

FRASER RIVER ACTION PLAN



Change in Contaminant

Concentration in Fraser

River Suspended

Sediments and Water

During the Onset of

Freshet

(Marguerite - 1993)

DOE FRAP 1994-29



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**CHANGE IN CONTAMINANT CONCENTRATION IN FRASER RIVER
SUSPENDED SEDIMENTS AND WATER DURING
THE ONSET OF FRESHET
(MARGUERITE - 1993)**

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ABSTRACT

Concentrations of trace organic contaminants associated with pulp mill effluent were measured in suspended sediments and water collected from the Fraser River at Marguerite, British Columbia. Sampling was conducted during the initial rise of the hydrograph (March 30 to April 22, 1993) to determine if there was a change in the concentration of the following contaminants during this period: dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), chlorophenolics, resin acids and fatty acids. The data indicate that: i) trace organic contaminants are detectable in suspended sediments measured at Marguerite which is located approximately 59 river kilometres downstream of the nearest pulp mill source, ii) suspended sediments showed a measurable increase in contaminant concentration during the onset of freshet and this increase was likely due to the resuspension of bed sediment material deposited during the previous winter low flow period, iii) the calculated loadings of 2,3,7,8-T4CDD and 2,3,7,8-T4CDF in suspended sediments at Marguerite were highest on April 7, corresponding to the peak in suspended sediment concentration during the freshet sampling period, iv) dioxins/furans and PAHs were found to partition almost exclusively in suspended sediments thereby confirming that suspended sediments are an appropriate method of sampling for these contaminants and v) none of the contaminants measured exceeded existing water quality guidelines for the protection of freshwater aquatic life.



Marguerite Ferry Landing

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1.0 INTRODUCTION

In June 1991, the federal government announced the Fraser River Action Plan (FRAP). The overall goals of FRAP are 1) to restore the natural productive capacity of Fraser River ecosystems 2) to arrest and reverse the existing environmental contamination and degradation of Fraser River ecosystems and 3) to build partnerships with provincial and local governments as well as other interested groups to develop a cooperative management program for the Fraser Basin based on the principles of sustainability. As part of FRAP, the Environmental Quality program is responsible for providing a baseline of the environmental conditions in the aquatic environment and measuring the effects of major pollution sources on the aquatic environment. The present study was aimed at determining the effects of pulp mill effluents on the Fraser River receiving environment.

Previous studies have identified pulp and paper mill effluent as a source of trace organic contaminants such as dioxins/furans, chlorophenolics and resin acids (Dwernychuk, 1991, Dwernychuk, 1994; Merriman, 1988; Amendola *et al.*, 1987). The Fraser River from Prince George to Quesnel receives effluent from five pulp and/or paper mills. Three bleached kraft mills are located in Prince George and one bleached kraft mill and one thermo-mechanical pulp and paper mill are located in Quesnel.

In 1989, elevated levels of dioxins and furans were measured in bed sediments and fish collected from the vicinity of pulp and paper mills in the Fraser basin (Mah *et al.*, 1989). In 1990 and 1991, Dwernychuk *et al.* (1991), reported measurable levels of chlorophenolics in bed sediments collected from the Fraser River in the vicinity of Prince George and Quesnel. Similarly, in the same two years, dioxins, furans and chlorophenolics were measured in pulp mill effluent biosolids and Fraser River suspended sediments (Derksen and Mitchell, in preparation). Sampling conducted by Merriman (1988) also showed elevated levels of these contaminants, as well as polycyclic aromatic hydrocarbons, in pulp mill effluent and suspended sediments from the Rainy River in northern Ontario.

A more recent study (Owens *et al.*, 1994) conducted in the Wapiti-Smoky river system in Alberta concluded that the environmental transport of dioxins and furans in that riverine system occurred predominately in suspended sediments, and the observed seasonal fluctuations in the concentration of these compounds were due to flow variations.

The Fraser River typically experiences a period of low flow and decreased suspended sediment load from December to April (Carson, 1988). During this period, the concentrations of pulp mill contaminants in suspended sediments have been shown to be higher than at other flow periods (Sekela *et al.*, in preparation).

Evidence of fine sediment deposition under low flow conditions has been found by Krishnappan *et al.* (1994) in the Athabasca River downstream of a pulp mill at Hinton, Alberta. It was found that during low flows, widespread deposition of fine sediment particles (silts and clays) is possible due to flocculation of the fines in the presence of pulp mill effluents in low energy environments that are sheltered from the main flow of the river. In a more recent laboratory study conducted by Krishnappan and Engel, (1994) using sediments and pulp mill effluent collected from the Fraser River system, it was found that this pulp mill effluent similarly enhanced sediment flocculation and deposition.

It is hypothesized that in the Fraser River, suspended sediments contaminated with trace organic substances would be deposited as bed material in low energy environments during the winter low flow period. These contaminated sediments would accumulate and remain as bed material until such time (spring freshet) that the river velocity increased sufficiently to resuspend the bed material. Based on data provided by Carson (1988), the initial onset of spring freshet (increase in flow) in the Fraser River results in a peak in the suspended sediment concentration, and this peak consists predominantly of fine material.

The purpose of the current study was to investigate changes in contaminant concentrations in suspended sediments and water during the onset of spring freshet in the Fraser River at Marguerite.

2.0 STUDY AREA, PULP MILL OPERATIONS AND SAMPLE TIMING

2.1 Study Area

All suspended sediment and water samples were collected from the east bank of the Fraser River at the Marguerite Ferry landing (Figure 1). Marguerite is located approximately 59 river kilometres (rkm) downstream of Quesnel and 209 rkm downstream of Prince George.

2.2 Pulp Mill Operations

Five mills are located on the Fraser River upstream of Marguerite. Three of the mills are located at Prince George: Northwood Pulp and Timber Ltd., Intercontinental Pulp Company Ltd. and Prince George Pulp and Paper Ltd.. In 1978 Intercontinental Pulp Company Ltd. and Prince George Pulp and Paper Ltd. combined to form Canadian Forest Products Ltd. (Canfor). The two Canfor mills share a single discharge to the Fraser River. The two remaining mills, Cariboo Pulp and Paper Company and Quesnel River Pulp Company, are located in Quesnel. Refer to Figure 1 for mill locations.

At the time of sampling, all mills utilized a combination of molecular chlorine and chlorine dioxide (ranging from 40 to 100% chlorine dioxide substitution) in their production processes except for Quesnel River Pulp Company. The Quesnel River Pulp Company mill is a chemi-thermo-mechanical mill which does not employ chlorine in its process. All five mills treat their effluent in aerated stabilization basins prior to discharging into the Fraser River. During the biological treatment process in the stabilization basins the dissolved organic waste material is broken down thereby reducing the biochemical oxygen demand and acute toxicity to fish (Derksen and Mitchell, in preparation). During the study period all five mills were operating normally (personal communication Northwood Pulp & Timber Ltd., Canadian Forest Products Ltd., Quesnel River Pulp Company and Cariboo Pulp & Paper Company).

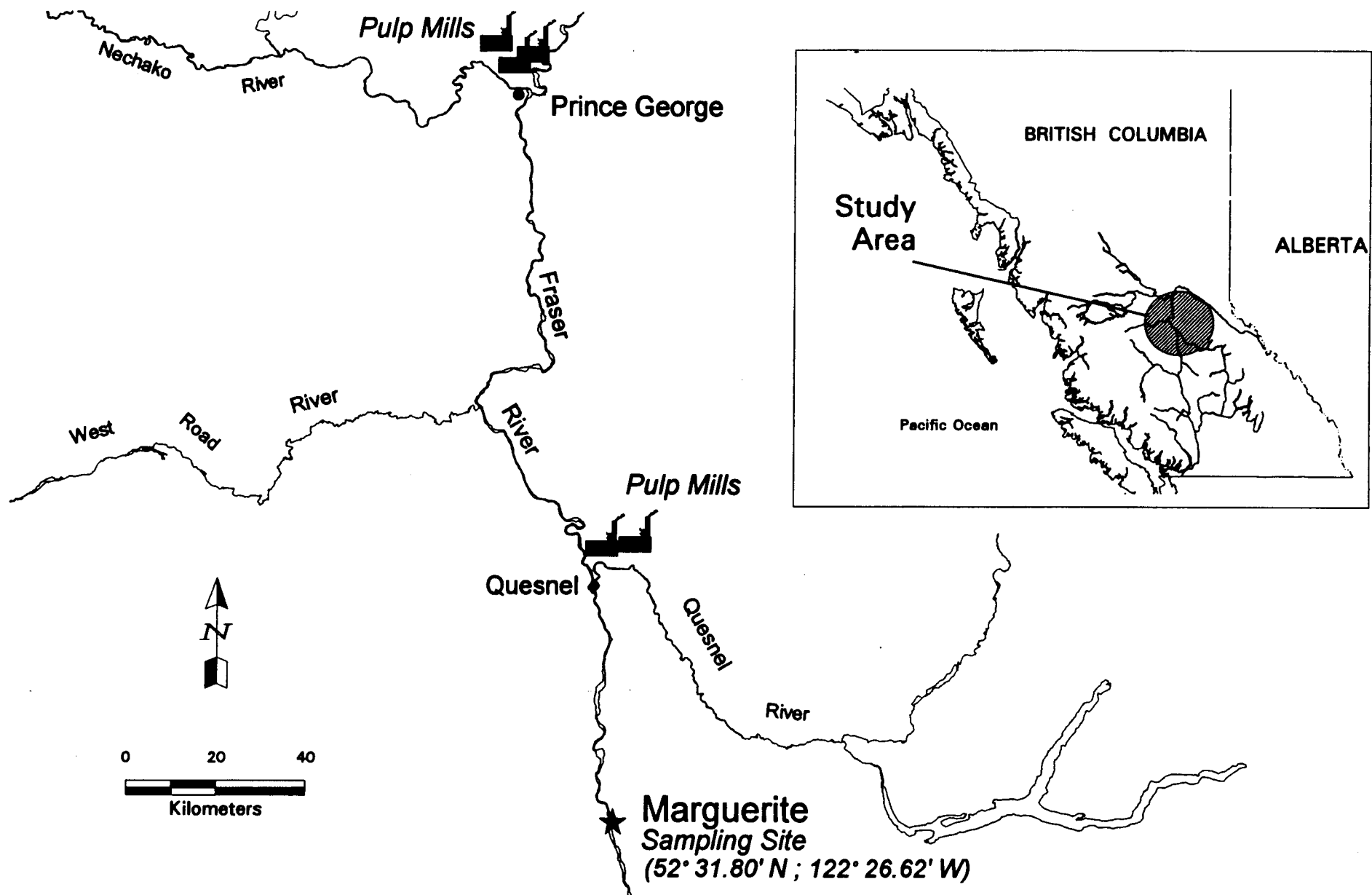


Figure 1 Locations of the Sampling Site and Pulp and/or Paper Mills in the Upper Fraser River

2.3 Sample Timing

In 1993, ice break-up on the Fraser River at Marguerite commenced on March 29 and was completed on March 30 (Water Survey of Canada, 1993). Samples were collected four times in 1993: March 30, April 7, April 15 and April 22.

3.0 FIELD METHODS

3.1 Sampling Equipment Cleaning Procedures

3.1.1 Field Equipment and Sample Containers

All field sampling equipment and sample containers used for organic contaminants were cleaned as follows: (1) washed with tap water and laboratory detergent; (2) rinsed with tap water then deionized water (18 meg-ohm); (3) rinsed with pesticide grade acetone followed by hexane; (4) air dried. All cleaned field equipment was wrapped in heat treated (325 °C) aluminum foil until used. Prior to use, all equipment was rinsed with water from the sample collection site.

3.1.2 River (Whole) Water Sample Containers

Four litre glass amber bottles with Teflon lined caps were used to collect all river water samples. The bottles were cleaned as follows: (1) washed with tap water and laboratory detergent; (2) rinsed with tap water then deionized water (18 meg-ohm); (3) heat treated to 330°C for six hours.

3.1.3 XAD Column Preparation

Clarified water from the continuous flow centrifuge was sampled for dioxins, furans and polycyclic aromatic hydrocarbons using XAD columns. These were pre-cleaned by AXYS Analytical (Sydney B.C.) by eluting them with dichloromethane followed by a final rinse of methanol. The columns were

left wet with methanol to prevent drying of the resin.

3.2 Sample Collection

Refer to Figure 2 for a schematic flow diagram of sample collection.

3.2.1 Suspended Sediment Collection

Suspended sediment samples were collected using a Westfalia Separator model KA-2-06-175 continuous flow centrifuge. The centrifuge operates by delivering sample water continuously to a four chambered bowl assembly where it is evenly distributed by means of a vane insert. The bowl assembly rests on a spindle which rotates the bowl assembly at a rate of 11,000 rpm. The centrifugally separated solids accumulate in the four chambers of the bowl while the clarified water is pressure discharged by means of a centripetal pump. For a detailed description of the operation of the Westfalia centrifuge refer to Horowitz *et al.*, 1989.

Sample water was delivered from the river to the centrifuge via a submersible pump (March model 5C-MD). All wetted plastic parts of the pump assembly were made of Glass Filled Polypropylene with ceramic spindles and Vitron gaskets. The pump intake was suspended in the river approximately 3 m from shore and 1 m below the surface. Stainless steel encased Teflon tubing was used to deliver the sample water from the pump to the centrifuge.

The centrifuge was positioned onshore and power was supplied to it and the submersible pump by a 5000 watt generator. The generator was located approximately 30 m from the centrifuge to reduce the possibility of contamination from fuel and exhaust. The centrifuge was operated at 4 L/min, as this flow velocity was found to be ideal for efficient recovery of suspended sediment (90-99%) and because loss of particles is restricted to those $< 1 \mu\text{m}$ in diameter (Churchland *et al.*, 1987). The sampling periods ranged from a maximum of 7.5 hrs on March 30 to a minimum of 6.0 hrs on April 15 and April 22. Table I lists the flow rates, sampling period and total volume of water centrifuged for each sample.

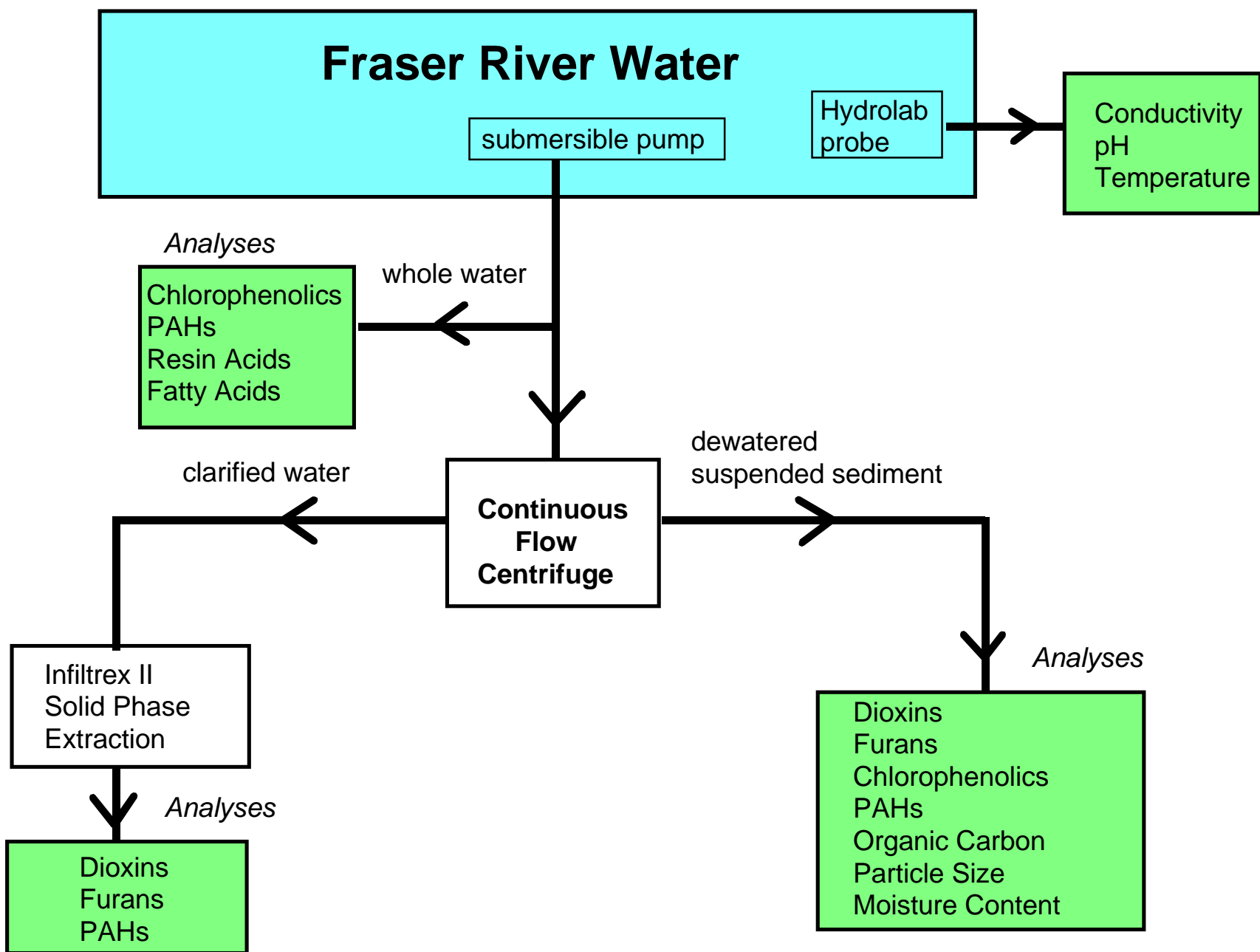


Figure 2 Schematic Flow Diagram of Suspended Sediment and Water Sample Collection in the Fraser River

**Table I Suspended Sediment Collection Data and Total Suspended Sediment Concentration
for the Fraser River (Marguerite - 1993)**

<i>Sampling Date</i>	<i>Sample Period (hrs)</i>	<i>Sample Volume ¹ (L)</i>	<i>Centrifuge Flow Rate (L/min)</i>	<i>Sample Wet Weight (g)</i>	<i>Sample Dry Weight (g)</i>	<i>Total Suspended Solids ² (mg/L)</i>	<i>Fraser River Flow ³ (m3/s)</i>
March 30	7.5	1800	4	366	220.3	122.4	520
April 7	6.5	1560	4	523	320.6	205.5	1050
April 15	6.0	1440	4	360	256.7	146.7	1240
April 22	6.0	1440	4	344	205.0	142.4	1440

1 Sample volume was calculated by multiplying sample period by centrifuge flow rate.

2 Total suspended solids was calculated by dividing sample dry weight by sample volume.

3 Flow was obtained from Water Survey of Canada.

Once sufficient sample water was clarified, the centrifuge was stopped. The entire bowl assembly was removed intact from the centrifuge and taken to the on-site mobile field laboratory for sediment removal. Once removed, the sediments were placed into a pre-weighed Teflon jar and total sample weight was recorded. The sample was mixed thoroughly and subsamples for analytical splits and particle size determination were removed prior to freezing on dry ice.

3.2.2 River (Whole) Water Collection

River whole water samples for trace polycyclic aromatic hydrocarbons, chlorophenolics, and resin/fatty acids analyses were collected on each sampling date. Discrete samples were collected in a 4 litre amber glass bottle from an in-line T-valve placed in the stainless steel encased Teflon tubing prior to entering the centrifuge (Figure 2). Sample bottles and Teflon lined caps were rinsed three times with sample water before filling. Sample bottles were filled so that no air space remained under the cap. Once filled, samples were kept cool (4 °C) until shipped to the laboratory for analysis.

3.2.3 Solid Phase Extracted Water Collection

Clarified water from the centrifuge was passed through an Infiltrex II *in situ* water sampler (AXYS Environmental Systems Ltd.) for dioxins/furans and PAH sampling. The Infiltrex II uses a resin column (solid phase extraction) filled with XAD-2 resin to extract organic contaminants from sample water. The resin column was sent to the laboratory to be eluted, and the eluate was then analysed. A detailed description of the operation of the Infiltrex II is provided in AXYS, 1991.

A single sample was collected on each sampling date. For all samples, 50 litres of clarified sample water was passed through the column at 250 mL/min. In order to determine the recovery of the XAD-2 resin, two internal dioxin field surrogates (Cambridge Isotope Laboratories, Massachusetts) were added to the sample at 0.7 mL/min over the entire extraction period. The two internal surrogates added to the sample were: 50 nanograms per millilitre (ng/mL) of Carbon thirteen (¹³C) labelled 1,2,3,4-tetrachlorodibenzo-para-dioxin and 100 ng/mL of ¹³C labelled 1,2,3,7,8,9-hexachlorodibenzo-para-dioxin. The whole operation was conducted on site in the mobile field laboratory.

3.2.4 Temperature, pH and Conductivity

Water temperature, pH and conductivity were measured *in situ* with a Hydrolab DataSonde 3 transmitter (HYDROLAB Corporation, Texas). The transmitter was suspended 1 m below the surface at approximately the same distance from shore as the submersible pump intake for the centrifuge. Readings of pH, temperature and conductivity were electronically logged every 15 minutes during each centrifuge sampling period.

4.0 ANALYTICAL METHODS

Due to the lengthy nature of organic chemical nomenclature, abbreviations have been used. Refer to Table II for a list of abbreviations with the corresponding full nomenclature.

4.1 Sample Analysis

Dioxins and furans were analysed by high resolution gas chromatography and high resolution mass spectroscopic detection (HRGC/HRMS). Chlorophenolics, polycyclic aromatic hydrocarbons and fatty/resin acids were analysed by high resolution gas chromatography with low resolution (quadruple) mass spectrometric detection (HRGC/LRMS). Total organic carbon (TOC) was determined using a LECO Carbon Analyser. Particle size was determined via a Malvern 2600l laser particle size analyser. Refer to Appendix I for a more detailed description of analytical methods.

4.2 Quality Assurance/Quality Control (QA/QC) Methods

4.2.1 Field QA/QC Methods

The field quality assurance/quality control (QA/QC) component consisted of field blanks, field

Table II**List of Abbreviations for Organic Compounds and Corresponding Full Nomenclature**

<i>Abbreviation</i>	<i>Full Nomenclature</i>
<i>Dioxins</i>	
T4CDD	Tetrachlorodibenzo - p - dioxin
P5CDD	Pentachlorodibenzo - p - dioxin
H6CDD	Hexachlorodibenzo - p - dioxin
H7CDD	Heptachlorodibenzo - p - dioxin
O8CDD	Octachlorodibenzo - p - dioxin
<i>Furans</i>	
T4CDF	Tetrachlorodibenzofuran
P5CDF	Pentachlorodibenzofuran
H6CDF	Hexachlorodibenzofuran
H7CDF	Heptachlorodibenzofuran
O8CDF	Octachlorodibenzofuran
<i>Chlorophenolics</i>	
2,4,6-TCP	2,4,6-Trichlorophenol
4,5-DCG	4,5-Dichloroguaiacol
4,6-DCG	4,6-Dichloroguaiacol
3,4,5-TCG	3,4,5-Trichloroguaiacol
3,5-DCC	3,5-Dichlorocatechol
4,5-DCC	4,5-Dichlorocatechol
3,4,5-TCC	3,4,5-Trichlorocatechol
3,4,5,6-TeCC	3,4,5,6-Tetrachlorocatechol
6-MCV	6-Monochlorovanillin

splits and field surrogates. Deionized water blanks were taken "Mid-field" (sample containers filled in the field during sampling) and "Post-field" (sample containers filled at the laboratory after sampling). Deionized water blanks were analysed for chlorophenols, PAHs, resin acids and fatty acids. Suspended sediment field splits were obtained by subsampling each original sediment sample, while whole water field splits were obtained by taking a second sample immediately following the original sample. Splits were submitted to the laboratory as blind samples. Field surrogates were added during solid phase extraction for dioxin and furan samples as described under section 3.2.3.

4.2.2 Laboratory QA/QC Methods

The QA/QC component of the analytical methods consisted of procedural blanks, lab duplicates, surrogate standard recoveries and reference samples (lab spikes and references). Samples were worked up in batches with accompanying QA/QC samples. Refer to Appendix I, Section 2.0, for a detailed description of the QA/QC methods.

5.0 RESULTS

5.1 Physical Parameters During Sample Collection

Conductivity and pH remained relatively constant on all sampling dates while temperature increased over the sampling period. Table III presents a summary of physical parameters during sample collection, refer to Appendix II, Table 1 for a complete list of results.

5.2 Quality Assurance/Quality Control Results

The reproducibility between field splits of suspended sediment and whole water samples was generally good for all contaminants (coefficient of variation of 15% or less for 75% of all field splits taken). Field deionized water blanks were also acceptable. Laboratory duplicates were in agreement with the original samples ($\pm (20\% + \text{Method Detection Limit}\{\text{MDL}\})$) and laboratory

Table III**Temperature, Conductivity and pH in Fraser River Water (Marguerite - 1993)**

<i>Sampling Date</i>	<i>Median Temperature (celsius)</i>	<i>Median pH</i>	<i>Median Conductivity (mS/cm)</i>
March 30 {range}	0.61 {0.54 - 0.66}	8.14 {7.99 - 8.16}	0.1414 {0.1402 - 0.1416}
April 7 {range}	1.99 {1.96 - 2.03}	7.80 {7.75-7.90}	0.1056 {0.1053 - 0.1057}
April 15 {range}	3.33 {3.11 - 3.44}	7.51 {6.80 - 7.93}	0.1051 {0.1040 - 0.1055}
April 22 {range}	7.69 {7.39 - 8.06}	7.94 {7.89 - 7.95}	0.1030 {0.1027 - 0.1034}

blanks, spikes and references were similarly acceptable for the compounds tested. Due to high background levels, PAH levels were often higher in the field and lab blanks than in the whole water samples, thereby precluding us from analyzing the whole water data for PAHs. Refer to Appendix I, Section 3.0, for a detailed description of field and laboratory QA/QC results.

5.3 Suspended Sediment Results

Table IV presents the results for trace organic contaminants detected in suspended sediments. Appendix II presents the results of all trace organic analyses.

5.3.1 Particle Size Distribution, Flow and Total Organic Carbon

Figure 3 presents the particle size distribution and flow for suspended sediment samples collected during the freshet period extending from March 30 to April 22, 1993. During each sampling period silt comprised the largest fraction (approximately 75%) of the suspended sediment, followed by clay and then sand. No definitive conclusions could be drawn regarding changes in particle size distribution between sampling periods due to analytical variability which ranged from 1.4-7.0% in the field splits. However, there is an apparent decrease in the percentage of sand and an increase in the percentage of clay on the latter two sampling dates (April 15 and April 22). Flow was lowest on March 30 at 520 m³/s followed by a sharp increase to 1050 m³/s on April 7, after which it gradually increased to 1440 m³/s on April 22.

Refer to Figure 4 for the total organic carbon and suspended sediment concentration during the March 30 to April 22 sampling period. The suspended sediment concentration of the Fraser River (calculated from the total sediment collected by the centrifuge over the total volume of water clarified) increased from March 30 to April 7 and then decreased to April 22. The organic carbon fraction of the suspended sediment progressively increased throughout the sampling period (from 0.94 % on March 30 to 1.14% on April 22). Although this increase was quite small, the high degree of precision between the field splits and samples, gives us a high level of confidence in the data values.

Table IV

**Concentrations of Dioxins, Furans, Chlorophenolics and PAHs in Suspended Sediment Samples Collected from the Fraser River (Marguerite -1993)
Expressed as pg/g or ng/g Dry Weight Suspended Sediment and pg/L or ng/L Fraser River Water**

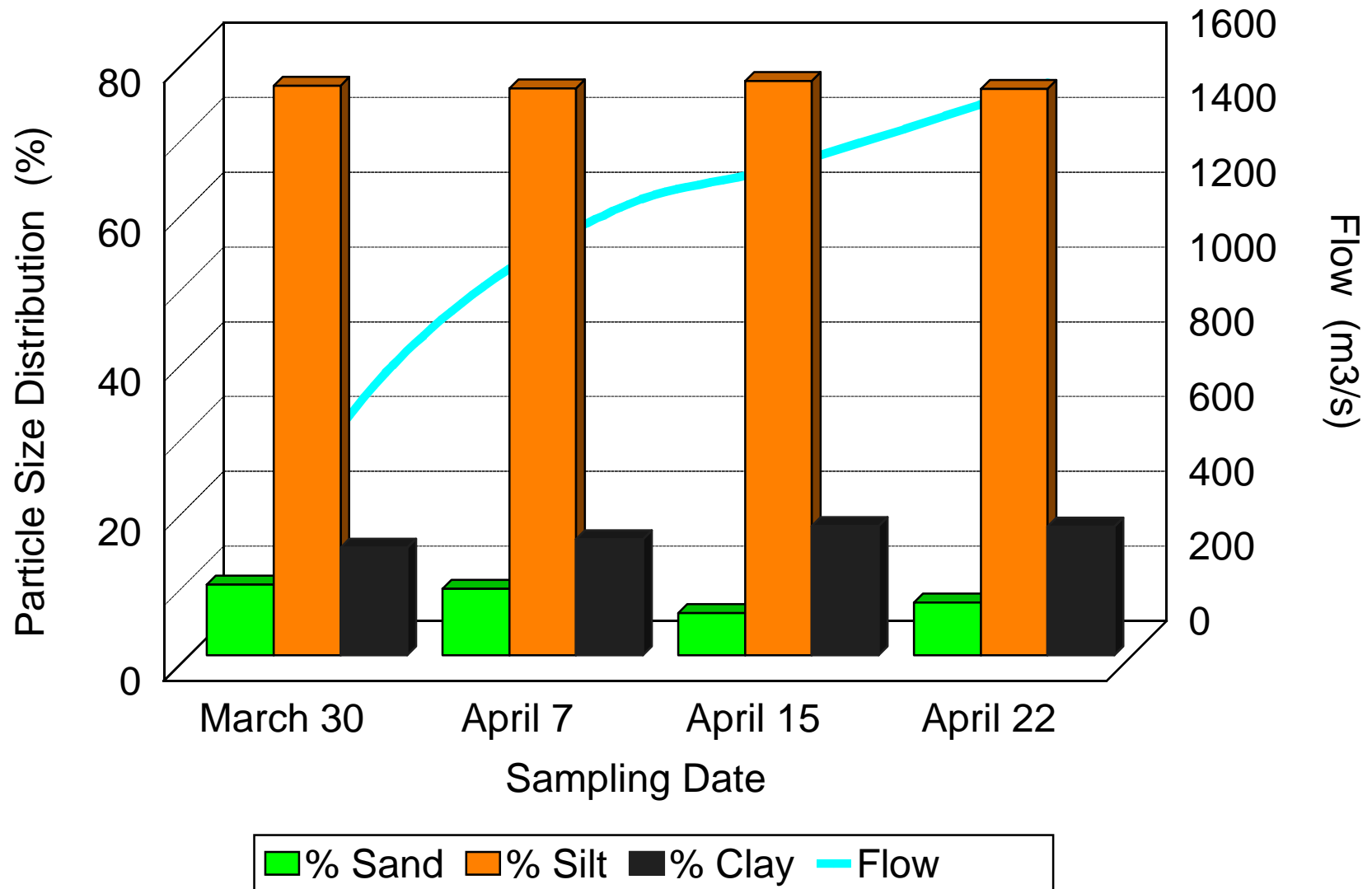
	<u>Dry Weight Suspended Sediment</u>					<u>Fraser River Water</u>			
<i>Dioxins (pg/g)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>	<i>Dioxins (pg/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
2,3,7,8-T4CDD	0.2	0.2	0.1	0.1	2,3,7,8-T4CDD	0.024	0.041	0.015	0.014
Total T4CDD	2.7	4.3	4.1	4.1	Total T4CDD	0.330	0.884	0.601	0.584
Total P5CDD	0.5	2.6	1.7	2.3	Total P5CDD	0.061	0.534	0.249	0.328
Total H6CDD	10.2	16.8	14.5	16.5	Total H6CDD	1.248	3.452	2.127	2.350
Total H7CDD	30.8	52.0	49.0	54.0	Total H7CDD	3.770	10.686	7.188	7.690
Total O8CDD	142.5	202.5	195.0	215.0	Total O8CDD	17.442	41.614	28.607	30.616
<i>Furans (pg/g)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>	<i>Furans (pg/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
2,3,7,8-T4CDF	0.7	0.6	0.3	0.5	2,3,7,8-T4CDF	0.086	0.113	0.044	0.064
Total T4CDF	1.1	0.3	0.4	0.5	Total T4CDF	0.135	0.051	0.059	0.071
Total P5CDF	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	Total P5CDF	ND(0.012)	ND(0.021)	ND(0.161)	ND(0.014)
Total H6CDF	0.4	0.4	0.5	0.4	Total H6CDF	0.049	0.082	0.073	0.057
Total H7CDF	1.3	2.3	2.1	1.2	Total H7CDF	0.159	0.473	0.308	0.171
Total O8CDF	1.6	2.2	1.9	1.6	Total O8CDF	0.196	0.452	0.279	0.228
<i>Chlorophenolics (ng/g)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>	<i>Chlorophenolics (ng/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
4,5-DCG	2.6	3.1	0.7	1.1	4,5-DCG	0.318	0.637	0.103	0.157
3,4,5-TCG	2.6	2.8	2.7	2.2	3,4,5-TCG	0.318	0.575	0.396	0.313
3,5-DCC	ND(4.0)	ND(5.7)	9.2	ND(9.7)	3,5-DCC	ND(0.490)	ND(1.17)	1.350	ND(1.38)
4,5-DCC	21.3	100.0	37.0	37.5	4,5-DCC	2.607	20.550	5.428	5.340
3,4,5-TCC	5.2	4.2	2.6	2.2	3,4,5-TCC	0.636	0.863	0.381	0.313
3,4,5,6-TeCC	NQ	ND (11)	5.0	6.2	3,4,5,6-TeCC	NQ	ND(2.26)	0.734	0.883
2,4,6-TCP	ND(0.5)	ND(0.7)	ND(0.3)	ND(0.4)	2,4,6-TCP	ND(0.061)	ND((0.144)	ND(0.044)	ND(0.056)
6-MCV	11.1	6.2	ND (7.2)	ND (11.6)	6-MCV	1.359	1.274	ND(1.06)	ND(1.65)
<i>PAHs (ng/g)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>	<i>PAHs (ng/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
Naphthalene	5.8	11.2	8.1	7.2	Naphthalene	0.710	2.302	1.188	1.025
Acenaphthene	1.9	0.5	ND(1.0)	0.8	Acenaphthene	0.233	0.109	ND(0.147)	0.114
Fluorene	2.7	3.3	3.5	3.5	Fluorene	0.330	0.678	0.513	0.498
Phenanthrene	7.6	11.0	14.0	11.5	Phenanthrene	0.930	2.261	2.054	1.638
Fluoranthene	5.2	5.3	4.7	3.3	Fluoranthene	0.636	1.089	0.689	0.470
Pyrene	6.0	5.3	4.9	4.3	Pyrene	0.731	1.089	0.711	0.605
Benz(a)anthracene	2.3	1.8	2.8	1.2	Benz(a)anthracene	0.282	0.370	0.411	0.171
Chrysene	4.1	5.0	5.2	4.2	Chrysene	0.502	1.028	0.763	0.598
Benzofluoranthenes	4.3	4.8	6.4	4.9	Benzofluoranthenes	0.526	0.986	0.939	0.698
Perylene	27.8	40.0	55.5	57.0	Perylene	3.403	8.220	8.142	8.117
Benzo(ghi)perylene	3.2	3.2	3.2	3.0	Benzo(ghi)perylene	0.392	0.658	0.469	0.427

Note: all results presented are a mean of field splits and samples - one half the detection limit

was used when only one of the samples was below the detection limit.

ND denotes below the indicated detection limit when both field splits and samples were below detection.

NQ denotes not quantifiable.



particle size categories are defined as follows: sand = 2.0 - 0.062 mm, silt = 0.004 - 0.062 mm, clay = <0.004 mm.

Figure 3 Fraser River Flow and Particle Size Distribution of Suspended Sediments (Marguerite - 1993)

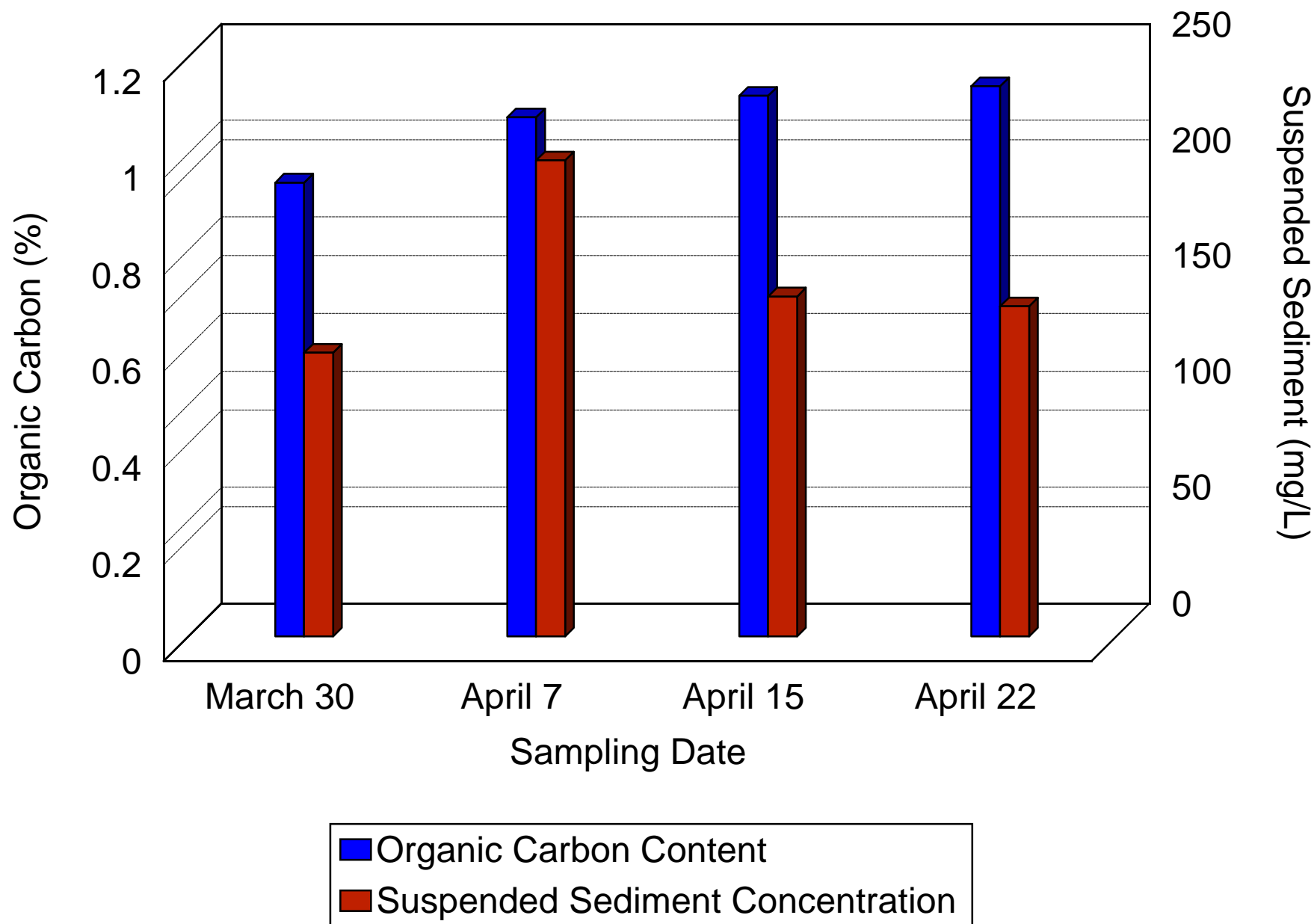


Figure 4 Suspended Sediment Concentration and Organic Carbon Content of Suspended Sediment in the Fraser River (Marguerite - 1993)

5.3.2 Dioxins and Furans

Dioxins

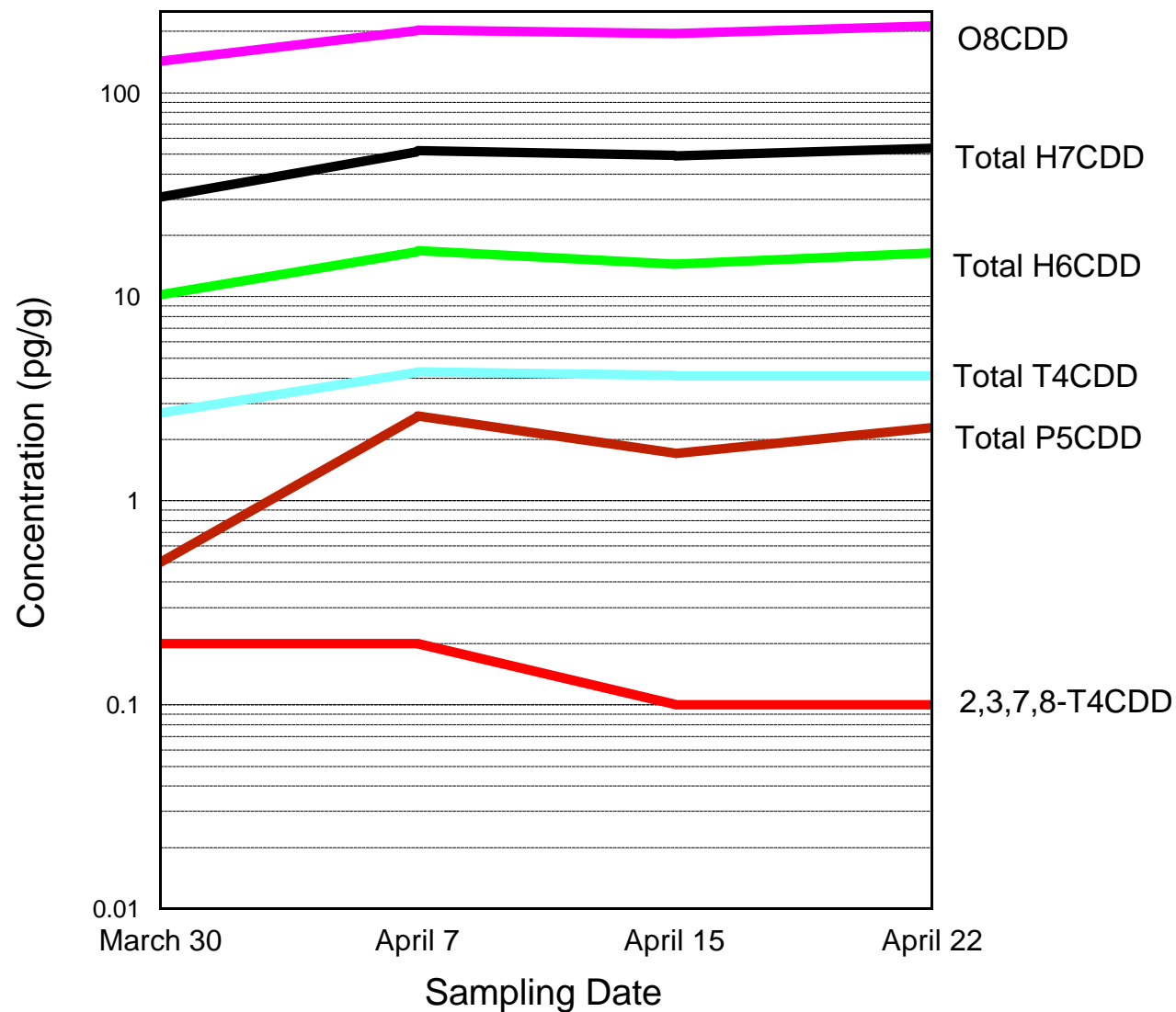
Figure 5 shows the concentration of dioxins measured during the onset of freshet. The highest concentration of dioxins was measured on April 7. Concentration peaks on this date were observed for total T4CDD, total P5CDD, total H6CDD, total H7CDD and O8CDD. Although total T4CDD concentration ranged from 2.7 to 4.3 ng/g, 2,3,7,8-T4CDD levels did not exceed 0.2 ng/g and remained relatively constant throughout the sampling period. Furthermore, the higher chlorine substituted dioxin congeners were found to have higher concentrations in the suspended sediments than the lesser chlorine substituted congeners. Overall, O8CDD had the highest concentration of all dioxins measured at 215 pg/g.

Furans

Refer to Table IV and Figure 6 for furan concentrations in suspended sediments. Generally, furan concentrations were lower than dioxin concentrations with the exception of 2,3,7,8-T4CDF which had a higher concentration than 2,3,7,8-T4CDD. The former ranged between 0.3-0.7 pg/g, whereas the latter ranged between 0.1-0.2 pg/g. Both 2,3,7,8-T4CDF and total T4CDF were highest in concentration at the onset of freshet and declined thereafter, whereas total H7CDF and O8CDF peaked on April 7. No increase in concentration was observed for total H6CDF, and total P5CDF levels were below detection. As was the case for dioxin concentrations, the higher chlorine substituted furans, total H7CDF and O8CDF, had the highest overall concentrations in the suspended sediments measured.

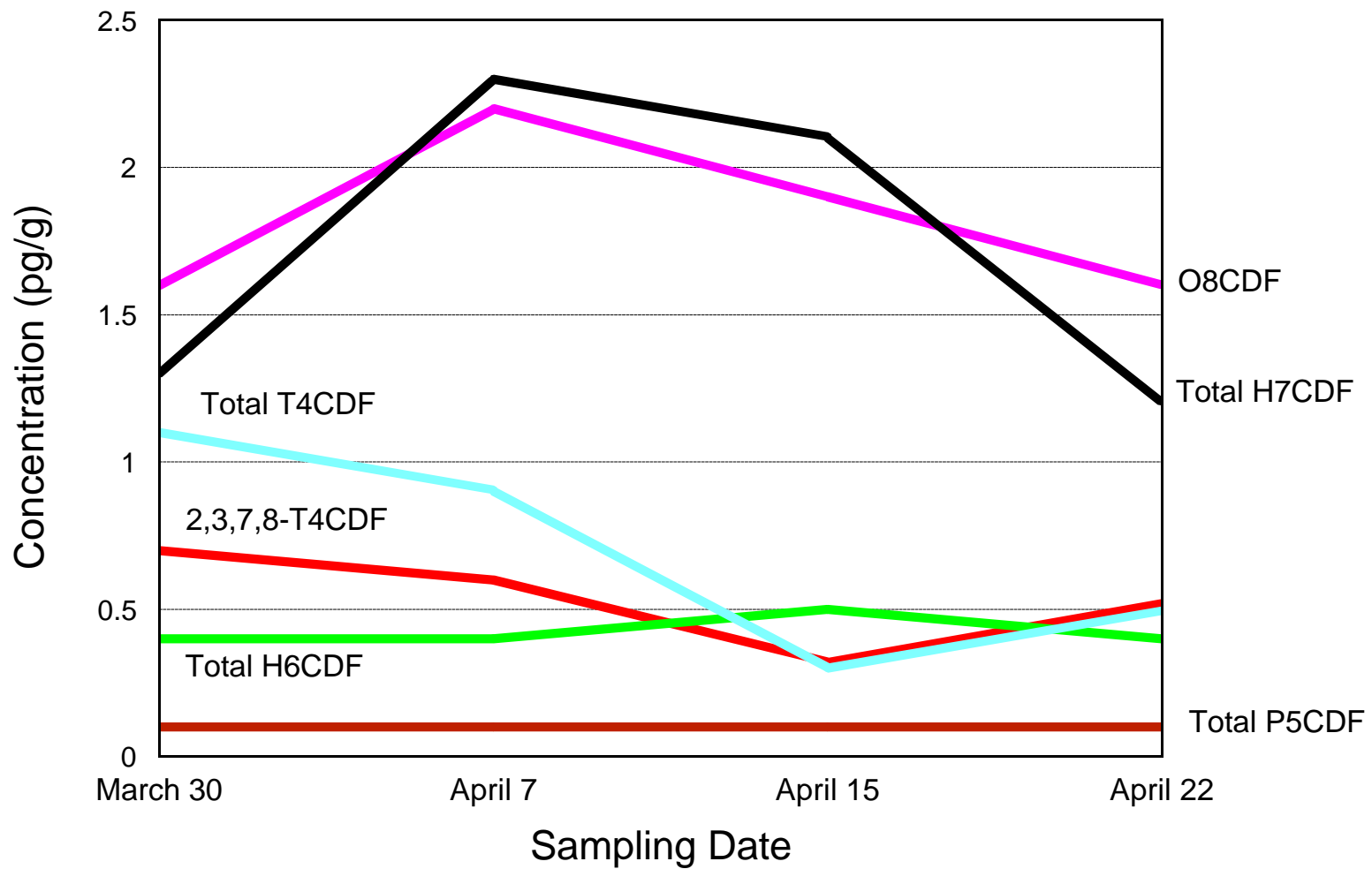
Loadings

Loadings of 2,3,7,8-T4CDD and 2,3,7,8-T4CDF were estimated for each of the four sampling dates by using contaminant concentrations in suspended sediments and flow for each individual sampling date at Marguerite. Based on supporting data (see section 5.5.1), the assumption was made that these contaminants partition primarily in the suspended sediment fraction versus the water fraction. These loadings were compared with April 1993 average combined loadings for these contaminants from the Canfor, Northwood and Cariboo mills (Table V and Figure 7). (Although a comparison with daily mill loadings would have been ideal, this was not possible due to the lack of availability of daily contaminant measures from the mills). Results show that 2,3,7,8-T4CDD loadings calculated from the Marguerite data were as much as four times higher during the sampling period than the



Results are presented as the mean of field splits and sample and one half the detection limit was used for non-detect samples.

Figure 5 Dioxin Concentration in Suspended Sediments Collected from the Fraser River (Marguerite - 1993)



Results are presented as the mean of field splits and sample and one half the detection limit was used for measurements below the detection limit.

Figure 6 Furan Concentration in Suspended Sediments Collected from the Fraser River (Marguerite - 1993)

Table V

Concentrations and Loadings of 2,3,7,8-T4CDD and 2,3,7,8-T4CDF in Suspended Sediments at Marguerite, and Combined Mill Effluent Loadings from the Canfor, Northwood and Cariboo Pulp and Paper Mills

Sampling Date	Flow (m3/s)	2,3,7,8-T4CDD in susp. sed. (pg/L)	2,3,7,8-T4CDF in susp. sed (pg/L)	2,3,7,8-T4CDD loading at Marguerite (mg/day)	2,3,7,8-T4CDF loading at Marguerite (mg/day)	2,3,7,8-T4CDD *Combined mill loading (mg/day)	2,3,7,8-T4CDF *Combined mill loading (mg/day)
March 30	520	0.024	0.086	1.078	3.864	0.9	3.9
April 7	1050	0.041	0.113	3.720	10.251	0.9	3.9
April 15	1240	0.015	0.044	1.607	4.714	0.9	3.9
April 22	1440	0.014	0.064	1.742	7.963	0.9	3.9

** Combined mill loadings are reported as averages for the month of April 1993
(based on mill submitted data courtesy of Environmental Protection, Environment Canada)*

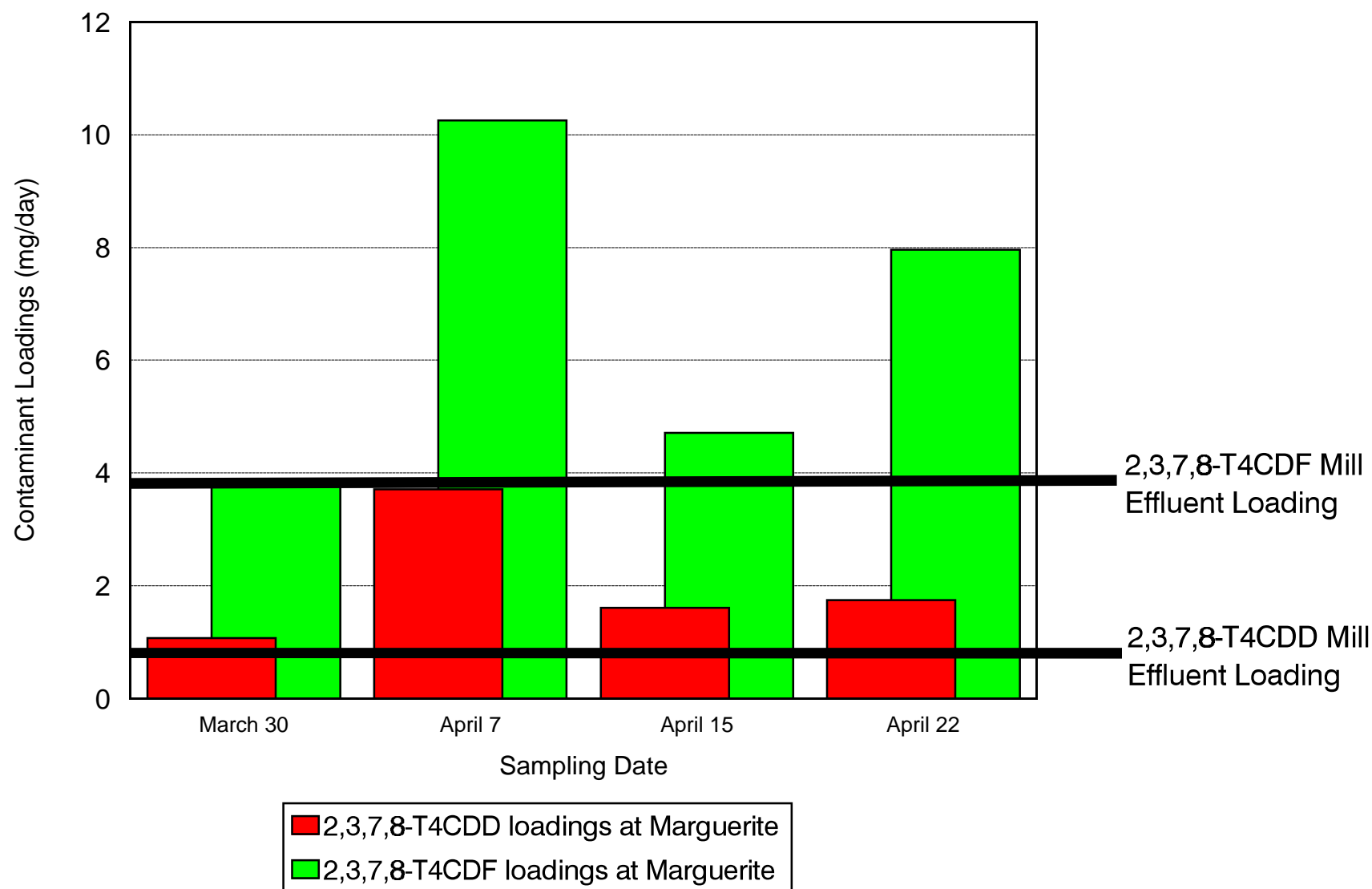


Figure 7 Estimated Loadings for 2,3,7,8-T4CDD and 2,3,7,8-T4CDF in Suspended Sediment at Marguerite and Mean Combined Loadings for Effluents from Canfor, Northwood and Cariboo Pulp and Paper Mills for the Month of April 1993

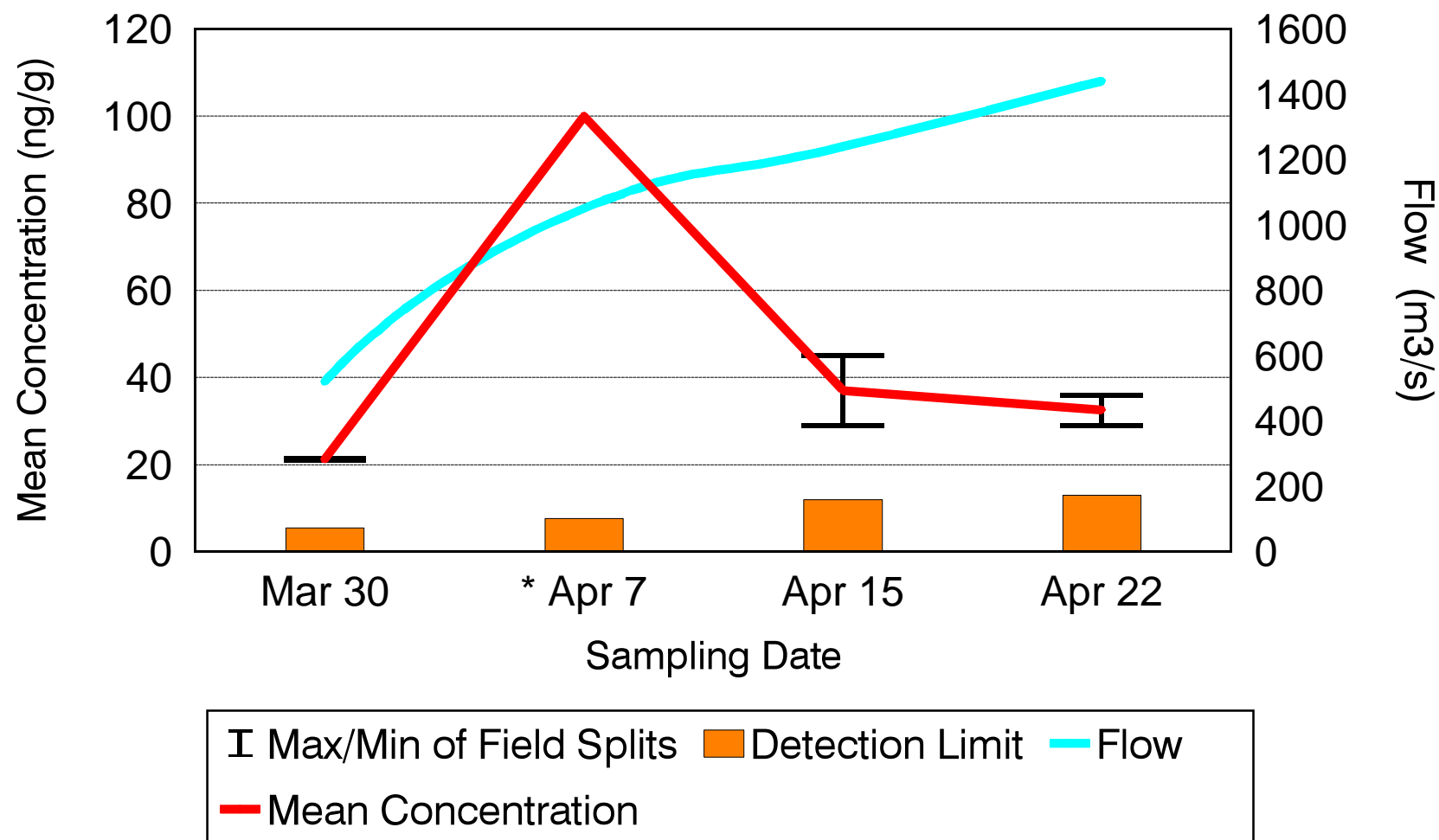
average combined loadings from the three mills. Furthermore, the peak loading for 2,3,7,8-T4CDD at Marguerite occurred on April 7 coinciding with the peak in suspended sediment concentration (Figure 4). Similarly, the 2,3,7,8-T4CDF loadings calculated from the Marguerite data were higher than the combined loadings from the pulp mills for each of the dates sampled, with the exception of March 30 when the Marguerite loading was slightly lower than the average combined mill loading. As was the case for 2,3,7,8-T4CDD, the peak loading of 2,3,7,8-T4CDF at Marguerite also occurred on April 7. In considering the difference between the loading levels in suspended sediments and mills' effluents, it must be recognized that the loading measured from the mills represent an average for the month which would mask daily fluctuations.

5.3.3 Chlorophenolics

Refer to Table IV for the concentrations of chlorophenolics measured in suspended sediments at Marguerite. Two chlorophenolics, 4,5-DCG and 4,5-DCC peaked in concentration on April 7. Figure 8 shows the change in concentration of 4,5-DCC during the freshet period. The 100 ng/g April 7 peak detected for this contaminant was the highest for all chlorophenolics measured. A single reading was detected for 3,5-DCC on April 15, as the rest of the dates showed concentrations below detection limits. Two chlorophenolics, 6-MCV and 3,4,5-TCG, were detected in the suspended sediment but did not show a peak. Levels of 3,4,5-TCC progressively decreased with the rising hydrograph, whereas 3,4,5,6-TeCC was not detected until April 15. All other chlorophenolics were below detection limits.

5.3.4 Polycyclic Aromatic Hydrocarbons

Refer to Table IV for the results of PAHs detected during the onset of freshet. A number of PAHs showed small peaks in concentration on either April 7 or 15. Figure 9 shows a graph of these PAH concentrations during the freshet sampling period. As the figure indicates, phenanthrene, benz(a)anthracene, and benzo(a)fluoranthene peaked on April 15, whereas naphthalene peaked on April 7. In contrast, acenaphthene, fluoranthene and pyrene concentrations were highest on March 30 and then decreased with the increasing hydrograph. Two PAHs, fluorene and perylene, increased with the rising hydrograph, whereas chrysene and benzo(ghi)perylene levels remained relatively constant.



* note: only one sample was available on April 7.

Figure 8 4,5-DCC Concentration in Suspended Sediments Collected from the Fraser River (Marguerite - 1993)

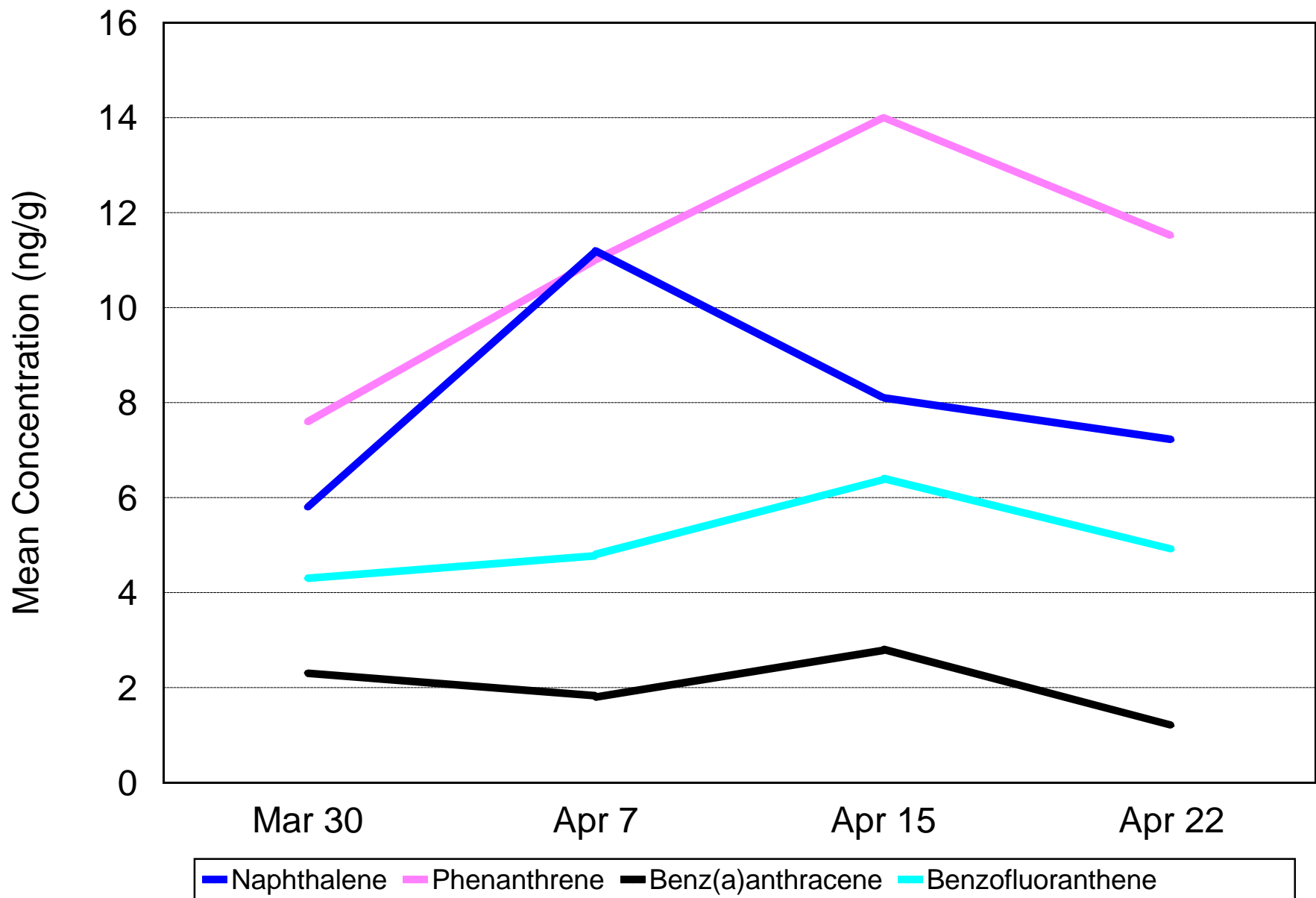


Figure 9 Naphthalene, Phenanthrene, Benz(a)anthracene and Benzo(a)fluoranthene Concentration in Suspended Sediments Collected from the Fraser River (Marguerite - 1993)

5.4 Whole Water Results

Whole water is defined as river water containing suspended sediments whereas clarified water as whole water minus the suspended sediments. Table VI presents the results of organic contaminants detected in whole water samples. Refer to Appendix II for the results of all trace organic analyses on whole water samples.

5.4.1 Chlorophenolics

The majority of chlorophenolics analysed were below detection limits, with the exception of those presented in Table VI. Levels of 4,5-DCC, 3,4,5-TCG, 4,5-DCG and 2,4,6-TCP were highest at the onset of freshet and declined with the increase in flow. Figure 10 shows the concentration profile of 4,5-DCC throughout the freshet sampling period. This contaminant had the highest overall concentration of all chlorophenols measured (45 ng/L) in whole water. The only contaminant which showed a slight concentration peak was 3,4,5-TCC, whose levels peaked on April 15. High detection limits for the rest of the chlorophenolics in Table IV prevented any further conclusions from being drawn. A comparison of chlorophenolic concentrations in whole water versus suspended sediments (Table VII) reveals that all of the chlorophenolics measured were found in higher concentrations in the water fraction of the whole water samples.

5.4.2 Polycyclic Aromatic Hydrocarbons

Refer to Table VI for the concentration values for PAHs in whole water samples. A comparison of these values to laboratory water blanks (Appendix III, Table 6) reveals that none of the PAHs detected in the whole water samples had values exceeding those of the laboratory water blanks. Due to the ubiquitous nature of these compounds, it was assumed that the values measured in the whole water samples represented background levels, and consequently there was no further investigation of the data.

Table VI

Concentrations of Chlorophenolics, PAHs, Fatty Acids and Resin Acids in Whole Water Samples Collected from the Fraser River (Marguerite - 1993)

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<i>Chlorophenolics (ng/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
4,5-DCG	1.3	ND(1.6)	ND(2.0)	1.1
4,6-DCG	1.7	1.6	ND (1.8)	1.4
3,4,5-TCG	5.6	4.7	5.5	4.0
3,5-DCC	7.3	ND (15.5)	4.4	ND (3.8)
4,5-DCC	45.0	45.5	19.0	13.3
3,4,5-TCC	10.3	3.8	13.0	8.0
3,4,5,6-TeCC	3.5	ND(12)	ND(4.2)	4.0
2,4,6-TCP	7.7	4.9	3.8	1.4
6-MCV	ND(5.0)	ND(4.6)	ND(6.6)	ND(4.9)
<i>PAHs (ng/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
Naphthalene	13.0	14.5	14.0	13.0
Fluorene	4.8	5.0	5.2	3.3
Phenanthrene	7.0	9.3	7.2	5.6
Fluoranthene	3.9	5.2	3.9	3.7
Pyrene	4.3	9.3	5.2	2.0
Benz(a)anthracene	1.8	1.0	2.1	2.1
Chrysene	2.6	1.7	3.2	1.9
Benzofluranthene	2.3	ND(3.8)	ND(2.4)	ND(2.6)
Perylene	3.2	2.3	1.7	ND(2.4)
Benzo(ghi)perylene	2.1	2.0	4.1	2.9
<i>Fatty Acids (ng/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
Lauric	91.3	155.0	ND (150)	ND (790)
Myristic	537.5	375.0	190.0	ND (730)
Palmitic	875.0	770.0	975.0	ND (2400)
Linoleic/Oleic	117.0	445.0	ND (347)	ND (2150)
Stearic	640.0	580.0	675.0	ND (1450)
Arachidic	23.5	27.5	25.0	ND (34)
Behenic	197.5	210.0	132.5	83.0
Lignoceric	515.0	460.0	270.0	110.0
<i>Resin Acids (ng/L)</i>	<i>March 30</i>	<i>April 7</i>	<i>April 15</i>	<i>April 22</i>
Pimaric	36.8	49.5	28.5	28.5
Sandaracopimaric	7.2	9.9	ND (5.7)	ND (4.9)
Isopimaric	49.5	49.0	21.0	28.5
Palustric	77.8	77.0	125.0	120.0
Dehydroabietic	150.0	155.0	59.0	77.0
Abietic	79.3	94.0	ND (51.3)	ND (51)
12,14 Chlorodehydrabietic	35.8	15.0	ND (8.1)	ND (7.5)
12,14 Dichlorodehydrabietic	3.6	ND (0.9)	ND (9.5)	ND (9.0)

Note: all results presented are a mean of field splits and samples - one half the detection limit was used when only one of the samples was below the detection limit.

ND denotes below the indicated detection limit when both field splits and samples were below detection.

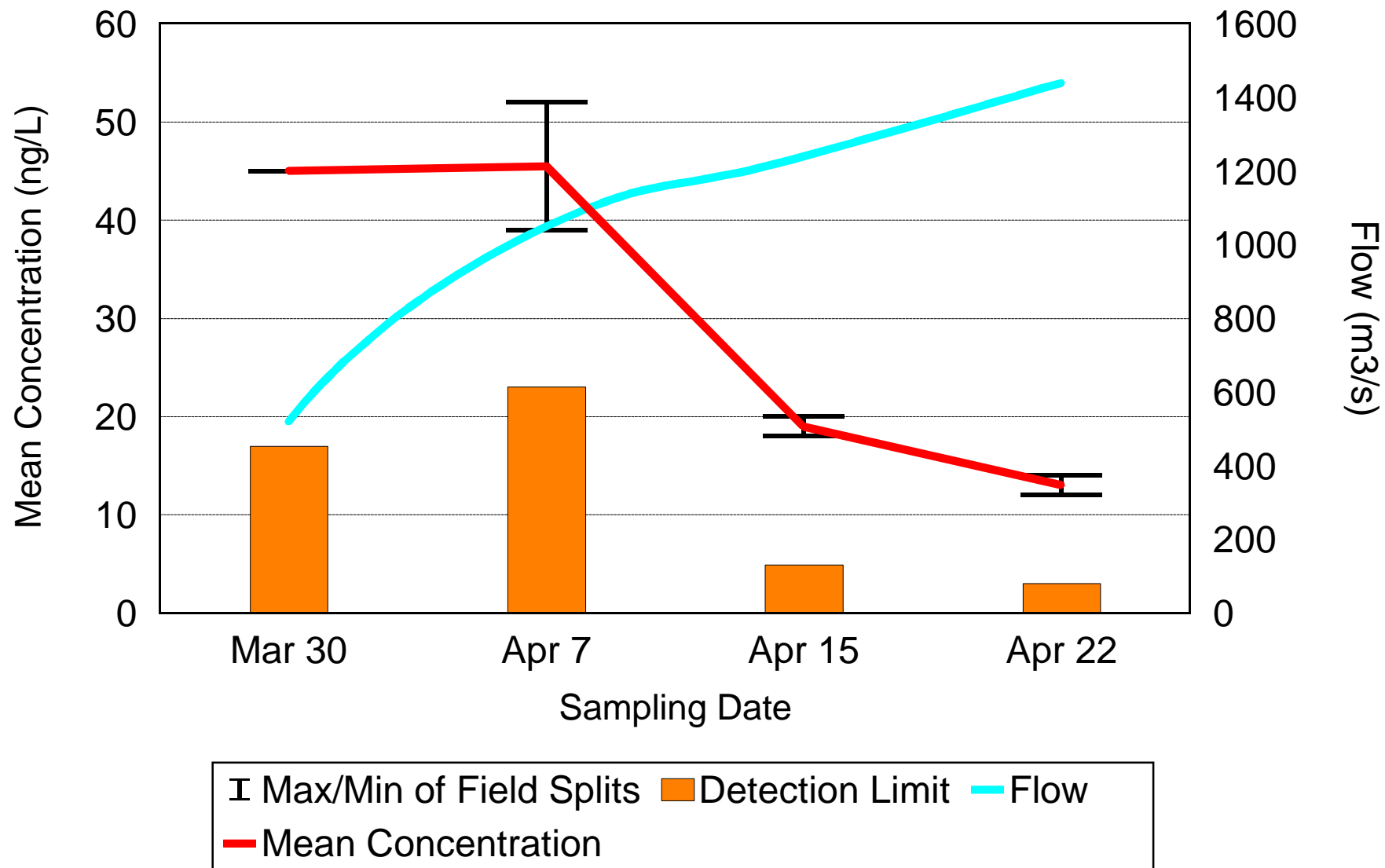


Figure 10 4,5-DCC Concentration in Fraser River Whole Water (Marguerite - 1993)

Table VII**Chlorophenolic Concentrations in Whole Water Versus the Suspended Sediment Fraction - Fraser River (Marguerite - 1993)**

<i>Chlorophenolics (ng/L)</i>	<i>March 30</i>			<i>April 7</i>			<i>April 15</i>			<i>April 22</i>		
	Whole Water	Susp Sed.	% in Susp Sed.	Whole Water	Susp Sed.	% in Susp Sed.	Whole Water	Susp Sed.	% in Susp Sed.	Whole Water	Susp Sed.	% in Susp Sed.
4,5-DCG	1.3	0.318	24.5	ND(1.6)	0.637	39.8	ND(2.0)	0.103	5.1	1.1	0.157	14.2
4,6-DCG	1.7	N/A	N/A	1.8	N/A	N/A	ND (1.8)	N/A	N/A	1.4	N/A	N/A
3,4,5-TCG	5.6	0.318	5.67	4.7	0.575	12.2	5.5	0.396	7.2	4.0	0.313	7.82
3,5-DCC	7.3	ND(0.490)	0.67	ND (15.5)	ND(1.17)	N/A	4.4	1.350	30.7	ND (3.8)	ND(1.38)	N/A
4,5-DCC	45.0	2.607	5.79	45.5	20.550	45.2	19.0	5.428	28.6	13.3	5.340	40.2
3,4,5-TCC	10.3	0.636	6.18	3.8	0.863	22.7	13.0	0.381	2.9	8.0	0.313	3.91
3,4,5,6-TeCC	3.5	NQ	N/A	ND(12)	ND(2.26)	40.4	ND(4.2)	0.734	17.4	4.0	0.883	22.1
2,4,6-TCP	7.7	ND(0.061)	0.79	4.9	ND(0.144)	2.9	3.8	ND(0.044))	1.2	1.4	ND(0.056)	4
6-MCV	ND(5.0)	1.359	27.2	ND(4.6)	1.274	27.7	ND(6.6)	ND(1.06)	N/A	ND(4.9)	ND(1.65)	N/A

ND denotes below the indicated detection limit when both field splits and samples were below detection; the detection limit was used in the calculation when the concentration of one of the samples was below detection

NQ denotes Not Quantifiable

N/A denotes Not Available

5.4.3 Fatty Acids

The concentrations of behenic acid (Figure 11), lauric acid, linoleic/oleic acids and arachidic acid all peaked on April 7, whereas concentrations of stearic and palmitic acids peaked on April 15. Furthermore, concentrations of myristic and lignoceric acids were highest on March 30 and progressively decreased thereafter. Palmitic acid had the highest overall concentration (975 ng/L on April 15) of all fatty acids measured. Capric and linolenic acid levels were below detection.

5.4.4 Resin Acids

Generally, resin acids showed a concentration peak on either April 7 or 15. These included pimaric, sandaracopimaric, palustric, dehydroabietic, and abietic acids. Figure 12 presents the concentration of pimaric acid throughout the freshet period, showing the typical concentration peak. In contrast, concentrations of isopimaric and 12,14-chlorodehydroabietic acids were highest on March 30 and progressively decreased thereafter. The highest overall concentration was measured for dehydroabietic acid (155 ng/L on April 7). Dehydroisopimaric and neoabietic acid levels were below detection.

5.5 Solid Phase Extracted Clarified Water Results

5.5.1 Dioxins and Furans

In general, dioxin concentrations were below detection limits with the exception of total H6CDD. A concentration of 4.9 pg/L was detected for this contaminant on March 30, however upon further investigation a contaminated field surrogate was found to be the source of the high H6CDD levels. Trace levels of O8CDD were also detected in the range of 0.3-0.4 pg/L. No furans were detected in the extracted water, as all values were below detection limits or not quantifiable. A comparison of dioxin and furan levels in solid phase extracted water with levels in suspended sediments (Table VIII) reveals that dioxin and furans were partitioning primarily in the suspended sediment fraction.

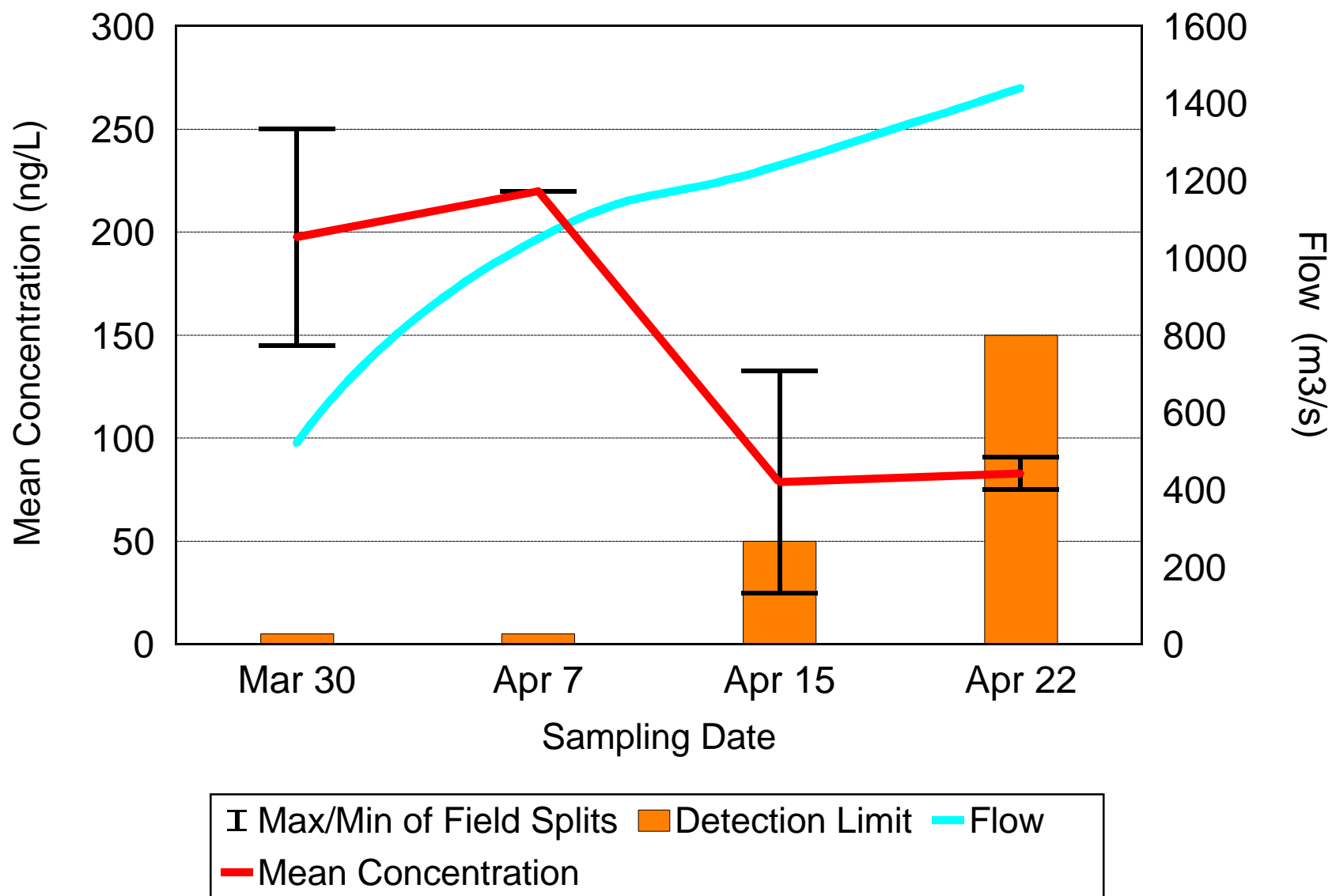


Figure 11 Behenic Acid Concentration in Fraser River Whole Water (Marguerite - 1993)

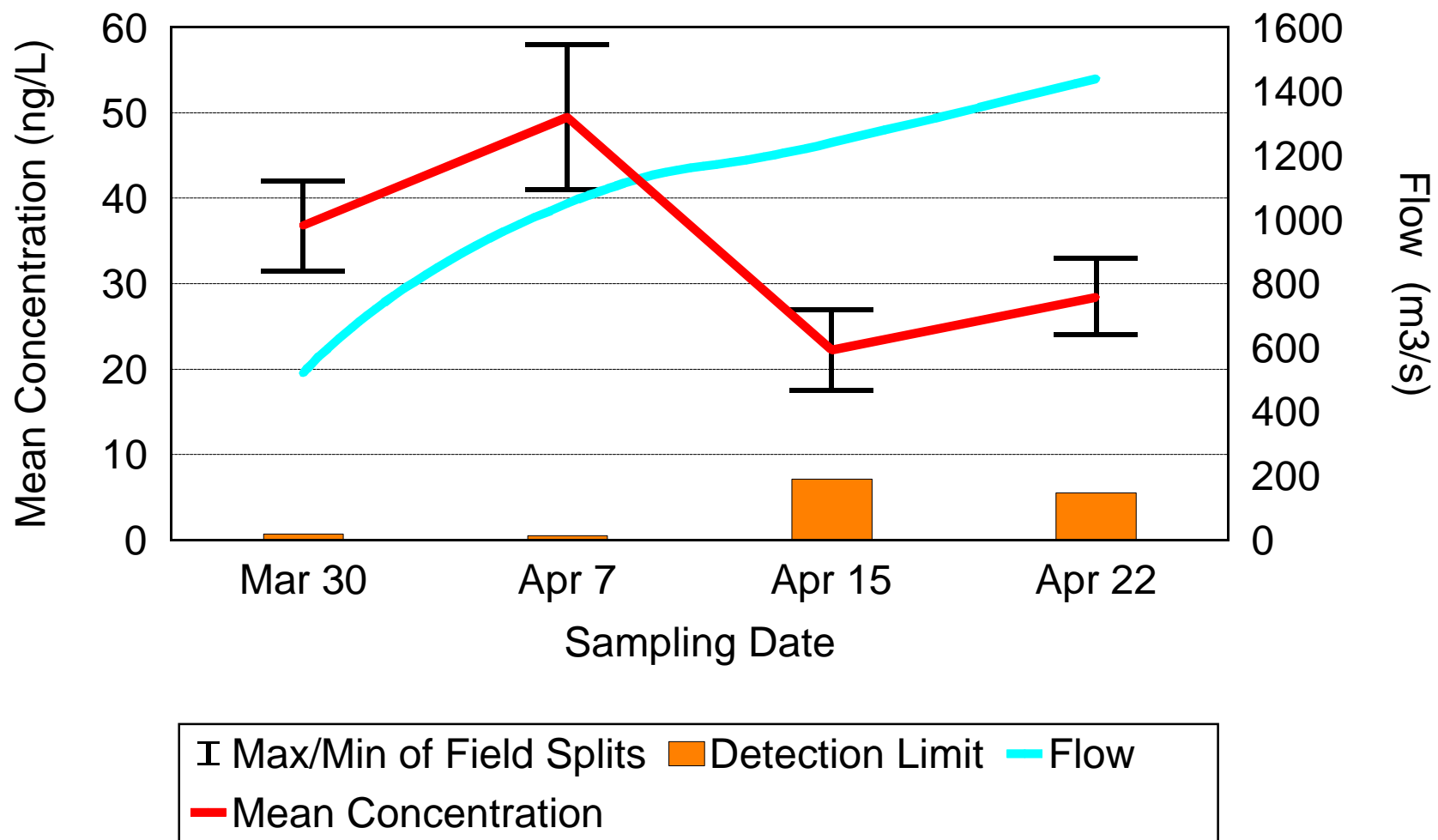


Figure 12 Pimaric Acid Concentration in Fraser River Whole Water (Marguerite - 1993)

Table VIII

Dioxin/Furan and PAH Concentrations in Suspended Sediment Samples Versus Solid Phase Extracted Clarified Water Samples*

Dioxins (pg/L)	March 30		April 7		April 15		April 22	
	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water
2,3,7,8-T4CDD	0.024	NDR(0.1)	0.041	ND(0.07)	0.015	ND(0.7)	0.014	ND(0.05)
Total T4CDD	0.330	ND(0.08)	0.884	ND(0.07)	0.601	ND(0.7)	0.584	0.09
Total P5CDD	0.061	ND(0.1)	0.534	ND(0.2)	0.249	ND(0.2)	0.328	ND(0.1)
Total H6CDD	1.248	4.9**	3.452	ND(0.2)	2.127	ND(0.09)	2.350	ND(0.06)
Total H7CDD	3.770	ND(0.2)	10.686	ND(0.1)	7.188	ND(0.1)	7.690	ND(0.1)
Total O8CDD	17.442	ND(0.6)	41.614	0.4	28.607	0.4	30.616	0.3
Furans (pg/L)	March 30		April 7		April 15		April 22	
	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water
2,3,7,8-T4CDF	0.086	ND(0.05)	0.113	ND(0.06)	0.044	ND(0.05)	0.064	ND(0.04)
Total T4CDF	0.135	ND(0.05)	0.051	ND(0.06)	0.059	ND(0.05)	0.071	ND(0.04)
Total P5CDF	ND(0.012)	ND(0.1)	ND(0.021)	ND(0.1)	ND(0.161)	ND(0.08)	ND(0.014)	ND(0.06)
Total H6CDF	0.049	ND(0.08)	0.082	ND(0.1)	0.073	ND(0.1)	0.057	ND(0.07)
Total H7CDF	0.159	ND(0.2)	0.473	ND(0.2)	0.308	ND(0.1)	0.171	ND(0.1)
Total O8CDF	0.196	ND(0.6)	0.452	ND(0.2)	0.279	ND(0.2)	0.228	ND(0.3)
PAHs (ng/L)	March 30		April 7		April 15		April 22	
	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water	Susp. Sed.	Clar. Water
Acenaphthene	0.233	0.300	0.109	0.300	ND(0.147)	0.500	0.114	1.100
Fluorene	0.330	0.300	0.678	0.300	0.513	0.500	0.498	1.100
Phenanthrene	0.930	NDR(0.6)	2.261	NDR(0.8)	2.054	1.100	1.638	1.200
Fluoranthene	0.636	NDR(0.2)	1.089	0.400	0.689	NDR(0.4)	0.470	0.400
Pyrene	0.731	NDR(0.2)	1.089	NDR(0.3)	0.711	NDR(0.2)	0.605	NDR(0.3)
Benz(a)anthracene	0.282	ND(0.1)	0.370	ND(0.1)	0.411	ND(0.1)	0.171	ND(0.1)
Chrysene	0.502	ND(0.1)	1.028	ND(0.1)	0.763	ND(0.1)	0.598	ND(0.1)
Benzofluoranthenes	0.526	ND(0.1)	0.986	ND(0.1)	0.939	ND(0.2)	0.698	ND(0.1)
Perylene	3.403	ND(0.1)	8.220	ND(0.1)	8.142	ND(0.2)	8.117	ND(0.1)
Benzo(ghi)perylene	0.392	ND(0.2)	0.658	ND(0.1)	0.469	ND(0.3)	0.427	ND(0.2)

* Solid phase extracted samples contain centrifuged river water (suspended sediments have been removed)

** Contaminated field surrogate

ND denotes below the indicated detection limit when both field splits and samples were below detection.

NDR denotes peak detected but did not meet quantification criteria

5.5.2 Polycyclic Aromatic Hydrocarbons

The majority of PAHs were either below detection limits or not quantifiable with the exception of naphthalene, fluoranthene, acenaphthene and fluorene. Figure 13 presents the concentration profiles of fluoranthene, acenaphthene and fluorene during the sampling period. Whereas fluoranthene levels remained relatively constant, acenaphthene and fluorene progressively increased in concentration during the course of the freshet period reaching concentrations of 1.1 ng/L and 0.8 ng/L, respectively. Naphthalene had the highest concentrations of all PAHs analysed (10-24 ng/L), but this was likely due to naphthalene contamination as this compound is known to form as a byproduct of polymer breakdown in the resin column (Georgina Brooks, AXYS Analytical, personal communication). A comparison of PAH concentrations in suspended sediment versus clarified solid phase extracted river water (Table VIII) reveals that with the exception of acenaphthene, all measured PAHs were found in higher concentrations in the suspended sediment fraction.

6.0 DISCUSSION

6.1 Suspended Sediment Properties and Flow

6.1.1 Flow and Suspended Sediment Concentration

The Fraser River upstream of Marguerite has received effluent from pulp and/or paper mills since 1966. These effluents typically contain high levels of suspended solids composed primarily of biosolids (Derksen and Mitchell, in preparation). The total suspended solids, 2,3,7,8-TCDD and 2,3,7,8-TCDF loading measured in the final effluent of the four upstream mills for the month of April 1993 are presented in Table IX (mill submitted data, courtesy of Environmental Protection, Environment Canada). Total suspended solids ranged from a high of 10,880 kg/day for Canadian Forest Products Ltd. to a low of 3,745 kg/day for Cariboo Pulp and Paper Company. Northwood Pulp and Timber had the highest 2,3,7,8-TCDD loading, whereas Canadian Forest Products had the highest 2,3,7,8-TCDF loading. Furthermore, 2,3,7,8-TCDF loadings were higher than 2,3,7,8-TCDD loadings in all effluents measured.

Figure 13

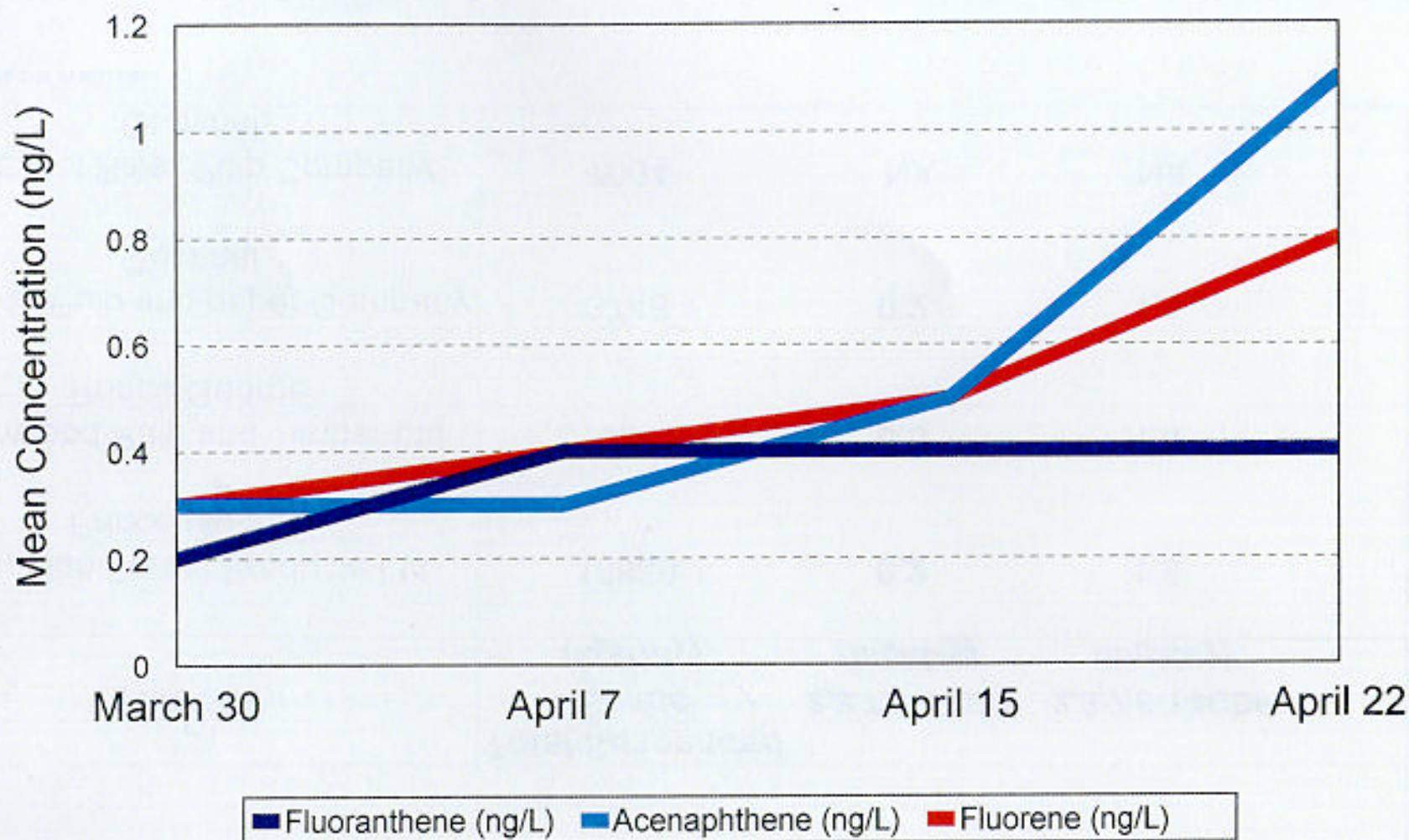


Figure 13 Fluoranthene, Acenaphthene and Fluorene Concentrations in Solid Phase Extracted Water Samples (Marguerite - 1993)

Table IX

Dioxin, Furan and Total Suspended Solids Loading in the Final Whole Effluent of the Prince George and Quesnel Pulp Mills Located on the Fraser River - April 1993

<i>Pulp Mill</i>	<i>Total Suspended Solids (kg/day)</i>	<i>2,3,7,8-TCDD (mg/day)</i>	<i>2,3,7,8-T4CDF (mg/day)</i>
Canadian Forest Products Ltd. Prince George	10880	0.2	1.8
Northwood Pulp and Timber Ltd. Prince George	10241	0.5	1.0
Cariboo Pulp and paper Company Quesnel	3745	0.2	1.1
Quesnel River Pulp Company Quesnel	7004	NA	NA

NA denotes not available.

Hydrophobic and semi-hydrophobic organic contaminants such as dioxins, furans and chlorophenolics have been measured in the suspended solids fraction of the final effluent from all upstream mills (Derksen and Mitchell, in preparation; Duncan, in preparation). These suspended biosolids are released into the Fraser River as part of the mills' final effluent and are thought to interact with ambient suspended sediment, flocculate and then deposit as bed sediment during the winter low flow period (Krishnappan *et al*, 1994).

At the onset of freshet, the flow increases sufficiently to resuspend the deposited bed sediments (Tassone, personal communication). The resuspended portion of sediment may be observed as a "peak" in the suspended sediment concentration. Figure 14 shows the mean daily flow and suspended sediment concentration (measured by depth integrated suspended sediment sampler) at Marguerite from 1971 to 1986 (Carson, 1988).

Prior to March 30, the Fraser River at Marguerite was ice covered with a mean monthly flow for January, February and March of 334 m³/s, 321 m³/s, and 360 m³/s, respectively (Water Survey of Canada, 1993). Both suspended sediment concentration, as measured by centrifuge, and flow rapidly increased from March 30 (no ice cover) to April 7 (Figure 15). A peak in suspended sediment concentration was observed on April 7.

6.1.2 Particle Size Distribution

Although suspended sediment concentrations changed over the freshet period, the silt fraction of the suspended sediment remained relatively constant (Figure 3). The apparent higher sand fraction in the first two weeks of freshet versus the last two weeks corresponded with the rapid increase in flow observed between March 30 and April 7. The increased flow may have resuspended the larger and heavier sand particles which had been deposited as bed sediment throughout the winter period (Tassone, personal communication).

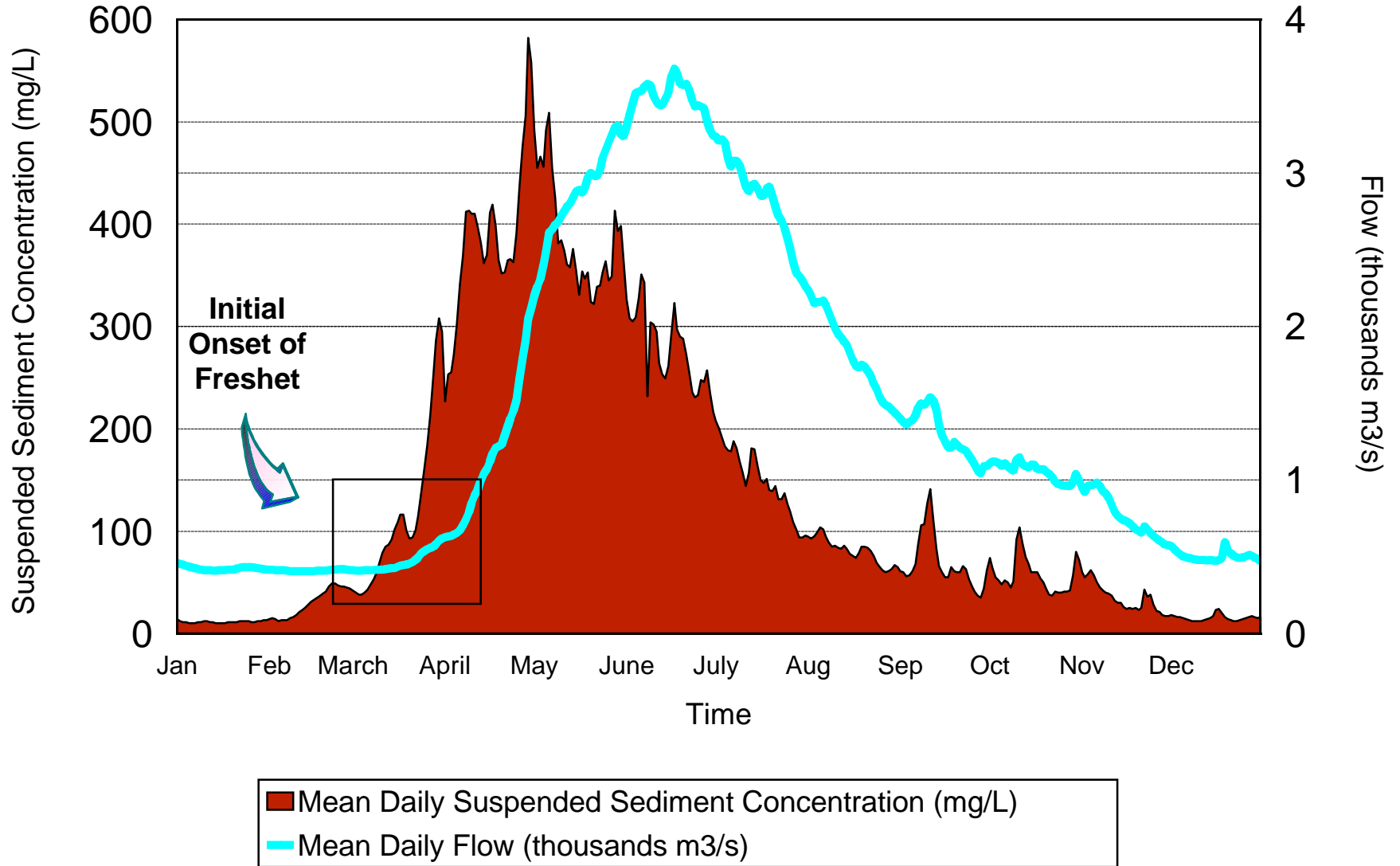


Figure 14 Fraser River Mean Daily Flow Rate and Suspended Sediment Concentration (Marguerite, 1971 - 1986)

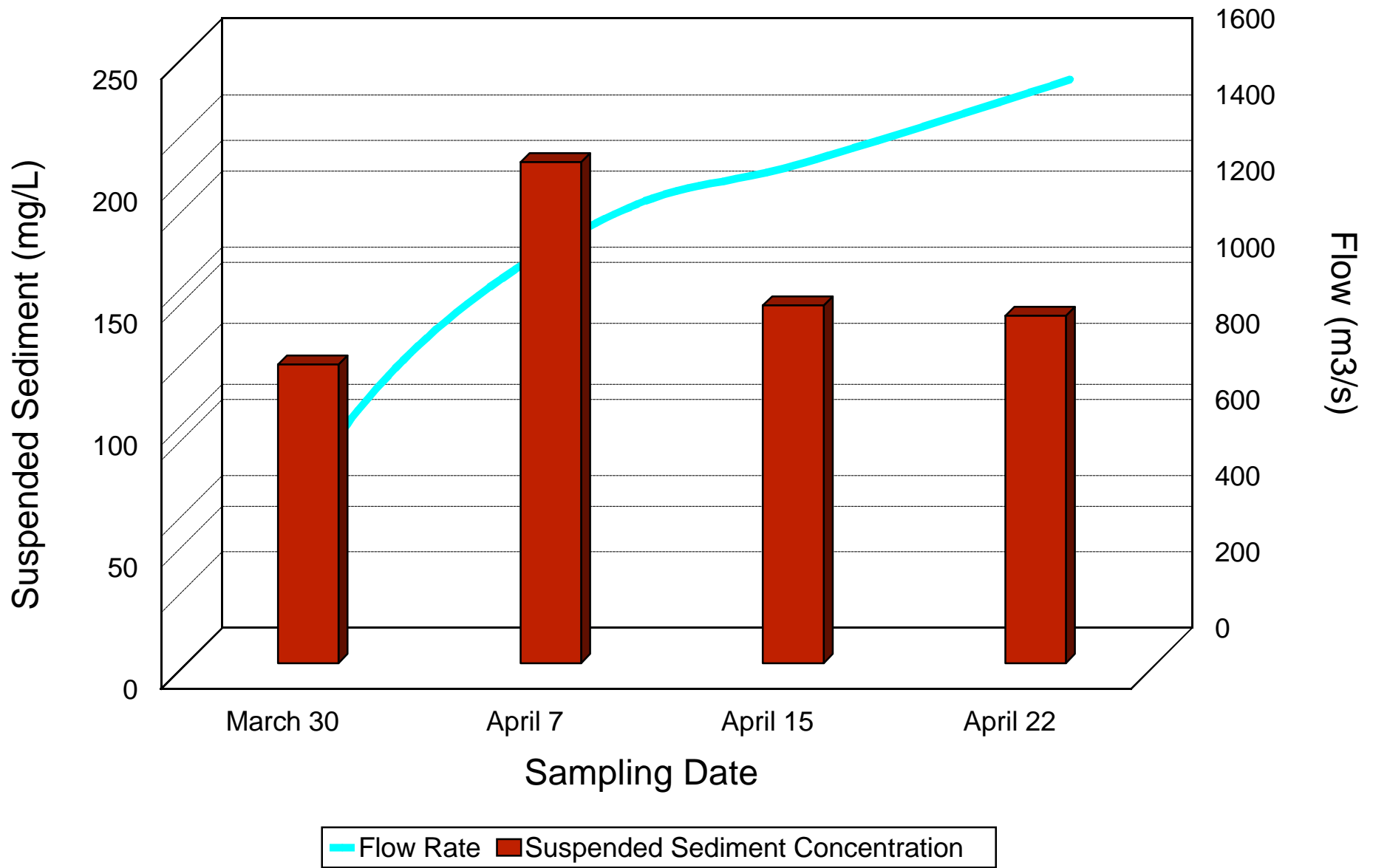


Figure 15 Suspended Sediment Concentration (Calculated from Centrifuge Data) and Mean Daily Flow (Marguerite - 1993)

6.1.3 Organic Matter Content

Particulate organic matter is derived from biotic material such as living and dead faunal material and detritus of both aquatic and terrestrial origin (Fletcher and McKay, 1993). Particulate organic carbon has been shown to be associated with fine sediment (silt and clay) rather than with coarse sediment (sand). This is attributed to a greater surface area and the availability of more sites for absorption on the former versus the latter (McLaren *et al.*, 1993). Clays and silts are thus expected to contain higher organic carbon levels and therefore more effectively bind hydrophobic and semi-hydrophobic contaminants (Karickhoff *et al.*, 1978).

In the current study, organic carbon content in suspended sediment increased with increasing flow, indicating that organic carbon content may be more closely associated with the clay fraction which appeared to similarly increase with flow. Since many of the contaminant peaks were associated with the period of highest suspended sediment concentration suggests that resuspension of previously deposited sediment, and not organic carbon or clay content of suspended sediment, was likely the most important factor in the observed contaminant peak during the study. Mah *et al.* (1989) also observed that concentrations of furans measured in bed sediment samples collected downstream of pulp and paper mills in the Fraser River were not significantly correlated with organic carbon content.

6.2 Contaminants in Suspended Sediment

6.2.1 Dioxins and Furans

Due to their hydrophobic nature, dioxins and furans (K_{ow} 6-7) have a high affinity for both particulate and dissolved organic carbon (Webster *et al.*, 1986; Servos *et al.*, 1989). Sediments which have a high organic carbon content and surface area (such as silts and clays) have been shown to be a sink for dioxins and furans (Czuczwa and Hites, 1984). Previous studies have shown that furans are detectable in bed sediment material (Mah *et al.*, 1989) and dioxins and furans are detectable in suspended sediments (Derksen and Mitchell, in preparation; Sekela *et al.*, in preparation) collected downstream of the five Fraser River mills.

Pulp and/or paper mills utilizing the chlorine bleached kraft process have been a source of the lesser chlorinated dioxin and furan congeners (e.g. tetra and penta) (Amendola, 1987), whereas Czuczwa and Hites (1986) found that combustion was the most common source of the more highly chlorinated congeners (e.g. hepta and octa). The fact that hepta and octa substituted dioxins and furans were found in the highest concentrations during the freshet period suggests that combustion may be a significant source of these contaminants to the Fraser River. Some possible sources of the highly chlorinated congeners measured at Marguerite may be from surface runoff originating from slash burning of clearcut logging areas and forest fires. Atmospheric transport may also play a significant role in the total load of these contaminants to the Fraser River basin, since previous studies have shown atmospheric loading as a source of hepta and octa dioxins/furans to sediments in the Great Lakes (Czuczwa and Hites, 1986). One such possible atmospheric source may originate from combustion of waste wood material in the beehive burners of saw mills upstream of Marguerite. Once in the atmosphere, these contaminants may enter the river through either wet or dry deposition.

The peak in concentration observed on April 7 for many of the dioxins and furans coincides with the measured peak in suspended sediment concentration. Since mill operations remained constant throughout the freshet period (Canadian Forest Products, Northwood Pulp and Paper, Cariboo Pulp and Paper, Quesnel River Pulp, personal communications), the likely source for the observed peak in dioxin and furan concentrations appears to be the result of resuspension of contaminated bed sediment material.

Following April 7, as flow continued to increase and as more natural sediment particles were added to the overall suspended sediment load, the "pulse" of contaminated resuspended bed material was carried beyond the Marguerite sampling site resulting in the observed decrease in dioxin and furan levels. Overall, the dioxins showed the largest percent change (up to 79.7%) in contaminant levels in the time between the onset of freshet (March 30) and April 22.

Although total T4CDD concentrations were higher than total T4CDF concentrations (Table IV), 2,3,7,8-T4CDD levels were considerably lower than 2,3,7,8-T4CDF levels during the sampling period. The latter observation supports data on loading from the mill effluents (Table IX) and findings of previous studies. Mah *et al.* (1988) did not detect any measurable levels of 2,3,7,8-T4CDD in bed sediments at sites downstream of Prince George or Quesnel. However, concentrations of up to 274 pg/g of 2,3,7,8-T4CDF were measured downstream of these sites. Nevertheless it should be noted that the detection limits in the Mah *et al.* study were an average of

200 times higher than those of our study. More recently suspended sediment samples taken by Derksen and Mitchell (in preparation) at Marguerite in October 1990 measured concentrations of 3.7 pg/g for 2,3,7,8-T4CDD and 6.4 pg/g for 2,3,7,8-T4CDF. Their detection limits were similar to those in our study (0.1-0.5 pg/g).

The relatively high loadings of 2,3,7,8-T4CDD and 2,3,7,8-T4CDF found at Marguerite on April 7 (Table V) during the peak in concentrations of these contaminants may be attributed to resuspension of bed sediment material deposited during the winter low flow period. This increase in loading of 2,3,7,8-T4CDD and 2,3,7,8-T4CDF during the freshet period may represent a significant period of transport of these contaminants from the upper reaches of the Fraser River to the lower reaches of the Fraser River.

6.2.2 Chlorophenolics

Chlorinated phenolics are released into the aquatic environment through industrial effluents from pulp and paper mills and wood treatment facilities and via leaching of agricultural products (Health and Welfare Canada, 1980). Chlorinated phenolics are also formed by chlorination of sewage treatment plant effluents and drinking water that contains phenols (U.S. EPA, 1979). Previous studies have shown that chlorophenolics are measurable in bottom sediments (Voss and Yunker, 1983) and in suspended sediments (Sekela *et al.*, in preparation; Duncan, in preparation) collected from the Fraser River at Marguerite.

The three main classes of chlorinated phenolic compounds are phenols, guaiacols and catechols. The environmental behaviour of these individual compounds is related to their physical and chemical properties. Volatility and water solubility decrease with increasing molecular weight, and sorption appears to play a significant role in the removal of some chlorinated phenols from the water column (CCREM, 1987). Chlorophenolic K_{ow} values vary between 0.88 to 5.0. Highly chlorinated chlorophenolics such as pentachlorophenol ($K_{ow} = 5.0$) tend to be more hydrophobic (Solomon *et al.*, 1993). In general, as the degree of chlorine substitution increases, the octanol/water partition coefficient (K_{ow}) of individual compounds also increases, indicating a greater affinity for the organic content of sediments (CCREM, 1987).

Partition coefficients (K_p) also increase with increasing hydrophobicity of a compound but represent

a more accurate measure of the potential of a compound to partition into the sediment versus the water phase. Therefore, although the K_{ow} of chloroguaiacols is higher than that of chlorocatechols, their K_p values are lower (Allard *et al.*, 1988). This is most likely attributed to the higher affinity of the hydroxy functional groups of catechols to the positively charged clay particles in the sediment versus the less polar methoxy functional group of guaiacols.

The highest concentration of chlorophenolics measured in suspended sediments was 100 ng/g of 4,5-DCC on April 7. Although all the chlorophenolics measured were found to partition primarily in the water phase, 4,5-DCC had the highest percentage of all chlorophenolics measured in suspended sediments (up to 45.2%). This could be due to its higher K_p value which makes it more likely to become associated with clay rich bottom sediments. Consequently, the observed increase in 4,5-DCC on April 7 may be partially attributed to chlorophenol contaminated sediments which were resuspended from bed sediment material during the onset of freshet. However, with the exception of 4,5-DCC, which had a 78.8% increase in concentration over the freshet period between March 30 to April 7, the change in concentration peaks of chlorophenolics was not as great as that for dioxins and furans. This is likely the result of the lower hydrophobicity of chlorophenolics in comparison to that of dioxins and furans.

6.2.3 Polycyclic Aromatic Hydrocarbons

PAHs are formed by the incomplete combustion of organic material, diagenesis (chemical and physical changes occurring during and after their deposition) and biosynthesis (CCREM, 1987). They are hydrophobic in nature ($K_{ow} = 3.37 - 7.66$) and their aqueous solubilities are low (0.3 - 3,420 $\mu\text{g/L}$), with the exception of naphthalene (12,500 - 34,000 $\mu\text{g/L}$) (Neff, 1979; CCREM, 1987). As a result, most PAHs are likely to adsorb strongly to the organic carbon fraction of suspended and bed sediments (CCREM, 1987).

Perylene was found in the highest concentration (57 ng/g) in the suspended sediments. The fact that perylene levels increased proportionately with flow may be due to its known association with bottom sediments and possible resuspension during periods of high flow. A study conducted by Broman and Naf (submitted) found perylene to occur in low concentrations in the atmosphere but higher concentrations in surface sediments. Perylene seems to form anaerobically during surface sediment decomposition (Broman and Naf, submitted; Wakeham *et al.*, 1980) although the exact mechanism

is unknown. Based on this information, Broman and Naf used perylene as a tracer of surface sediments and concluded that perylene found in suspended sediment traps most likely resulted from resuspension of bed sediments.

Although there is a natural background of PAHs resulting from forest fires, volcanic activity, diagenesis and possibly production by some plants and microorganisms, a significant fraction of the PAHs present in the environment is the result of anthropogenic activities (Seuss, 1976; NRCC, 1983). Although Merriman (1988) recorded detectable levels of PAHs in effluents from two Ontario pulp mills, Derksen and Mitchell (in preparation) found that, with the exception of naphthalene and phenanthrene, PAHs were not generally detectable in the organically rich solids centrifuged from the Fraser River pulp mill effluents upstream of Marguerite. The peaks in concentration observed at Marguerite for naphthalene, phenanthrene, benz(a)anthracene and benzo(a)fluoranthene indicate that PAHs in suspended sediment increased in concentration with the onset of freshet. Since the pulp mills do not seem to be the source of most of the PAHs measured at Marguerite, there appear to be other sources of these contaminants to the river.

Atmospheric deposition is believed to be a significant route of entry for PAHs into the aquatic environment and is responsible for much of the background concentration of PAHs (CCREM, 1987). Such atmospheric sources of PAHs in the area include burning of wood waste in beehive burners of saw mills, slash burning and forest fires. Another likely source of PAHs to the Fraser River may be automobile exhaust deposited on the major highway located adjacent to the Fraser River. It has been shown that following wet or dry deposition, PAH contaminated particles may enter the river as surface runoff (Gschwend and Hites, 1981; Hites and Gschwend, 1982). Furthermore, over the winter period vehicles travelling the highway may deposit petroleum products containing PAHs on the highway surface (Water Quality Branch, 1993). These petroleum products remain overland until the first spring melt period, at which time they are transported with the melt into the Fraser River. Other possible sources of PAHs may include creosote logs (CCREM, 1987) and urban runoff from upstream communities (Boom and Marsalek, 1988).

6.3 Contaminants in Water

6.3.1 Dioxins and Furans

Solid Phase Extracted Clarified Water

The absence of all but very low levels of dioxins and furans in solid phase extracted water samples (Table VIII) confirms the tendency of these contaminants to partition to the solid phase (such as sediments) as opposed to the water phase, as predicted by their high K_{ow} which range between 6-7. Other investigators similarly have not found appreciable levels of dioxins and furans in water downstream of pulp and paper mills in the Fraser River (Dwernychuk, 1994). Based on these findings, it appears that sediments still remain the best sampling medium for the detection of dioxins and furans in the Fraser River.

6.3.2 Chlorophenolics

Whole Water

The results indicate that the majority of chlorophenolics whose levels were above detection limits showed a decrease in concentration with the increasing hydrograph. This can be partially attributed to the fact that many of the chlorophenolics, specifically the mono and di-chlorinated forms, have K_{ow} values between 2-4 and are thus expected to primarily partition in the water phase. This was confirmed by data presented in Table VII. Conversely, the tri and tetra chlorinated phenolics have K_{ow} values between 4-5 and are therefore expected to partition in the organically rich solid phase of the water column. However, our data indicates that, as with the mono and di-chlorinated phenolics, these compounds are also partitioning primarily in the water phase as opposed to the solid phase. This apparent discrepancy could be explained by the fact that whole water not only contains suspended sediments but also dissolved and colloidal organic matter. Dissolved organic matter is defined as that which passes through a filter of usually between 0.2 μm and 0.45 μm pore size (Fletcher and McKay, 1993). Colloidal particles and other macromolecules may pass through 0.45 μm filter sizes and thus are also included in the dissolved phase. Consequently, dissolved organic matter represents a possible binding medium for hydrophobic contaminants in water samples thereby increasing their apparent water solubility (Kulovaara *et al.*, 1987). This apparent increase in solubility could therefore account for the observed low levels of tri and tetra chlorinated phenolics

found in the suspended sediment fraction of whole water at Marguerite.

6.3.3 Polycyclic Aromatic Hydrocarbons

Solid Phase Extracted Clarified Water

Acenaphthene was the sole PAH found in greater concentrations in solid phase extracted water than in suspended sediments (Table VIII). Since PAHs have low water solubilities (with the exception of naphthalene) it is unlikely that this compound was dissolved in the water phase but rather bound to dissolved organic matter. Conversely, the remainder of the PAHs measured were found in higher proportions in suspended sediments than in solid phase extracted water. A noteworthy observation was that acenaphthene is composed of a three ringed structure having a higher solubility, whereas the majority of the PAHs measured were composed of four, five and six ringed structures having lower water solubilities.

6.3.4 Fatty Acids

Whole Water

Fatty acids are composed of both hydrophilic and hydrophobic groups. They are poorly soluble in water and are known to associate with suspended solids in water (TECW, 1987). Because of their dual hydrophilic and hydrophobic nature, fatty acids tend to concentrate at the interfaces of aqueous mixtures (CCREM, 1987). In lakes and rivers sources of fatty acids have been identified as pulp mill effluent and natural processes such as the breakdown of vegetation and wood fibre in the water (Fox, 1977).

The measured increase in fatty acid concentration during the freshet period indicates that these compounds may be associating with particulate organic matter in whole water which becomes resuspended during freshet. This could be confirmed by measuring fatty acids in both solid and aqueous phases of the water.

6.3.5 Resin Acids

Whole Water

Resin acids are unsaturated, tricyclic monocarboxylic acids. They are normally insoluble in water but are soluble in various organic solvents and in dilute sodium hydroxide through the formation of sodium salts (Windholtz *et al.*, 1983). Resin acids are present in oleoresin, a composition of hydrophobic material of conifers (Swan, 1973), and in tall oil, a resin containing by-product of the kraft pulping process (Rogers and Harris, 1970). While resin acids represent only a few per cent of the total weight of wood (Enos *et al.*, 1970), the concentrations which can be present in pulp mill effluents may reach toxic levels (Davis and Hoos, 1975). Even when diluted by receiving waters, concentrations of these compounds may still be sufficient enough to exert chronic effects on the aquatic community (Brownlee *et al.*, 1977).

Numerous resin acids have been identified in mechanical pulping effluents, unbleached white water, woodroom wastes, bleached kraft whole mill effluents, sulphite effluents and paper mill effluents (Hemmigway and Greaves, 1973; Leach and Thakore, 1976). Resin acids have been detected in the final effluent of pulp and/or paper mills located upstream of Marguerite (IRC, in preparation).

The measured increase in resin acid concentration during the freshet period indicates that these compounds may be associating with particulate organic matter that is resuspended at the higher flows accompanying freshet. The fact that dehydroabietic acid was found in the highest concentration throughout the study period confirms its environmental persistence which is attributed to its aromatic ring structure (Brownlee *et al.*, 1977).

6.3.6 Comparison to Existing Guidelines

Currently no guidelines exist for contaminants in suspended sediment, therefore the concentration of contaminants in suspended sediments were expressed as units per litre of water (Table IV) so that they could be compared to existing water quality guidelines for the protection of freshwater aquatic life. None of the contaminants measured in suspended sediments, whole water or clarified solid phase extracted water had levels which exceeded existing water quality guidelines for the protection of freshwater aquatic life, including those of the Canadian Council of Ministers of Environment and British Columbia Ministry of Environment Lands and Parks, as presented in Haines *et al.* (1995).

7.0 CONCLUSIONS

1. Trace organic contaminants are detectable in suspended sediment measured at Marguerite which is located approximately 59 river kilometres downstream of the nearest pulp mill source.
2. Suspended sediment showed an increase in contaminant concentration during the onset of freshet and this increase was likely due to the resuspension of bed sediment material deposited during the previous winter low flow period.
3. The calculated loadings of 2,3,7,8-T4CDD and 2,3,7,8-T4CDF in suspended sediment at Marguerite were highest on April 7, corresponding to the peak in suspended sediment concentration during the freshet sampling period. This increase in loadings during the spring freshet indicates that there is a considerable movement (flushing) of contaminated sediment from upper reaches of the Fraser River to lower reaches of the Fraser River at this time.
4. Dioxins/furans and PAHs were found to partition almost exclusively into suspended sediment, thereby confirming that suspended sediment is the appropriate medium for measuring these contaminants.
5. None of the contaminants measured exceeded existing water quality guidelines for the protection of freshwater aquatic life.

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APPENDIX I**Laboratory Analytical and Quality Assurance/Quality Control Methods
and Sample Quality Assurance/Quality Control Results**

1.0 ANALYTICAL METHODS

1.1 Dioxin and Furan Analysis

All samples were first spiked with an aliquot of surrogate standard solution containing nine ^{13}C -labelled dioxin and furan congeners. The XAD resin columns were also spiked with an aliquot of surrogate standard solution containing deuterated PAHs.

The XAD columns were extracted by elution first with methanol and then with dichloromethane. Each extract was gravimetrically split into two halves and one half was set aside for PAH analysis. The other half of each extract was carried through for dioxin/furan analysis. It was backwashed with base, then acid and processed through a series of four chromatographic cleanup columns (silica, alumina, carbon, alumina).

Wet sediments were ground with sodium sulphate and extracted by refluxing in a soxhlet apparatus for 20 hours. The extract was backwashed with base, then acid and processed through the four cleanup columns described above.

An aliquot of ^{13}C -labelled recovery standard was added to each extract prior to analysis by high resolution gas chromatography with high resolution mass spectroscopic detection (HRGC/HRMS).

1.2 PAH Analysis

Sediment, water and XAD resin columns analyzed for PAHs were first spiked with an aliquot of surrogate standard solution containing nine perdeuterated PAHs.

Each sediment sample was ground with sodium sulphate, packed in a glass chromatographic column and eluted with methanol and dichloromethane. The eluate was backwashed with dilute base and

extracted with water. Water samples were extracted with dichloromethane in a separatory funnel. The extraction of the XAD resin columns was identical as that for dioxins/furans.

Sediment, water and XAD column extracts were then solvent exchanged with iso-octane and cleaned up by column chromatography on silica gel. An aliquot of recovery standard containing three perdeuterated PAHs was added to each extract in preparation for analysis by high resolution gas chromatography with mass spectrometric detection (GC/MS).

1.3 Chlorophenolic Analysis

Sediment samples were first spiked with an aliquot of surrogate standard solution containing twelve ^{13}C -labelled chlorinated phenolics and one deuterated chlorophenol. Each sample was then extracted with base. The extracts were filtered, acidified and reacted with acetic anhydride to convert the chlorophenolics to their acetate derivatives. The derivatives were then back extracted with solvent, dried over sodium sulphate and cleaned up by column chromatography on silica gel. An aliquot of recovery standard (deuterated fluoranthene) was added to each extract prior to analysis by HRGC/LRMS.

Water samples were first spiked with an aliquot of surrogate standard solution containing twelve ^{13}C -labelled chlorophenolics. Each sample was acidified, extracted with solvent, dried over sodium sulphate and concentrated by rotary evaporation. The extract was then acetylated, back extracted and prepared for clean-up by silica column. An aliquot of recovery standard solution was added to each extract prior to analysis by high resolution gas chromatography with low resolution (quadruple) mass spectrometric detection (HRGC/LRMS).

1.4 Resin and Fatty Acid Analysis

A one to three litre water sample was spiked with an aliquot of internal standard solution containing surrogate standards for both resin and fatty acid analysis. Each sample was acidified, solvent extracted, dried over sodium sulphate and concentrated by rotary evaporation. The extract was then reacted with diazomethane to derivitize the resin and fatty acids to their methyl esters. It was then cleaned up on a basic silica gel chromatographic column. An aliquot of recovery standard was added to each extract prior to analysis by HRGC/LRMS.

2.0 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) METHODS

Refer to Appendix III, Table 1 for the laboratory blank and spike reference table for sediment samples, Table 5 for the laboratory blank and spike reference table for whole water samples, and to Table 10 for the laboratory blank and spike reference table for solid phase extracted samples. The sample results were reviewed and evaluated in relation to the QA/QC samples worked up at the same time.

2.1 Procedural Blanks

One procedural blank was analysed with each batch sample. Sediment blanks were analysed for dioxins, furans, chlorophenolics and PAHs. Water blanks were analysed for chlorophenolics, PAHs, fatty acids and resin acids. XAD column blanks were analysed for dioxins/furans and PAHs.

2.2 Laboratory Duplicates

One laboratory duplicate was analysed with each batch sample. Duplicates must agree within acceptable limits, generally \pm (20% + Method Detection Limit (MDL)). Results for laboratory duplicates are reported with the sample results in Appendix II.

2.3 Surrogate Standard Recoveries

These consist of internal standards which are added to samples prior to analysis and are expressed as percent recoveries. Quality assurance protocols require that surrogate standard recoveries must be within an acceptable range for data to be reported. In cases where this criterion was not achieved samples were repeated. Surrogate standard recoveries were performed for all PCDD/PCDF resin and fatty acid samples.

2.4 Reference Samples

Reference samples were used as a method performance test. Each batch of samples analysed included a spiked matrix sample or a certified reference sample. Spiked sediment samples were analysed with field sediment samples for dioxins, furans and chlorophenolics. A marine sediment certified reference material, HS-6 (National Research Council of Canada), was used to provide an indication of the accuracy of the PAH sediment data. Spiked water samples were used as reference samples with whole water samples analysed for chlorophenolics, PAHs, resin acids and fatty acids. A spiked XAD resin column extract was analysed along with solid phase extraction samples for both PCDDs/PCDFs and PAHs.

2.5 Detection Limits

Method detection limits were calculated on a sample-specific basis and were reported with each sample result. The detection limit was calculated as the concentration corresponding to the area reject. The area reject, determined from the mass chromatogram of each compound, is the area of a peak with height three times the maximum height of the noise. Only peaks with responses greater than three times the background noise level were quantified.

Fatty acid results were reported with statistically-derived Limits of Detection (LOD) since procedural blank levels usually had detectable concentrations. LODs were calculated by multiplying by three the standard deviation of the analyte concentration in twelve fatty acid blanks. Behenic and lignoceric acids, however, were reported with method detection limits since these two fatty acids were not detected in the procedural blanks.

3.0 SAMPLE QUALITY ASSURANCE/QUALITY CONTROL RESULTS

3.1 Sediment Samples

3.1.1 Particle Size and Total Organic Carbon

QA/QC results for particle size and total organic carbon (TOC) in suspended sediment field split samples were in agreement with the original samples, indicating a high degree of reproducibility. Furthermore, the April 7 lab duplicate was also in agreement with the original sample. Refer to Appendix II, Table 2 for field split and lab duplicate data.

3.1.2 Dioxins and Furans

Results of dioxin and furan field splits showed a high degree of agreement. Laboratory duplicates were generally acceptable, and satisfied the requirement of $\pm(20\% + \text{MDL})$. Furthermore, laboratory sediment blanks were below detection limits except for O8CDD and O8CDF which showed very low background levels. Dioxin blank SBLK 838 had a low recovery of the O8CDD surrogate, but was worked up with samples that had acceptable surrogate recoveries and so the batch was therefore deemed acceptable. Laboratory sediment spikes were also acceptable. Refer to Appendix II, Table 3 for field split and lab duplicate data and Appendix III, Table 4 for laboratory blank and spike data.

3.1.3 Chlorophenolics

Field splits were in agreement with the original samples, indicating a high level of reproducibility. Lab duplicates were generally acceptable, and satisfied the requirement of $\pm(20\% + \text{MDL})$. In addition, all sediment blanks were below the detection limits, and the sediment spike recoveries were generally acceptable. Refer to Appendix II, Table 4 for field split and lab duplicate data and Appendix III, Table 3 for lab blank and spike data.

3.1.4 Polycyclic Aromatic Hydrocarbons

Field splits were in good agreement with original samples. Laboratory duplicates were generally acceptable and satisfied the requirement of $\pm(20\% + \text{MDL})$. Laboratory sediment blanks showed not detectable or low background levels of the target analytes. Furthermore, laboratory reference recoveries were acceptable. Refer to Appendix II, Table 5 for field split and lab duplicate data and Appendix III, Table 4 for lab blank and reference data.

3.2 Whole Water

3.2.1 Chlorophenolics

Results of field splits were in good agreement with original samples. Laboratory duplicates also showed good replication to within $\pm(20\% \text{ of mean} + \text{MDL})$. Furthermore, laboratory water blanks were below detection limits with the exception of 3,4,5-trichlorocatechol and 5,6-dichlorovanillin. (Catechols are known to be unstable due to oxidation reactions, (AXYS data report, 1994)). Water spikes generally showed acceptable recovery values. Refer to Appendix II, Table 6 for field split and lab duplicate data and Appendix III, Table 7 for laboratory blank and spike data. Field blank results were below detection limits with the exception of pentachlorophenol which registered values up to 39 ng/L. Refer to Appendix IV, Table 1 for field blank data.

3.2.2 Polycyclic Aromatic Hydrocarbons

Results of field splits were in good agreement with original sample values. Lab duplicates were generally acceptable and satisfied the requirement of $\pm(20\% + \text{MDL})$. Laboratory water blanks showed background values for the majority of PAHs, the majority of which were similar or higher than in the actual whole water samples. Moreover, laboratory water spikes showed acceptable recovery levels. Refer to Appendix II, Table 7 for field split and lab duplicate data and Appendix III, Table 6 for lab blanks and spike data.

Field deionized water blanks were either below detection limits or did not meet quantification

criteria with the exception of naphthalene, acenaphthene, fluorene and phenanthrene. Naphthalene levels ranged between 20-100 ng/L, acenaphthene ranged between 2.7-8.3 ng/L, fluorene between 3.4-26 ng/L and phenanthrene between 5-34 ng/L. These PAHs were several orders of magnitude higher in the field blanks than the in the water samples. Refer to Appendix IV, Table 2 for field blank data.

3.2.3 Fatty Acids

Results of the field splits showed some variability between samples. Laboratory duplicates were acceptable as they agreed to within $\pm(20\%$ of mean + MDL). Lab water blanks showed background levels for most fatty acids with the highest being for palmitic (25-2,600 ng/L) and stearic acids (20-1,600 ng/L). Since fatty acid blanks are normally above sample detection limits, the background contribution to the observed response can be significant. For this reason, fatty acid samples have been blank corrected for the amount detected in each batch blank. However, the levels of fatty acids detected in the blanks in most cases did not exceed 1000 ng/L. Furthermore, laboratory water spikes showed an acceptable level of recovery. In addition, field blanks collected on March 30 showed levels of lauric acid, myristic acid, palmitic acid, and stearic acid with values ranging between 100-520 ng/L, which are considered normal background levels (Georgina Brooks, AXYS, personal communication). Refer to Appendix II, Table 8 for field split and lab duplicate data and Appendix III, Table 8 for laboratory blank and spike data. Appendix IV, Table 3 presents field blank data.

3.2.4 Resin Acids

Field splits were in good agreement with original samples, indicating a high level of reproducibility. Laboratory duplicates showed good replication, to within $\pm(20\%$ of mean + MDL). Moreover, laboratory water blanks showed mostly non-detectable or low background levels of the target resin acids. Field deionized water blanks were below detection limits, with the exception of palustric (66-130 ng/L) and dehydroabietic acid (21-24 ng/L). All laboratory spiked samples had acceptable levels of recovery. Refer to Appendix II, Table 9 for field split and lab duplicate data and Appendix III, Table 9 for lab blank and spike data. Appendix IV, Table 4 presents field blank data.

3.3 Solid Phase Extraction

3.3.1 Dioxins and Furans

QA/QC results showed low background levels of total H7CDD, O8CDD, total T4CDF, total H6CDF and total H7CDF in column blanks. Column spikes showed an acceptable level of recovery. Refer to Appendix III, Table 11 for data.

3.3.2 Polycyclic Aromatic Hydrocarbons

QA/QC results showed no detections in laboratory column blanks and proofs. Furthermore, the laboratory spike showed acceptable recovery values. Refer to Appendix III, Table 12 for data.

APPENDIX II

Sampling and Analytical Data for Suspended Sediment, Whole Water and Solid Phase Extracted Water Samples

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TABLE 1 Chemical and Physical Parameters of the Fraser River at the Time of Sampling (Marguerite - 1993)

Date	Time of day	Temperature (C)	pH	Conductivity (mS/cm)
March 30	14:10	0.59	7.99	0.1402
	14:25	0.56	8.09	0.141
	14:40	0.54	8.12	0.1402
	14:55	0.56	8.14	0.1406
	15:10	0.56	8.12	0.1409
	15:25	0.57	8.16	0.1412
	15:40	0.61	8.14	0.1413
	15:55	0.61	8.14	0.1415
	16:10	0.62	8.12	0.1415
	16:25	0.61	8.13	0.1414
	16:40	0.63	8.14	0.1414
	16:55	0.63	8.16	0.1413
	17:10	0.61	8.13	0.1414
	17:25	0.59	8.14	0.1414
	17:40	0.63	8.14	0.1414
	17:55	0.64	8.13	0.1415
	18:10	0.64	8.13	0.1415
	18:25	0.66	8.15	0.1415
	18:40	0.66	8.13	0.1416
	18:55	0.66	8.14	0.1415
April 7	12:20	1.96	7.75	0.1055
	12:35	1.97	7.75	0.1057
	12:50	1.97	7.77	0.1056
	13:05	2.01	7.78	0.1057
	13:20	2.03	7.79	0.1057
	13:35	2.01	7.8	0.1057
	13:50	2.03	7.8	0.1056
	14:05	2.03	7.8	0.1056
	14:20	2.01	7.81	0.1056
	14:35	1.99	7.8	0.1054
	14:50	1.99	7.79	0.1054
	15:05	1.98	7.8	0.1054
	15:20	1.99	7.8	0.1053
	15:35	1.99	7.8	0.1053
	15:50	1.98	7.77	0.1053
April 15	11:27	3.11	N/A	0.1045
	11:42	3.12	N/A	0.104
	11:57	3.16	N/A	0.1048
	12:12	3.17	6.8	0.1048
	12:27	3.21	7.21	0.1049
	12:42	3.24	7.36	0.1049
	12:57	3.28	7.42	0.1051
	13:12	3.33	7.63	0.1051
	13:27	3.33	7.51	0.1052
	13:42	3.36	7.52	0.1052
	13:57	3.38	7.56	0.1053
	14:12	3.39	7.87	0.1054
	14:27	3.39	7.91	0.1054
	14:42	3.43	7.92	0.1054
	14:57	3.44	7.93	0.1055
April 22	11:30	7.39	7.93	0.1027
	11:45	7.45	7.95	0.1028
	12:00	7.47	7.95	0.1027
	12:15	7.55	7.93	0.1028
	12:30	7.6	7.95	0.1029
	12:45	7.67	7.95	0.1029
	13:00	7.69	7.94	0.103
	13:15	7.78	7.94	0.103
	13:30	7.87	7.94	0.1029
	13:45	7.91	7.89	0.1032
	14:00	7.93	7.92	0.1032
	14:15	7.98	7.93	0.1034
	14:30	8.03	7.94	0.1032
	14:45	8.06	7.93	0.1031

N/A = data not available

TABLE 2 Organic Carbon Content and Particle Size of Fraser River Suspended Sediments (Marguerite - 1993)

Sampling Date	Sample ID	Total Organic Carbon	Particle Size *				Suspended Sediment Concentration (mg/L)	Flow (m3/s)
		(%)	% Gravel	% Sand	% Silt	% Clay		
March 30, 1993	MAR-3C	0.94	0	7.04	76.08	16.88	122.4	520
March 30, 1993	FRS-10C (field split of MAR-3C)	0.94	0	11.84	76.23	11.93	N/A	520
April 7, 1993	MAR-4CA	1.07	0	9.41	75.06	15.54	205.5	1050
April 7, 1993	MAR-4CB (lab duplicate of MAR-4CA)	1.08	N/A	N/A	N/A	N/A	N/A	1050
April 7, 1993	FRS-12C (field split of MAR-4CA)	1.07	0	8.37	76.55	15.08	N/A	1050
April 15, 1993	MAR-5C	1.14	0	4.67	78.04	17.29	146.7	1240
April 15, 1993	FRS-14C (field spit of MAR-5C)	1.10	0	6.66	75.57	17.76	N/A	1240
April 22, 1993	MAR-6C	1.15	0	3.55	77.45	19.01	142.4	1440
April 22, 1993	FRS-16C (field split of MAR-6C)	1.12	0	10.55	74	15.45	N/A	1440

*particle size categories are defined as follows:

gravel = 2-64 mm

sand = 0.062-2 mm

silt = 0.004-0.062 mm

clay = < 0.004 mm

N/A = sample was not analyzed

TABLE 3 Dioxin and Furan Concentrations in Fraser River Suspended Sediments (Marguerite - 1993)

Sampling Date:	March 30, 1993		March 30, 1993		March 30, 1993		April 7, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 22, 1993		April 22, 1993	
Sample ID:	MAR-3CA		MAR-3CB (lab duplicate of MAR-3CA)		FRS-10C (field split of MAR-3CA)		MAR-4CA		MAR-4CB (lab duplicate of MAR-4CA)		FRS-12C (field split of MAR-4CA)		MAR-5C		FRS-14C (field split of MAR-5C)		MAR-6C		FRS-16C (field split of MAR-6C)	
Compounds	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL
Dioxins																				
T4CDD - Total 2,3,7,8	2.4 NDR(0.2)	0.1 0.1	3.5 NDR(0.2)	0.1 0.1	2.5 0.2	0.1 0.1	4.5 NDR(0.2)	0.1 0.1	4.1 NDR(0.2)	0.1 0.1	4.3 0.2	0.1 0.1	4.4 ND	0.3 0.3	3.7 0.1	0.1 0.1	4.6 NDR(0.2)	0.1 0.1	3.5 0.1	0.1 0.1
P5CDD - Total 1,2,3,7,8	1.0 0.2	0.1 0.1	1.0 0.2	0.1 0.1	ND NDR(0.1)	0.1 0.1	2.9 0.4	0.1 0.1	2.6 0.4	0.1 0.1	2.4 0.3	0.1 0.1	2.3 0.3	0.1 0.1	1.1 NDR(0.3)	0.1 0.1	2.1 0.4	0.1 0.1	2.5 0.4	0.2 0.2
H6CDD - Total 1,2,3,4,7,8 1,2,3,6,7,8 1,2,3,7,8,9	9.9 0.3 NDR(0.6) 1.2	0.1 0.1 0.1 0.1	11 0.3 NDR(0.8) 1.1	0.1 0.1 0.1 0.1	10 NDR(0.2) 0.8 1.2	0.1 0.1 0.1 0.1	19 0.5 1.4 2.1	0.1 0.1 0.1 0.1	18 0.5 1.1 1.5	0.1 0.1 0.1 0.1	15 0.4 1.0 1.9	0.1 0.1 0.1 0.1	14 0.4 1 1.7	0.1 0.1 0.1 0.1	15 0.5 1.0 1.8	0.1 0.1 0.1 0.1	17 NDR(0.6) 1.1 2.0	0.1 0.1 0.1 0.1	16 0.5 0.9 1.9	0.1 0.1 0.1 0.1
H7CDD - Total 1,2,3,4,6,7,8	30 11	0.1 0.1	35 13	0.1 0.1	29 11	0.1 0.1	58 22	0.2 0.2	56 21	0.1 0.1	47 18	0.1 0.1	49 18.6	0.1 0.1	49 19	0.1 0.1	54 20	0.1 0.1	54 20	0.1 0.1
O8CDD	150	0.2	160	0.3	140	0.2	240	0.2	210	0.1	180	0.2	200	0.1	190	0.1	220	0.1	210	0.1
Furans																				
T4CDF - Total 2,3,7,8	1.1 0.7	0.1 0.1	1.1 0.7	0.1 0.1	1.0 0.7	0.1 0.1	0.9 0.6	0.1 0.1	0.8 0.6	0.1 0.1	0.8 0.5	0.1 0.1	0.4 0.3	0.1 0.1	0.4 0.3	0.1 0.1	0.5 0.3	0.1 0.1	0.4 0.2	0.1 0.1
P5CDF - Total 1,2,3,7,8 2,3,4,7,8	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1	ND ND ND	0.1 0.1 0.1
H6CDF - Total 1,2,3,4,7,8 1,2,3,6,7,8 2,3,4,6,7,8 1,2,3,7,8,9	0.3 ND ND ND ND	0.1 0.1 0.1 0.1 0.1	0.5 ND ND ND ND	0.1 0.1 0.1 0.1 0.1	0.4 ND ND ND ND	0.2 0.2 0.2 0.2 0.2	0.7 ND ND ND ND	0.2 0.2 0.2 0.2 0.2	0.4 ND ND ND ND	0.2 0.2 0.2 0.2 0.2	0.3 ND ND ND ND	0.1 0.1 0.1 0.1 0.1	0.4 ND ND ND ND	0.1 0.1 0.1 0.1 0.1	0.6 ND ND ND ND	0.2 0.2 0.2 0.2 0.2	ND ND ND ND ND	0.2 0.2 0.2 0.2 0.2	0.4 ND ND ND ND	0.1 0.1 0.1 0.1 0.1
H7CDF - Total 1,2,3,4,6,7,8 1,2,3,4,7,8,9	1.5 0.6 ND	0.1 0.1 0.1	1.5 0.6 ND	0.1 0.1 0.1	2.6 0.8 ND	0.1 0.1 0.1	2.2 ND ND	0.2 0.2 0.2	2.3 0.9 ND	0.2 0.2 0.2	2.0 ND ND	0.1 0.1 0.1	2 ND ND	0.1 0.1 0.1	2.2 0.8 ND	0.1 0.1 0.1	1.0 0.7 NDR(0.2)	0.1 0.1 0.1	1.3 0.5 ND	0.1 0.1 0.1
O8CDF	1.3	0.3	1.6	0.3	1.8	0.1	2.3	0.2	2.4	0.2	2.0	0.1	1.7	0.3	2.0	0.1	2.1	0.2	1.1	0.2
Surrogate Standard	% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery	
13C-T4CDD:	96		78		94		91		91		98		97		100		96		100	
13C-T4CDF:	94		87		92		95		98		104		102		109		105		106	
13C-P5CDD:	86		87		80		97		95		104		100		119		116		105	
13C-H6CDD:	78		86		69		89		92		75		103		99		88		98	
13C-H7CDD:	68		71		75		81		88		98		95		98		80		96	
13C-O8CDD:	48		47		60		59		63		83		79		85		58		87	

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

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TABLE 4 Chlorophenolic Concentrations in Fraser River Suspended Sediments (Marguerite - 1993)

Sampling Date:	March 30, 1993		March 30, 1993		March 30, 1993		April 7, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 15, 1993		April 22, 1993		April 22, 1993	
Sample ID:	MAR-3CA		MAR-3CB (lab duplicate of MAR-3CA)		FRS-10C (field split of MAR-3CA)		MAR-4CA		MAR-4CB (lab duplicate of MAR-4CA)		FRS-12C (field split of MAR-4CA)		MAR-5CA		MAR-5CB (lab duplicate of MAR-5CA)		FRS-14C (field split of MAR-5CA)		MAR-6C		FRS-16C (field split of MAR-6C)	
Compounds	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD	Concentration (ng/g)	SD
4-chlorophenol	ND	0.5	ND	0.4	ND	0.4	ND	1.1	ND	0.5	ND	0.3	ND	0.4	ND	0.7	ND	1.2	ND	1.2	ND	0.6
2,6-dichlorophenol	ND	0.3	ND	0.5	ND	0.5	ND	1.2	ND	0.3	ND	0.4	ND	0.4	ND	0.5	ND	0.6	ND	0.6	ND	0.4
2,4,7,5-DCEP	ND	0.2	ND	0.3	ND	0.3	ND	0.8	ND	0.7	ND	0.3	ND	0.3	ND	0.4	ND	0.4	ND	0.5	ND	0.3
3,5-dichlorophenol	ND	0.3	ND	0.4	ND	0.5	ND	1.1	ND	0.3	ND	0.4	ND	0.4	ND	0.5	ND	0.5	ND	0.6	ND	0.4
2,3-dichlorophenol	ND	0.3	ND	0.4	ND	0.4	ND	1.0	ND	0.3	ND	0.4	ND	0.3	ND	0.5	ND	0.5	ND	0.6	ND	0.4
3,4-dichlorophenol	ND	0.2	ND	0.3	ND	0.3	ND	0.7	ND	0.2	ND	0.3	ND	0.3	ND	0.3	ND	0.4	ND	0.4	ND	0.3
6-chloroguaiacol	ND	0.2	ND	0.5	ND	0.2	ND	0.8	ND	0.6	ND	0.2	ND	0.5	ND	0.5	ND	1.4	ND	1.5	ND	0.2
4-chloroguaiacol	ND	0.3	ND	0.6	ND	0.3	ND	1.1	ND	0.8	ND	0.2	ND	0.6	ND	0.6	ND	1.7	ND	1.9	NDR(0.4)	0.3
5-chloroguaiacol	ND	0.3	ND	0.6	ND	0.3	ND	1.1	ND	3.4	NDR(0.3)	0.2	ND	0.6	ND	0.6	ND	1.6	ND	1.8	ND	0.3
2,4,6-trichlorophenol	ND	0.3	ND	0.5	ND	0.4	ND	0.7	ND	0.4	ND	0.2	ND	0.2	ND	0.3	ND	0.3	0.3	0.3	ND	0.4
2,3,6-trichlorophenol	ND	0.3	ND	0.4	ND	0.4	ND	0.6	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.3
2,3,5-trichlorophenol	ND	0.3	ND	0.4	ND	0.4	ND	0.6	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.3
2,4,5-trichlorophenol	ND	0.2	ND	0.4	ND	0.3	ND	0.5	ND	0.2	ND	0.1	ND	0.1	ND	0.1	ND	0.2	ND	0.2	ND	0.2
2,3,4-trichlorophenol	ND	0.3	ND	0.4	ND	0.3	ND	0.5	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	NDR(0.2)	0.2	ND	0.2
3,4,5-trichlorophenol	ND	0.3	ND	0.4	ND	0.4	ND	0.6	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2
3-chlorocatechol	ND	0.5	ND	0.8	ND	0.5	ND	0.9	ND	0.5	ND	0.3	NDR(1.3)	0.4	NDR(0.8)	0.3	ND	0.4	NDR(0.7)	0.4	ND	0.4
4-chlorocatechol	ND	0.8	ND	1.3	ND	0.8	ND	0.1	ND	0.4	ND	0.5	ND	0.6	ND	0.5	ND	0.4	ND	0.6	ND	0.7
3,4,4,6-dichloroguaiacol	ND	0.8	ND	1.2	ND	1.0	ND	1.0	ND	0.1	ND	0.2	ND	0.3	ND	0.2	0.3	0.2	ND	0.2	ND	0.4
4,5-dichloroguaiacol	2.3	0.4	2.3	0.6	2.9	0.5	1.4	0.8	1.3	0.3	4.8	0.1	1.2	0.2	1.2	0.2	ND	0.2	0.6	0.2	1.6	0.4
3-chlorosyringol	ND	0.2	ND	0.3	ND	0.4	ND	0.5	ND	0.2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.2
3,4-dichlorocatechol	ND	4.0	ND	4.0	ND	2.3	NQ	ND	ND	2.4	ND	5.6	ND	6.9	ND	5.7	ND	8.8	ND	6.6	ND	9.6
3,6-dichlorocatechol	ND	5.0	ND	5.0	ND	2.8	NQ	ND	ND	4.4	ND	6.7	ND	8.4	ND	6.9	ND	10	ND	8.0	ND	11
3,5-dichlorocatechol	ND	4.0	ND	4.0	ND	2.3	NQ	ND	ND	4.0	ND	5.7	NDR(8.8)	7.0	NDR(14)	5.7	ND	8.9	ND	6.7	ND	9.7
4,5-dichlorocatechol	22	5.4	21	5.0	21	3.1	NQ	ND	41	3.1	100	7.8	45	9.5	45	7.9	29	12	36	8.9	29	13
2,3,5,6-tetrachlorophenol	ND	0.7	ND	1.0	ND	1.0	ND	1.1	ND	0.4	ND	0.3	ND	0.3	ND	0.2	ND	0.3	ND	0.5	ND	0.4
2,3,4,6-tetrachlorophenol	ND	0.8	ND	1.0	ND	1.2	ND	1.2	ND	0.5	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.6	ND	0.4
2,3,4,5-tetrachlorophenol	ND	0.5	ND	0.7	ND	0.8	ND	0.8	ND	0.3	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.4	ND	0.3
5-chlorovanillin	ND	9.8	ND	8.3	ND	4.8	ND	6.8	ND	4.2	ND	6.6	ND	6.5	ND	4.8	ND	7.0	ND	6.0	ND	13
6-chlorovanillin	NDR(17)	11	NDR(12)	10	7.6	5.6	ND	7.9	ND	7.8	15	8.4	ND	7.9	ND	5.8	ND	8.5	ND	7.2	ND	16
3,5-dichlorosyringol	ND	1.2	ND	1.5	ND	1.0	ND	1.8	ND	0.5	ND	0.6	ND	0.5	ND	0.4	ND	0.4	ND	0.4	ND	0.6
3,4,6-trichloroguaiacol	ND	0.6	ND	1.0	ND	0.6	ND	1.3	ND	0.4	ND	0.2	ND	0.3	ND	0.3	ND	0.4	ND	0.4	ND	0.3
3,4,5-trichloroguaiacol	2.7	0.7	2.9	1.1	2.4	0.6	1.8	1.3	2.4	0.4	3.5	0.2	3.5	0.3	3.4	0.3	2.0	0.4	2.4	0.4	2.0	0.3
4,5,6-trichloroguaiacol	ND	0.7	ND	0.7	ND	0.4	ND	0.8	ND	0.3	NDR(0.5)	0.1	NDR(0.3)	0.2	NDR(0.3)	0.2	ND	0.3	ND	0.3	ND	0.2
3,4,6-trichlorocatechol	ND	0.7	ND	0.9	ND	0.7	ND	0.8	ND	0.5	ND	0.3	ND	0.3	ND	0.3	ND	0.4	ND	0.3	ND	1.1
3,4,5-trichlorocatechol	4.1	0.6	5.4	0.6	5.7	0.6	NDR(2.2)	0.7	9.5	0.4	6.2	0.2	2.5	0.3	NDR(2.7)	0.2	1.3	0.3	2.2	0.3	2.1	1.0
5,6-dichlorovanillin	ND	0.7	ND	1.0	ND	1.0	ND	0.9	ND	0.6	ND	0.2	ND	0.4	ND	0.2	ND	0.3	ND	0.3	ND	0.4
pentachlorophenol	ND	0.8	ND	1.3	ND	0.9	ND	0.6	ND	0.7	ND	0.5	ND	0.4	ND	0.3	ND	0.3	ND	0.3	ND	0.6
2-chlorosyringaldehyde	ND	0.6	ND	0.9	ND	0.5	ND	0.7	ND	0.4	ND	0.3	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.5
3,4,5,6-tetrachloroguaiacol	ND	0.5	ND	1.0	ND	0.5	ND	0.7	ND	0.5	ND	0.3	ND	0.3	ND	0.2	ND	0.3	ND	0.3	ND	0.4
3,4,5-trichlorosyringol	ND	0.7	ND	1.0	ND	0.7	ND	0.8	ND	0.5	ND	0.3	ND	0.2	ND	0.3	ND	0.4	ND	0.3	ND	0.5
3,4,5,6-trichlorocatechol	NQ		NQ		ND	11	NQ		NDR(9.4)	3.1	NDR(11)	6.3	NDR(4.4)	4.1	6.8	2.6	NDR(4.2)	3.6	6.2	2.8	ND	80
2,6-dichlorosyringaldehyde	NQ		NQ		NDR(18)	10	NQ		ND	4.6	NDR(44)	17	ND	9.1	NDR(15)	6.6	ND	9.4	ND	8.5	56	35

(1) SDL = Sample Detection Limit

(2) ND = Not Detected

(3) NDR = Peak detected but did not meet quantification criteria

(4) Data have not been blank corrected

(5) Reactive compounds such as chlorocatechols, chloroguaiacols, chlorosyringols, chlorosyringaldehydes

and chlorovanillins may not be accurately quantified due to degradative oxidation reactions

(6) 3,4,6 dichloroguaiacol are reported as a co-eluting pair due to sample matrix effects

(7) NQ = Not Quantifiable

TABLE 5 PAH Concentrations in Fraser River Suspended Sediments (Marguerite - 1993)

Sampling Date:	March 30, 1993			March 30, 1993			March 30, 1993			April 7, 1993			April 7, 1993			April 7, 1993			April 15, 1993			April 15, 1993			April 22, 1993			April 22, 1993		
Sample ID:	MAR-3CA			MAR-3CB (lab duplicate of MAR-3CA)			FRS-10C (field split of MAR-3CA)			MAR-4C			FRS-12CA (field split of MAR-4C)			FRS-12CB (lab duplicate of field split of MAR-4C)			MAR-5C			FRS-14C (field split of MAR-5C)			MAR-6C			FRS-16C (field split of MAR-6C)		
Compounds	Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL		Concentration (ng/g)	SDL	
Naphthalene	5.3	0.1		6.4	0.6		5.8	0.6		14	1.7		NDR(7.2)	1.2		NDR(9.6)	1.7		7.3	1.4		NDR(8.9)	1.8		NDR(7.9)	3.0		NDR(6.4)	1.1	
Acenaphthylene	NDR(1.0)	0.6		1.0	0.4		NDR(1.0)	0.4		NDR(1.8)	0.6		NDR(1.9)	0.7		NDR(1.0)	0.7		ND	0.9		NDR(1.1)	0.6		NDR(0.8)	0.6		NDR(0.7)	0.4	
Acenaphthene	1.2	0.7		0.8	0.5		0.9	0.7		NDR(0.8)	0.8		ND	0.7		ND	0.9		ND	1.0		ND	1.0		NDR(1.3)	1.0		ND	0.6	
Fluorene	3.3	0.4		2.6	0.6		2.5	0.3		3.9	0.5		2.5	0.6		3.3	0.6		3.9	1.0		3	0.7		3.7	0.6		3.2	0.8	
Phenanthrene	8.4	0.2		8.3	0.2		7.6	0.2		14	0.2		9.9	0.2		10	0.2		15	0.2		13	0.2		12	0.2		11	0.2	
Anthracene	2.4	0.2		NDR(1.5)	0.2		2.1	0.2		NDR(0.8)	0.2		1.1	0.2		1.2	0.2		0.8	0.3		1.1	0.2		NDR(1.1)	0.2		1.0	0.2	
Fluoranthene	4.9	0.2		4.4	0.1		3.8	0.2		5.7	0.1		4.8	0.1		5.4	0.1		4.9	0.1		4.4	0.1		3.3	0.1		3.3	0.1	
Pyrene	6.3	0.2		6.2	0.2		5.7	0.2		6.2	0.1		4.5	0.1		5.2	0.1		5.0	0.1		4.7	0.1		4.8	0.1		3.7	0.1	
Benz(a)anthracene	NDR(2.2)	0.5		NDR(2.4)	0.4		NDR(2.3)	0.5		2.2	0.4		2.6	0.3		NDR(1.4)	0.4		NDR(3.2)	0.5		NDR(2.3)	0.4		1.2	0.3		1.1	0.3	
Chrysene	4.3	0.5		4.4	0.4		3.8	0.6		5.1	0.3		5.0	0.3		4.8	0.4		5.6	0.4		4.8	0.4		4.7	0.3		3.6	0.2	
Benzo(a)fluoranthene	4.6	0.3		4.2	0.3		4.1	0.4		NDR(2.8)	0.3		NDR(4.8)	0.2		NDR(5.8)	0.3		NDR(6.5)	0.4		6.2	0.3		4.9	0.2		4.8	0.2	
Benzo(e)pyrene	3.0	0.3		3.2	0.3		2.3	0.4		NDR(3.6)	0.3		NDR(3.6)	0.2		NDR(3.1)	0.3		NDR(3.9)	0.4		NDR(3.3)	0.3		NDR(3.1)	0.2		NDR(3.2)	0.2	
Benzo(a)pyrene	NDR(1.0)	0.4		NDR(1.2)	0.3		NDR(0.8)	0.4		NDR(1.3)	0.3		NDR(0.8)	0.3		ND	0.4		NDR(1.1)	0.4		NDR(1.5)	0.4		NDR(1.2)	0.3		ND	0.2	
Perylene	29	0.3		28	0.3		27	0.4		40	0.3		40	0.2		40	0.3		57	0.4		54	0.3		58	0.2		56	0.2	
Dibenz(ah)anthracene	NDR(1.4)	0.9		NDR(0.8)	0.5		NDR(1.1)	0.5		NDR(1.0)	0.9		NDR(0.5)	0.5		ND	0.7		ND	1.5		NDR(0.9)	0.8		ND	0.6		ND	0.8	
Indeno(1,2,3-cd)pyrene	NDR(1.3)	0.6		NDR(1.4)	0.5		NDR(1.1)	0.8		NDR(1.1)	0.6		NDR(1.1)	0.4		NDR(0.7)	0.6		NDR(0.8)	0.8		NDR(0.8)	0.6		NDR(1.0)	0.5		NDR(0.7)	0.4	
Benzo(ghi)perylene	3.1	0.5		3.3	0.4		3.2	0.6		NDR(3.5)	0.4		NDR(3.1)	0.3		NDR(3.0)	0.4		NDR(3.5)	0.6		NDR(2.9)	0.4		NDR(3.1)	0.4		NDR(2.8)	0.3	

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have not been blank corrected

TABLE 6 Chlorophenolic Concentrations in Fraser River Whole Water (Marguerite - 1993)

Sampling Date:	March 30, 1993		March 30, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 22, 1993		April 22, 1993		April 22, 1993	
Sample ID:	MAR-3CH		FRS-8CH (field split of MAR-3CH)		MAR-4CH		FRS-11CH (field split of MAR-4CH)		MAR-5CH		FRS-13CH (field split of MAR-5CH)		MAR-6CH		FRS15-CHA (field split of MAR-6CH)		FRS-15CHB (Lab. duplicate of the field split of MAR-6CH)	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL
4-chlorophenol	ND	2.3	ND	1	ND	1.1	ND	1	ND	2.6	ND	2.1	ND	1.2	ND	2.0	ND	3.0
2,6-dichlorophenol	ND	3.9	ND	1.8	ND	1.9	ND	2.3	ND	2.2	ND	2.9	ND	6.8	ND	2.9	ND	4.6
2,4,5-DCP	ND	3.0	NDR(6.7)	1.4	NDR(6.8)	1.4	NDR(6.2)	1.8	ND	1.6	ND	2.1	ND	4.9	ND	2.1	NDR(17)	3.4
3,5-dichlorophenol	ND	3.6	ND	1.6	ND	1.7	ND	2.1	ND	2	ND	2.6	ND	6.1	ND	2.6	ND	4.1
2,3-dichlorophenol	ND	3.4	ND	1.6	ND	1.6	ND	2	ND	1.8	ND	2.4	ND	5.7	ND	2.4	ND	3.9
3,4-dichlorophenol	ND	2.3	ND	1.1	ND	1.2	ND	1.4	ND	1.3	ND	1.7	ND	4	ND	1.5	ND	2.4
6-chloroguaiacol	ND	1.9	ND	1.2	ND	1.1	ND	1.4	ND	4.7	ND	5.3	ND	3.5	ND	2.0	ND	3.4
4-chloroguaiacol	ND	2.2	ND	1.4	ND	1.3	ND	1.7	ND	5.6	ND	6.5	ND	4.2	ND	2.3	ND	3.9
5-chloroguaiacol	ND	2.2	NDR(2.1)	1.4	NDR(1.4)	1.3	ND	1.7	ND	5.5	ND	6.3	NDR(14)	4	NDR(3.5)	2.4	ND	4.0
2,4,6-trichlorophenol	8.8	2.1	6.5	1.7	NDR(4.9)	2.0	NDR(4.9)	1.2	NDR(4.0)	2.8	NDR(3.6)	1.6	ND	2.5	NDR(2.0)	1.8	ND	2.5
2,3,6-trichlorophenol	ND	1.8	ND	1.4	ND	1.6	ND	1	ND	2.2	ND	1.2	ND	2	ND	1.3	ND	1.8
2,3,5-trichlorophenol	ND	1.7	ND	1.4	ND	1.6	ND	1	ND	2.3	ND	1.3	ND	2	ND	1.4	ND	1.9
2,4,5-trichlorophenol	ND	1.2	ND	1.1	ND	1.2	ND	0.8	ND	1.7	ND	1.2	ND	1.1	ND	1.2	ND	1.5
2,3,4-trichlorophenol	ND	1.2	ND	1.1	NDR(9.4)	1.2	ND	0.8	ND	1.7	ND	1.2	ND	1.2	ND	1.0	ND	1.2
3,4,5-trichlorophenol	ND	1.3	ND	1.2	ND	1.3	ND	0.8	ND	1.8	ND	1.3	ND	1.2	ND	1.2	ND	1.4
3-chlorocatechol	ND	2.4	ND	2	ND	1.9	ND	1.2	ND	4.5	ND	3.4	ND	2	ND	1.8	ND	2.5
4-chlorocatechol	ND	3.7	ND	3	ND	2.9	ND	1.8	ND	6.9	ND	5.3	ND	3	ND	2.5	ND	3.5
3,4-dichloroguaiacol	ND	1.6	ND	1.3	ND	1.4	ND	1	ND	1.7	ND	1.4	ND	1.1	ND	1.4	ND	2.3
4,6-dichloroguaiacol	2.5	2.0	ND	1.6	2.6	1.8	ND	1.2	ND	2.3	ND	1.9	ND	1.5	ND	1.8	ND	2.8
4,5-dichloroguaiacol	ND	1.5	2	1.3	ND	1.6	ND	1	ND	2	ND	1.7	ND	1.3	NDR(1.6)	1.3	ND	2.2
3-chlorosyringol	ND	0.9	ND	0.8	ND	0.8	ND	0.5	ND	0.9	ND	1.0	ND	0.7	ND	0.8	ND	1.4
3,4-dichlorocatechol	ND	7.3	ND	13	ND	17	ND	14	ND	3.5	ND	3.8	ND	2.3	ND	4.3	ND	4.0
3,6-dichlorocatechol	ND	8.7	ND	16	ND	20	ND	16	ND	4.3	ND	4.5	ND	2.8	ND	4.8	ND	4.4
3,5-dichlorocatechol	8.1	7.2	ND	13	ND	17	ND	14	ND	3.5	7.0	3.5	ND	2.2	ND	3.9	ND	3.6
4,5-dichlorocatechol	45	9.4	45	17	39	23	52	18	20	4.5	18	4.9	12	3	15	5.3	13	4.7
2,3,5,6-tetrachlorophenol	ND	1.6	ND	1.8	ND	1.9	ND	1.1	ND	2.3	ND	3.0	ND	1.4	ND	2.2	ND	2.0
2,3,4,6-tetrachlorophenol	ND	1.8	ND	2	ND	2.0	ND	1.2	ND	2.5	ND	3.2	ND	1.5	ND	2.4	ND	2.3
2,3,4,5-tetrachlorophenol	ND	1.1	ND	1.2	ND	1.2	ND	0.8	ND	1.5	ND	1.9	ND	1	ND	1.4	ND	1.3
5-chlorovanillin	ND	2.8	ND	4.1	ND	3.8	ND	2.2	ND	3.7	ND	5.2	ND	2	ND	3.9	ND	4.5
6-chlorovanillin	ND	3.4	ND	5	ND	4.6	ND	2.7	ND	4.6	ND	6.6	ND	2.5	ND	4.2	ND	4.9
3,5-dichlorosyringol	ND	1.9	ND	2.1	ND	1.8	ND	1.3	ND	2.7	ND	2.8	ND	1.7	ND	3.1	ND	3.9
3,4,6-trichloroguaiacol	ND	1.9	ND	2.4	ND	1.6	ND	1.4	ND	3.8	ND	7.8	ND	1.2	ND	3.1	ND	3.6
3,4,5-trichloroguaiacol	6.3	1.8	4.8	2.2	4.5	1.5	4.8	1.3	7.1	3.7	ND	7.6	3.1	1.2	3.6	2.9	5.1	3.4
4,5,6-trichloroguaiacol	ND	1.3	ND	1.6	ND	1.0	ND	0.9	ND	2.5	ND	5.1	ND	0.8	ND	2.2	ND	2.5
3,4,6-trichlorocatechol	ND	1.6	ND	2.1	ND	1.8	ND	1	ND	2.6	ND	3.4	ND	1.9	2.4	2.2	ND	2.7
3,4,5-trichlorocatechol	13	1.3	7.6	1.7	4.5	1.5	3.0	0.8	11	2.1	15	2.9	12	1.5	8.4	1.6	7.6	1.3
5,6-dichlorovanillin	ND	1.5	ND	1.9	ND	1.3	ND	1.1	ND	2.6	ND	3.6	ND	2.6	ND	1.4	ND	1.2
pentachlorophenol	2.2	1.1	ND	2.6	3.2	2.3	3.4	1.2	ND	2.7	ND	4.2	ND	2.2	2.5	2.1	ND	2.4
2-chlorosyringaldehyde	ND	0.6	ND	1.5	ND	1.0	ND	0.8	ND	1.9	ND	2.8	ND	1.8	ND	1.1	ND	0.9
3,4,5,6-tetrachloroguaiacol	NDR(3.1)	1.3	ND	1.8	NDR(2.0)	1.6	2.4	1	ND	2.8	ND	5.0	NDR(1.7)	1.5	NDR(2.1)	1.7	ND	3.0
3,4,5-trichlorosyringol	ND	1.0	ND	1.8	ND	1.4	ND	1.1	ND	3.2	ND	5.8	ND	1.6	ND	1.8	ND	3.5
3,4,5,6-tetrachlorocatechol	3.7	2.8	ND	6.4	ND	5.2	ND	12	ND	4.2	ND	4.1	NDR(2.2)	1.9	NDR(4.6)	3.7	NDR(4.6)	4.2
2,6-dichlorosyringaldehyde	ND	1.5	ND	1.7	ND	2.1	ND	1.6	ND	2.6	ND	4.0	ND	3.2	ND	4.3	ND	4.7

(1) SDL = Sample Detection Limit

(2) ND = Not Detected

(3) NDR = Peak detected but did not meet quantification criteria

(4) Data have not been blank corrected

(5) Chlorocatechols are prone to oxidation reactions, therefore, reported concentrations may not accurately reflect true values.

TABLE 7 PAH Concentrations in Fraser River Whole Water (Marguerite - 1993)

Sampling Date:	March 30, 1993		March 30, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 22, 1993		April 22, 1993	
Sample ID:	MAR-3PH		FRS-9PH (field split of MAR-3PH)		MAR-4PH		FRS-10PH (field split of MAR-4PH)		MAR-5PH		FRS-12PH (field split of MAR-5PH)		MAR-6PH		FRS-14-PH (field split of MAR-6PH)	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL
Naphthalene	NDR(15)	1.4	NDR(11)	0.7	15	1.7	NDR(14)	1.1	NDR(14)	1.7	14	2.2	NDR(12)	1.4	13	1.9
Acenaphthylene	NDR(5.3)	1.4	NDR(2.6)	0.7	NDR(4.2)	1.5	NDR(3.4)	1.4	NDR(2.5)	1.2	NDR(3.2)	2.0	NDR(1.7)	0.8	NDR(2.7)	0.8
Acenaphthene	ND	1.5	ND	0.8	ND	1.9	ND	1.3	3.8	1.9	3.1	2.4	NDR(2.7)	1.5	2.2	2.1
Fluorene	6.3	1.5	3.3	1.3	5.6	1.7	4.3	1.4	4.7	1.6	5.6	1.6	2.3	1.3	4.2	1.3
Phenanthrene	NDR(8.3)	0.7	NDR(5.7)	0.5	11	0.8	NDR(7.5)	0.7	7.0	0.8	7.1	0.9	5.3	0.7	5.9	0.9
Anthracene	NDR(3.3)	0.7	NDR(1.6)	0.5	NDR(3.9)	0.9	2.3	0.8	NDR(3.6)	0.8	3.6	1.0	NDR(1.8)	0.7	NDR(2.6)	1.0
Fluoranthene	5.6	0.4	NDR(2.6)	0.3	6.2	0.4	NDR(4.2)	0.4	4.8	1.0	NDR(3.1)	1.1	NDR(3.3)	0.8	4.1	1.1
Pyrene	NDR(5.3)	0.4	NDR(3.3)	0.3	NDR(7.4)	0.5	3.0	0.4	3.9	1.0	NDR(1.3)	1.1	2.3	0.8	NDR(2.4)	1.1
Benz(a)anthracene	NDR(2.2)	0.6	NDR(1.4)	0.5	ND	2.1	NDR(1.0)	0.7	NDR(2.2)	0.9	NDR(2.0)	0.9	ND	0.8	NDR(3.7)	1.1
Chrysene	NDR(3.8)	0.7	NDR(1.4)	0.5	ND	2.2	NDR(2.2)	0.7	2.5	0.8	NDR(3.8)	0.9	NDR(2.2)	0.7	1.6	0.9
Benzofluoranthenes	NDR(4.4)	0.6	ND	0.5	ND	3.8	ND	0.7	ND	2.4	ND	1.0	ND	2.5	ND	2.6
Benzo(e)pyrene	ND	0.6	ND	0.5	ND	3.6	ND	0.6	ND	2.4	ND	1.0	ND	2.4	ND	2.4
Benzo(a)pyrene	NDR(2.6)	0.7	NDR(1.6)	0.6	ND	4.2	NDR(1.4)	0.7	ND	2.8	ND	1.2	ND	2.9	ND	3.0
Perylene	NDR(2.8)	0.6	NDR(3.6)	0.5	ND	3.4	NDR(2.9)	0.6	ND	2.3	NDR(2.3)	0.9	ND	2.4	ND	2.3
Dibenz(ah)anthracene	ND	3.0	ND	2.6	ND	5.4	ND	3.6	NDR(4.9)	3.5	ND	3.9	ND	4.3	ND	9.6
Indeno(1,2,3-cd)pyrene	NDR(2.6)	1.0	NDR(1.5)	0.8	ND	4.5	NDR(1.4)	1.1	ND	4.1	ND	3.8	ND	5.7	ND	5.6
Benzo(ghi)perylene	NDR(2.4)	0.9	NDR(1.7)	0.7	ND	3.9	NDR(2.0)	1.0	NDR(4.4)	2.9	NDR(3.8)	2.7	ND	4.0	NDR(3.8)	3.6

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have not been blank corrected

TABLE 8 Fatty Acid Concentrations in Fraser River Whole Water (Marguerite - 1993)

Sampling Date:	March 30, 1993		March 30, 1993		March 30, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 22, 1993		April 22, 1993	
Sample ID:	MAR-3CHA		MAR-3CHB (lab duplicate of MAR-3CHA)		FRS-8CH (field split of MAR-3CHA)		MAR-4CH		FRS-11CH (field split of MAR-4CH)		MAR-5CH		FRS-13CH (field split of MAR-5CH)		MAR-6CH		FRS-15CH (field split of MAR-6CH)	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL
Capric	ND	150	ND	150	ND	150	ND	150	ND	150	ND	160	ND	160	ND	1100	ND	340
Lauric	ND	85	ND	85	140	87	130	85	180	85	ND	130	ND	190	ND	1200	ND	380
Myristic	140	92	310	92	850	92	490	92	260	92	ND	340	210	170	ND	1100	ND	360
Palmitic	400	130	700	130	1200	130	1000	130	540	130	ND	1900	1000	650	ND	3500	ND	1300
Linolenic	ND	120	ND	120	ND	120	ND	120	ND	120	ND	120	NDR(290)	200	ND	1300	ND	400
Linoleic/Oleic	ND	100	NDR(320)	100	ND	100	520	100	370	100	ND	270	ND	500	ND	3300	ND	1000
Stearic	390	51	490	57	840	57	670	57	490	57	ND	1300	700	400	ND	2100	ND	800
Arachidic	12	12	22	12	30	12	33	12	22	12	ND	26	37	12	ND	50	ND	18
Behenic	130	5.0	160	5.1	250	5.0	220	5.0	200	5.0	ND	50	240	5	ND	150	91	29
Lignoceric	320	10	400	20	670	20	480	20	420	20	250	50	290	20	ND	220	110	43
Internal Standards	% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery	
D23-LAURIC	57		44		61		64		77		43		130		92		120	
D27-MYRISTIC	65		53		79		67		81		56		150		100		140	
D31-PALMITIC	56		46		79		51		62		63		160		100		160	
D35-STEARIC	40		29		53		29		38		36		120		73		120	
D39-ARACHIDIC	43		26		48		23		36		46		140		86		140	

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

N/A = Not available

Note: Data have been blank corrected where required

Table 9 Resin Acid Concentrations in Fraser River Whole Water (Marguerite - 1993)

Sampling Date:	March 30, 1993		March 30, 1993		March 30, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 15, 1993		April 22, 1993		April 22, 1993	
Sample ID:	MAR-3CHA		MAR-3CHB (lab duplicate of MAR-3CHA)		FRS-8CH (field split of MAR-3CHA)		MAR-4CH		FRS-11CH (field split of MAR-4CH)		MAR-5CHA		MAR-5CHB (lab duplicate of MAR-5CHA)		FRS-13-CH (field split of MAR-5CH)		MAR-8CH		FRS-15CH (field split of MAR-8CH)	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL
Pimaric	34	0.7	29	0.5	42	0.5	58	0.5	41	0.5	NDR(15)	3.9	NDR(20)	7.1	27	5.0	33	5.5	24	3.5
Sandaracopimaric	5.6	0.8	6.5	0.5	8.4	0.8	11	0.5	8.7	0.5	ND	4.3	ND	7.5	ND	5.4	ND	5.9	ND	3.8
Isopimaric	46	2.3	44	1.7	54	1.7	80	1.8	55	1.8	16	13	ND	20	26	20	NDR(29)	21	28	11
Palustic *	75	3.2	78	2.3	80	2.3	78	2.2	76	2.2	NDR(120)	18	NDR(120)	29	NDR(130)	27	NDR(120)	29	NDR(120)	16
Dehydroisopimaric	ND	1.9	ND	1.4	ND	1.4	ND	1.3	ND	1.3	ND	21	ND	26	ND	31	ND	32	ND	18
Dehydroabietic	110	2.8	130	2.0	180	2.2	170	1.9	140	2.0	50	16	64	24	68	24	89	21	65	15
Abietic *	62	8.9	79	2.7	88	2.7	92	8.3	96	2.6	ND	42	ND	58	ND	54	ND	67	ND	35
Neosabietic *	ND	1.2	ND	1.7	ND	1.4	ND	1.1	NDR(2.5)	1.3	ND	6.8	ND	7.1	ND	8.5	ND	8.9	ND	5.3
12/14 Chlorodehydroabietic	33	0.6	34	0.4	38	0.4	18	0.4	12	0.9	ND	6.1	ND	8.1	ND	10	ND	9.4	ND	5.5
12,14 Dichlorodehydroabietic	3.9	1.3	2.2	0.8	4.1	1.0	ND	1	ND	0.7	ND	5.5	ND	11	ND	12	12	11	ND	6.0
Internal Standard	% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery	
o-Methyl Podocarpic	81		116		104		110		130		80		65		57		36		78	

* These compounds are known to be unstable, data should be interpreted cautiously.

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have not been blank corrected

TABLE 10 Dioxin and Furan Concentrations in Fraser River Water Collected By Solid Phase Extraction (Marguerite - 1993)

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Sampling Date:	March 30, 1993		April 7, 1993		April 15, 1993		April 22, 1993	
Sample ID:	797		798		799		800	
Compounds	Concentration (pg/L)	SDL	Concentration (pg/L)	SDL	Concentration (pg/L)	SDL	Concentration (pg/L)	SDL
Dioxins								
T4CDD - Total	ND	0.08	ND	0.07	ND	0.07	0.09	0.05
2,3,7,8	NDR(0.1)	0.08	ND	0.07	ND	0.07	ND	0.05
P5CDD - Total	ND	0.1	ND	0.2	ND	0.2	ND	0.1
1,2,3,7,8	ND	0.1	ND	0.2	ND	0.2	ND	0.1
H6CDD - Total	4.9	0.09	ND	0.2	ND	0.09	ND	0.06
1,2,3,4,7,8	ND	0.09	ND	0.2	ND	0.09	ND	0.06
1,2,3,6,7,8	4.9	0.09	ND	0.2	ND	0.09	ND	0.06
1,2,3,7,8,9	ND	0.09	ND	0.2	ND	0.09	ND	0.06
H7CDD - Total	ND	0.2	ND	0.1	ND	0.1	ND	0.1
1,2,3,4,6,7,8	ND	0.2	ND	0.1	ND	0.1	ND	0.1
O8CDD	ND	0.6	0.4	0.2	0.4	0.2	0.3	0.2
Furans								
T4CDF - Total	ND	0.05	ND	0.06	ND	0.05	ND	0.04
2,3,7,8	ND	0.05	ND	0.06	ND	0.05	ND	0.04
P5CDF - Total	ND	0.1	ND	0.1	ND	0.08	ND	0.06
1,2,3,7,8	ND	0.1	ND	0.1	ND	0.08	ND	0.06
2,3,4,7,8	ND	0.1	ND	0.1	ND	0.08	ND	0.06
H6CDF - Total	ND	0.08	ND	0.1	ND	0.1	ND	0.07
1,2,3,4,7,8	ND	0.08	ND	0.1	ND	0.1	ND	0.07
1,2,3,6,7,8	NDR(0.08)	0.08	ND	0.1	ND	0.1	ND	0.07
2,3,4,6,7,8	ND	0.08	ND	0.1	ND	0.1	ND	0.07
1,2,3,7,8,9	ND	0.08	ND	0.1	ND	0.1	ND	0.07
H7CDF - Total	ND	0.2	ND	0.2	ND	0.1	ND	0.1
1,2,3,4,6,7,8	ND	0.2	ND	0.2	ND	0.1	ND	0.1
1,2,3,4,7,8,9	ND	0.2	ND	0.2	ND	0.1	ND	0.1
O8CDF	ND	0.6	ND	0.2	ND	0.2	ND	0.3
Lab Surrogates								
13C-T4CDD	84		80		90		120	
13C-T4CDF	76		81		100		130	
13C-P5CDD:	76		77		90		120	
13C-H6CDD:	65		66		74		86	
13C-H7CDD:	55		64		81		90	
13C-O8CDD:	30		45		69		58	
Field Surrogates								
13C6-1,2,3,4-T4CDD	88		23		73		54	
13C-1,2,3,7,8,9-H6CDD	40		12		44		30	

SDL = Sample Detection Limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

TABLE 11 PAH Concentrations in Fraser River Water Collected By Solid Phase Extraction (Marguerite - 1993)

Sampling Date:	March 30, 1993		April 7, 1993		April 15, 1993		April 22, 1993	
Sample ID:	797		798		799		800	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL
Naphthalene	10	0.1	12	0.1	24	0.1	19	0.1
Acenaphthylene	NDR(0.1)	0.1	NDR(0.1)	0.1	NDR(0.2)	0.1	NDR(0.1)	0.1
Acenaphthene	0.3	0.1	0.3	0.1	0.5	0.1	1.1	0.1
Fluorene	0.3	0.1	0.4	0.1	0.5	0.1	0.8	0.1
Phenanthrene	NDR(0.6)	0.1	NDR(0.8)	0.1	1.1	0.1	1.2	0.1
Anthracene	NDR(0.2)	0.1	NDR(0.1)	0.1	ND	0.1	NDR(0.1)	0.1
Fluoranthene	NDR(0.2)	0.1	0.4	0.1	NDR(0.4)	0.1	0.4	0.1
Pyrene	NDR(0.2)	0.1	NDR(0.3)	0.1	NDR(0.2)	0.1	NDR(0.3)	0.1
Benz(a)anthracene	ND	0.1	ND	0.1	ND	0.1	ND	0.1
Chrysene	ND	0.1	ND	0.1	ND	0.1	ND	0.1
Benzofluoranthenes	ND	0.1	ND	0.1	ND	0.2	ND	0.1
Benzo(e)pyrene	ND	0.1	ND	0.1	ND	0.2	ND	0.1
Benzo(a)pyrene	ND	0.1	ND	0.1	ND	0.3	ND	0.1
Perylene	ND	0.1	ND	0.1	ND	0.2	ND	0.1
Dibenz(ah)anthracene	ND	0.4	ND	0.3	ND	0.6	ND	0.2
Indeno(1,2,3-cd)pyrene	ND	0.3	ND	0.2	ND	0.4	ND	0.2
Benzo(ghi)perylene	ND	0.2	ND	0.1	ND	0.3	ND	0.2

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

APPENDIX III

Laboratory QA/QC Data

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TABLE 1 Laboratory QA/QC Reference Table for Fraser River Suspended Sediments (Marguerite - 1993)

Contaminant Type	Sampling Date	Sample ID	Lab Blank ID	Lab Spike ID	Lab Reference ID
PAHs	March 30, 1993	MAR-3CA	SBLK 397		CCRM 89
		MAR-3CB	SBLK 397		CCRM 89
		FRS-10C	SBLK 397		CCRM 89
	April 7, 1993	MAR-4C	SBLK 398		SCRM 90
		FRS-12CA	SBLK 398		SCRM 90
		FRS-12CB	SBLK 398		SCRM 90
	April 15, 1993	MAR-5C	SBLK 398		SCRM 90
		FRS-14C	SBLK 398		SCRM 90
CHLOROPHENOLS	March 30, 1993	MAR-6C	SBLK 398		SCRM 90
		FRS-16C	SBLK 398		SCRM 90
	April 7, 1993	MAR-3C	SBLK 267	SSPM 165	
		FRS-10C	SBLK 267	SSPM 165	
	April 15, 1993	MAR-4C	SBLK 265, 267, 281	SSPM 165, 194	
		FRS-12C	SBLK 265	2836-61	
DIOXINS/FURANS	March 30, 1993	MAR-5C	SBLK 265	2836-61	
		FRS-14C	SBLK 265	2836-61	
	April 7, 1993	MAR-6C	SBLK 265	2836-61	
		FRS-16C	SBLK 265	2836-61	
	April 15, 1993	MAR-3CA	SBLK 838	SSPM 106	
		MAR-3CB	SBLK 838	SSPM 106	
		FRS-10C	SBLK 838	SSPM 106	
	March 30, 1993	MAR-4C	SBLK 849	SSPM 109	
		FRS-12C	SBLK 849	SSPM 109	
	April 7, 1993	MAR-5C	SBLK 849	SSPM 109	
		FRS-14C	SBLK 849	SSPM 109	
	April 15, 1993	MAR-6C	SBLK 849	SSPM 109	
		FRS-16C	SBLK 849	SSPM 109	

TABLE 2 Analytical Quality Control Results for Dioxins and Furans - Laboratory Sediment Blanks and Spikes

QA/QC Lab Blanks or Spikes	SBLK 838		SBLK 849		SSPM 106	SSPM 109
Compounds	Concentration (pg/g)	SDL	Concentration (pg/g)	SDL	% Recovery	% Recovery
Dioxins						
T4CDD - Total	ND	0.1	ND	0.1	N/A	N/A
2,3,7,8	ND	0.1	ND	0.1	110	97
P5CDD - Total	ND	0.2	ND	0.2	N/A	N/A
1,2,3,7,8	ND	0.2	ND	0.2	110	90
H6CDD - Total	ND	0.3	ND	0.2	N/A	N/A
1,2,3,4,7,8	ND	0.3	ND	0.2	110	94
1,2,3,6,7,8	ND	0.3	ND	0.2	130	94
1,2,3,7,8,9	ND	0.3	ND	0.2	93	81
H7CDD - Total	ND	0.4	ND	0.2	N/A	N/A
1,2,3,4,6,7,8	ND	0.4	ND	0.2	110	94
O8CDD	ND	0.9	0.8	0.2	93	90
Furans						
T4CDF - Total	ND	0.1	ND	0.1	N/A	N/A
2,3,7,8	ND	0.1	ND	0.1	110	100
P5CDF - Total	ND	0.2	ND	0.1	N/A	N/A
1,2,3,7,8	ND	0.2	ND	0.1	110	100
2,3,4,7,8	ND	0.2	ND	0.1	100	100
H6CDF - Total	ND	0.3	ND	0.2	N/A	N/A
1,2,3,4,7,8	ND	0.3	ND	0.2	100	100
1,2,3,6,7,8	ND	0.3	ND	0.2	110	100
2,3,4,6,7,8	ND	0.3	ND	0.2	110	90
1,2,3,7,8,9	ND	0.3	ND	0.2	98	95
H7CDF - Total	ND	0.4	ND	0.2	N/A	N/A
1,2,3,4,6,7,8	ND	0.4	ND	0.2	100	110
1,2,3,4,7,8,9	ND	0.4	ND	0.2	77	100
O8CDF	ND	0.9	0.6	0.3	110	100
Surrogate Standard	% Recovery		% Recovery		% Recovery	% Recovery
14C-T4CDD	60		95		N/A	N/A
13C-T4CDF	63		100		N/A	N/A
13C-P5CDD	58		86		N/A	N/A
13C-H6CDD	47		79		N/A	N/A
13C-H7CDD	36		75		N/A	N/A
13C-O8CDD	17		52		N/A	N/A

SDL = Sample Detection Limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

N/A = Not available

TABLE 3 Analytical Quality Control Results for Chlorophenolics - Laboratory Sediment Blanks and Spikes

QA/QC Lab Blank or Spike	SBLK 265		SBLK 267		SBLK 281		SSPM 165		SSPM 172		SSPM 194		2836-61	
Compounds	Concentration (ng/g)	SDL	Concentration (ng/g)	SDL	Concentration (ng/g)	SDL	Determined (ng/g)	Expected (ng/g)	Determined (ng/g)	Expected (ng/g)	Determined (ng/g)	Expected (ng/g)	Determined (ng/g)	Expected (ng/g)
4-chlorophenol	ND	0.6	ND	0.6	ND	1	83	100	100	100	98	100	9.1	10
2,6-dichlorophenol	ND	0.5	ND	1.6	ND	0.9	84	98	100	98	80	98	7.8	10
2,4/2,5-DCP	ND	0.4	ND	1.1	ND	1.3	160	200	180	200	190	200	18	20
3,5-dichlorophenol	ND	0.4	ND	1.5	ND	0.8	91	110	92	110	98	110	9.9	10
2,3-dichlorophenol	ND	0.4	ND	1.4	ND	0.7	120	130	110	130	110	130	11	13
3,4-dichlorophenol	ND	0.3	ND	0.9	ND	0.5	100	100	85	100	100	100	9.6	10
6-chloroguaiacol	ND	0.9	ND	0.6	ND	1.1	78	100	88	100	72	100	7.3	5.9
4-chloroguaiacol	ND	1.1	ND	0.8	ND	1.3	140	140	140	140	140	140	14	14
5-chloroguaiacol	ND	1.1	ND	0.7	ND	1.3	100	100	99	100	130	100	12	10
2,4,6-trichlorophenol	ND	0.3	ND	1.9	ND	0.9	310	300	30	300	330	300	32	30
2,3,6-trichlorophenol	ND	0.3	ND	1.6	ND	0.7	65	78	55	78	69	78	6.5	7.8
2,3,5-trichlorophenol	ND	0.3	ND	1.6	ND	0.7	89	100	76	100	99	100	8.9	9.8
2,4,5-trichlorophenol	ND	0.2	ND	0.9	ND	0.5	120	130	120	130	130	130	12	12
2,3,4-trichlorophenol	ND	0.2	ND	1.1	ND	0.6	120	110	87	110	120	110	8.8	11
3,4,5-trichlorophenol	ND	0.2	ND	1.1	ND	0.5	82	80	67	80	88	80	7.5	7.9
3-chlorocatechol	ND	0.6	ND	2	ND	0.8	28	110	17	110	12	110	1.7	3.3
4-chlorocatechol	ND	0.9	ND	3.2	ND	1.2	38	110	20	110	21	110	1.6	5.9
3,4/4,6-dichloroguaiacol	ND	0.3	ND	0.7	ND	0.3	260	200	77	100	110	200	7.1	7
4,5-dichloroguaiacol	ND	0.3	ND	1.4	ND	0.6	150	110	82	110	92	110	9.7	12
3-chlorosyringol	ND	0.1	ND	0.8	ND	0.4	56	110	29	110	5.7	110	1.2	17
3,4-dichlorocatechol	ND	4	ND	1.3	ND	1.2	110	110	110	110	170	160	11	11
3,6-dichlorocatechol	ND	4.8	ND	1.6	ND	1.5	110	110	110	110	190	170	15	11
3,5-dichlorocatechol	ND	4	ND	1.3	ND	1.2	110	106	80	110	160	150	14	10
4,5-dichlorocatechol	ND	5.4	ND	1.7	ND	1.6	110	100	100	100	210	190	31	61
2,3,5,6-tetrachlorophenol	ND	0.5	ND	1.4	ND	1	240	330	310	330	240	330	25	24
2,3,4,6-tetrachlorophenol	ND	0.6	ND	1.6	ND	1.1	230	240	290	240	230	240	24	24
2,3,4,5-tetrachlorophenol	ND	0.4	ND	1.1	ND	0.7	130	180	160	180	160	180	15	17
5-chlorovanillin	ND	13	ND	9	ND	12	120	120	130	120	78	120	11	11
6-chlorovanillin	ND	15	ND	11	ND	15	290	120	240	120	170	120	30	52
3,5-dichlorosyringol	ND	0.5	ND	1.7	ND	1.4	220	430	270	310	82	430	12	15
3,4,6-trichloroguaiacol	ND	0.6	ND	1	ND	0.8	66	100	94	100	77	100	7.8	70
3,4,5-trichloroguaiacol	ND	0.6	ND	1.1	ND	0.8	170	210	190	210	240	210	22	22
4,5,6-trichloroguaiacol	ND	0.4	ND	0.7	ND	0.6	120	130	120	130	120	130	12	11
3,4,6-trichlorocatechol	ND	0.5	ND	1.7	ND	1	48	140	30	140	57	140	4	9.9
3,4,5-trichlorocatechol	ND	0.5	ND	1.4	ND	0.9	280	230	59	230	99	230	13	21
5,6-dichlorovanillin	ND	0.4	ND	1.8	ND	1	100	160	71	290	25	22	9.4	4.6
pentachlorophenol	ND	0.7	ND	1.7	ND	1.4	500	500	520	500	500	500	50	47
2-chlorosyringaldehyde	ND	0.3	ND	1.1	ND	0.7	35	91	32	160	5.7	29	3	9
3,4,5,6-tetrachloroguaiacol	ND	0.3	ND	1.2	ND	0.9	320	350	330	350	330	350	32	35
3,4,5-trichlorosyringol	ND	0.5	ND	1.5	ND	0.8	240	300	230	300	130	300	17	30
3,4,5,6-trichlorocatechol	ND	3.4	ND	2.2	ND	2.1	200	100	150	100	160	100	12	31
2,6-dichlorosyringaldehyde	ND	2.9	ND	2.8	ND	2.2	900	410	670	410	40	44	47	41

(1) SDL = Sample Detection Limit

(2) ND = Not Detected

(3) NDR = Peak detected but did not meet quantification criteria

(4) Data have not been blank corrected

(5) Reactive compounds such as chlorocatechols, chloroguaiacols, chlorosyringols, chlorosyringaldehydes and chlorovanillins may not be accurately quantified due to degradative oxidation reactions

(6) 3,4/4,6 dichloroguaiacol are reported as a co-eluting pair due to sample matrix effects

TABLE 4 Analytical Quality Control Results for PAHs - Laboratory Sediment Blanks and Spikes

QA/QC Lab Blanks or References	SBLK 397		SBLK 398		CCRM 89		CCRM 90	
Compounds	Concentration (ng/g)	SDL	Concentration (ng/g)	SDL	Determined (ng/g)	Expected (ng/g)	Determined (ng/g)	Expected (ng/g)
Naphthalene	NDR(2.5)	0.3	3.6	0.7	3300	4100 +/- 1100	4300	4100 +/- 1100
Acenaphthylene	NDR(0.8)	0.5	NDR(1.0)	0.6	270	190 +/- 50	440	190 +/- 50
Acenaphthene	1.6	0.6	ND	0.8	110	230 +/- 70	130	230 +/- 70
Fluorene	2.1	0.7	NDR(1.4)	0.6	390	470 +/- 120	470	470 +/- 120
Phenanthrene	2.6	0.2	NDR(1.6)	0.3	2600	3000 +/- 600	3100	3000 +/- 600
Anthracene	NDR(1.2)	0.3	NDR(0.7)	0.3	720	1100 +/- 400	820	1100 +/- 400
Fluoranthene	1.8	0.2	0.8	0.1	2900	3540 +/- 650	3500	3540 +/- 650
Pyrene	1.5	0.2	NDR(0.6)	0.1	2400	3000 +/- 600	2500	3000 +/- 600
Benz(a)anthracene	1.3	0.5	NDR(0.6)	0.4	1500	1800 +/- 300	1600	1800 +/- 300
Chrysene	1.3	0.5	0.8	0.4	2200	2000 +/- 300	2300	2000 +/- 300
Benzofluoranthenes	NDR(2.3)	0.5	ND	0.4	4400	4230 +/- 750	5000	4230 +/- 750
Benzo(e)pyrene	NDR(1.1)	0.5	ND	0.4	1700		1800	
Benzo(a)pyrene	NDR(1.4)	0.6	NDR(0.7)	0.5	1500	2200 +/- 400	1600	2200 +/- 400
Perylene	NDR(1.0)	0.5	NDR(0.6)	0.4	440		430	
Dibenz(ah)anthracene	NDR(6.1)	1.8	ND	1.3	430	490 +/- 160	450	490 +/- 160
Indeno(1,2,3-cd)pyrene	NDR(2.2)	1.3	ND	0.9	2200	1950 +/- 580	2100	1950 +/- 580
Benzo(ghi)perylene	NDR(2.7)	1.0	NDR(0.7)	0.6	1600	1780 +/- 720	1500	1780 +/- 720

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

TABLE 5 Laboratory QA/QC Reference Table for Fraser River Whole Water (Marguerite - 1993)

Contaminant Type	Sampling Date	Sample ID	Lab Blank ID	Lab Spike ID
PAHs	March 30, 1993	MAR-3PH	WBLK 385	WSPB 153
		FRS-9PH	WBLK 385	WSPB 153
		FRS-8PH	WBLK 385	WSPB 153
		FRS-11PHA	WBLK 385	WSPB 153
	April 7, 1993	MAR-4PH	WBLK 385	WSPB 153
		FRS-10PH	WBLK 385	WSPB 153
		FRS-11PHB	WBLK 385	WSPB 153
		FRS-11PHB	WBLK 385	WSPB 153
	April 15, 1993	MAR-5PH	WBLK 396	WSPB 159
		FRS-12PH	WBLK 396	WSPB 159
		FRS-13PH	WBLK 396	WSPB 159
	April 22, 1993	MAR-6PH	WBLK 396	WSPB 159
		FRS-14PH	WBLK 396	WSPB 159
		FRS-15PH	WBLK 396	WSPB 159
CHLOROPHENOLS	March 30, 1993	MAR-3CH	WBLK 264	WSPM 156
		FRS-8CH	WBLK 264	WSPM 156
		FRS-9CH	WBLK 264	WSPM 156
		FRS-10CH	WBLK 264	WSPM 156
	April 7, 1993	MAR-4CH	WBLK 264	WSPM 156
		FRS-11CH	WBLK 264	WSPM 156
		FRS-12CH	WBLK 268	WSPM 166
	April 15, 1993	MAR-5CH	WBLK 268	WSPM 166
		FRS-13CH	WBLK 268	WSPM 166
		FRS-14CH	WBLK 268	WSPM 166
	April 22, 1993	MAR-6CH	WBLK 268	WSPM 166
		FRS-15CH	WBLK 275	WSPM 175
		FRS-16CH	WBLK 268	WSPM 166
FATTY ACIDS	March 30, 1993	MAR-3CH	WBLK 85	WSPM 177
		FRS-8CH	WBLK 85	WSPM 177
		FRS-9CH	WBLK 85	WSPM 177
		FRS-10CH	WBLK 85	WSPM 177
	April 7, 1993	MAR-4CH	WBLK 85	WSPM 177
		FRS-11CH	WBLK 85	WSPM 177
		FRS-12CH	WBLK 96 & WBLK 97	WSPM 194
	April 15, 1993	MAR-5CH	WBLK 96 & WBLK 97	WSPM 194
		FRS-13CH	WBLK 98 & WBLK 99	WSPM 195
		FRS-14CH	WBLK 98 & WBLK 99	WSPM 195
	April 22, 1993	MAR-6CH	WBLK 98 & WBLK 99	WSPM 194
		FRS-15CH	WBLK 98 & WBLK 99	WSPM 195
		FRS-16CH	WBLK 98 & WBLK 99	WSPM 195
RESIN ACIDS	March 30, 1993	MAR-3CH	WBLK 85	WSPM 177
		FRS-8CH	WBLK 85	WSPM 177
		FRS-9CH	WBLK 85	WSPM 177
		FRS-10CH	WBLK 85	WSPM 177
	April 7, 1993	MAR-4CH	WBLK 85	WSPM 177
		FRS-11CH	WBLK 85	WSPM 177
		FRS-12CH	WBLK 88	WSPM 184
	April 15, 1993	MAR-5CHA	WBLK 88	WSPM 184
		MAR-5CHB	WBLK 88	WSPM 184
		FRS-13CH	WBLK 88	WSPM 184
		FRS-14CH	WBLK 88	WSPM 184
	April 22, 1993	MAR-6CH	WBLK 88	WSPM 184
		FRS-15CH	WBLK 88	WSPM 184
		FRS-16CH	WBLK 88	WSPM 184

TABLE 6 Analytical Quality Control Results for Polycyclic Aromatic Hydrocarbons in Laboratory Water Blanks and Spikes

QA/AC Lab Blanks or Spikes	WBLK 385		WBLK 396		WSPM 153		WSPM 159	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Determined (ng/L)	Expected (ng/L)	Determined (ng/L)	Expected (ng/L)
Naphthalene	NDR(19)	3.2	NDR(14)	1.3	2200	2350	2500	2300
Acenaphthylene	NDR(9.1)	3.4	NDR(2.8)	1.3	2300	2000	2600	2000
Acenaphthene	ND	2.2	3.6	1.3	2100	2300	2400	2300
Fluorene	12	3.3	4.3	0.8	3400	2540	4100	2500
Phenanthrene	12	0.8	5.8	0.5	2200	2400	2400	2400
Anthracene	NDR(5.4)	0.9	NDR(3.6)	0.6	2200	2500	2300	2500
Fluoranthene	NDR(9.4)	0.4	NDR(5.2)	0.6	2700	2500	2900	2500
Pyrene	5.0	0.5	NDR(3.8)	0.6	1900	2100	2100	2100
Benz(a)anthracene	NDR(2.8)	0.7	NDR(3.5)	0.5	1800	2100	2100	2100
Chrysene	NDR(4.1)	0.7	NDR(4.4)	0.5	1900	2100	2100	2100
Benzofluoranthenes	NDR(4.1)	0.6	NDR(3.4)	0.6	2600	2700	2900	2700
Benzo(e)pyrene	NDR(2.2)	0.5	NDR(1.5)	0.5	2300	2200	2500	2200
Benzo(a)pyrene	NDR(3.3)	0.7	NDR(2.4)	0.7	1800	1900	2000	1900
Perylene	ND	0.6	NDR(3.2)	0.6	2100	2100	2200	2100
Dibenz(ah)anthracene	NDR(3.9)	2.9	NDR(6.9)	1.2	2400	2400	1900	2400
Indeno(1,2,3-cd)pyrene	NDR(3.1)	0.9	NDR(5.4)	1.2	1800	1800	2000	1800
Benzo(ghi)perylene	NDR(2.5)	0.8	NDR(4.7)	0.8	2000	2100	2100	2100

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria



TABLE 7 Analytical Quality Control Results for Chlorophenolics - Laboratory Water Blanks and Spikes

QA/QC Lab Blanks or Spikes	WBLK 264		WBLK 268		WBLK 275		WSPM 156		WSPM 166		WSPM 175	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Determined (ng/L)	Expected (ng/L)	etermined (ng/L)	Expected (ng/L)	etermined (ng/L)	Expected (ng/L)
4-chlorophenol	ND	2.2	ND	1	ND	8.2	98	100	100	100	93	100
2,6-dichlorophenol	ND	5.1	ND	2	ND	8.9	99	98	100	98	98	98
2,4/2,5-DCP	ND	3.9	ND	1.4	ND	6.4	200	200	190	200	190	200
3,5-dichlorophenol	ND	4.8	ND	1.7	ND	8	130	110	120	110	100	110
2,3-dichlorophenol	ND	4.4	ND	1.6	ND	7.5	130	130	130	130	120	130
3,4-dichlorophenol	ND	3	ND	1.1	ND	4.6	130	100	120	100	100	100
6-chloroguaiacol	ND	1.8	ND	0.8	ND	4.6	160	100	110	100	150	100
4-chloroguaiacol	ND	2.1	ND	1	ND	5.4	160	140	180	140	140	140
5-chloroguaiacol	ND	2.1	ND	1	ND	5.4	120	100	110	100	120	100
2,4,6-trichlorophenol	ND	2.1	ND	1.6	ND	4.5	340	300	340	300	320	300
2,3,6-trichlorophenol	ND	1.7	ND	1.3	ND	3.2	78	78	66	78	58	78
2,3,5-trichlorophenol	ND	1.7	ND	1.3	ND	3.3	100	100	92	100	83	100
2,4,5-trichlorophenol	ND	1.1	ND	1.1	ND	2.5	130	130	120	130	120	130
2,3,4-trichlorophenol	ND	1.1	ND	1.1	ND	2.1	120	110	110	110	95	110
3,4,5-trichlorophenol	ND	1.2	ND	1.2	ND	2.3	93	80	90	80	76	80
3-chlorocatechol	ND	3	ND	2.4	ND	4.2	20	46	32	110	63	46
4-chlorocatechol	ND	4.6	ND	3.6	ND	6	5.6	28	17	110	48	28
3,4-dichloroguaiacol	ND	2.1	ND	1.1	ND	3.5	92	100	120	100	63	100
4,6-dichloroguaiacol	ND	2.7	ND	1.5	ND	4.3	66	100	88	100	56	100
4,5-dichloroguaiacol	ND	2.3	ND	1.2	ND	3.3	74	110	120	110	50	110
3-chlorosyringol	ND	1.1	ND	0.7	ND	1.6	58	110	120	110	39	110
3,4-dichlorocatechol	ND	3.1	ND	2.5	ND	2.3	140	110	170	110	140	110
3,6-dichlorocatechol	ND	3.6	ND	3	ND	2.6	160	100	180	110	140	110
3,5-dichlorocatechol	ND	3	ND	2.4	ND	2.1	150	100	210	100	140	100
4,5-dichlorocatechol	ND	4	ND	3	ND	2.8	110	100	110	100	140	100
2,3,5,6-tetrachlorophenol	ND	1.8	ND	2.5	ND	3.4	290	330	230	330	230	330
2,3,4,6-tetrachlorophenol	ND	1.9	ND	2.7	ND	3.8	250	240	230	240	250	240
2,3,4,5-tetrachlorophenol	ND	1.2	ND	1.6	ND	2.2	170	180	160	180	160	180
5-chlorovanillin	ND	2.1	ND	2.7	ND	15	130	120	140	120	150	120
6-chlorovanillin	ND	2.5	ND	3.2	ND	16	140	120	130	120	160	120
3,5-dichlorosyringol	ND	2.2	ND	1.9	ND	4.1	350	430	460	430	260	430
3,4,6-trichloroguaiacol	ND	1.5	ND	1.2	ND	4	100	100	70	100	110	100
3,4,5-trichloroguaiacol	ND	1.5	ND	1.2	ND	3.8	100	210	170	210	190	210
4,5,6-trichloroguaiacol	ND	1	ND	0.8	ND	2.8	130	130	120	130	130	130
3,4,6-trichlorocatechol	ND	1.3	ND	1.6	ND	2.5	18	29	46	140	130	29
3,4,5-trichlorocatechol	ND	1	ND	1.4	NDR(3.2)	1.9	70	87	130	230	210	87
5,6-dichlorovanillin	ND	1.3	ND	2.3	3.2	1.9	250	290	480	290	190	290
pentachlorophenol	ND	1.9	ND	2.6	ND	3.2	530	500	530	500	510	500
2-chlorosyringaldehyde	ND	0.6	ND	1.1	ND	1.2	150	160	330	160	110	160
3,4,5,6-tetrachloroguaiacol	ND	0.8	ND	1	ND	3.8	340	350	340	350	330	350
3,4,5-trichlorosyringol	ND	1	ND	1.3	ND	3	240	300	360	300	190	300
3,4,5,6-tetrachlorocatechol	ND	2.5	ND	2.2	ND	5.9	19	21	90	100	110	21
2,6-dichlorosyringaldehyde	ND	1.3	ND	1.7	ND	4.8	370	410	580	410	310	410

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

TABLE 8 Analytical Quality Control Results for Fatty Acids - Laboratory Water Blanks and Spikes

QA/QC Lab Blanks or Spikes	WBLK 85		WBLK 96		WBLK 97		WBLK 98		WBLK 99		WSPM 177		WSPM 194		WSPM 195	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Determined (ng/L)	Expected (ng/L)	Determined (ng/L)	Expected (ng/L)	Determined (ng/L)	Expected (ng/L)
Capric	ND	5	100	3.4	89	3	NDR(14)	4.1	68	5.5	1500	1500	2200	2570	440	420
Lauric	10	3.1	230	2.9	220	2.7	190	2.9	180	4.1	2300	2300	5000	3369	520	520
Myristic	16	2.3	340	3.6	320	3.4	180	2.1	180	3.4	2200	1900	3500	2596	510	460
Palmitic	25	1.7	2600	7.6	2400	6.5	650	3.7	620	6.5	2100	1600	3100	2676	310	430
Linolenic	ND	10	NDR(180)	17	NDR(180)	18	NDR(200)	12	NDR(2200)	22	2500	2500	4100	4350	760	570
Linoleic/Oleic	ND	14	250	42	270	44	500	27	550	51	4400	5000	6600	6686	600	500
Stearic	20	3.5	1600	11	1500	11	390	5.3	410	10	2000	2000	3400	2564	570	470
Arachidic	ND	1	25	13	24	20	9.2	7.2	ND	9.9	2100	2000	4000	3023	130	600
Behenic	ND	2.8	ND	30	ND	34	ND	16	ND	28	1800	1900	3500	2740	430	420
Lignoceric	ND	8.6	51	34	53	50	ND	18	ND	34	1300	1600	3600	3135	530	560
Internal Standards	% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery		% Recovery	
D23-LAURIC	40		75		88		61		69		54		54		N/A	
D27-MYRISTIC	51		83		98		89		86		67		67		N/A	
D31-PALMITIC	49		61		82		100		97		63		63		N/A	
D35-STEARIC	37		58		69		87		75		69		69		N/A	
D39-ARACHIDIC	52		87		97		101		95		65		65		N/A	

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have been blank corrected where required

TABLE 9 Analytical Quality Control Results for Resin Acids - Laboratory Water Blanks and Spikes

QA/QC Lab Blanks or Spikes	WBLK 85		WBLK 88		WSPM 177		WSPM 184	
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	Determined (ng/L)	Expected (ng/L)	Determined (ng/L)	Expected (ng/L)
Pimaric	ND	1.2	ND	2.3	360	370	500	420
Sandaracopimaric	ND	1.3	ND	2.5	480	510	600	510
Isopimaric	ND	3.8	ND	14	400	410	520	460
Palustric *	ND	5.3	ND	20	330	400	300	430
Dehydroisopimaric	NDR(70)	3.1	NDR(130)	22	480	510	720	570
Dehydroabietic	ND	4.8	ND	11	540	490	630	500
Abietic *	ND	9.7	ND	38	320	390	81	470
Neoabietic *	ND	1.3	ND	6.6	180	410	NA	NA
12/14 Chlorodehydroabietic	ND	1	ND	5.4	340	340	470	560
12,14 Dichlorodehydroabietic	ND	1.4	ND	6.6	400	450	650	420
Internal Standard	% Recovery		% Recovery		% Recovery		% Recovery	
o-Methyl Podocarpic	57		77		65		51	

* These compounds are known to be unstable, data should be interpreted cautiously.

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

NA = Not available

Note: Data have not been blank corrected.

TABLE 10 Laboratory QA/QC Reference Table for Solid Phase Extracted Fraser River Water

Contaminant Type	Sampling Date	Sample ID	Lab Blank ID	Lab Spike ID
PAHs	March 30, 1993	797	CBLK 383	CSPM 151
	April 7, 1993	798	CBLK 383	CSPM 151
	April 15, 1993	799	CBLK 383	CSPM 151
	April 22, 1993	800	CBLK 383	CSPM 151
DIOXINS/FURANS	March 30, 1993	797	CBLK 901	CSPM 220 CSPM323
	April 7, 1993	798	CBLK 901	CSPM 220 CSPM323
	April 15, 1993	799	CBLK 901	CSPM 220 CSPM323
	April 22, 1993	800	CBLK 901	CSPM 220 CSPM323

TABLE 11 Analytical Quality Control Results for Dioxins and Furans - Laboratory Solid Phase Extraction Column Blanks, Spikes and Proofs

QA/QC Lab Blank Spike, or Proof	CBLK 901		CUSM 301		CSPM 220	CSPM 323	COMPOSITE COLUMN PROOF (797, 798, 799, 800)	
Compounds	Concentration (pg/L)	SDL	Concentration (pg/L)	SDL	% Recovery	% Recovery	Concentration (pg/L)	SDL
Dioxins								
T4CDD - Total	ND	0.08	ND	0.03	N/A	N/A	ND	0.02
2,3,7,8	ND	0.08	ND	0.03	110	97	ND	0.02
P5CDD - Total	ND	0.1	ND	0.05	N/A	N/A	ND	0.02
1,2,3,7,8	ND	0.1	ND	0.05	95	92	ND	0.02
H6CDD - Total	ND	0.1	ND	0.07	N/A	N/A	ND	0.04
1,2,3,4,7,8	ND	0.1	ND	0.07	110	97	ND	0.04
1,2,3,6,7,8	ND	0.1	ND	0.07	100	78	ND	4
1,2,3,7,8,9	NDR(0.2)	0.1	ND	0.07	100	90	ND	0.04
H7CDD - Total	0.2	0.09	ND	0.06	N/A	N/A	ND	0.03
1,2,3,4,6,7,8	0.2	0.09	ND	0.06	89	87	ND	0.03
O8CDD	0.5	0.2	ND	0.1	100	120	0.7	0.02
Furans								
T4CDF - Total	0.07	0.05	ND	0.03	N/A	N/A	ND	0.01
2,3,7,8	0.07	0.05	ND	0.03	95	100	ND	0.01
P5CDF - Total	ND	0.09	ND	0.04	N/A	N/A	ND	0.01
1,2,3,7,8	NDR(0.1)	0.09	ND	0.04	90	91	ND	0.01
2,3,4,7,8	ND	0.09	ND	0.04	95	110	ND	0.01
H6CDF - Total	0.2	0.05	ND	0.07	N/A	N/A	ND	0.01
1,2,3,4,7,8	0.1	0.05	ND	0.07	90	99	ND	0.01
1,2,3,6,7,8	0.1	0.05	ND	0.07	100	110	ND	0.01
2,3,4,6,7,8	NDR(0.1)	0.05	ND	0.07	90	94	ND	0.01
1,2,3,7,8,9	NDR(0.3)	0.05	ND	0.07	95	110	ND	0.01
H7CDF - Total	0.2	0.1	ND	0.05	N/A	N/A	ND	0.04
1,2,3,4,6,7,8	0.2	0.1	ND	0.05	94	92	ND	0.04
1,2,3,4,7,8,9	NDR(0.2)	0.1	ND	0.05	100	92	ND	0.04
O8CDF	ND	0.3	ND	0.2	100	93	0.05	0.03
Surrogate Standard	% Recovery		% Recovery		% Recovery	% Recovery	% Recovery	
13C-T4CDF:	79		82		100	80	114	
13C-T4CDD:	90		90		96	91	94	
13C-P5CDF:	N/A		92		N/A	85	N/A	
13C-P5CDD:	87		100		103	94	109	
13C-H6CDF:	N/A		93		N/A	58	N/A	
13C-H6CDD:	74		86		101	85	78	
13C-H7CDF:	N/A		80		N/A	94	N/A	
13C-H7CDD:	76		93		105	110	93	
13C-O8CDD:	50		80		81	73	90	

SDL = Sample Detection Limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

N/A = Not available

TABLE 12 Analytical Quality Control Results for PAHs - Laboratory Solid Phase Extraction Column Blanks, Spikes and Proofs

QA/QC Lab Blank, Proof or Spike	CBLK 383		COMPOSITE COLUMN PROOF (797, 798, 800, 802)		CSPM 151
Compounds	Concentration (ng/L)	SDL	Concentration (ng/L)	SDL	% Recovery
Naphtalene	NDR(0.7)	0.1	ND	15	92
Acenaphthylene	ND	0.1	ND	3	100
Acenaphthene	ND	0.1	ND	3	100
Fluorene	ND	0.1	ND	5	96
Phenanthrene	NDR(0.1)	0.1	ND	5	96
Anthracene	ND	0.1	ND	2	96
Fluoranthene	NDR(0.1)	0.1	ND	2	100
Pyrene	NDR(0.1)	0.1	ND	2	95
Benz(a)anthracene	ND	0.1	ND	5	95
Chrysene	ND	0.1	ND	3	95
Benzo(a)fluoranthene	ND	0.1	ND	2	96
Benzo(e)pyrene	ND	0.1	ND	2	100
Benzo(a)pyrene	ND	0.1	ND	2	95
Perylene	ND	0.1	ND	3	95
Dibenz(ah)anthracene	ND	0.2	ND	4	63
Indeno(1,2,3-cd)pyrene	ND	0.2	ND	6	100
Benzo(ghi)perylene	ND	0.1	ND	13	95

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

APPENDIX IV**Field QA/QC Data**

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TABLE 1 Field Quality Control Results for Chlorophenolics in Deionized Water

Sampling Date:	March 30, 1993		March 30, 1993		April 7, 1993		April 15, 1993		April 22, 1993		April 22, 1993	
Sample ID:	FRS-9CH (mid-field bank)		FRS-10CH (post-field bank)		FRS-12CH (mid-field blank)		FRS-14CH (mid-field blank)		FRS-16CHA (mid-field blank)		FRS-16CHB (mid-field blank)	
Compounds	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)
4-chlorophenol	ND	2.1	ND	5.3	ND	1.5	ND	0.8	ND	1.9	ND	0.9
2,6-dichlorophenol	ND	5.4	ND	8.8	ND	1.8	ND	1.4	ND	2.7	ND	2.0
2,4/2,5-DCP	ND	4.2	ND	6.7	ND	1.3	ND	1.0	ND	1.9	ND	1.4
3,5-dichlorophenol	ND	5.0	ND	8.0	ND	1.6	ND	1.3	ND	2.4	ND	1.8
2,3-dichlorophenol	ND	4.7	ND	7.6	ND	1.5	ND	1.2	ND	2.2	ND	1.6
3,4-dichlorophenol	ND	3.3	ND	5.3	ND	1	ND	0.8	ND	1.6	ND	1.1
6-chloroguaiacol	ND	2.6	ND	2.2	ND	0.8	ND	1.0	ND	0.9	ND	2.3
4-chloroguaiacol	ND	3.1	ND	2.6	ND	1	ND	1.2	ND	1.1	ND	2.8
5-chloroguaiacol	ND	3.1	ND	2.6	ND	1	ND	1.2	ND	1.0	ND	2.7
2,4,6-trichlorophenol	ND	2.9	ND	5.8	ND	1.8	NDR(3.6)	1.5	ND	2.2	ND	1.7
2,3,6-trichlorophenol	ND	2.3	ND	4.7	ND	1.4	ND	1.2	ND	1.8	ND	1.3
2,3,5-trichlorophenol	ND	2.3	ND	4.6	ND	1.4	ND	1.2	ND	1.8	ND	1.4
2,4,5-trichlorophenol	ND	1.5	ND	3.0	ND	1.1	ND	1.0	ND	1.1	ND	1.0
2,3,4-trichlorophenol	NDR(18)	1.4	NDR(18)	2.9	ND	1.1	ND	1.0	ND	1.1	ND	1.1
3,4,5-trichlorophenol	ND	1.6	ND	3.2	ND	1.2	ND	1.0	ND	1.2	ND	1.1
3-chlorocatechol	ND	2.5	ND	4.8	ND	2.3	ND	2.0	ND	2.1	ND	2.4
4-chlorocatechol	ND	3.8	ND	7.2	ND	3.4	ND	3.1	ND	3.2	ND	3.6
3,4-dichloroguaiacol	ND	1.9	ND	4.1	ND	1.3	ND	1.1	ND	1.4	ND	1.4
4,6-dichloroguaiacol	ND	2.3	ND	5.0	ND	1.7	ND	1.4	ND	1.7	ND	1.7
4,5-dichloroguaiacol	ND	2	ND	4.3	ND	1.4	ND	1.2	ND	1.5	ND	1.5
3-chlorosyringol	ND	0.9	ND	1.6	ND	0.6	ND	0.4	ND	0.7	ND	0.7
3,4-dichlorocatechol	ND	53	ND	10	ND	3.5	ND	2.8	ND	8.0	ND	2.8
3,6-dichlorocatechol	ND	63	ND	12	ND	4.3	ND	3.3	ND	9.5	ND	3.3
3,5-dichlorocatechol	ND	52	ND	10	ND	3.5	ND	2.5	ND	7.8	ND	2.8
4,5-dichlorocatechol	ND	69	ND	13	ND	4.5	ND	3.5	ND	10	ND	3.5
2,3,5,6-tetrachlorophenol	ND	1.9	ND	3.4	ND	2	ND	1.3	ND	1.8	ND	2.5
2,3,4,6-tetrachlorophenol	ND	2.1	ND	3.7	6	2.3	ND	1.4	ND	2.0	ND	2.7
2,3,4,5-tetrachlorophenol	ND	1.3	ND	2.2	2.4	1.3	ND	0.8	ND	1.2	ND	1.6
5-chlorovanillin	ND	2.2	ND	3.3	ND	2.8	ND	2.5	ND	2.8	ND	3.6
6-chlorovanillin	ND	2.7	ND	4.0	ND	3.4	ND	3.1	ND	3.3	ND	4.4
3,5-dichlorosyringol	ND	2.2	ND	3.7	ND	2.8	ND	2.1	ND	1.9	ND	2.5
3,4,6-trichloroguaiacol	ND	2.5	ND	2.4	ND	1.4	ND	1.0	ND	1.1	ND	2.0
3,4,5-trichloroguaiacol	ND	2.4	ND	2.2	ND	1.3	ND	1.0	ND	1.0	ND	1.9
4,5,6-trichloroguaiacol	ND	1.7	ND	1.6	ND	0.9	ND	0.6	ND	0.7	ND	1.3
3,4,6-trichlorocatechol	ND	1.2	ND	2.3	ND	1.6	ND	0.7	ND	1.6	ND	2.5
3,4,5-trichlorocatechol	ND	1	ND	1.9	ND	1.4	ND	0.6	ND	1.3	ND	2.1
5,6-dichlorovanillin	ND	1.3	ND	1.8	ND	2.4	ND	1.5	ND	2.0	ND	2.7
pentachlorophenol	13	2.1	20	3.3	39	2.5	15	1.5	ND	2.3	ND	3.3
2-chlorosyringaldehyde	ND	0.8	ND	1.5	ND	1.1	ND	1.0	ND	0.9	ND	1.3
3,4,5,6-tetrachloroguaiacol	ND	1.1	ND	1.6	ND	1.3	ND	1.1	ND	1.0	ND	1.6
3,4,5-trichlorosyringol	ND	1.8	ND	1.6	ND	1.5	ND	1.0	ND	1.5	ND	2.5
3,4,5,6-tetrachlorocatechol	ND	14.0	ND	3.0	ND	3.0	ND	1.6	ND	37	ND	1.9
2,6-dichlorosyringaldehyde	ND	1.3	ND	2.6	ND	1.5	ND	2.9	ND	1.7	ND	2.2

(1) SDL = Sample Detection Limit

(2) ND = Not Detected

(3) NDR = Peak detected but did not meet quantification criteria

(4) Data have not been blank corrected

(5) Chlorocatechols are prone to oxidation reactions, therefore, reported concentrations may not accurately reflect true values.

TABLE 2 Field Quality Control Results for PAHs in Deionized Water

Sampling Date:	March 30, 1993		April 7, 1993		April 7, 1993		April 15, 1993		April 15, 1993		April 22, 1993	
Sample ID:	FRS-8PH (mid-field blank)		FRS-11PHA (mid -field blank)		FRS-11PHB (mid-field blank) duplicate		FRS-13PHA (mid-field blank)		FRS-13PHB (mid-field blank)		FRS-15PH (mid-field blank)	
Compounds	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)
Naphthalene	91	1.5	88	0.9	88	1.2	99	2.7	100	2.8	20	1.8
Acenaphthylene	NDR(4.8)	2.5	NDR(5.7)	2.7	NDR(6.4)	2.2	NDR(3.3)	1.9	NDR(3.8)	2.6	NDR(2.4)	1.2
Acenaphthene	5.7	1.5	7.9	1.0	8.3	1.4	7.2	2.9	5.7	3.1	2.7	1.9
Fluorene	11.0	2.8	23	1.5	26	2.1	12	2.5	11	2.7	3.4	1.6
Phenanthrene	31.0	0.8	34	0.5	34	0.7	30	1.1	29	1.3	5.0	0.8
Anthracene	NDR(3.1)	0.9	NDR(2.3)	0.5	NDR(2.4)	0.7	NDR(4.1)	1.2	NDR(4.1)	1.4	NDR(2.7)	0.9
Fluoranthene	NDR(7.0)	0.4	NDR(2.1)	0.3	3.0	0.4	NDR(2.9)	1.4	NDR(4.5)	1.5	NDR(2.5)	1.0
Pyrene	NDR(5.0)	0.5	NDR(2.1)	0.3	NDR(3.6)	0.4	2.8	1.4	3.0	1.5	NDR(2.3)	1.0
Benz(a)anthracene	ND	2.3	NDR(1.4)	0.5	ND	0.6	NDR(1.8)	1.1	ND	3.3	NDR(2.1)	0.9
Chrysene	ND	2.4	NDR(1.1)	0.5	ND	0.6	NDR(2.1)	1.1	ND	3.1	NDR(3.0)	0.8
Benzofluoranthenes	NDR(2.8)	0.7	ND	0.5	ND	0.6	ND	1.4	ND	3.6	ND	1.0
Benzo(e)pyrene	ND	0.7	ND	0.5	ND	0.6	ND	1.4	ND	3.5	ND	0.9
Benzo(a)pyrene	NDR(2.0)	0.8	ND	0.5	ND	0.7	ND	1.6	ND	4.1	ND	1.2
Perylene	NDR(1.7)	0.7	ND	0.5	ND	0.6	ND	1.3	ND	3.2	NDR(2.0)	0.9
Dibenz(ah)anthracene	ND	2.6	ND	2.5	ND	3.6	ND	5.1	ND	11	ND	3.8
Indeno(1,2,3-cd)pyrene	ND	1.3	ND	1.2	ND	1.1	ND	4.2	ND	8.9	ND	4.3
Benzo(ghi)perylene	NDR(1.8)	1.1	ND	0.9	ND	0.9	ND	3.0	ND	6.4	ND	2.7

SDL = Sample Detection Limit

ND = Not Detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have not been blank corrected

TABLE 3 Field Quality Control Results for Fatty Acids in Deionized Water

Sampling Date:	March 30, 1993		March 30, 1993		April 7, 1993		April 15, 1993		April 22, 1993	
Sample ID:	FRS-9CH (mid-field bank)		FRS-10CH (post-field bank)		FRS-12CH (mid -field blank)		FRS-14CH (mid- field blank)		FRS-16CH (mid -field blank)	
Compounds	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)
Capric	ND	150	ND	150	ND	230	ND	240	ND	390
Lauric	100	85	110	85	ND	200	ND	290	ND	400
Myristic	210	92	260	92	ND	290	ND	260	ND	370
Palmitic	400	130	520	130	ND	1400	ND	930	ND	1300
Linolenic	ND	120	ND	120	ND	170	ND	230	ND	600
Linoleic/Oleic	ND	100	ND	100	ND	140	ND	600	ND	1200
Stearic	350	57	500	57	ND	1300	ND	570	ND	980
Arachidic	ND	12	ND	12	ND	20	ND	170	ND	61
Behenic	ND	6.0	7.2	5.0	ND	37.0	ND	200	ND	140
Lignoceric	ND	20	28	20	ND	30	ND	220	ND	130
Internal Standards	% Recovery		% Recovery		% Recovery		% Recovery		% Recovery	
D23-LAURIC	61		86		79		16		39	
D27-MYRISTIC	79		103		97		20		45	
D31-PALMITIC	79		83		110		20		49	
D35-STEARIC	53		62		80		15		36	
D39-ARACHIDIC	48		68		110		19		44	

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have been blank corrected where required

TABLE 4 Field Quality Control Results for Resin Acids in Deionized Water

Sampling Date:	March 30, 1993		March 30, 1993		April 7, 1993		April 15, 1993		April 22, 1993	
Sample ID:	FRS-9CH (mid-field bank)		FRS-10CH (post-field bank)		FRS-12CH (mid -field blank)		FRS-14CH (mid- field blank)		FRS-16CH (mid -field blank)	
Compounds	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)	Concentration (ng/L)	(SDL)
Pimaric	ND	1.3	ND	1.3	ND	4.3	ND	9.2	ND	3.0
Sandaracopimaric	ND	1	ND	0.7	ND	4.6	ND	9.9	ND	3.2
Isopimaric	ND	3.1	ND	2.7	ND	24	ND	50	ND	14
Palustric *	67	4.2	66	2.9	NDR(120)	33	NDR(120)	71	NDR(130)	19
Dehydroisopimaric	ND	2.5	ND	1.7	ND	34	ND	62	ND	22
Dehydroabietic	24	3.8	21	2.8	ND	24	ND	57	30	15
Abietic *	ND	9.2	ND	4.5	ND	53	ND	130	ND	38
Neoabietic *	ND	1.3	ND	0.8	ND	11	ND	21	ND	4.9
12/14 Chlorodehydroabietic	ND	0.6	ND	0.5	ND	11	ND	16	ND	5.4
12,14 Dichlorodehydroabietic	ND	0.9	ND	0.6	ND	15	ND	17	ND	7.6
Internal Standard	% Recovery		% Recovery		% Recovery		% Recovery		% Recovery	
o-Methyl Podocarpic	83		99		50		20		64	

* These compounds are known to be unstable, data should be interpreted cautiously.

SDL = Sample detection limit

ND = Not detected

NDR = Peak detected but did not meet quantification criteria

Note: Data have not been blank corrected.