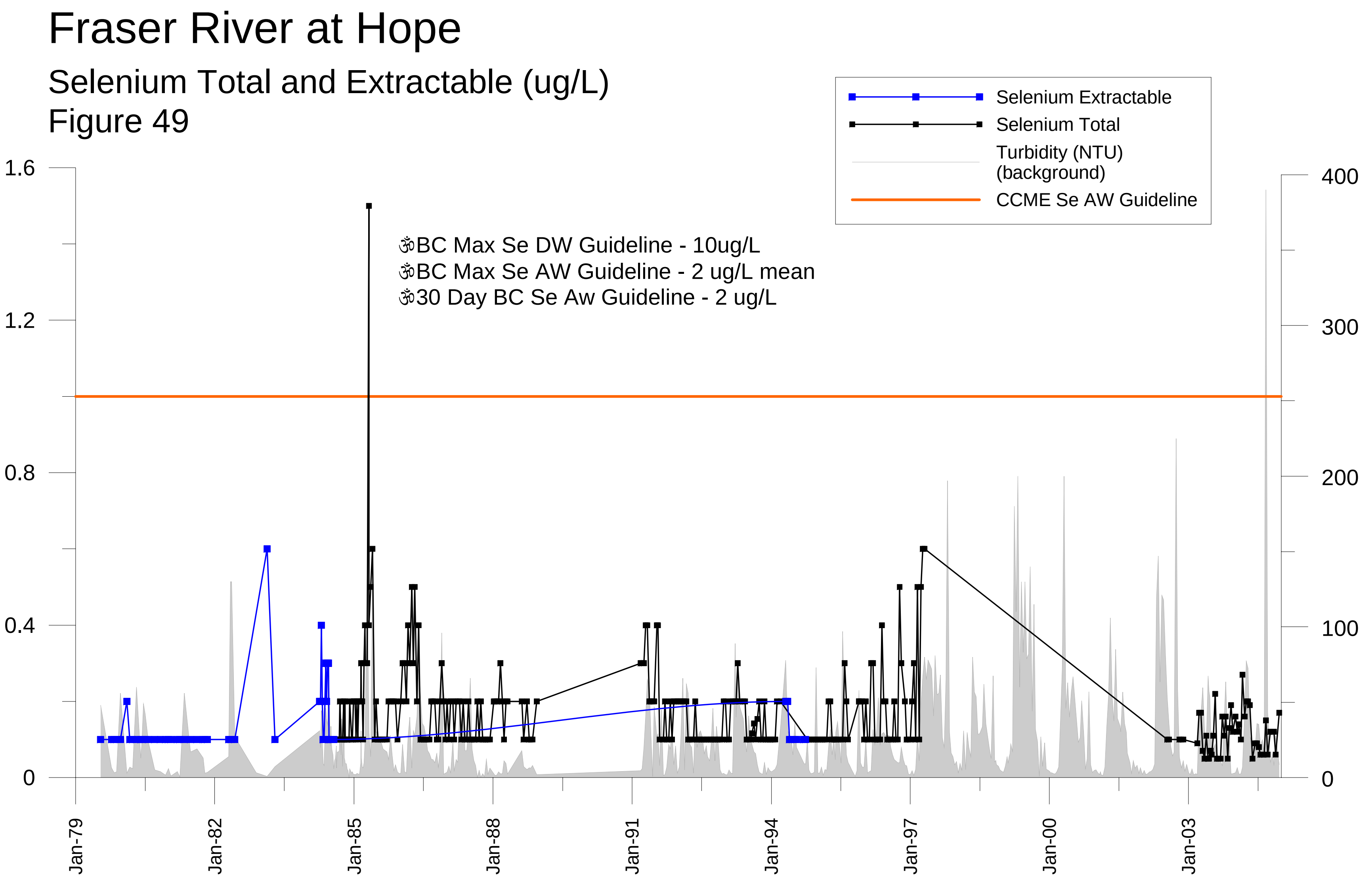
Total Antimony (ug/L)

Figure 46

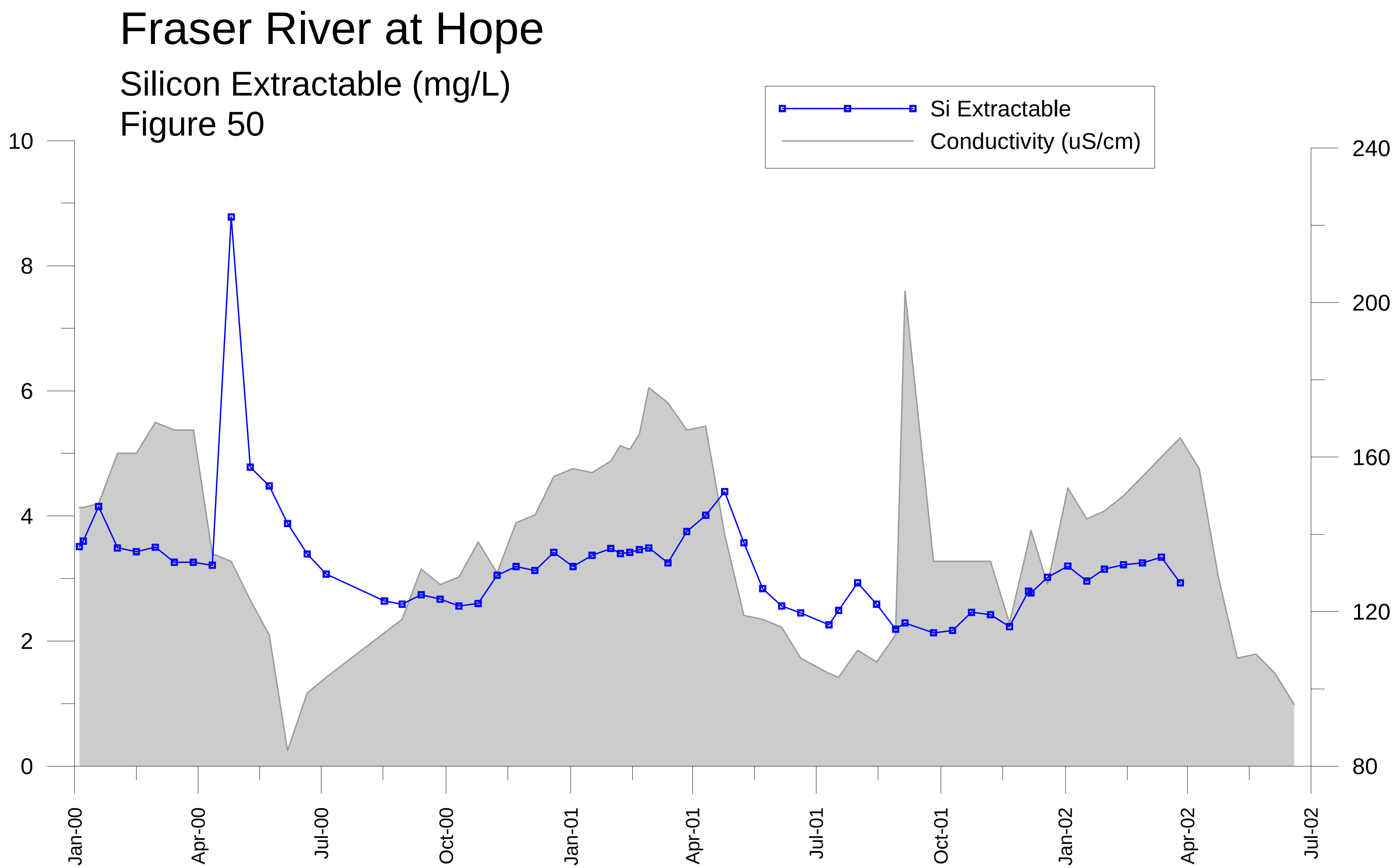



Fraser River at Hope
Total Silver (ug/L)
Figure 47
Silver Total
Turbidity (NTU)
Missing Turbidity Outlier: 390 NTU 8/31/2004
2.5
2
1.5
1
0.5
0
400
300
200
100
0
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

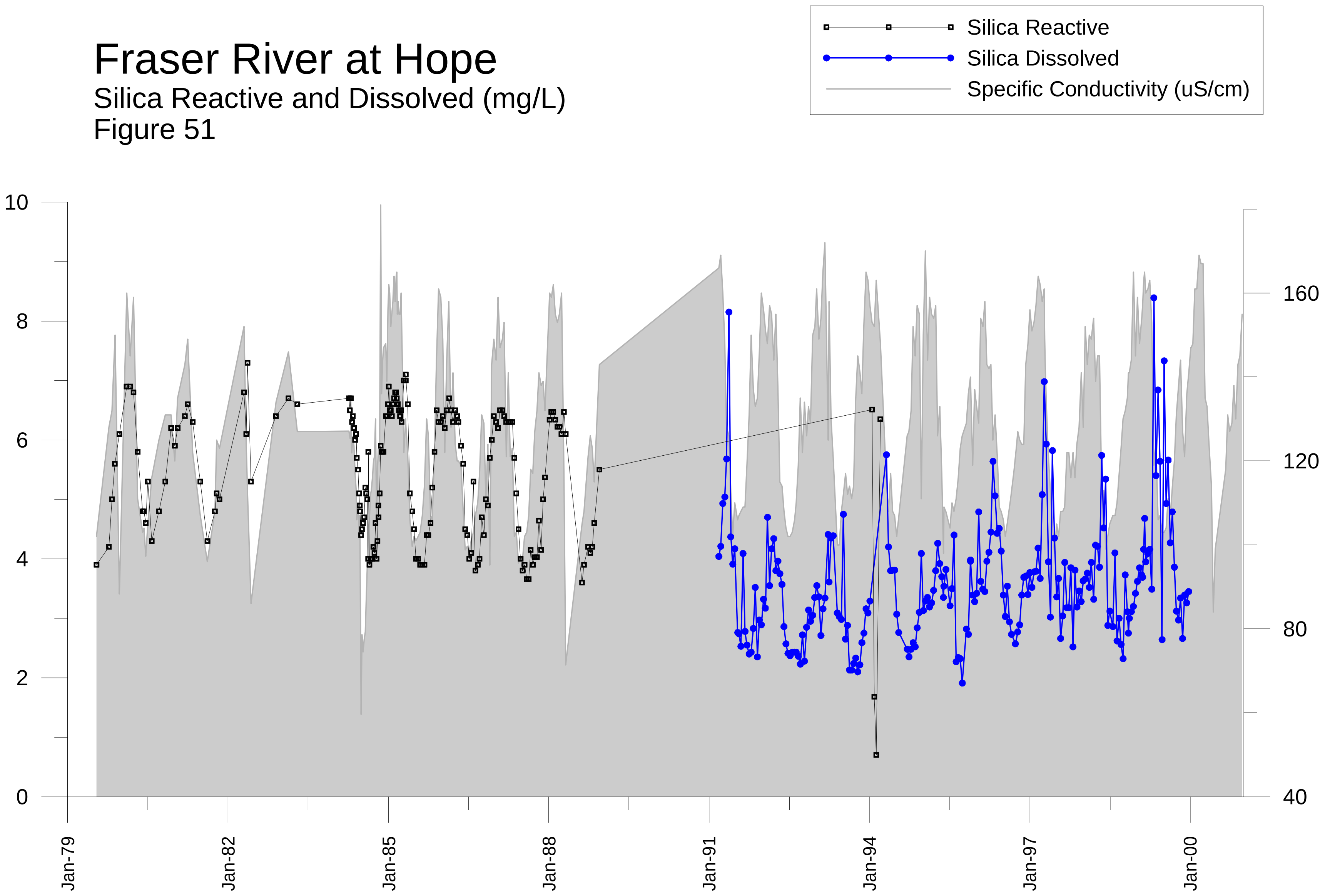

Fraser River at Hope
Total Silver (ug/L)
Figure 48
Missing Turbidity Outlier: 390 NTU 8/31/2004
Silver Total
Turbidity
Max BC/CCME AW Guideline
BC 30 day AW Guideline
0.1
0.08
0.06
0.04
0.02
0
400
300
200
100
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

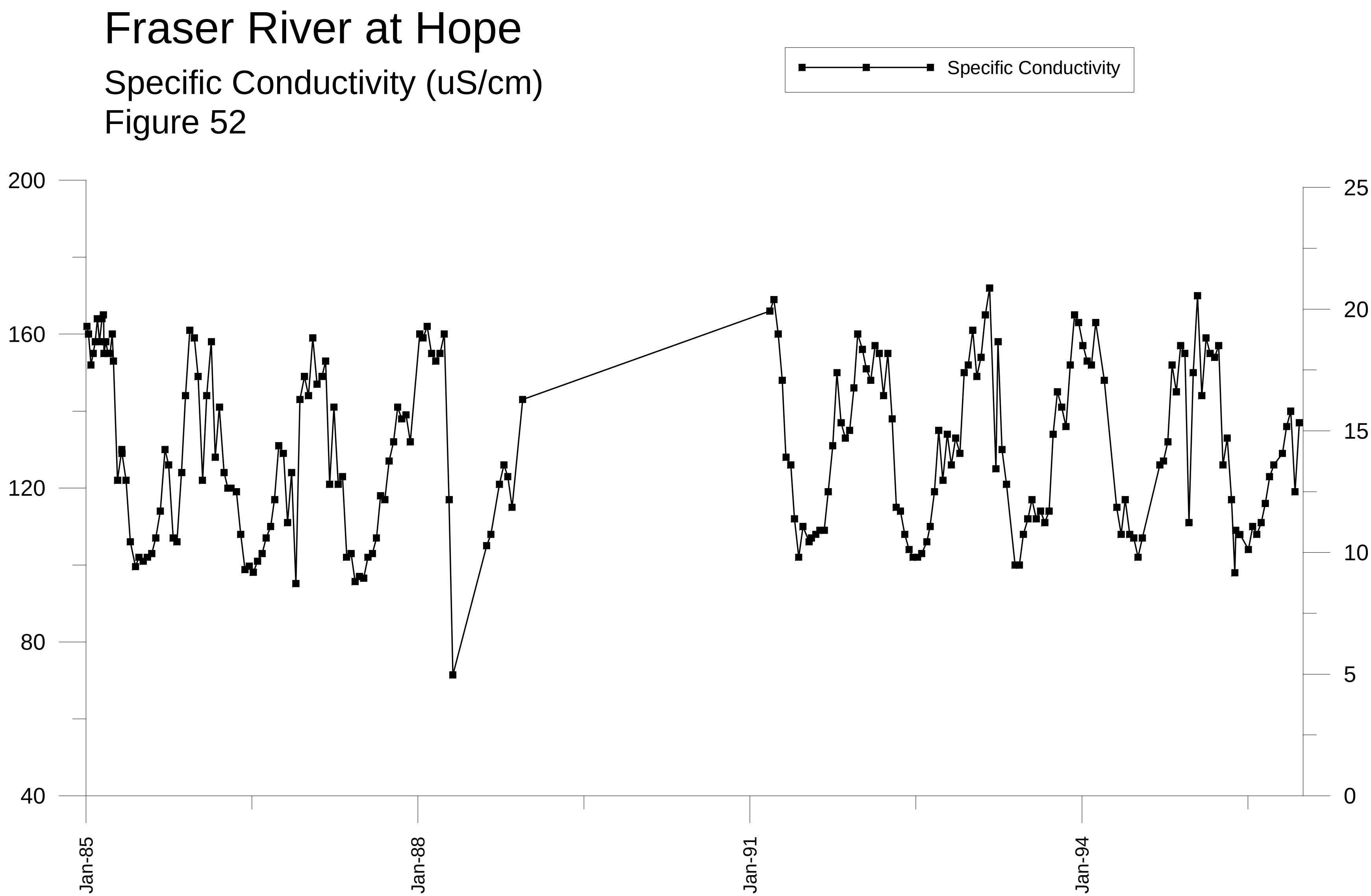


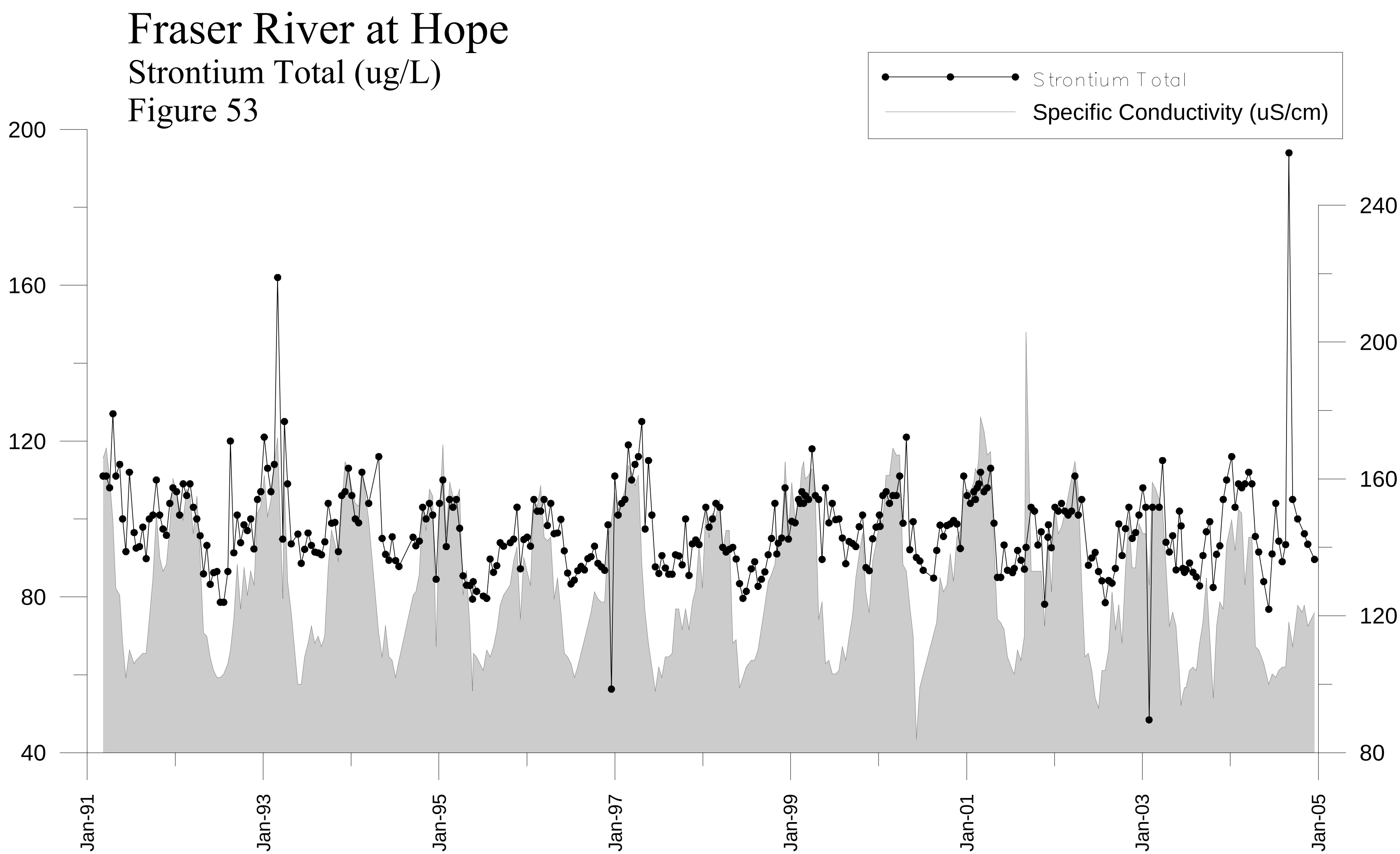
Fraser River at Hope
Selenium Total and Extractable (ug/L)
Figure 49
Selenium Extractable
Selenium Total
Turbidity (NTU) (background)
CCME Se AW Guideline
ॐBC Max Se DW Guideline - 10ug/L
ॐBC Max Se AW Guideline - 2 ug/L mean
ॐ30 Day BC Se Aw Guideline - 2 ug/L
1.6
1.2
0.8
0.4
0
400
300
200
100
0
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

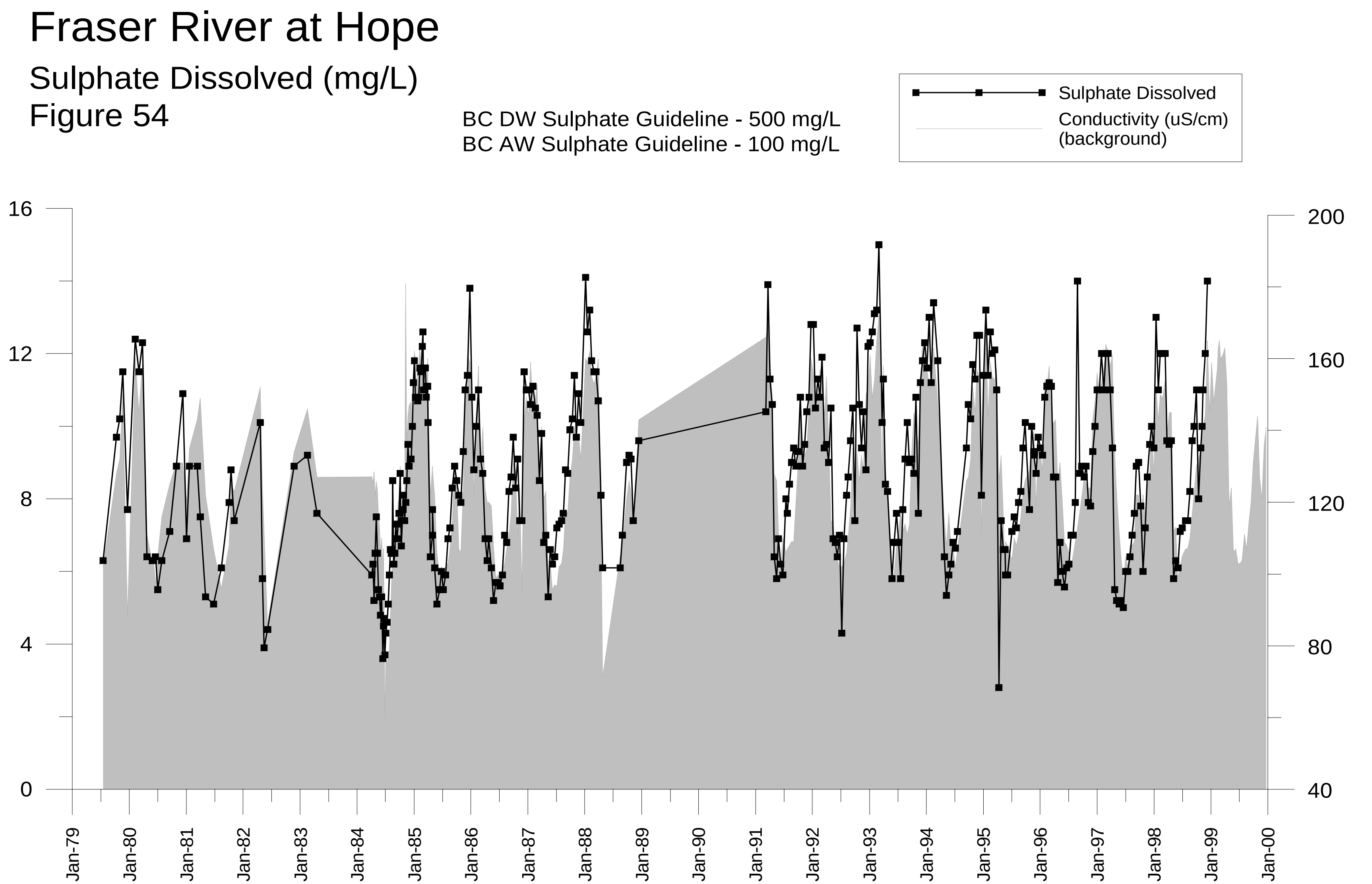


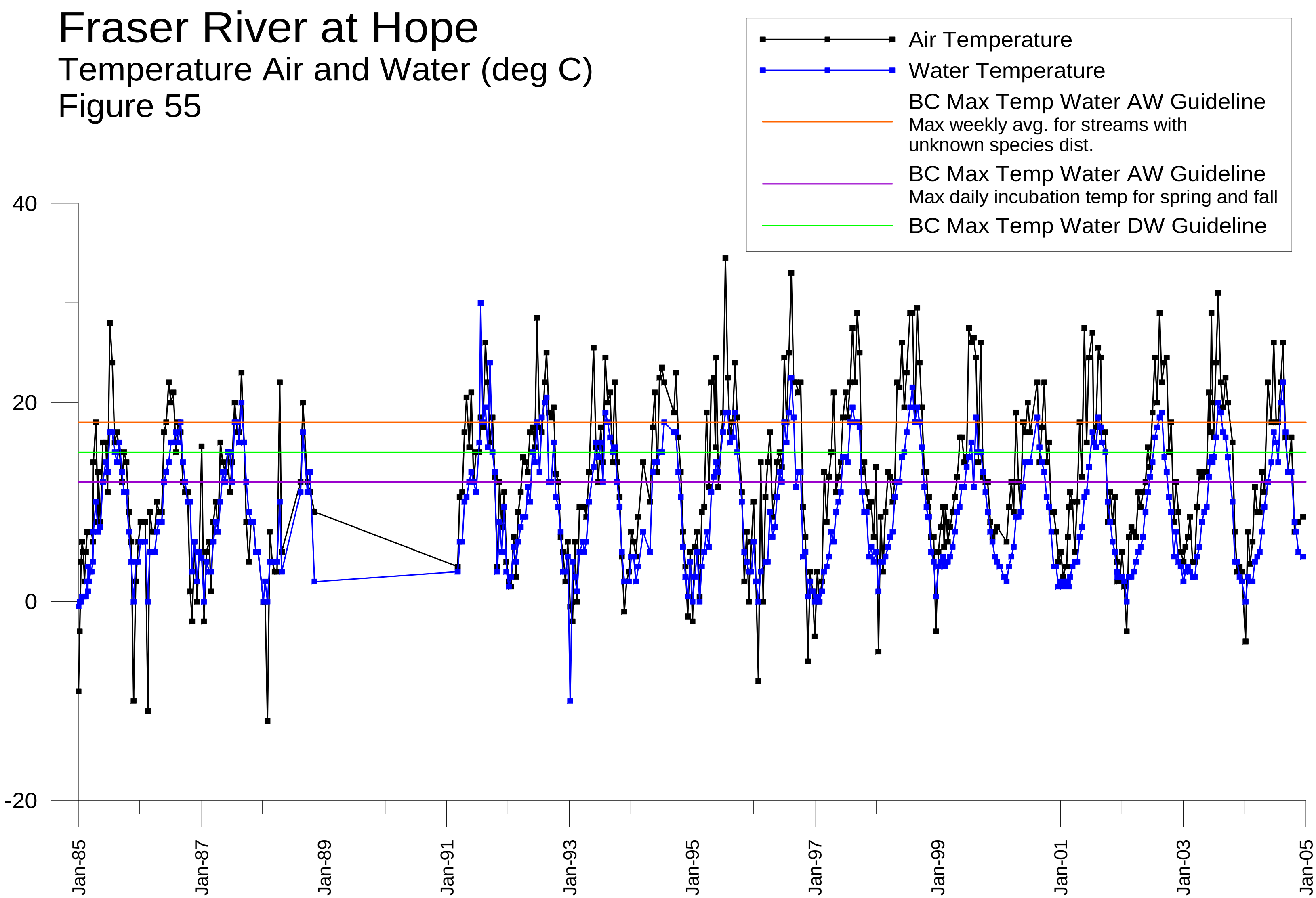
Fraser River at Hope
Silicon Extractable (mg/L)
Figure 50
Si Extractable
Conductivity (uS/cm)
0
2
4
6
8
10
80
120
160
200
240
Jan-00
Apr-00
Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02


Fraser River at Hope
Silica Reactive and Dissolved (mg/L)
Figure 51
Silica Reactive
Silica Dissolved
Specific Conductivity (uS/cm)
10
8
6
4
2
0
160
120
80
40
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00

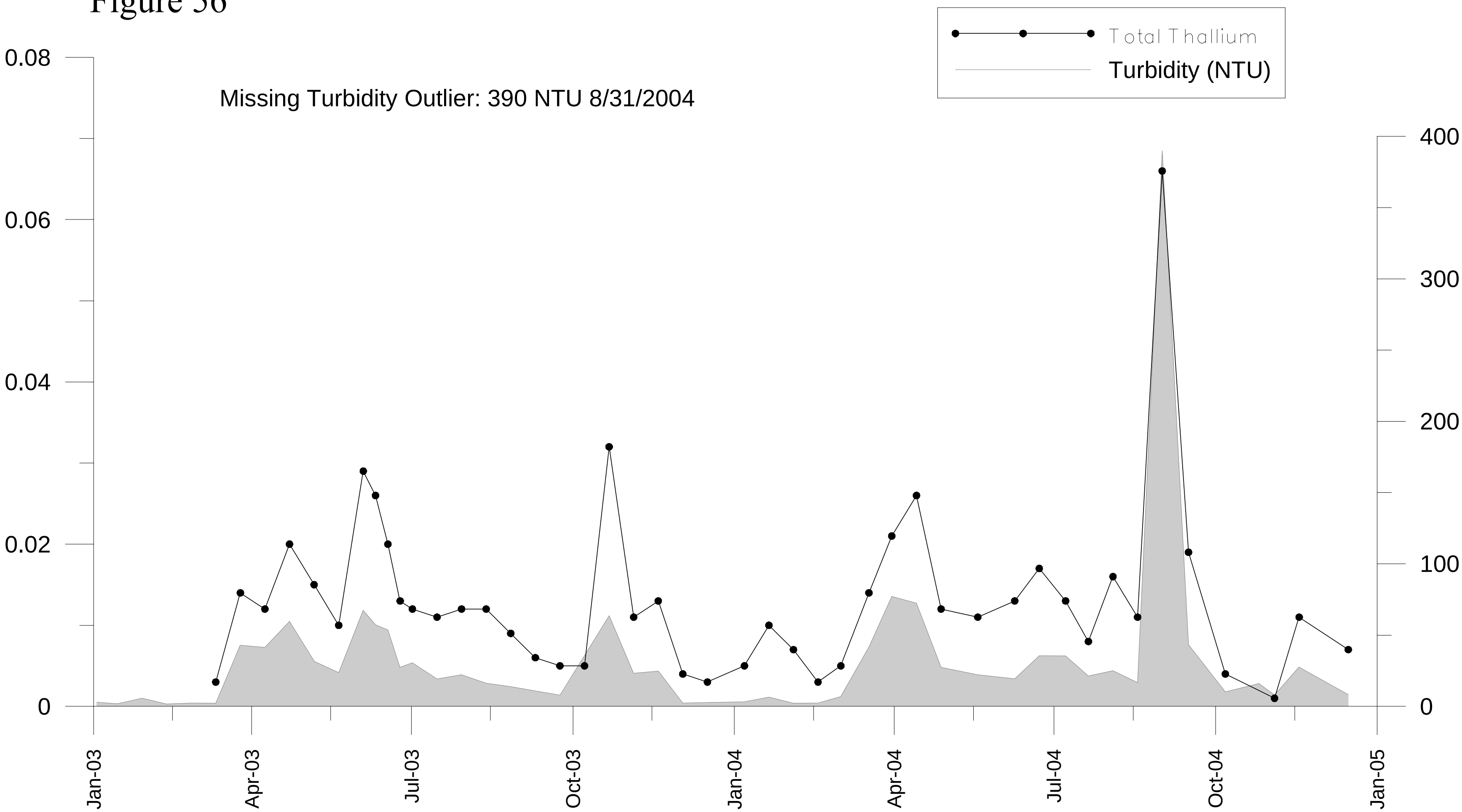

Fraser River at Hope
Specific Conductivity (uS/cm)
Figure 52
Specific Conductivity
200
160
120
80
40
25
20
15
10
5
0
Jan-85
Jan-88
Jan-91
Jan-94

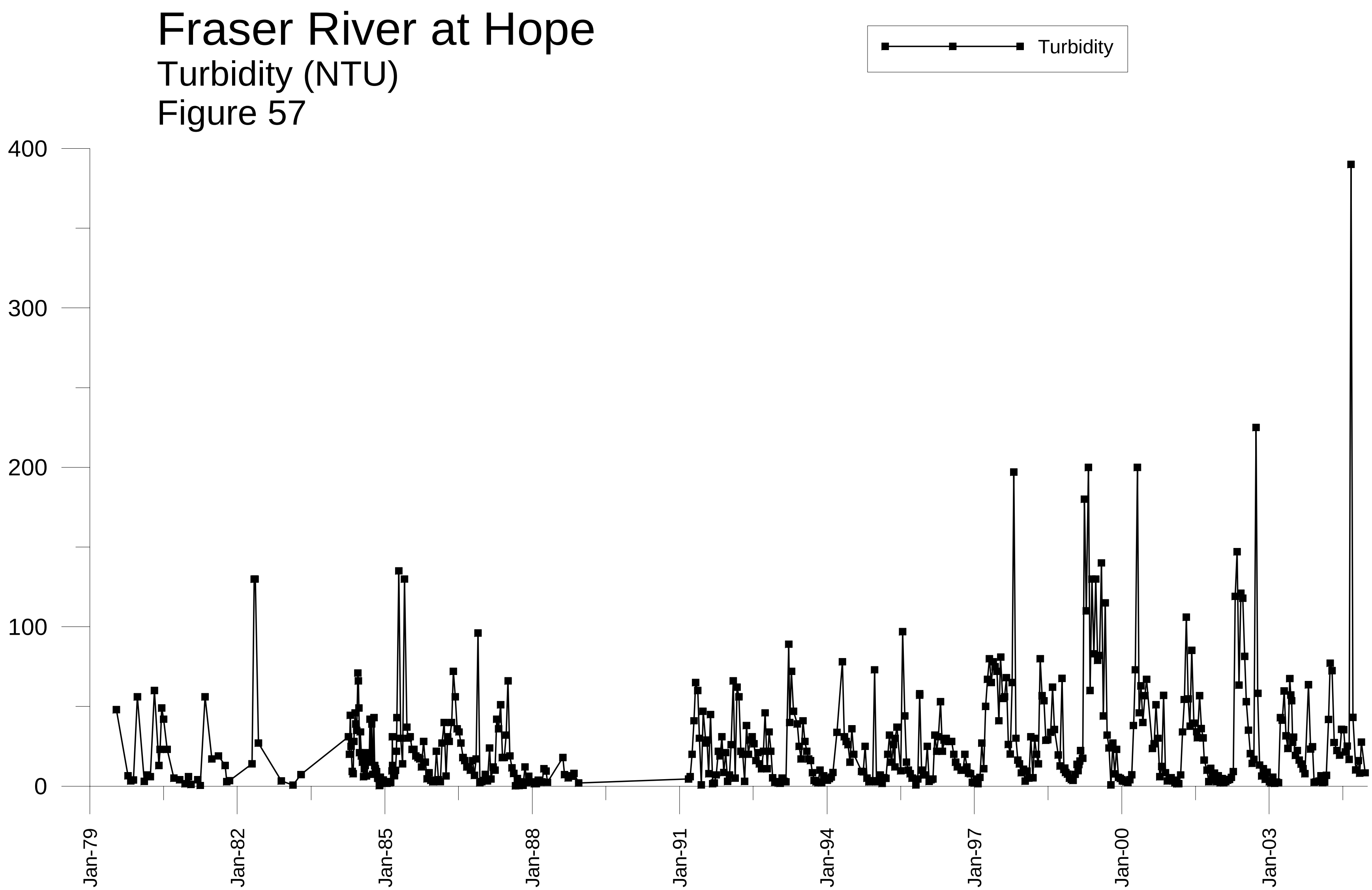

Fraser River at Hope
Strontium Total (ug/L)
Figure 53
Strontium Total
Specific Conductivity (uS/cm)
200
160
120
80
40
240
200
160
120
80
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

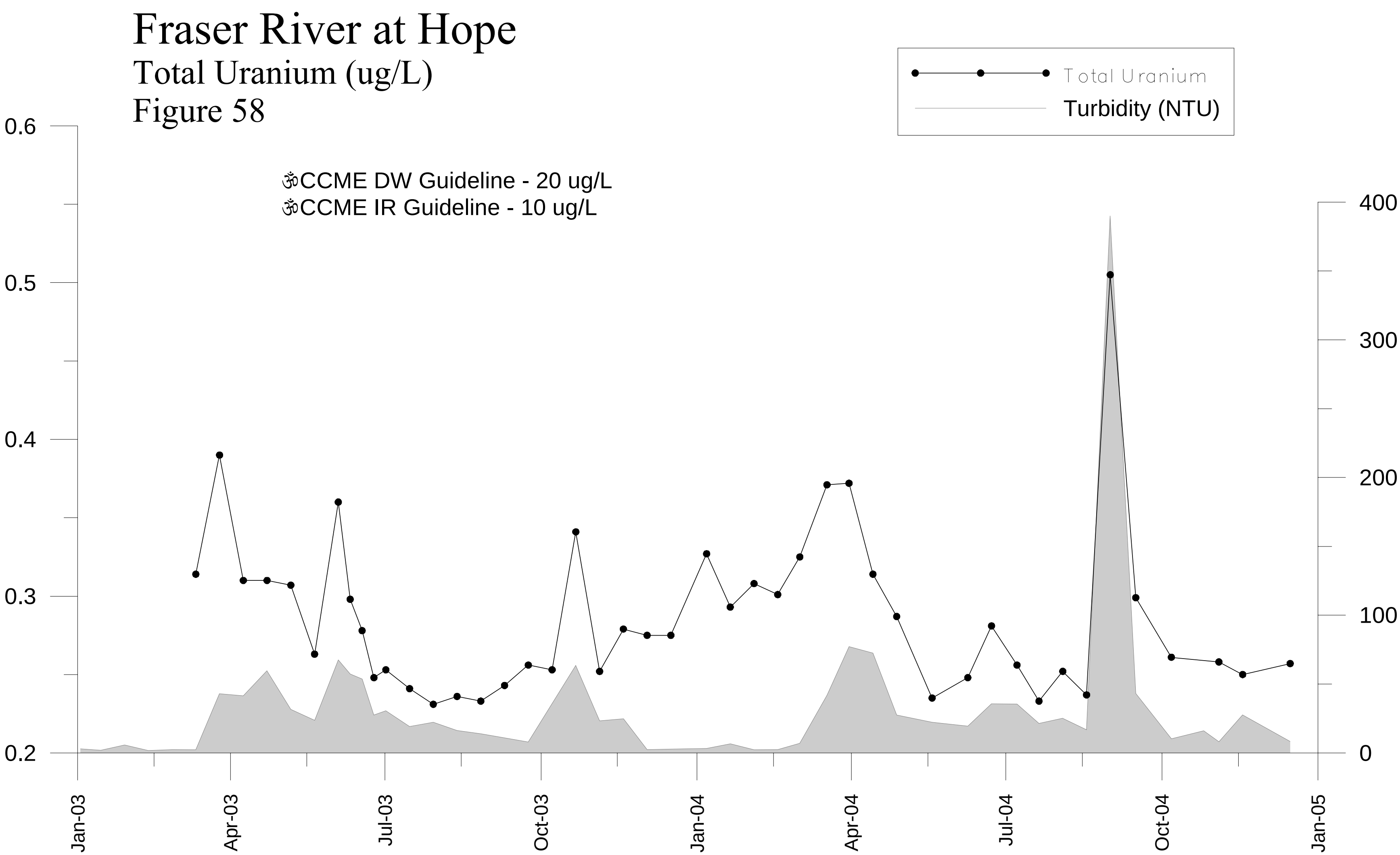

Fraser River at Hope
Sulphate Dissolved (mg/L)
Figure 54
BC DW Sulphate Guideline - 500 mg/L
BC AW Sulphate Guideline - 100 mg/L
Sulphate Dissolved
Conductivity (uS/cm) (background)
16
12
8
4
0
200
160
120
80
40
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00

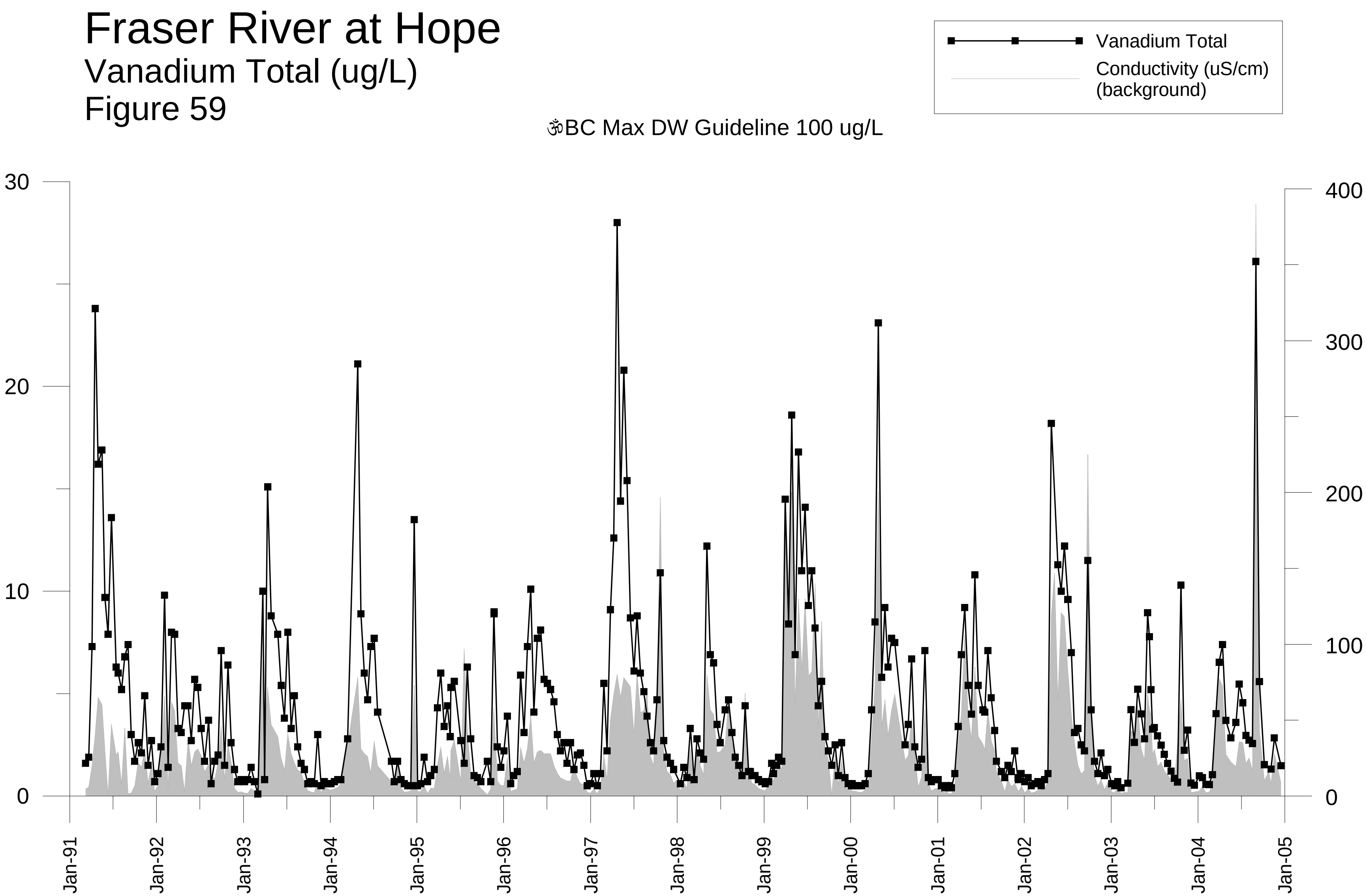

Fraser River at Hope
Temperature Air and Water (deg C)
Figure 55
Air Temperature
Water Temperature
BC Max Temp Water AW Guideline
Max weekly avg. for streams with unknown species dist.
BC Max Temp Water AW Guideline
Max daily incubation temp for spring and fall
BC Max Temp Water DW Guideline
40
20
0
-20
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

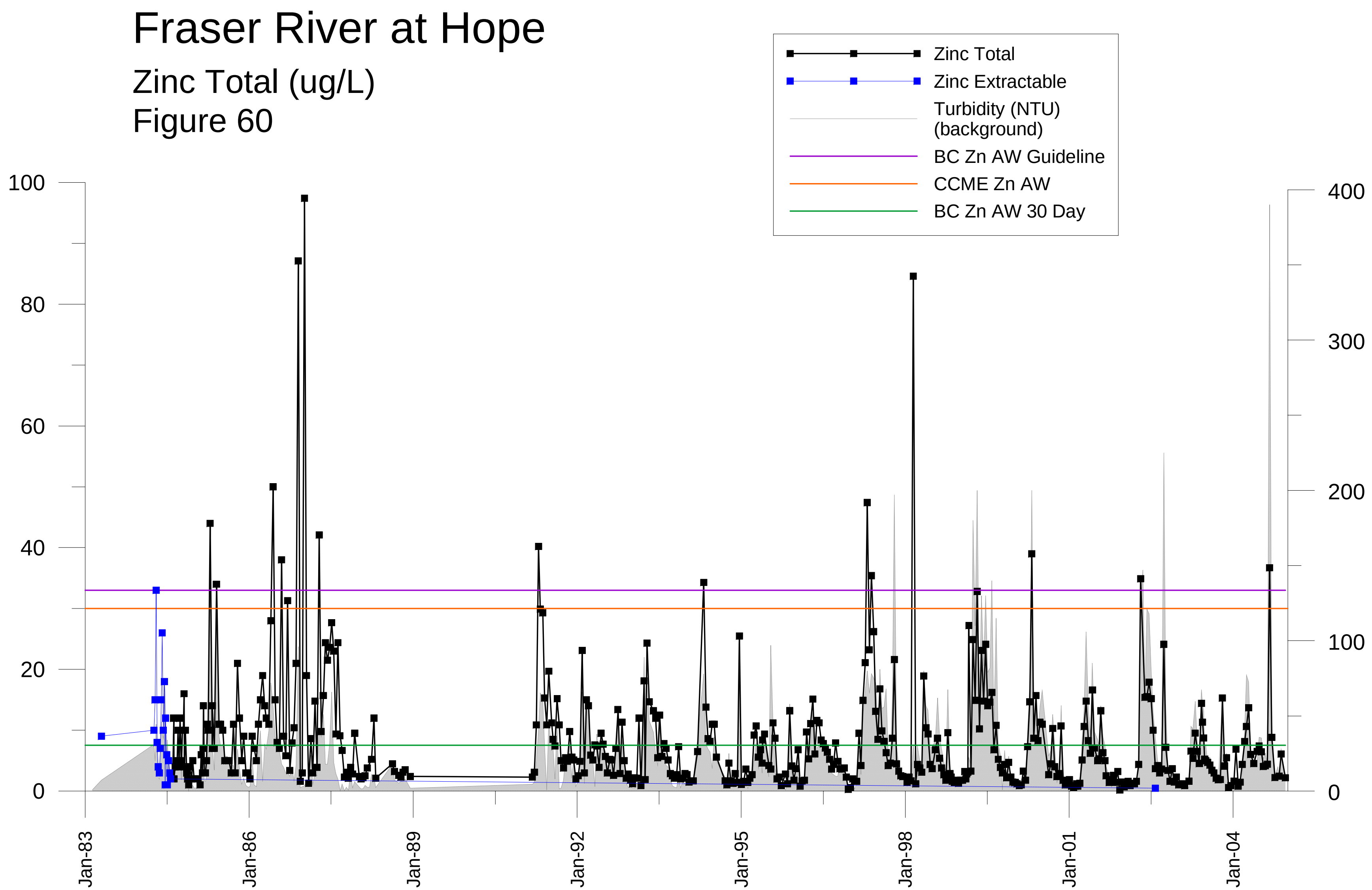
Fraser River at Hope
Total Thallium (ug/L)
Figure 56




Fraser River at Hope
Turbidity (NTU)
Figure 57
Turbidity
400
300
200
100
0
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03


Fraser River at Hope
Total Uranium (ug/L)
Figure 58
ॐCCME DW Guideline - 20 ug/L
ॐCCME IR Guideline - 10 ug/L
Total Uranium
Turbidity (NTU)
0.6
0.5
0.4
0.3
0.2
400
300
200
100
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05


Fraser River at Hope
Vanadium Total (ug/L)
Figure 59
BC Max DW Guideline 100 ug/L
Vanadium Total
Conductivity (uS/cm)
(background)
0
10
20
30
0
100
200
300
400
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Fraser River at Hope
Zinc Total (ug/L)
Figure 60
Zinc Total
Zinc Extractable
Turbidity (NTU) (background)
BC Zn AW Guideline
CCME Zn AW
BC Zn AW 30 Day
100
80
60
40
20
0
400
300
200
100
0
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Jan-01
Jan-04