CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Salmon River AT SALMON ARM (1985 – 2004)

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Prepared for:
B.C. Ministry of Environment
and
Environment Canada

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Environment Canada **Environnement Canada**

BRITISH COLUMBIA
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Ministry of Environment

EXECUTIVE SUMMARY

The Salmon River at Salmon Arm is located in the southern-interior portion of the province. Its headwaters originate about 15 km northeast from Salmon Lake. Some of the river's flow is diverted into Salmon Lake; much of that flow returns to the river via McInnis Creek, the outlet from Salmon Lake. From the confluence with McInnis Creek, the Salmon River flows northeast to Falkland, then southeast and east to Glenemma, and finally north to Salmon Arm before entering Shuswap Lake. The total length and drainage area of the Salmon River are approximately 120 km and 1510 km^2, respectively.

The Salmon River is an important tributary of Shuswap Lake, which drains into the South Thompson River. In addition to supporting anadromous salmonids, resident fish species and other aquatic organisms, the Salmon River and its tributaries provide important sources of raw water for domestic water supplies, irrigation, and livestock watering. Recreation and aesthetics also represent important uses of the aquatic environment, both of which generate social and economic benefits to area residents.

Concerns related to environmental quality conditions in the Salmon River are primarily associated with non-point source contaminant discharges. Such contaminants arise from a variety of land use activities, including forest management, agriculture and urban development. Contaminants of concern in the watershed include suspended solids, turbidity, ammonia, phosphorus, nitrogen, metals and fecal coliforms. In addition, water withdrawals from the river and nearby infiltration galleries have resulted in decreased stream flows and associated effects on water temperatures and other habitat features in the river.

CONCLUSIONS

- Flows fluctuate throughout the year, but peak in the May-June period on a yearly basis. Low flows seem to be consistent through most of the other months of the year.

- Water temperatures and dissolved oxygen often exceed water quality objectives, especially during the hot summer periods.
- Several metals exceeded guidelines or water quality objectives on occasion; however, these seemed to be correlated with turbidity and were likely in particulate form and not biologically available. Such metals included: aluminum, cobalt, chromium, copper, iron, lead, silver, and zinc. Cadmium also often exceeded guidelines, and was not always related to turbidity, which means that it could potentially be more available to aquatic life. This has just become evident over the past couple of years since the cadmium detection limit has decreased; cadmium will continue to be monitored at these low levels to track this potential concern.
- Colour values and fecal coliforms and E. Coli often exceeded guidelines for drinking water at the source; however, these were related to turbidity events and complete treatment of the source water would be needed prior to use for drinking.
- Arsenic values may be showing a slight increase in concentration through the period of record. This may be due to a larger groundwater contribution to the flow.
- Lithium and extractable silicon were showing distinct decreases in concentrations over time.

RECOMMENDATIONS

- We recommend monitoring be continued for the Salmon River at Salmon Arm to track the possible increases in variables, and guideline exceedences that have been identified in this report.

- Either trivalent and hexavalent forms of chromium should be measured in the future, or alternately, guidelines be developed for total chromium values.

- A statistical analysis of the data for arsenic, lithium, and silicon should be conducted to confirm whether the identified trends are real.

Water quality indicators that are important for future monitoring are:

- flow, water temperature, specific conductivity, pH, turbidity, hardness, and dissolved oxygen,
- appropriate forms of metals for comparison to their respective guidelines, and
- other variables related to drinking water such as colour, fecal coliforms and E. Coli.

ACKNOWLEDGEMENTS

The graphs in this report were prepared by Sacha Wassick of Environment Canada. The draft report was reviewed by Andrea Ryan from Environment Canada. We thank these individuals for their contributions to improving this document. Any errors or omissions are the responsibility of the author.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF FIGURES
(CONTINUED)

LIST OF FIGURES
(CONTINUED)

Page

LIST OF FIGURES
(CONTINUED)

Page

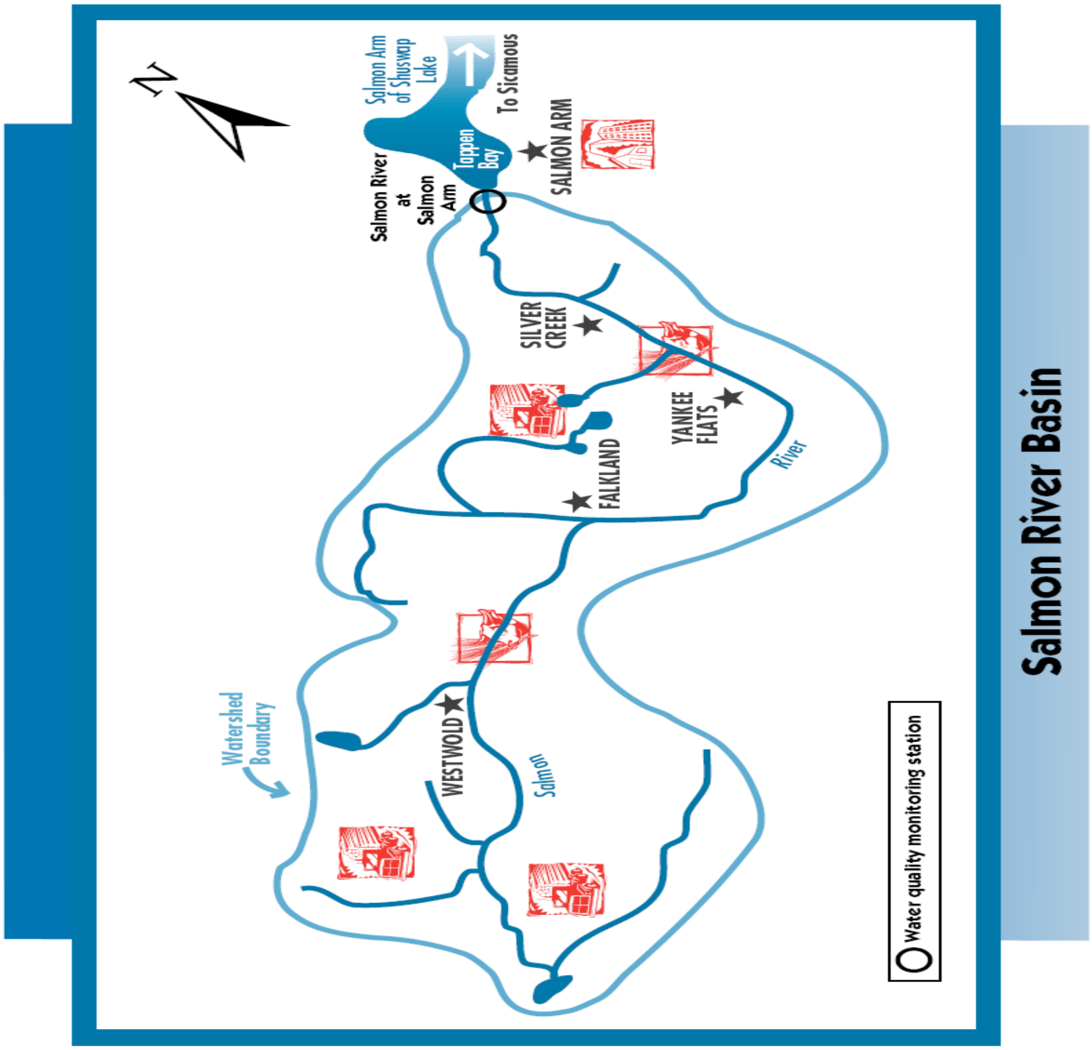
Introduction

The Salmon River, near Salmon Arm B.C., is located in the southern-interior portion of the province (Figure 1). Its headwaters originate in the vicinity of Tahaetkun and Bouleau Mountains, south of Westwold and northeast of Merritt. The river's headwaters are located in Monte Hills Provincial Forest, some 15 km northeast from Salmon Lake. Some of the river's flow is diverted into Salmon Lake; much of that flow returns to the river via McInnis Creek, the outlet from Salmon Lake. From the confluence with McInnis Creek, the Salmon River flows northeast to Falkland, then southeast and east to Glenemma, and finally north to Salmon Arm before entering Shuswap Lake. The total length and drainage area of the Salmon River are approximately 120 km and 1510 km^2, respectively.

The Salmon River is an important tributary of Shuswap Lake, which drains into the South Thompson River. In addition to supporting anadromous salmonids, resident fish species and other aquatic organisms, the Salmon River and its tributaries provide important sources of raw water for domestic water supplies, irrigation, and livestock watering. Recreation and aesthetics also represent important uses of the aquatic environment, both of which generate social and economic benefits to area residents.

Concerns related to environmental quality conditions in the Salmon River are primarily associated with non-point source contaminant discharges. Such contaminants arise from a variety of land use activities, including forest management, agriculture and urban development. Contaminants of concern in the watershed include suspended solids, turbidity, ammonia, phosphorus, nitrogen, metals and fecal coliforms. In addition, water withdrawals from the river and nearby infiltration galleries have resulted in decreased stream flows and associated effects on water temperatures and other habitat features in the river.

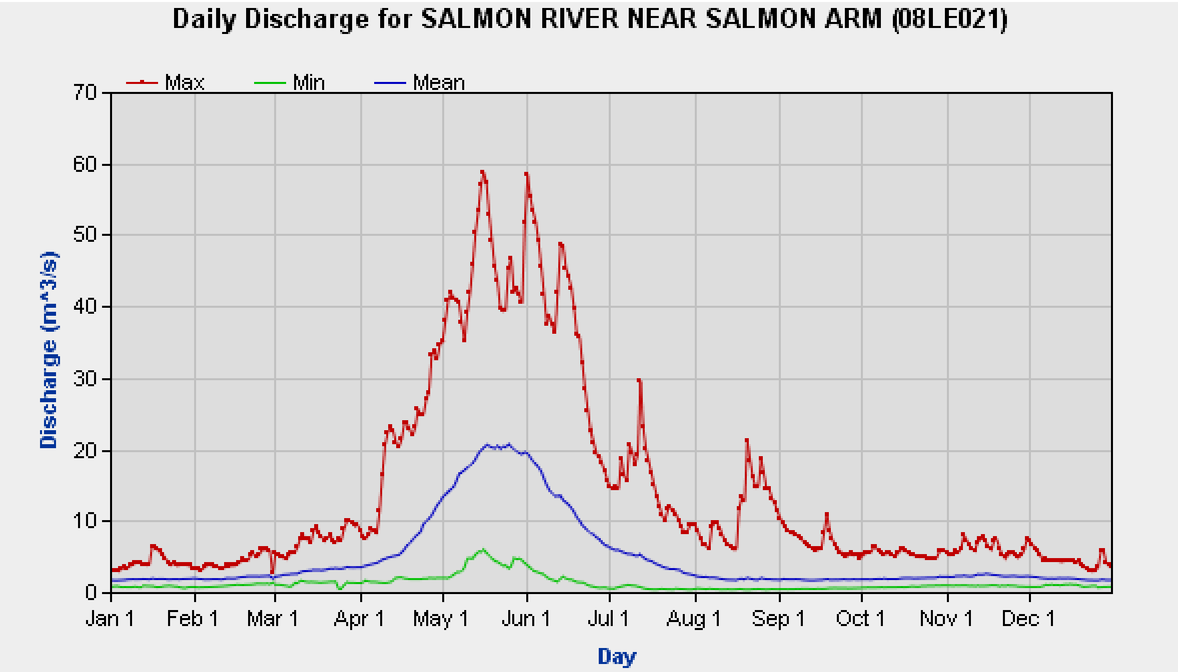
FIGURE 1: Salmon River at Salmon Arm



This report discusses water quality data collected by the provincial and federal governments between 1985 and 2004 from a station on Salmon River near its mouth at Salmon Arm. Data for the Salmon River at Salmon Arm 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 federal data are stored under ENVIRODAT station number BC08LE0004 and the BC Environment station E206092. The water quality variables are plotted in Figures 3 to 79. Water Survey of Canada operates a flow gauge at the same site (site number BC08LE021). Flow data from 1911 to 2004 are graphed in Figure 2.

FIGURE 2: Water Survey of Canada Flow Data for Salmon River near Salmon Arm



WATER QUALITY ASSESSMENT

The state of the water quality was assessed by comparing the values to B.C.'s approved and working guidelines for water quality (B.C. Ministry of Environment, Lands and Parks, 2001), and by looking for any obvious trends in the data. Any levels or apparent trends that were found to be deleterious or potentially deleterious to sensitive water uses, including drinking water, aquatic life, wildlife, recreation, irrigation, and livestock watering were noted in the following variable-by-variable discussion.

The following water quality indicators are not discussed as they met all water quality guidelines and showed no clearly visible trends: phenolphthalein alkalinity, ammonia, barium, bromide, nitrite, total nitrogen, fixed non-filterable residue, fixed filterable residue, non-filterable residue, extractable silicon, and tin.

The following water quality indicators seemed to fluctuate through the year according to turbidity concentrations, but were below guideline values and had no other trends: antimony, beryllium, bismuth, dissolved organic carbon, gallium, lanthanum, manganese, nickel, total phosphorus, rubidium, thallium, and vanadium.

Other water quality indicators seemed to fluctuate through the year according to the specific conductivity of the water. 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, ammonia, boron, dissolved inorganic carbon, calcium, chloride, potassium, magnesium, molybdenum, nitrate, total dissolved nitrogen, pH, sodium, hardness, strontium, sulphate, and uranium.

Flows (Figure 2): fluctuate throughout the year, but peak in the May-June period on a yearly basis. Mean flows throughout the year are about 2 m^3/s; although mean peak flows are about 20 m^3/s. Absolute peak flows have been as high as 60 m^3/s.

Aluminum (Figure 3): values exceed the drinking water guideline; however, values have fluctuated with turbidity, are likely in particulate form, and not biologically available. There does not appear to be any trend in values during the period of record.

Arsenic (Figure 8): values have been below guidelines but seem to be increasing in value during the period of record. When we used a linear regression, we found that there was a weak correlation of values increasing through time ($R^2 = 0.05$). Total arsenic values also seem to increase with turbidity, meaning that higher values are likely in particulate form and not biologically available.

Cadmium (Figures 18 and 19): values seemed to fluctuate with turbidity, which means that higher values would be associated with particulate matter and would likely not be biologically available. Although values seem to be getting lower through the period of record, this is likely more a phenomenon related to decreasing detection limits and improved analytical capabilities through time, rather than a real decrease in concentration. Lower cadmium values, and their detection limits, during the 2003-2004 period also coincided with lower turbidity concentrations. Additional data need to be collected to determine whether turbidity and cadmium are in fact beginning to decline.

Cyanide (Figure 21): values generally were well below the maximum and 30-day average guidelines for weak-acid dissociable cyanide. One exception was a total cyanide value in October 2004. Since data for only one year have been collected, additional sampling is required before any trends might become evident.

Cobalt (Figure 22): values seemed to be correlated with turbidity, which means that higher cobalt values are associated with particulate matter and not likely biologically available. The occasional individual value has exceeded the BC guideline of 4 µg/L for the 30-day mean concentration; however, all individual values were well below the guideline for maximum concentrations of 110 µg/L. Lower cobalt values in 2003-2004 coincided with lower turbidity concentrations. Additional data need to be collected to determine whether turbidity and cobalt are in fact beginning to decline.

Colour: apparent colour (Figure 23) values from 1988 until 1998 seemed to fluctuate with turbidity and regularly exceeded the drinking water guideline of 15 TCU for true colour; however, this is to be expected since true colour is measured on a filtered sample (i.e., turbidity removed). True colour values (Figure 24) began to be measured in 1997 and were lower than apparent colour values, as expected; however, values seem to fluctuate with turbidity and regularly exceeded the drinking water guideline.

Chromium (Figure 25): values in the 1990’s exceeded the guideline for trivalent chromium and hexavalent chromium; however, since the year 2000, only the guideline for hexavalent chromium has been exceeded. Values seem to fluctuate with turbidity values, meaning that the higher chromium values are likely in particulate form and not biologically available. There is a very weak trend identified using a linear regression ($R^2 = 0.017$) of decreasing concentrations through time; however, this is likely related to lower turbidity concentrations in the post-2000 period. We recommend that either trivalent and hexavalent forms of chromium be measured in the future or guidelines be developed for total chromium values.

Copper (Figures 26 and 27): values generally met the guidelines (hardness-dependent) for maximum and 30-day mean concentrations; however, when these were exceeded, turbidity values were also high. This mean that the higher copper values are in particulate form and not likely biologically available. Higher values in the late 1980’s were quite high due to widespread contamination because of the failure of preservative vial cap liners between 1986 and 1991.

E. Coli (Figure 28) and **Fecal Coliforms** (Figure 31): regularly exceeded the water quality guideline and short and long-term water quality objectives, respectively, for drinking water sources. High fecal coliforms seem to be correlated with high turbidity concentrations. Drinking water taken form the Salmon River would require complete treatment.

Fluoride (Figure 29): values were measured only between 1988 and 1999. Values generally met the aquatic life guideline of 0.3 µg/L. High fluoride values coincided with periods of high specific conductivity and low river flows, suggesting that the fluoride was a result of groundwater contributions to the base flow of the river.

Iron (Figure 30): values regularly exceeded the guideline for the protection of aquatic life and drinking water supplies (aesthetics) of 300 µg/L. High iron values were correlated with high turbidity concentrations, meaning that the iron was in particulate form and not biologically available. It would also be removed in water treatment processes for drinking water supplies. Peak iron values since 2000 seem to be lower than during the previous decade; however, these lower values are likely the result of lower turbidity values during that period.

Hardness (Figure 33): values were strongly correlated with specific conductivity and low river flows, suggesting that the hardness was a result of groundwater contributions to the base flow of the river. Values throughout the year were generally higher than the 100 mg/L level for drinking water supplies.

Lead (Figure 36): values seem to correlate with turbidity, meaning that high lead values are in particulate form and not likely biologically available. Values were generally below all guidelines for aquatic life and drinking water supplies, with only two individual values exceeding the lowest BC 30-day mean guideline of 4.5 µg/L. Analytical detection limits for lead were reduced in 2003 from the 0.2 µg/L level, which means that in future years, trends to lower values might be suspected; however, the lower detection limits may be responsible for such observations.

Lithium (Figure 37): values have shown a strong decline during the period of record ($R^2 = 0.31$) but have always been below the BC guideline to protect aquatic life of 67 µg/L. Values also seem to be correlated with high specific conductivity and low flows, meaning that the lower values are likely associated with a groundwater contribution to base river flow.

Dissolved Oxygen (Figure 48): values seem to fluctuate with conductivity, which is not surprising in that conductivity peaks occur when there are low flows in the colder months of the year, and under normal situations, dissolved oxygen concentrations rise at colder temperatures. Only one value was slightly below the 8 mg/L water quality objective.

Selenium (Figure 56): values on occasion exceeded the guideline to protect aquatic life of 1 µg/L. Selenium values seemed to be correlated with specific conductivity with highest values occurring during low flow conditions.

Silica and Silicon (Figure 58): Values for extractable silicon have decreased considerably over the period from 1999 until 2002, with a linear regression having a R^2 value of 0.23.

Silver (Figures 59 and 60): values on occasion exceeded the BC aquatic life guideline of 0.1 µg/L, but this usually happened when detection limits were at that level. The detection limit for silver was reduced to 0.001 µg/L in early 2003, and no values have exceeded the guideline since that time. Data from that latter period seem to fluctuate with turbidity concentrations, meaning that the higher silver values are related to particulate and not likely biologically available.

Water Temperature (Figure 65): varies with flow and the time of year. Temperatures have exceeded objective levels especially during the hot summer periods.

Zinc (Figures 71 and 72): values fluctuate with turbidity, which means that high values are associated with particulate matter and not likely biologically available. Occasional values exceed aquatic life guidelines that are hardness-dependent.

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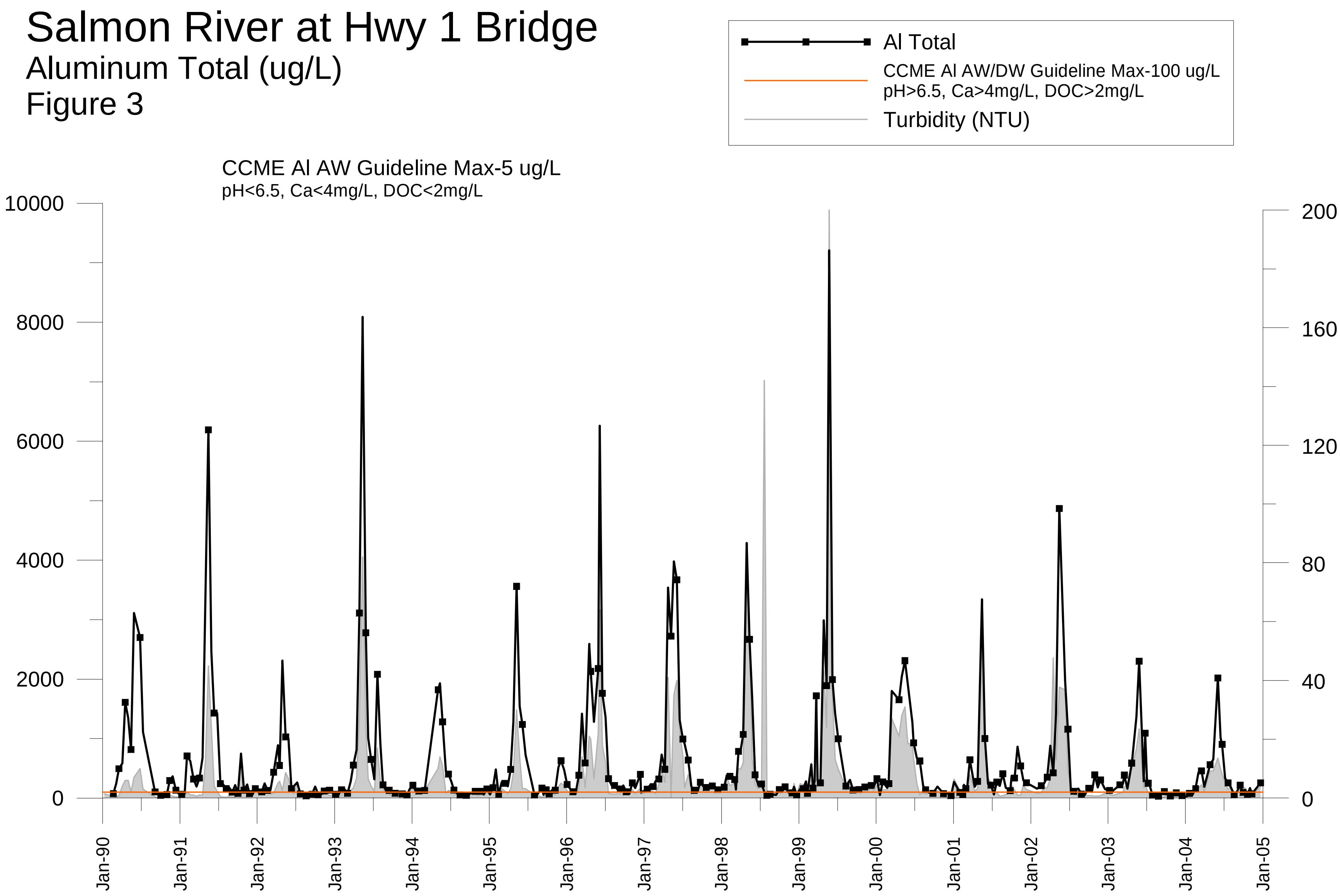
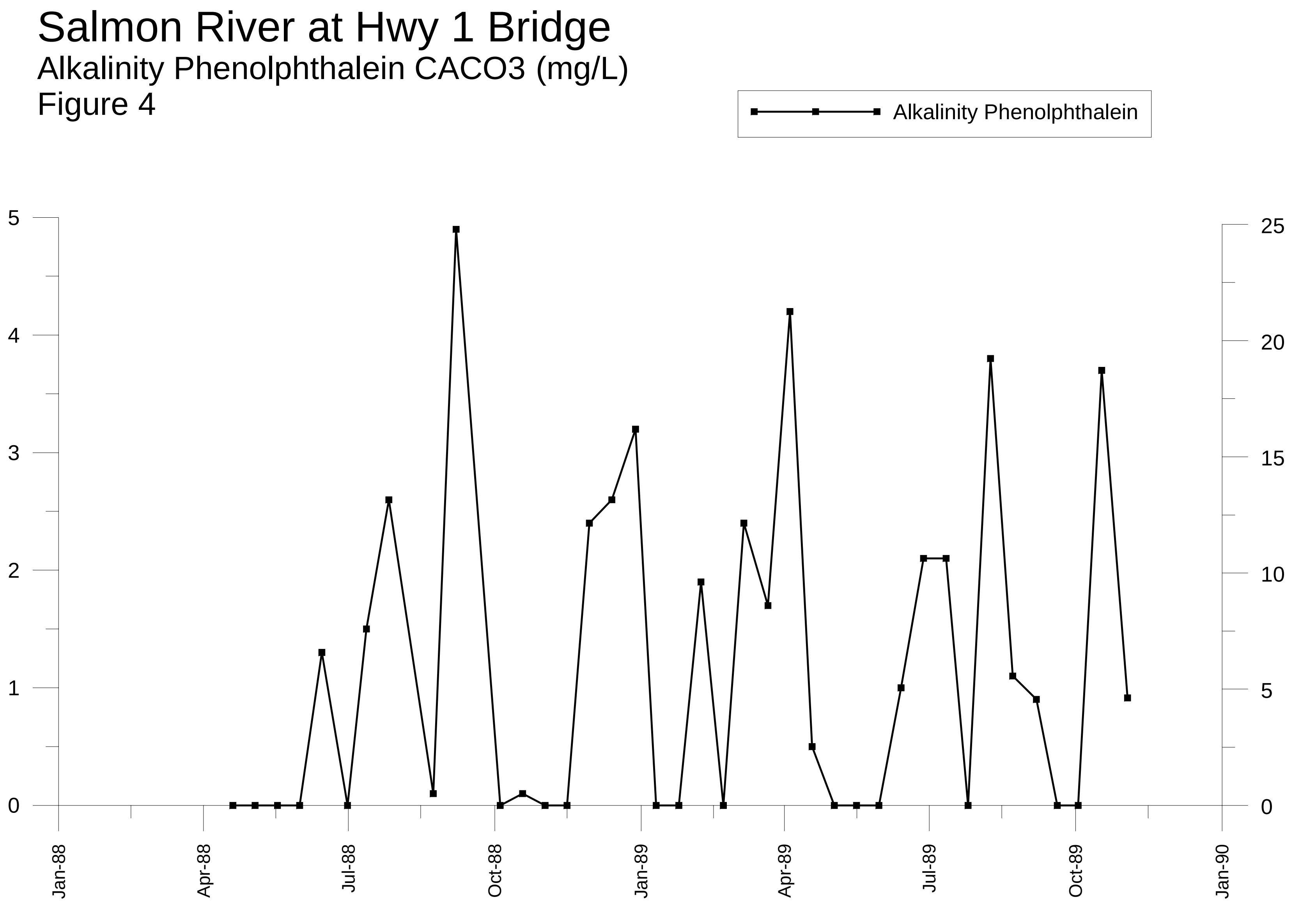
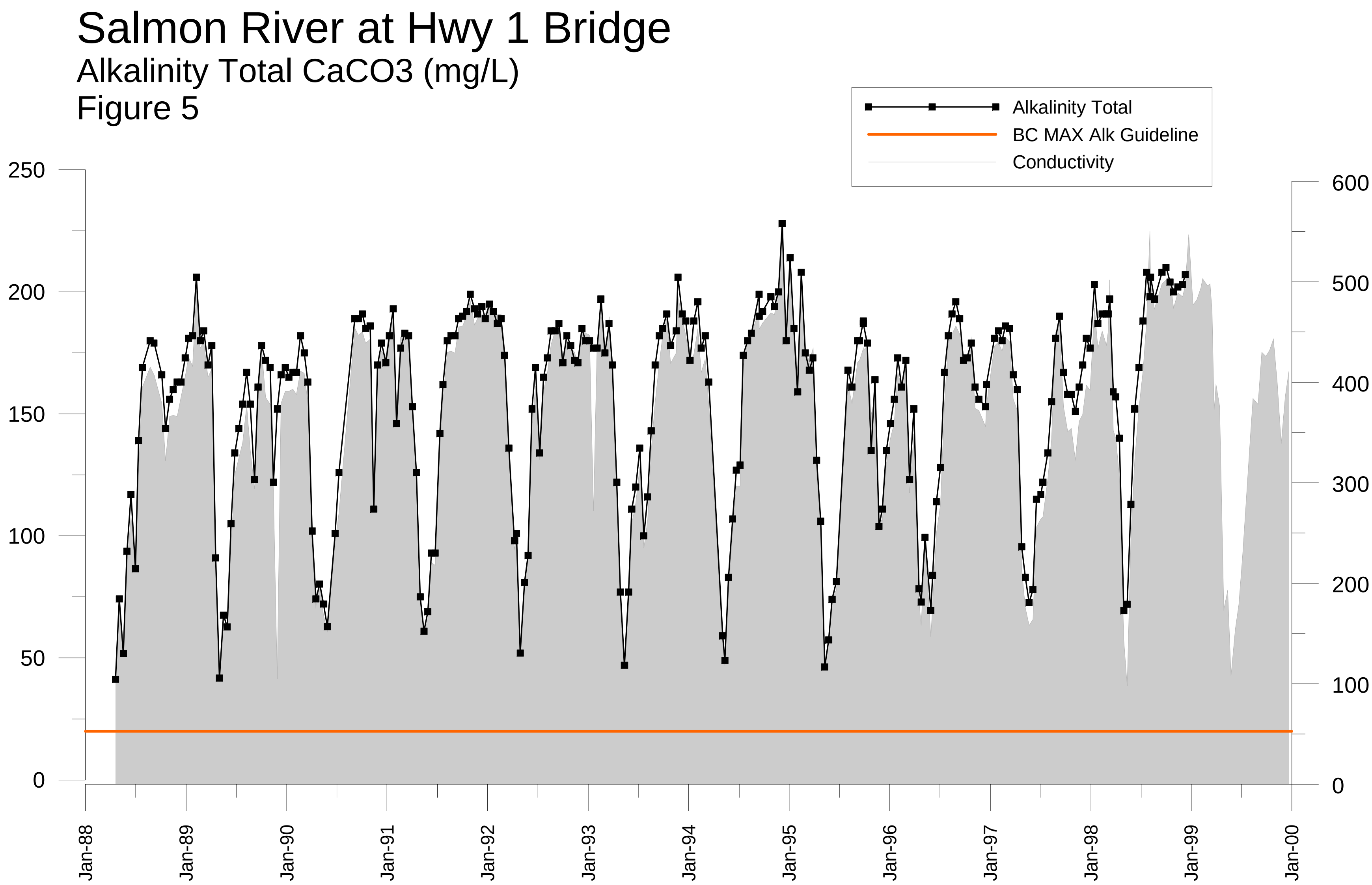
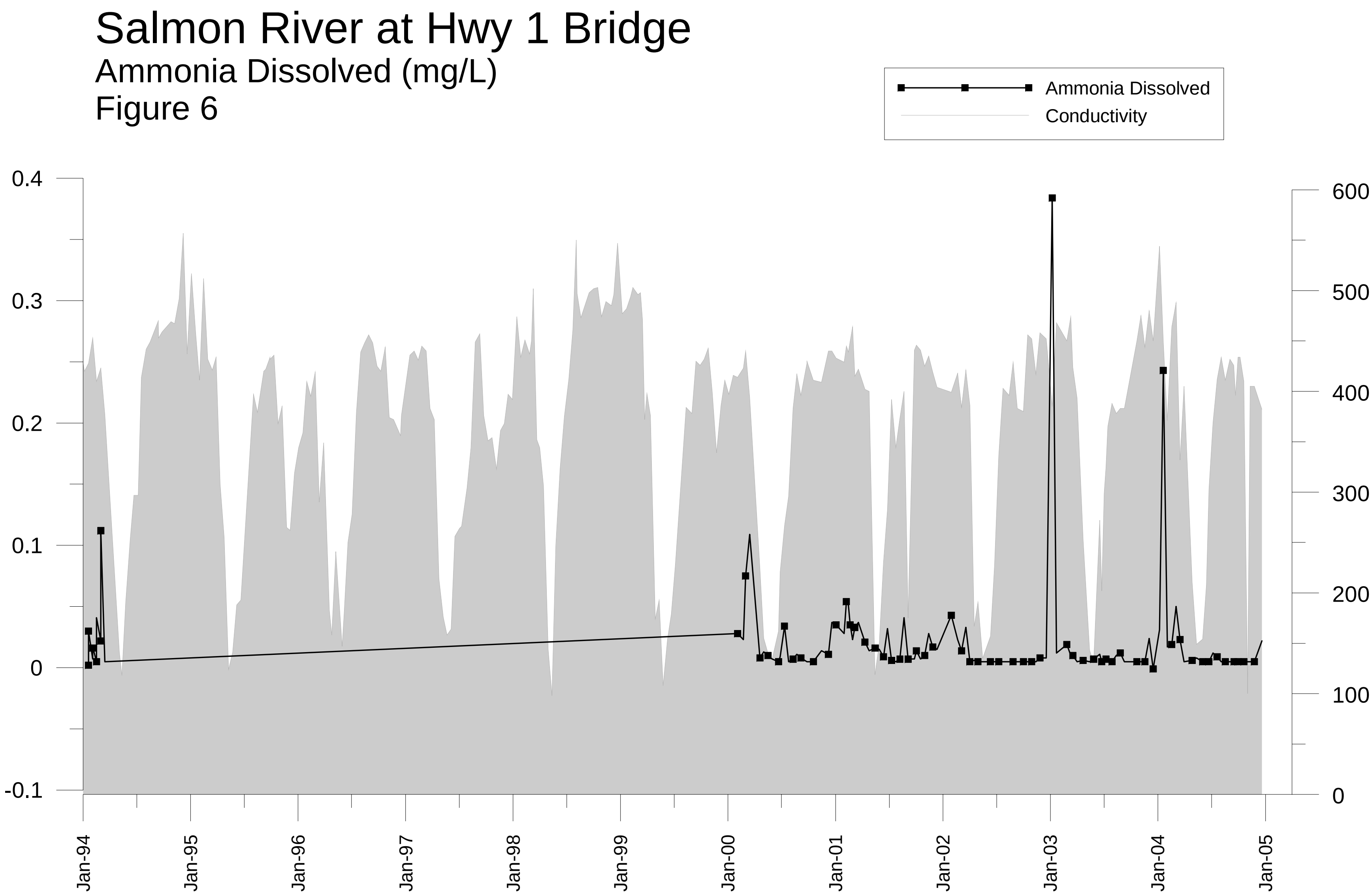

Salmon River at Hwy 1 Bridge
Aluminum Total (ug/L)
Figure 3
Al Total
CCME Al AW/DW Guideline Max-100 ug/L
pH>6.5, Ca>4mg/L, DOC>2mg/L
Turbidity (NTU)
CCME Al AW Guideline Max-5 ug/L
pH<6.5, Ca<4mg/L, DOC<2mg/L
10000
8000
6000
4000
2000
0
200
160
120
80
40
0
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Salmon River at Hwy 1 Bridge
Alkalinity Phenolphthalein CACO3 (mg/L)
Figure 4
Alkalinity Phenolphthalein
0
1
2
3
4
5
0
5
10
15
20
25
Jan-88
Apr-88
Jul-88
Oct-88
Jan-89
Apr-89
Jul-89
Oct-89
Jan-90

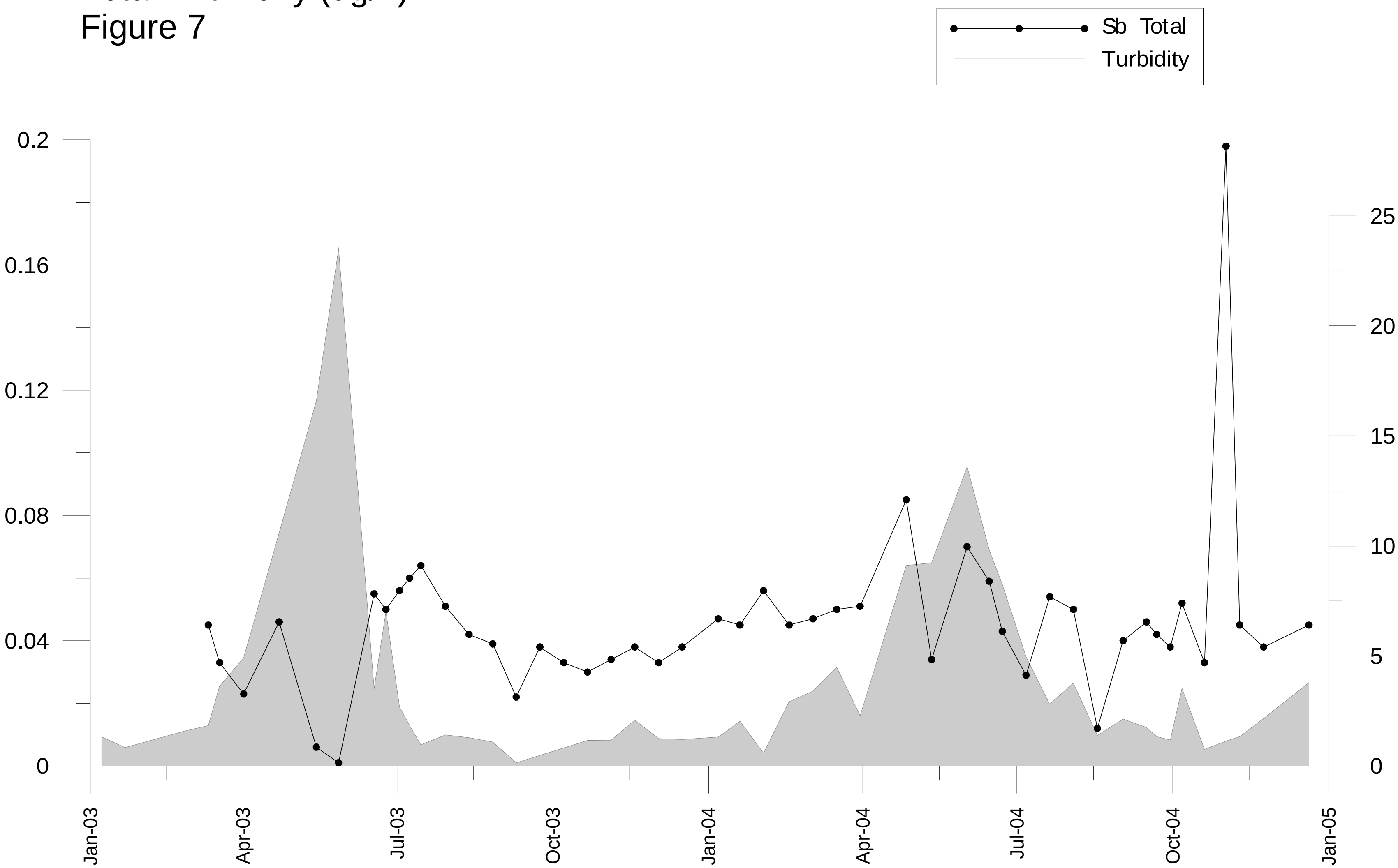

Salmon River at Hwy 1 Bridge
Alkalinity Total CaCO3 (mg/L)
Figure 5
Alkalinity Total
BC MAX Alk Guideline
Conductivity
0
50
100
150
200
250
0
100
200
300
400
500
600
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00


Salmon River at Hwy 1 Bridge
Ammonia Dissolved (mg/L)
Figure 6
Ammonia Dissolved
Conductivity
0.4
0.3
0.2
0.1
0
-0.1
600
500
400
300
200
100
0
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

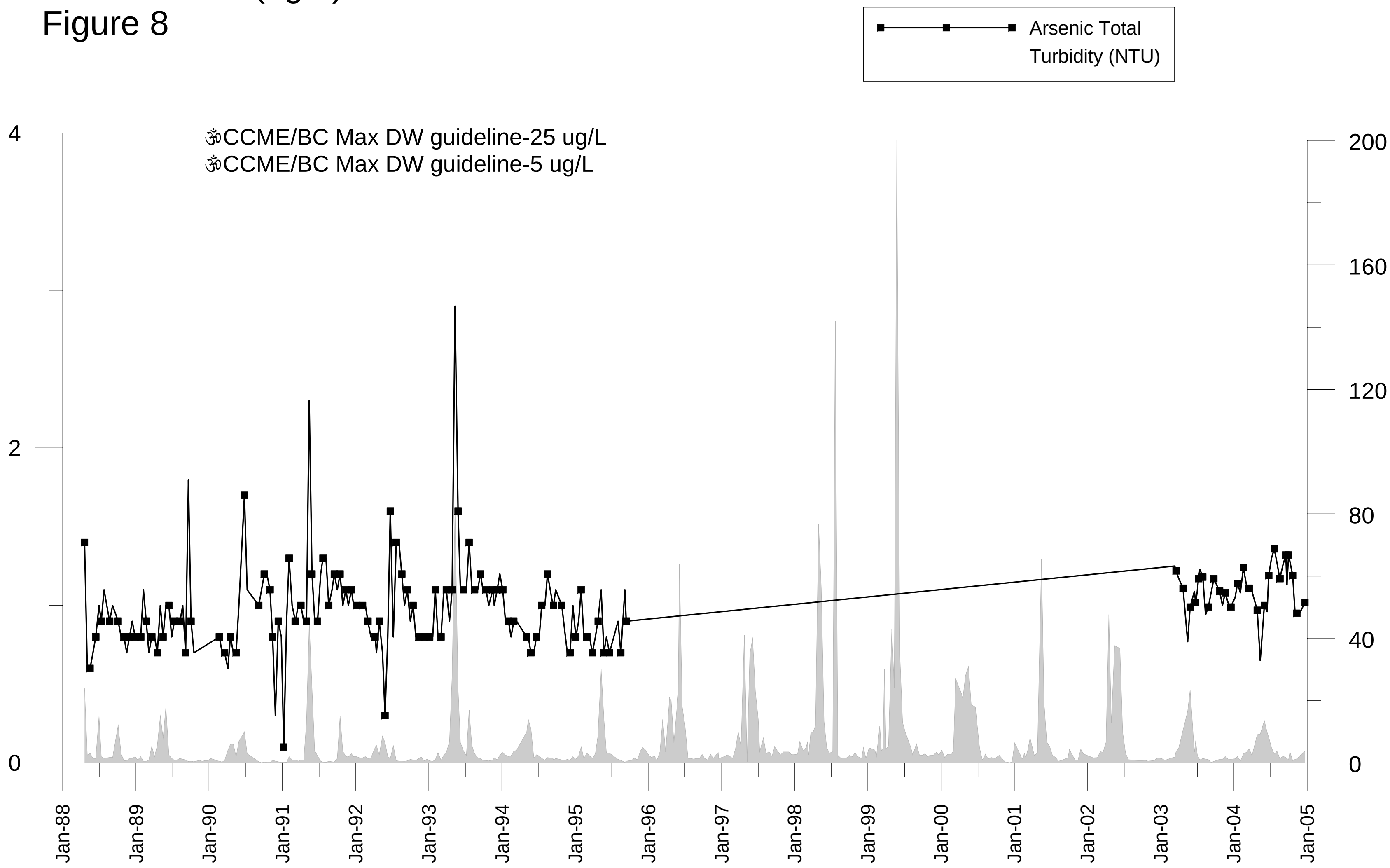
Salmon River at Hwy 1 Bridge

Total Antimony (ug/L)

Figure 7



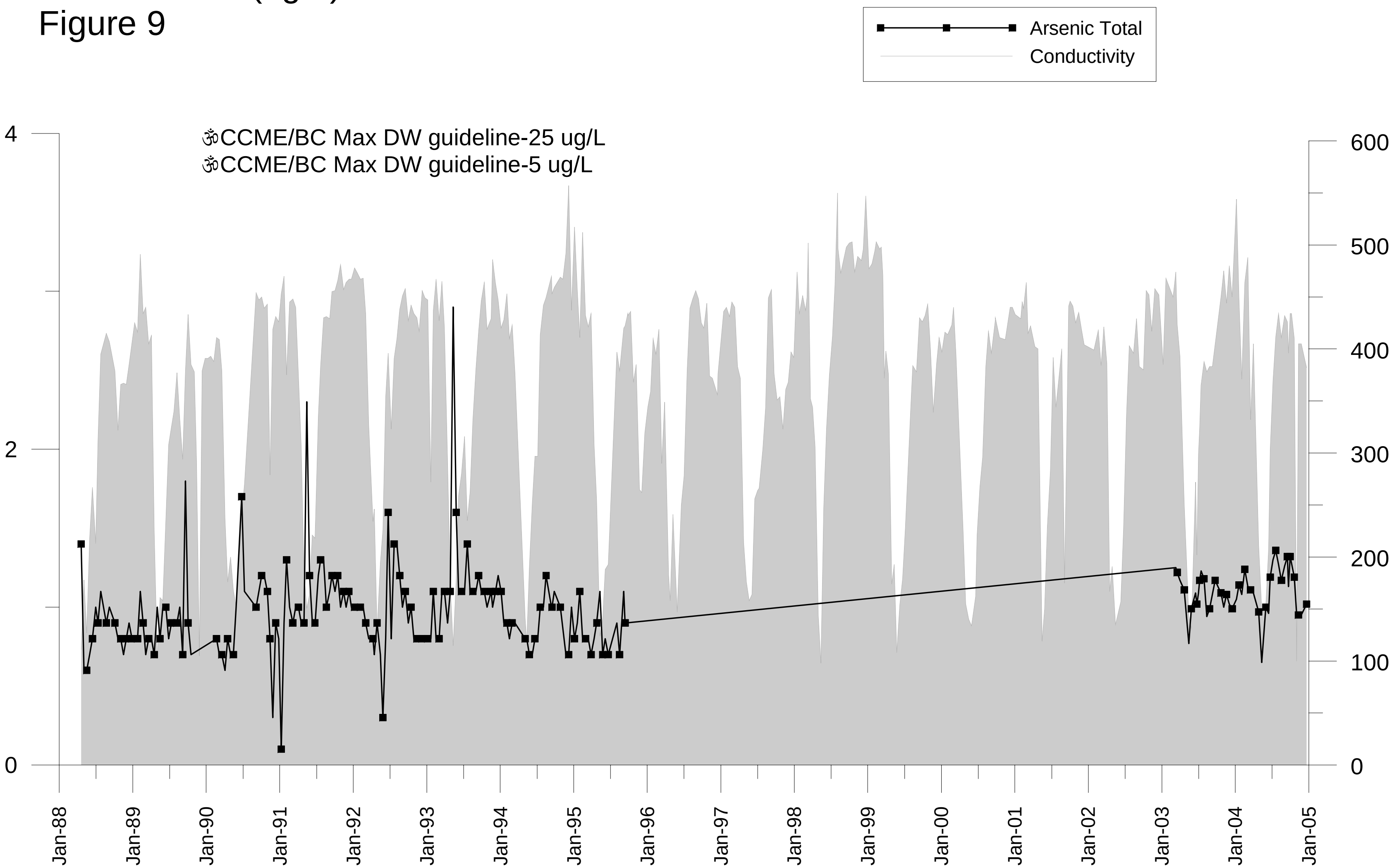
Salmon River at Hwy 1 Bridge
Arsenic Total (ug/L)
Figure 8

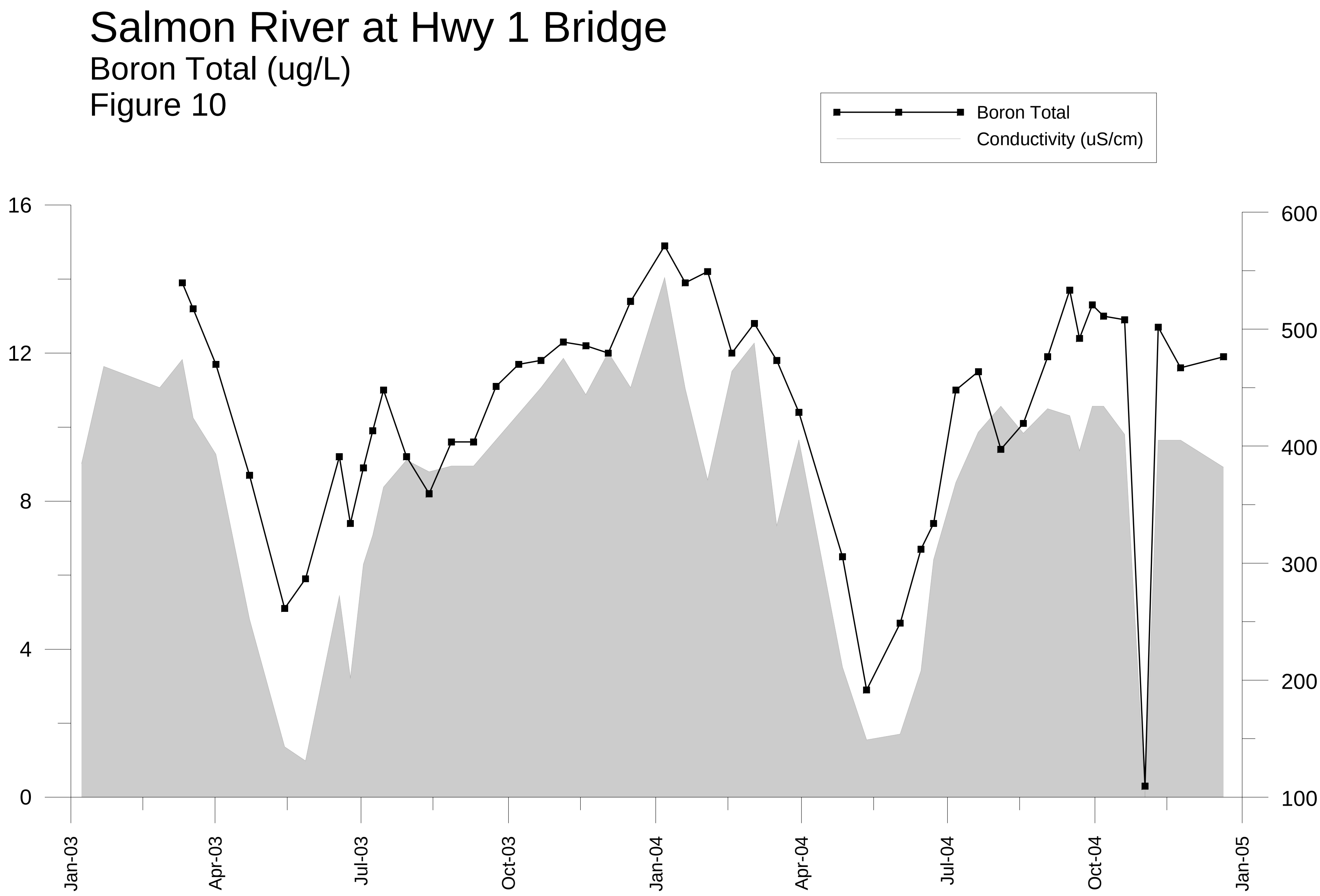


Salmon River at Hwy 1 Bridge

Arsenic Total (ug/L)

Figure 9

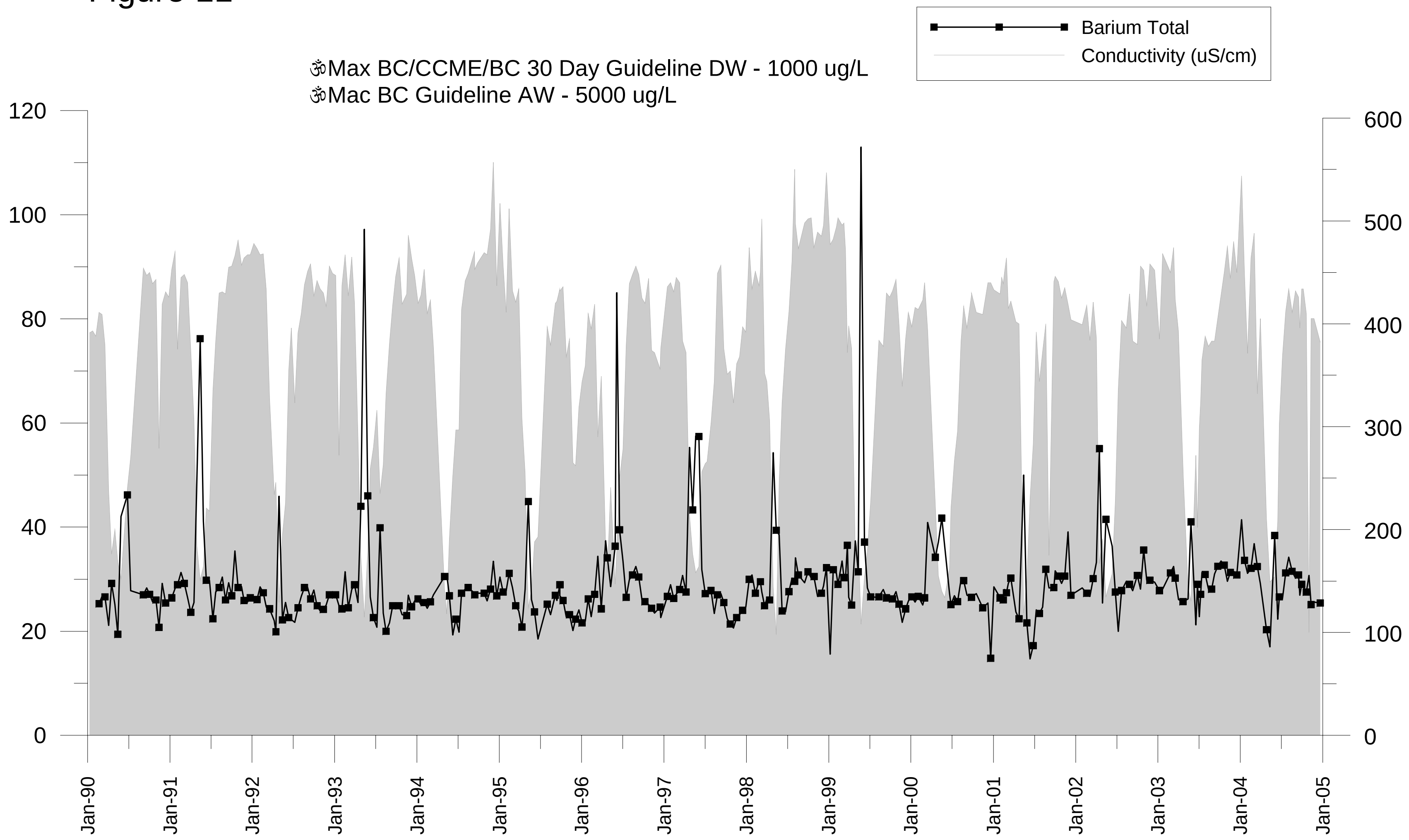



Salmon River at Hwy 1 Bridge
Boron Total (ug/L)
Figure 10
Boron Total
Conductivity (uS/cm)
0
4
8
12
16
100
200
300
400
500
600
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

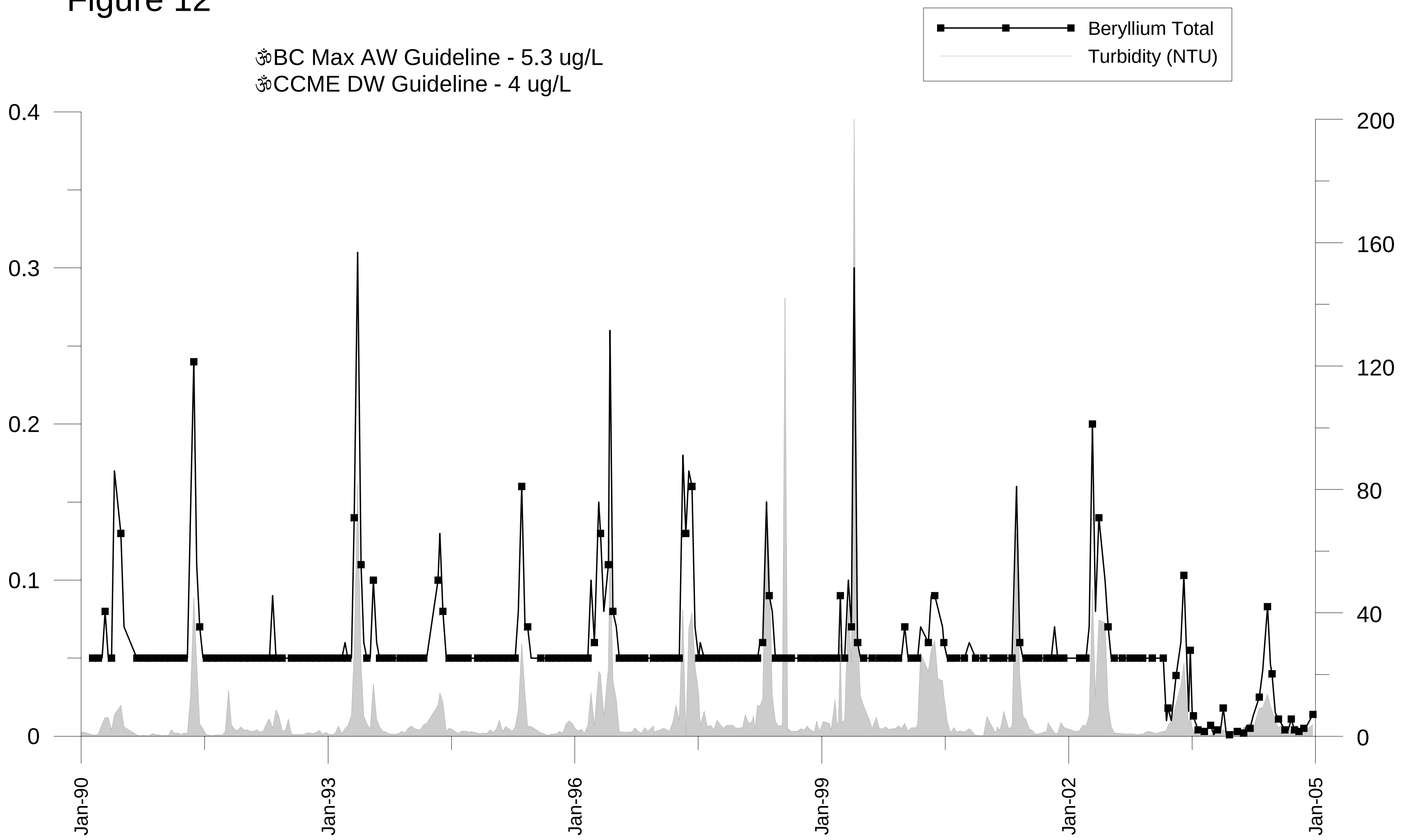
Salmon River at Hwy 1 Bridge

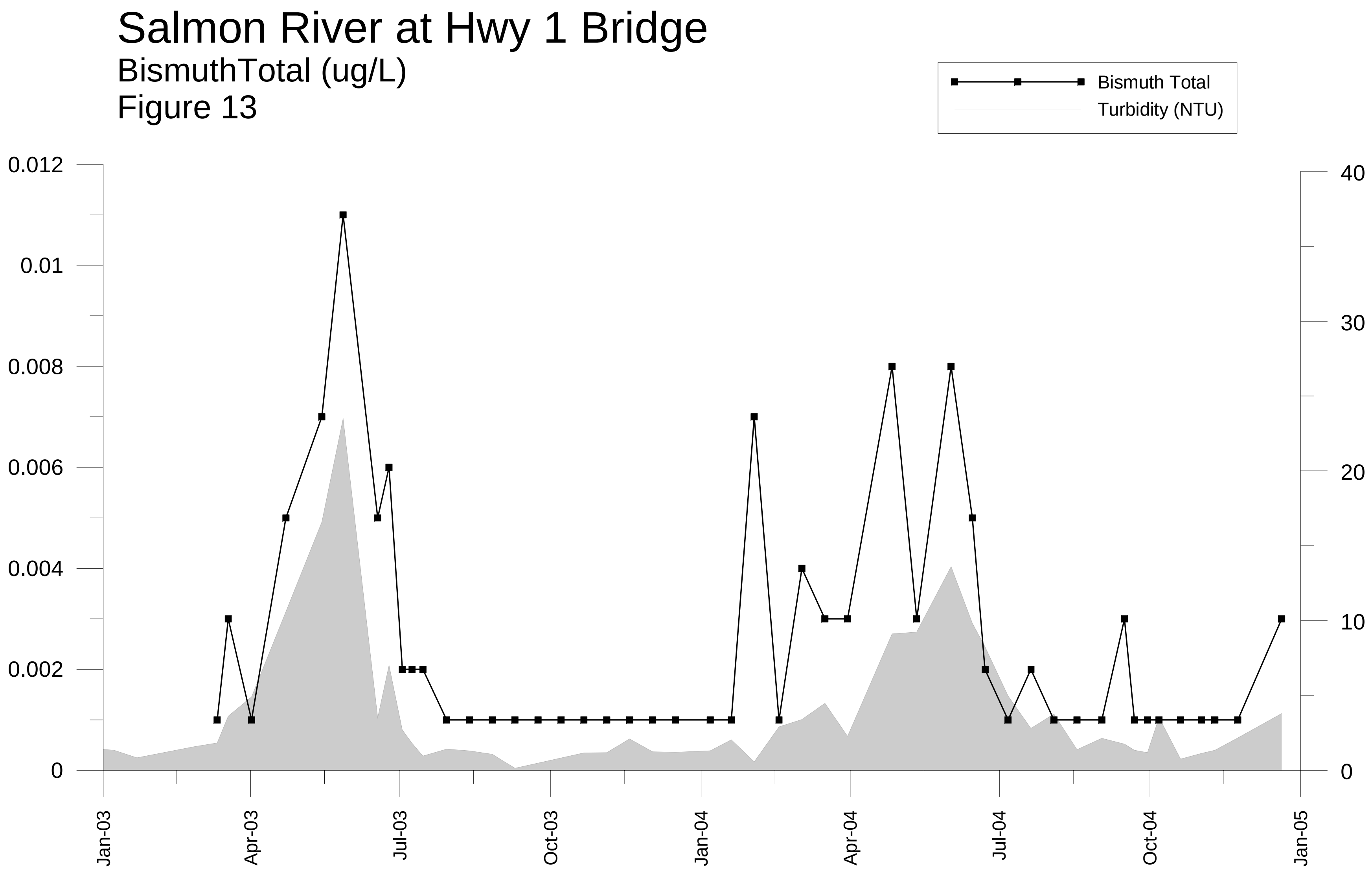
Barium Total (ug/L)

Figure 11



Salmon River at Hwy 1 Bridge
Beryllium Total (ug/L)
Figure 12

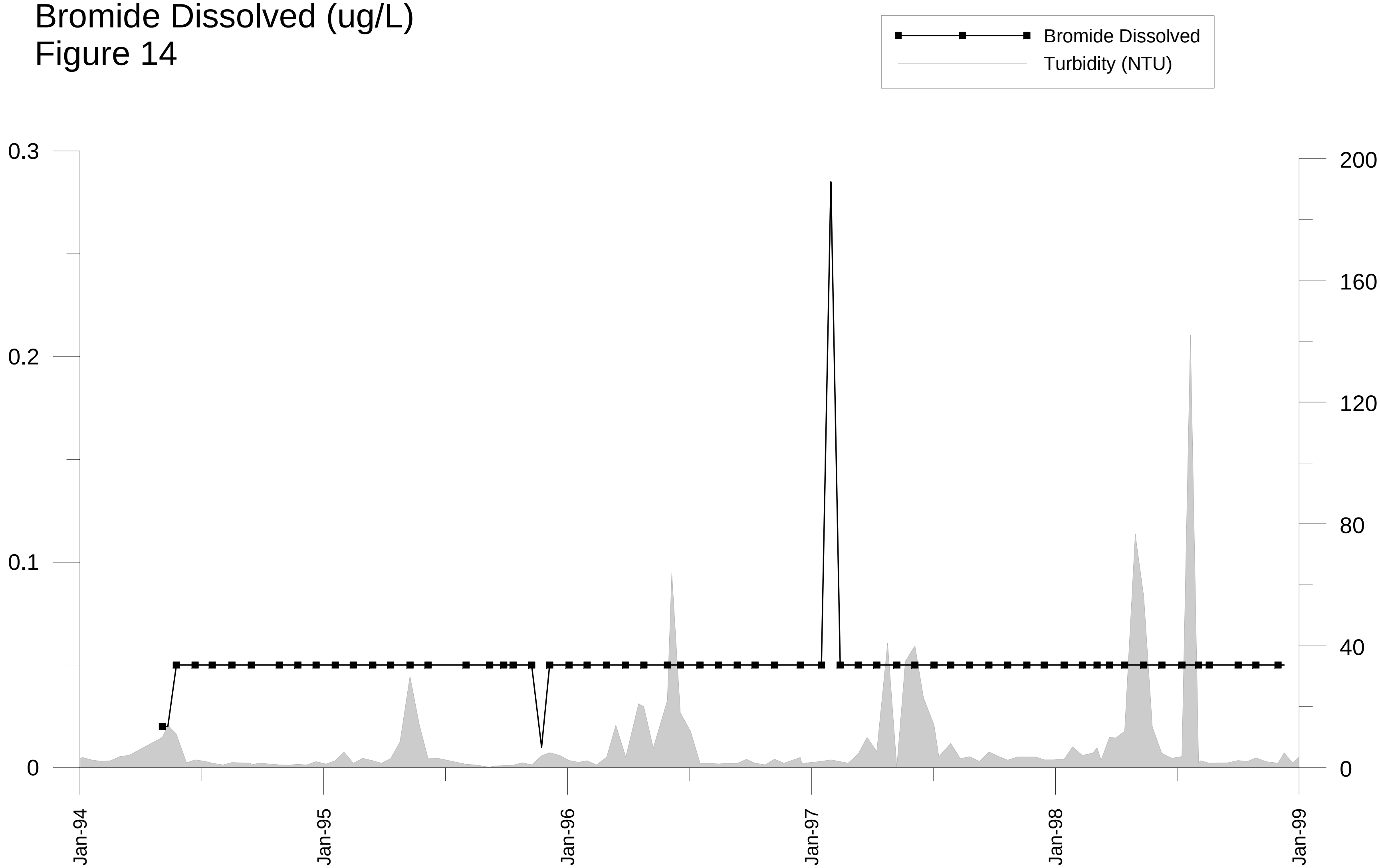


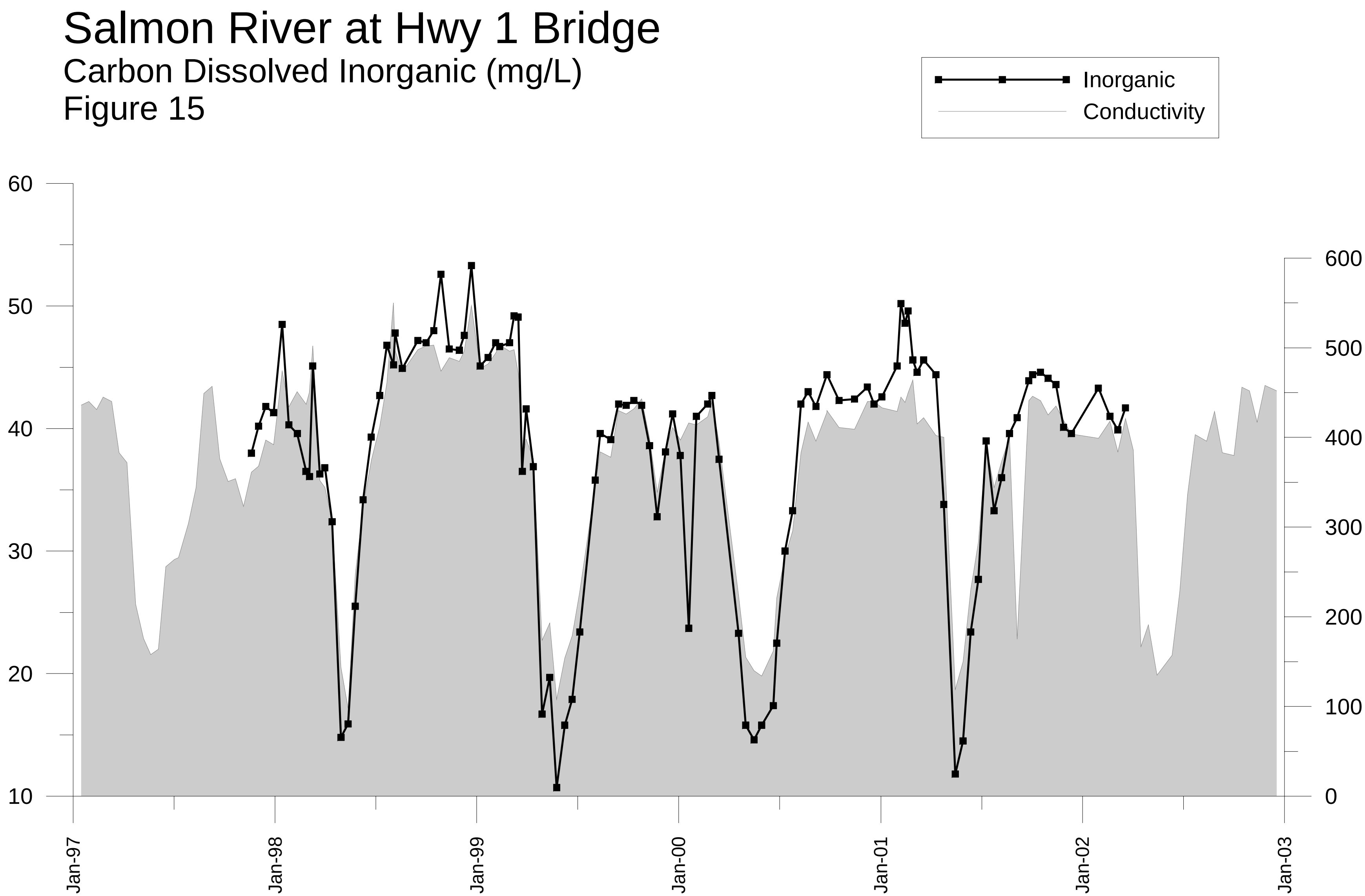

Salmon River at Hwy 1 Bridge
BismuthTotal (ug/L)
Figure 13
Bismuth Total
Turbidity (NTU)
0.012
0.01
0.008
0.006
0.004
0.002
0
40
30
20
10
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

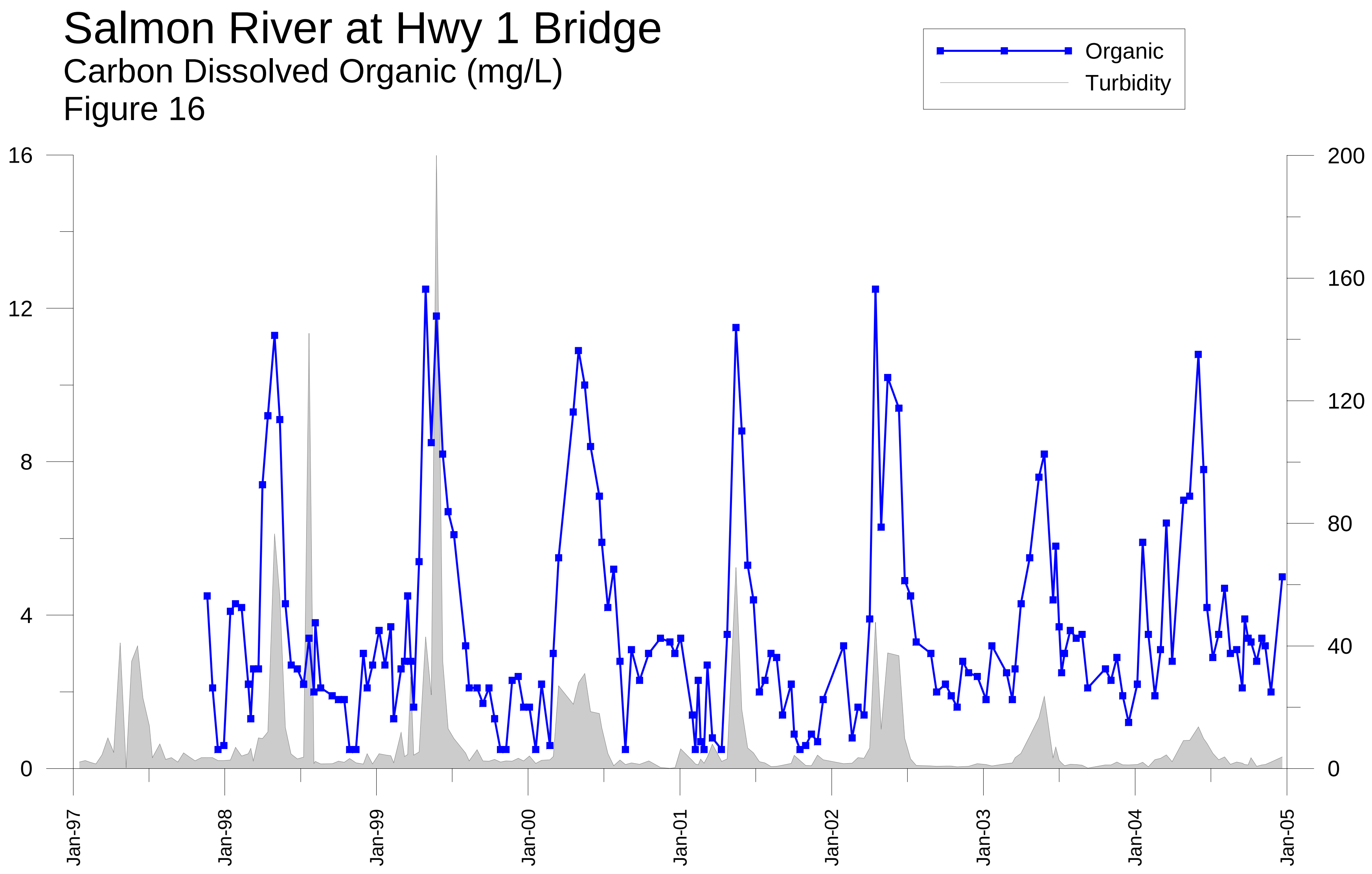
Salmon River at Hwy 1 Bridge

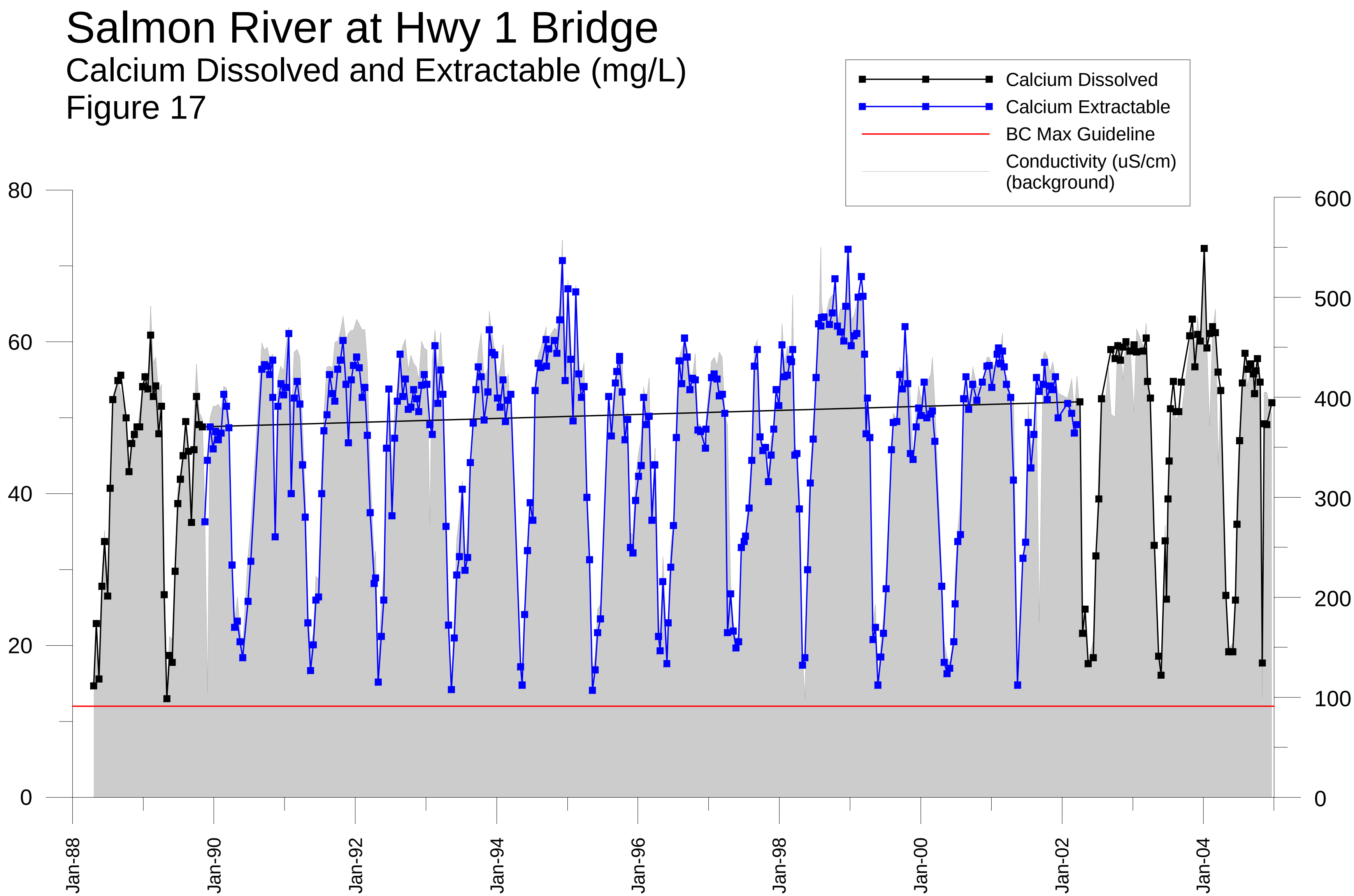
Bromide Dissolved (ug/L)

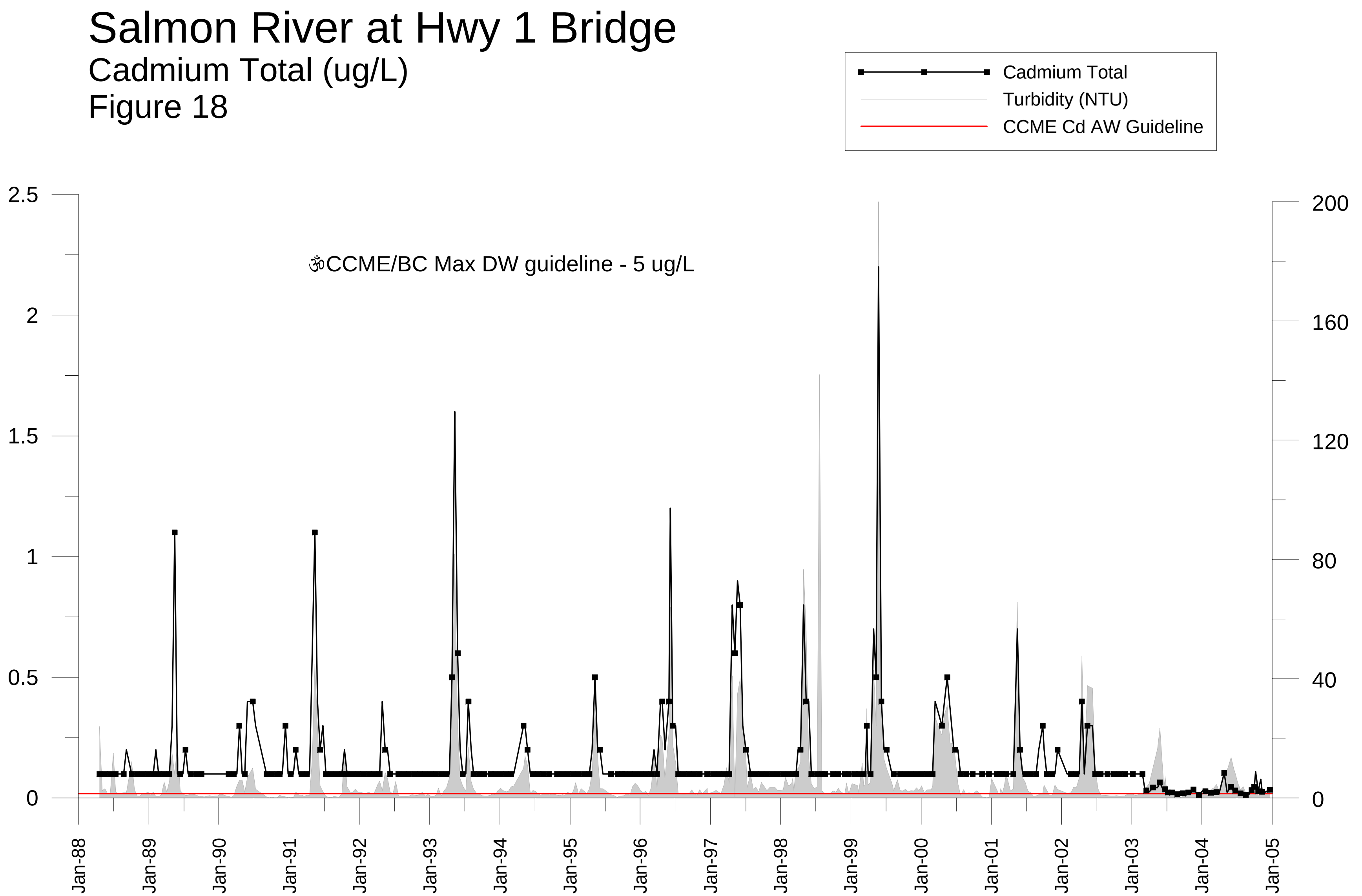
Figure 14




Salmon River at Hwy 1 Bridge
Carbon Dissolved Inorganic (mg/L)
Figure 15
Inorganic
Conductivity
60
50
40
30
20
10
600
500
400
300
200
100
0
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03


Salmon River at Hwy 1 Bridge
Carbon Dissolved Organic (mg/L)
Figure 16
Organic
Turbidity
16
12
8
4
0
200
160
120
80
40
0
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Salmon River at Hwy 1 Bridge
Calcium Dissolved and Extractable (mg/L)
Figure 17
Calcium Dissolved
Calcium Extractable
BC Max Guideline
Conductivity (uS/cm) (background)
80
60
40
20
0
600
500
400
300
200
100
0
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04


Salmon River at Hwy 1 Bridge
Cadmium Total (ug/L)
Figure 18
Cadmium Total
Turbidity (NTU)
CCME Cd AW Guideline
CCME/BC Max DW guideline - 5 ug/L
2.5
2
1.5
1
0.5
0
200
160
120
80
40
0
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
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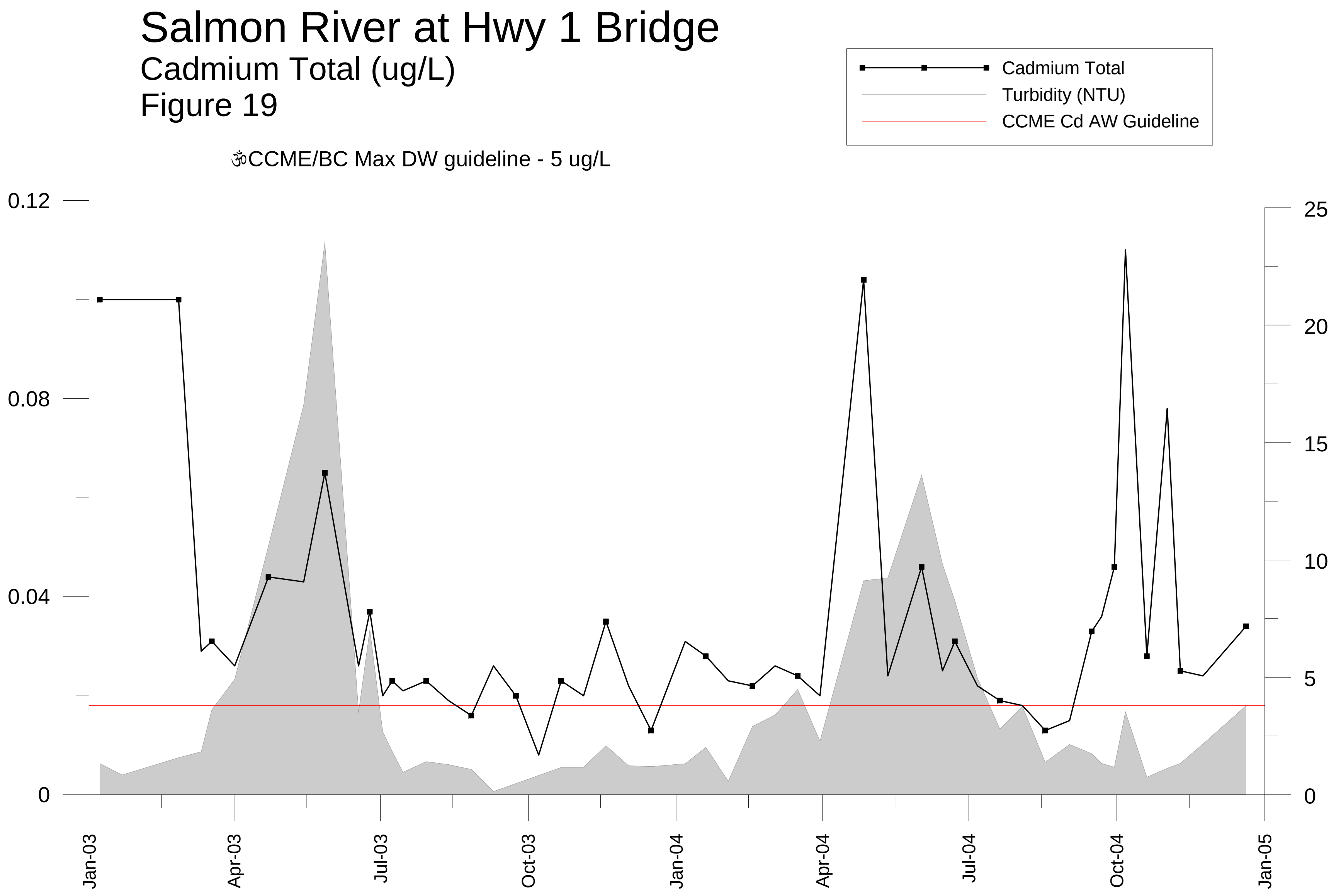
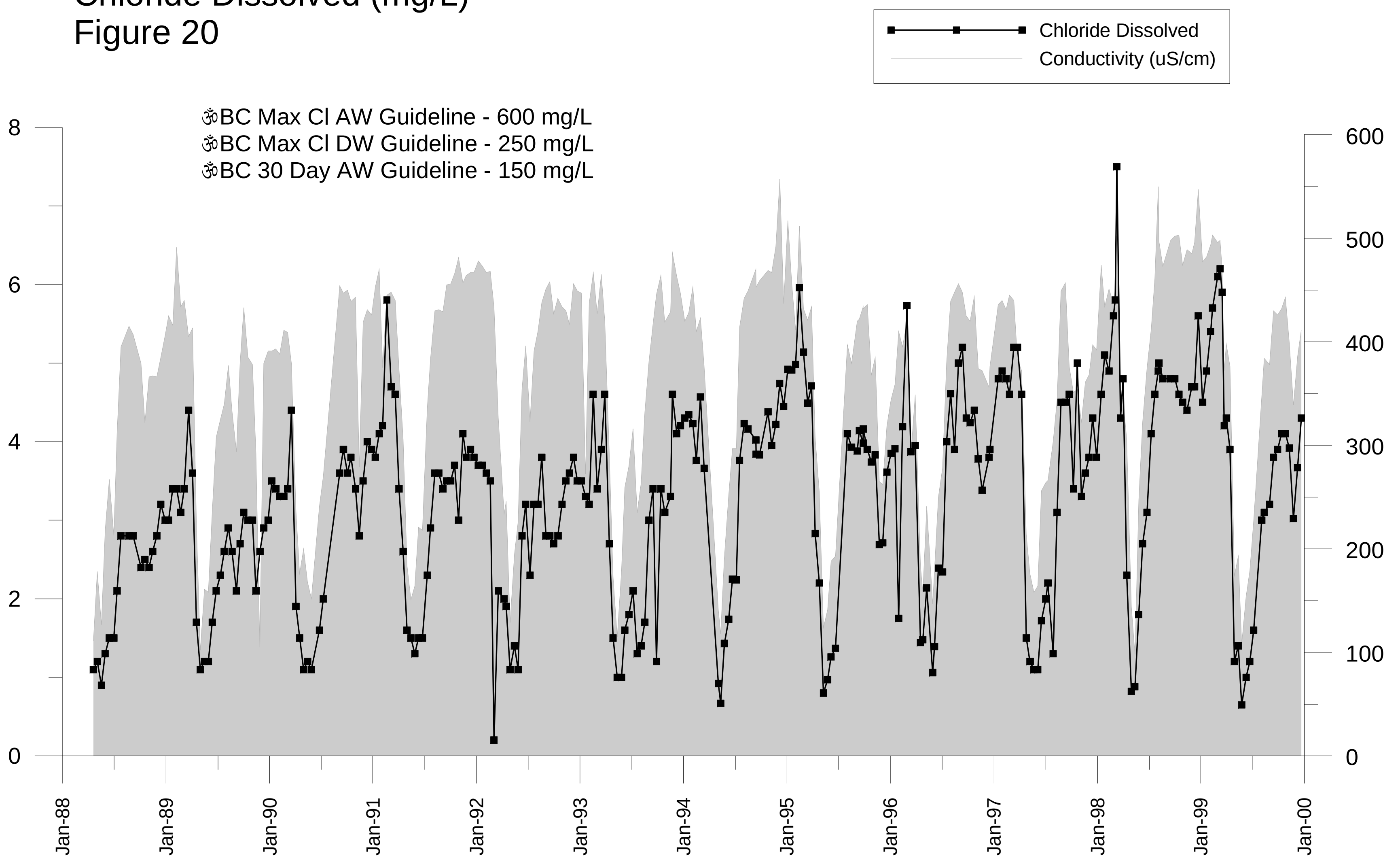
Jan-02
Jan-03
Jan-04
Jan-05


Salmon River at Hwy 1 Bridge
Cadmium Total (ug/L)
Figure 19
Cadmium Total
Turbidity (NTU)
CCME Cd AW Guideline
CCME/BC Max DW guideline - 5 ug/L
0.12
0.08
0.04
0
25
20
15
10
5
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

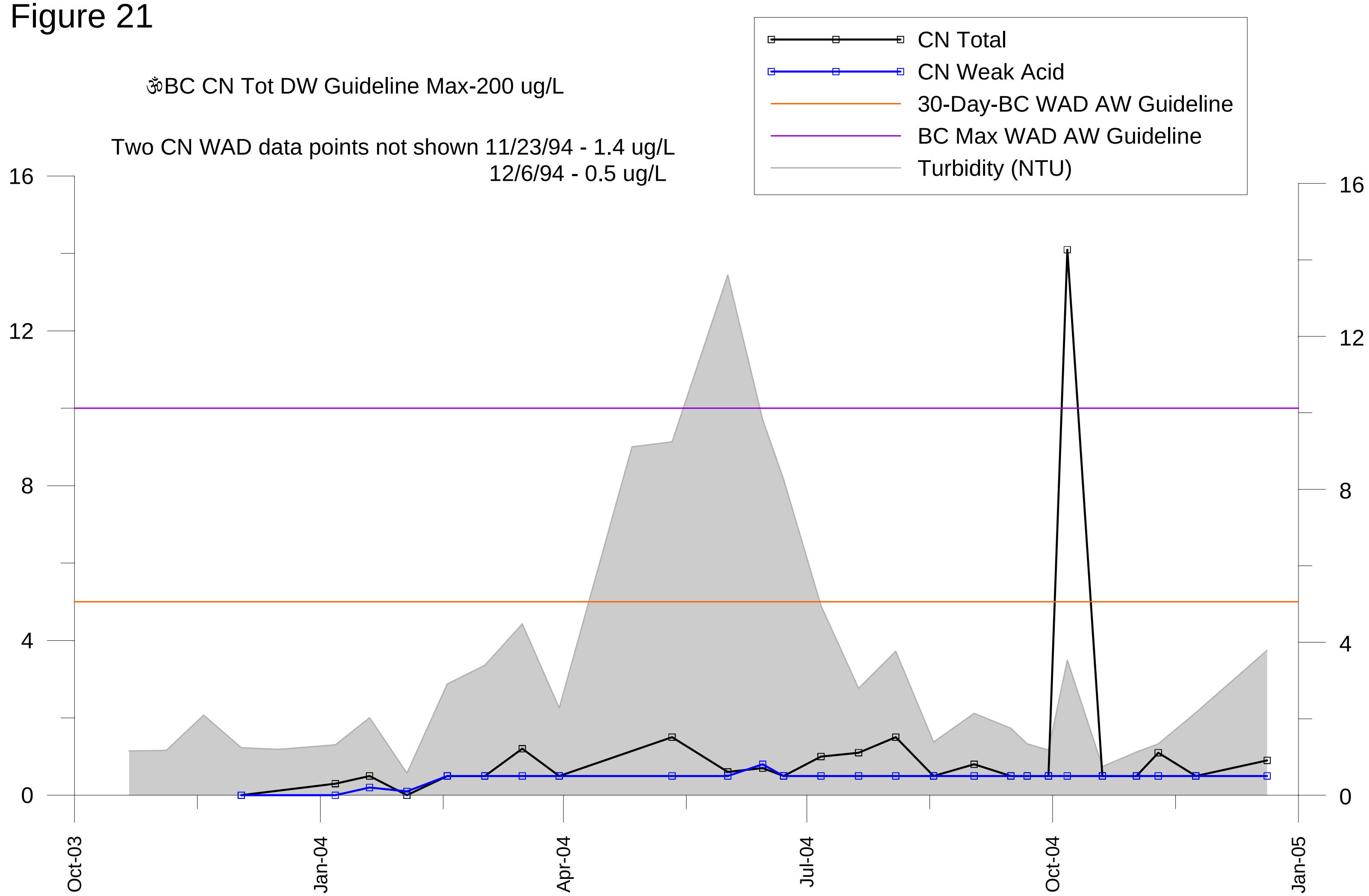
Salmon River at Hwy 1 Bridge
Chloride Dissolved (mg/L)
Figure 20

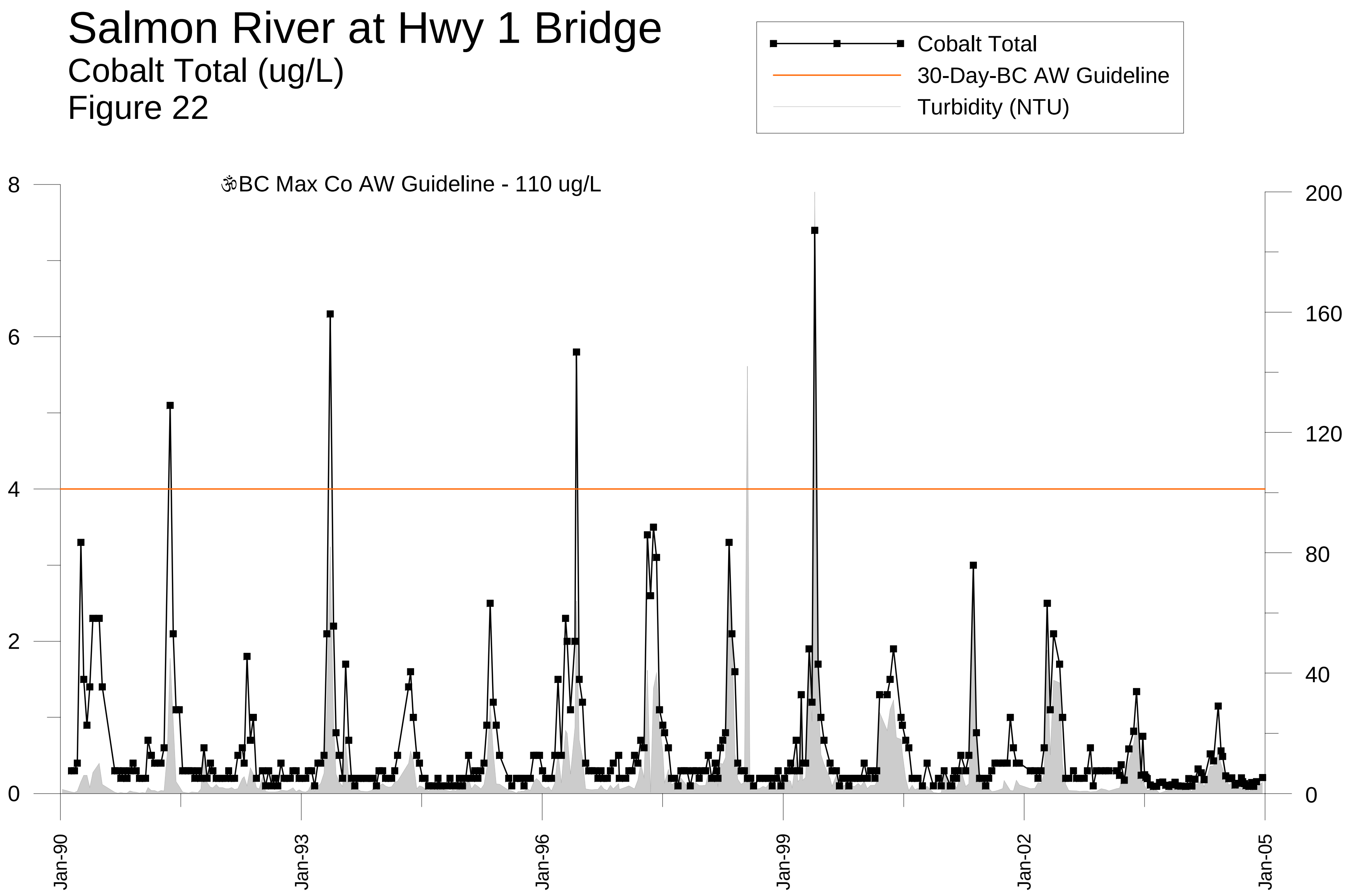


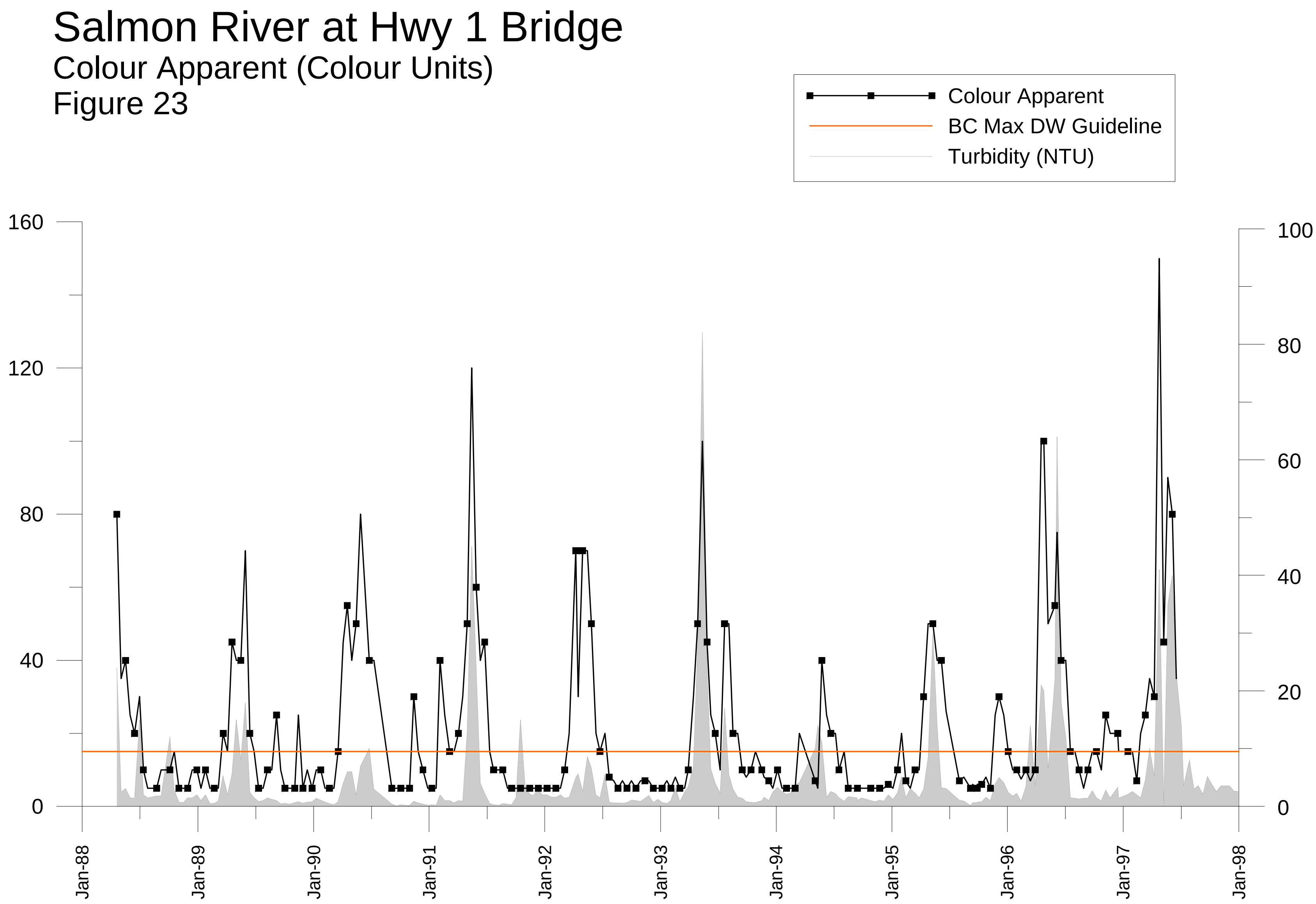
Salmon River at Hwy1 Bridge

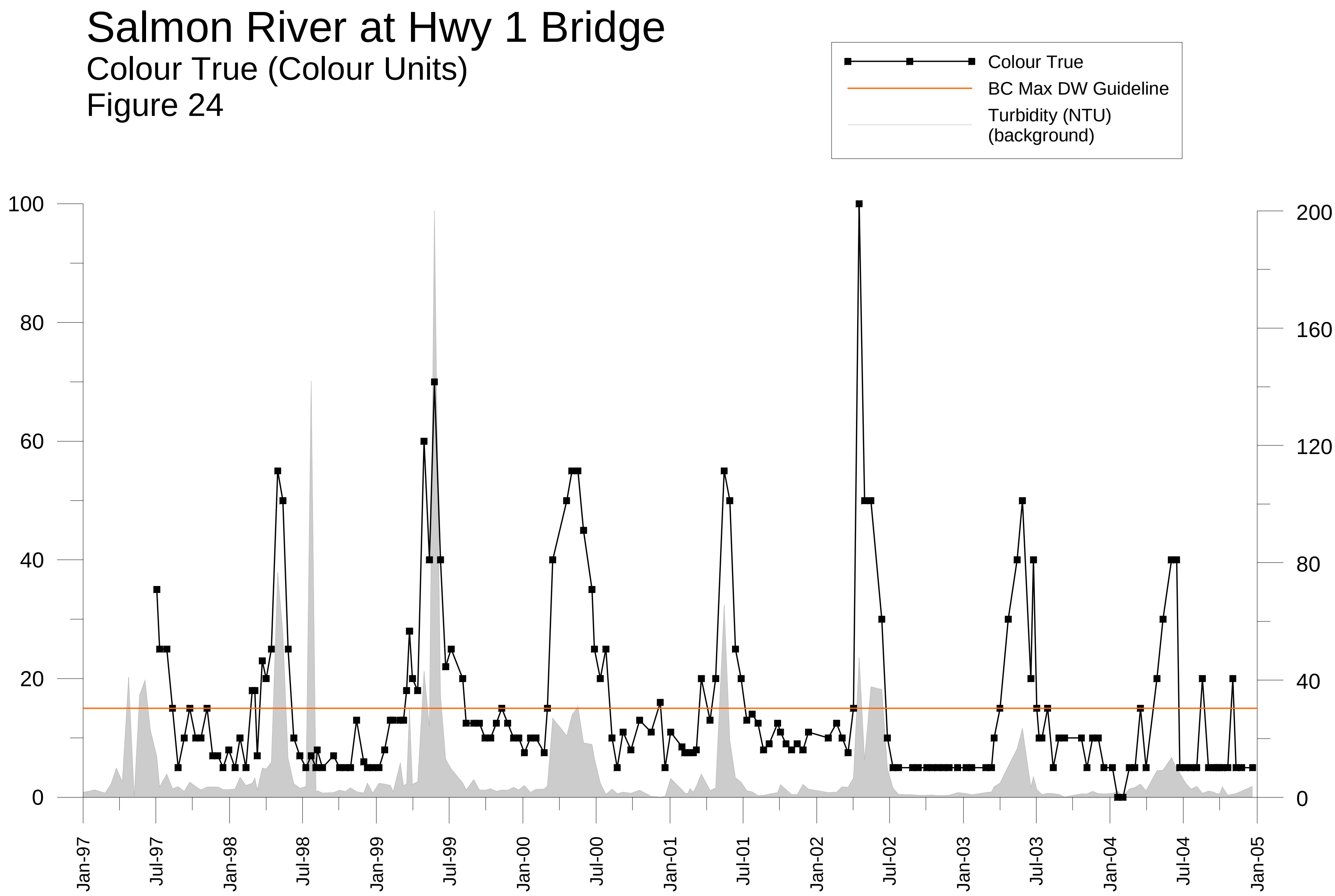
Cyanide Total and Weak Acid Dissociable (ug/L)

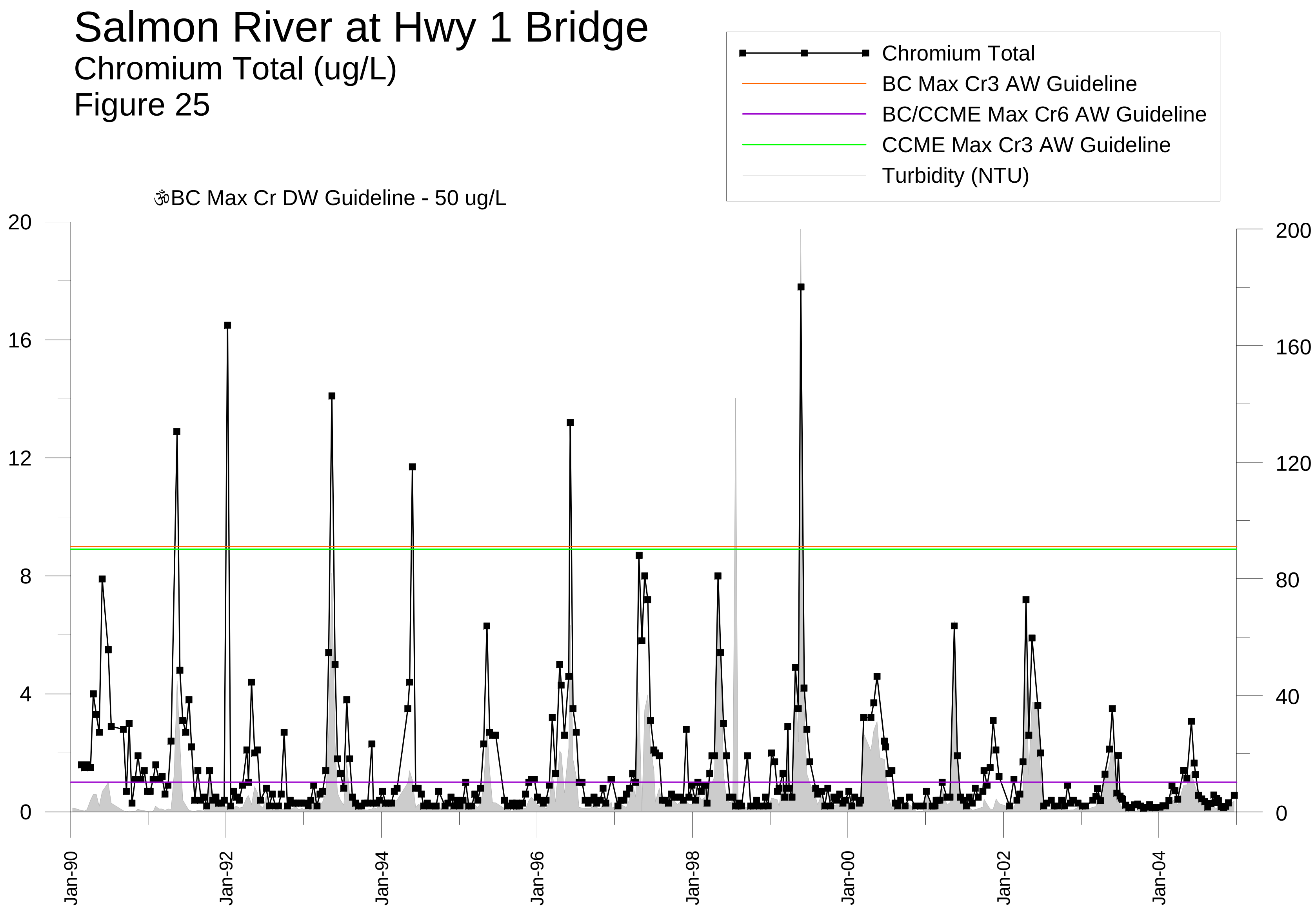
Figure 21

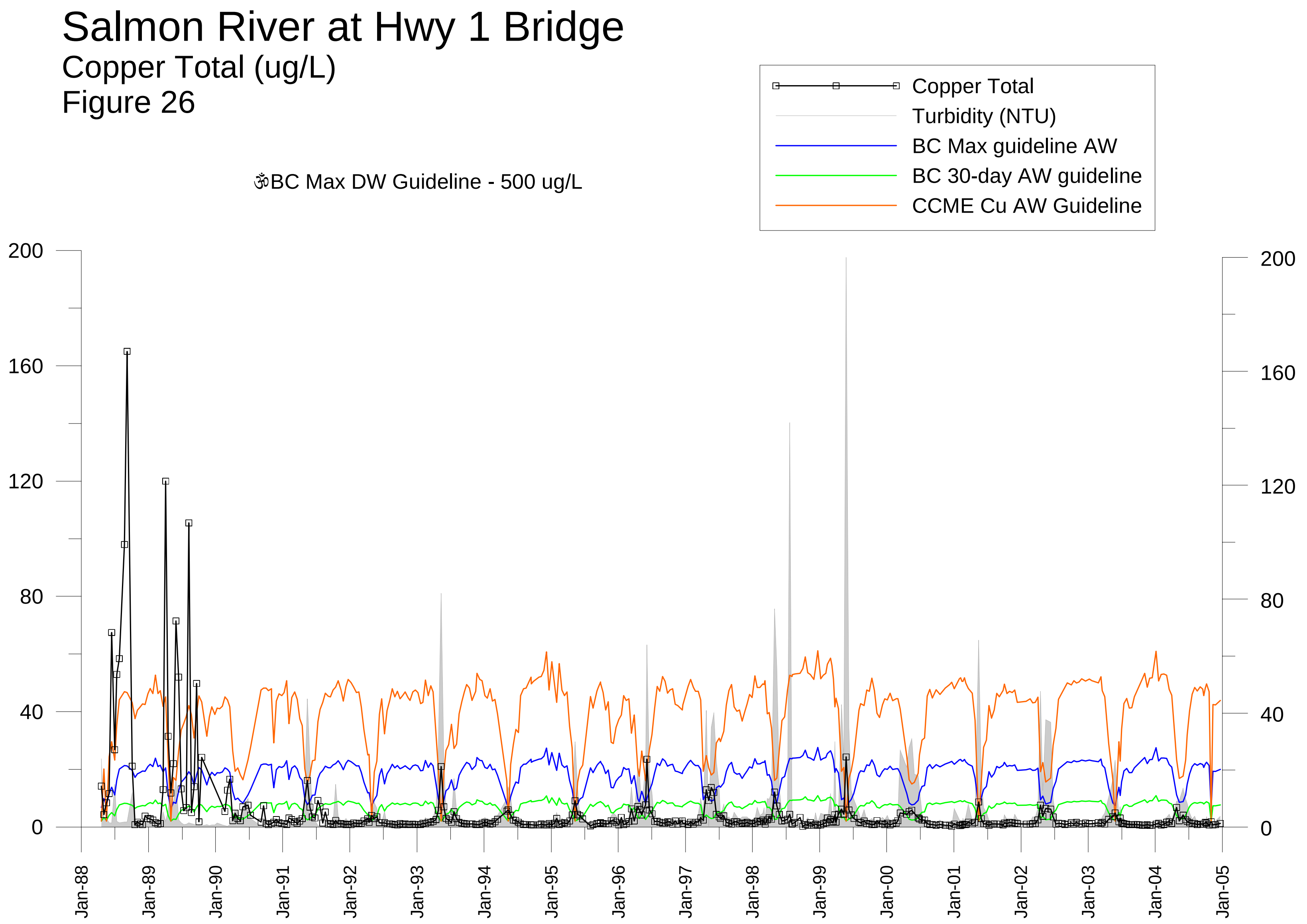


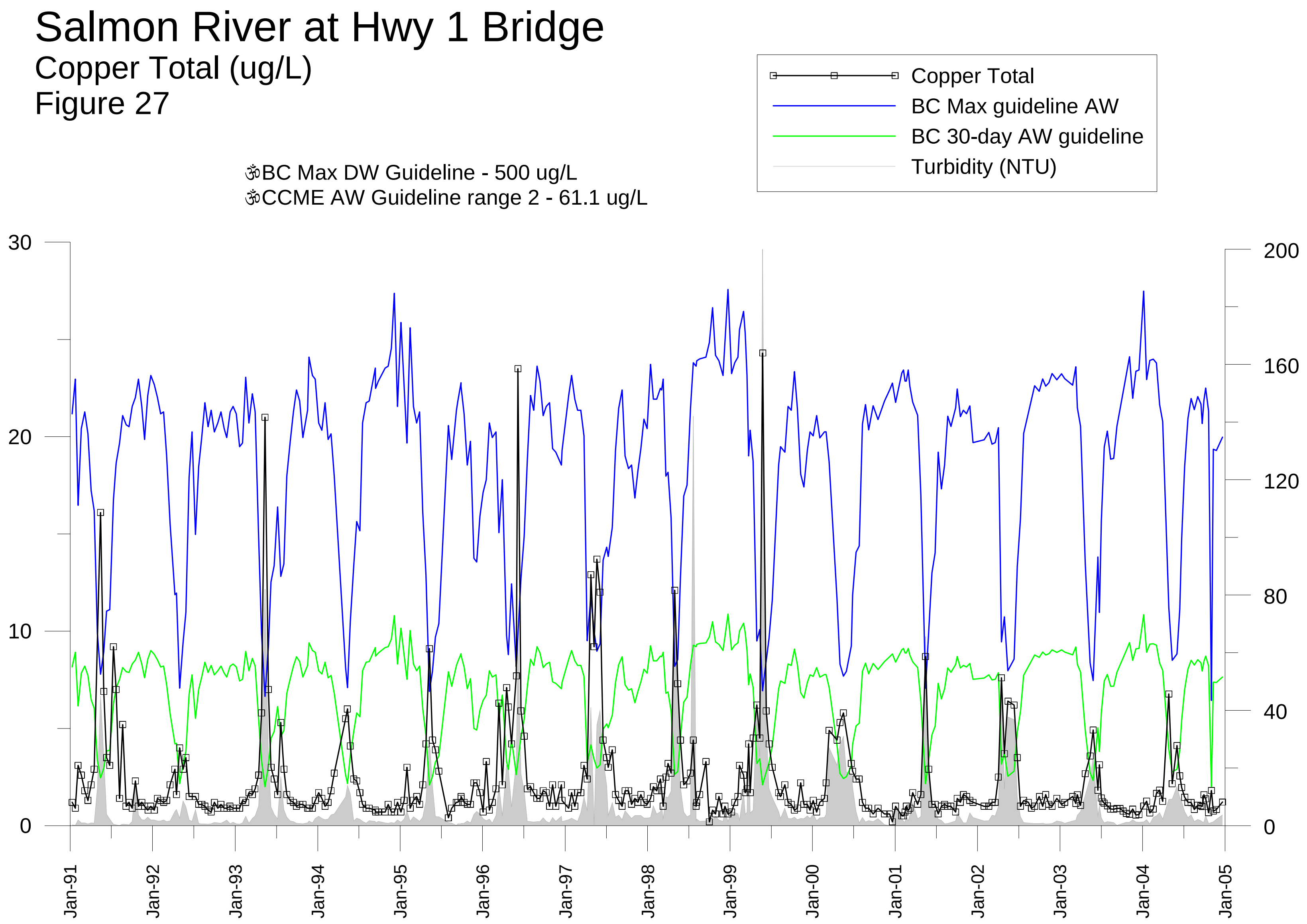

Salmon River at Hwy 1 Bridge
Cobalt Total (ug/L)
Figure 22
Cobalt Total
30-Day-BC AW Guideline
Turbidity (NTU)
BC Max Co AW Guideline - 110 ug/L
0
2
4
6
8
0
40
80
120
160
200
Jan-90
Jan-93
Jan-96
Jan-99
Jan-02
Jan-05

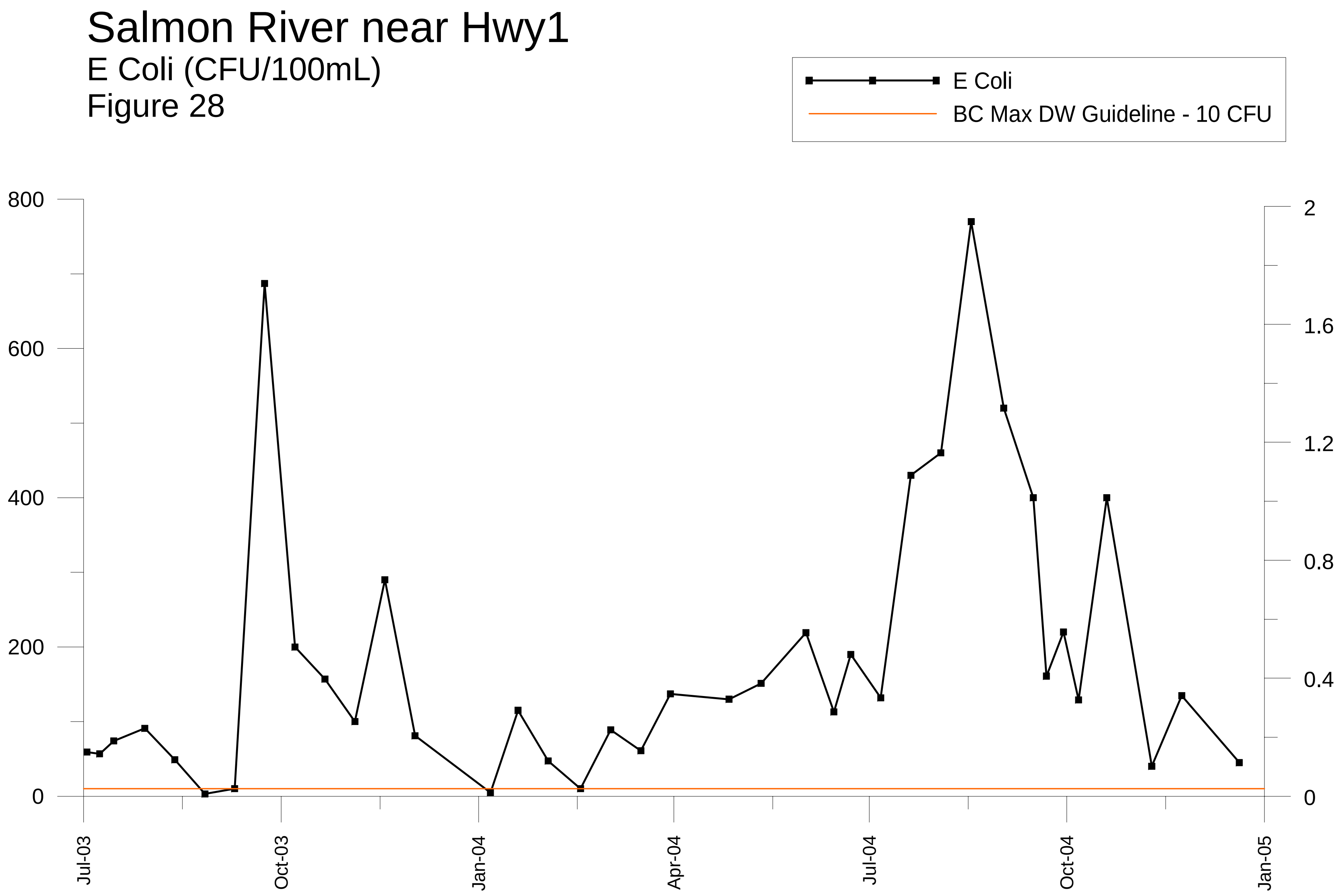

Salmon River at Hwy 1 Bridge
Colour Apparent (Colour Units)
Figure 23
Colour Apparent
BC Max DW Guideline
Turbidity (NTU)
160
120
80
40
0
100
80
60
40
20
0
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98

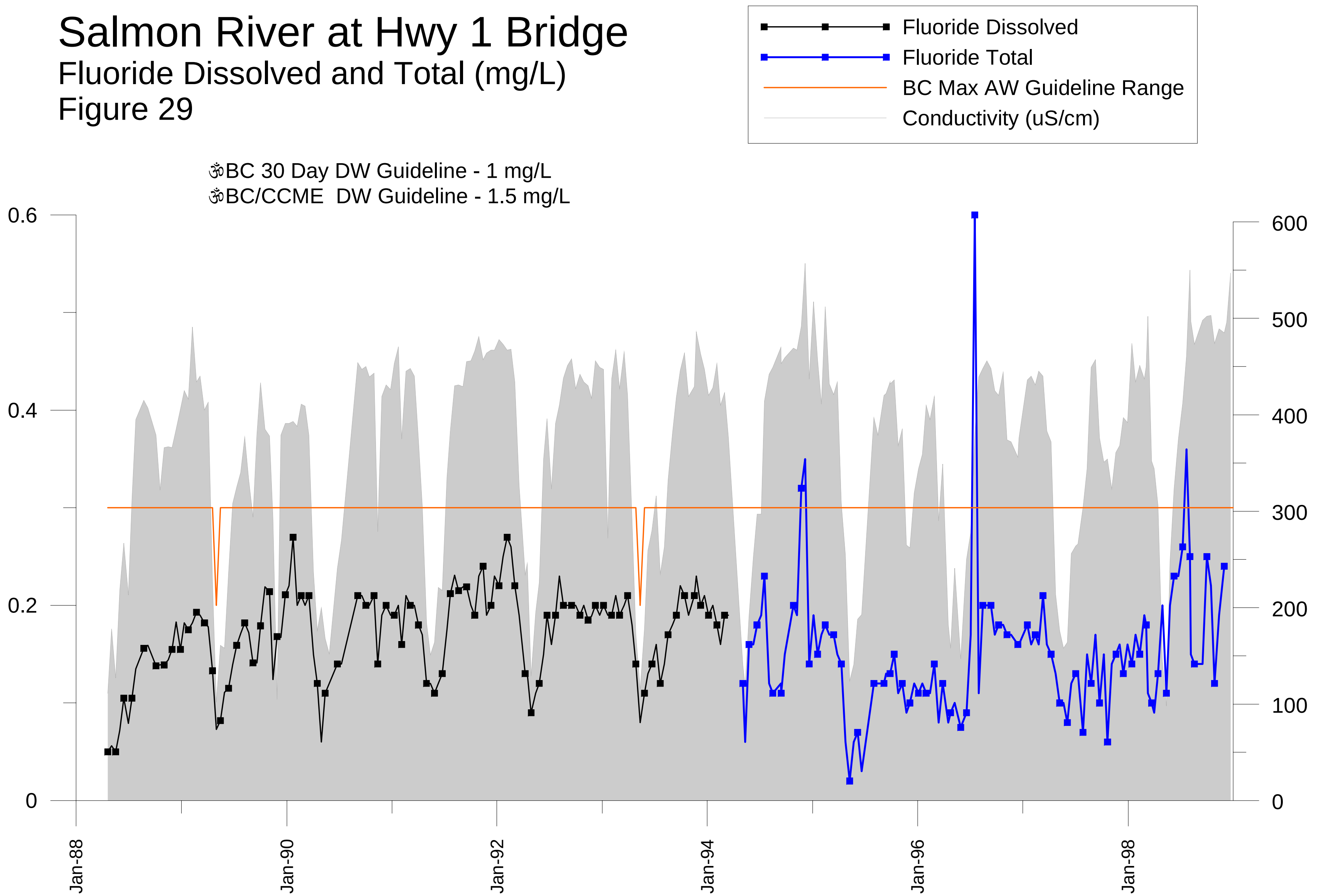

Salmon River at Hwy 1 Bridge
Colour True (Colour Units)
Figure 24
Colour True
BC Max DW Guideline
Turbidity (NTU)
(background)
100
80
60
40
20
0
200
160
120
80
40
0
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05

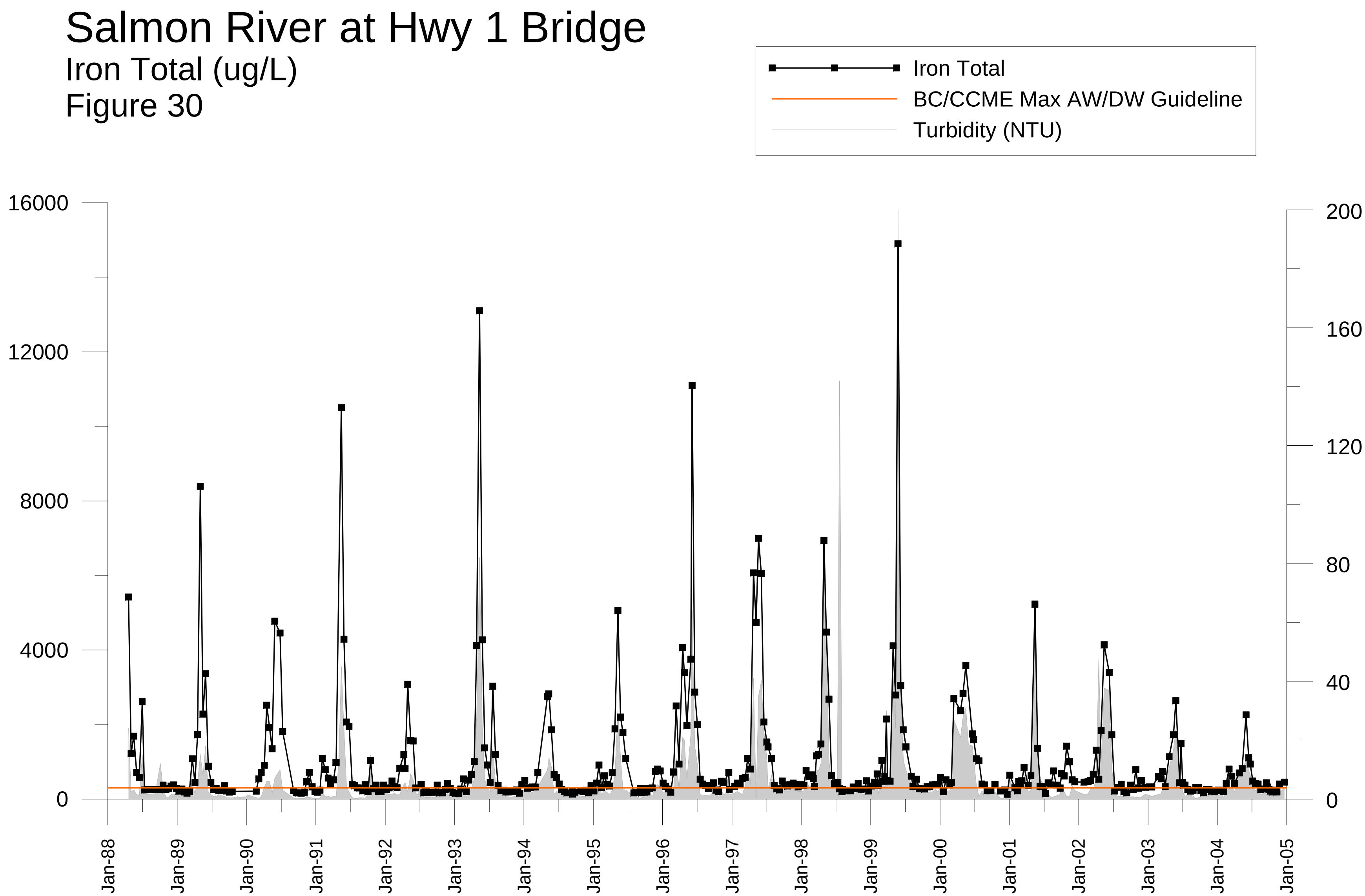

Salmon River at Hwy 1 Bridge
Chromium Total (ug/L)
Figure 25
Chromium Total
BC Max Cr3 AW Guideline
BC/CCME Max Cr6 AW Guideline
CCME Max Cr3 AW Guideline
Turbidity (NTU)
ॐBC Max Cr DW Guideline - 50 ug/L
20
16
12
8
4
0
200
160
120
80
40
0
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04

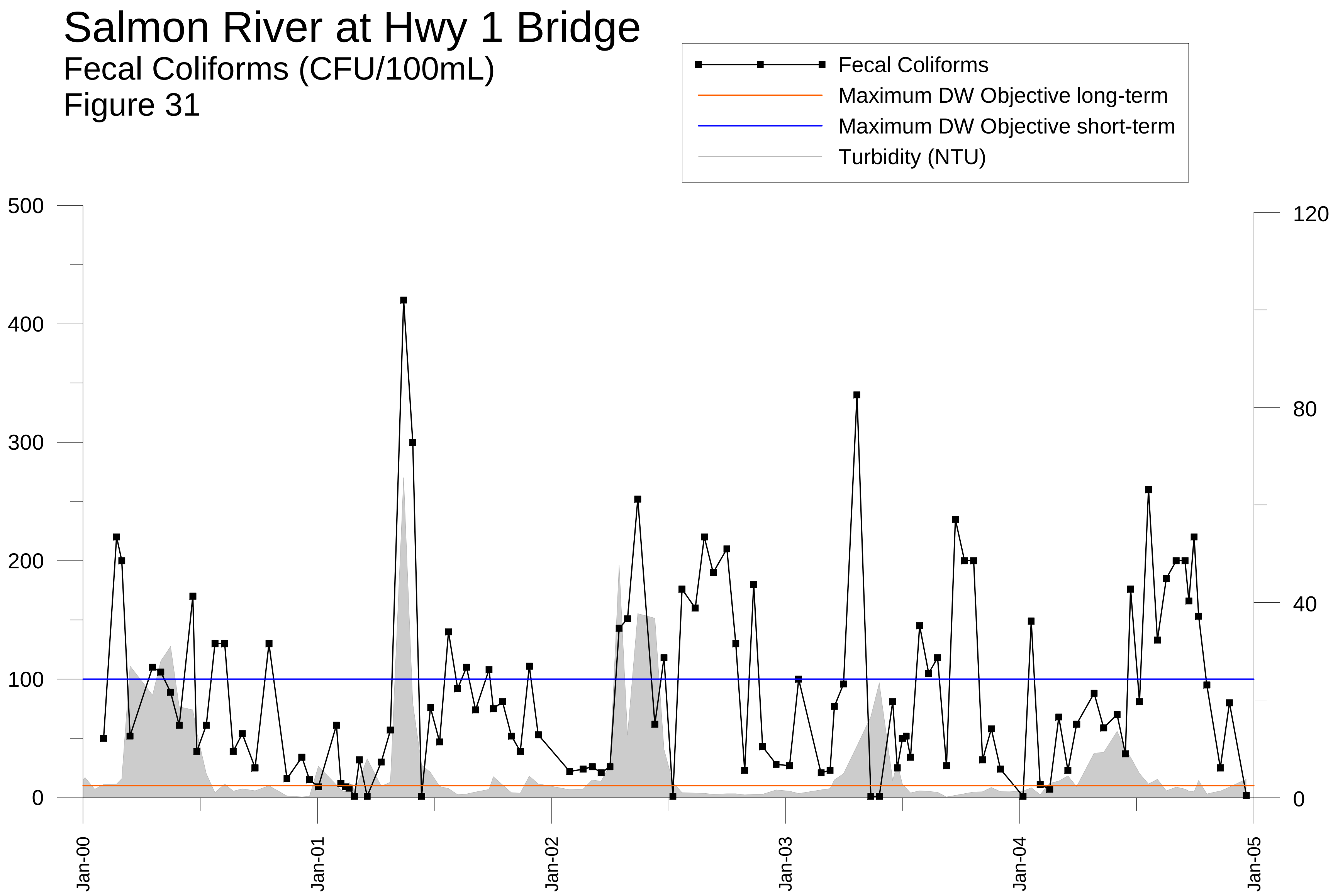

Salmon River at Hwy 1 Bridge
Copper Total (ug/L)
Figure 26
ॐBC Max DW Guideline - 500 ug/L
Copper Total
Turbidity (NTU)
BC Max guideline AW
BC 30-day AW guideline
CCME Cu AW Guideline
200
160
120
80
40
0
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

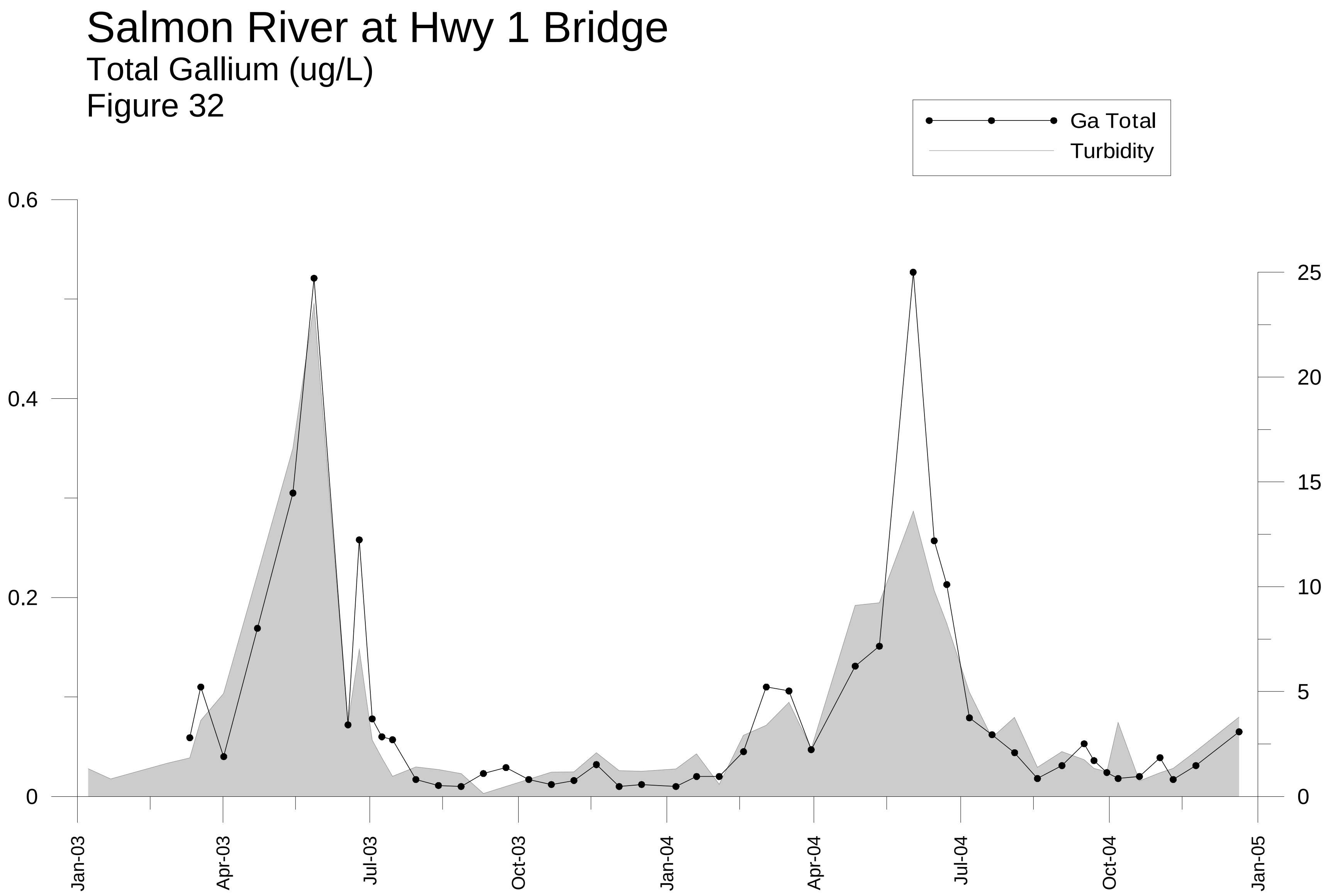

Salmon River at Hwy 1 Bridge
Copper Total (ug/L)
Figure 27
ॐBC Max DW Guideline - 500 ug/L
ॐCCME AW Guideline range 2 - 61.1 ug/L
Copper Total
BC Max guideline AW
BC 30-day AW guideline
Turbidity (NTU)
30
20
10
0
200
160
120
80
40
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

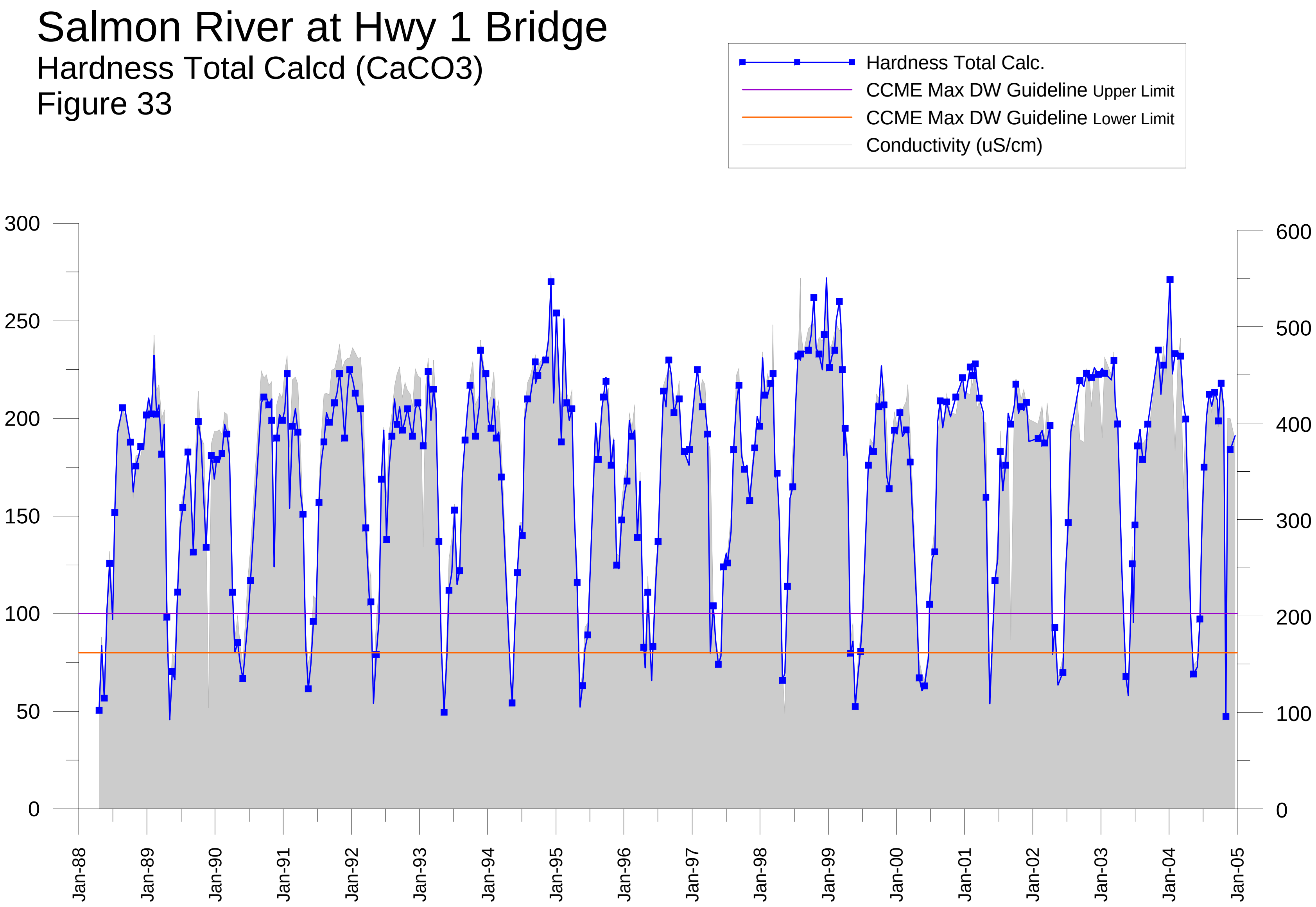

Salmon River near Hwy1
E Coli (CFU/100mL)
Figure 28
E Coli
BC Max DW Guideline - 10 CFU
800
600
400
200
0
2
1.6
1.2
0.8
0.4
0
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

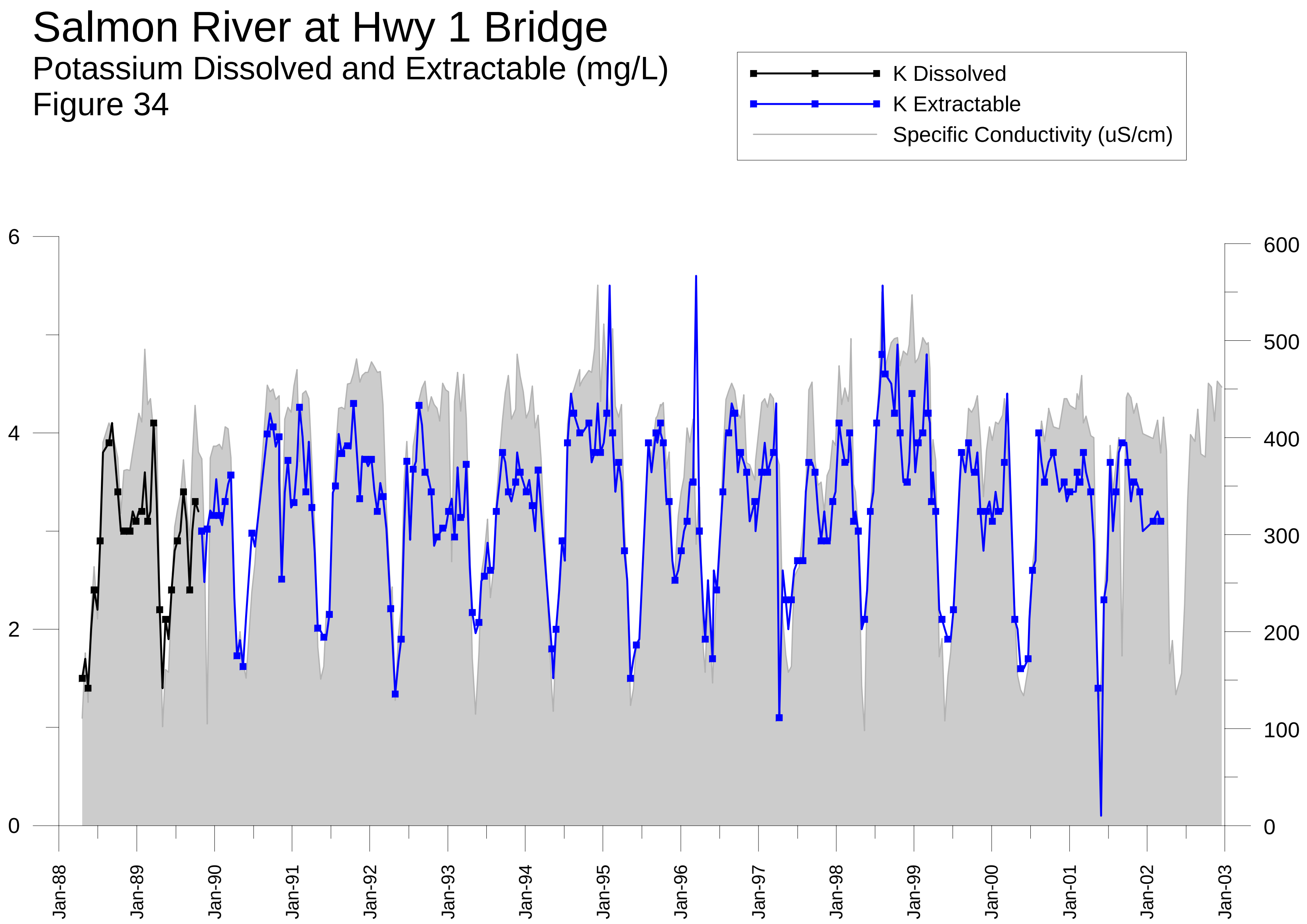

Salmon River at Hwy 1 Bridge
Fluoride Dissolved and Total (mg/L)
Figure 29
Fluoride Dissolved
Fluoride Total
BC Max AW Guideline Range
Conductivity (uS/cm)
ॐBC 30 Day DW Guideline - 1 mg/L
ॐBC/CCME DW Guideline - 1.5 mg/L
0.6
0.4
0.2
0
600
500
400
300
200
100
0
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98


Salmon River at Hwy 1 Bridge
Iron Total (ug/L)
Figure 30
Iron Total
BC/CCME Max AW/DW Guideline
Turbidity (NTU)
16000
12000
8000
4000
0
200
160
120
80
40
0
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
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Salmon River at Hwy 1 Bridge
Fecal Coliforms (CFU/100mL)
Figure 31
Fecal Coliforms
Maximum DW Objective long-term
Maximum DW Objective short-term
Turbidity (NTU)
500
400
300
200
100
0
120
80
40
0
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Salmon River at Hwy 1 Bridge
Total Gallium (ug/L)
Figure 32
Ga Total
Turbidity
0.6
0.4
0.2
0
25
20
15
10
5
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05

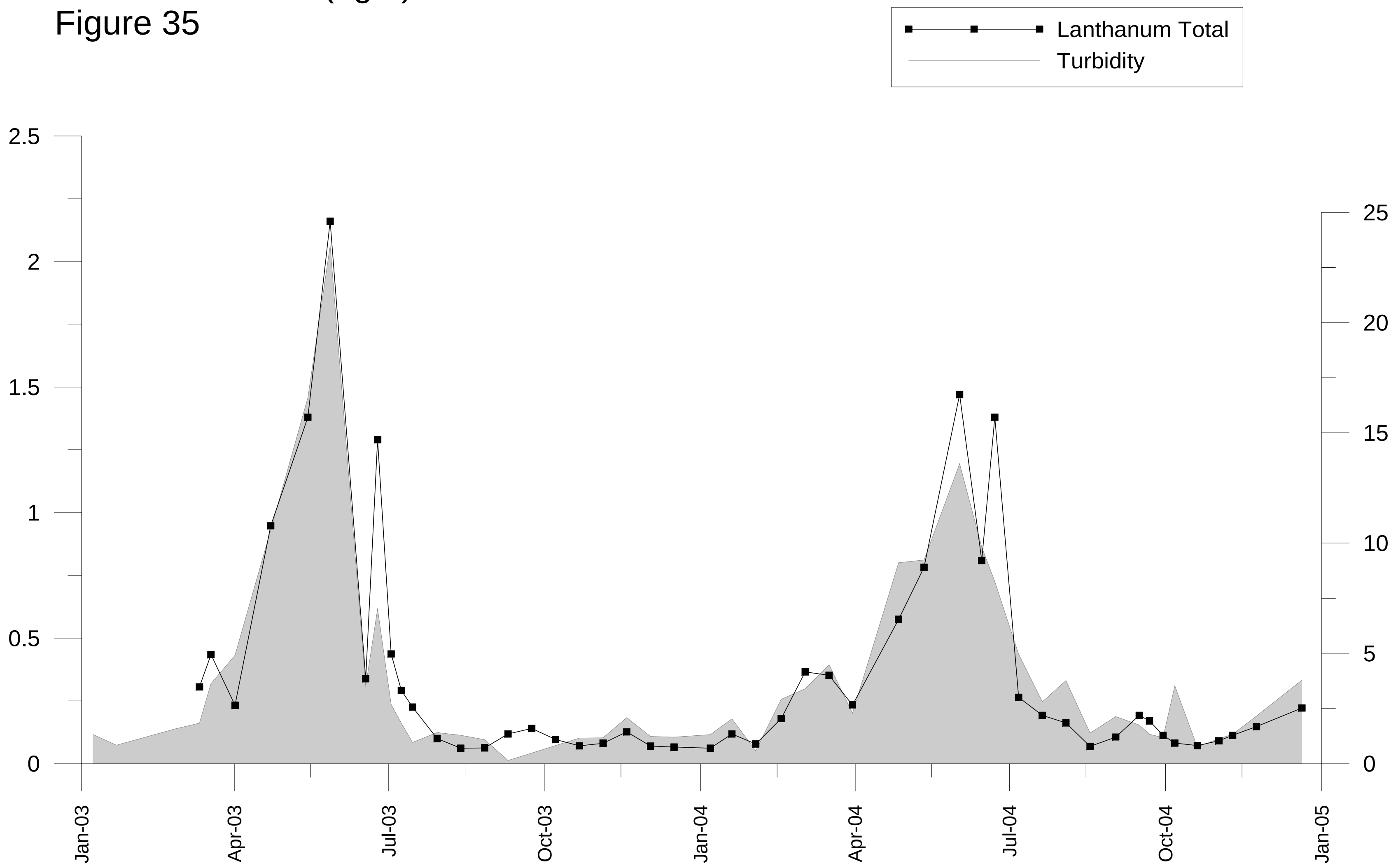

Salmon River at Hwy 1 Bridge
Hardness Total Calcd (CaCO3)
Figure 33
Hardness Total Calc.
CCME Max DW Guideline Upper Limit
CCME Max DW Guideline Lower Limit
Conductivity (uS/cm)
300
250
200
150
100
50
0
600
500
400
300
200
100
0
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05


Salmon River at Hwy 1 Bridge
Potassium Dissolved and Extractable (mg/L)
Figure 34
K Dissolved
K Extractable
Specific Conductivity (uS/cm)
6
4
2
0
600
500
400
300
200
100
0
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
Jan-01
Jan-02
Jan-03

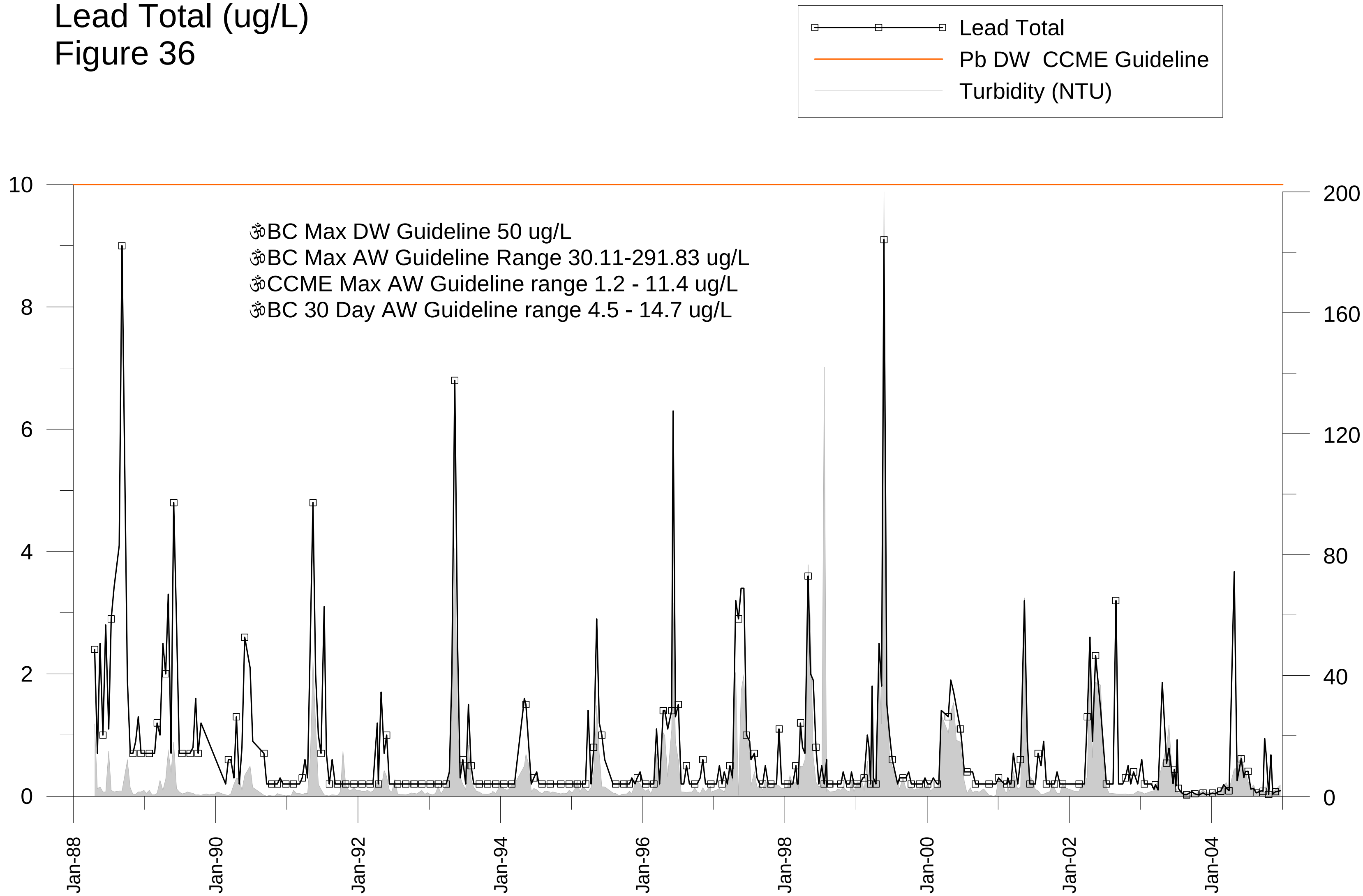
Salmon River at Hwy 1 Bridge

Lanthanum Total (ug/L)

Figure 35



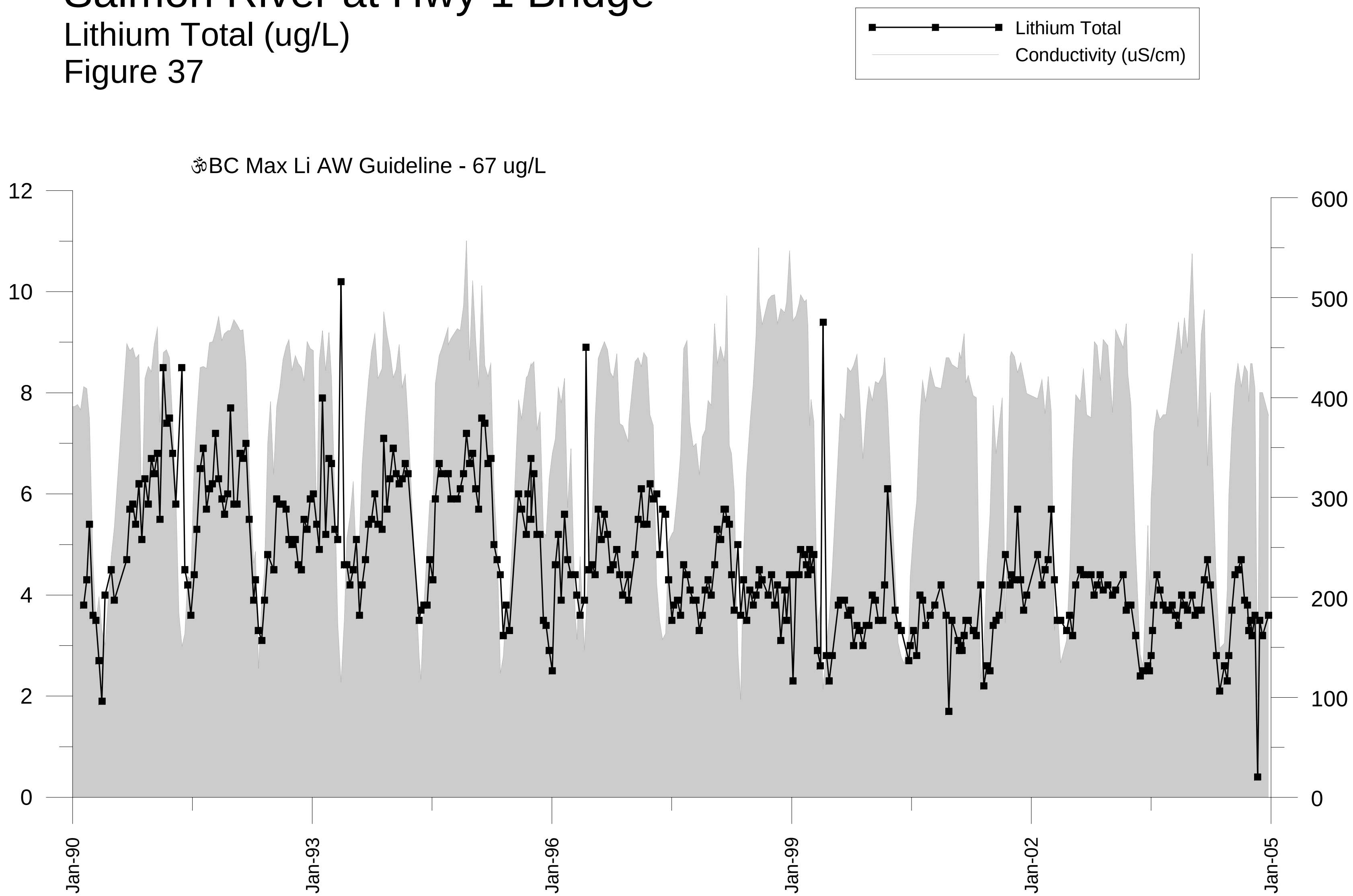
Salmon River at Hwy 1 Bridge
Lead Total (ug/L)
Figure 36



Salmon River at Hwy 1 Bridge

Lithium Total (ug/L)

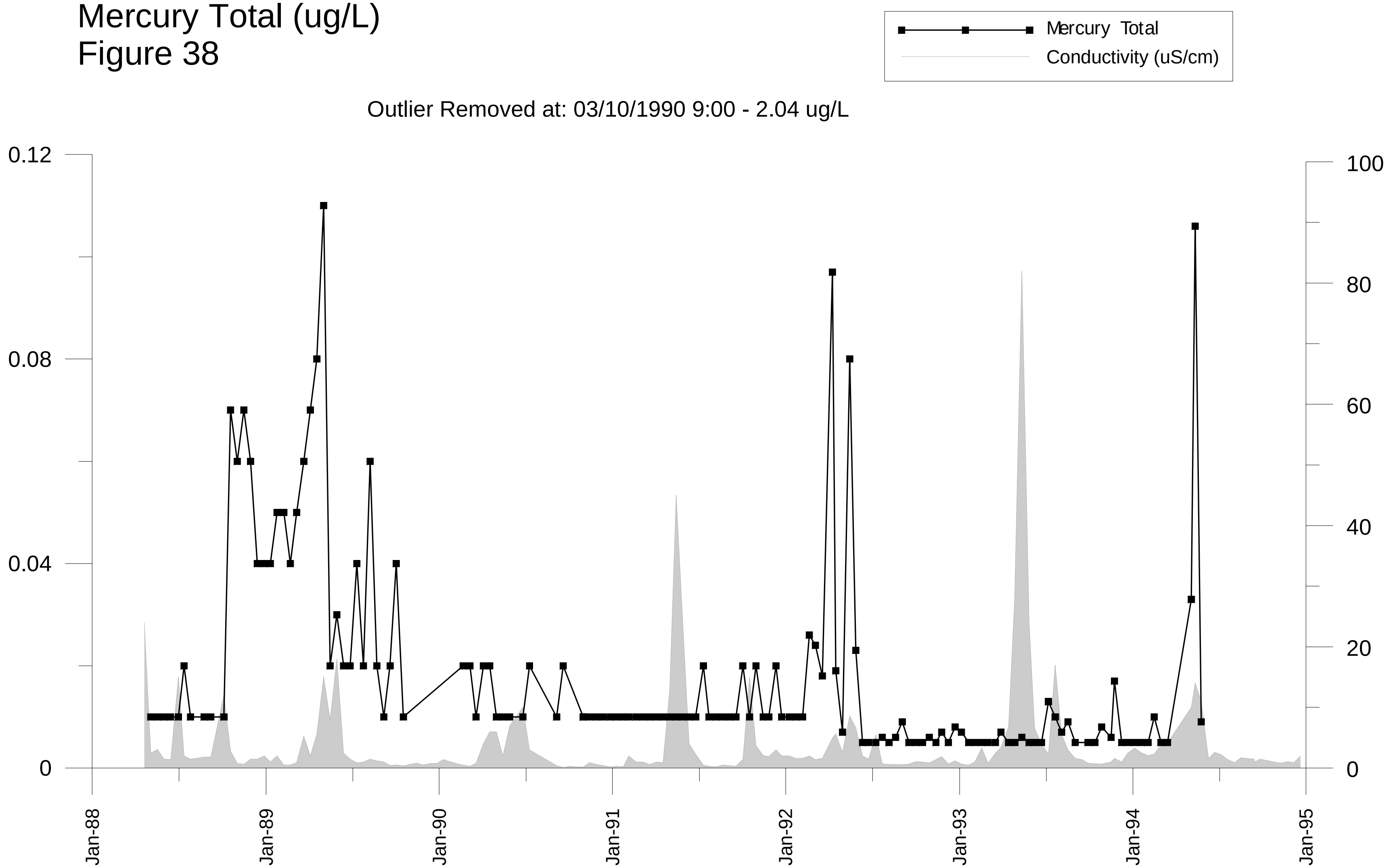
Figure 37



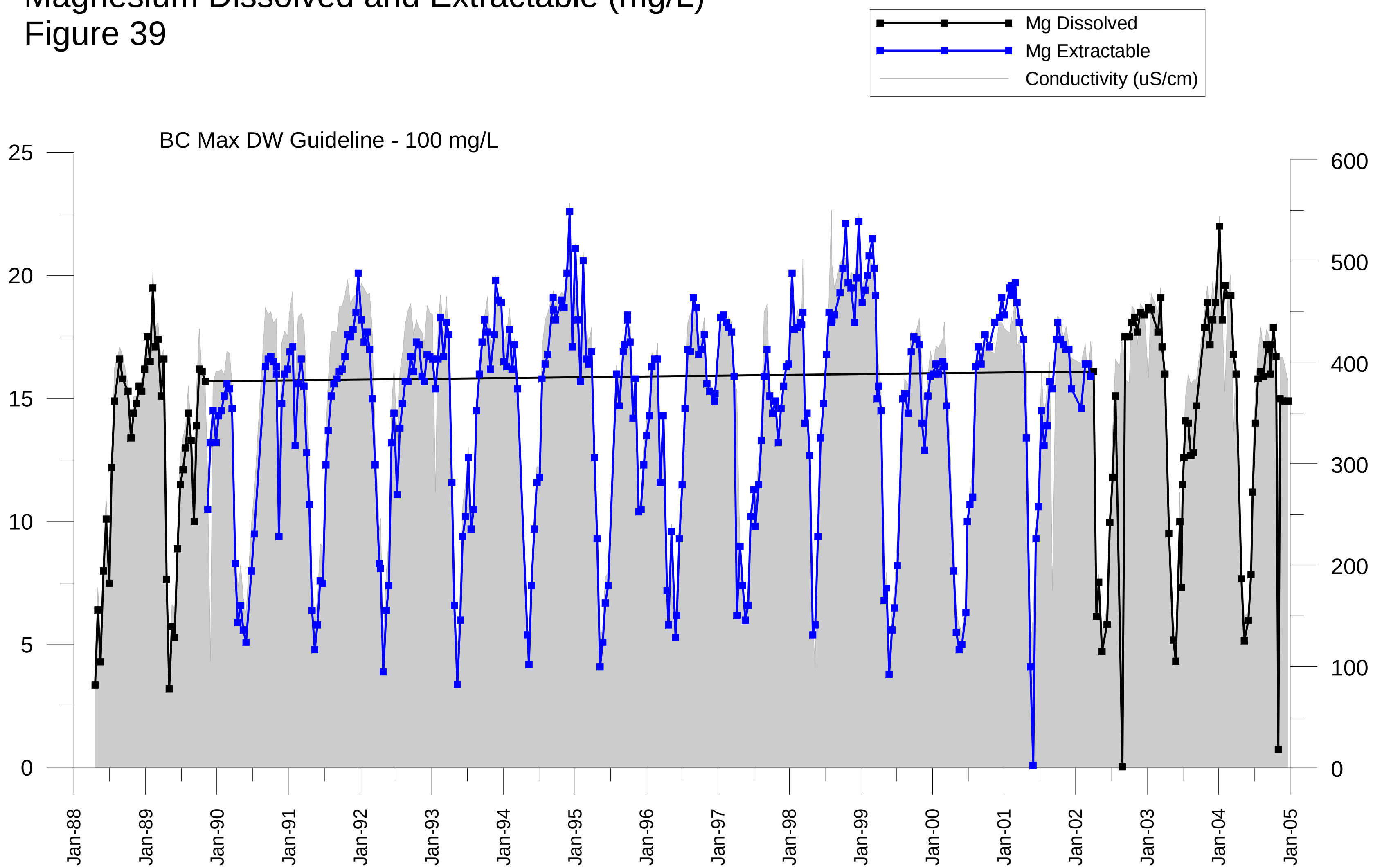
Salmon River at Hwy 1 Bridge

Mercury Total (ug/L)

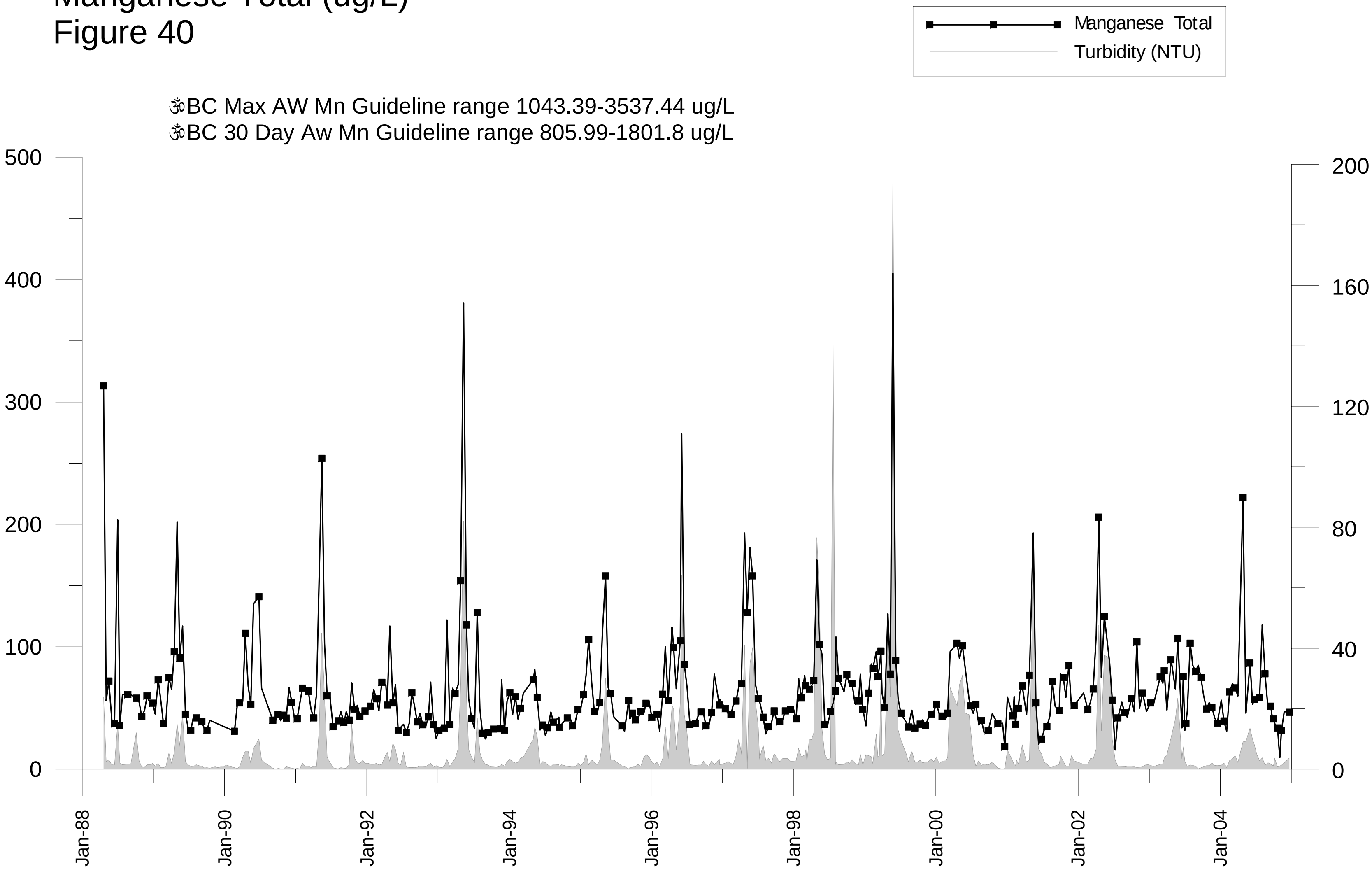
Figure 38



Salmon River at Hwy 1 Bridge
Magnesium Dissolved and Extractable (mg/L)
Figure 39



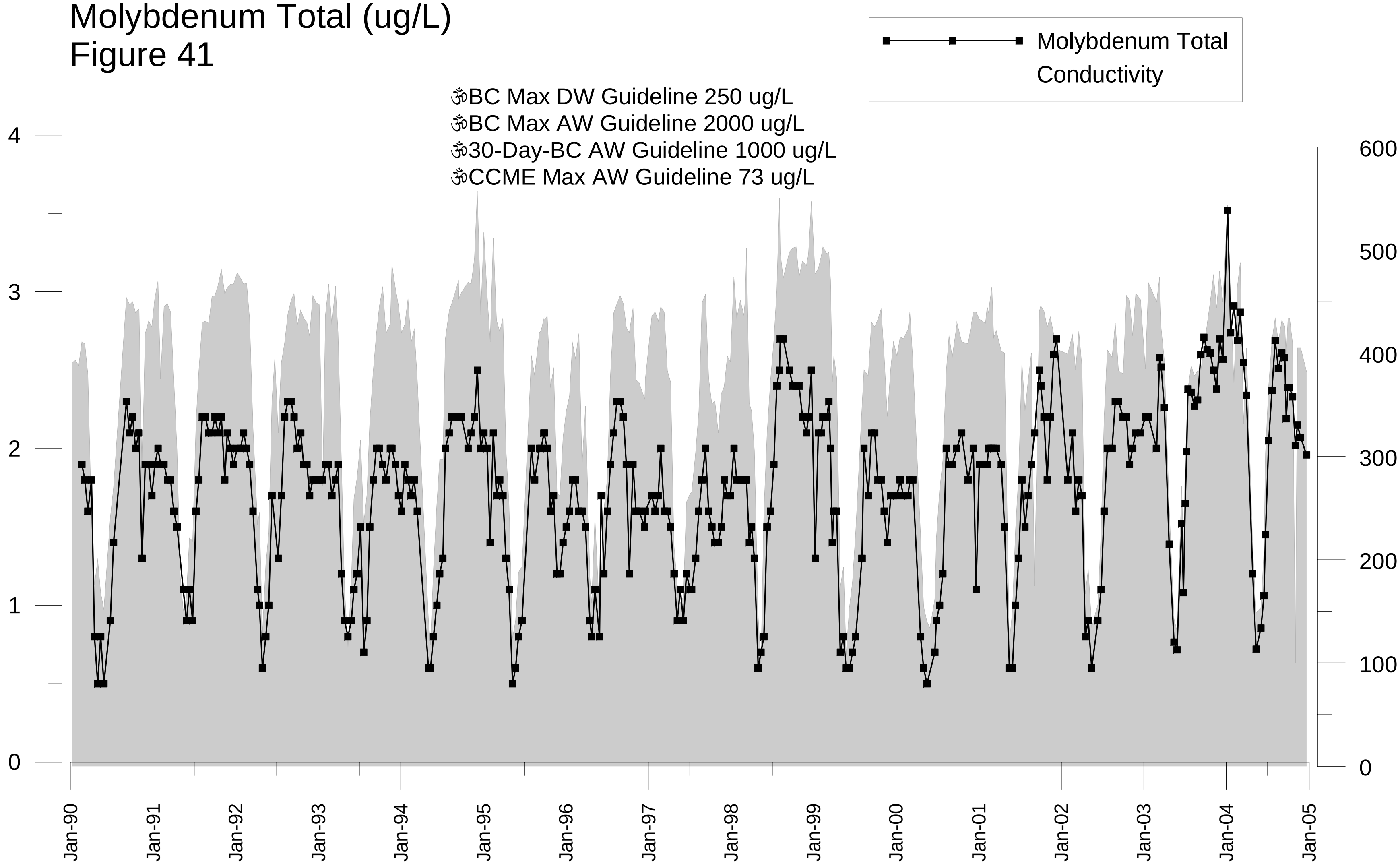
Salmon River at Hwy 1 Bridge
Manganese Total (ug/L)
Figure 40



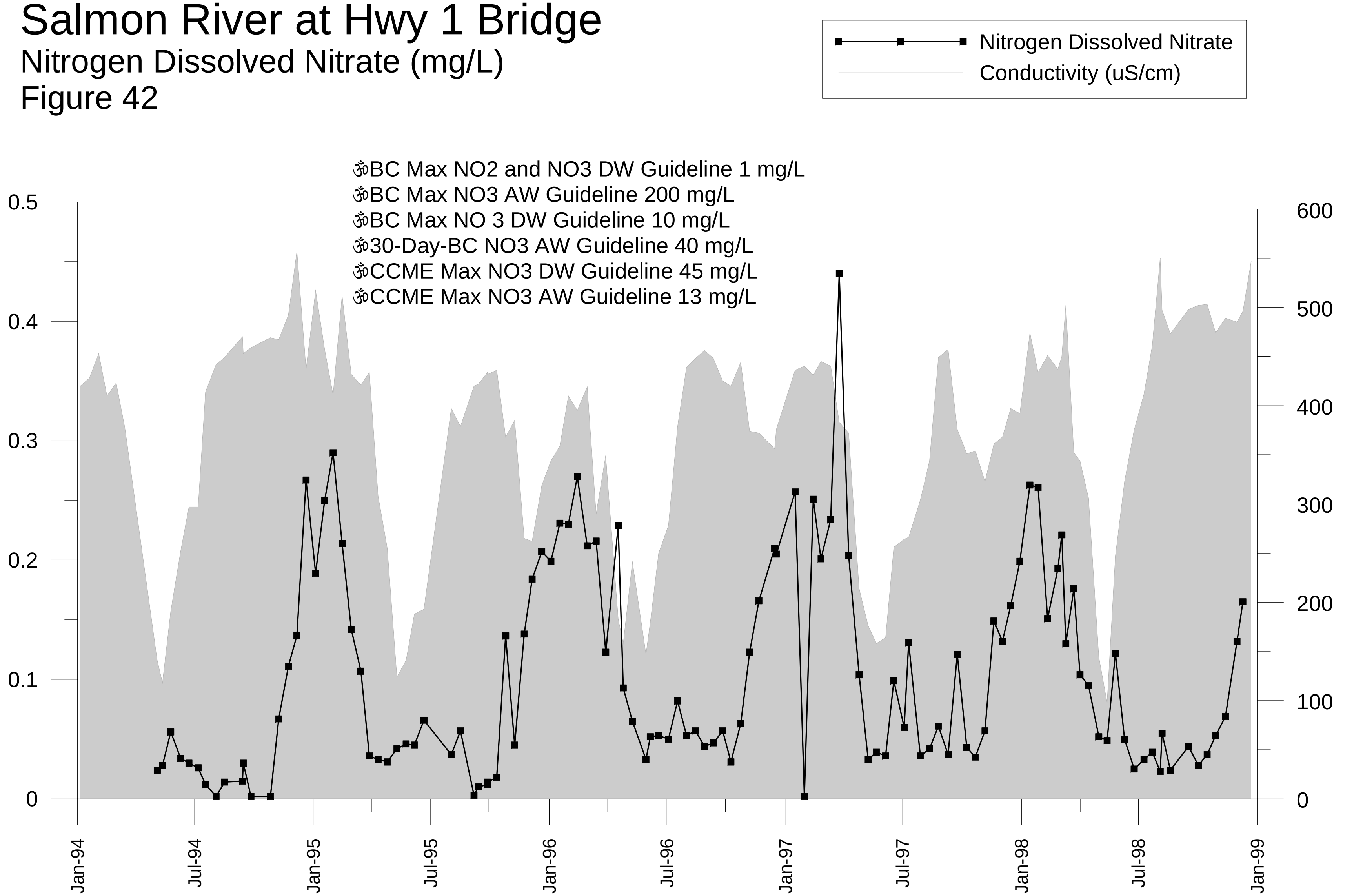
Salmon River at Hwy 1 Bridge

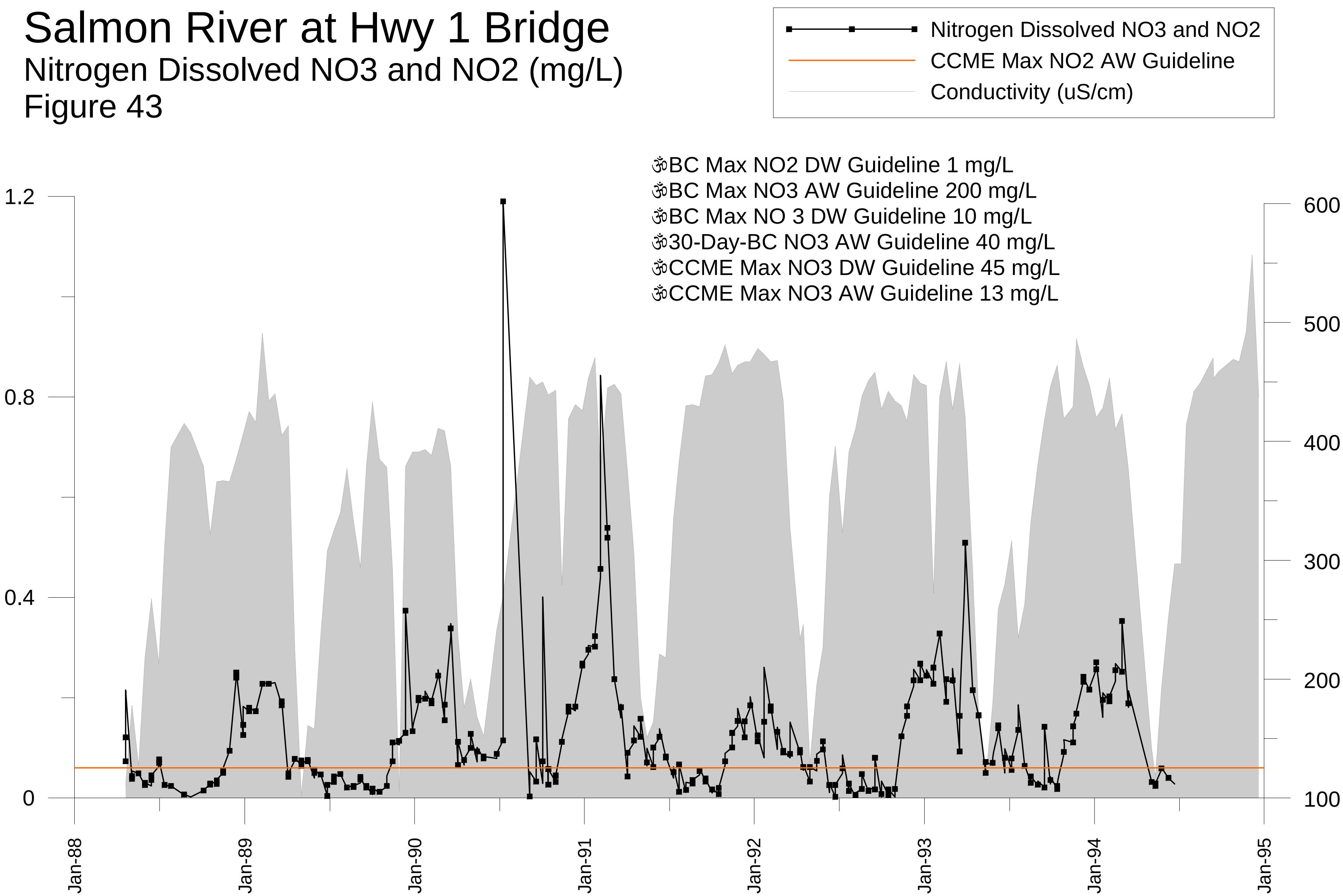
Molybdenum Total (ug/L)

Figure 41



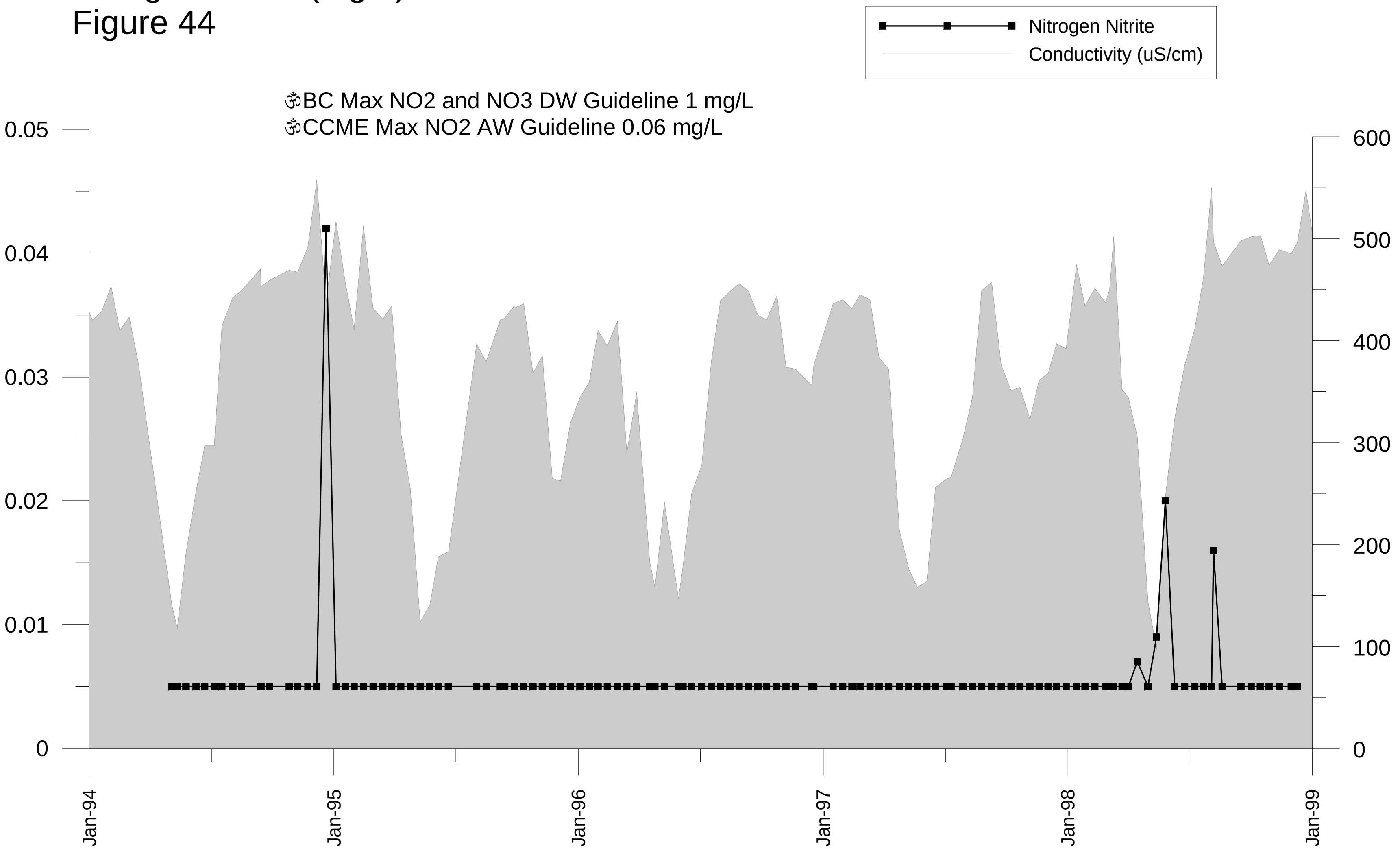
Salmon River at Hwy 1 Bridge
Nitrogen Dissolved Nitrate (mg/L)
Figure 42





Salmon River at Hwy 1 Bridge
Nitrogen Dissolved NO3 and NO2 (mg/L)
Figure 43
Nitrogen Dissolved NO3 and NO2
CCME Max NO2 AW Guideline
Conductivity (uS/cm)
ॐBC Max NO2 DW Guideline 1 mg/L
ॐBC Max NO3 AW Guideline 200 mg/L
ॐBC Max NO 3 DW Guideline 10 mg/L
ॐ30-Day-BC NO3 AW Guideline 40 mg/L
ॐCCME Max NO3 DW Guideline 45 mg/L
ॐCCME Max NO3 AW Guideline 13 mg/L
1.2
0.8
0.4
0
600
500
400
300
200
100
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95

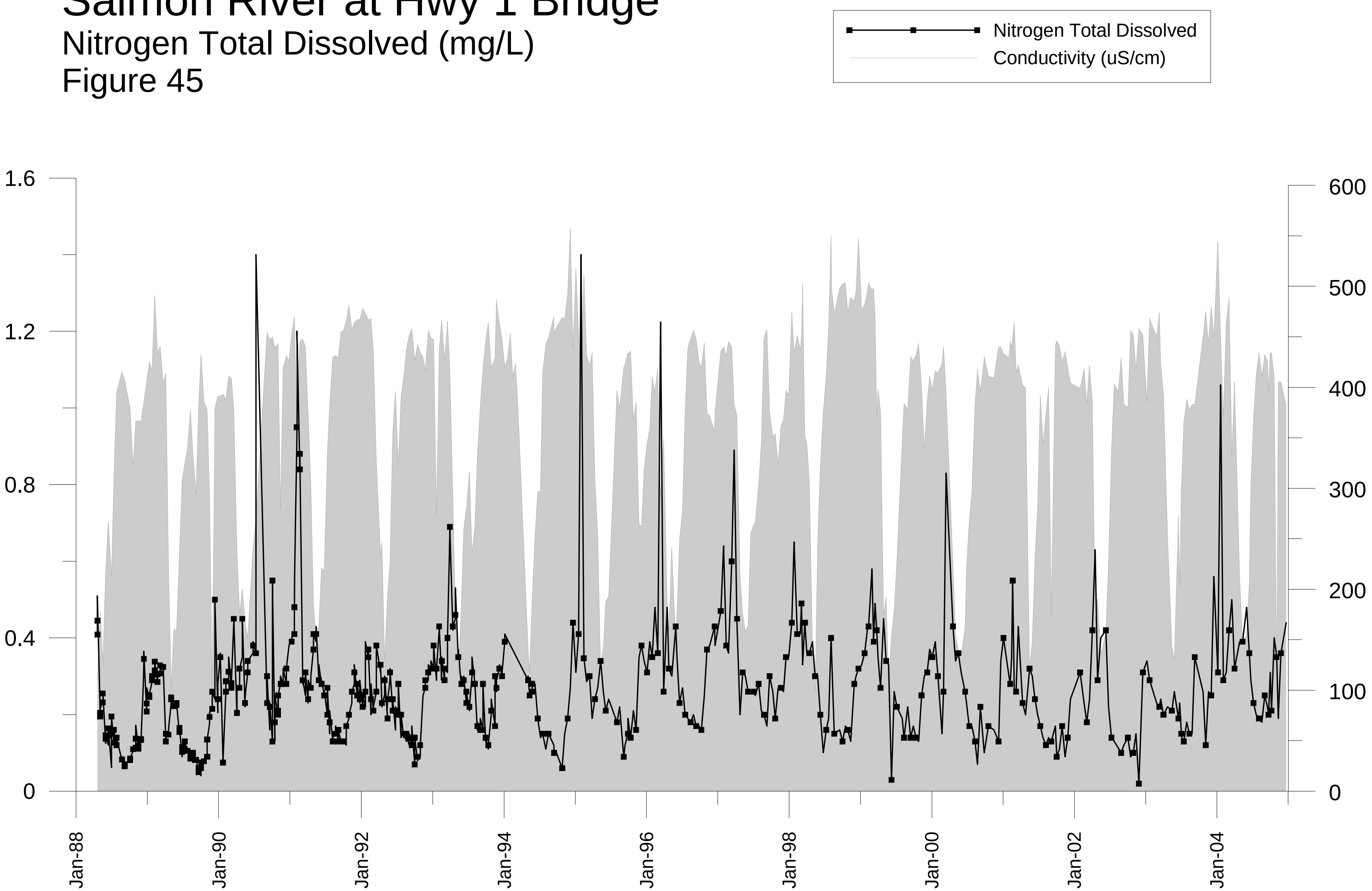
Salmon River at Hwy 1 Bridge
Nitrogen Nitrite (mg/L)
Figure 44

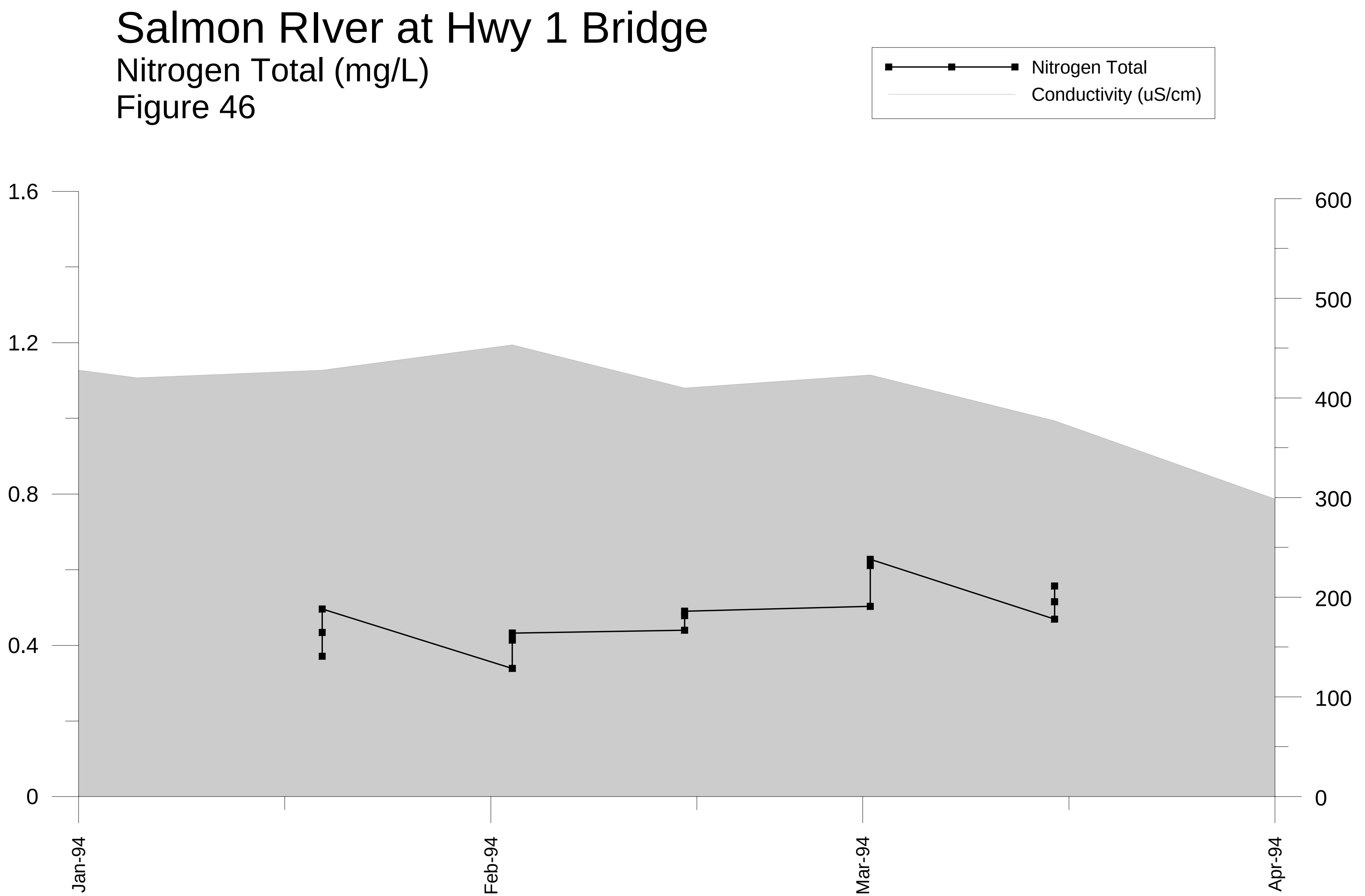


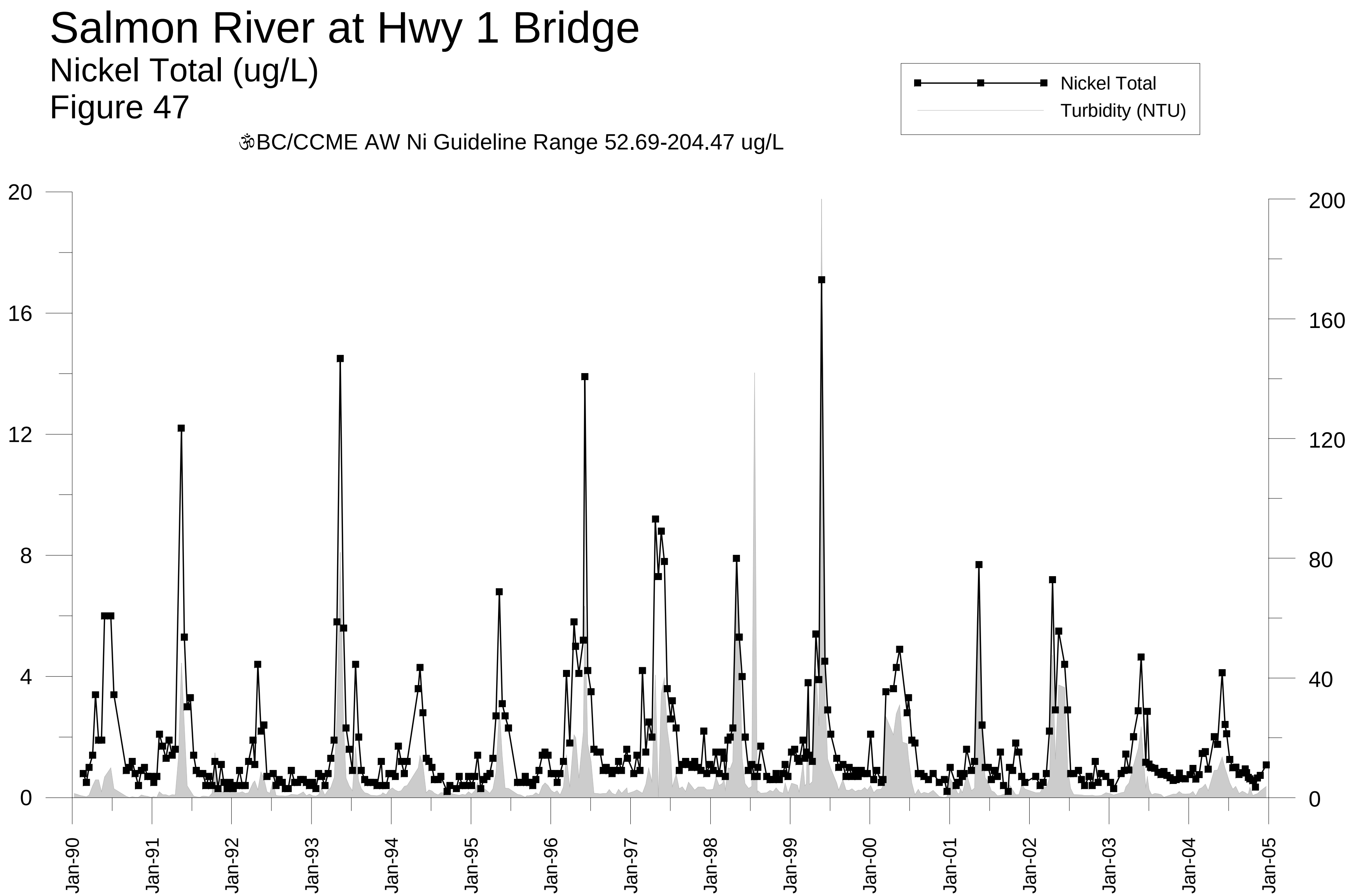
Salmon River at Hwy 1 Bridge

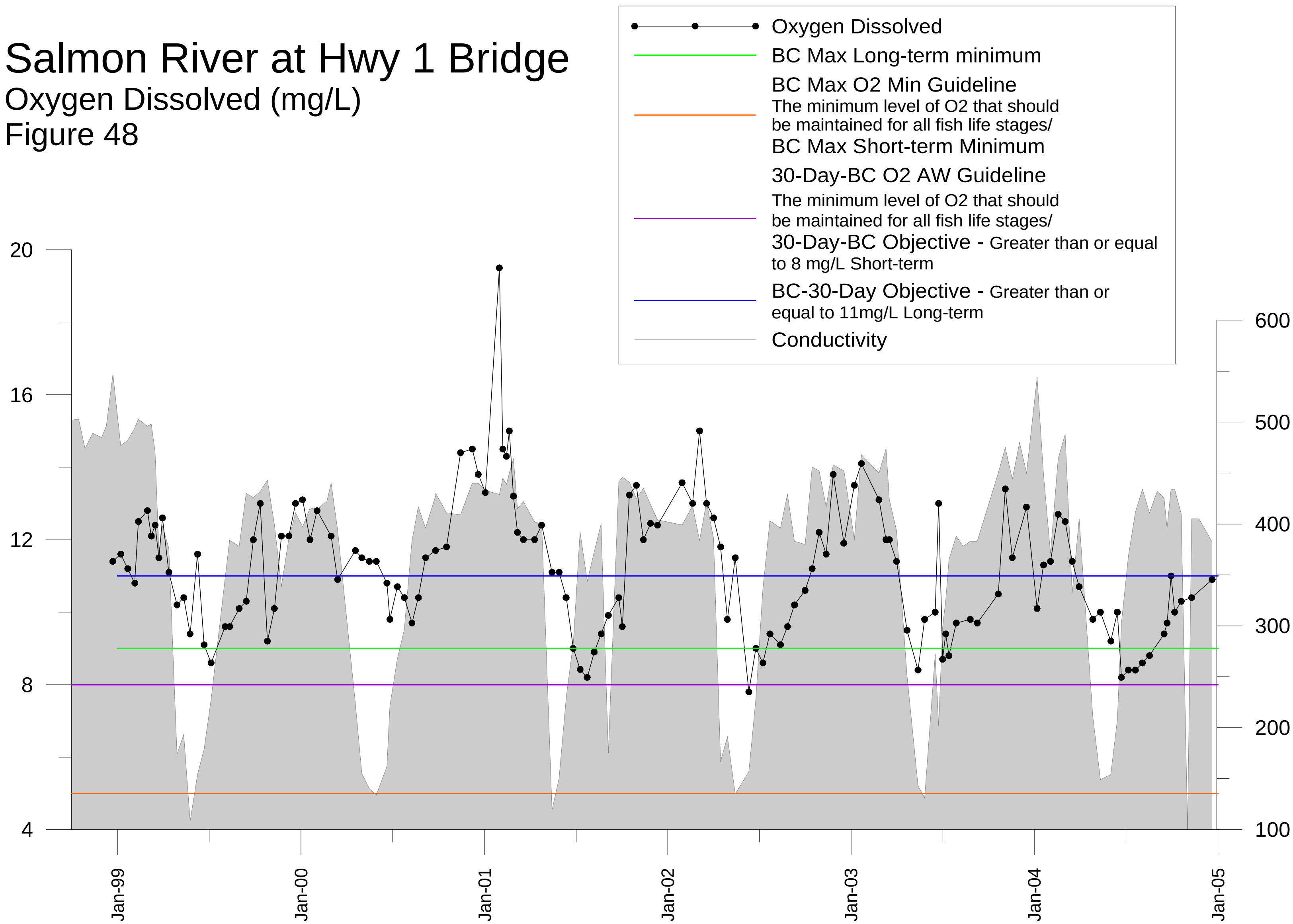
Nitrogen Total Dissolved (mg/L)

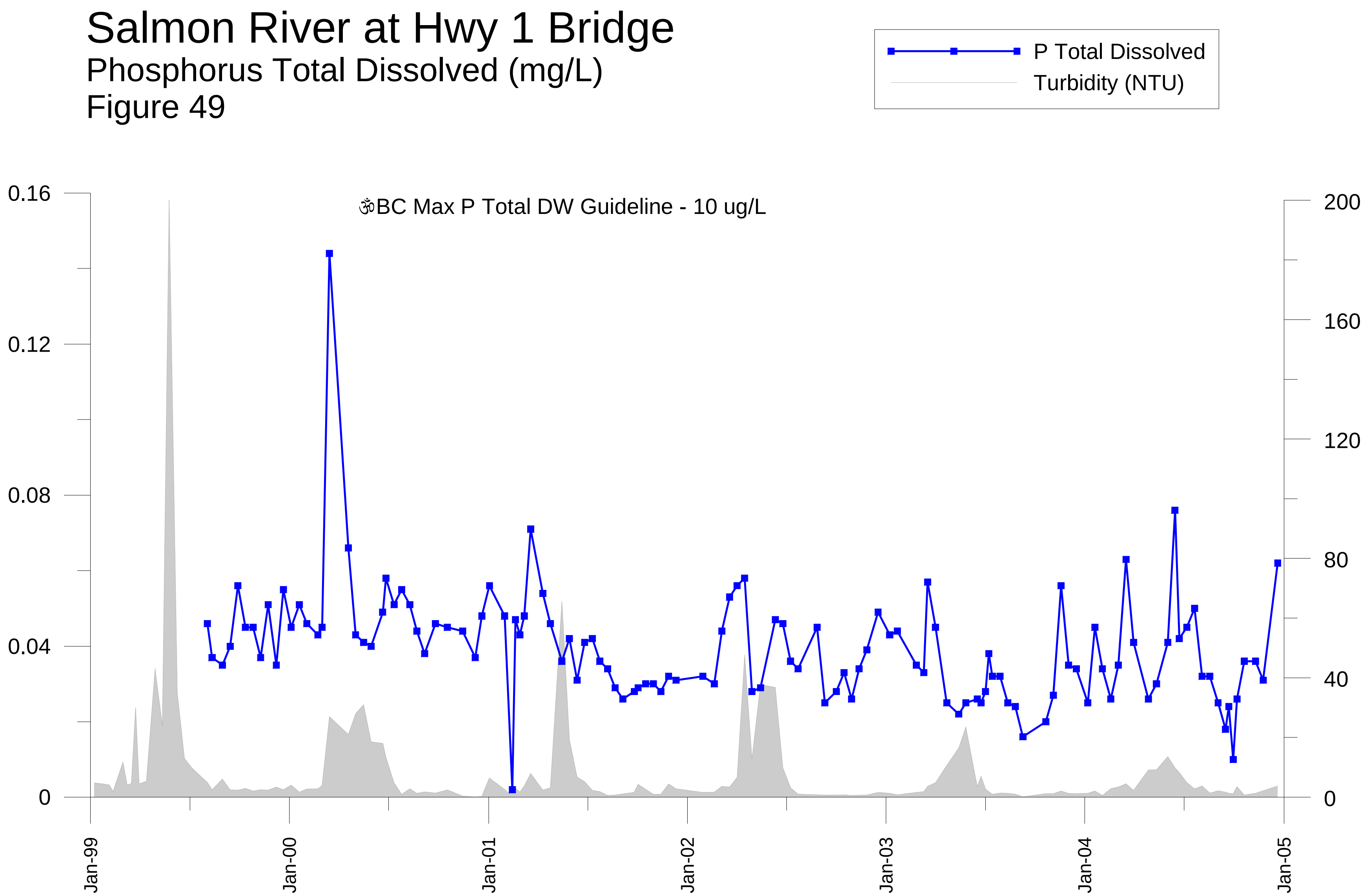
Figure 45




Salmon RIver at Hwy 1 Bridge
Nitrogen Total (mg/L)
Figure 46
Nitrogen Total
Conductivity (uS/cm)
1.6
1.2
0.8
0.4
0
600
500
400
300
200
100
0
Jan-94
Feb-94
Mar-94
Apr-94


Salmon River at Hwy 1 Bridge
Nickel Total (ug/L)
Figure 47
ॐBC/CCME AW Ni Guideline Range 52.69-204.47 ug/L
Nickel Total
Turbidity (NTU)
0
4
8
12
16
20
0
40
80
120
160
200
Jan-90
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

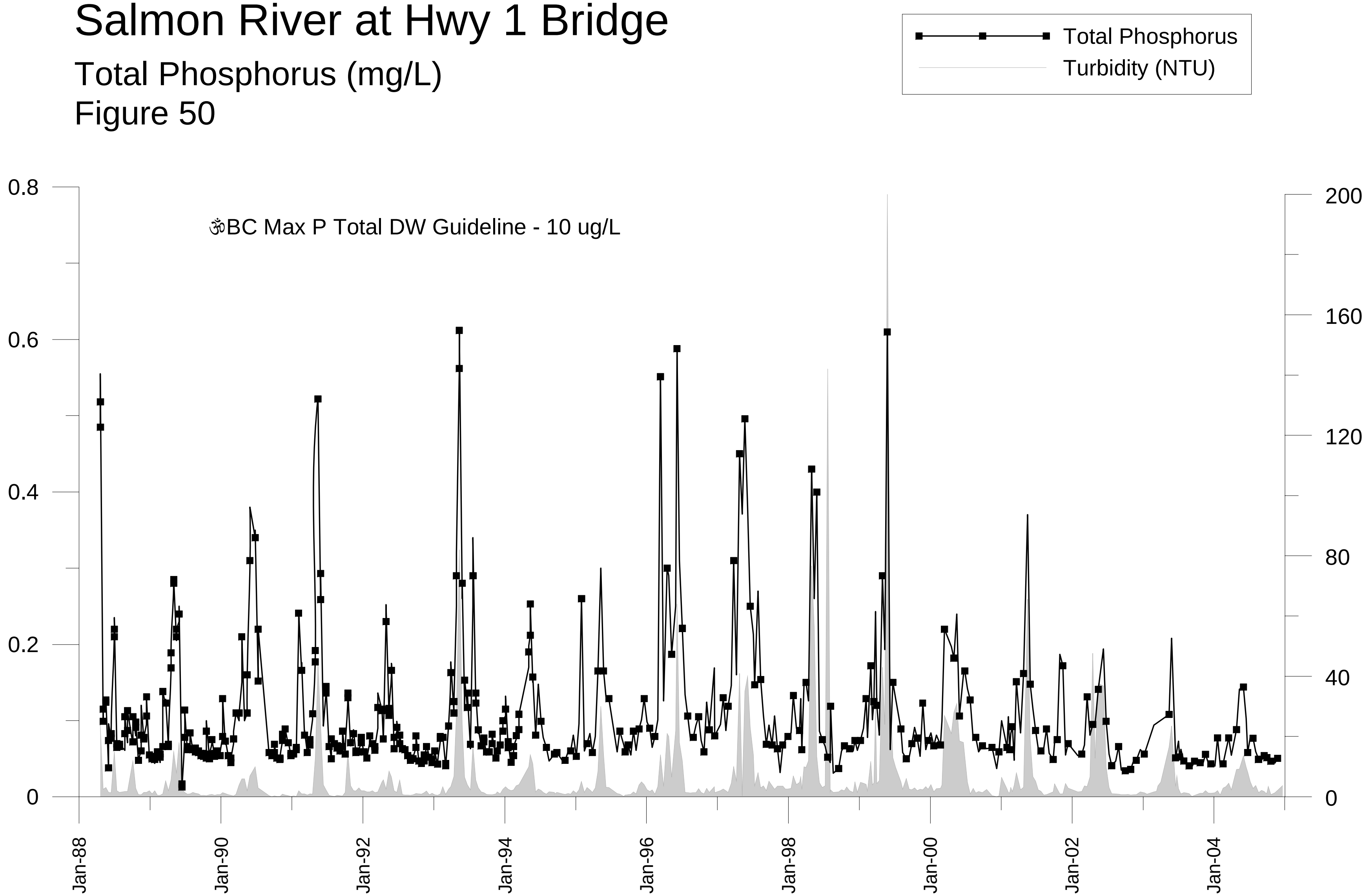

Salmon River at Hwy 1 Bridge
Oxygen Dissolved (mg/L)
Figure 48
Oxygen Dissolved
BC Max Long-term minimum
BC Max O2 Min Guideline
The minimum level of O2 that should be maintained for all fish life stages/
BC Max Short-term Minimum
30-Day-BC O2 AW Guideline
The minimum level of O2 that should be maintained for all fish life stages/
30-Day-BC Objective - Greater than or equal to 8 mg/L Short-term
BC-30-Day Objective - Greater than or equal to 11mg/L Long-term
Conductivity
20
16
12
8
4
600
500
400
300
200
100
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

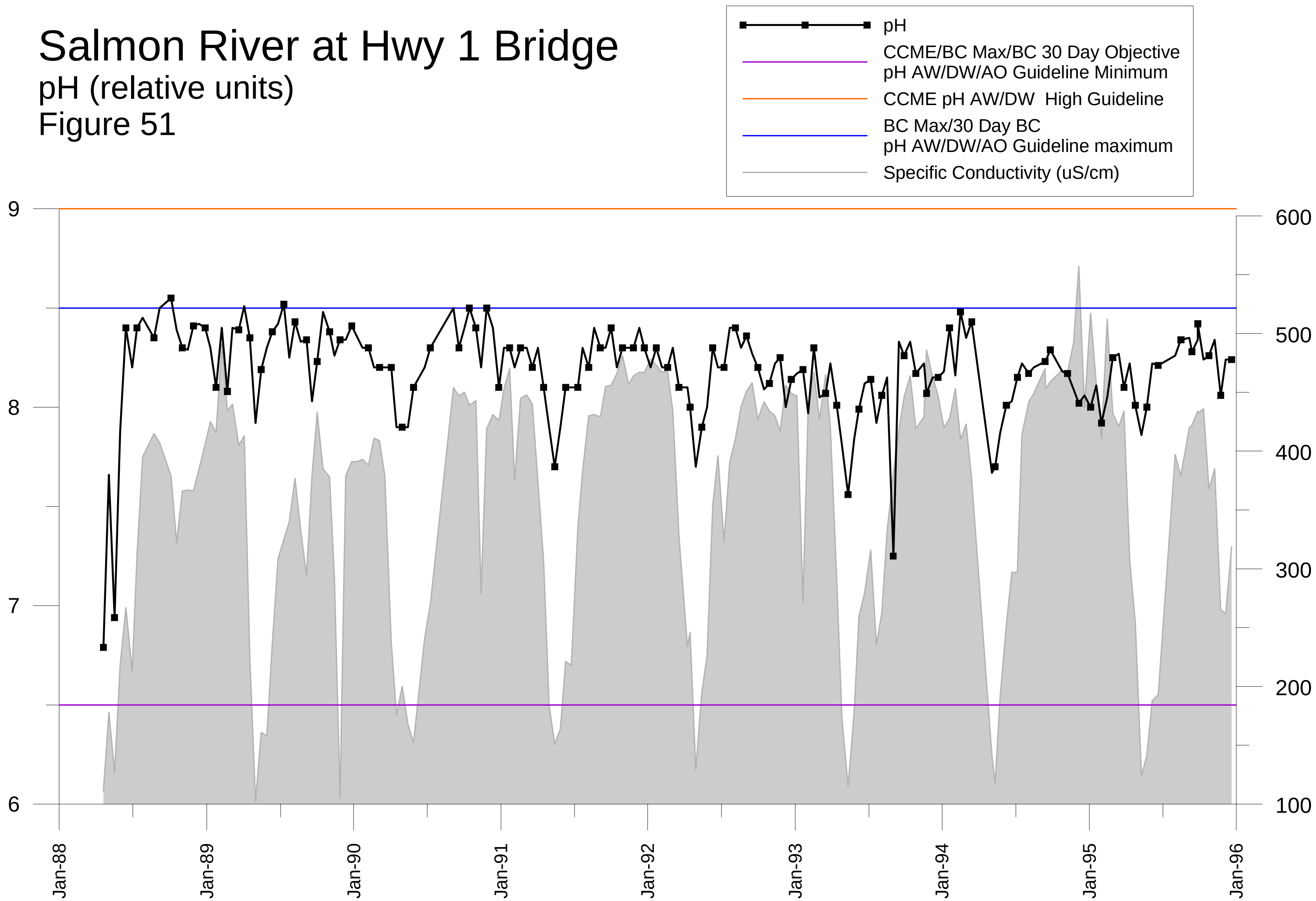

Salmon River at Hwy 1 Bridge
Phosphorus Total Dissolved (mg/L)
Figure 49
P Total Dissolved
Turbidity (NTU)
ॐBC Max P Total DW Guideline - 10 ug/L
0.16
0.12
0.08
0.04
0
200
160
120
80
40
0
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

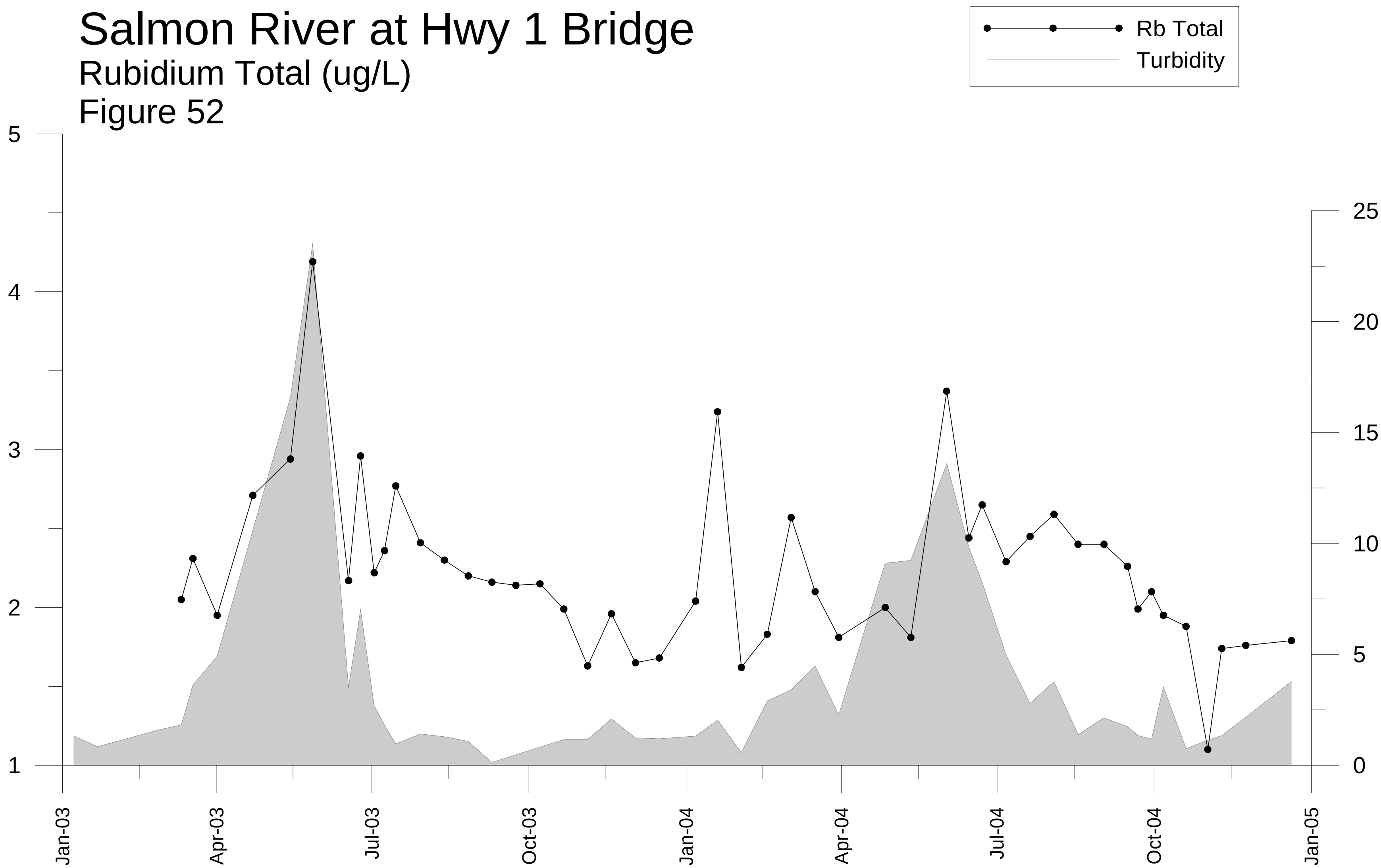
Salmon River at Hwy 1 Bridge

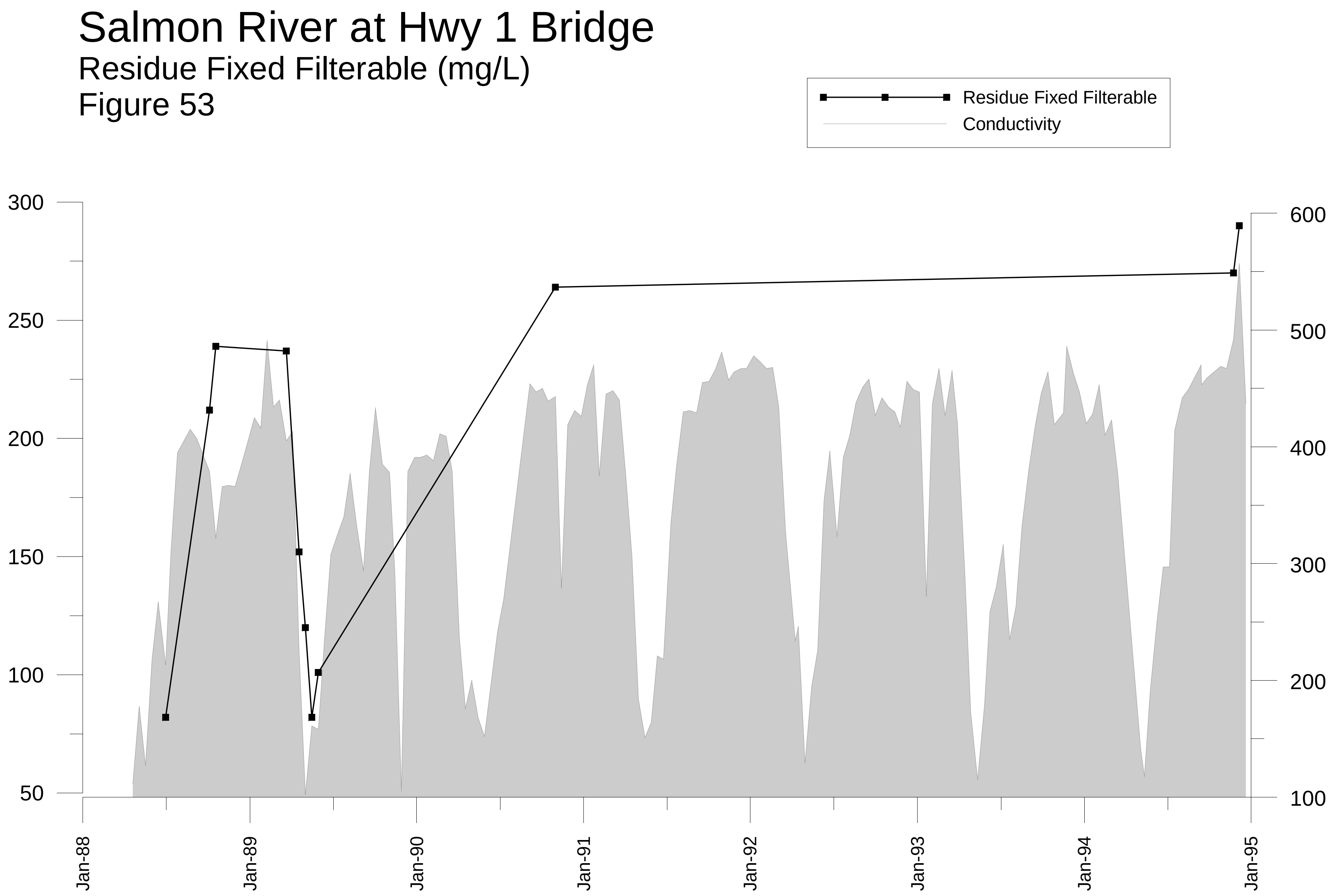
Total Phosphorus (mg/L)

Figure 50




Salmon River at Hwy 1 Bridge
pH (relative units)
Figure 51
pH
CCME/BC Max/BC 30 Day Objective
pH AW/DW/AO Guideline Minimum
CCME pH AW/DW High Guideline
BC Max/30 Day BC
pH AW/DW/AO Guideline maximum
Specific Conductivity (uS/cm)
9
8
7
6
600
500
400
300
200
100
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96

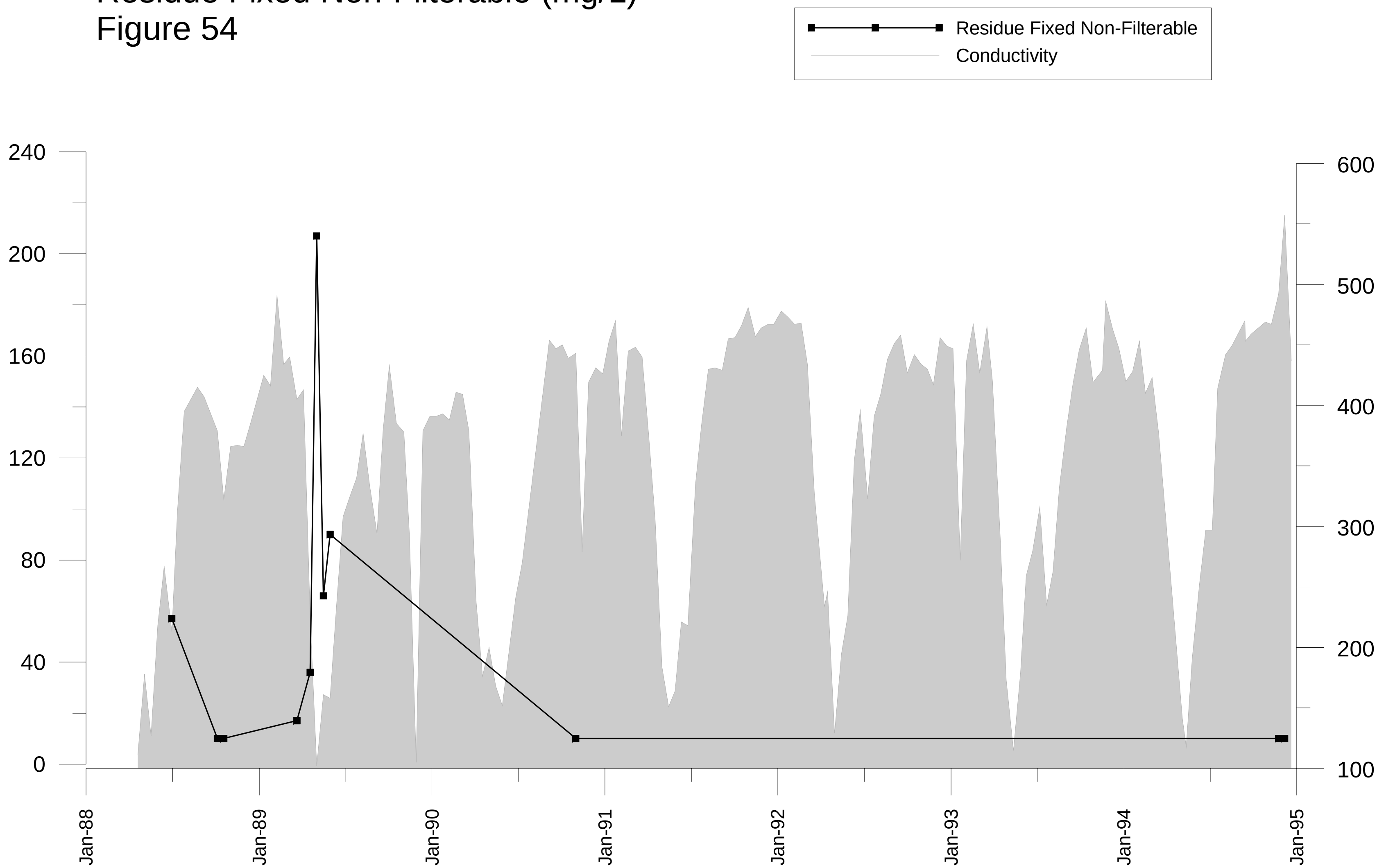

Salmon River at Hwy 1 Bridge
Rubidium Total (ug/L)
Figure 52
Rb Total
Turbidity
5
4
3
2
1
25
20
15
10
5
0
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05


Salmon River at Hwy 1 Bridge
Residue Fixed Filterable (mg/L)
Figure 53
Residue Fixed Filterable
Conductivity
300
250
200
150
100
50
600
500
400
300
200
100
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95

Salmon River at Hwy 1 Bridge

Residue Fixed Non-Filterable (mg/L)

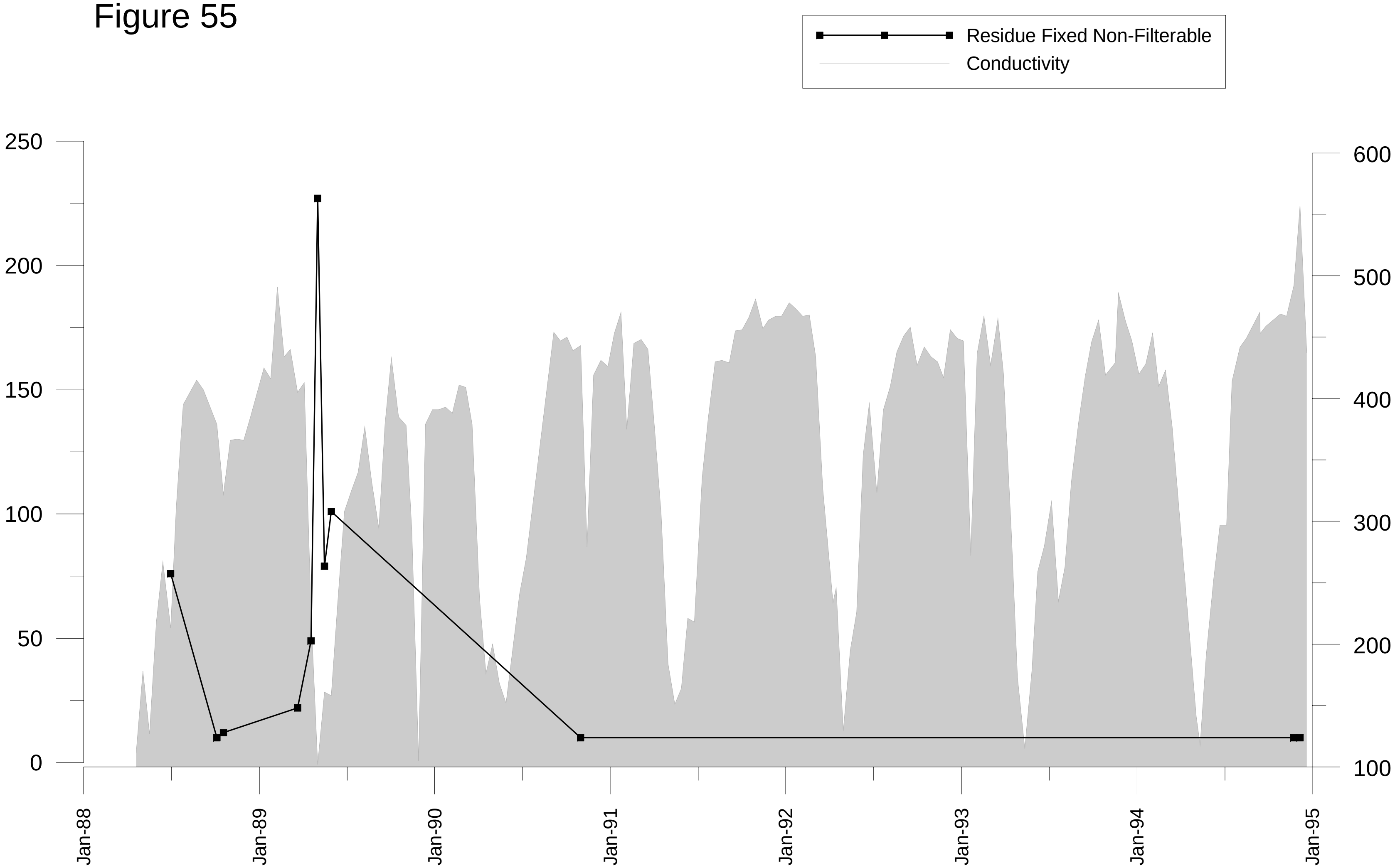
Figure 54

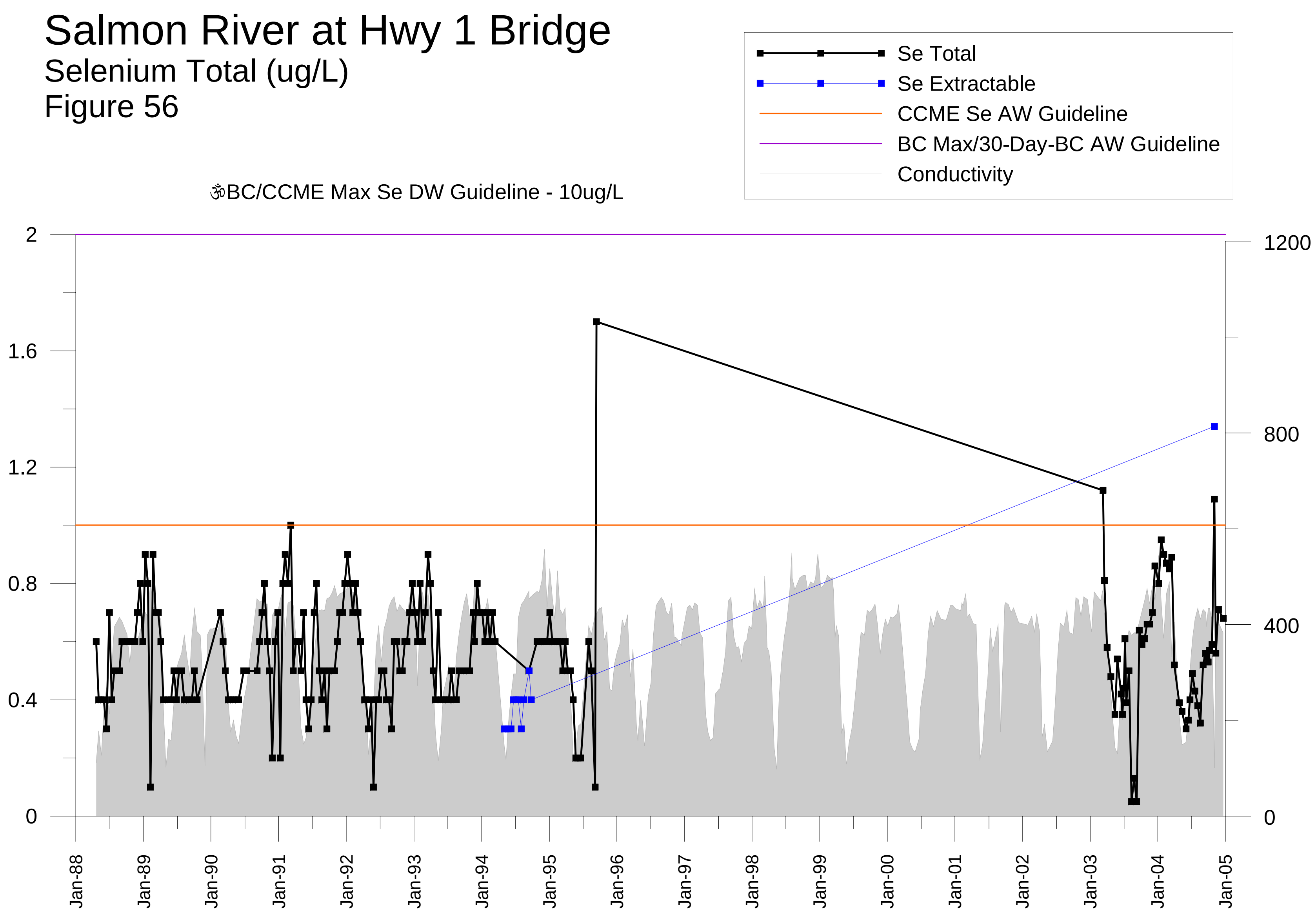


Salmon River at Hwy 1 Bridge

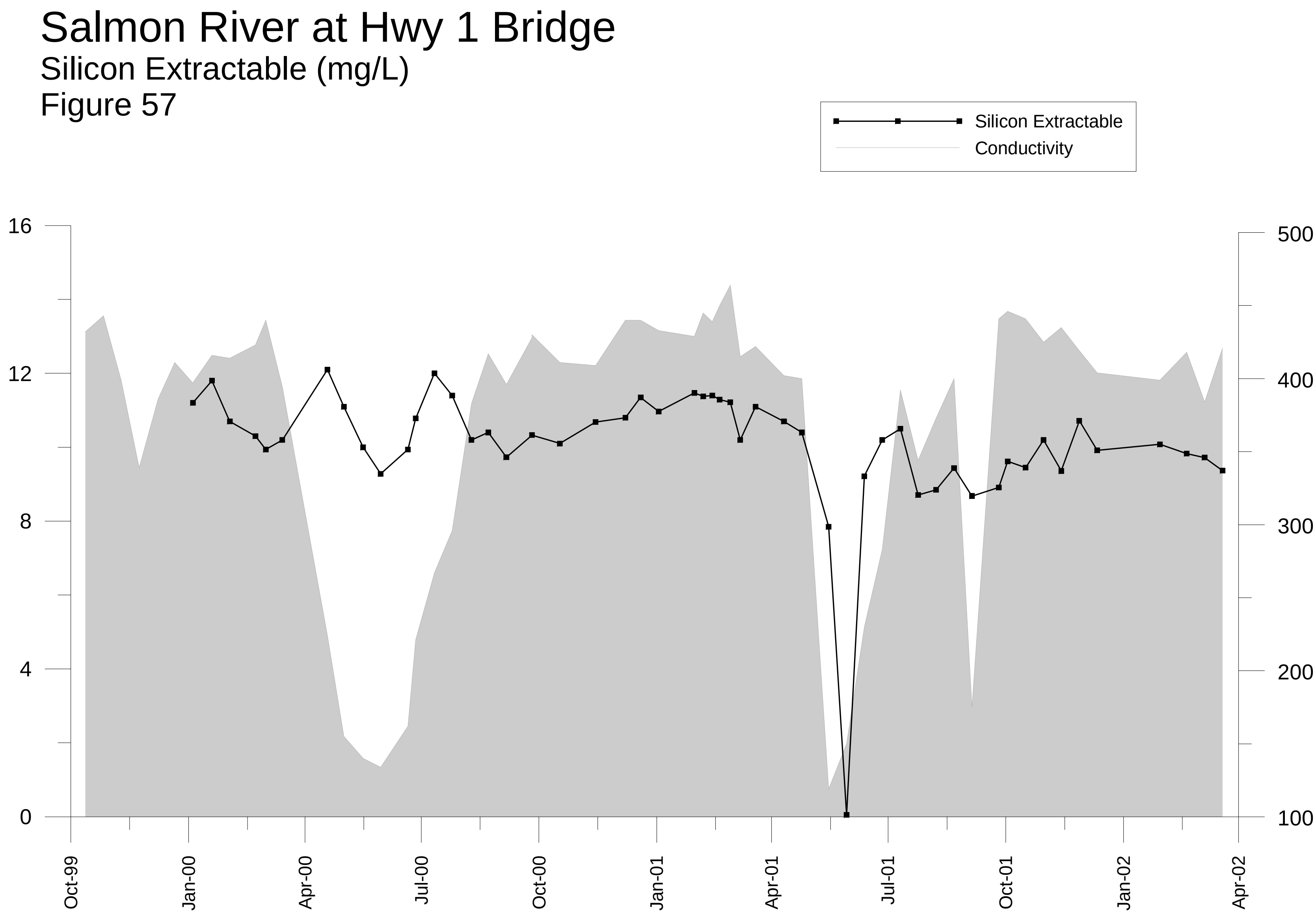
Residue Non-Filterable (mg/L)

Figure 55





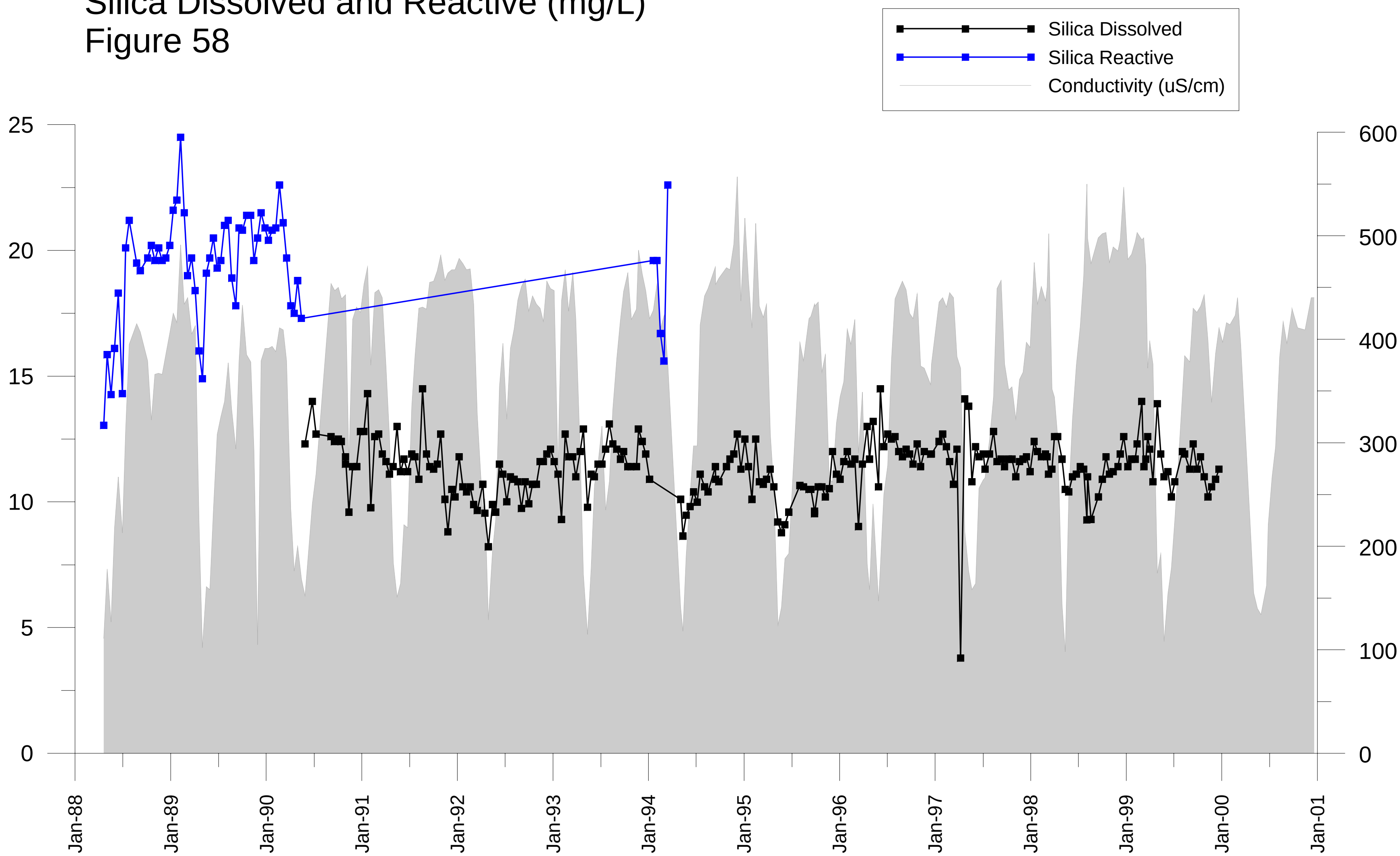
Salmon River at Hwy 1 Bridge
Selenium Total (ug/L)
Figure 56
Se Total
Se Extractable
CCME Se AW Guideline
BC Max/30-Day-BC AW Guideline
Conductivity
ॐBC/CCME Max Se DW Guideline - 10ug/L
2
1.6
1.2
0.8
0.4
0
1200
800
400
0
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

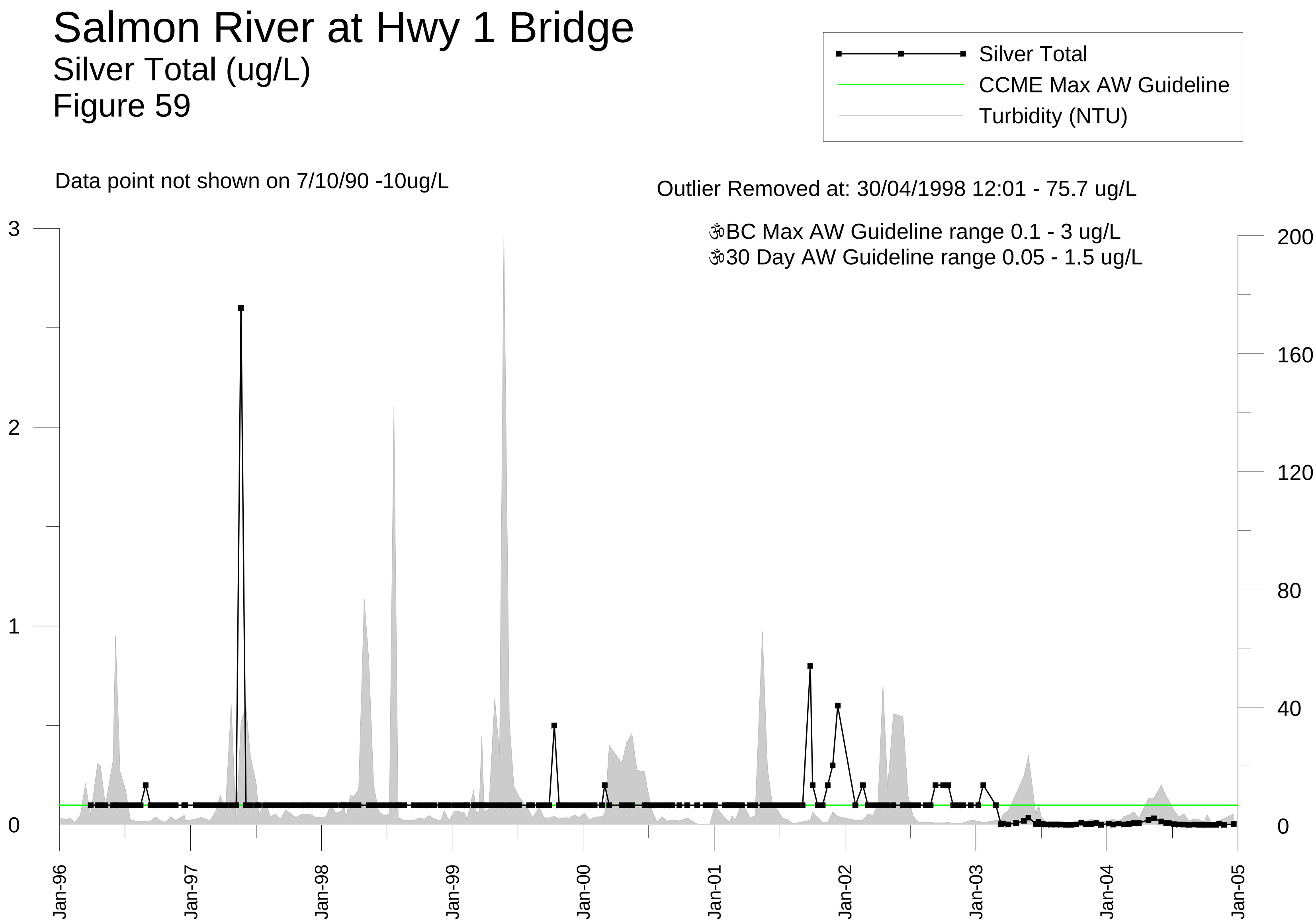

Salmon River at Hwy 1 Bridge
Silicon Extractable (mg/L)
Figure 57
Silicon Extractable
Conductivity
16
12
8
4
0
500
400
300
200
100
Oct-99
Jan-00
Apr-00
Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02

Salmon River at Hwy 1 Bridge

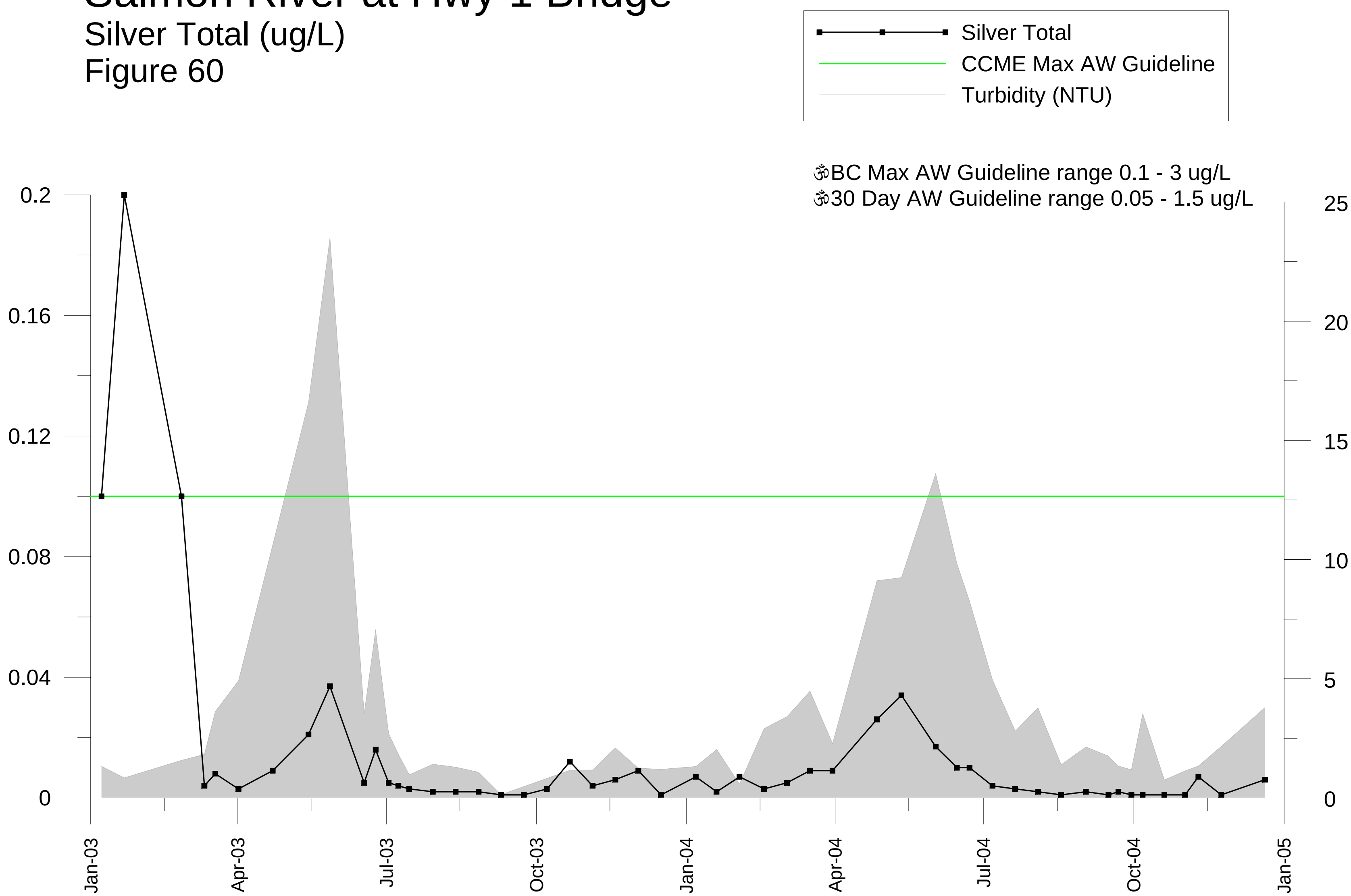
Silica Dissolved and Reactive (mg/L)

Figure 58

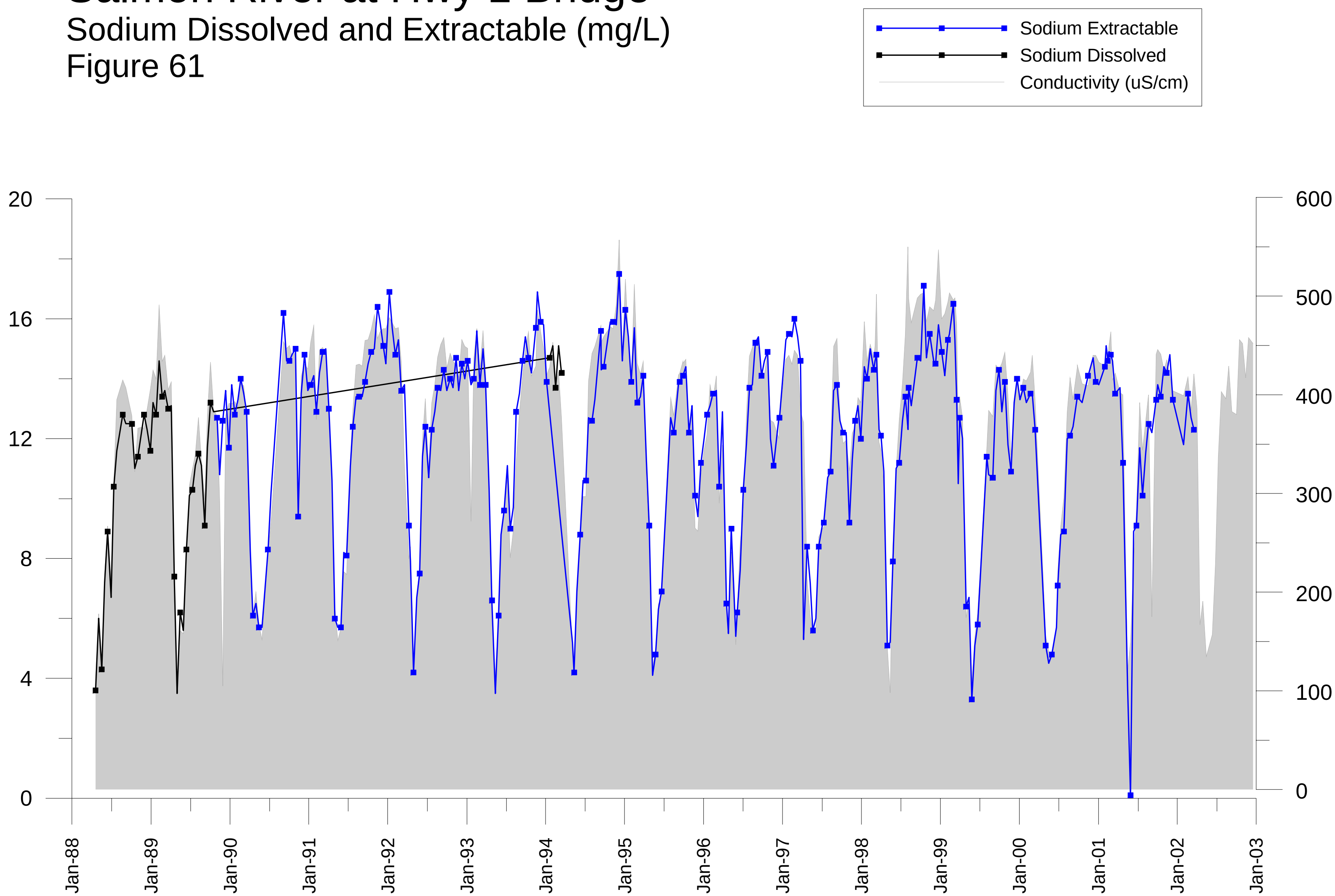


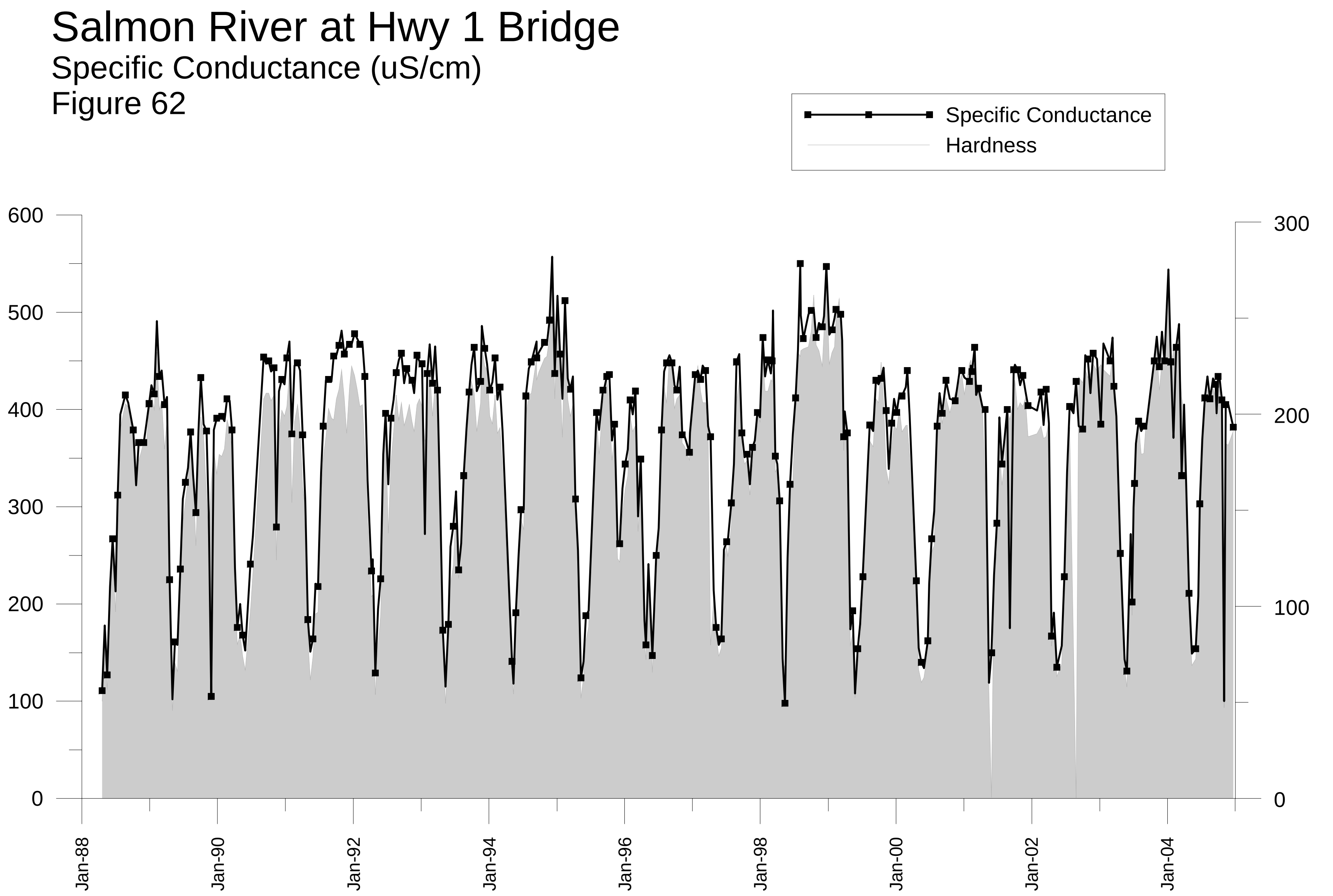

Salmon River at Hwy 1 Bridge
Silver Total (ug/L)
Figure 59
Silver Total
CCME Max AW Guideline
Turbidity (NTU)
Data point not shown on 7/10/90 -10ug/L
Outlier Removed at: 30/04/1998 12:01 - 75.7 ug/L
ॐBC Max AW Guideline range 0.1 - 3 ug/L
ॐ30 Day AW Guideline range 0.05 - 1.5 ug/L
3
2
1
0
200
160
120
80
40
0
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05

Salmon River at Hwy 1 Bridge
Silver Total (ug/L)
Figure 60



Salmon River at Hwy 1 Bridge
Sodium Dissolved and Extractable (mg/L)
Figure 61

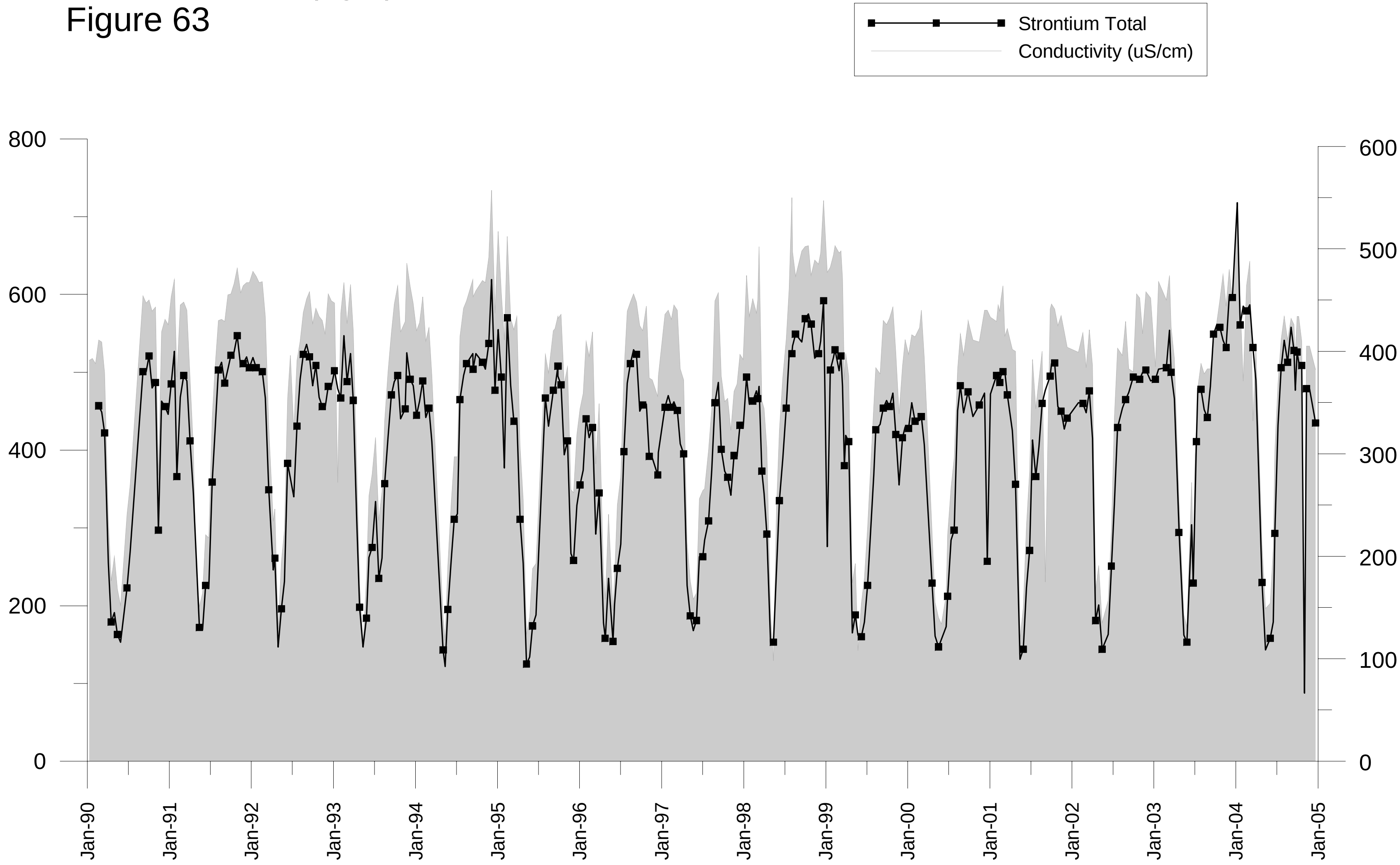



Salmon River at Hwy 1 Bridge
Specific Conductance (uS/cm)
Figure 62
Specific Conductance
Hardness
600
500
400
300
200
100
0
300
200
100
0
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04

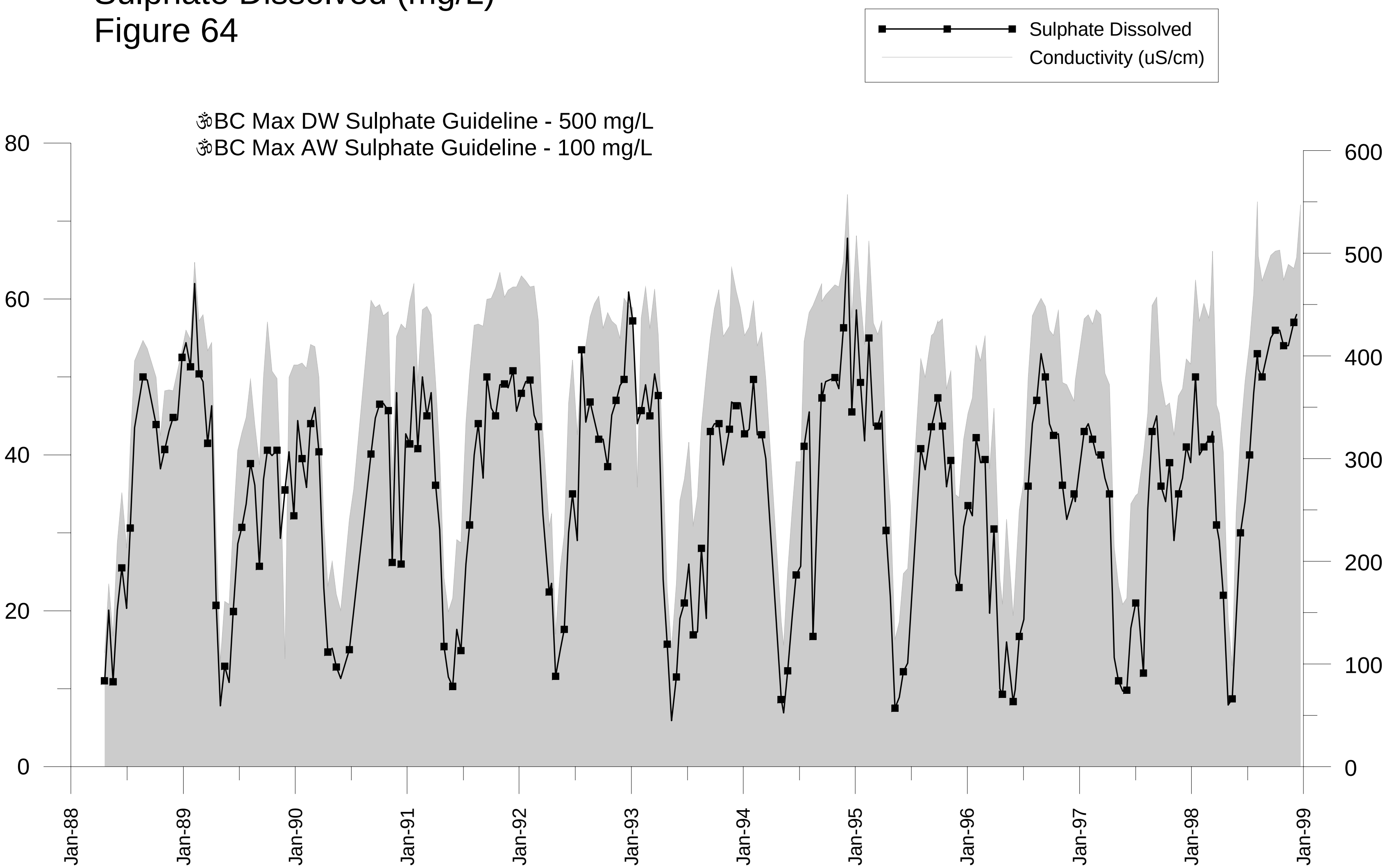
Salmon River at Hwy 1 Bridge

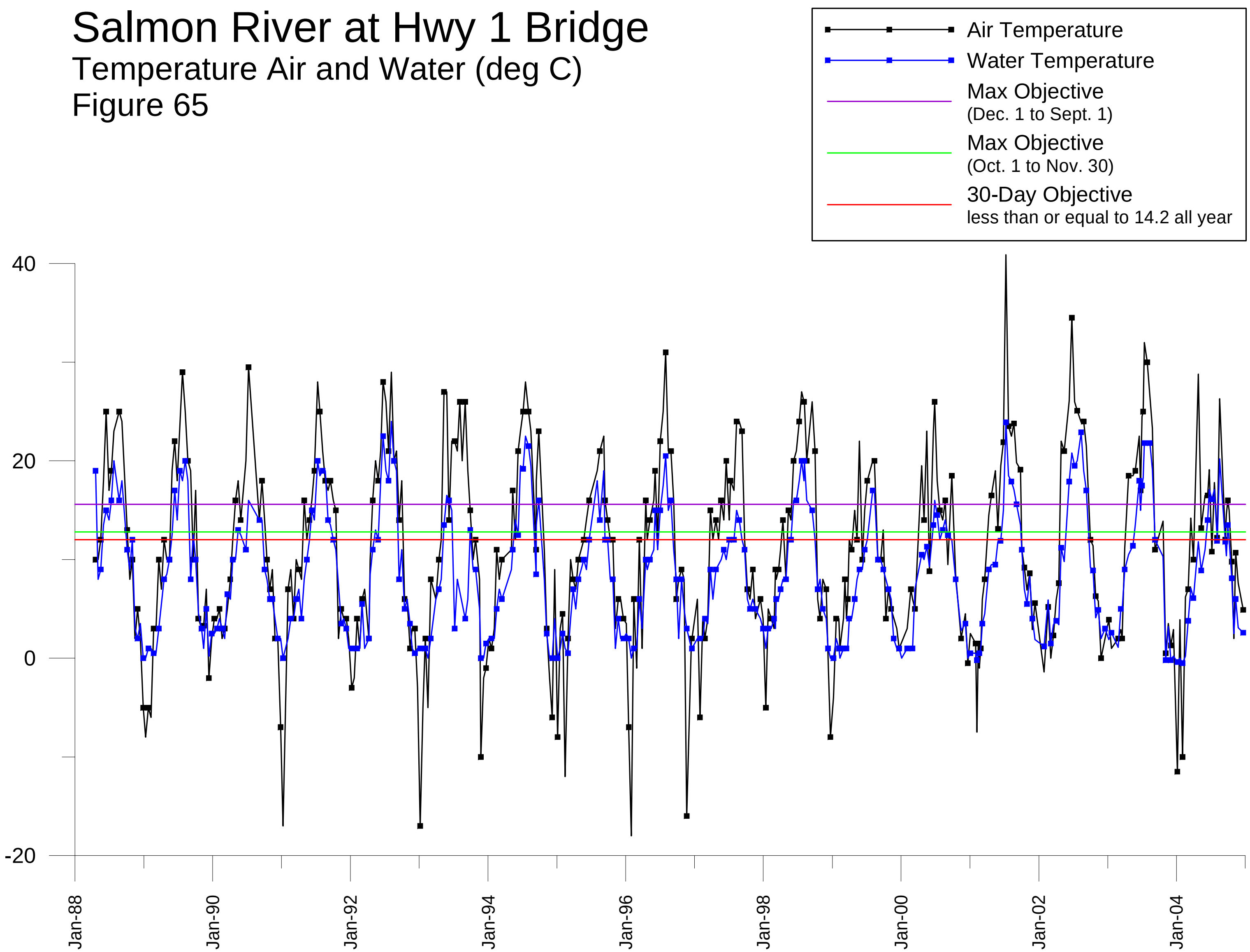
Strontium Total (ug/L)

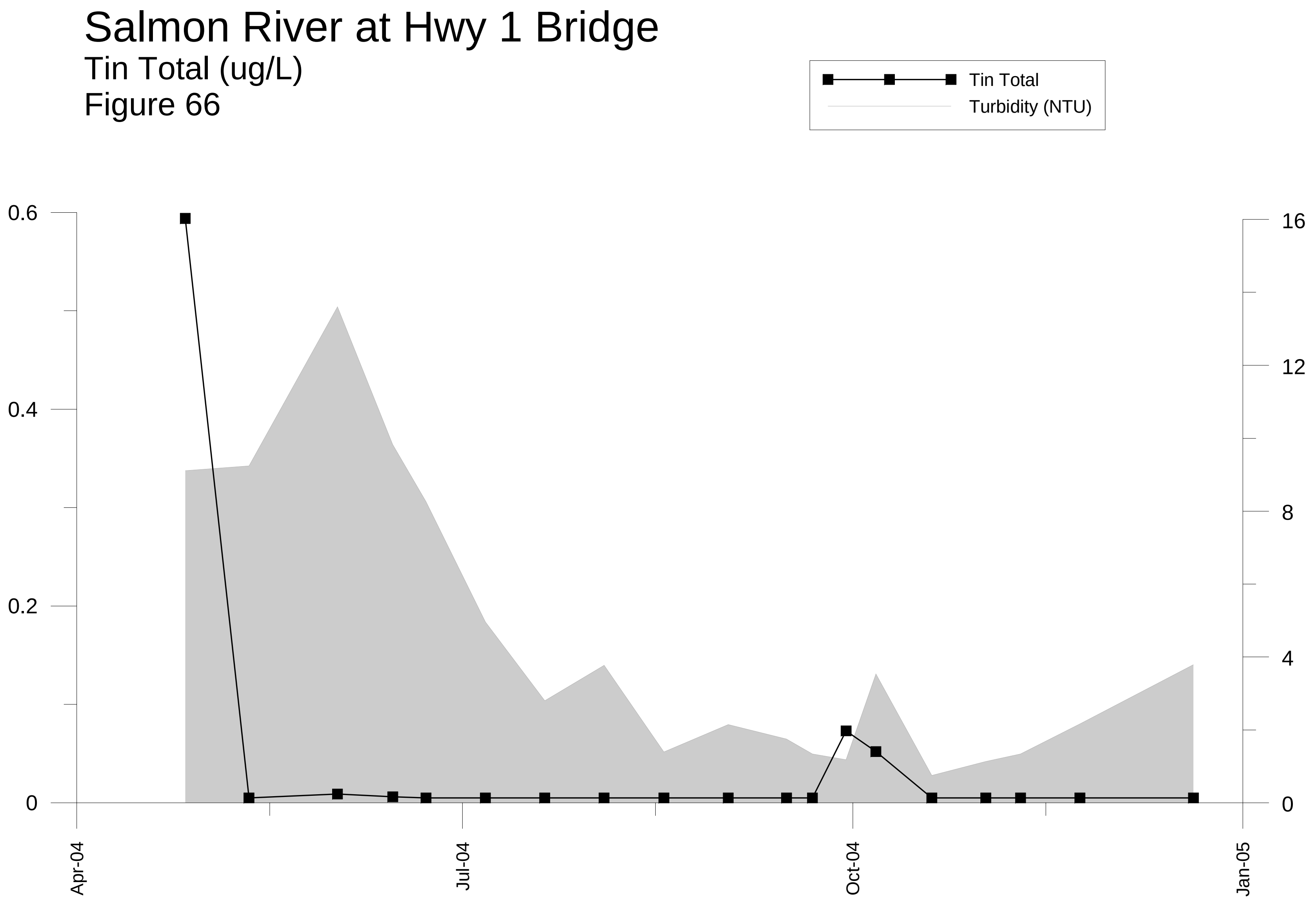
Figure 63



Salmon River at Hwy 1 Bridge
Sulphate Dissolved (mg/L)
Figure 64



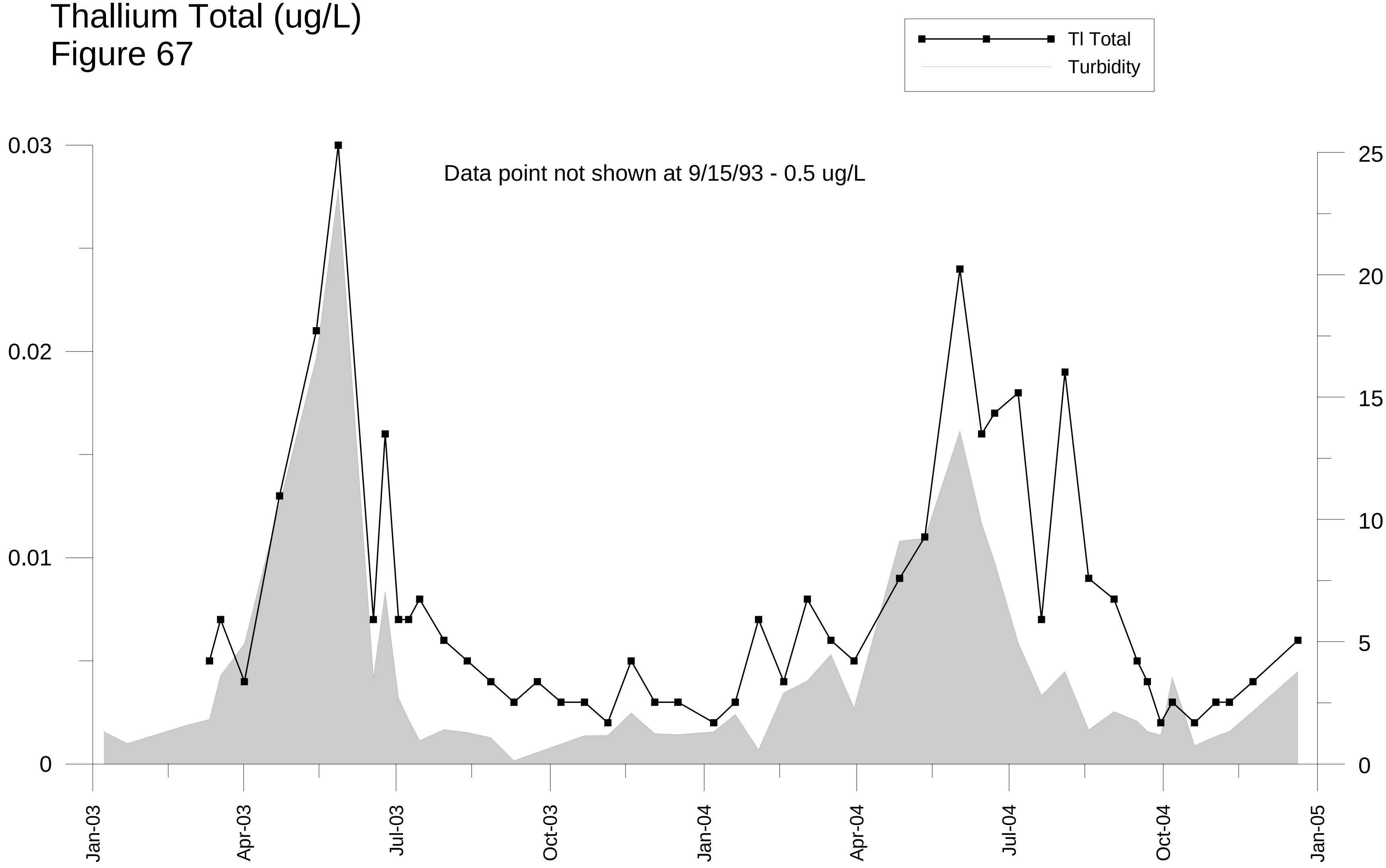

Salmon River at Hwy 1 Bridge
Temperature Air and Water (deg C)
Figure 65
Air Temperature
Water Temperature
Max Objective
(Dec. 1 to Sept. 1)
Max Objective
(Oct. 1 to Nov. 30)
30-Day Objective
less than or equal to 14.2 all year
40
20
0
-20
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04

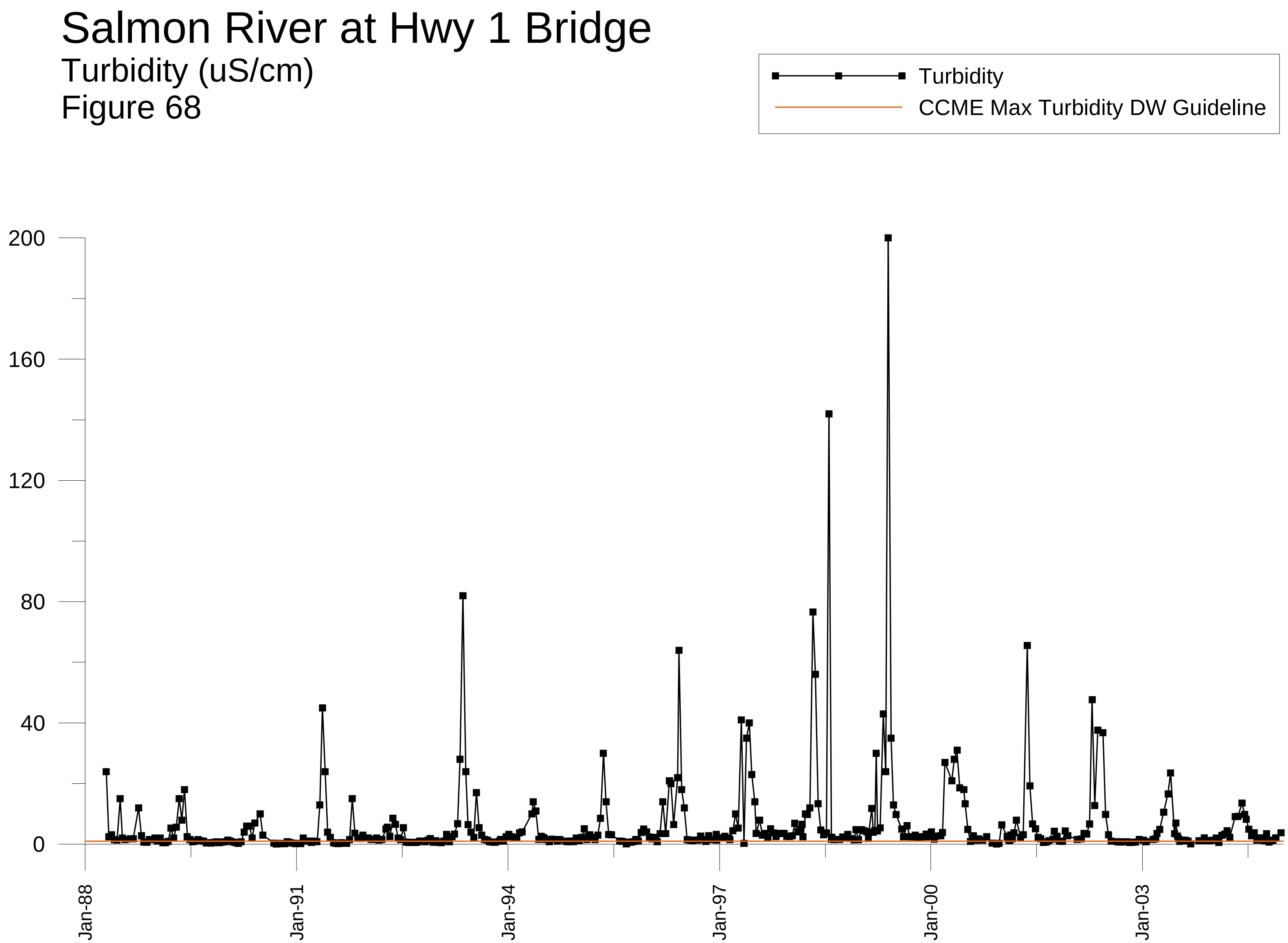

Salmon River at Hwy 1 Bridge
Tin Total (ug/L)
Figure 66
Tin Total
Turbidity (NTU)
0.6
0.4
0.2
0
16
12
8
4
0
Apr-04
Jul-04
Oct-04
Jan-05

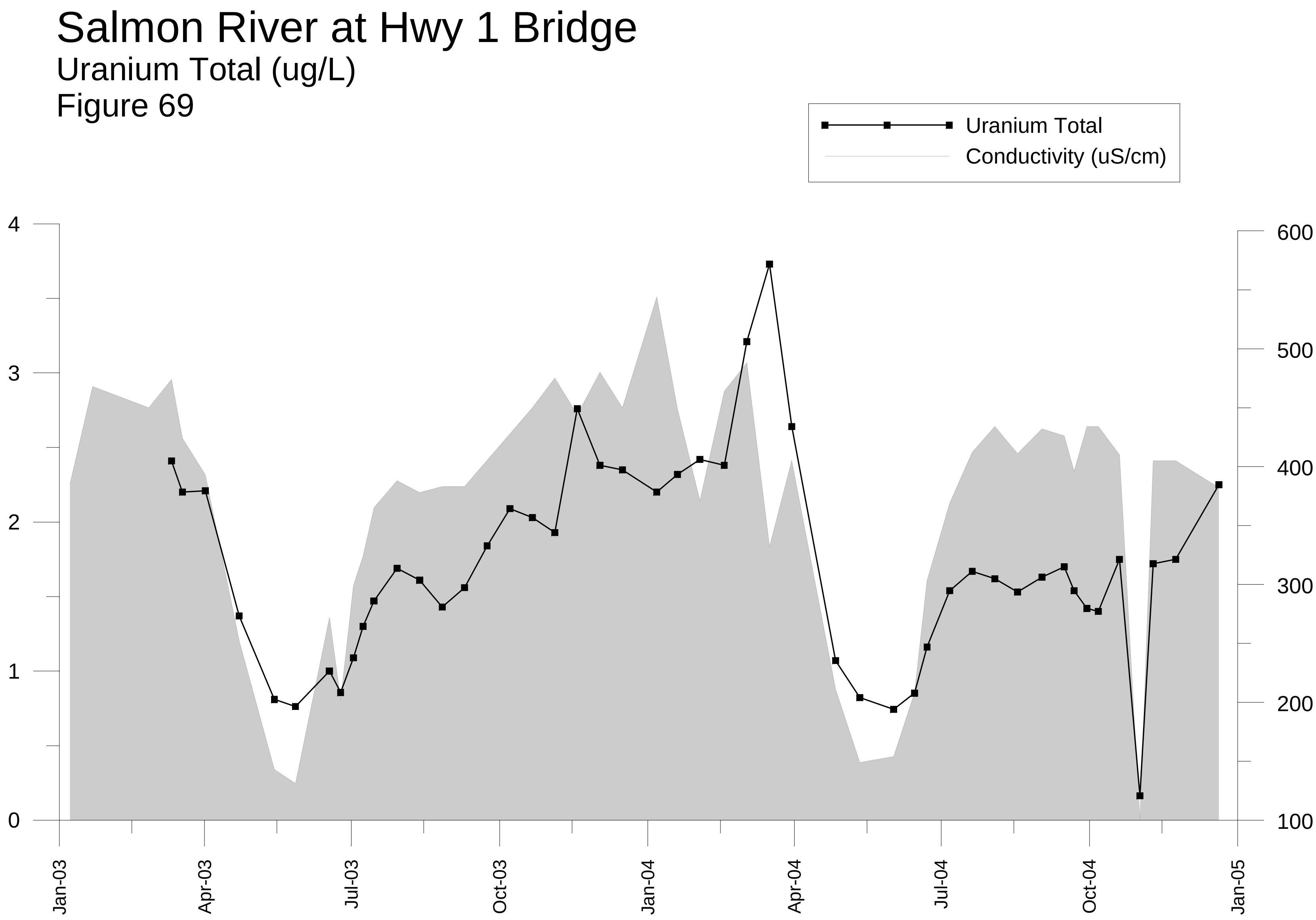
Salmon River at Hwy 1 Bridge

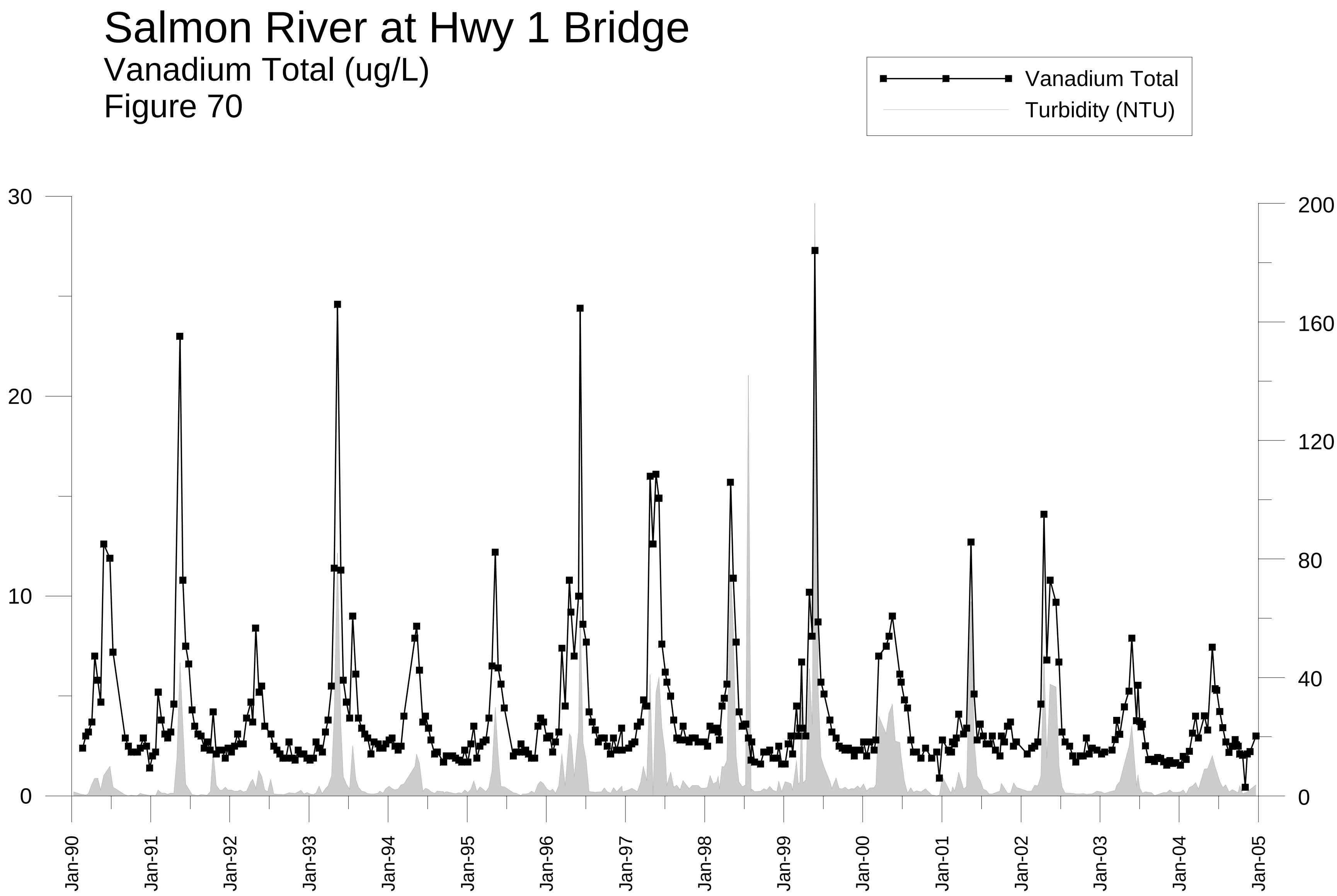
Thallium Total (ug/L)

Figure 67




Salmon River at Hwy 1 Bridge
Turbidity (uS/cm)
Figure 68
Turbidity
CCME Max Turbidity DW Guideline
200
160
120
80
40
0
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

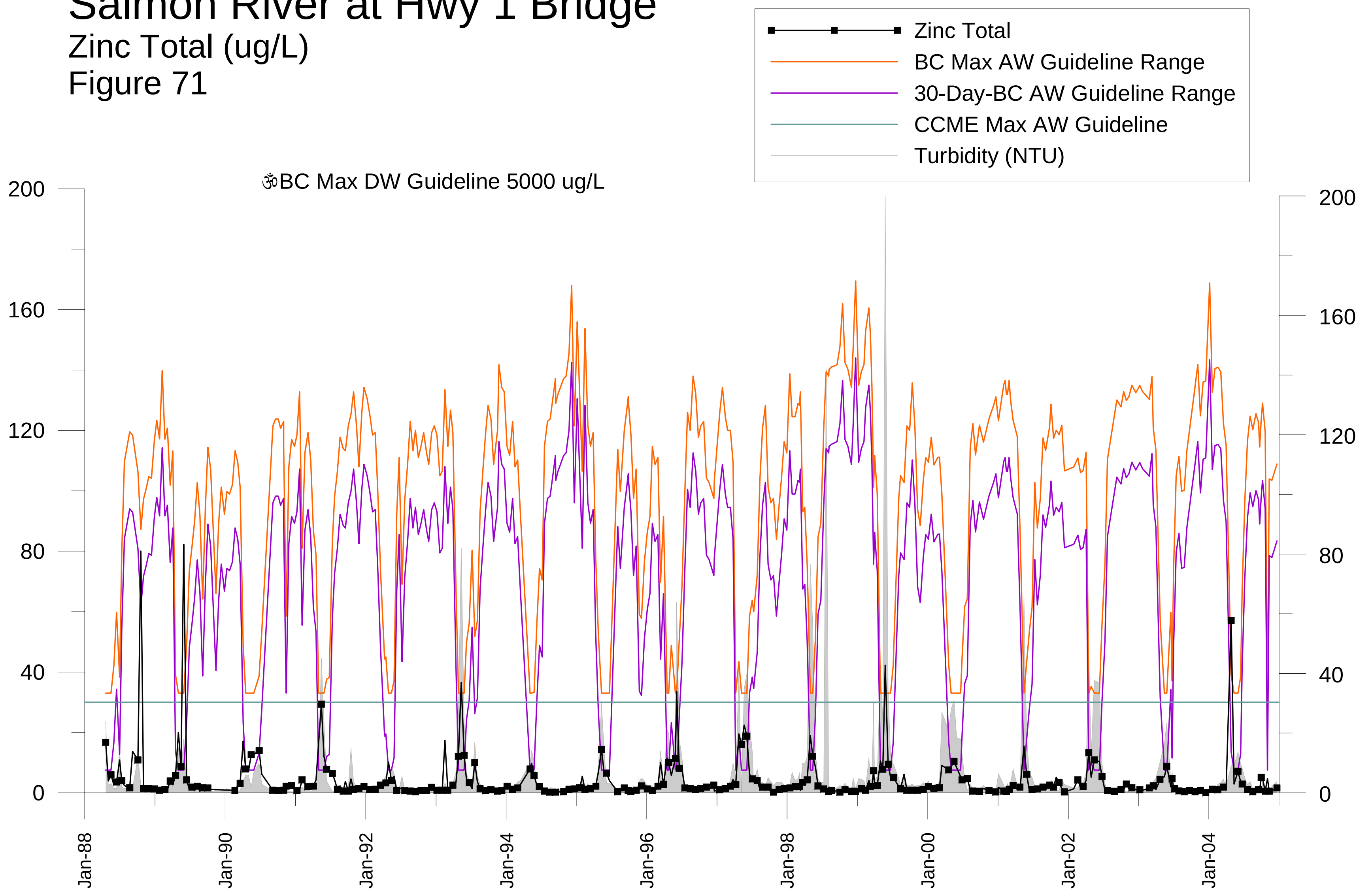

Salmon River at Hwy 1 Bridge
Uranium Total (ug/L)
Figure 69
Uranium Total
Conductivity (uS/cm)
0
1
2
3
4
100
200
300
400
500
600
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05


Salmon River at Hwy 1 Bridge
Vanadium Total (ug/L)
Figure 70
Vanadium Total
Turbidity (NTU)
0
10
20
30
0
40
80
120
160
200
Jan-90
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

Salmon River at Hwy 1 Bridge

Zinc Total (ug/L)

Figure 71



Salmon River at Hwy 1 Bridge
Zinc Total (ug/L)
Figure 72