1993 ST. CROIX REPORT
WATER QUALITY REPORT

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ADDENDUM

Name changes due to re-organization have occurred twice in two years, therefore to avoid confusion, the two changes are as follows:

1992 - Conservation and Protection Service

- Inland Waters Directorate became Water Resources Directorate
- Water Quality Branch became Monitoring & Evaluation Branch

1993/4 - Monitoring & Evaluation Branch staff have been divided in 3 services. The authors are divided into 2 of the services:

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ABSTRACT

This report presents the results of the 1993 St. Croix River water quality monitoring program. Physical parameter values, major ion, nutrient and heavy metal concentrations are given for three sampling stations for the period from January to December, 1993. Monitoring and Evaluation Branch grab sample data and the provisional data from the USGS Milltown Automatic Water Quality Monitor for the period from January to September 1993 met the established water quality objectives for dissolved oxygen and pH with the exception of one dissolved oxygen value of 4.2 mg/L at Woodland on June 29. An explanation of this low value is provided in Section 3.1.

RÉSUMÉ

Ce rapport présente les résultats du programme de surveillance continue de la qualité des eaux de la rivière Sainte-Croix pour 1993. Les résultats d'analyse des paramètres physiques, ainsi que les concentrations mesurées d'ions principaux, de métaux lourds et d'éléments nutritifs sont présentés pour la période de janvier à septembre 1993. Des données provisoires provenant d'un enregistreur automatique de la qualité des eaux installé à Milltown pour la période de janvier à décembre 1993 ont rencontrées les objectifs établis de la qualité des eaux pour le pH et l'oxygène dissous sauf pour une valeur d'oxygène dissous de 4.2 mg/L trouvée à Woodland le 29 juin. Une explication est donnée à la section 3.1.

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INTRODUCTION

The St. Croix River and its tributary, Monument Brook, have a reach of approximately 124 km and form the international boundary between the Canadian Province of New Brunswick, and the American State of Maine. In the upper 110 km of the St. Croix River, the water quality is subjected to limited anthropogenic influence and is considered to represent background conditions. The region of concern in this study is a 14 km stretch between Woodland, Me. and Milltown, N.B. which is the mixing zone of a major industrial discharge from the Georgia-Pacific Kraft Pulp Mill at Woodland, Me.

The International Advisory Board on Pollution Control in the St. Croix was established by the International Joint Commission (IJC) in 1962 to coordinate water quality planning and management efforts in the basin. To assist the Board in fulfilling its mandate, the Water Quality Branch conducts systematic water quality sampling and assessment at three sites in the international portion of the river. The St. Croix River at the Kellyland station is considered to be pristine and indicative of background water quality whereas the Woodland station is located 200 m below the Georgia-Pacific Pulp Mill effluent outfall and serves to characterize the chemical composition of the effluent after a slight dilution by river water. The data from the Milltown station, 14 km below Woodland, provides information on the river water quality after assimilation and dilution of the pulp mill effluent by the river. Sampling station location descriptions are presented in Table 1 and plotted in Figure 1. The samples are analyzed for physical parameters, major ions, nutrients and trace metals.

The Monitoring & Evaluation Branch, in cooperation with the United States Geological Survey (USGS), also collects real-time data for temperature, specific conductance, pH and dissolved oxygen via satellite retransmission from an automatic water quality monitor (AWQM) at Milltown, Me. Similarly, river discharge data are collected at the USGS gauging station at Baring, Me.

These data are used to monitor compliance with established Water Quality Objectives and will be used for the future development of other water quality objectives for the St. Croix River Basin. In 1961, water quality objectives were formulated with the stated goal of restoration of anadronomous fish runs, in particular, Atlantic Salmon (Salmo salar). Objectives for dissolved oxygen (5.0 mg/L and 60% saturation) and pH (6.0 to 8.5 pH units) were established (ABPC, 1980). By 1978, improvements in the water quality of the lower 14 km stretch of the river had made possible the passage of Atlantic Salmon, and in 1980 a re-introduction program was started (Bailey, 1988b).

This report assesses the water quality data from three sampling stations in the St. Croix River Basin which were sampled 8 times during the period of January to December 1993. The St. Croix River at Milltown AWQM data are also discussed.

Previous St. Croix River Water Quality reports include Clair (1980), Lockerbie and Cullen (1981), Howell and Lockerbie (1983; 1984), Howell (1985), Lockerbie (1987), Bailey (1988a, 1989, 1990, 1991, 1992) Bailey et al., (1994).

2. METHODOLOGY

Environment Canada, Monitoring and Evaluation Branch (formerly), Water Resources Branch technicians collected samples from the St. Croix River on eight occasions (every six weeks $\pm$ 1 week) between January 15, 1993 and December 2, 1993 at three sites in the river basin - Kellyland, Woodland, and Milltown.

Water quality sampling was conducted as outlined in "Sampling for Water Quality" (Environment Canada, 1983) and the analytical methods employed are described in the NAQUADAT Dictionary (Environment Canada, 1991). Water quality parameters, analyzed for the St. Croix River, are listed in Table 2 along with their NAQUADAT codes and detection limits.

Monitoring & Evaluation Branch, Atlantic Region, quality control procedures require that at least 15% of the samples be collected in triplicate and distilled water trip blanks prepared for each sampling occasion (Arseneault, et al., 1985). Due to a modification in the QC procedures, the triplicates, blanks and spikes are based on the technician's entire sampling program, therefore the number of triplicates has decreased from one per trip for the St. Croix to one each for two to three trips. One set of blanks and spikes is also dedicated to the entire run. Only the mean value for the triplicate samples, which have been included in the data tables, was used in the preparation of the boxplots in order to eliminate bias for those sampling dates.

The grab sample data are compared to the two water quality objectives, that have been established for the St. Croix River Basin. Data for other selected parameters will also be compared to the Canadian Water Quality Guidelines for the protection of freshwater aquatic life where applicable. These guidelines are listed in Table 3.

The hourly data from the USGS AWQM at Milltown were obtained by using a Labarge GOES satellite retransmission platform. Data are distributed in daily format with minimum, maximum and mean. In addition to the measured parameters, percent dissolved oxygen saturation has been calculated. The provisional daily mean data which have been plotted and discussed are corrected to compensate for changes in calibration from information supplied by the USGS. For this report, the data discussed are for the period from January to September 1993. The calibration record had not been received at the time of writing for the October to December period. Unlike previous reports, the monthly AWQM data summary sheets for 1993 have not been appended in this report. These data are available in hard copy or 3.5" diskette from the author upon request.

The river discharge data from the Baring gauging station have been similarly formatted and are included in the monthly tables. The AWQM and discharge data are considered to be provisional until published by the USGS.

3. RESULTS AND DISCUSSION

3.1 1993 Grab Sample Data versus Water Quality Objectives

As a result of the small number of samples collected during the sampling program, this report will be primarily a presentation of the data with limited interpretation of the data. The grab sample data for physical parameters and major ions, metals and nutrients are provided in Tables 4 to 6 respectively.

The 1993 Water Quality Branch grab sample data for dissolved oxygen are illustrated in box and whisker plots in Figures 2 and 3. Figure 2 indicates that dissolved oxygen concentrations for the grab samples were above the established Water Quality Objectives of 5 mg/L with the exception of one value of 4.2 mg/L at Woodland on June 29. A value equal to the water quality objective (5.0 mg/L) was also reported on August 29. The median values were in the 8.5 to 11 mg/L range.

The value of 4.2 mg/L expressed as percentage saturation also fell slightly below the water quality objective of 60% with a value of 56% (Figure 3). The median values for the three stations ranged from 93 to 98% saturation.

The data for dissolved oxygen are suspect on a number of occasions. In a comparison of grab sample values versus the AWQM at Milltown, 3 values at Milltown differed by 1.9 mg/L or more. On April 5, the grab sample value of 9.4 mg/L (68% saturation) was low compared to the 12.3 mg/L (89% saturation) for the AWQM. On

October 18 and December 2, grab samples were 1.9 and 2.2 mg/L high, respectively, compared to the AWQM.

There is no way to verify the dissolved oxygen data at the other two sites. The values of 4.2 (June 29) and 5.0 (August 19) mg/L at Woodland are very low for that site, There are two possibilities for the low values: (1) The aeration system in the secondary treatment lagoon was not functioning properly; or (2) there was an error in determining the D.O. values at that site. The discrepancies in D.O. values at Milltown may suggest the second choice, however, it should be noted that on the days when the low values occurred at Woodland, the D.O. values determined at Milltown by the technician agreed with the Milltown AWQM values.

It should also be noted that these values are measured in the effluent plume and not in the main channel of the river at Woodland. Water temperatures at sampling were in the 29-30°C which result in % saturation values slightly below the objective.

The pH values met the water quality objective of 6.0 to 8.5 at all sites as illustrated in Figure 4.

3.2 AWQM data versus the Water Quality Objectives

Dissolved oxygen concentrations met the water quality objective of 5.0 mg/L and 60 as percent saturation in 1993. Figure 5 illustrates that the yearly lows for the mean daily dissolved oxygen ranged from 6 to 7 mg/L from mid-June through

September, with values moderately lower than in 1992. Lower values continued on into September with a range of 6 to 7.5 mg/L as compared to 7.5 to 8.5 mg/L in 1992. This was probably attributable to lower river discharge in September of 1993. Based on historical data, dissolved oxygen values usually begin a strong upswing in October, therefore the missing data are not critical to this discussion. Similarly, yearly lows for dissolved oxygen as percentage saturation were slightly lower with values ranging from 72 to 88 percent.

pH values were also within the 6.0 to 8.5 water quality objective range. For the most part, pH values were nearly neutral ranging from 6.5 to 7.3 (Figure 7).

3.3 St. Croix River at Kellyland - Station No. NB01AR0013

Water temperature ranged from 1.0°C for 4 sampling periods to 7.3°C on August 19. Dissolved oxygen concentrations ranged from 7.3 mg/L (71% saturation) on May 12 to 13.2 mg/L (96% saturation) on February 17. Laboratory measured pH ranged from 6.5 to 6.9 for the sampling period. The apparent colour was between 15-80 relative units (Table 4).

The background waters of the St. Croix River are dilute, with specific conductance ranging from 27 to 35 μS/cm. The dominant cation has been calcium followed by sodium, magnesium and potassium. The anions have been dominated by bicarbonate followed by sulphate and chloride (Table 7).

Concentrations of copper, lead, zinc, cadmium, mercury and nickel (Table 5) were below the limit of detection in all samples collected, whereas single detection limit value was reported for arsenic. Values for chromium were at or near detection limit values on all occasions. Extractable iron values were below the Canadian Water Quality Guidelines for the protection of freshwater aquatic life of 0.3 mg/L (as total iron) ranging from 0.09 to 0.18 mg/L (Table 5).

The Canadian Water Quality Guidelines for metals are expressed as total metals, i.e. the sample has been digested in strong acid to dissolve the silicate matrix present in the water so that the total metal has been accounted for. The Monitoring & Evaluation Laboratory, Atlantic Region, performs extractable metal analysis using a weak acid which measures only metals dissolved or adsorbed to particulate matter. In this region, total and extractable compare well because of the low suspended sediment load. A sample with a higher sediment load, as indicated by turbidity, will not have a good relationship between total and extractable metals.

There is no Canadian Water Quality Guideline for the protection of freshwater aquatic life for manganese. At the Kellyland sampling station, manganese ranged from below to slightly above the detection limit with values of ranging from <0.01 to 0.03 mg/L. Aluminum values ranged from 0.023 to 0.12 mg/L meeting the Canadian Water Quality Guideline of 0.100 mg/L for waters where the pH is greater than 6.5 pH units, with the exception of one sample which slightly exceeded the guideline with a value of 0.12 mg/L.

Nutrient concentrations (Table 6) were low at Kellyland with nitrate nitrogen and total nitrogen ranging from <0.01 to 0.06 and 0.13 to 0.27 mg/L respectively. Total phosphorus ranged from 0.004 to 0.009 mg/L while dissolved organic carbon ranged from 3.7 to 8.2 mg/L.

3.4 St. Croix River at Woodland - Station No. NB01AR0014

Samples at this site are collected in the effluent plume and serve to characterize the chemical composition of the effluent after slight dilution by river water.

The temperature of the St. Croix River at the Woodland station is primarily due to the effluent temperature and thus remains high throughout the year (15 to 31 °C). The lowest dissolved oxygen concentration recorded was 4.2 mg/L representing 56 percent saturation on June 23. pH was slightly higher (7.2-7.7 units) at Woodland as compared to Kellyland due to the alkaline nature of the Kraft effluent. The apparent color ranged from 700 to 1350 relative units in 1993, which represents an increase as compared to 1992 and 1991 when values ranged from 35 to 1000 and 25 to 770 relative units respectively.

The specific conductance at Woodland ranged from 1880 to 3500 μS/cm with a median value of 2870 for the eight sampling trips. This represents a significant increase compared to 1992 where conductance values ranged from 660 to 2890 with a median value of 2140. This was approximately 90 times higher than the background station. There is also a change in the major ion chemistry which has been shown in

previous reports. At Kellyland, the cation and anion dominance were Ca > Na > Mg > K and $HCO_3 > SO_4 > Cl$ respectively, while sodium strongly dominates the cations followed by Ca > K > Mg at Woodland. Similarly chloride dominates the anions closely followed by sulphate and bicarbonate (Table 7) This shift in ion dominance is a result of the Kraft process.

Copper, lead, cadmium, mercury and chromium were below or slightly above their respective detection limits. The Canadian Water Quality Guidelines for copper and lead are dependent on water hardness. At Woodland, the hardness varies from hard to very hard, therefore the guidelines for copper and lead, which would range from 0.004 to 0.006 mg/L and 0.004 to 0.007 mg/L respectively were met. Limited analysis of nickel and arsenic resulted in values of <0.002 to 0.010 mg/L and <0.0005 to 0.0034 mg/L. Iron and manganese concentrations ranged from 0.27 to 0.61 mg/L and 1.0 to 2.1 mg/L respectively. Extractable aluminum concentrations remain high (2.1 to 4.0 mg/L), which probably results from the use of alum in process water treatment at the mill. The 1993 values were very similar to those of 1992.

Although iron and aluminum concentrations greatly exceed the water quality guidelines of 0.3 and 0.1 mg/L respectively, the highly organic nature of the effluent would suggest the metals are bound to the organic matter and therefore not readily available to aquatic organisms.

The organic nature of the Kraft Mill effluent is also reflected in the elevated concentrations of nutrients. In 1993, dissolved organic carbon (DOC) values ranged

from 21 to 85 mg/L with a median of 41. This represents little change from 1992 based on median values.

Nitrate nitrogen and total nitrogen values ranged from <0.45 to 5.3 mg/L and 3.3 to 6.4 mg/L respectively. Total phosphorus determinations which were not usually done at this station due to analytical interferences, were completed in 1993. Values ranged from 0.55 to 1.05 mg/L.

3.5 St. Croix River at Milltown - Station No. NB01AR0001

Fourteen kilometres downstream from Woodland at Milltown, the effluent plume appears to be incorporated into the river water and there is little indication of any horizontal differentiation in water quality (Howell and Lockerbie, 1983). This station provides information on the river water quality after assimilation of the pulp mill effluent by the river.

Water temperatures (0 to 22°C) were similar to the background station at Kellyland. Apparent color at Milltown ranged from 25-115 relative units which represents only a moderate increase over the values at Kellyland. The specific conductance values were variable ranging from 58 to 179 μS/cm, which is significantly higher than in previous years - 36 to 118 μS/cm in 1991 and 40 to 89 μS/cm in 1992. The high of 179 μS/cm occurred on February 17 and was virtually the same on all samples of a triplicate. The river discharge was low at 27.6 m^3/s. Dissolved oxygen exceeded the water quality objectives of 5.0 mg/L and 60% saturation on all occasions. It ranged from 6.6 to 15.0 mg/L and 78 to 109 percent saturation.

The few grab samples values for dissolved oxygen did not compare well with the AWQM dissolved oxygen values for the same time as previously discussed in Section 3.1.

Major ion chemistry at Milltown reflects a mixture of the background calcium bicarbonate dominated waters of the St. Croix River and the sodium chloride dominated pulp mill effluent. Sodium was the dominant cation over calcium on all occasions. For the first time, chloride was the dominant anion on four of seven occasions, but was exceeded by bicarbonate on the other three. Dominance of the major effluent ions was more pronounced in 1993 due to low river discharge.

Copper, lead, zinc, cadmium, mercury and nickel were not detected at Milltown. Near detection limit values were recorded for arsenic and chromium. Extractable aluminum ranged from 0.068 to 0.270 mg/L with five of eight exceeding the Canadian Water Quality Guideline of 0.1 mg/L. Iron and manganese values ranged from 0.14 to 0.40 mg/L and .04 to 0.11 mg/L respectively. Iron and manganese concentrations at Milltown were only slightly higher than values at Kellyland. The more elevated values for aluminum, iron and manganese were also determined on February 17 as a result of low river discharge.

Nutrient concentrations at Milltown are slightly higher than those observed at Kellyland. Total phosphorus ranged from 0.015 to 0.045 mg/L, nitrite-nitrate from <0.10 to 0.21 mg/L, total nitrogen from 0.19 to 0.45 mg/L and dissolved organic carbon ranged from 3.5 to 9.7 mg/L.

3.6 Milltown AWQM Data

The daily mean AWQM data for the period from January to September 1993, have been corrected to compensate for changes in calibration from information supplied by the USGS and are considered provisional. Copies of the data will be distributed on a need basis. A table utilizing only these mean values, will be available on request in hardcopy or a 3.5" diskette. In lieu of providing the data tables in an appendix, the mean daily data for each parameter are plotted in Figures 5 to 11. In this report, monthly boxplots have been used since they provide clearer and more useful information as well as a better means of comparison from year to year.

Small blocks of AWQM data in April (8 days) and June (2 days x 3) were discarded due to operational problems.

Dissolved oxygen as concentration (Figure 5) and percent saturation (Figure 6) began a moderate decline in May with values reaching their lowest values in July, August and September. The lowest mean value was reported on September 4 with a daily mean of 6.03 mg/L. The median values for July, August and September ranged from 6.7 to 6.9 mg/L, somewhat lower than 1992 when the medians ranged from 7.2 to 7.8 mg/L. The lowest mean value as percent saturation also occurred on September 4 at 71 percent saturation. The median value for September was 77 percent saturation whereas the median values for July and August, normally the months with the lowest reported values, were in the 85 percent range. The median dissolved oxygen value in September 1992 was significantly higher at 92 percent saturation.

The lower Dissolved Oxygen values for this three-month period are directly attributable to greatly reduced river discharge in 1993. The median discharge ranged from 25 to 35 m^3/s in 1992.

As noted in Section 3.2, pH values remained stable in the 6.5 to 7.0 pH unit range (Figure 7).

Daily mean values for water temperature (°C) were above 20°C for July and August reaching its peak of 26.0°C on July 9 (Figure 8).

Specific conductance (Figure 9) was highly variable for most months with overall values ranging from 44 μS/cm on April 27, to 197 μS/cm on February 11 and 15. The maximum values for conductance reached the 190 mark for five of the nine months reported. The maximum value in 1992 was 169 μS/cm. This probably reflects the low discharge values reported throughout the period.

3.7 USGS Gauging Station at Baring

This regulated gauging station is located 9.1 km downstream of the Woodland dam at Baring, Maine and is maintained by the United States under agreement with Canada. Due to sporadic data collection for the gauging station in Moncton, provisional data were provided by the USGS.

The 1993 mean discharge of 63 m^3/s was significantly less than the average discharge for the 32 year period of record of 74.9 m^3/s, but was the same as reported in 1992. The maximum daily discharge was recorded on April 13 with a value of 493 m^3/s (Figure 10) or 17400 cfs (Figure 11) and represented the peak of the spring freshette which began in late March.

Although the mean discharge value were the same in 1992 and 1993, the discharge patterns were quite different. In 1992, there were numerous peaks with a broad range of values within the monthly period whereas in 1993, there were two very high peaks in April and December, while seven of the remaining months had a very tight range of values with median values in the 25 to 40 m^3/s range. With the exception of April and December, 1993, there was little relationship between discharge and precipitation.

3.8 Quality Assurance/Quality Control

Quality Assurance and Quality Control procedures are implemented in all monitoring programs to ensure consistent, high quality data are being generated by field and laboratory personnel. The QA/QC program is essential to the credibility of the data so users can interpret the results with a high degree of confidence.

In 1993, the International St. Croix River monitoring was indicated as part of the newly implemented Canada-N.B. Water Quality Agreement and a comprehensive QA/QC program including blanks, spikes and triplicate sampling.

Trip blanks and spikes for the entire suite of parameters which were prepared in the laboratory and transported to the field and back unopened, are used to determine if the sample results have been influenced by contamination during transport or analysis. The sequential triplicate samples include the entire suite of parameters and provide an indication of sampling techniques, analytical precision and data management components. Since the base for triplicate sampling was increased, the complement of triplicates in the St. Croix River itself was reduced from one per trip to one per three trips.

Concurrent with these field procedures, the Monitoring and Evaluation Branch Laboratory also maintains an internal QA/QC process that includes control charts and ionic balance verifications, the use of internal laboratory reference materials and standard reference materials. The laboratory also participates in several interlaboratory round robins.

The triplicate sample results for the 1993 survey year are presented in Table 8. Historical analysis of triplicate data has indicated that dissolved nitrate and extractable aluminum have been highly variable and are therefore included in the QA/QC data analysis. Field pH, laboratory pH, Gran Alkalinity, and dissolved organic carbon have been included to represent the physical and nutrient parameter groups respectively. For each set of triplicate samples, the arithmetic mean, standard deviation and coefficient of variation have been calculated. The coefficient of variation - C.V. (%) = Standard Deviation/Mean X 100, is used as a test statistic because this formula is independent of units and many analytical methods express precision in that manner.

Arseneault and Howell (1985) indicate that a rough guide for comparison of triplicate samples would be a reproducibility of results of 10 percent or less. Variation greater than 10 percent should be of concern if results are not close to the detection limit. Results near the analytical detection limit can commonly vary up to 50 percent.

With a larger data set, the median coefficient of variation is taken as the average variability among replicates for the sampling period. Since there are only 3 sets of triplicate samples, a screening of Table 8 will provide a reasonable evaluation of the data analysis. The two nutrients, dissolved nitrate and DOC, had the largest variability, however, it should be noted that the 34.6% coefficient of variability for nitrate on May 12 was derived from detection limit values.

The trip blank and spikes were prepared in the laboratory a week or two prior to scheduled field trips. To maintain consistency, the blank and spikes were prepared by the same chemists utilizing the same distilled water source. The spikes are not preserved prior to the trip. They are preserved as are the regular samples, when returned to the lab.

The trip blank data (sample type-8) in Table 9, indicates that the values for most parameters were below the detection limit on 6 of 7 occasions, with four of the values at the detection limit value of 0.05 mg/L. Chromium and total phosphorus also had values at the detection limit on 3 and 2 occasions, respectively.

4. CONCLUSIONS

During the study period, from January to December 1993, the sampling sites were visited on eight occasions. Dissolved oxygen and pH were in compliance with the established Water Quality Objectives at all sites, with the exception of one dissolved oxygen value of 4.2 mg/L on June 29 at Woodland as discussed in Section 3.1.

The AWQM data for the period from January to September, 1993 met the Water Quality Objectives for both dissolved oxygen and pH. The discharge data from the Baring gauging station were unique discharge patterns compared to previous years. The very low discharge for the July to September period resulted in much lower dissolved oxygen values in September compared to the same month in 1992.

Six trip spikes were analysed during the sampling period, however, most parameters have only four to five values due to lost bottles within the sample. The design spike value has been included in Table 9 as well as the mean percent recovery. Due to the small number of samples involved, only a cursory overview of the results will be provided.

The percent recovery for major ions ranged from 85 to 108 percent, with magnesium (85%) and calcium (88%) on the low end, with potassium (108%) and sulphate (106%) on the upper range. With the exception of mercury, metals had excellent recoveries with 7 of 11 in the 99 to 101% range. Mercury recoveries fell to 50% in 3 of the 6 samples.

For the nutrients, total phosphorus and metals had excellent recoveries of 97 and 95%, respectively. DOC with a recovery of 89% was slightly more variable, with individual samples ranging from 73 to 113%. Total nitrogen had the lowest recovery at 75% with no variability between samples, suggesting that the total nitrogen in the spiking solution may have deteriorated.

The triplicates, trip blank and spike results indicate that the QA/QC procedures were within defined control limits and that the 1993 St. Croix River monitoring data can therefore be interpreted with confidence.

5. RECOMMENDATIONS

The Monitoring & Evaluation Branch, Analytical Laboratories Division, utilizes a methodology of colour (apparent colour - NAQUADAT Parameter Code - 02011L) which is not compatible to waters which contain pulp mill effluent. The State of Maine has also established standards (to become effective in 1993) for true colour in water.

It is the recommendation of the Advisory Board on Pollution Control in the St. Croix River that consistent methods for determining colour in river water are needed and that true colour would best conform with most needs (ABPC, 1990).

The Monitoring & Evaluation Branch has produced monitoring and compliance reports for the St. Croix River Basin since 1980. These reports have been focused on one or two years of monitoring data with little reference to preceding years. It is recommended that a 1980-1992 report for the St. Croix River Basin monitoring stations be produced, with emphasis on the temporal analysis of data.

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TABLE 1

NAQUADAT IDENTIFICATION NUMBERS AND SITE DESCRIPTIONS OF STATIONS SAMPLED ON THE ST. CROIX RIVER

NAQUADAT No.	Site Description
00NB01AR0013	St. Croix River at Kellyland
00NB01AR0014	St. Croix River, 200 m below Woodland Mill on the U.S. side of the river.
00NB01AR0001	St. Croix River at Milltown International bridge - mid-river.

TABLE 2

LIST OF PARAMETERS, QUANTIFIED BY ENVIRONMENT CANADA WITH PARAMETER CODES AND DETECTION LIMITS

Parameter	NAQUADAT Code	Detection Limit
Water Temperature	02065S	--
Dissolved Oxygen (meter)	08102S	--
Specific Cond. (field)	02042S	2 µS/cm
pH (field)	10301F	--
Specific Cond. (lab.)	02041L	0.2 µS/cm
pH (lab)	10301L	--
Colour	02011L	--
Turbidity	02073L	--
Calcium	20110L	0.040 mg/L
Sodium	11103L	0.10 mg/L
Potassium	19103L	0.10 mg/L
Magnesium	12107L	0.005 mg/L
Chloride (IC)	17209L	0.100 mg/L
Sulphate (IC)	16309L	0.50 mg/L
Total Alkalinity	10101L	0.5 mg/L
Extractable Iron	26304L	0.050 mg/L
Extractable Manganese	25304L	0.010 mg/L
Extractable Copper	29305L	0.002 mg/L
Extractable Lead	82302L	0.002 mg/L
Extractable Mercury	80315L	0.02 µg/L
Extractable Aluminum	13305L	0.002 mg/L
Extractable Cadmium	48302L	0.001 mg/L
Total Phosphorus	15413L	0.005 mg/L
Total Nitrogen	07601L	0.025 mg/L
Nitrate N (IC)	07315L	0.01 mg/L
Dissolved Organic Carbon	06107L	0.4 mg/L

TABLE 3

WATER QUALITY GUIDELINES FOR FRESHWATER AQUATIC LIFE AS TOTAL METALS (CCREM, 1987)

Parameter	Guideline	Comments
Aluminum	0.005 $mg.L^{-1}$	$pH < 6.5$; $(Ca^{2+}) < 4.0$ $mg.L^{-1}$; $DOC < 2.0$ $mg.L^{-1}$
	0.1 $mg.L^{-1}$	$pH \geq 6.5$; $(Ca^{2+}) > 4.0$ $mg.L^{-1}$; $DOC \geq 2.0$ $mg.L^{-1}$
Arsenic	0.05 $mg.L^{-1}$	
Cadmium	0.2 $\mu g.L^{-1}$	Hardness 0-60 $mg.L^{-1}$ ($CaCO_3$)
	0.8 $\mu g.L^{-1}$	Hardness 60-120 $mg.L^{-1}$ ($CaCO_3$)
	1.3 $\mu g.L^{-1}$	Hardness 120-180 $mg.L^{-1}$ ($CaCO_3$)
	1.8 $\mu g.L^{-1}$	Hardness > 180 $mg.L^{-1}$ ($CaCO_3$)
Copper	2 $\mu g.L^{-1}$	Hardness 0-60 $mg.L^{-1}$ ($CaCO_3$)
	2 $\mu g.L^{-1}$	Hardness 60-120 $mg.L^{-1}$ ($CaCO_3$)
	4 $\mu g.L^{-1}$	Hardness 120-180 $mg.L^{-1}$ ($CaCO_3$)
	6 $\mu g.L^{-1}$	Hardness > 180 $mg.L^{-1}$ ($CaCO_3$)
Iron	0.3 $mg.L^{-1}$	
Lead	1 $\mu g.L^{-1}$	Hardness 0-60 $mg.L^{-1}$ ($CaCO_3$)
	2 $\mu g.L^{-1}$	Hardness 60-120 $mg.L^{-1}$ ($CaCO_3$)
	4 $\mu g.L^{-1}$	Hardness 120-180 $mg.L^{-1}$ ($CaCO_3$)
	7 $\mu g.L^{-1}$	Hardness > 180 $mg.L^{-1}$ ($CaCO_3$)
Zinc	0.03 $mg.L^{-1}$	

TABLE 4

PHYSICAL VARIABLES AND MAJOR ION CONCENTRATIONS (mg/L)

FOR THE ST. CROIX RIVER STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	1 STATION NO	2 SDATE	3 STIME	4 02065(S) TEMPERATURE DEG C	5 00102(S) O_DIS MG/L	6 O-DIS 5 SAT	7 10301(F) PH PH UNITS	8 10301 PH PH UNITS
1	NB01AR0013	15-JAN-93	1015	1	11.80	86	6.44	6.7
2	NB01AR0013	17-FEB-93	1310	1	13.20	96	6.50	6.7
3	NB01AR0013	05-APR-93	1140	1	12.00	87	6.19	6.7
4	NB01AR0013	12-MAY-93	900	13	7.25	71	6.49	6.6
5	NB01AR0013	12-MAY-93	905	13	7.25	71	6.62	6.7
6	NB01AR0013	12-MAY-93	910	13	7.25	71	6.63	6.5
7	NB01AR0013	29-JUN-93	830	21	8.20	94	6.76	6.8
8	NB01AR0013	19-AUG-93	1100	23	7.80	93	6.52	6.9
9	NB01AR0013	18-OCT-93	1130	9	10.80	96	6.60	6.8
10	NB01AR0013	02-DEC-93	1300	1	14.40	104	6.59	6.7
11								
12	NB01AR0014	15-JAN-93	1050	18	7.80	85	7.70	7.3
13	NB01AR0014	17-FEB-93	1400	18	9.40	102	7.70	7.2
14	NB01AR0014	05-APR-93	1220	16	10.80	113	7.49	7.4
15	NB01AR0014	12-MAY-93	950	22	8.20	96	7.61	7.3
16	NB01AR0014	29-JUN-93	1000	30	4.20	56	7.77	7.6
17	NB01AR0014	19-AUG-93	1245	31	5.00	68	7.74	7.4
18	NB01AR0014	18-OCT-93	1215	15	10.20	104	7.89	7.4
19	NB01AR0014	18-OCT-93	1220	15	10.20	104	7.94	7.6
20	NB01AR0014	18-OCT-93	1122	15	10.00	104	7.97	7.6
21	NB01AR0014	02-DEC-93	1340	18	10.40	113	7.73	7.7
22								
23	NB01AR0001	15-JAN-93	1120	1	12.80	93	7.56	
24	NB01AR0001	17-FEB-93	1440	0	13.30	94	6.80	6.7
25	NB01AR0001	17-FEB-93	1442	0	13.30	94	6.80	6.8
26	NB01AR0001	17-FEB-93	1445	0	13.30	94	6.70	6.8
27	NB01AR0001	05-APR-93	1300	1	9.40	68	6.70	6.7
28	NB01AR0001	12-MAY-93	1215	13	9.80	96	7.35	6.9
29	NB01AR0001	29-JUN-93	1215	22	7.80	92	7.20	7.1
30	NB01AR0001	19-AUG-93	1210	22	6.60	78	7.17	7.0
31	NB01AR0001	18-OCT-93	1200	10	12.00	110	7.24	6.9
32	NB01AR0001	02-DEC-93	1410	1	15.00	109	6.94	6.8

TABLE 4

PHYSICAL VARIABLES AND MAJOR ION CONCENTRATIONS (mg/L)

FOR THE ST. CROIX RIVER STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	9 02042(F) SP_COND USIE/CM	10 02041 SP_COND USIE/CM	11 02011 COLOUR_AP REL UNITS	12 02073 TURBIDITY JTU	13 10110 ALK_GRAN MG/L	14 20110 CA_DIS MG/L	15 12107 MG_DIS MG/L
1	36.1	35.0	50	0.4	8.9	4.10	1.30
2	35.3	33.0	30	0.4	9.0	3.50	0.70
3	34.3	32.0	65	0.8	6.7	2.80	0.69
4	30.8	28.0	80	0.8	5.7	2.70	0.57
5	28.2	28.0	80	0.7	5.8	2.70	0.58
6	28.0	28.0	75	0.7	5.6	2.70	0.57
7	29.4	28.6	65	0.8	7.2	1.80	0.23
8	29.9	27.0	15	0.4	7.4	3.00	0.58
9	32.0	29.0	15	0.5	7.2	3.20	0.67
10	36.5	34.0	50	1.1	6.6	4.10	0.90
11							
12	2940.0	2900.0	1300	3.7	354.4	57.80	4.20
13	3110.0	3500.0	1350	5.6	258.2	89.00	6.00
14	2770.0	2680.0	700	20.0	264.7	72.00	5.20
15	2870.0	2900.0	1350	6.5	333.1	49.00	5.20
16	2390.0	2370.0	1300	6.7	344.1	3.10	0.55
17	2510.0	2350.0	1300	7.7	371.9	39.00	3.10
18	2068.0	1880.0	730	3.5	373.7	26.20	0.27
19	2082.0	1880.0	730	4.2	370.3	26.70	0.27
20	2083.0	1880.0	730	3.8	374.4	26.80	0.27
21	2882.0	2830.0	1200	9.7	481.0	47.00	5.00
22							
23	197.0	143.0	85	0.5		6.40	1.40
24	188.0	179.0	85	3.1	15.5	6.90	0.92
25	191.0	178.0	85	2.7	16.5	7.00	0.95
26	190.0	179.0	85	3.4	16.8	7.00	1.14
27	133.0	96.0	65	3.0	11.0	4.50	0.91
28	100.2	58.0	115	0.9	12.5	3.20	0.67
29	150.0	132.0	60	1.3	19.5	5.10	4.20
30	99.2	90.0	40	1.0	16.3	4.40	0.56
31	67.8	63.0	25	0.9	12.3	4.49	0.89
32	77.7	70.0	65	2.0	11.0	5.00	1.10

TABLE 4

PHYSICAL VARIABLES AND MAJOR ION CONCENTRATIONS (mg/L)
FOR THE ST. CROIX RIVER STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	16 19103 K_DIS MG/L	17 11103 NA_DIS MG/L	18 17209 CL_DIS MG/L	19 16309 SO4_DIS MG/L	20 DISCHARGE -BARING
1	0.46	1.9	2.10	4.00	
2	0.52	1.9	1.80	3.40	
3	0.51	1.9	2.40	3.00	
4	0.45	1.7	2.00	2.80	
5	0.45	1.6	2.10	2.80	
6	0.48	1.6	2.10	2.80	
7	0.39	1.6	1.70	2.50	
8	0.42	1.5	1.50	2.40	
9	0.49	1.8	1.40	4.02	
10	0.42	1.9	2.20	4.80	
11					
12	35.00	630.0	546.00	416.00	
13	31.00	600.0	472.00	510.00	
14	29.00	550.0	346.00	496.00	
15	29.00	600.0	432.00	537.00	
16	25.00	525.0	349.00	296.00	
17	26.00	530.0	355.00	300.00	
18	29.00	450.0	244.10	429.00	
19	29.00	440.0	238.50	394.00	
20	29.00	450.0	241.50	418.00	
21	23.00	665.0	389.00	535.00	
22					
23	1.60	23.0	19.80	17.30	33.1110
24	1.70	28.0	28.20	22.60	27.5925
25	1.70	28.0	28.00	22.50	
26	1.70	28.0	28.60	22.60	
27	0.91	12.8	16.90	8.20	80.9380
28	0.69	6.2	5.80	7.40	82.9190
29	1.30	21.0	18.00	14.40	32.8280
30	1.10	14.1	10.90	10.40	46.6950
31	0.96	8.3	5.60	11.30	60.5620
32	0.60	8.4	9.76	15.20	67.9200

TABLE 5
METAL CONCENTRATIONS (mg/L) FOR THE ST. CROIX RIVER
STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	1 STATION NO	2 SDATE	3 STIME	4 29305 CU_EXT MG/L		5 82302 PB_EXT MG/L		6 30304 ZN_EXT MG/L		7 48302 CD_EXT MG/L		8 80315 HG_EXT UG/L	
1	NB01AR0013	15-JAN-93	1015	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
2	NB01AR0013	17-FEB-93	1310	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
3	NB01AR0013	05-APR-93	1140	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
4	NB01AR0013	12-MAY-93	900	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
5	NB01AR0013	12-MAY-93	905	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
6	NB01AR0013	12-MAY-93	910	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
7	NB01AR0013	29-JUN-93	830	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
8	NB01AR0013	19-AUG-93	1100	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
9	NB01AR0013	18-OCT-93	1130	L	0.0020	L	0.0020	L	0.0100			L	0.0200
10	NB01AR0013	02-DEC-93	1300			L	0.0020	L	0.0100			L	0.0200
11													
12	NB01AR0014	15-JAN-93	1050		0.003		0.002		0.08		0.001	L	0.0200
13	NB01AR0014	17-FEB-93	1400		0.002		0.002		0.08		0.001	L	0.0200
14	NB01AR0014	05-APR-93	1220		0.004				0.07		0.001		0.02
15	NB01AR0014	12-MAY-93	950		0.002		0.002		0.05	L	0.0010		0.05
16	NB01AR0014	29-JUN-93	1000		0.004		0.003		0.10		0.001	L	0.0200
17	NB01AR0014	19-AUG-93	1245	L	0.0020	L	0.0020		0.06	L	0.0010	L	0.0200
18	NB01AR0014	18-OCT-93	1215		0.005		0.002		0.05			L	0.0200
19	NB01AR0014	18-OCT-93	1220		0.005		0.002		0.05			L	0.0200
20	NB01AR0014	18-OCT-93	1122		0.005		0.002		0.05			L	0.0200
21	NB01AR0014	02-DEC-93	1340			L	0.0020		0.10			L	0.0200
22													
23	NB01AR0001	15-JAN-93	1120	L	0.0020	L	0.0020	L	0.0100	L	0.0010		
24	NB01AR0001	17-FEB-93	1440	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
25	NB01AR0001	17-FEB-93	1442	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
26	NB01AR0001	17-FEB-93	1445	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
27	NB01AR0001	05-APR-93	1300	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
28	NB01AR0001	12-MAY-93	1215	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
29	NB01AR0001	29-JUN-93	1215	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
30	NB01AR0001	19-AUG-93	1210	L	0.0020	L	0.0020	L	0.0100	L	0.0010	L	0.0200
31	NB01AR0001	18-OCT-93	1200	L	0.0020	L	0.0020	L	0.0100			L	0.0200
32	NB01AR0001	02-DEC-93	1410			L	0.0020	L	0.0100			L	0.0200

TABLE 5
METAL CONCENTRATIONS (mg/L) FOR THE ST. CROIX RIVER
STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	9 28302 NI_EXT MG/L		10 13305 AL_EXT MG/L		11 13302 AL_EXT MG/L		12 26304 FE_EXT MG/L		13 25304 MN_EXT MG/L		14 33007 AS_TOT MG/L		15 24004 CR_TOT MG/L	
1			0.078				0.14		0.02					
2			0.043				0.10	L	0.0100					
3			0.048				0.08	L	0.0100					
4	L	0.0020	0.063				0.11		0.02	L	0.0005		0.0003	
5	L	0.0020	0.068				0.11		0.02	L	0.0005		0.0003	
6	L	0.0020	0.070				0.10		0.02	L	0.0005		0.0003	
7	L	0.0020	0.069				0.11		0.01	L	0.0005		0.0002	
8	L	0.0020	0.023				0.09		0.03		0.0005		0.0003	
9	L	0.0020					0.12		0.02	L	0.0005		0.0003	
10			0.120				0.18		0.02					
11														
12					3.8		0.52		1.70					
13					3.9		0.61		2.10					
14					2.1		0.74		1.80					
15		0.010			3.2		0.36		1.20		0.0017			
16	L	0.0020			3.9		0.48		1.60		0.0024		0.0042	
17		0.006			2.8		0.27		1.20	L	0.0005		0.0020	
18		0.008			2.3		0.60		10.00		0.0034	L	0.0002	
19		0.009			2.3		0.61		10.00		0.0034	L	0.0002	
20		0.009			2.3		0.60		10.00		0.0034	L	0.0002	
21					4.0		0.54							
22														
23			0.160				0.16		0.07					
24			0.260				0.40		0.11					
25			0.270				0.38		0.11					
26			0.270				0.37		0.11					
27			0.140				0.29		0.05					
28	L	0.0020	0.100				0.14		0.04	L	0.0005	L	0.0002	
29	L	0.0020	0.170				0.22		0.08		0.0005		0.0003	
30	L	0.0020	0.068				0.16		0.04		0.0024		0.0003	
31	L	0.0020					0.18		0.04	L	0.0005		0.0004	
32			0.180				0.24		0.04					

TABLE 6

NUTRIENT CONCENTRATIONS (mg/L) FOR ST. CROIX RIVER
STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	1 STATION NO	2 SDATE	3 STIME	4 15413 P_TOT MG/L	5 07315 N_DIS_NO3 MG/L	6 07110 NO3/NO2 DIS MG/L	7 07601 N_TOT MG/L	8 06107 DOC MG/L
1	NB01AR0013	15-JAN-93	1015	0.006	0.06			6.6
2	NB01AR0013	17-FEB-93	1310	0.004	0.05			4.2
3	NB01AR0013	05-APR-93	1140	0.006	0.04		0.13	3.7
4	NB01AR0013	12-MAY-93	900	0.008	0.02		0.27	3.8
5	NB01AR0013	12-MAY-93	905	0.008	0.01		0.24	4.8
6	NB01AR0013	12-MAY-93	910	0.009	0.02		0.15	4.8
7	NB01AR0013	29-JUN-93	830	0.009	L 0.0100		0.22	6.4
8	NB01AR0013	19-AUG-93	1100	0.006	0.01		0.18	4.6
9	NB01AR0013	18-OCT-93	1130	0.007	0.02		0.17	4.3
10	NB01AR0013	02-DEC-93	1300	0.006		0.03	0.23	8.2
11								
12	NB01AR0014	15-JAN-93	1050	0.700	3.80		4.50	71.0
13	NB01AR0014	17-FEB-93	1400	0.820	4.20		5.20	64.9
14	NB01AR0014	05-APR-93	1220	0.620	1.00		3.50	21.0
15	NB01AR0014	12-MAY-93	950	0.660	3.50		3.80	37.0
16	NB01AR0014	29-JUN-93	1000	1.050	4.20		5.80	45.5
17	NB01AR0014	19-AUG-93	1245	0.850	3.20		6.40	56.1
18	NB01AR0014	18-OCT-93	1215	0.600	5.30		4.80	37.5
19	NB01AR0014	18-OCT-93	1220	0.550	4.60		4.90	36.0
20	NB01AR0014	18-OCT-93	1122	0.550	4.90		5.30	36.5
21	NB01AR0014	02-DEC-93	1340	0.880		0.45	3.30	85.0
22								
23	NB01AR0001	15-JAN-93	1120	0.025	0.11			6.7
24	NB01AR0001	17-FEB-93	1440	0.045	0.16			5.3
25	NB01AR0001	17-FEB-93	1442	0.045	0.13			6.1
26	NB01AR0001	17-FEB-93	1445	0.044	0.15			5.5
27	NB01AR0001	05-APR-93	1300	0.022	0.15		0.23	3.5
28	NB01AR0001	12-MAY-93	1215	0.015	0.04		0.19	5.8
29	NB01AR0001	29-JUN-93	1215	0.039	0.21		0.45	7.6
30	NB01AR0001	19-AUG-93	1210	0.025	0.15		0.37	6.0
31	NB01AR0001	18-OCT-93	1200	0.015	0.05		0.22	5.2
32	NB01AR0001	02-DEC-93	1410	0.018		0.10	0.27	9.7

TABLE 7

MAJOR ION EQUIVALENT CONCENTRATIONS (meq/L) FOR THE ST CROIX RIVER STATIONS AT KELLYLAND, WOODLAND AND MILLTOWN

0	1 STATION NO	2 SDATE	3 Ca meq/L	4 Mg meq/L	5 Na meq/L	6 K meq/L	7 Cl meq/L	8 SO4 meq/L	9 HCO3 meq/L
1	NB01AR0013	15-JAN-93	0.204590	0.106938	0.08265	0.011762	0.059241	0.083280	0.177822
2	NB01AR0013	17-FEB-93	0.174650	0.057582	0.08265	0.013296	0.050778	0.070788	0.179820
3	NB01AR0013	05-APR-93	0.139720	0.056759	0.08265	0.013041	0.067704	0.062460	0.133866
4	NB01AR0013	12-MAY-93	0.134730	0.046888	0.07395	0.011507	0.056420	0.058296	0.113886
5	NB01AR0013	29-JUN-93	0.089820	0.018920	0.06960	0.009972	0.047957	0.052050	0.143856
6	NB01AR0013	19-AUG-93	0.149700	0.047711	0.06525	0.010739	0.042315	0.049968	0.147852
7	NB01AR0013	18-OCT-93	0.159680	0.055114	0.07830	0.012529	0.039494	0.083696	0.143856
8	NB01AR0013	02-DEC-93	0.204590	0.074034	0.08265	0.010739	0.062062	0.099936	0.131868
9									
10	NB01AR0014	15-JAN-93	2.884220	0.345492	27.40500	0.894950	15.402660	8.661120	7.080912
11	NB01AR0014	17-FEB-93	4.441100	0.493560	26.10000	0.792670	13.315120	10.618200	5.158836
12	NB01AR0014	05-APR-93	3.592800	0.427752	23.92500	0.741530	9.760660	10.326720	5.288706
13	NB01AR0014	12-MAY-93	2.445100	0.427752	26.10000	0.741530	12.186720	11.180340	6.655338
14	NB01AR0014	29-JUN-93	0.154690	0.045243	22.83750	0.639250	9.845290	6.162720	6.875118
15	NB01AR0014	19-AUG-93	1.946100	0.255006	23.05500	0.664820	10.014550	6.246000	7.430562
16	NB01AR0014	18-OCT-93	1.307380	0.022210	19.57500	0.741530	6.886061	8.931780	7.466526
17	NB01AR0014	02-DEC-93	2.345300	0.411300	28.92750	0.588110	10.973690	11.138700	9.610380
18									
19	NB01AR0001	15-JAN-93	0.319360	0.115164	1.00050	0.040912	0.558558	0.360186	
20	NB01AR0001	17-FEB-93	0.344310	0.075679	1.21800	0.043469	0.795522	0.470532	0.309690
21	NB01AR0001	05-APR-93	0.224550	0.074857	0.55680	0.023269	0.476749	0.170724	0.219780
22	NB01AR0001	12-MAY-93	0.159680	0.055114	0.26970	0.017643	0.163618	0.154068	0.249750
23	NB01AR0001	29-JUN-93	0.254490	0.345492	0.91350	0.033241	0.507780	0.299808	0.389610
24	NB01AR0001	19-AUG-93	0.219560	0.046066	0.61335	0.028127	0.307489	0.216528	0.325674
25	NB01AR0001	18-OCT-93	0.224051	0.073211	0.36105	0.024547	0.157976	0.235266	0.245754
26	NB01AR0001	02-DEC-93	0.249500	0.090486	0.36540	0.015342	0.275330	0.316464	0.219780

TABLE 8
RESULTS OF TRIPLICATE SAMPLING IN THE ST CROIX RIVER BASIN
GRAB SAMPLE DATA - 1993

0	1 STATION NO	2 SDATE	3 10301(F) PH PH UNITS	4 10301 PH PH UNITS	5 10110 ALK_GRAN MG/L	6 07315 NO3 (MG/L)	7 06107 DOC MG/L	8 13305 AL_EXT MG/L
1	NB01AR0013	12-MAY-93	6.490	6.600	5.700	0.020	3.800	0.063
2	NB01AR0013	12-MAY-93	6.620	6.700	5.800	0.010	4.800	0.068
3	NB01AR0013	12-MAY-93	6.630	6.500	5.600	0.020	4.800	0.070
4								
5	MEAN		6.580	6.600	5.700	0.017	4.467	0.067
6	STDEV		0.078	0.100	0.100	0.006	0.577	0.004
7	COEFF OF VAR.		1.187	1.515	1.754	34.641	12.926	5.381
8								
9	NB01AR0014	18-OCT-93	7.890	7.400	373.700	5.300	37.500	
10	NB01AR0014	18-OCT-93	7.940	7.600	370.300	4.600	36.000	
11	NB01AR0014	18-OCT-93	7.970	7.600	374.400	4.900	36.500	
12								
13	MEAN		7.933	7.533	372.800	4.933	36.667	
14	STDEV		0.040	0.115	2.193	0.351	0.764	
15	COEFF OF VAR.		0.509	1.533	0.588	7.119	2.083	
16								
17	NB01AR0001	17-FEB-93	6.800	6.700	15.500	0.160	5.300	0.260
18	NB01AR0001	17-FEB-93	6.800	6.800	16.500	0.130	6.100	0.270
19	NB01AR0001	17-FEB-93	6.700	6.800	16.800	0.150	5.500	0.270
20								
21	MEAN		6.767	6.767	16.267	0.147	5.633	0.267
22	STDEV		0.058	0.058	0.681	0.015	0.416	0.006
23	COEFF OF VAR.		0.853	0.853	4.185	10.415	7.391	2.165
24								

TABLE 9
TRIP BLANK AND TRIP SPIKE DATA FOR MAJOR IONS,
METALS AND NUTRIENTS - 1993

0	1 STATION NO	2 SDATE	3 SAM TYPE	4 10301 PH PH UNITS	5 02041 SP_COND USIE/CM	6 02073 TURBIDITY JTU	7 10110 ALK_GRAN MG/L	8 20110 CA_DIS MG/L
1	NB01BU0068	13-JAN-93	8	5.6		0.1	-0.4 L	0.1000
2	NB01BU0068	11-FEB-93	8	6.0	0.7	0.2	0.4 L	0.1000
3	NB01BU0068	31-MAR-93	8	5.6	1.2	0.1	-0.4 L	0.1000
4	NB01BU0068	21-MAY-93	8	6.0	0.6	0.2	0.1 L	0.1000
5	NB01BU0068	15-JUL-93	8	6.0	0.0	0.1	-0.2 L	0.1000
6	NB01BU0068	31-AUG-93	8					
7	NB01BU0068	18-OCT-93	8	5.7	0.8	0.1	0.2 L	0.1000
8	NB01BU0068	08-DEC-93	8	5.9	0.8	0.1	0.3 L	0.1000
9								
10								
11								
12	NB01BU0068	13-JAN-93	28	5.4		0.1	-0.4	1.80
13	NB01BU0068	31-MAR-93	28	5.3	38.0	0.2	-0.3	1.70
14	NB01BU0068	21-MAY-93	28	5.3	37.0	0.2	-0.5	1.80
15	NB01BU0068	31-AUG-93	28					
16	NB01BU0068	21-OCT-93	28	5.7	35.0	0.1	0.5	1.65
17	NB01BU0068	08-DEC-93	28	5.4	37.0	0.1	0.2	1.90
18								
19	SPIKE VALUE							2.00
20	MEAN ----	% RECOVERY						88.00

0	9 12107 MG_DIS MG/L	10 19103 K_DIS MG/L	11 11103 NA_DIS MG/L	12 16309 SO4_DIS MG/L	13 17209 CL_DIS MG/L	14 29305 CU_EXT MG/L	15 82302 PB_EXT MG/L
1	L 0.1000	0.07	L 0.0500			L 0.0020	L 0.0020
2	L 0.1000	0.07	L 0.0500	L 0.5000	L 0.5000	L 0.0020	L 0.0020
3	L 0.1000	0.05	L 0.0500	L 0.5000	L 0.5000	L 0.0020	L 0.0020
4	L 0.1000	0.05	L 0.0500	L 0.5000	L 0.5000	L 0.0020	L 0.0020
5	L 0.1000	L 0.0500	L 0.0500	L 0.5000	L 0.5000	L 0.0020	L 0.0020
6						L 0.0020	L 0.0020
7	L 0.1000	0.05	L 0.0500	L 0.5000	L 0.5000		L 0.0020
8	L 0.1000	0.05	L 0.0500	L 0.5000	L 0.5000		
9							
10							
11							
12	0.23	0.71	2.3			0.01	0.009
13	0.22	0.81	2.5	5.2	5.6	0.01	0.010
14	0.22	0.75	2.4	5.4	5.9	0.01	0.010
15						0.01	0.009
16	0.19	0.76	2.4	5.1	5.8		0.010
17	0.20	0.74	2.3	5.4	5.9		
18							
19	0.25	0.70	2.3	5.0	6.1	0.01	0.010
20	85.00	108.00	103.0	106.0	95.0	100.00	96.000

TABLE 9
TRIP BLANK AND TRIP SPIKE DATA FOR MAJOR IONS,
METALS AND NUTRIENTS - 1993

0	16 30304 ZN_EXT MG/L		17 48302 CD_EXT MG/L		18 80315 HG_EXT UG/L		19 24004 CR_TOT MG/L		20 28302 NI_EXT MG/L		21 13305 AL_EXT MG/L		22 26305 FE_EXT MG/L	
1	L	0.0100	L	0.0010	L	0.0200	L	0.0002	L	0.0020	L	0.0100	L	0.0020
2	L	0.0100	L	0.0010	L	0.0200	L	0.0002	L	0.0020	L	0.0100	L	0.0020
3	L	0.0100	L	0.0010	L	0.0200		0.0002	L	0.0020	L	0.0100	L	0.0020
4	L	0.0100	L	0.0010	L	0.0200		0.0002	L	0.0020	L	0.0100	L	0.0020
5	L	0.0100	L	0.0010	L	0.0200		0.0003	L	0.0020	L	0.0100	L	0.0020
6	L	0.0100	L	0.0010	L	0.0200	L	0.0002			L	0.0100	L	0.0020
7	L	0.0100			L	0.0200	L	0.0002	L	0.0020	L	0.0100	L	0.0020
8	L	0.0100			L	0.0200								
9														
10														
11														
12		0.11		0.01		0.05		0.0024		0.01		0.100		0.020
13		0.11		0.01		0.05		0.0022		0.01		0.100		0.019
14		0.11		0.01		0.07		0.0025		0.01		0.097		0.020
15		0.11		0.01		0.10		0.0026		0.01		0.100		0.020
16		0.10				0.10		0.0027		0.01		0.110		0.021
17		0.11				0.05								
18														
19		0.10		0.01		0.10		0.0025		0.01		0.100		0.020
20		108.00		100.00		70.00		99.0000		100.00		101.000		100.000

0	23 25304 MN_EXT MG/L		24 33007 AS_TOT MG/L		25 15413 P_TOT MG/L		26 07315 N_DIS_NO3 MG/L		27 07601 N_TOT MG/L		28 06107 DOC MG/L	
1	L	0.0100	L	0.0005	L	0.0010					L	0.5000
2	L	0.0100	L	0.0005	L	0.0010	L	0.0100			L	0.5000
3	L	0.0100	L	0.0005	L	0.0010	L	0.0100	L	0.0100	L	0.5000
4	L	0.0100	L	0.0005		0.001	L	0.0100	L	0.0100	L	0.5000
5	L	0.0100	L	0.0005		0.001	L	0.0100	L	0.0100	L	0.5000
6	L	0.0100			L	0.0010						
7	L	0.0100	L	0.0005	L	0.0010	L	0.0200	L	0.0100	L	0.5000
8	L	0.0100					L	0.0200	L	0.0100	L	0.5000
9												
10												
11												
12		0.11		0.0046		0.020						0.90
13		0.10		0.0050		0.023		0.27		0.42		1.00
14		0.11		0.0050		0.024		0.28		0.43		1.40
15		0.10				0.024						
16		0.10		0.0051		0.023		0.27		0.42		1.10
17		0.11				0.020		0.21		0.42		1.10
18												
19		0.10		0.0050		0.023		0.27		0.56		1.24
20		105.00		99.0000		97.000		95.00		75.00		89.00

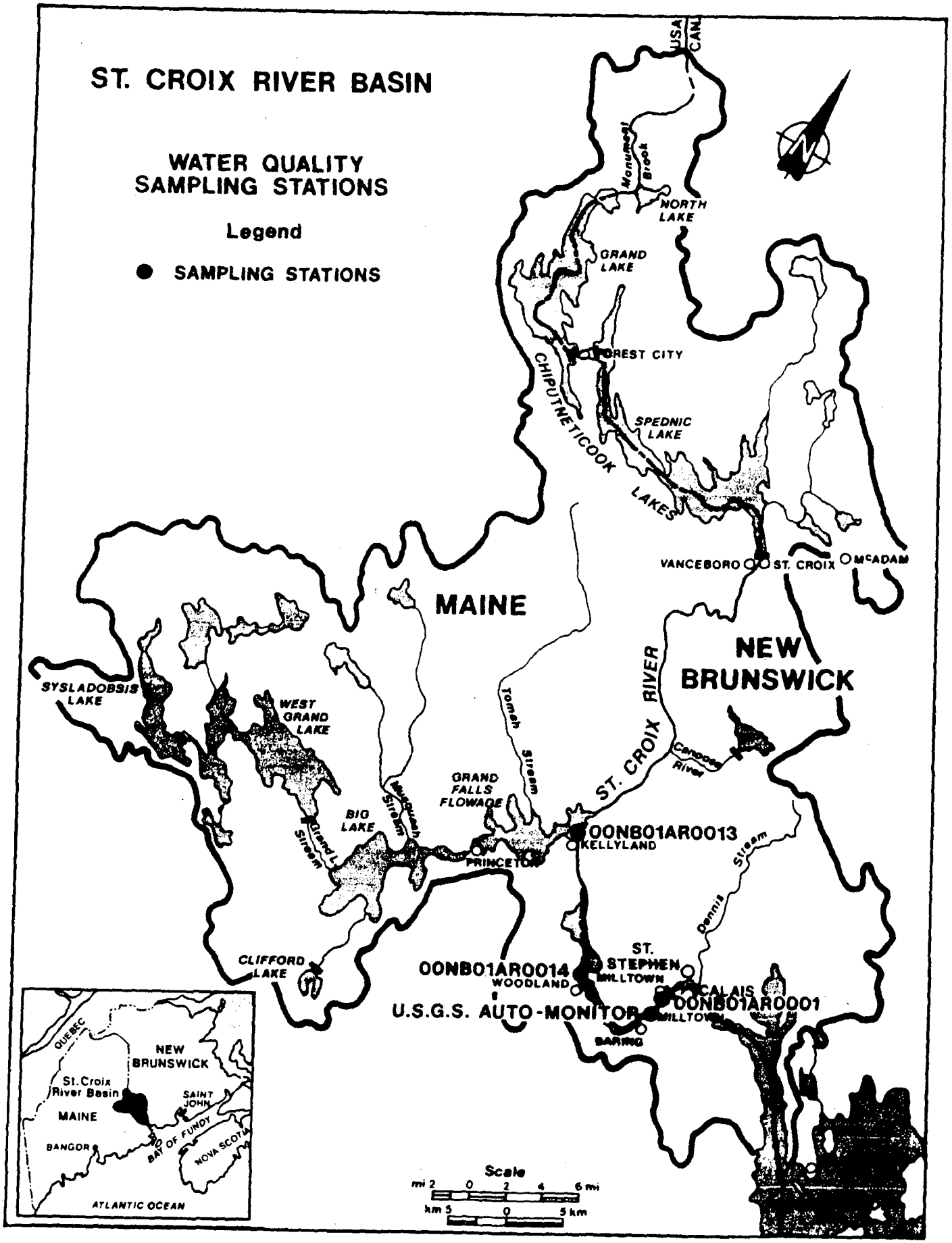
ST. CROIX RIVER BASIN
WATER QUALITY SAMPLING STATIONS
Legend
SAMPLING STATIONS
USA
CAN
Monument Brook
NORTH LAKE
GRAND LAKE
FOREST CITY
CHIPUTNETICOOK LAKES
SPEDNIC LAKE
VANCEBORO
ST. CROIX
McADAM
MAINE
NEW BRUNSWICK
ST. CROIX RIVER
SYSLADOBSIS LAKE
WEST GRAND LAKE
Tomah Stream
Canoose River
GRAND FALLS FLOWAGE
Mattawamkeag Stream
Broad L Stream
BIG LAKE
PRINCETON
00NB01AR0013
KELLYLAND
Dennis Stream
CLIFFORD LAKE
00NB01AR0014
WOODLAND
ST. STEPHEN
MILLTOWN
CALAIS
00NB01AR0001
U.S.G.S. AUTO-MONITOR
BARING
QUEBEC
NEW BRUNSWICK
St. Croix River Basin
SAINT JOHN
MAINE
BANGOR
BAY OF FUNDY
NOVA SCOTIA
ATLANTIC OCEAN
Scale
mi 2 0 2 4 6 mi
km 5 0 5 km

Figure 1

FIGURE 2
DISSOLVED OXYGEN (mg/L) AT THE ST CROIX RIVER
GRAB SAMPLING STATIONS - 1993

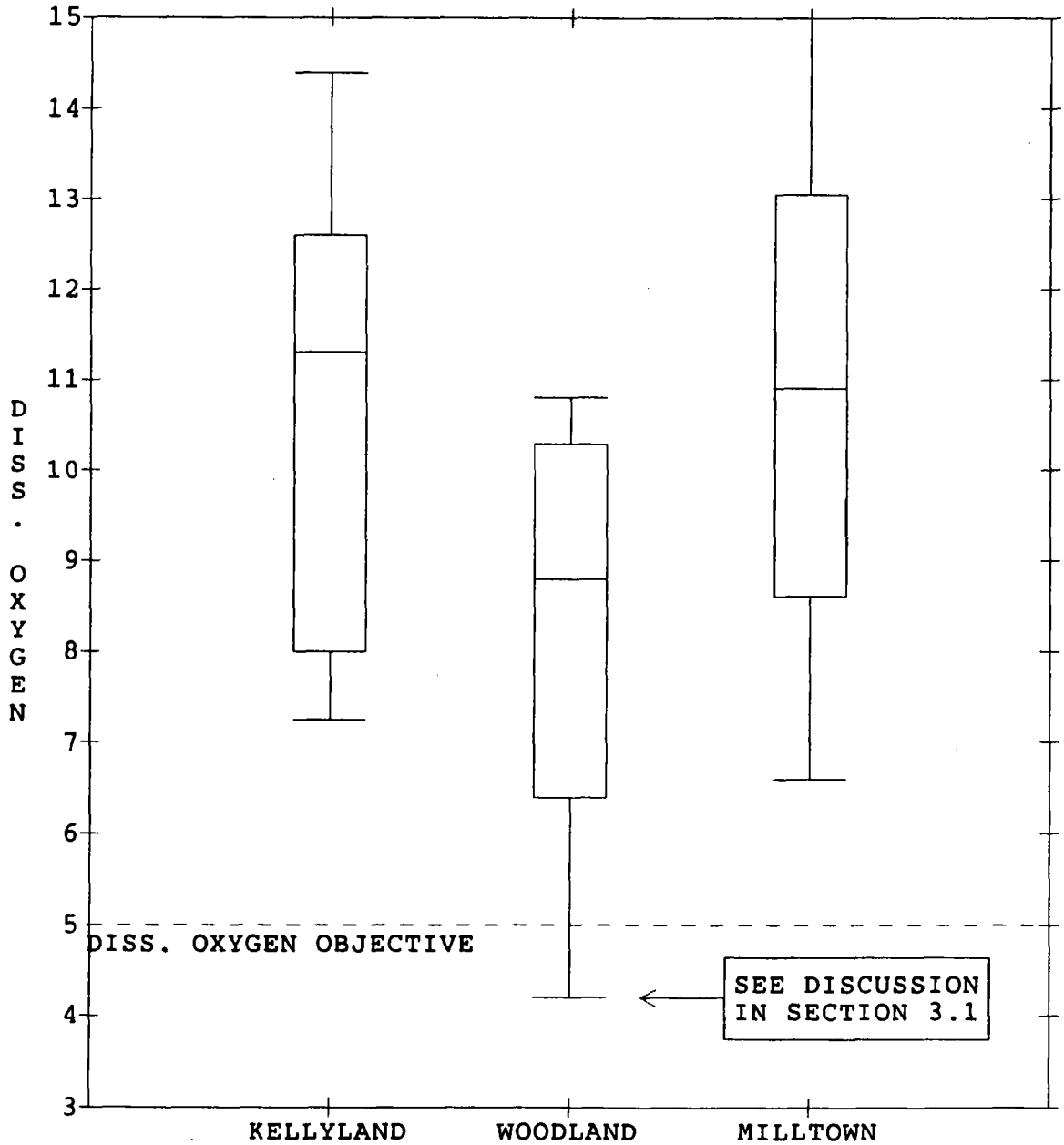

FIGURE 3
DISSOLVED OXYGEN (% SATURATION) AT THE ST CROIX RIVER
GRAB SAMPLING STATIONS - 1993

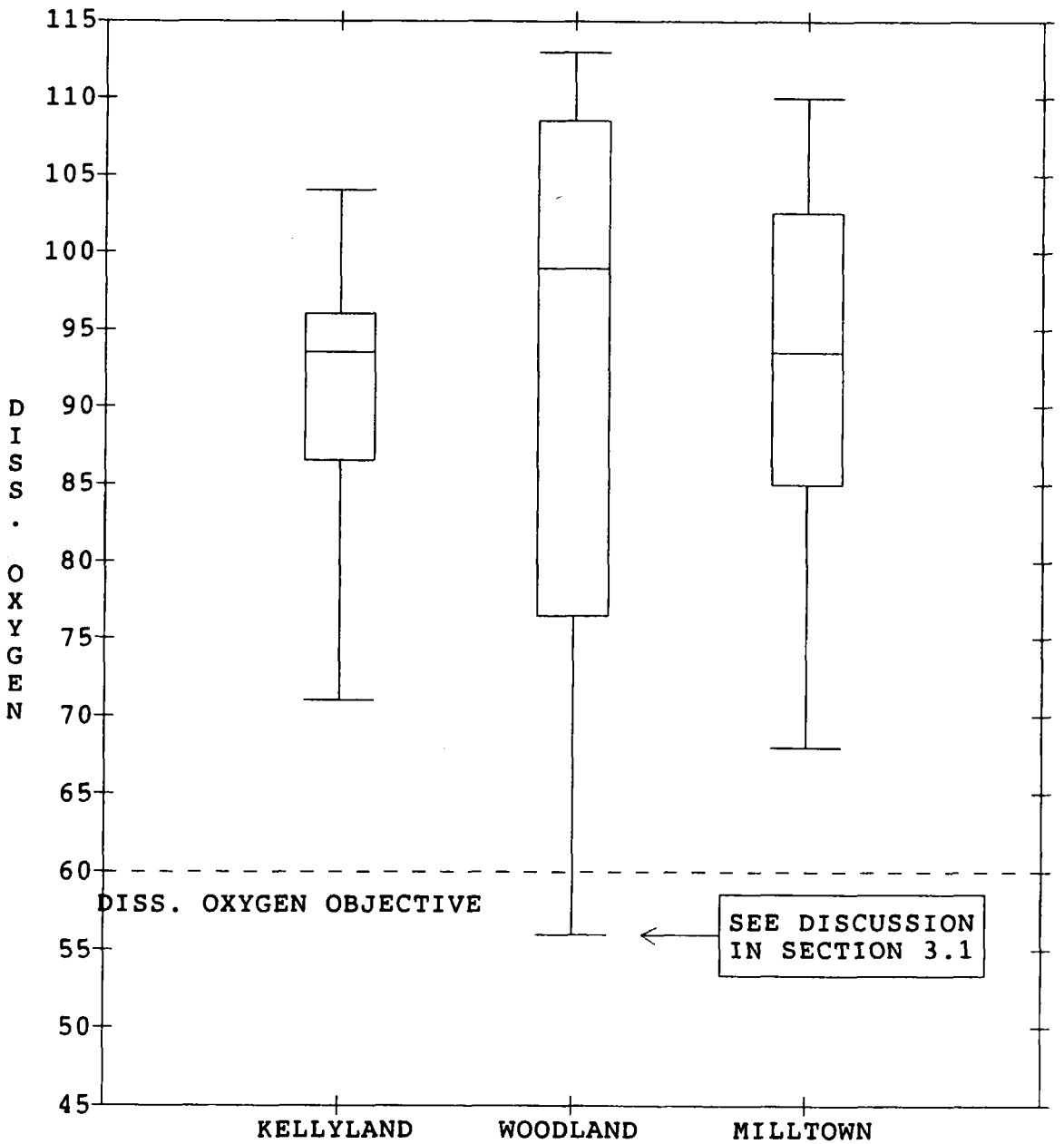

FIGURE 4
pH (pH UNITS) AT THE ST CROIX RIVER
GRAB SAMPLING STATIONS - 1993

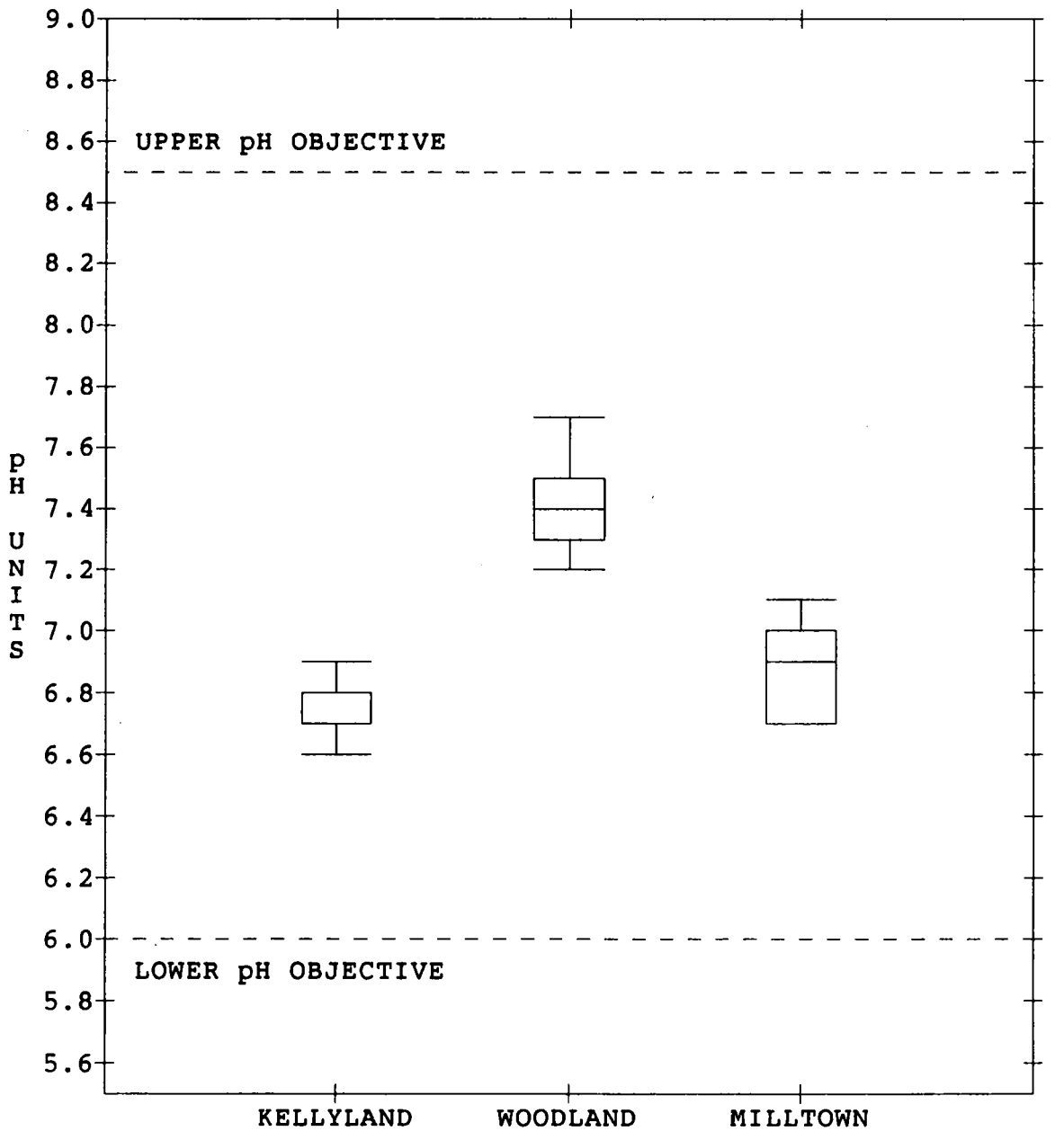

FIGURE 5
ST CROIX RIVER AT MILLTOWN AWQM DATA
MEAN DAILY DISSOLVED OXYGEN (mg/L) - 1993

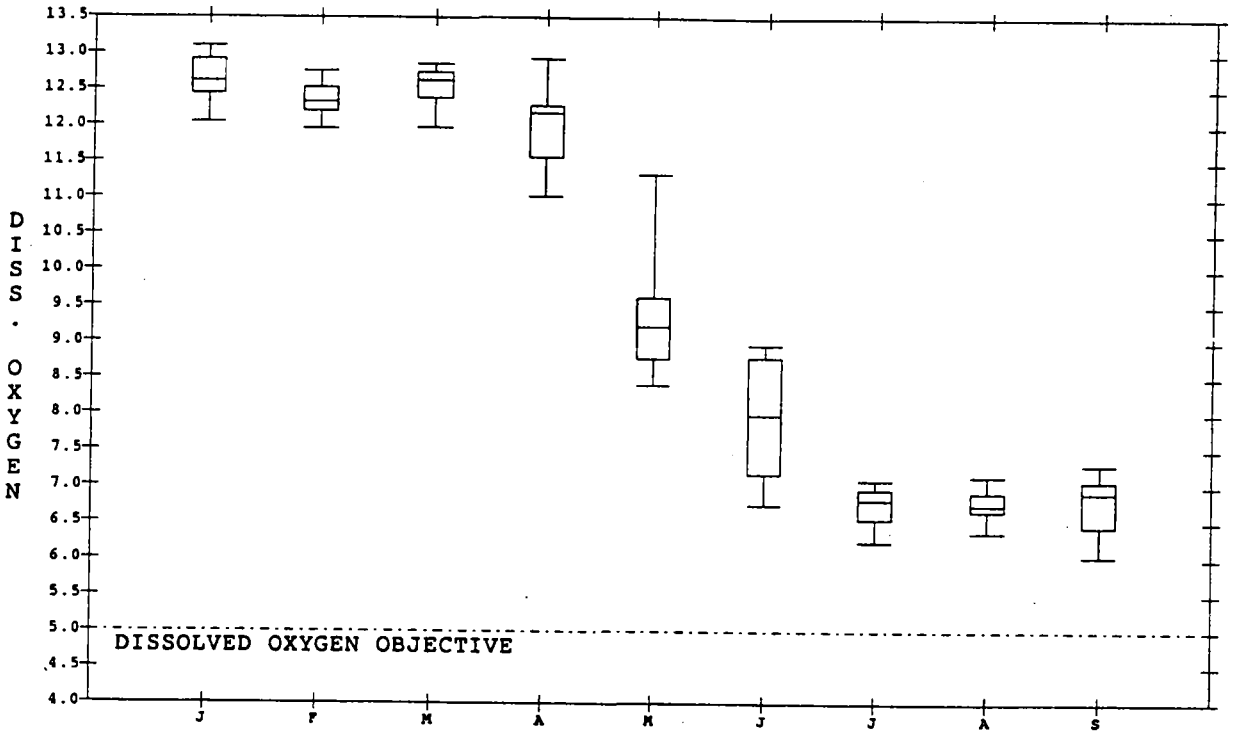

FIGURE 6
ST CROIX RIVER AT MILLTOWN AWQM DATA
DAILY MEAN DISSOLVED OXYGEN (% SATURATION) - 1993

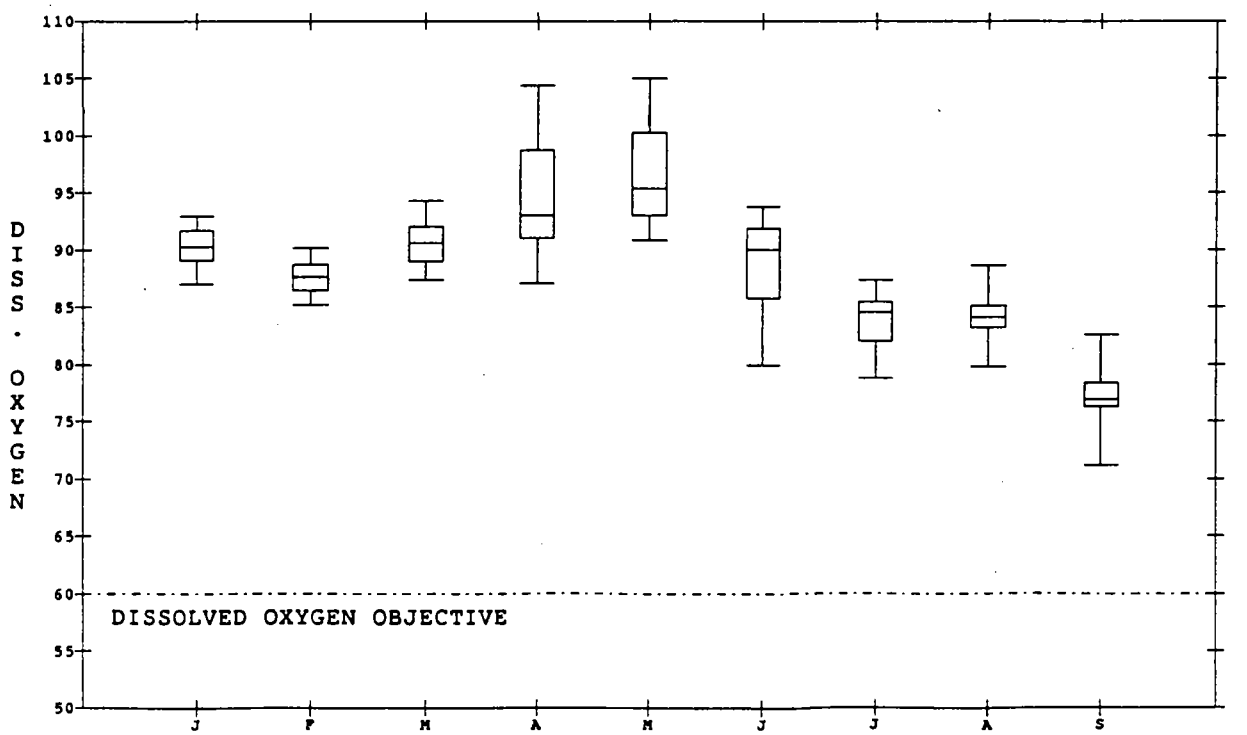

FIGURE 7
ST CROIX RIVER AT MILLTOWN AWQM
MEAN DAILY pH (pH UNITS) - 1993

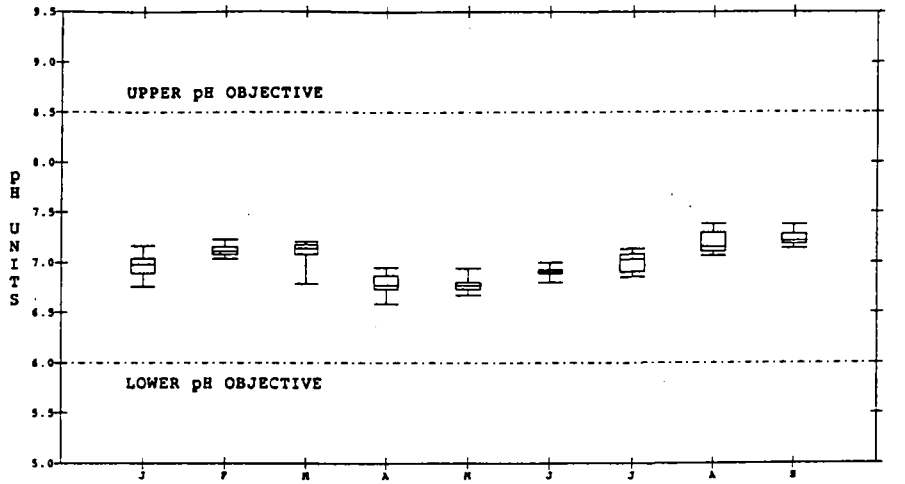

FIGURE 8
ST CROIX RIVER AT MILLTOWN AWQM DATA
MEAN DAILY TEMPERATURE (DEG. C) - 1993

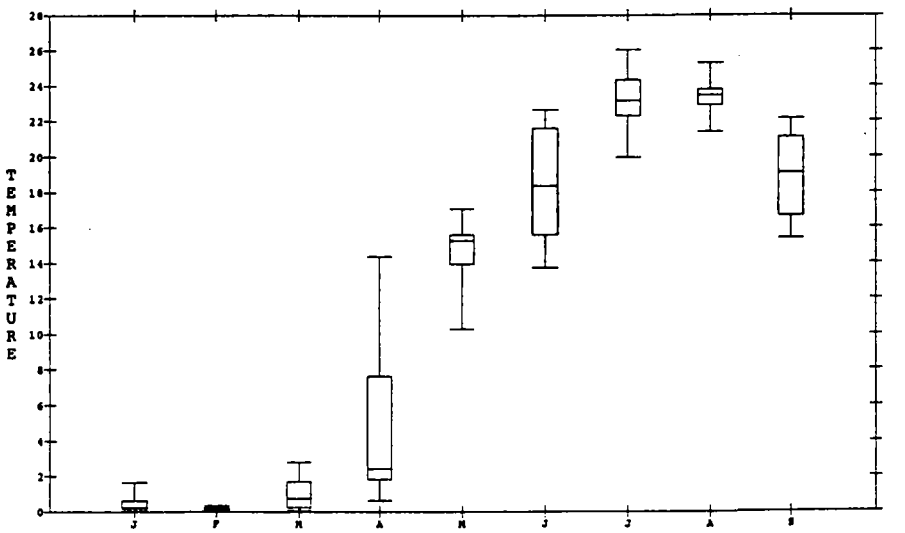

FIGURE 9
ST CROIX RIVER AT MILLTOWN AWQM DATA
DAILY MEAN SPECIFIC CONDUCTANCE (uS/cm) - 1993

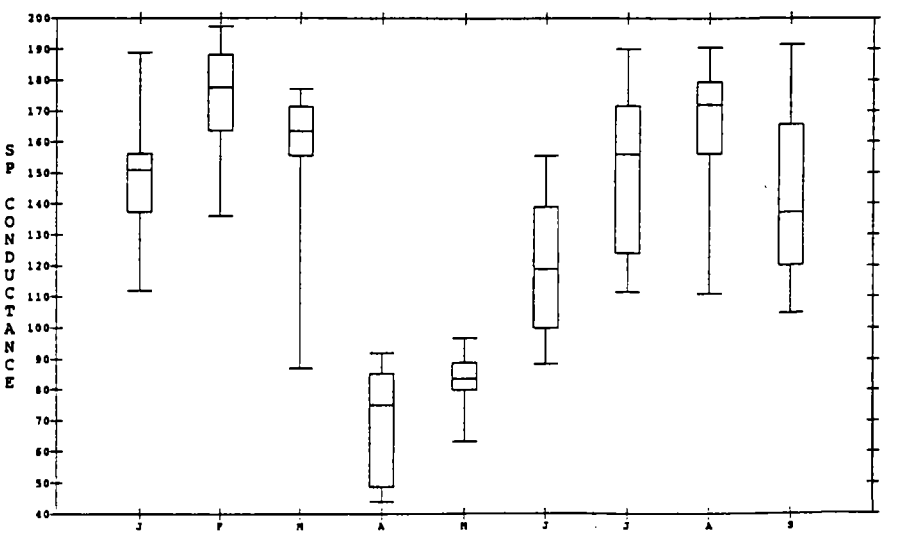

FIGURE 10
ST CROIX RIVER AT BARING PROVISIONAL DISCHARGE DATA
MEAN DAILY DISCHARGE (M**3/S) - 1993

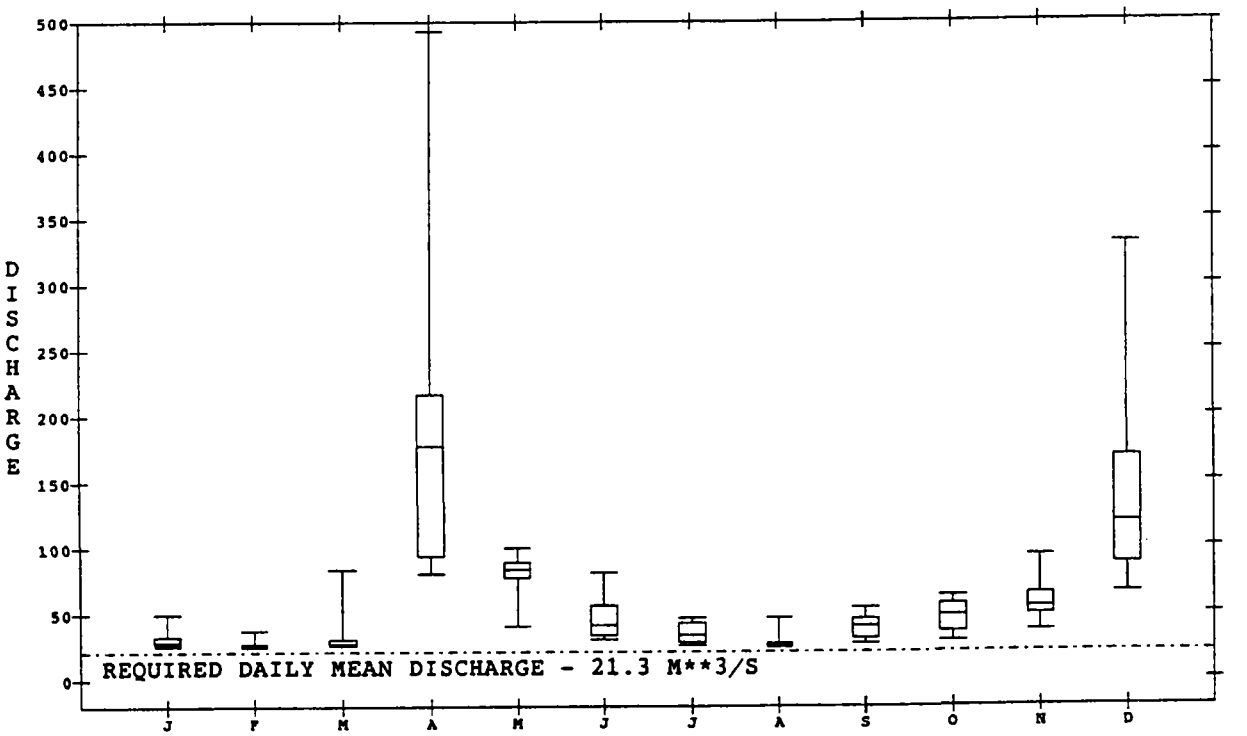

FIGURE 11
ST CROIX RIVER AT BARING PROVISIONAL DISCHARGE DATA
DAILY MEAN DISCHARGE (cfs) - 1993