The Influences of Intensive Agriculture on Matsqui Slough, A South-Coastal British Columbia Watershed

Top, V., J.C. Nener, B.G. Wernick, B.J. Locken, and G.A. Derksen

Fraser River Action Plan
Department of Fisheries and Oceans
555 West Hastings Street
Vancouver, B.C. V6B 5G3

1997

Canadian Technical Report of Fisheries and Aquatic Sciences 2160

nd Oceans Pêches et Océans
Canada

Canada

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by

Top, V.,[1] J.C. Nener,[2] B.G. Wernick,[2] B.J. Locken[3] and G.A. Derksen[4].

Fraser River Action Plan
Department of Fisheries and Oceans
555 West Hastings St.
Vancouver, B.C. V6B 5G3

[1] 6 - 1065 W. 10th Avenue, Vancouver, B.C. V6H 1H9

[2] Fraser River Action Plan, Department of Fisheries and Oceans, 555 W. Hastings St., Vancouver, B.C. V6B 5G3

[3] BC Ministry Of Environment, Lands And Parks, 10334-152A St., Surrey, B.C. V3R 7P8

[4] Environment Canada, 224 West Esplanade, North Vancouver, B.C. V7M 3H7

Cat. No. Fs 97-6/2160E ISSN 0706-6457

Correct citation for this publication:

Top, V., J.C. Nener, B.G. Wernick, B.J. Locken and G.A. Derksen. 1997. The Influences of Intensive Agriculture on Matsqui Slough, A South-Coastal British Columbia Watershed. Can. Tech. Rep. Fish. Aquat. Sci. 2160: 59 pp.

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Abstract

A water quality monitoring program was initiated in 1993 in the Matsqui Slough Watershed, a salmonid stream in the Lower Fraser Valley of British Columbia. The watershed supports intensive dairy, hog, poultry, and commercial crop production. Monitoring was limited to the fall heavy rain season (October/November), and late winter (February/March). Parameters analyzed during the program included nutrients, fecal coliforms, dissolved oxygen, temperature, pH, non-filterable residues, organic carbon and aquatic productivity indicators. Overall, nutrient concentrations and organic carbon were elevated at the agriculturally impacted, downstream sites compared to the upper-reach, less impacted sites. In addition, dissolved oxygen levels were depleted at the downstream sites. Correlation analysis of the relationships between fecal coliforms and ammonia or phosphorus demonstrated that elevated nutrient levels may be associated with fecal inputs, most likely from manure. Levels of ammonia and nitrate were generally below the water quality guidelines for the protection of aquatic life. Dissolved oxygen and oxygen percent saturation levels were often below the guidelines established for the protection of aquatic life while fecal coliform counts were usually above the levels considered suitable for drinking water or irrigation waters used on crops eaten raw. Overall, water quality in the agricultural area of the Matsqui Slough Watershed was shown to be degraded in comparison with upstream reaches, with clear links between adjacent land uses and the measured water quality impacts.

Résumé

En 1993, les auteurs ont entrepris un programme de surveillance de la qualité de l'eau dans le bassin hydrographique du chenal Matsqui Slough dans la vallée inférieure du Fraser (Colombie-Britannique). Le bassin hydrographique permet l'élevage intensif de bovins laitiers, de porcs et de volailles et la production intensive de cultures commerciales. La surveillance a été limitée à l'automne (octobre-novembre), période où l'on enregistre de fortes précipitations, et à la fin de l'hiver (février-mars). L'analyse effectuée dans le cadre du programme a porté sur les paramètres suivants : matières nutritives, coliformes fécaux, oxygène dissous, température, pH, résidus non filtrables, carbone organique et indicateurs de la productivité aquatique. En général, les concentrations de matières nutritives et le carbone organique étaient élevés dans les sites agricoles en aval touchés par les pratiques agricoles comparativement aux sites moins touchés dans le cours supérieur. En outre, les concentrations d'oxygène dissous étaient diminuées dans les sites en aval. L'analyse de corrélation des rapports entre les coliformes fécaux et l'ammoniac ou le phosphore a montré que des concentrations élevées de matières nutritives peuvent être associées à des apports de matières fécales, plus probablement de fumier. Les concentrations d'ammoniac et de nitrates étaient généralement inférieures aux recommandations pour la qualité de l'eau en vue de la protection de la vie aquatique. Les pourcentages de saturation de l'oxygène dissous et de l'oxygène étaient souvent inférieurs aux recommandations établies pour la protection de la vie aquatique, tandis que les dénombrements de coliformes fécaux étaient en général supérieurs aux concentrations jugées acceptables pour l'eau potable ou les eaux d'irrigation utilisées pour les cultures consommées crues. Dans l'ensemble, on a constaté une dégradation de la qualité de l'eau dans les régions agricoles du bassin hydrographique du chenal Matsqui Slough comparativement aux eaux du cours supérieur, des liens clairs existant entre les utilisations des terres adjacentes et les effets mesurés sur la qualité de l'eau.

1.0 Introduction

In 1992 the British Columbia Ministry of Environment, Lands and Parks (MELP) enacted the Agricultural Waste Control Regulation under the *Waste Management Act*, as a means of regulating the inappropriate disposal of agricultural wastes such as manure. At the same time the Fraser River Action Plan, a joint Department of Fisheries and Oceans (DFO) and Environment Canada (DOE) program was underway, with a mandate for identifying and addressing sources of pollution in the Fraser River Basin. Working cooperatively, the three agencies initiated a study in 1993 in the Matsqui Slough Watershed to document agricultural practices and collect baseline water quality information so that the effectiveness of the new MELP legislation at addressing environmental impacts could be assessed following implementation.

Water quality and contamination issues are of particular concern in the Lower Fraser due to the intensive nature of the agricultural activities in the region combined with the high precipitation and runoff levels encountered in this area. Small watersheds like Matsqui Slough support populations of coho and chum salmon as well as other non-anadromous fish species. The Fraser River tributaries located downstream from Hope, B.C., collectively support about 65% of the Fraser River coho runs, and 85% of the Fraser River Chum salmon populations. The fall return of adults to spawn often coincides with the time when farmers have traditionally emptied manure pits before the winter. The spreading of manure on bare fields is subsequently followed by heavy rains. It was expected that the combination of fall manure spreading and heavy rainfall would lead to significant water quality impacts in streams which drain agricultural land in the Lower Fraser Valley.

The Matsqui Slough Watershed study was initiated to develop an information base from which to assess whether implementation of the *Agricultural Waste Control Regulation* and supporting *Code of Agricultural Practice for Waste Management* would provide adequate protection of water quality so that fish populations are sustained. Two components of the overall project were: a) identification of the agricultural practices and contaminant sources present in the watershed and, b) determine the water quality conditions in the Matsqui Slough system during fall and winter months. Results of the first study component are provided by IRC (1994), who described in detail the land uses and specific agricultural practices in the watershed. This report presents findings of the water quality assessment work. The results of this study are applicable to the many other Lower Fraser and Georgia Basin tributaries which are also subject to intensive agricultural activities.

The Matsqui Slough watershed is used intensively for dairy, hog and poultry, as well as commercial crop production. The following description of agricultural practices in the watershed are summarized from IRC (1994). Of the 1,540 hectares of land used for animal production in the watershed, approximately 88% is used by dairy farms, 8% by hog farms and 6% by poultry farms. It was estimated that a total of about 386,000 L of manure are produced on a daily basis in the area; 70% of the manure is generated from dairy operations, 23% from hog producers and 7% from poultry producers. Most of the dairy producers spread manure on their own property and in 1993 were determined to have an average 3.4 months of manure storage capacity. Sixty percent of the primary manure storage facilities on dairy farms are concrete and about half of these were covered at the time of site visits. The remaining pits were earthen. The hog farmers in the watershed had an average 4.6 months of manure storage and two of the producers spread all of the manure on their own farm while the other two spread part of the manure on neighboring farms as well. One storage facility was covered concrete, two were uncovered concrete and one was earthen. Finally, sixty percent of the poultry producers had either covered or uncovered concrete manure storage facilities. Seventy percent of the poultry manure was exported off of the farm (the final destination was not identified). In addition to nutrient inputs from manure most of the farmers in the area also applied chemical fertilizers to their land. Summer irrigation is used extensively throughout the watershed.

As well as surveying agricultural land use in the Matsqui Watershed, IRC (1994) also conducted a preliminary sampling of fish species presence and abundance. Fish populations were sampled at the six locations initially selected for the water quality study (Sites 1 to 6). The majority of salmonids were found in the upper reaches of Clayburn Creek (Site 2). Salmonids were also found in Willband and Page Creeks (Sites 1 and 3). The smallest numbers of fish and fish species were detected at the Matsqui Slough sites downstream from Clayburn Creek and the Clayburn Creek site at Harris Road (Sites 4-6).

This report provides an analysis of the water quality data obtained in the Matsqui Slough Watershed from the fall of 1993 to the fall of 1995. The data are analyzed for upstream-downstream trends, seasonal variation, relationships between parameters and association with known land use practices. In addition, the water quality data are assessed in terms of implications for fish and other biota by comparison with the *Guidelines for the Protection of Aquatic Life* (CCREM, 1987). Where applicable, comparisons to the MELP *Approved and Working Criteria for Water Quality* are also made (MELP, 1995).

2.0 Methods

2.1 Study Area

The Matsqui Slough Watershed encompasses about 4,200 hectares of land and drains to the Fraser River just downstream from the community of Matsqui (Figure 1). In the upper watershed most of the flows are contributed by Clayburn Creek, which drains a forested area. Willband Creek drains an urban area, and joins Clayburn Creek at the upper end of the agricultural area. Agricultural land within the basin is generally very flat with elevations of between 5 and 8 meters above sea level. The soils of the area are highly variable and range from fine to coarse textures. Relatively large areas of predominantly organic soil materials are also present. Due to the high diversity of soil types, drainage is also highly variable ranging from very poor to rapid (Luttmerding, 1980; 1981). The waterways in the area consist of a network of ditches, sloughs and creeks with several pumps and check gates controlling the system in the Fraser River floodplain. With the exception of drainage off Sumas Mountain, the area has low gradients and the creeks have slow water velocities. The watershed is used for intensive agricultural production, supporting more than 3,500 milking cow equivalents, 263,000 broiler equivalents and 1,250 sow equivalents along with cole, blueberry and nursery crops (IRC, 1994).

2.2 Water Sampling and Analysis

Water samples for the study were collected at weekly intervals in the fall (October - December) and late winter (February and March) of each year beginning in October of 1993, through to the fall of 1995. Site descriptions and sampling dates are provided in Table 1. The parameters and the sampling sessions in which they were tested are listed in Table 2.

Six sites within the watershed were initially sampled. Additional sites (3b and 6b) were added during the Fall 1993 sampling period. Another four sites located outside of the boundaries of the Matsqui Slough Watershed were added to the sampling program in the fall of 1994. Sites 1 and 2 are the upper-reach sites and are expected to be the least impacted by agricultural activities in the watershed. Site 1, however, is located immediately downstream of an urban area and thus may be affected by urban runoff. Sites 3 through 6b are all located in the agricultural areas. Sites 7 through 10 are also located within an agricultural area on neighboring streams.

Water samples for laboratory analyses, including biomass and chlorophyll *a*, were collected using a sampling pole to ensure that mid-stream samples were collected. Sample bottles were prepared and supplied by the analytical laboratory. Bottles used for fecal coliform samples were autoclaved. For all samples except fecal coliform counts the collection bottles were rinsed several times with the stream water prior to filling. The samples were transported on ice in a cooler to the laboratory within 24 hours and were usually near 4°C upon arrival. Water samples were not filtered or preserved in the field. Laboratory analyses were performed by Zenon Laboratories, except for one winter set of ammonia which was analyzed by Elemental Research Inc. Fecal coliform analyses were performed by J.R. Laboratories.

Dissolved oxygen and water temperature were measured in the field using a Yellow Springs Instrument Dissolved Oxygen meter (Model 57) during both the fall and winter sampling period. Field pH, measured with a Canlab Model 607 pH meter, and conductivity, measured with a YSI Model 33, were added to the winter survey (IRC, 1994).

During the first sampling session in which fecal coliforms were analyzed (Winter 1994), a most probable number (MPN) method was used. For the latter three sampling sessions (Fall 1994 to Fall 1995) fecal coliform levels were analyzed by determining the number of colony forming units (CFU). As such one should not attempt to compare the Winter 1994 fecal coliform values to the values obtained in the later sampling seasons.

2.3 Data Analysis

The data were analyzed for upstream-downstream trends, seasonal variation, relationships between parameters and association with known land use practices using parametric tests. The parametric and non-parametric statistical methods used in this study have been used and described in previous studies for the evaluation of water quality data (Environment Canada, 1995). Upstream-downstream trends were analyzed with a single factor analysis of variance and seasonal variations were analyzed with two-sample *t*-tests. The relationships between parameters were examined using parametric correlation analysis methods. Extreme values were excluded from the correlation analysis. A significance level of $\alpha = 0.05$ was used for interpreting results of all statistical tests.

Extreme values were initially identified using the sample z-score method (Mendenhall, 1987) to estimate whether a given value was unusually high or low. For the sample z-score analysis, the observations of a particular parameter for all sampling dates from a site were combined to obtain a mean concentration and a standard deviation for that site. The z-score was then calculated by subtracting the suspected extreme value from the mean and dividing by the standard deviation:

$$z = \frac{\bar{y} - y}{s}$$

In instances where the resulting z-score was greater than 2 or -2 it was marked as a potential extreme value. The resulting "statistically" obtained extreme values for a particular parameter were then compared to the data for all sites in order to determine whether the value should indeed be considered unusually high or low. Values which were within the range typically observed in other sites were generally not treated as extreme values. Any remaining values which then still appeared to be unusual based on data from all of the sites and taking the particular site of interest into consideration were treated as extreme values, and were excluded from correlation analyses.

3.0 Results and Discussion

Tables 3 through 7 summarize the data obtained for all parameters tested from the fall of 1993 to the fall 1995. Maximum, minimum, mean and standard deviation values are given for each parameter in each sampling session. In the tables any data which are underlined and in bold are considered to be extreme values as determined by the z-score method. In instances where concentrations were below the detection limits, the value of the detection limit was used in calculating averages, standard deviations and minimum values.[1] The averages shown in the tables are in all cases arithmetic means except for fecal coliforms, for which a geometric mean was calculated, as per standard practice. The guidelines which were used to assess data are summarized in Table 8

3.1 Upstream-downstream Relationships and Overall Trends

Upstream-downstream relationships for all parameters studied are shown on a seasonal basis using bar graphs (Figures 2 - 11). Average values for each site were calculated using all of the available data from the sampling periods of interest. For example, the data from the fall sampling periods in 1993, 1994 and 1995 were combined on a site by site basis. Likewise, the data for the winter sampling periods in 1994 and 1995 were combined. Ranges in data for all of the parameters are displayed by the vertical lines in the bar graphs. Where maximum values were beyond the scale of the graph a broken vertical line is shown and the maximum value is displayed above the line. These maximum data points often represent extreme values. Averages displayed for fecal coliforms represent geometric rather than arithmetic means. The Matsqui Slough Watershed data, sites 1 through 6, are arranged by site in an upstream to downstream

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[1] A "<" sign before a value in the tables denotes a sample in which concentrations were below the detection limits, the value itself denoting the detection limit (e.g. 0.005 mg L^{-1} in the case of ammonia-N).

direction in the figures, with arrows indicating where tributaries join the mainstem. Sites 7 through 10, located in neighboring watersheds, are arranged in numerical order.

3.1.1 Dissolved Ammonia-Nitrogen

Ammonia-N concentrations were often at or near the detection limits at Site 2 (Figure 2). While Site 1 is also an upstream station, ammonia-N values reached up to 1.0 $mg \cdot L^{-1}$ in the fall, likely due to runoff from the urban area which drains to Willband Creek. Sites 6 and 6b in the unnamed Matsqui Slough tributary and Site 9 in Nathan Slough tended to have the highest concentrations of ammonia-N and were statistically different than all other stations. Extreme values (as determined by the *z*-score method) of 7.66 $mg \cdot L^{-1}$ at Site 6 in the fall and 16.7 $mg \cdot L^{-1}$ at Site 6b during the winter resulted in elevated averages for the two sampling sites in those seasons. Site 6 was the only station which had significantly higher fall versus winter average values.

Ammonia is produced naturally from the decomposition of nitrogenous organic matter and sources include biological litter, animal manure and forest fires. In addition, commercial fertilizers often contain high levels of ammonia and ammonium salts. In natural waters ammonia and ammonium compounds are typically found in concentrations below 0.1 $mg \cdot L^{-1}$, with high concentrations resulting from anthropogenic inputs and organic pollution (McNeely *et al.*, 1979). Under most conditions ammonia is present as dissociated ammonium ions (NH_4^+), however, some ammonia is always present as the undissociated form (NH_3) which is highly toxic to fish. As dissolved oxygen decreases and pH and temperature increase, the acute toxicity of ammonia to fish increases (CCREM, 1987). Animal manure is the most likely source of ammonia in the watershed as it is often spread on fields during fall months. Heavy rainfalls at that time combine with the manure, generating runoff with high ammonia concentrations. Septic tank discharges may also contribute relatively small amounts.

The CCREM guidelines for ammonia define concentrations of total ammonia which should not be exceeded at specific temperatures and pH values since it is these parameters which determine the amount of ammonia which will be in the toxic undissociated form. At a pH of 7 and temperatures of 5°C and 10°C, which approximate the fall and winter conditions in the watershed, the guidelines for total ammonia are 2.4 and 2.2 $mg \cdot L^{-1}$, respectively (equivalent to ammonia-N values of 2.0 and 1.8 $mg \cdot L^{-1}$). These guidelines correspond to the MELP average 30-day total ammonia-N criteria. MELP also defines maximum concentrations of total ammonia-N which should not be exceeded. At a pH of 7 and temperatures of 5°C and 10°C the maximum concentrations are 21.6 $mg \cdot L^{-1}$, and 20.5 $mg \cdot L^{-1}$, respectively.

While the extreme values of 7.66 and 16.7 $mg \cdot L^{-1}$ did not exceed the guideline for maximum total ammonia concentration, they did, along with several other individual measurements at Sites 6, 6b and 9, approach or exceed the 30-day exposure criteria. These elevated concentrations indicate that there are ammonia inputs into the stream, and they may be toxic to fish in the area where runoff enters the stream. The ammonia-N concentrations measured at the remaining stations were below the 30-day exposure criteria but in most cases they still indicated that a source of contamination may be present.

3.1.2 Nitrate+nitrite-Nitrogen

All of the sites located in the agricultural areas, except 6b, showed statistically higher nitrate+nitrite-N concentrations compared to those measured at the upstream sites, 1 and 2 (Figure 3). The highest average values for both fall and winter were measured in the sites outside of the Matsqui Slough Watershed (Sites 7 through 10). Nitrate+nitrite-N values were notably lower in the winter and Sites 3 through 6b had levels near or even below those detected at Sites 1 and 2. Average nitrate+nitrite-N values were generally less than 5 $mg \cdot L^{-1}$. Values of greater than 9 $mg \cdot L^{-1}$ and up to 10.5 and 13.5 $mg \cdot L^{-1}$ were also measured in some instances. Sites 3b, 4, and 10 had significantly higher fall versus winter average concentrations, and at Site 1 the winter levels were significantly higher than fall levels.

Nitrate and nitrite, like ammonia, may be produced naturally from the decomposition of nitrogenous organic matter or, in agricultural situations, they may be introduced in the form of chemical fertilizers. The oxidation of ammonia, via nitrification, results in the formation of nitrite and nitrate. Nitrite is quickly oxidized to nitrate and is not present at high concentrations. Human and animal wastes are major sources of nitrate contamination and concentrations above 5 $mg \cdot L^{-1}$ indicate unsanitary conditions. Nitrate is a major nutrient for aquatic vegetation and excessive amounts may cause prolific weed growth. Nitrate is of low toxicity to fish and invertebrates (McNeely *et al.*, 1979), although it is of significant concern for human health when present in drinking water.

The current criteria for nitrate in drinking water in B.C. is 10 $mg \cdot L^{-1}$ nitrate-N. At present the CCREM guidelines for the protection of aquatic life do not provide numerical recommendations for nitrate, while the MELP criteria for protection of freshwater aquatic life include maximum and average values of 200 $mg \cdot L^{-1}$ and 40 $mg \cdot L^{-1}$ nitrate-N, respectively. Nitrite, due to its higher toxicity to fish, is of greater concern for aquatic life than nitrate. MELP criteria for nitrite consist of a maximum of 0.06 $mg \cdot L^{-1}$ and an average of 0.02 $mg \cdot L^{-1}$ nitrite-N. In the analysis of nitrate+nitrite the majority of the nitrogen is assumed to be in the nitrate form. Thus, the nitrate guidelines are more readily applicable for the purposes of this study.

The nitrate concentrations measured in this study are well below the criteria for freshwater aquatic life, although the drinking water criteria was exceeded at times. Nitrate and nitrite were analyzed separately on only one sampling date during the study (November 30, 1995) (Table 7). On this date, the nitrite-N levels exceeded the maximum criteria of 0.06 $mg \cdot L^{-1}$ at several sites (3b, 6, 9 and 10) indicating that nitrite levels in the watershed may be affecting aquatic life.

3.1.3 Total Phosphorus

Sites located in the unnamed Matsqui Slough tributary (Sites 6 and 6b) and outside of the watershed in Nathan Slough (Site 9) tended to have elevated phosphorus concentrations compared to the upper-reach sites during both seasons, although this trend was most apparent during the fall (Figure 4). Sites in the Clayburn Creek mainstem (1 through 5) and in Page Creek (3 and 3b) had similar average values. The highest concentrations were measured at Site 6b (2.23 $mg \cdot L^{-1}$) in the fall and Site 9 (2.55 $mg \cdot L^{-1}$) in the winter. Site 9 was statistically higher than all other stations, while Sites 6 and 6b were also statistically higher than the upper reach stations, 1 and 2. Sites 10, 6, 7 and 8 had significantly higher fall versus winter concentrations.

Leaching from rocks, decomposition of organic matter, and drainage from fertilized land all contribute to phosphorus loading in aquatic environments. High phosphorus concentrations are rarely found in surface waters largely because phosphorus is relatively immobile in soils and is actively taken up by plants (CCREM, 1987). Phosphorus levels are commonly cited as the primary factor limiting algal populations in unpolluted freshwater systems, and eutrophication is in most instances associated with excessive phosphorus concentrations. Most natural waters contain phosphorus concentrations in the range of 0.01 to 0.05 $mg \cdot L^{-1}$ (Wetzel, 1983).

There are no Canadian or B.C. provincial guidelines for phosphorus associated with the protection of aquatic life in rivers. MELP has established a criteria of 0.005-0.015 $mg \cdot L^{-1}$ total phosphorus for lakes where salmonids are the predominant fish species. Flow in the lower reach of Matsqui Slough is controlled by a flood gate which creates lake-like conditions, so it may be appropriate to compare measured phosphorus concentrations with the MELP criteria. The average concentrations of total phosphorus at all sites in the lower reaches adjacent to the agricultural areas exceed the provincial criteria, particularly during the fall season. At least half of the individual measurements at Sites 1 and 2 also exceed the 0.015 $mg \cdot L^{-1}$ criterion. While these more riverine sites may not be affected by the elevated phosphorus levels they are contributing loading to the stagnant downstream sites. Overall, the phosphorus concentrations measured may be indicative of naturally high levels in headwaters, with additional nutrient enrichment throughout much of the watershed resulting from agricultural runoff.

3.1.4 Dissolved Oxygen

Dissolved oxygen and oxygen percent saturation (Figures 5 and 6) tended to be highest at Site 2, where there is very little upstream development. Sites 2, 8 and 10 had statistically significantly higher dissolved oxygen levels than all other sites. Site 1, the other upper reach station, was not as well oxygenated as some of the downstream stations, which may reflect the influence of urban activities in the headwaters of Willband Creek. Sites 3, 6, 6b and 9 were the least oxygenated and statistically lower than all other stations. Sites 1, 3, 3b, 4, 5, 6, 6b, and 7 had significantly higher fall versus winter average values.

Dissolved oxygen levels are a good indicator of the ability of a body of water to support aquatic life. Oxygen in surface waters is derived from both the atmosphere and from photosynthesis by aquatic plants. Depletion of dissolved oxygen levels may result from metabolism by aquatic organisms, the decomposition of organic matter, or the chemical oxidation of organic and inorganic wastes, including ammonia. Large seasonal and geographic variations in dissolved oxygen are expected to occur due to differences in temperature, photosynthetic activity, river discharge, and atmospheric pressure. The oxygen content of water decreases as temperature and salinity increase (CCREM, 1987). Thus high temperatures may cause adverse effects both because oxygen content and oxygen tension are decreased and because higher temperatures increase the metabolic demand for oxygen in ectothermic organisms (Davis, 1975). In addition to direct metabolic effects, low dissolved oxygen levels are known to enhance the toxicity of several contaminants, such as copper, lead, zinc, ammonia and pentachlorophenol (CCREM, 1987).

The CCREM guidelines for dissolved oxygen are 9.5 $mg \cdot L^{-1}$ during the early life stages and 6.5 mg L^{-1} during other life stages for cold-water biota such as salmonids. Early life stages encompass spawning (i.e. egg deposition) through to 30 days after hatching. It is assumed that if all life stages of fish are protected, then the invertebrate communities should also be reasonably well protected. Some authorities regard oxygen percent saturation to be a better indicator of the ability of a water body to support fish (Davis, 1975), rather than just the dissolved oxygen concentration. This is because percent saturation encompasses both oxygen content and oxygen partial pressure at various temperatures. The partial pressure of oxygen in water, rather than oxygen concentration alone, governs the availability of oxygen to aquatic organisms. Because of the temperature effects on solubility, a dissolved oxygen content of 8 $mg \cdot L^{-1}$ represents a percent saturation of only 55% at 0°C, while at 15°C the percent saturation is approximately 80%. The blood of salmonids ceases to be saturated below about 75% oxygen saturation of the water column. Thus, a value of 80% saturation has been suggested for the protection of aquatic habitat supporting anadromous species including salmonids.

Most of the sites in the Matsqui Slough Watershed, especially those in the lower reaches of the watershed, do not meet the criteria (9.5 $mg \cdot L^{-1}$) for protection of early life stages of cold-water biota. In addition, a number of the sites do not meet the 6.5 $mg \cdot L^{-1}$ guideline for other life stages. Sites which have particularly low dissolved oxygen include 6, 6b and 9. Site 3 also had concentrations below 6.5 $mg \cdot L^{-1}$ during the fall sampling dates. When analyzed according to the 80% saturation level (Figure 6), only Sites 2, 8 and 10 meet the criteria in the fall sampling sessions, while Sites 4, 5 and 7 also meet the criteria in the winter sampling sessions. Some sites in the lower reaches of Matsqui Slough (e.g. sites 3b, 6, 6b) had very low % saturation throughout sampling periods - in the range of 30% saturation for 8 sampling days.

Reductions in dissolved oxygen concentrations are particularly acute in the lower reaches of Matsqui Slough during the fall months from October to December, which coincides with the return of adult salmon to the system. The low oxygen concentrations (and % saturation) can act as an environmental barrier, preventing adult salmon from reaching their spawning grounds in the upper reaches of the watershed. The low dissolved oxygen levels are likely due to a combination of oxygen-consuming substances being washed into the system (manure runoff), and the decay of large amounts of algae, which die off during the fall after flourished during the summer months in the nutrient-enriched waters. Overall, depressed oxygen concentrations in the stream may constrain use of the watershed by aquatic organisms, particularly species such as salmonids which are sensitive to low oxygen availability.

3.1.5 Fecal Coliforms

Fecal coliform levels fluctuated considerably during the sampling seasons (Figure 7). Values were generally below 5,000 CFU/100 mL but on occasion approached 15,000 CFU/100 mL and in two instances reached extremely high values of 77,000 at Site 8 and 170,000 CFU/100 mL at Site 6b. Sites 2, the least impacted site on in the Matsqui Slough watershed, generally had less than 200 CFU/100 mL. Sites 1, 6b, and 10 also tended to have relatively low fecal coliform levels. An analysis of variance showed that there is no statistically significant difference between stations, likely due to the high variability in coliform levels within sites. As with the nutrients, the levels of fecal coliforms tended to be higher during the fall sampling dates than the winter dates. Sites 2 and 4 had significantly different fall versus winter counts.

Fecal coliforms refer to a group of coliform bacteria associated with the gut of warm-blooded animals. They are generally short-lived in the environment and in rural areas often come from leaking septic tanks and runoff from agricultural lands. Coliform bacteria in water do not pose a threat to aquatic life but may be of concern for human health where a possibility for ingestion or recreational contact exists because they are an indicator of contamination by animal and human wastes which are often accompanied by pathogenic organisms (Environment Canada, 1995).

The MELP criteria require a complete absence of fecal coliforms from raw drinking water. The criteria for irrigation water used on crops eaten raw has been set at a geometric mean of ≤200 CFU/100 mL where the geometric mean is calculated from at least 5 samples in a 30 day period. The general irrigation parameter has been set at a geometric mean of ≤1000 CFU/100 mL.

In some cases the extreme values for fecal coliforms, those above 5,000 CFU/100 mL, may be associated directly with specific instances of manure runoff or manure application. This is indicated by an occurrence of very high fecal coliform numbers with elevated concentrations of dissolved ammonia and total phosphorus, all of which are present in relatively large quantities in manure. On October 27, 1994, at Site 6, a value of 15,000 CFU/100mL was recorded for fecal coliforms along with 7.66 $mg \cdot L^{-1}$ ammonia-N and 1.2 $mg \cdot L^{-1}$ phosphorus. An even stronger association was observed on March 15, 1995, at Site 6b, where the highest fecal coliform value of 170,000 CFU/100mL coincided with values of 16.7 $mg \cdot L^{-1}$ ammonia-N and 2.23 $mg \cdot L^{-1}$ phosphorus. The highest concentration of total organic carbon (TOC), 57.8 $mg \cdot L^{-1}$, which may also be associated with manure input, was measured during the latter sampling date.

All sites had detectable levels of fecal coliforms and therefore are not suitable for raw drinking water. Many of the sites, particularly during fall sampling, had fecal coliform levels above the criteria acceptable for irrigation of crops eaten raw. The criteria for general irrigation was not exceeded at any of the sites although the fall sampling data for Site 9 had a geometric mean close to 1000 CFU/100 mL. Aside from the relatively high geometric mean values found in samples from many of the sites, the extremely high values obtained on a sporadic basis may also be a cause for concern.

3.1.6 Chemical Oxygen Demand and Total Organic Carbon

Samples were analyzed for chemical oxygen demand (COD) only during the Fall 1994 sampling (Figure 8). Sites 1 and 2 had the lowest levels of COD (means of 14 $mg \cdot L^{-1}$) while Site 8 in Hanna Creek and Site 10 in Nathan Creek had only slightly higher values. Site 9 in Nathan Slough, along with Sites 3, 3b and 6 in Matsqui Slough, were statistically higher than all other stations (means in the range of 30-35 $mg \cdot L^{-1}$). A similar trend may be observed for total organic carbon (TOC), which is expected to correlate strongly with COD (Figure 9). Similarly to COD, Site 9 had very high values of TOC during the fall and winter sampling dates, but the differences between this site and the others was most pronounced in the fall sampling. Overall, levels of COD and TOC at Site 9 were statistically higher than all other stations. As with COD, Sites 1, 2, and 10 tended to have the lowest TOC levels. With the exception of Site 6b, all TOC levels were lower during the winter sampling sessions than in the fall sessions. Sites 1, 2, 3, 4 and 9 had statistically different fall versus winter averages.

Both chemical oxygen demand (COD) and total organic carbon (TOC) are measures of the organic matter content of a water body. COD is a measure of the oxygen equivalent of the organic matter content in a water sample that is susceptible to oxidation by a strong chemical oxidant (CCREM, 1987). In COD tests, the nature of the oxidizable material is not identified. TOC is directly related to COD and the difference between the two parameters varies according to the nature of the organic matter present in the water. TOC measurements include organic carbon which is not oxidizable by COD methods and as such it is a more direct expression of total organic content (APHA, 1980). TOC is calculated as the difference between total carbon and total inorganic carbon. Major sources of organic carbon production in aquatic ecosystems include plant photosynthesis and, to a lesser degree, bacterial fixation. Runoff from agricultural lands and municipal and industrial waste discharges may further increase organic carbon levels (CCREM, 1987).

The TOC in natural waters may range from 1 to 30 $mg \cdot L^{-1}$ (McNeely *et al.*, 1979) and in the Pacific Region of Canada concentrations ranging from 0.01 to 26 $mg \cdot L^{-1}$ have been measured in surface waters. There are no Canadian or B.C. provincial water quality guidelines for TOC or COD.

The TOC and COD levels detected in this study were generally within the ranges previously found in the Pacific Region. Higher values of these parameters at some of the downstream sites located in the agricultural area relative to the upper-reach sites likely result from a combination of higher photosynthetic production at downstream sites and greater run-off of organic materials from the land surface.

3.1.7 Non-Filterable Residues

Many of the sites in agricultural areas had non-filterable residues (NFR) levels which were similar to those found at the upper-reach sites (Figure 10). Statistically, all stations were similar, except for Sites 1 and 3 which were significantly lower than Site 8. On several sampling dates peak NFR levels of greater than 100 $mg \cdot L^{-1}$ were observed. These may have been associated with particular storm events. Overall, NFR concentrations were not well correlated with the season of sampling; only Sites 6b and 9 had significantly different fall versus winter averages. This lack of seasonality may reflect the continuation of erosion processes throughout the fall and winter seasons with the heavy rainfalls encountered in the Lower Fraser Basin from October through to March.

Non-filterable residue (NFR), also known as total suspended solids (TSS), is a measure of the amount of particulate matter suspended within the water column and it can be indicative of erosion associated with runoff from land surfaces. NFR is closely related to parameters such as turbidity. Water flow, geology and topography all affect NFR levels due primarily to their influence on erosion processes (Environment Canada, 1995). The effects of high NFR levels include decreased light penetration, abrasive action on gills, habitat alteration and sedimentation.

A guideline for induced NFR of 10 $mg \cdot L^{-1}$ when background concentrations are less than 100 $mg \cdot L^{-1}$ has been set in both the MELP and the CCREM guidelines. Assuming that Site 2 best represents background levels, most of the sites had average NFR concentrations either below those at Site 2 or less than 10 $mg \cdot L^{-1}$ above them. Thus, it would appear that NFR residues are generally not a concern in the watershed except on sporadic occasions which may be associated with periods of heavy rainfall.

3.1.8 Biomass Estimates and Chlorophyll *a*

In this study the upper reach sites were not analyzed for biomass or chlorophyll *a* levels in the water column. Rather, only the downstream sites were chosen at which to monitor changes through time. It is not possible, therefore, to determine upstream-downstream relationships. The only apparent trend is that in all cases both biomass and chlorophyll *a* levels were lower during the winter sampling sessions than in the fall; the difference was statistically significant at Site 3b (Figure 11). This may reflect either decreased productivity due to decreased temperature and light during the winter months, or it could indicate the flushing of phytoplankton from the system which may occur with the heavy rains in the fall season.

Biomass measurements are an indicator of the productivity of a water body as a whole and do not have any associated guidelines. The biomass dry weight in this study was determined by gravimetric methods which can be affected by interference due to the presence of silt and other detritus. Biomass dry weight is determined by drying at 105°C whereas biomass fixed weight is determined by ignition at 550°C. Thus, the biomass fixed weight takes into consideration only those parts of the sample which are organic and as such it is often preferred to dry weight when used for comparative purposes (APHA, 1980).

Chlorophyll *a* is specifically indicative of algal growth and was measured in the present study to assess phytoplankton levels. Assuming that portions of Matsqui Slough approximate lake conditions, the criteria for lakes, set in $mg{\cdot}L^{-1}$, may be applied for a general indication of relative algal growth. The criterion of 1-3.5 $mg{\cdot}L^{-1}$ for aquatic life and 2-2.5 $mg{\cdot}L^{-1}$ for drinking water are given in terms of summer averages, when algal productivity could be expected to be at its highest. MELP's working criteria for rivers have been determined in terms of mg/m^2 and refer specifically to periphyton, and as such are not comparable to the data obtained for this study.

In the current study the criteria for chlorophyll *a* were, on average, exceeded during both the fall and winter sampling when algal productivity is expected to be quite low relative to summer months. The results show there is excessive algal growth in the Matsqui Slough area, associated with the eutrophic conditions present.

3.1.9 pH

In the current study average pH values were generally within the range of 6.5 to about 7.3. However, the pH was below 6.5 at Site 9 in both fall and winter and Site 3 in winter.

pH is a measure of the acidity or alkalinity of a water. Most aquatic organisms are capable of tolerating a pH range from 5 to 9 although physiological stress symptoms may begin to occur at pH 6.5 (McNeely *et al.*, 1979). The toxicity of many pollutants such as metals, dissolved ammonia and some organic compounds in particular, may be affected strongly by pH (CCREM, 1987). The CCREM guidelines as well as the MELP criteria state that the pH of water should not vary beyond the range of pH 6.5 to 9.0. Overall, pH levels in the watershed should not be inhibitory to aquatic populations. The lower levels measured may have been associated with large precipitation events, as other studies in Lower Fraser streams have shown that the acidic rainfall of the area can strongly influence stream pH (Whitfield *et al.*, 1993).

3.1.10 Temperature

Temperatures for the fall and winter sampling seasons covered in this study were generally within the range of 0°C to about 12°C. Water temperature was not expected to be a critical factor for fish populations during the study periods, however, stream temperatures are likely high during the summer in the study area due to a lack of riparian vegetation. In the nearby Salmon River watershed (Langley), summer water temperatures of up to 25°C have been measured during summer months (Wernick, 1996), and this system has proportionately more riparian vegetation than the Matsqui Slough system.

Temperature can have both a direct and an indirect effect on aquatic life. All aquatic organisms have upper and lower thermal tolerance limits, optimum temperatures for growth and preferred temperatures in thermal gradients. Temperature has an indirect affect through the influence on water quality parameters such as the solubility of oxygen, and the toxicity of ammonia metals, and other substances. Guidelines for temperature are species-specific and are based on physiological optimum temperatures, lower thermal tolerance limits and requirements for migration, spawning, and egg incubation. Temperatures in excess of 20°C can be lethal to Pacific anadromous salmon.

3.1.11 Seasonal Variation

Data for virtually all parameters indicate some degradation of water quality in the farmed areas of the watershed, particularly during the fall months. For example, nutrient, TOC, COD and fecal coliform levels were on average higher in the period from October to December at the downstream sites than in the period of February to March. Conversely, dissolved oxygen was found to be lower in the fall months and higher in the winter months. Similar trends occurred at the upstream sites, although overall averages and ranges were lower for nutrients and higher for oxygen than those measured at the downstream sites. The only exception was for fecal coliforms measured at Site 1, for which the winter values were higher than in the fall.

Large amounts of manure are typically spread on bare fields which lack substantial riparian buffer strips during fall months in the Matsqui Slough Watershed. Manure is the most likely source of high nutrient concentrations, although excess chemical fertilizers may also be washed from soils during the fall rains. High fecal coliform levels indicate a relatively fresh source of contamination. Malfunctioning septic tanks may also contribute some contaminants. Ammonia from manure runoff may result in decreased oxygen concentrations as nitrification processes use oxygen to convert ammonia (NH_3) to nitrate (NO_3^-) (Wetzel, 1983). Organic residues from manure runoff, reflected in TOC, COD and fixed biomass valuations, could also deplete oxygen as decomposers use oxygen for degradation processes. The collective effects of runoff from manure reaching the watershed result in worse water quality conditions in the fall than were measured in February and March.

Over a longer time frame the addition of nutrients, phosphorus in particular, can lead to oxygen depletion via eutrophication. Eutrophication occurs when increases in the productivity of an aquatic ecosystem take place. Increased productivity, often characterized by algal blooms, is eventually followed by die-off and decomposition of the algae (Ricklefs, 1983). Concentrations of 0.1 $mg \cdot L^{-1}$ of phosphorus in lakes have been associated with algal blooms and eutrophication, resulting in oxygen depletion and potentially severe impacts on aquatic life (Schreier *et al.*, 1991). This concentration was exceeded in many cases during the sampling periods covered in this study.

Eutrophication can result in large daily fluctuations in dissolved oxygen concentrations during summer months when algae produce lots of oxygen during the day but are net oxygen consumers at night. This is not likely to have been an issue in the present study which targeted fall and winter months.

3.2 Relationships Between Parameters

A preliminary examination of the relationships between parameters was done using parametric correlation analysis methods. The results of the analyses are presented in Table 9. A higher value of the correlation coefficient r indicates a stronger relationship between two parameters. A "significance F" value of less than α=0.05 indicates statistically significant relationship between the two parameters. Some of the stronger relationships are presented graphically in Figure 12A-12F

The analysis of relationships between parameters was confined to relationships between nutrients and other parameters which are expected to be influenced by or associated with nutrient levels in watercourses. Thus the relationships between nutrients and dissolved oxygen, biomass, and chlorophyll *a* were determined since high nutrient levels may be associated with increases in productivity in aquatic systems, as well as decreases in oxygen levels.

The relationships between fecal coliforms, ammonia and phosphorus were investigated because the nutrients and microbes occur in relatively high quantities in manure. Table 10 summarizes data with respect to approximate ammonia and phosphorus content (in terms of P_2O_5) of manure from various types of livestock and using differing manure handling systems. Ammonia and phosphorus are also present in commercial fertilizers. While both ammonia and phosphorus are relatively immobile once applied to soils (Tisdale *et al.*, 1985) they could be transported into a watercourse attached to soil particles during erosive processes or from runoff of non-adsorbed or unprecipitated forms. Therefore, one would expect a positive correlation of fecal coliforms with the nutrients, as well as between the two nutrients.

Finally, the relationship between TOC and dissolved oxygen was investigated. A negative correlation is expected for these parameters due to the influence of decomposing organic matter on oxygen concentrations.

Most of the pairs of parameters investigated appear to be significantly related to one another (Table 9). The strongest relationships were the significant negative correlations between dissolved oxygen and dissolved ammonia or total phosphorus. This may reflect inputs of Biological Oxygen Demand (BOD) from manure runoff, which would accompany nutrient inputs. The relationship between TOC and dissolved oxygen was also found to be significant (negative) as would be expected based upon the oxygen depletion which is associated with decomposition of organic materials. Relatively strong positive relationships were likewise observed between fecal coliforms and dissolved ammonia or total phosphorus, implicating manure as one of the primary sources of nutrient addition to the watercourses. Dissolved ammonia was also found to have a significant positive correlation to total phosphorus, which is not surprising given that both are present in manure.

The relationship between nitrate+nitrite-N and dissolved oxygen was not significant. Past studies have shown that adding carbon and nitrate to aquatic systems usually does not stimulate algal blooms or eutrophication (Ricklefs, 1983). The lack of a significant relationship between nitrate+nitrite-N and dissolved oxygen in this study may reflect those results. In addition, ammonia may be the preferred nitrogen source for some organisms since energy is saved when it is used instead of nitrate for the synthesis of protein (Tisdale *et al.*, 1985). From a productivity point of view, then, ammonia may in some cases impact the aquatic ecosystem more than nitrate. One might expect that a high nitrate+nitrite concentration would be associated with a low dissolved oxygen content since nitrate and nitrite result from the oxidation of ammonia via nitrification. Nitrate and nitrite, however, are highly water soluble and do not adsorb significantly to soils. Thus, their presence in aquatic systems often results from movement through soils, having already undergone nitrification prior to transport into either ground and surface waters.

The data for biomass fixed weight and chlorophyll *a* are somewhat more difficult to interpret. Biomass fixed weight was positively correlated with dissolved ammonia and total phosphorus concentrations but not with nitrate+nitrite-N concentrations. Chlorophyll *a* levels, however, were positively correlated with total phosphorus and nitrate+nitrite-N but not with dissolved ammonia. This may indicate differences in the nutrient requirements of the planktonic populations as a whole versus the algal component alone. A limited number of samples were collected for biomass and chlorophyll *a* and collection only occurred at two sites which were very similar with respect to nutrient levels. Due to this limited sampling, a full range of nutrient levels is not represented in the statistical analyses. As well, because the significance F values suggest that the correlations are not very strong the results of the analysis should not be over-emphasized.

Overall, the comparison of parameters shows that many of the expected trends are apparent; dissolved ammonia and total phosphorus levels have a significant negative correlation with dissolved oxygen and a significant positive correlation with fecal coliform levels. Dissolved oxygen also has a significant negative correlation with TOC.

A number of interacting factors may affect the behavior of the parameters observed in this study. Farming practices such as the timing and quantity of manure spread and the presence or absence of riparian buffers around streams are significant influencing factors. Naturally occurring factors such as climate and changing of the seasons are also important. The timing and volume of rainfall will affect the amounts of contaminants delivered to a stream. Heavy rains which coincide with fall manure application will likely result in significant loading of ammonia, phosphorus and organic matter to streams. The fall die-off of algae can further aggravate oxygen depletion.

4.0 Conclusions and Recommendations

Many of the water quality trends which are often associated with intensive agricultural practices were observed in this study of the Matsqui Slough Watershed. The upper-reach sites, Sites 1 and 2, often had the lowest or among the lowest levels of nutrients, fecal coliforms, TOC and COD. This was especially true for Site 2 which is located in an undeveloped area of the Clayburn Creek headwaters. The remaining sites, from Site 3 to Site 6b, are in intensively used agricultural areas and had elevated nutrient and organic carbon levels, although values fluctuated considerably and were in some cases close to or below those observed at the upper reaches. The lowest dissolved oxygen and oxygen percent saturation levels were observed at four of the sites in the agriculturally impacted area in Page Creek (Sites 3 and 3b) and the unnamed Matsqui Slough tributary (Sites 6 and 6b). Oxygen levels at these sites were statistically lower than all other sites in the watershed and fall values were significantly lower than winter values.

With respect to Sites 7 through 10, those located outside of the Matsqui Slough Watershed, Site 9, in Nathan Slough, appeared to be the most impacted, with high levels of nutrients, fecal coliforms and organics combined with low dissolved oxygen levels. Sites 8 and 10 generally appeared to be the least impacted of the latter four sites.

The knowledge of practices in the area and the correlation analysis show that inputs from manure are the likely source of the elevated nutrient concentrations and coliform levels. Improperly functioning septic systems may contribute to degraded water quality, however, they are likely a relatively small source, given the small number of people compared to the numbers of livestock.

Several relationships between parameters were demonstrated using parametric correlation analysis methods. The strongest relationships were found between the nutrients, dissolved ammonia and total phosphorus, and both dissolved oxygen and fecal coliform levels. The negatively correlated nutrient-dissolved oxygen relationship may be indicative of the oxidation of ammonia to nitrate and nitrite and eutrophic conditions. The positively correlated nutrient-fecal coliform relationship suggests that manure sources are at least partially responsible for the elevated nutrient levels. A relatively strong negative relationship was also found between TOC and dissolved oxygen. This relationship may reflect the oxygen demand of decomposing organic materials.

Ammonia and nitrate concentrations were generally below the applicable guidelines or criteria for protection of aquatic life and nitrate sometimes exceeded the MELP drinking water criteria. Nitrite, more of a concern than nitrate with respect to aquatic life, exceeded the recommended criteria at several sites although only a very limited number of samples were tested specifically for this parameter. More extensive testing for nitrite during future sampling should be undertaken. The only available guideline for phosphorus is the MELP water quality criterion for lakes, and it was exceeded at all study sites.

Although fecal coliforms may not be directly hazardous to the health of aquatic life, they are a concern when they contaminate filter feeding organisms (i.e. shellfish) in downstream areas, such as the estuary, and are consumed. Likewise, fecal coliform contamination of irrigation water can be hazardous on crops that are eaten unprocessed (raw). Sampling was conducted during fall and winter months when crop irrigation is not an issue, however, the Matsqui slough system is used as a source of irrigation water for crops during summer months, and coliforms should be measured during this season.

From the perspective of protecting aquatic life, the measured levels of dissolved oxygen present the greatest concern. Levels at many of the study sites did not meet the CCREM guidelines for either the "early-life stages" or the "other life stages" of cold-water biota. In addition, the 80% oxygen saturation guideline was not met at many of the sites located in agricultural areas, especially during the fall sampling sessions. The low dissolved oxygen levels measured during the fall may create an environmental barrier which prevents adult coho salmon from accessing upstream spawning areas. Dissolved oxygen concentrations may also limit the amount of rearing habitat available for juvenile coho, which spend a minimum of one year in small streams prior to their seaward migration.

Depressed oxygen concentrations result directly from inputs of BOD associated with manure runoff into watercourse, and indirectly from eutrophication resulting from the input of nutrients. The cumulative inputs of nutrients and BOD are significantly degrading water quality in the watershed. If all producers in the Matsqui Slough system were to attain compliance with the *Code of Agricultural Practice for Waste Management*, water quality would likely improve, however, additional measures may be necessary to protect coho salmon. Many of fields are farmed right up to the stream bank with no intact riparian zone. Therefore, nutrients and manure are still likely to be washed into the system with rain and irrigation water even with improved nutrient and manure management practices. Producers should be encouraged to establish vegetated riparian buffer zones along streams and ditches to minimize contaminant loading to streams.

Water quality data obtained from other streams in agricultural areas near Matsqui Slough suggest that other Lower Fraser Valley streams draining agricultural areas can be expected to have degraded water quality because of manure runoff and nutrient inputs. Given the importance of Lower Fraser Valley streams to Fraser River coho and chum stocks it is recommended that MELP and DFO work with farmers to reduce contaminant inputs to streams, and to encourage the re-establishing of vegetated riparian zones. A strategic approach for addressing the agricultural industry is required, in addition to resolving individual site-specific problems.

5.0 Acknowledgments

This study was funded by the Department of Fisheries and Oceans and Environment Canada through their Fraser River Action Plans, and by the Ministry of Environment, Lands, and Parks. IRC Consultants collected the 1994 water quality samples.

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Table 1 Surface Water Sampling Locations and Sampling Times in the Matsqui Slough Watershed

Site #	Site Description	Sampling Times
1	Willband Creek @ Valley Avenue	all dates
2	Clayburn Creek @ Clayburn Road	all dates
3	Page Creek @ Beharrell Road	all dates
3b	Page Creek @ Bell Road	Fall 1993 (Nov. 1 & 15), Fall 1994, Winter 1995, Fall 1995
4	Clayburn Creek @ Harris Road	all dates
5	Matsqui Slough @ Riverside Street	all dates
6	Matsqui Slough Tributary @ Riverside St	all dates
6b	Matsqui Slough Tributary @ Bell Road	Fall 1993 (Nov. 15), Fall 1994, Winter 1995, Fall 1995
7	McLennan Creek	Fall 1994, Winter 1995, Fall 1995
8	Hanna Creek	Fall 1994, Winter 1995, Fall 1995
9	Nathan Slough and Benson Canal	Fall 1994, Winter 1995, Fall 1995
10	Nathan Creek	Fall 1994, Winter 1995, Fall 1995

Table 2 Field Sampling Times and Parameters Measured in the Matsqui Slough Watershed

Parameters	Sampling Time				
	Fall 1993	Winter 1994	Fall 1994	Winter 1995	Fall 1995
Temperature	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X
Fecal Coliforms		X	X	X	X
pH		X	X	X	X
Non-Filterable Residue			X	X	X
Total Organic Carbon		X	X	X	X
Ammonia - N	X	X	X	X	X
Chemical Oxygen Demand			X		
Nitrite+Nitrate-N		X	X	X	X
Nitrate-N*					X (Nov. 30)
Nitrite-N*					X (Nov. 30)
Total Phosphorus		X	X	X	X
Biomass Dry Weight*			X (3b, 5)	X (3b, 5)	X (3b, 5)
Biomass Fixed Weight*			X (3b, 5)	X (3b, 5)	X (3b, 5)
Chlorophyll *a**			X (3b,5)	X (3b,5)	X (3b,5)

* information in brackets indicates date or sampling site in instances where sampling for the parameter was conducted on a limited number of occasions or at a limited number of sites.

Table 3 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1993)

	Site 1				Site 2			
Date (1993)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)
Oct. 6	12.2	7.9	74	0.446	11.0	10.6	96	< 0.005
Oct. 12	12.0	7.1	66	0.038	10.5	10.8	97	0.008
Oct. 18	11.8	10.0	92	0.094	10.5	11.4	102	0.009
Oct. 25	7.8	10.6	89	0.091	6.2	12.2	99	< 0.005
Nov. 1	8.3	9.8	83	0.078	7.0	12.2	101	0.012
Nov. 8	6.8	11.1	91	0.093	5.3	12.8	101	0.016
Nov. 15	6.8	10.1	83	0.559	5.7	12.3	98	0.034
Nov. 24	1.9	11.2	81	0.134	-1.0	14.1	94	0.012
Dec. 15	8.0	9.7	82	0.139	7.1	12.0	99	0.019
Average	8.4	9.7	82	0.186	6.9	12.0	99	0.013
Std. Dev.	3.3	1.4	8	0.184	3.7	1.1	3	0.010
Minimum	1.9	7.1	66	0.038	-1.0	10.6	94	< 0.005
Maximum	12.2	11.2	92	0.559	11.0	14.1	102	0.034

	Site 3				Site 3b			
Date (1993)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)
Oct. 6	12.5	2.5	23	0.011	-	-	-	-
Oct. 12	11.0	1.2	11	< 0.005	-	-	-	-
Oct. 18	12.0	0.9	8	0.018	-	-	-	-
Oct. 25	8.8	2.0	17	0.11	-	-	-	-
Nov. 1	8.0	2.5	21	0.077	8.6	7.9	68	-
Nov. 8	4.8	4.5	35	0.101	-	-	-	-
Nov. 15	5.2	5.5	43	0.083	5.9	9.1	73	-
Nov. 24	-0.1	6.6	45	0.138	-	-	-	-
Dec. 15	7.8	6.5	55	0.105	-	-	-	-
Average	7.8	3.6	29	0.072	7.3	8.5	71	-
Std. Dev.	4.0	2.2	16	0.049	1.9	0.8	4	-
Minimum	-0.1	0.9	8	< 0.005	5.9	7.9	68	-
Maximum	12.5	6.6	55	0.138	8.6	9.1	73	-

Table 3 (cont) **Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1993).**

	Site 4				Site 5			
Date (1993)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Dissolved Ammonia Nitrogen (mg·L^{-1})	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Dissolved Ammonia Nitrogen (mg·L^{-1})
Oct. 6	12.0	6.8	63	0.139	12.3	3.8	36	0.139
Oct. 12	12.2	7.4	69	0.165	12.1	5.5	51	0.088
Oct. 18	12.2	7.1	66	0.285	12.1	5.8	54	0.319
Oct. 25	8.0	8.2	69	0.19	8.4	6.5	55	0.233
Nov. 1	9.1	7.9	69	< 0.005	9.0	4.5	39	0.226
Nov. 8	5.0	10.1	79	0.197	4.5	9.4	73	0.233
Nov. 15	6.3	9.7	79	0.416	6.5	10.0	81	0.297
Nov. 24	-0.4	11.6	78	0.149	-0.3	11.6	79	0.206
Dec. 15	7.3	8.9	74	0.113	7.8	8.0	67	0.133
Average	8.0	8.6	72	0.184	8.0	7.2	59	0.208
Std. Dev.	4.1	1.6	6	0.115	4.1	2.7	16	0.076
Minimum	-0.4	6.8	63	< 0.005	-0.3	3.8	36	0.088
Maximum	12.2	11.6	79	0.416	12.3	11.6	81	0.319

	Site 6				Site 6b			
Date (1993)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Dissolved Ammonia Nitrogen (mg·L^{-1})	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Dissolved Ammonia Nitrogen (mg·L^{-1})
Oct. 6	12.0	2.4	22	1.23	-	-	-	-
Oct. 12	13.5	2.9	28	0.973	-	-	-	-
Oct. 18	11.6	3.7	34	0.895	-	-	-	-
Oct. 25	8.0	4.8	41	0.981	-	-	-	-
Nov. 1	8.2	1.4	12	3.18	-	-	-	-
Nov. 8	6.0	3.8	31	1.43	-	-	-	-
Nov. 15	7.0	7.3	60	0.664	6.6	6.1	50	-
Nov. 24	1.0	4.8	34	0.766	-	-	-	-
Dec. 15	7.9	7.7	65	0.338	-	-	-	-
Average	8.4	4.3	36	1.162	6.6	6.1	50	-
Std. Dev.	3.7	2.1	17	0.819	-	-	-	-
Minimum	1.0	1.4	12	0.338	6.6	6.1	50	-
Maximum	13.5	7.7	65	3.180	6.6	6.1	50	-

Table 4 Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1994)

Site 1

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Fecal Coliforms (MPN· 100 mL^{-1})	pH	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 10	5.2	11.2	88	80	6.9	4.50	0.103	1.790	0.062
Feb. 22	4.0	11.0	84	50	6.4	3.20	0.115	1.090	0.040
Mar. 3	8.5	6.7	57	23	6.1	4.40	0.159	0.942	0.043
Mar. 10	8.0	10.4	88	1000	6.3	3.60	0.330	1.140	0.127
Mar. 24	5.5	10.4	82	170	6.8	4.00	0.039	1.520	0.040
Average	6.2	9.9	80	109	6.5	3.94	0.149	1.296	0.062
Std. Dev.	1.9	1.8	13	415	0.3	0.55	0.110	0.349	0.037
Minimum	4.0	6.7	57	23	6.1	3.20	0.039	0.942	0.040
Maximum	8.5	11.2	88	1000	6.9	4.50	0.330	1.790	0.127

Site 2

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Fecal Coliforms (MPN· 100 mL^{-1})	pH	T.O.C. ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 10	2.0	12.4	90	30	6.8	1.20	0.009	1.350	0.012
Feb. 22	4.0	13.0	99	80	6.5	1.90	< 0.005	1.840	0.023
Mar. 3	8.1	12.4	105	22	6.3	1.90	0.010	1.930	0.035
Mar. 10	6.0	12.4	100	30	6.4	4.20	0.007	1.590	0.055
Mar. 24	4.0	13.4	102	14	6.9	1.50	< 0.005	1.390	0.006
Average	4.8	12.7	99	29	6.6	2.14	0.024	1.620	0.026
Std. Dev.	2.3	0.5	6	26	0.3	1.19	0.038	0.260	0.020
Minimum	2.0	12.4	90	14	6.3	1.20	< 0.005	1.350	0.006
Maximum	8.1	13.4	105	80	6.9	4.20	0.010	1.930	0.055

Site 3

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	Percent Saturation (%)	Fecal Coliforms (MPN· 100 mL^{-1})	pH	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 10	3.0	5.1	38	17	6.7	4.54	0.220	1.070	0.089
Feb. 22	4.0	9.6	73	170	6.2	11.60	0.073	5.300	0.084
Mar. 3	8.6	8.0	69	130	6.1	8.80	0.090	2.600	0.040
Mar. 10	7.0	6.0	49	240	6.2	6.25	0.105	1.490	0.062
Mar. 24	6.0	7.6	61	80	6.5	8.30	0.105	1.660	0.067
Average	5.7	7.3	58	94	6.3	7.90	0.119	2.424	0.068
Std. Dev.	2.3	1.8	14	85	0.3	2.68	0.058	1.702	0.019
Minimum	3.0	5.1	38	17	6.1	4.54	0.073	1.070	0.040
Maximum	8.6	9.6	73	240	6.7	11.60	0.220	5.300	0.089

Table 4 (cont) **Surface Water Quality for the Matsqui Slough Watershed (Winter 1994)**

Site 4

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Fecal Coliforms (MPN·100 mL^{-1})	pH	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Total Phosphorus (mg·L^{-1})
Feb. 10	5.2	11.2	88	70	7.0	2.98	0.270	1.670	0.105
Feb. 22	5.0	11.2	88	300	6.2	6.40	0.228	4.290	0.114
Mar. 3	8.2	7.2	61	900	6.1	5.10	0.280	1.910	0.133
Mar. 10	7.0	10.4	86	130	6.4	3.84	0.108	1.640	0.085
Mar. 24	5.0	10.6	83	80	6.5	4.20	0.127	1.950	0.117
Average	6.1	10.1	81	181	6.4	4.50	0.203	2.292	0.111
Std. Dev.	1.5	1.7	11	350	0.4	1.30	0.080	1.125	0.018
Minimum	5.0	7.2	61	70	6.1	2.98	0.108	1.640	0.085
Maximum	8.2	11.2	88	900	7.0	6.40	0.280	4.290	0.133

Site 5

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Fecal Coliforms (MPN·100 mL^{-1})	pH	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Total Phosphorus (mg·L^{-1})
Feb. 10	2.3	10.4	76	4	6.9	2.76	0.200	1.500	0.078
Feb. 22	4.5	10.8	83	900	6.2	7.50	0.200	4.550	0.109
Mar. 3	8.2	7.5	64	900	6.1	5.70	0.260	1.950	0.148
Mar. 10	7.0	10.2	84	170	6.5	9.65	0.125	1.630	0.068
Mar. 24	6.0	10.2	82	50	6.6	5.40	0.138	1.910	0.066
Average	5.6	9.8	78	122	6.5	6.20	0.185	2.308	0.094
Std. Dev.	2.3	1.3	8	456	0.3	2.56	0.055	1.267	0.035
Minimum	2.3	7.5	64	4	6.1	2.76	0.125	1.500	0.066
Maximum	8.2	10.8	84	900	6.9	9.65	0.260	4.550	0.148

Site 6

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	Percent Saturation (%)	Fecal Coliforms (MPN·100 mL^{-1})	pH	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Total Phosphorus (mg·L^{-1})
Feb. 10	6.0	4.9	39	14	7.0	1.91	0.700	0.439	0.096
Feb. 22	4.0	7.0	53	300	6.4	8.00	0.811	5.830	0.266
Mar. 3	8.9	4.5	39	900	6.4	6.70	1.140	2.410	0.318
Mar. 10	8.5	4.0	34	*5000*	6.5	3.11	1.210	0.523	0.192
Mar. 24	6.0	7.2	58	900	6.7	3.60	0.576	1.140	0.107
Average	6.7	5.5	45	443	6.6	4.66	0.887	2.068	0.196
Std. Dev.	2.0	1.5	10	2036	0.3	2.57	0.276	2.246	0.097
Minimum	4.0	4.0	34	14	6.4	1.91	0.576	0.439	0.096
Maximum	8.9	7.2	58	5000	7.0	8.00	1.210	5.830	0.318

Table 5 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1994)

Site 1

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	11	7.4	67	220	7.4	< 4	2.1	0.019	-	1.16	0.022
Oct. 13	9.7	6.4	56	80	7.4	< 4	-	0.038	10	1.17	0.016
Oct. 19	4.9	8.5	66	420	7.3	< 4	2.8	0.104	-	1.12	0.02
Oct. 27	-	-	-	900	6.5	9	-	0.035	21	0.29	0.051
Nov. 2	7.7	8.8	74	400	6.9	5	7	0.042	-	0.72	0.041
Nov. 8	7.1	7.8	64	76	6.9	< 4	-	0.038	14	0.65	0.021
Nov. 16	5	8.5	66	860	7	7	-	0.050	14	0.52	0.037
Nov. 24	4.5	8.7	68	40	7.3	5	-	0.054	12	1.06	0.015
Nov. 30	6.4	8	64	30	7.2	12	-	0.029	12	0.3	0.02
Average	7.0	8.0	66	181	7.1	6	4.0	0.045	14	0.78	0.027
Std. Dev.	2.4	0.8	5	341	0.3	3	2.7	0.024	4	0.36	0.013
Minimum	4.5	6.4	56	30	6.5	< 4	2.1	0.019	10	0.29	0.015
Maximum	11.0	8.8	74	900	7.4	12	7.0	0.104	21	1.17	0.051

Site 2

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	10	10.6	94	35	7.7	< 4	1.2	< 0.005	-	0.41	0.01
Oct. 13	8.8	9.3	80	90	7.7	< 4	-	< 0.005	10	0.38	0.004
Oct. 19	10.1	13.4	118	60	7.6	< 4	1.9	0.01	-	0.42	0.007
Oct. 27	-	-	-	170	6.9	17	-	< 0.005	17	0.9	0.058
Nov. 2	6.1	13.1	105	160	7.2	< 4	3.9	< 0.005	-	1.26	0.025
Nov. 8	6.9	12.5	103	110	7.1	5	-	< 0.005	10	1.63	0.12
Nov. 16	5	12.4	97	90	7.1	11	-	0.006	14	1.6	0.023
Nov. 24	3	13.2	98	37	7.4	< 4	-	< 0.005	10	1.53	0.004
Nov. 30	6.1	11.9	95	300	7.2	81	-	< 0.005	22	1.67	0.048
Average	7.0	12.1	99	94	7.3	15	2.3	0.006	14	1.09	0.033
Std. Dev.	2.5	1.4	11	84	0.3	25	1.4	0.002	5	0.57	0.038
Minimum	3.0	9.3	80	35	6.9	< 4	1.2	< 0.005	10	0.38	0.004
Maximum	10.1	13.4	118	300	7.7	81	3.9	0.010	22	1.67	0.120

Table 5 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1994)

Site 3

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L⁻¹)	% Saturation	Fecal Coliforms (CFU·100 mL⁻¹)	pH	Non-Filterable Residue (mg·L⁻¹)	Total Organic Carbon (mg·L⁻¹)	Dissolved Ammonia Nitrogen (mg·L⁻¹)	Chemical Oxygen Demand (mg·L⁻¹)	Nitrite+ Nitrate Nitrogen (mg·L⁻¹)	Total Phosphorus (mg·L⁻¹)
Oct. 6	12	***12.9***	***119***	240	7.2	12	4.5	0.400	-	0.31	***1.24***
Oct. 13	10.5	6.4	58	250	7.3	12	-	0.369	10	0.21	0.109
Oct. 19	6	4.6	37	300	7.1	14	4.5	0.605	-	0.22	0.128
Oct. 27	-	-	-	2300	6.5	106	-	0.263	46	9.32	0.359
Nov. 2	8.1	6.9	58	300	6.8	11	14	0.205	-	5.21	0.08
Nov. 8	7.1	6.2	51	240	6.4	9	-	0.096	38	5.74	0.58
Nov. 16	6.5	8.2	67	700	6.5	9	-	0.096	39	5.98	0.069
Nov. 24	4.6	7.7	60	160	6.9	14	-	0.158	29	1.93	0.054
Nov. 30	5.2	8.3	65	1700	6.3	25	-	0.050	38	4.56	0.057
Average	7.5	7.7	64	436	6.8	24	7.7	0.249	33	3.72	0.297
Std. Dev.	2.6	2.4	24	774	0.4	31	5.5	0.181	13	3.22	0.396
Minimum	4.6	4.6	37	160	6.3	9	4.5	0.050	10	0.21	0.054
Maximum	12.0	12.9	119	2300	7.3	106	14.0	0.605	46	9.32	1.240

Site 3b

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L⁻¹)	% Saturation	Fecal Coliforms (CFU·100 mL⁻¹)	pH	Non-Filterable Residue (mg·L⁻¹)	Total Organic Carbon (mg·L⁻¹)	Dissolved Ammonia Nitrogen (mg·L⁻¹)	Chemical Oxygen Demand (mg·L⁻¹)	Nitrite+ Nitrate Nitrogen (mg·L⁻¹)	Total Phosphorus (mg·L⁻¹)	Biomass Dry Weight (mg)	Biomass Fixed Weight (mg)	Chlorophyll A (mg·L⁻¹)
Oct. 6	12	9.4	87	760	7.1	26	4.5	0.508	-	0.19	0.132	48	41	13.2
Oct. 13	10.3	4.3	38	160	7.1	23	-	0.563	12	0.19	0.151	23	15	9.4
Oct. 19	6	4.8	38	200	7.1	19	4.9	0.684	-	0.17	0.14	41	41	7.9
Oct. 27	-	-	-	200	6.6	32	-	0.468	44	8.98	0.28	63	37	23.3
Nov. 2	7.9	6.35	53	1120	6.6	27	12.7	0.323	-	5.05	0.163	57	42	9.7
Nov. 8	6.8	6.4	53	470	6.4	20	-	0.136	37	6.17	0.082	55	31	10
Nov. 16	6.5	7.8	64	1200	6.9	16	-	0.102	38	6.26	0.082	51	27	8.4
Nov. 24	4	7.9	60	700	7	105	-	0.358	37	1.88	0.335	66	42	14.4
Nov. 30	7.9	8.5	72	10	6.4	27	-	0.098	40	4.55	0.068	42	23	8.4
Average	7.7	6.9	58	303	6.8	33	7.4	0.360	35	3.72	0.159	50	33	11.6
Std. Dev.	2.5	1.8	17	434	0.3	28	4.6	0.214	11	3.23	0.091	13	10	4.9
Minimum	4.0	4.3	38	10	6.4	16	4.5	0.098	12	0.17	0.068	23	15	7.9
Maximum	12.0	9.4	87	1200	7.1	105	12.7	0.684	44	8.98	0.335	66	42	23.3

Table 5 (cont)   Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1994)

Site 4

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· $100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	12	7.2	66	1010	7.4	9	2.5	0.103	-	1.01	0.055
Oct. 13	10.3	9.8	86	180	7.5	10	-	0.100	10	1	0.054
Oct. 19	11.4	10.2	92	100	7.3	18	3.5	0.132	-	1.01	0.056
Oct. 27	-	-	-	260	6.8	85	-	0.094	36	5.47	0.213
Nov. 2	8.2	8.3	70	172	6.7	9	9.9	0.091	-	6.19	0.56
Nov. 8	7.8	8.7	73	360	6.6	17	-	0.088	24	5.46	0.079
Nov. 16	6	9	72	650	6.7	14	-	0.058	23	4.29	0.056
Nov. 24	3.9	11	84	90	7.1	22	-	0.108	18	2.51	0.035
Nov. 30	6.2	9.7	78	700	6.4	56	-	0.179	29	3.29	0.091
Average	8.2	9.2	78	284	6.9	27	5.3	0.106	23	3.36	0.133
Std. Dev.	2.8	1.2	9	322	0.4	26	4.0	0.034	9	2.09	0.169
Minimum	3.9	7.2	66	90	6.4	9	2.5	0.058	10	1.00	0.035
Maximum	12.0	11.0	92	1010	7.5	85	9.9	0.179	36	6.19	0.560

Site 5

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· $100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)	Biomass Dry Weight (mg)	Biomass Fixed Weight (mg)	Chlorophyll A ($mg \cdot L^{-1}$)
Oct. 6	11.5	5.2	48	930	6.7	12	3.7	0.381	-	0.32	0.290	44	32	7.2
Oct. 13	10.8	6.3	57	340	7.3	16	-	0.104	10	0.87	0.072	21	15	5.2
Oct. 19	10.6	8.2	74	200	7.2	8	3.7	0.215	-	0.86	0.075	36	27	5.2
Oct. 27	-	-	-	410	6.7	88	-	0.159	36	5.49	0.075	57	48	18.3
Nov. 2	8.2	8	67	184	6.7	11	10.3	0.127	34	6.1	0.082	26	26	4.7
Nov. 8	8	8.4	71	800	6.6	24	-	0.161	34	5.61	0.082	50	28	5.8
Nov. 16	6	8.7	70	1300	6.8	24	-	0.104	25	4.8	0.083	43	25	7.7
Nov. 24	4	10.4	79	120	7.1	18	-	0.201	18	2.36	0.052	41	24	5.8
Nov. 30	6	9.8	79	1600	6.5	64	-	0.206	31	3.52	0.068	44	27	8.1
Average	8.1	8.1	68	462	6.8	29	5.9	0.184	27	3.33	0.098	40	28	7.6
Std. Dev.	2.7	1.7	11	534	0.3	28	3.8	0.085	10	2.29	0.073	11	9	4.2
Minimum	4.0	5.2	48	120	6.5	8	3.7	0.104	10	0.32	0.052	21	15	4.7
Maximum	11.5	10.4	79	1600	7.3	88	10.3	0.381	36	6.10	0.290	57	48	18.3

Table 5 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1994)

Site 6

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	11.5	3	28	100	7.3	45	1.1	0.93	-	0.11	0.158
Oct. 13	10.5	4.4	40	80	7.3	28	-	0.889	10	0.09	0.221
Oct. 19	11.5	7.2	66	48	7.2	23	2.3	1.23	-	0.12	0.174
Oct. 27	-	-	-	***15000***	7	36	-	***7.66***	87	1.74	***1.2***
Nov. 2	7.3	3.6	30	430	7.1	28	11.8	3.57	-	7.72	0.354
Nov. 8	8.2	3.6	30	4700	6.9	23	-	1.37	23	5.04	0.241
Nov. 16	6	5.6	45	2800	7	18	-	1.61	24	4.73	0.233
Nov. 24	5.3	6.5	51	320	7.3	46	-	1.14	18	1.27	0.178
Nov. 30	6	5.7	46	***13000***	6.6	65	-	2.41	55	6.72	0.396
Average	8.3	5.0	42	801	7.1	35	5.1	2.312	36	3.06	0.351
Std. Dev.	2.6	1.5	13	5878	0.2	15	5.9	2.181	29	3.02	0.329
Minimum	5.3	3.0	28	48	6.6	18	1.1	0.889	10	0.09	0.158
Maximum	11.5	7.2	66	15000	7.3	65	11.8	7.660	87	7.72	1.200

Site 6B

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	13	4	38	170	7.3	16	1.1	0.665	-	0.32	0.152
Oct. 13	9.4	1.4	12	60	7.2	31	-	0.746	10	0.17	0.261
Oct. 19	11.2	2.4	22	14	7.1	15	1.9	0.951	-	0.17	0.162
Oct. 27	-	-	-	160	6.8	17	-	0.46	12	0.57	0.18
Nov. 2	7.7	3.8	32	100	6.9	18	2	0.632	-	0.75	0.103
Nov. 8	8.3	3.3	28	470	6.8	35	-	0.583	11	0.81	0.292
Nov. 16	6.5	4.2	35	2400	7	19	-	1.18	15	0.88	0.281
Nov. 24	5.7	5.2	42	20	7.2	< 4	-	0.401	12	0.78	0.105
Nov. 30	7.3	5.4	44	1100	6.3	56	-	0.126	113	0.94	0.451
Average	8.6	3.7	32	157	7.0	23	1.7	0.638	29	0.60	0.221
Std. Dev.	2.5	1.3	11	792	0.3	15	0.5	0.308	41	0.30	0.112
Minimum	5.7	1.4	12	14	6.3	< 4	1.1	0.126	10	0.17	0.103
Maximum	13.0	5.4	44	2400	7.3	56	2.0	1.180	113	0.94	0.451

Table 5 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1994)

Site 7

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· $100 mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	-	-	-	-	-	-	-	-	-	-	-
Oct. 13	10.7	7.9	71	90	7.7	8	-	0.106	10	1.35	0.083
Oct. 19	11.4	7.8	70	460	7.4	6	4.2	1.09	-	1.55	0.175
Oct. 27	-	-	-	2400	6.7	33	-	0.042	39	7.24	0.286
Nov. 2	8.8	8.7	75	144	7	14	8.9	0.202	-	8.27	0.089
Nov. 8	8.5	8.7	75	870	6.8	20	-	0.164	22	7.6	0.135
Nov. 16	6.3	8.1	65	3200	6.8	24	-	0.301	24	7.87	0.156
Nov. 24	4	10.8	82	410	7.3	28	-	0.146	28	4.58	0.054
Nov. 30	6	9.2	74	1200	6.6	75	-	0.236	29	5.28	0.127
Average	8.0	8.7	73	612	7.0	26	6.6	0.286	25	5.47	0.138
Std. Dev.	2.7	1.0	5	1133	0.4	22	3.3	0.334	10	2.79	0.072
Minimum	4.0	7.8	65	90	6.6	6	4.2	0.042	10	1.35	0.054
Maximum	11.4	10.8	82	3200	7.7	75	8.9	1.090	39	8.27	0.286

Site 8

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· $100 mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	-	-	-	-	-	-	-	-	-	-	-
Oct. 13	10.2	10.3	91	140	7	< 4	-	0.009	14	1.34	0.023
Oct. 19	5.8	10.2	82	30	7	< 4	5.5	0.013	-	1.61	0.03
Oct. 27	-	-	-	2000	7.1	24	-	0.364	28	4.6	0.212
Nov. 2	12.3	7.6	70	132	7.2	10	4.7	0.039	-	5.4	0.066
Nov. 8	8.2	11.8	99	370	7.1	14	-	0.47	12	5.73	0.09
Nov. 16	6	11.8	95	530	7.2	21	-	0.164	18	5.72	0.138
Nov. 24	3.9	13.1	100	48	7.4	< 4	-	0.047	13	5.49	0.028
Nov. 30	6	11.3	91	700	6.8	*274*	-	0.216	25	5.26	0.147
Average	7.5	10.9	90	228	7.1	44	5.1	0.165	18	4.39	0.092
Std. Dev.	2.9	1.7	11	654	0.2	93	0.6	0.174	7	1.84	0.069
Minimum	3.9	7.6	70	30	6.8	< 4	4.7	0.009	12	1.34	0.023
Maximum	12.3	13.1	100	2000	7.4	274	5.5	0.470	28	5.73	0.212

Table 5 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1994)

Site 9

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100 mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	-	-	-	-	-	-	-	-	-	-	-
Oct. 13	12	2.4	22	2000	6.5	12	-	0.965	89	0.02	***2.55***
Oct. 19	5.8	1.5	12	1700	6.6	15	15.1	0.565	-	0.09	0.89
Oct. 27	-	-	-	1100	6.3	19	-	0.6	77	8.3	0.466
Nov. 2	9.9	4.5	40	190	6.4	12	21.9	0.322	-	6.95	0.449
Nov. 8	9.2	4.5	39	420	6.2	8	-	0.384	55	8.52	0.503
Nov. 16	7.3	4	33	5400	6.3	11	-	0.864	64	8.53	0.382
Nov. 24	5.5	4.9	39	380	6.6	10	-	0.618	56	3.49	0.261
Nov. 30	6	11.3	91	2200	6.1	15	-	0.332	64	8.45	0.185
Average	8.0	4.7	39	1038	6.4	13	18.5	0.581	68	5.54	0.711
Std. Dev.	2.5	3.2	25	1692	0.2	3	4.8	0.238	13	3.78	0.772
Minimum	5.5	1.5	12	190	6.1	8	15.1	0.322	55	0.02	0.185
Maximum	12.0	11.3	91	5400	6.6	19	21.9	0.965	89	8.53	2.550

Site 10

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100 mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Chemical Oxygen Demand ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 6	-	-	-	-	-	-	-	-	-	-	-
Oct. 13	10.6	9.7	88	30	7.4	< 4	-	< 0.005	10	0.47	0.089
Oct. 19	11	10.6	96	20	7.4	< 4	2.6	0.008	-	0.64	0.086
Oct. 27	-	-	-	4000	6.9	32	-	0.155	32	4.72	0.253
Nov. 2	8	11.2	94	360	7.1	9	6.6	0.046	-	4.86	0.086
Nov. 8	8	11.7	99	110	6.9	4	-	0.056	18	5.26	0.098
Nov. 16	5.5	11.7	94	130	7	5	-	0.035	18	6.06	0.145
Nov. 24	4	12.6	96	27	7.3	< 4	-	0.006	12	4.24	0.046
Nov. 30	5.1	11.8	92	-	6.6	42	-	0.094	25	4.74	0.093
Average	7.5	11.3	94	119	7.1	13	4.6	0.051	19	3.87	0.112
Std. Dev.	2.7	0.9	3	1474	0.3	15	2.8	0.052	8	2.12	0.063
Minimum	4.0	9.7	88	20	6.6	< 4	2.6	< 0.005	10	0.47	0.046
Maximum	11.0	12.6	99	4000	7.4	42	6.6	0.155	32	6.06	0.253

Table 6 Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1995)

Site 1

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	6.2	-	-		7.5	8	2.3	0.104	1.49	0.017
Feb. 16	5	-	-	60	6.7	13	2.3	0.189	1.46	0.023
Feb. 23	6.1	9.1	73	50	7.3	5	3	0.079	1.27	0.019
Mar. 1	4	10.4	79	96	6.7	30	2.2	0.068	1.69	0.047
Mar. 8	6.3	9.5	76	120	7.3	26	3.1	0.041	1.65	0.004
Mar. 15	7.9	9.5	80	1200	7.2	28	4.1	0.064	1	0.019
Mar. 22	7.2	8.8	72	70	7.3	10	3.7	0.079	1.38	0.016
Mar. 27	7.1	9.6	79	40	7.5	11	2.3	0.04	1.64	0.022
Average	6.2	9.5	77	102	7.2	16	2.9	0.083	1.45	0.021
Std. Dev.	1.3	0.5	3	427	0.3	10	0.7	0.048	0.23	0.012
Minimum	4.0	8.8	72	40	6.7	5	2.2	0.040	1.00	0.004
Maximum	7.9	10.4	80	1200	7.5	30	4.1	0.189	1.69	0.047

Site 2

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	5	-	-	-	7.5	4	1.0	< 0.005	1.21	0.010
Feb. 16	2.9	-	-	14	6.9	4	1.3	< 0.005	1.11	0.010
Feb. 23	5.4	12	94	10	7.3	12	1.4	< 0.005	1.22	0.013
Mar. 1	2.5	13.3	99	11	6.9	4	1.4	< 0.005	1.16	0.021
Mar. 8	4.1	12.1	92	40	7.4	78	1.7	< 0.005	0.99	0.007
Mar. 15	6.8	11.5	94	100	7.4	98	3.6	< 0.005	0.9	0.019
Mar. 22	5.8	11.9	95	24	7.4	9	< 1.0	< 0.005	1.04	0.005
Mar. 27	5.1	12.6	98	19	7.5	< 4	< 1.0	0.017	0.99	< 0.003
Average	4.7	12.2	95	22	7.3	27	1.6	0.007	1.08	0.011
Std. Dev.	1.5	0.6	3	32	0.2	38	0.9	0.004	0.12	0.006
Minimum	2.5	11.5	92	10	6.9	< 4	< 1.0	< 0.005	0.90	< 0.003
Maximum	6.8	13.3	99	100	7.5	98	3.6	0.017	1.22	0.021

Table 6 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1995)

Site 3

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Satur-ation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phos-phorus ($mg \cdot L^{-1}$)
Feb. 9	6.6	-	-	-	6.9	16	6.4	0.232	1.21	0.041
Feb. 16	4.5	-	-	750	6.8	24	7.1	0.367	1.1	0.107
Feb. 23	6.7	8.2	67	40	6.6	11	7.5	0.123	1.47	0.067
Mar. 1	2.2	12	87	290	6.8	22	4.9	0.204	1.17	0.089
Mar. 8	5.4	8.7	68	390	7.2	11	5.4	0.258	0.92	0.055
Mar. 15	7.1	8.5	70	180	6.8	15	12.5	0.163	1.33	0.057
Mar. 22	6.4	9.4	75	350	7	11	7.5	0.148	1.25	0.102
Mar. 27	6.7	7.6	62	70	7	9	10.7	0.137	0.94	0.084
Average	5.7	9.1	72	205	6.9	15	7.8	0.204	1.17	0.075
Std. Dev.	1.6	1.6	9	241	0.2	6	2.6	0.081	0.19	0.024
Minimum	2.2	7.6	62	40	6.6	9	4.9	0.123	0.92	0.041
Maximum	7.1	12.0	87	750	7.2	24	12.5	0.367	1.47	0.107

Site 3b

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Satur-ation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phos-phorus ($mg \cdot L^{-1}$)	Biomass Dry Weight (mg)	Biomass Fixed Weight (mg)	Chloro-phyll A ($mg \cdot L^{-1}$)
Feb. 9	7	-	-	-	6.7	27	6.1	0.292	1.15	0.041	41	26	4.4
Feb. 16	4.4	-	-	1080	7	73	6.8	0.407	0.99	0.238	50	35	10.6
Feb. 23	7	8.2	67	80	6.8	7	1	0.21	1.48	0.103	30	16	4.1
Mar. 1	2.3	12.6	91	300	7.1		5.2	0.222	1.08	0.347	45	23	10
Mar. 8	5.2	9.6	75	330	7.3	13	5	0.294	0.82	0.043	32	16	6.6
Mar. 15	7.1	8.4	69	200	6.9	18	10.2	0.167	1.6	0.091	30	18	7.3
Mar. 22	6.4	9.5	76	170	7.1	18	7.4	0.118	1.31	0.117	33	23	5.1
Mar. 27	7.9	8.1	68	210	7.1	15	13	0.186	0.86	0.115	27	24	5.3
Average	5.9	9.4	74	250	7.0	24	6.8	0.237	1.16	0.137	36	23	6.7
Std. Dev.	1.8	1.7	9	337	0.2	22	3.6	0.091	0.28	0.105	8	6	2.5
Minimum	2.3	8.1	67	80	6.7	7	1.0	0.118	0.82	0.041	27	16	4.1
Maximum	7.9	12.6	91	1080	7.3	73	13.0	0.407	1.60	0.347	50	35	10.6

Table 6 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1995)

Site 4

Date (1995)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	% Satur-ation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue (mg·L^{-1})	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Total Phos-phorus (mg·L^{-1})
Feb. 9	5.5	-	-	-	7	17	4	0.138	1.65	0.023
Feb. 16	3.4	-	-	180	6.9	23	3	0.213	1.38	0.036
Feb. 23	5.9	8.8	71	220	6.7	17	5.1	0.071	1.57	0.08
Mar. 1	2.6	11.9	88	100	6.9	64	3.2	0.061	1.51	0.062
Mar. 8	4.7	10.7	84	280	6.9	***189***	3.5	0.564	1.44	0.046
Mar. 15	7.1	9.6	79	260	6.9	20	10.7	0.116	1.79	0.047
Mar. 22	6	9.8	79	20	7	23	4.8	0.111	1.53	0.079
Mar. 27	6.5	10.4	85	460	7.3	17	8.9	0.112	1.32	0.057
Average	5.2	10.2	81	160	7.0	46	5.4	0.173	1.52	0.054
Std. Dev.	1.5	1.1	6	141	0.2	60	2.9	0.165	0.15	0.020
Minimum	2.6	8.8	71	20	6.7	17	3.0	0.061	1.32	0.023
Maximum	7.1	11.9	88	460	7.3	189	10.7	0.564	1.79	0.080

Site 5

Date (1995)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	% Satur-ation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue (mg·L^{-1})	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Total Phos-phorus (mg·L^{-1})	Biomass Dry Weight (mg)	Biomass Fixed Weight (mg)	Chloro-phyll A (mg·L^{-1})
Feb. 9	5	-	-	-	6.8	11	4	0.183	1.53	0.03	30	18	2.5
Feb. 16	3.5	-	-	420	7	17	3.1	0.304	1.25	0.054	53	45	5.4
Feb. 23	5.9	8.4	67	130	6.8	13	6.1	0.099	1.56	0.092	26	6	4.3
Mar. 1	2.8	12	89	40	7.6		3.4	0.086	1.41	0.082	31	20	4.8
Mar. 8	5	10	78	180	7.3	26	4	0.557	1.28	0.029	34	24	2.8
Mar. 15	7.3	9.3	76	480	7	22	7.5	0.16	1.77	0.064	27	18	3.8
Mar. 22	6.4	9.3	85	160	7.1	13	5.1	0.11	1.51	0.083	27	16	3.5
Mar. 27	6.6	9.9	81	100	7.4	26	10.5	0.102	1.24	0.048	28	22	1.5
Average	5.3	9.8	79	163	7.1	18	5.5	0.200	1.44	0.060	32	21	3.6
Std. Dev.	1.6	1.2	8	167	0.3	6	2.5	0.161	0.18	0.024	9	11	1.3
Minimum	2.8	8.4	67	40	6.8	11	3.1	0.086	1.24	0.029	26	6	1.5
Maximum	7.3	12.0	89	480	7.6	26	10.5	0.557	1.77	0.092	53	45	5.4

Table 6 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1995)

Site 6

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	7.1	-	-	-	6.9	61	3.3	1.14	0.7	0.009
Feb. 16	6.5	-	-	146	7	123	1.6	0.725	0.52	0.383
Feb. 23	7.4	4.9	40	90	6.9	20	1	0.596	1.39	0.165
Mar. 1	3.7	9.2	70	100	7	39	2.2	0.698	0.72	0.262
Mar. 8	6.5	6.6	54	1700	7.1	29	3	0.996	0.67	0.099
Mar. 15	8.4	5.9	50	4500	7.2	33	21.1	0.951	1.34	0.178
Mar. 22	7.4	5.4	44	900	7.3	28	3	0.514	1.19	0.189
Mar. 27	9.1	5.7	49	300	7.4	31	16.5	0.458	0.76	0.175
Average	7.0	6.3	51	430	7.1	46	6.5	0.760	0.91	0.183
Std. Dev.	1.6	1.5	10	1609	0.2	34	7.8	0.245	0.34	0.110
Minimum	3.7	4.9	40	90	6.9	20	1.0	0.458	0.52	0.009
Maximum	9.1	9.2	70	4500	7.4	123	21.1	1.140	1.39	0.383

Site 6b

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	9.5	-	-	-	7	42	2.1	0.611	0.56	0.004
Feb. 16	6.9	-	-	170	7	46	2	0.427	0.55	0.191
Feb. 23	9.5	5.1	45	30	7.1	25	1	0.379	0.53	0.243
Mar. 1	4.6	9.3	73	30	6.9	36	1.6	0.361	0.5	0.151
Mar. 8	6.8	6.9	57	50	7.2	29	1.6	0.396	0.51	0.045
Mar. 15	8.8	5.1	44	***170000***	7.3	74	***57.8***	***16.7***	0.45	***2.23***
Mar. 22	8.2	7	59	20	7.2	33	1.7	0.313	0.47	0.246
Mar. 27	9.2	5.4	47	10	7.3	29	23.9	0.292	0.5	0.187
Average	7.9	6.5	54	115	7.1	39	11.5	2.435	0.51	0.412
Std. Dev.	1.7	1.6	11	64234	0.1	16	20.3	5.765	0.04	0.740
Minimum	4.6	5.1	44	10	6.9	25	1.0	0.292	0.45	0.004
Maximum	9.5	9.3	73	170000	7.3	74	57.8	16.700	0.56	2.230

Table 6 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1995)

Site 7

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	6	-	-	-	7	12	4.4	0.111	4.03	0.034
Feb. 16	3.3	-	-	1560	7.1	37	4.9	0.349	4.26	0.195
Feb. 23	6.1	9.3	75	180	7.1	11	1	0.225	3.89	0.115
Mar. 1	2.7	11.8	88	120	7.3	27	3	0.237	3.74	0.087
Mar. 8	4.4	10.7	81	140	7.4	17	3.3	0.232	3.4	0.021
Mar. 15	7.4	9.4	77	2900	7.1	45	11.5	0.708	3.73	0.171
Mar. 22	6.4	9.7	78	200	7.2	12	5.7	0.197	3.42	0.119
Mar. 27	6.9	10.7	88	220	7.6	18	13.6	0.301	3.53	0.108
Average	5.4	10.3	81	347	7.2	22	5.9	0.295	3.75	0.106
Std. Dev.	1.7	1.0	6	1077	0.2	13	4.4	0.181	0.30	0.060
Minimum	2.7	9.3	75	120	7.0	11	1.0	0.111	3.40	0.021
Maximum	7.4	11.8	88	2900	7.6	45	13.6	0.708	4.26	0.195

Site 8

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms ($CFU \cdot 100\ mL^{-1}$)	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	4.8	-	-	-	7.1	11	2.5	0.019	4.1	0.033
Feb. 16	1.1	-	-	108	7.3	17	2.3	0.005	3.37	0.043
Feb. 23	5.9	11.9	95	52	7.2	45	1	0.016	4.11	0.043
Mar. 1	3.7	12.6	96	20	7.3	18	1.8	0.006	3.79	0.04
Mar. 8	3.5	12.7	97	120	7.5	57	3.6	0.008	3.22	0.012
Mar. 15	7.7	11.5	97	4400	7.3	22	7.2	0.129	0.02	0.094
Mar. 22	6.9	11.5	94	450	7.4	22	2.2	0.007	3.61	0.071
Mar. 27	7.1	11.9	98	130	7.6	12	7.5	0.01	3.48	0.037
Average	5.1	12.0	96	166	7.3	26	3.5	0.025	3.21	0.047
Std. Dev.	2.2	0.5	1	1614	0.2	17	2.5	0.042	1.33	0.025
Minimum	1.1	11.5	94	20	7.1	11	1.0	0.005	0.02	0.012
Maximum	7.7	12.7	98	4400	7.6	57	7.5	0.129	4.11	0.094

Table 6 (cont) Surface Water Quality Data for the Matsqui Slough Watershed (Winter 1995)

Site 9

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	-	-	-	-	6.4	15	12.8	0.503	1.61	0.152
Feb. 16	4.3	-	-	2000	6.9	26	12.5	0.922	9.48	0.5
Feb. 23	8.3	5	42	120	6.6	7	1	0.307	2.62	0.212
Mar. 1	7.1	7.2	59	300	6.7	19	10.9	0.426	1.4	0.237
Mar. 8	6.9	5.1	42	2000	6.9	27	15	1.08	0.85	0.166
Mar. 15	8.4	6.8	57	1900	7.3	39	17.5	0.382	4.09	0.291
Mar. 22	8	5.8	49	500	6.6	11	17.9	0.352	1.54	0.55
Mar. 27	12.6	7.5	71	300	7	24	16.5	0.377	1.13	0.507
Average	7.9	6.2	53	634	6.8	21	13.0	0.544	2.84	0.327
Std. Dev.	2.5	1.1	11	896	0.3	10	5.5	0.291	2.88	0.165
Minimum	4.3	5.0	42	120	6.4	7	1.0	0.307	0.85	0.152
Maximum	12.6	7.5	71	2000	7.3	39	17.9	1.080	9.48	0.550

Site 10

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Feb. 9	5.8	-	-	-	6.8	5	3.1	0.051	2.75	0.067
Feb. 16	3.5	-	-	128	7.2	5	2.7	0.047	2.29	0.073
Feb. 23	6.9	11.2	92	67	7	4	11	0.225	2.66	0.178
Mar. 1	5.6	11.8	95	11	7	4	2.4	0.021	2.36	0.067
Mar. 8	4.7	12.1	95	70	7.3	5	3.2	0.133	2.14	0.049
Mar. 15	8.4	11.3	95	700		63	7.6	0.134	2.35	0.087
Mar. 22	7.1	11	90	100	7.3	8	3.9	0.016	2.34	0.098
Mar. 27	10	11.9	105	10	7.5	6	3.1	< 0.005	2.07	0.064
Average	6.5	11.6	95	64	7.2	13	4.6	0.079	2.37	0.085
Std. Dev.	2.1	0.4	5	244	0.2	20	3.1	0.077	0.23	0.040
Minimum	3.5	11.0	90	10	6.8	4	2.4	< 0.005	2.07	0.049
Maximum	10.0	12.1	105	700	7.5	63	11.0	0.225	2.75	0.178

Table 7 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1995)

Site 1

Date (1995)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	% Satur-ation	Fecal Coliforms (CFU·100 mL^{-1})	pH	Non-Filterable Residue (mg·L^{-1})	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Nitrate Nitrogen (mg·L^{-1})	Nitrite Nitrogen (mg·L^{-1})	Total Phos-phorus (mg·L^{-1})
Oct. 4	10.2	-	-	140	6.9	< 4	2.6	0.033	1.21	-	-	0.017
Oct. 12	11.3	-	-	300	6	< 4	5.5	< 0.005	0.35	-	-	0.042
Oct. 18	10.8	4.2	38	70	6.4	< 4	16.6	0.006	0.41	-	-	0.065
Oct.26	8.8	-	-	300	7.5	< 4	5.5	0.029	0.86	-	-	0.031
Oct. 31	5.3	8.28	65	45	7.4	49	2.5	***1.09***	0.84	-	-	0.285
Nov. 7	5.8	10.78	86	750	6.6	17	9.1	0.087	0.55	-	-	0.033
Nov. 16	8.4	6.1	51	50	6.8	< 4	7.3	0.015	0.64	-	-	0.047
Nov. 22	7.8	7.55	64	190	7.3	5	3.2	0.118	1.04	-	-	0.009
Nov. 30	8.6	4.47	39	150	6.5	< 4	4.6	< 0.005	0.53	0.52	0.005	0.037
Average	8.6	6.9	57	152	6.8	11	6.3	0.154	0.71	0.52	0.005	0.063
Std. Dev.	2.1	2.5	18	220	0.5	15	4.4	0.353	0.29	-	-	0.085
Minimum	5.3	4.2	38	45	6.0	< 4	2.5	< 0.005	0.35	0.52	0.005	0.009
Maximum	11.3	10.8	86	750	7.5	49	16.6	1.090	1.21	0.52	0.005	0.285

Site 2

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L^{-1})	% Satur-ation	Fecal Coliforms (CFU·100 mL^{-1})	pH	Non-Filterable Residue (mg·L^{-1})	Total Organic Carbon (mg·L^{-1})	Dissolved Ammonia Nitrogen (mg·L^{-1})	Nitrite+ Nitrate Nitrogen (mg·L^{-1})	Nitrate Nitrogen (mg·L^{-1})	Nitrite Nitrogen (mg·L^{-1})	Total Phos-phorus (mg·L^{-1})
Oct. 4	9.6	-	-	350	6.9	17	5.3	< 0.005	0.56	-	-	0.039
Oct. 12	10.6	-	-	200	6.3	23	5.7	< 0.005	1.58	-	-	0.208
Oct. 18	10.4	10.8	95	60	6.8	7	6.9	< 0.005	1.44	-	-	0.03
Oct.26	10	-	-	120	7.4	< 4	3	< 0.005	1.14	-	-	0.019
Oct. 31	4	11.98	91	41	7.7	< 4	1.1	< 0.005	1.02	-	-	0.007
Nov. 7	4.2	14.13	108	270	6.6	***97***	9.4	0.011	0.59	-	-	0.094
Nov. 16	8.1	11.6	98	32	7.2	15	2.9	< 0.005	1.2	-	-	0.023
Nov. 22	7.2	11.67	96	14	7.3	6	2	< 0.005	0.99	-	-	0.011
Nov. 30	8	11.79	99	27	6.7	55	3.7	< 0.005	1.05	1.05	< 0.005	-
Average	8.0	12.0	98	74	7.0	25	4.4	0.006	1.06	1.05	0.005	0.054
Std. Dev.	2.5	1.1	6	122	0.4	31	2.6	0.002	0.34	-	-	0.068
Minimum	4.0	10.8	91	14	6.3	< 4	1.1	< 0.005	0.56	1.05	< 0.005	0.007
Maximum	10.6	14.1	108	350	7.7	97	9.4	0.011	1.58	1.05	0.000	0.208

Table 7 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1995)

Site 3

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L⁻¹)	% Saturation	Fecal Coliforms (CFU·100 mL⁻¹)	pH	Non-Filterable Residue (mg·L⁻¹)	Total Organic Carbon (mg·L⁻¹)	Dissolved Ammonia Nitrogen (mg·L⁻¹)	Nitrite+ Nitrate Nitrogen (mg·L⁻¹)	Nitrate Nitrogen (mg·L⁻¹)	Nitrite Nitrogen (mg·L⁻¹)	Total Phosphorus (mg·L⁻¹)
Oct. 4	11.1	-	-	3400	6.2	14	14.9	< 0.005	0.95	-	-	0.215
Oct. 12	12.5	-	-	170	5.9	8	17	0.38	7.97	-	-	0.097
Oct. 18	11.9	4.8	44	130	6.3	< 4	18.4	0.103	4.77	-	-	0.081
Oct.26	12	-	-	1400	7	5	17.3	0.089	4.94	-	-	0.395
Oct. 31	4.7	5.65	44	140	7.4	10	7.5	0.335	0.88	-	-	0.082
Nov. 7	4.5	10.12	79	320	6.5	6	10	0.225	0.77	-	-	0.088
Nov. 16	8.7	5.56	48	10	6.4	< 4	10.1	0.062	2.03	-	-	0.079
Nov. 22	8.3	4.53	38	870	7	5	8.1	0.297	1.04	-	-	0.097
Nov. 30	8.3	5.93	50	130	6.3	6	10.4	0.172	1.72	1.71	0.015	0.168
Average	9.1	6.1	51	259	6.6	7	12.6	0.185	2.79	1.71	0.015	0.145
Std. Dev.	3.0	2.0	15	1099	0.5	3	4.2	0.131	2.53	-	-	0.105
Minimum	4.5	4.5	38	10	5.9	< 4	7.5	< 0.005	0.77	1.71	0.015	0.079
Maximum	12.5	10.1	79	3400	7.4	14	18.4	0.380	7.97	1.71	0.015	0.395

Site 3b

Date (1994)	Temp. (°C)	Dissolved Oxygen (mg·L⁻¹)	% Saturation	Fecal Coliforms (CFU·100 mL⁻¹)	pH	Non-Filterable Residue (mg·L⁻¹)	Total Organic Carbon (mg·L⁻¹)	Dissolved Ammonia Nitrogen (mg·L⁻¹)	Nitrite+ Nitrate Nitrogen (mg·L⁻¹)	Nitrate Nitrogen (mg·L⁻¹)	Nitrite Nitrogen (mg·L⁻¹)	Total Phosphorus (mg·L⁻¹)	Biomass Dry Weight (mg)	Biomass Fixed Weight (mg)	Chlorophyll A (mg·L⁻¹)
Oct. 4	10.9	-	-	190	6.7	7	13.9	0.005	0.04	-	-	0.145	38	19	11.6
Oct. 12	12.3	-	-	100	6.1	5	15.8	0.287	9.15	-	-	0.073	68	44	
Oct. 18	12.1	-	-	80	6.3	4	20.4	0.03	6.35	-	-	0.089	55	29	
Oct.26	12	-	-	2600	7.1	4	17	0.042	4.99	-	-	0.12	52	29	
Oct. 31	5.3	8.28	65	110	7.2	79	8.8	0.213	0.88	-	-	0.324	64	49	
Nov. 7	4.8	9.9	77	190	6.9	13	8.1	0.01	1.21	-	-	0.119	47	33	
Nov. 16	8.6	4.62	40	40	7.4	4	10.7	0.014	2.55	-	-	0.086	20	18	
Nov. 22	7.6	3.23	27	41	7.1	4	7.1	0.163	1.17	-	-	0.081	37	23	
Nov. 30	8.3	5.02	42	-	6.5	-	-	0.021	2.38	2.14	0.236	-	31	21	
Average	9.1	6.2	50	139	6.8	15	12.7	0.087	3.19	2.14	0.236	0.130	46	29	11.6
Std. Dev.	2.9	2.8	20	883	0.4	26	4.8	0.106	3.02	-	-	0.082	16	11	
Minimum	4.8	3.2	27	40	6.1	4	7.1	0.005	0.04	2.14	0.236	0.073	20	18	11.6
Maximum	12.3	9.9	77	2600	7.4	79	20.4	0.287	9.15	2.14	0.236	0.324	68	49	11.6

Table 7 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1995)

Site 4

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	10.8	-	-	1400	6.7	87	16.5	0.124	1.02	-	-	0.271
Oct. 12	11.7	-	-	1400	6.2	21	8.9	0.034	7.26	-	-	0.126
Oct. 18	10.9	-	-	490	6.5	18	15.6	0.067	5.58	-	-	0.118
Oct.26	12	-	-	1400	7.1	11	9.8	0.186	5.37	-	-	0.128
Oct. 31	4.1	10.18	76	210	7.7	89	4.4	0.176	1.99	-	-	0.192
Nov. 7	4.9	-	-	1330	6.8	27	6.9	0.194	1.9	-	-	0.146
Nov. 16	8.4	7.17	60	640	6.8	12	8.5	0.165	2.61	-	-	0.131
Nov. 22	7.5	8.52	72	200	7.2	5	4.7	0.173	1.9	-	-	0.064
Nov. 30	8.3	7.69	65	260	6.4	13	7.4	0.133	1.86	1.85	0.009	0.173
Average	8.7	8.4	68	615	6.8	31	9.2	0.139	3.28	1.85	0.009	0.150
Std. Dev.	2.9	1.3	7	557	0.5	33	4.3	0.056	2.20	-	-	0.058
Minimum	4.1	7.2	60	200	6.2	5	4.4	0.034	1.02	1.85	0.009	0.064
Maximum	12.0	10.2	76	1400	7.7	89	16.5	0.194	7.26	1.85	0.009	0.271

Site 5

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)	Biomass Dry Weight (mg)	Biomass Fixed Weight (mg)	Chlorophyll A ($mg \cdot L^{-1}$)
Oct. 4	11.8	-	-	450	6.9	63	16.5	0.168	0.81	-	-	0.226	54	41	9.5
Oct. 12	12.6	-	-	1000	6.2	15	10.6	0.068	7.47	-	-	0.073	47	26	-
Oct. 18	11.9	-	-	100	6.5	18	13.8	0.096	5.87	-	-	0.123	-	-	-
Oct.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 31	4.7	7.94	62	260	7.4	17	5.8	0.224	1.81	-	-	0.113	46	34	-
Nov. 7	4.9	11.28	88	1050	6.9	15	6	0.211	1.58	-	-	0.097	-	-	-
Nov. 16	8.6	5.74	50	140	6.9	10	6.7	0.01	2.56	-	-	0.106	20	18	-
Nov. 22	7.5	7.11	60	230	7.2	17	5.1	0.251	1.8	-	-	0.081	34	24	-
Nov. 30	8.3	7.57	64	130	6.3	-	6.2	0.064	1.84	1.82	0.023	-	25	18	-
Average	8.8	7.9	65	291	6.8	22	8.8	0.137	2.97	1.82	0.023	0.117	38	27	9.5
Std. Dev.	3.1	2.1	14	389	0.4	18	4.3	0.089	2.37	-	-	0.051	13	9	-
Minimum	4.7	5.7	50	100	6.2	10	5.1	0.010	0.81	1.82	0.023	0.073	20	18	9.5
Maximum	12.6	11.3	88	1050	7.4	63	16.5	0.251	7.47	1.82	0.023	0.226	54	41	9.5

Table 7 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1995)

Site 6

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	13.4	-	-	210	7.1	23	24.6	1.59	0.05	-	-	0.165
Oct. 12	12	-	-	1200	6.1	14	9.4	0.473	7.42	-	-	0.198
Oct. 18	11.9	-	-	10	6.9	12	13.9	1.87	10.5	-	-	0.543
Oct.26	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 31	6.4	5.4	43	90	7.4	49	2.5	1.09	0.84	-	-	0.285
Nov. 7	6.4	6.15	49	1130	7	25	5.7	2.4	0.28	-	-	0.305
Nov. 16	8.8	1.88	16	8	7.1	12	7.3	1.03	4.49	-	-	0.306
Nov. 22	8.3	1.8	15	2900	7	17	4.4	2.77	0.141	-	-	0.244
Nov. 30	8.7	3.06	26	3000	6.8	37	9.3	2.01	2.12	2.06	0.064	0.782
Average	9.5	3.7	30	255	6.9	24	9.6	1.654	3.23	2.06	0.064	0.354
Std. Dev.	2.6	2.0	16	1256	0.4	13	7.0	0.764	3.92	-	-	0.207
Minimum	6.4	1.8	15	8	6.1	12	2.5	0.473	0.05	2.06	0.064	0.165
Maximum	13.4	6.2	49	3000	7.4	49	24.6	2.770	10.50	2.06	0.064	0.782

Site 6b

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	11	-	-	24	6.9	30	23.1	1.94	0.09	-	-	0.127
Oct. 12	11.7	-	-	88	6.8	16	2.1	0.699	0.81	-	-	0.149
Oct. 18	10.9	3.8	34	116	7.1	12	4.1	0.569	0.54	-	-	0.178
Oct.26	12	-	-	320	7.6	20	< 1.0	0.776	0.53	-	-	0.14
Oct. 31	5.1	6.43	50	60	7.4	19	2.0	0.598	0.47	-	-	0.109
Nov. 7	4.8	9.9	77	64	6.9	13	1.8	0.55	0.57	-	-	0.104
Nov. 16	9.1	2.23	19	190	7.4	22	3.3	0.58	0.65	-	-	0.224
Nov. 22	8.4	2.51	21	130	6.9	35	2.6	0.818	0.64	-	-	0.266
Nov. 30	8.7	2.42	21	340	6.9	21	5.8	0.729	0.79	0.75	0.043	0.418
Average	9.1	4.5	37	111	7.1	21	5.1	0.807	0.57	0.75	0.043	0.191
Std. Dev.	2.7	3.1	23	114	0.3	8	6.9	0.436	0.21	-	-	0.101
Minimum	4.8	2.2	19	24	6.8	12	< 1.0	0.550	0.09	0.75	0.043	0.104
Maximum	12.0	9.9	77	340	7.6	35	23.1	1.940	0.81	0.75	0.043	0.418

Table 7 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1995)

Site 7

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	-	-	-	50	7.3	< 4	19.6	0.186	1.5	-	-	0.186
Oct. 12	10.3	-	-	1900	6.4	10	12	0.072	9.3	-	-	0.229
Oct. 18	12.3	-	-	1510	6.3	9	12.5	0.009	8.94	-	-	0.23
Oct.26	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 31	4.7	9.11	71	1600	7.4	20	5.5	0.173	2.2	-	-	0.149
Nov. 7	6.8	9	74	2000	6.9	18	7.2	< 0.005	2.67	-	-	0.137
Nov. 16	8.8	6.82	59	100	7	6	9.2	0.105	5.22	-	-	0.194
Nov. 22	7.9	6	51	230	6.7	9	6.7	0.162	2.78	-	-	0.303
Nov. 30	8.5	6.93	60	230	6.7	14	7.3	0.25	3.51	3.48	0.035	0.31
Average	8.5	7.6	63	471	6.8	11	10.0	0.120	4.52	3.48	0.035	0.217
Std. Dev.	2.4	1.4	9	871	0.4	6	4.6	0.088	3.04	-	-	0.064
Minimum	4.7	6.0	51	50	6.3	< 4	5.5	< 0.005	1.50	3.48	0.035	0.137
Maximum	12.3	9.1	74	2000	7.4	20	19.6	0.250	9.30	3.48	0.035	0.310

Site 8

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 12	10	-	-	***77000***	6.4	< 4	8.3	0.703	5.89	-	-	0.26
Oct. 18	10.3	-	-	2400	7.4	21	7.3	0.584	5.7	-	-	0.245
Oct.26	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 31	3.8	12.48	95	110	7.2	< 4	3.6	< 0.005	3.48	-	-	0.081
Nov. 7	5.9	11.52	92	***21000***	6.4	***243***	11.6	0.019	4.12	-	-	0.55
Nov. 16	8.6	10.5	91	240	7.2	58	3.6	0.014	4.41	-	-	0.143
Nov. 22	7.5	10.45	88	70	6.9	33	4.1	0.101	3.83	-	-	0.149
Nov. 30	8.6	10.45	90	170	7	20	4.8	0.038	4.26	4.23	0.026	0.142
Average	7.8	11.1	91	1029	6.9	55	6.2	0.209	4.53	4.23	0.026	0.224
Std. Dev.	2.3	0.9	3	28632	0.4	85	3.0	0.300	0.92	-	-	0.157
Minimum	3.8	10.5	88	70	6.4	< 4	3.6	< 0.005	3.48	4.23	0.026	0.081
Maximum	10.3	12.5	95	77000	7.4	243	11.6	0.703	5.89	4.23	0.026	0.550

Table 7 Surface Water Quality Data for the Matsqui Slough Watershed (Fall 1995)

Site 9

Date (1995)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 12	10.4	-	-	70	6.2	6	24.1	0.403	8.45	-	-	0.77
Oct. 18	10.4	-	-	1000	6.2	8	22.2	0.347	13.5	-	-	0.368
Oct.26	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 31	6.2	6.58	53	1800	6.7	14	11.8	0.27	1.15	-	-	0.228
Nov. 7	5.3	11.34	89	***13000***	6	26	23.5	0.013	4.25	-	-	0.836
Nov. 16	10.2	2.27	20	***15000***	6.7	12	26.5	***2.42***	0.416	-	-	0.974
Nov. 22	7.8	2.53	21	420	6.3	8	15.1	0.696	3.01	-	-	0.25
Nov. 30	8.6	3.79	33	50	6.1	9	17	0.613	4.44	4.33	0.107	0.524
Average	8.4	5.3	43	910	6.3	12	20.0	0.680	5.03	4.33	0.107	0.564
Std. Dev.	2.1	3.8	29	6559	0.3	7	5.4	0.799	4.56	-	-	0.299
Minimum	5.3	2.3	20	50	6.0	6	11.8	0.013	0.42	4.33	0.107	0.228
Maximum	10.4	11.3	89	15000	6.7	26	26.5	2.420	13.50	4.33	0.107	0.974

Site 10

Date (1994)	Temp. (°C)	Dissolved Oxygen ($mg \cdot L^{-1}$)	% Saturation	Fecal Coliforms (CFU· 100 mL^{-1})	pH	Non-Filterable Residue ($mg \cdot L^{-1}$)	Total Organic Carbon ($mg \cdot L^{-1}$)	Dissolved Ammonia Nitrogen ($mg \cdot L^{-1}$)	Nitrite+ Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrate Nitrogen ($mg \cdot L^{-1}$)	Nitrite Nitrogen ($mg \cdot L^{-1}$)	Total Phosphorus ($mg \cdot L^{-1}$)
Oct. 4	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 12	10.2	-	-	190	6.8	20	7.6	0.044	4.67	-	-	0.246
Oct. 18	10.3	-	-	< 1	7.2	< 4	8.5	0.093	5.38	-	-	0.226
Oct.26	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 31	4.9	11.02	86	20	7.4	< 4	4.3	< 0.005	2.29	-	-	0.117
Nov. 7	5.3	11.34	89	5000	6.4	72	9.6	0.140	3	-	-	0.266
Nov. 16	9	10.2	88	2	7.3	20	5.6	0.075	4.12	-	-	0.141
Nov. 22	7.4	10.58	87	270	6.9	< 4	4.7	0.229	3.3	-	-	0.159
Nov. 30	8.1	10.65	90	40	7	24	5.8	0.050	3.51	3.43	0.082	0.197
Average	7.9	10.8	88	46	7.0	21	6.6	0.091	3.75	3.43	0.082	0.193
Std. Dev.	2.2	0.4	2	1860	0.3	24	2.0	0.074	1.05	-	-	0.056
Minimum	4.9	10.2	86	< 1	6.4	< 4	4.3	< 0.005	2.29	3.43	0.082	0.117
Maximum	10.3	11.3	90	5000	7.4	72	9.6	0.229	5.38	3.43	0.082	0.266

Table 8 Water Quality Canadian Guidelines and Provincial Criteria for Parameters Measured in this Study.

Parameter	CCREM Guidelines[1]		Provincial Criteria[2] (max. conc.)	
	Drinking Water (raw)	Freshwater Aquatic Life	Drinking Water (raw)	Freshwater Aquatic Life
Ammonia ($mg \cdot L^{-1}$-N)		pH 6.5/10°C = 2.2		pH 6.5/7°C = 26.2 [3] pH 6.5/7°C Avg 30-day conc. = 1.90
Chlorophyll *a*			2-2.5 $\mu g \cdot L^{-1}$, lakes[a]	1-3.5 $\mu g \cdot L^{-1}$, lakes[a] 100 mg/m^2 max., flowing water*
Dissolved Oxygen ($mg \cdot L^{-1}$)		9.5, early life stages 6.5, other life stages		7, embryo and larval stages 4, other life stages
Fecal coliforms (CFU/100mL)	0		0	
Nitrate ($mg \cdot L^{-1}$)	10		10	200
Nitrite ($mg \cdot L^{-1}$)	1		1	0.06
Nonfilterable Residues ($mg \cdot L^{-1}$)		10 if background < 100 10% if background > 100		10 if background < 100 10% if background > 100
Total Phosphorus ($\mu g \cdot L^{-1}$)			10	5-15
pH		6.5-9.0	6.5-8.5	6.5-9.0

[1] CCREM, 1987, Canadian Water Quality Guidelines
[2] MOELP, 1995, Approved and Working Criteria for Water Quality - 1995
[3] pH 6.5/7°C approximate winter conditions in the Matsqui Slough Watershed
[a] summer average
* refers to naturally growing periphytic algae

Table 9 Relationships Between Parameters Sampled in the Matsqui Slough Watershed

Parameter	Correlation Parameter	n	Correlation Coefficient (r)	Significance F	Conclusion ($p = 0.05$)
Ammonia Nitrogen	Dissolved Oxygen	307	0.5215	8.20E-23	significant
	Total Phosphorus	319	0.4124	1.57E-14	significant
	Fecal Coliforms	275	0.2807	2.26E-06	significant
	Biomass Fixed Wt.	49	0.3864	0.0061	significant
	Chlorophyll *a*	36	0.2896	0.0867	non-significant
Total Phosphorus	Dissolved Oxygen	250	0.4757	1.60E-15	significant
	Fecal Coliforms	273	0.2928	8.45E-07	significant
	Biomass Fixed Wt.	47	0.4147	0.00376	significant
	Chlorophyll *a*	36	0.5805	0.000206	significant
NO2 + NO3	Dissolved Oxygen	256	0.1059	0.0907	non-significant
	Biomass Fixed Wt.	49	0.2585	0.0729	non-significant
	Chlorophyll *a*	36	0.4413	0.00706	significant
TOC	Dissolved Oxygen	194	0.3139	8.33E-06	significant

Table 10 Approximate Nutrient Composition of Various Types of Animal Manure at the Time of Application to the Land[1]

Type of Livestock	Waste-Handling System	Dry Matter (%)	Nutrients (kg/tonne) Nitrogen Available*	Nitrogen Total**	P_2O_5
Dairy Cattle	Liquid pit	8	6	12	9
	Lagoon	1	1.25	2	2
Swine	Liquid pit	4	10	18	13.5
	Lagoon	1	1.5	2	1
Poultry	With litter	75	18	28	22.5
	Deep pit (compost)	76	22	34	32

[1] From: Tisdale et al. (1985)
* primarily ammonia-N (available to the plant during the growing season)
** ammonia-N plus organic N which is slow releasing

Figure 1 : Matsqui Slough Watershed Study Area

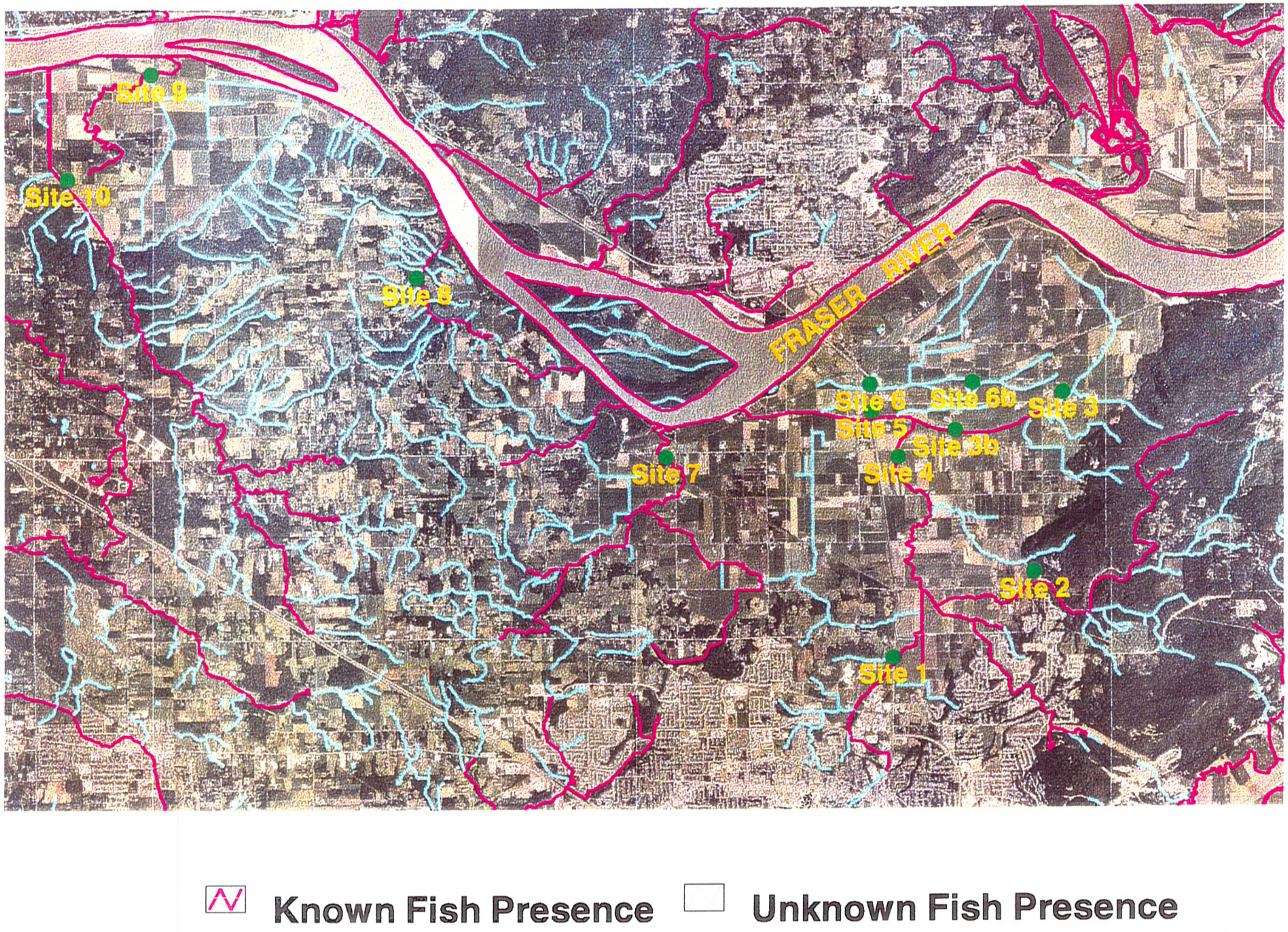


Figure 2 Spatial and Seasonal Variation in Streamwater Dissolved Ammonia-N

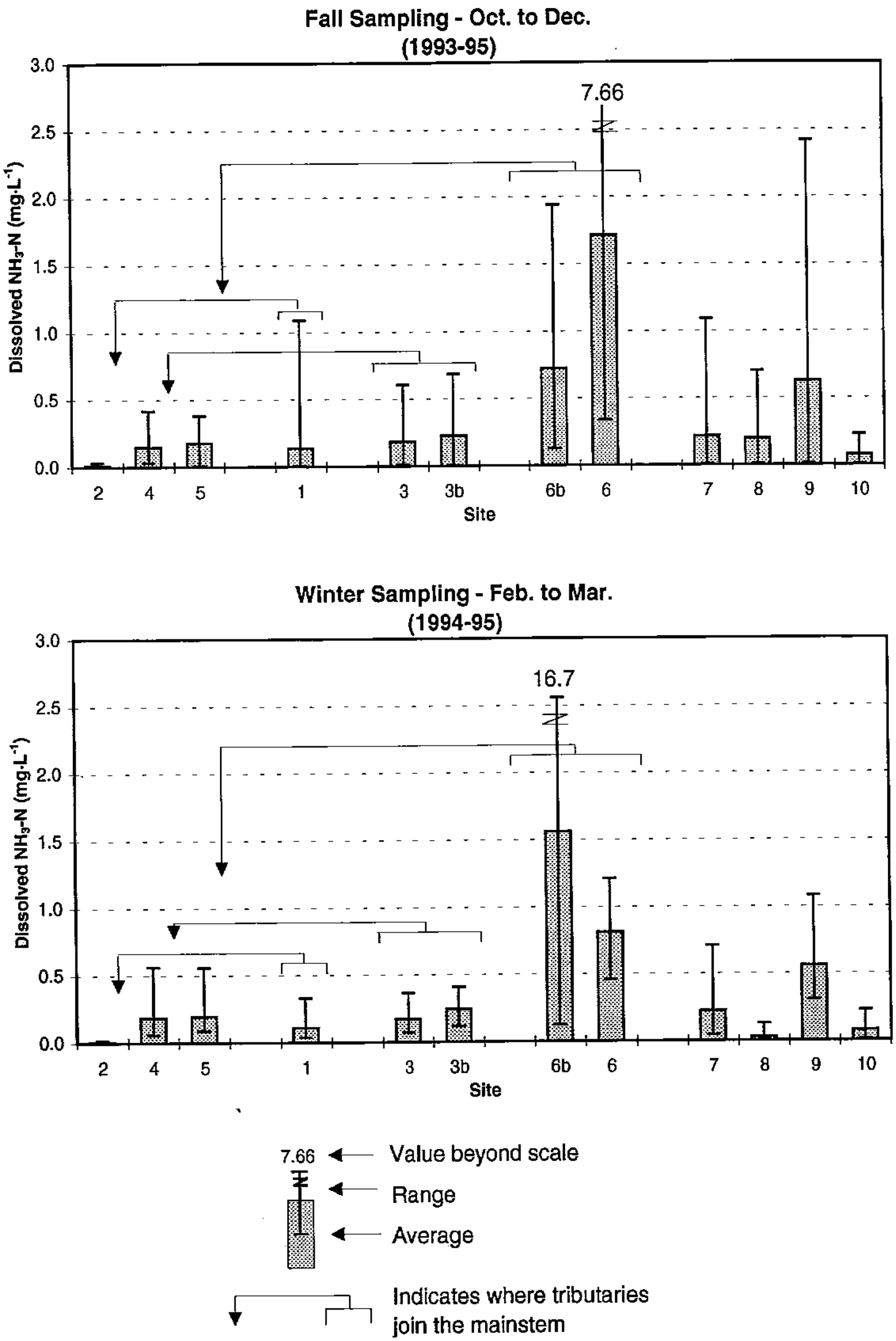
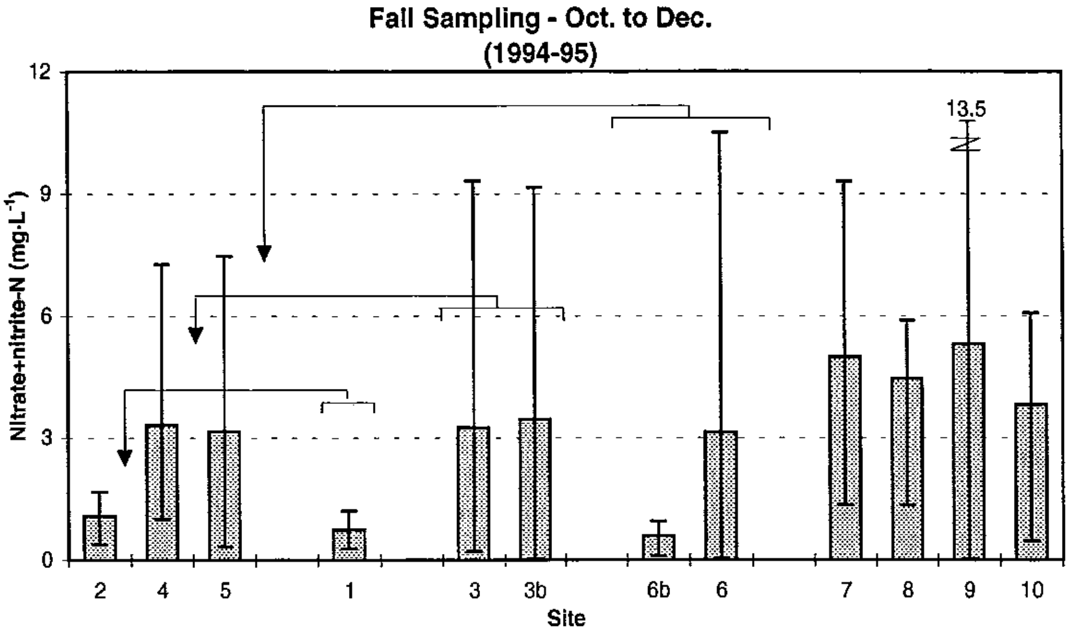
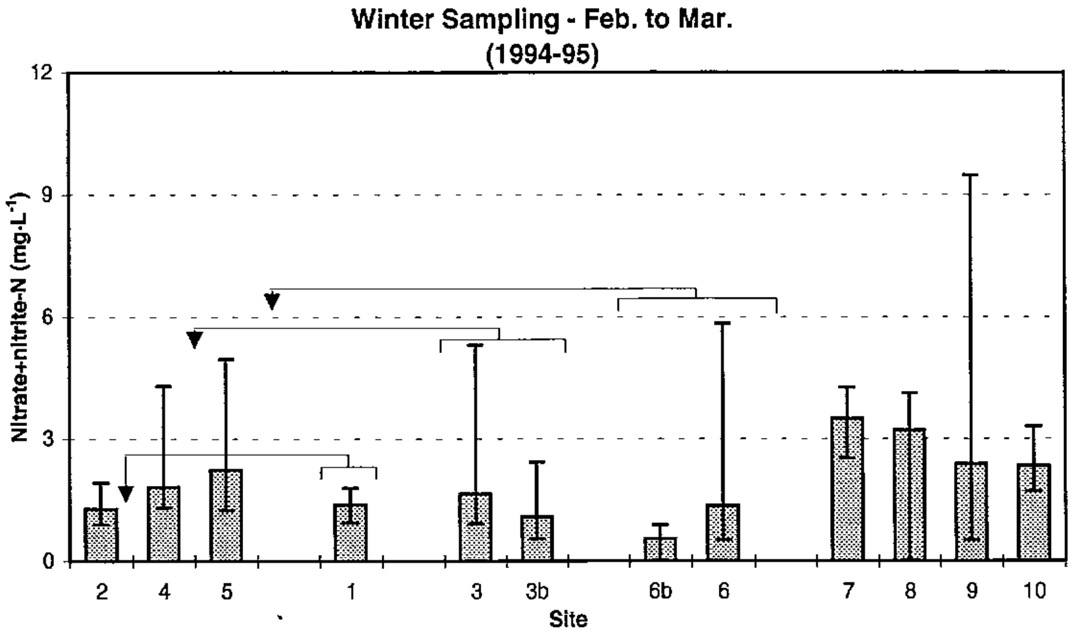


Figure 3 Spatial and Seasonal Variation in Nitrate+nitrite Nitrogen





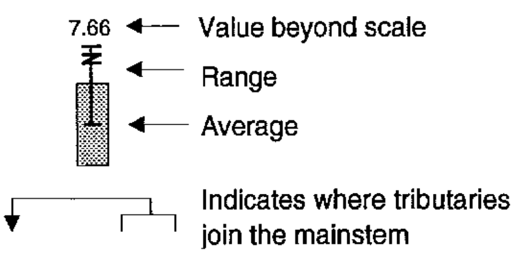
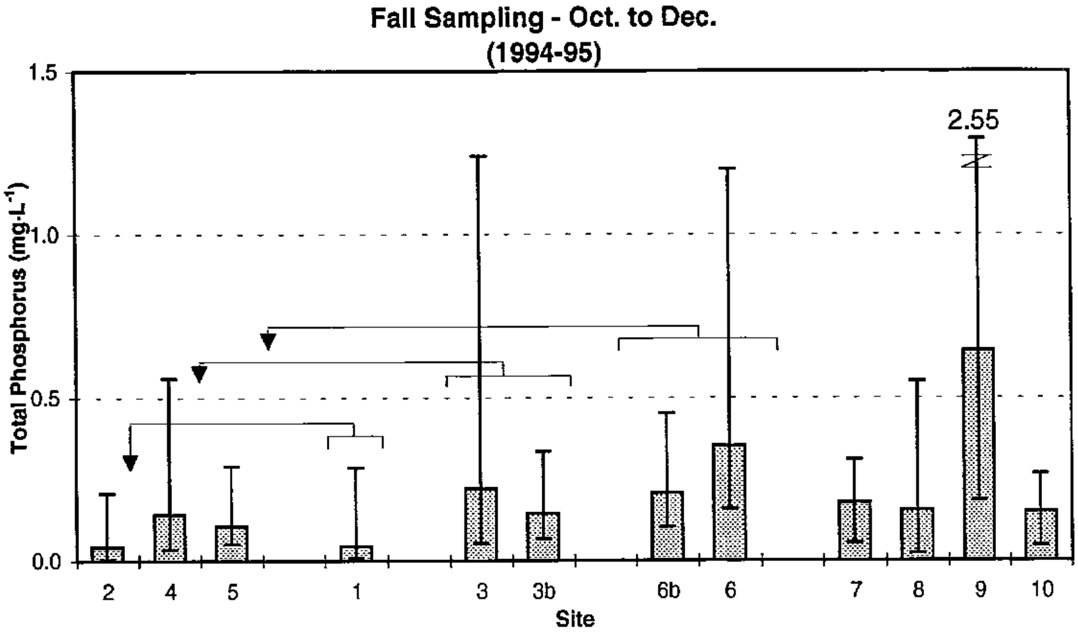
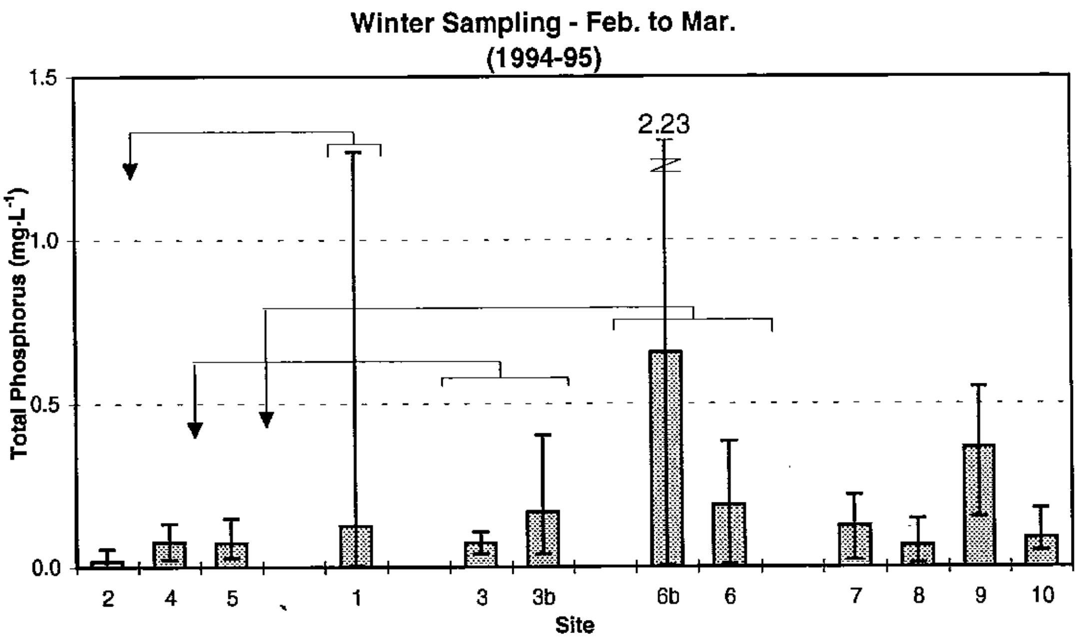


Figure 4 Spatial and Seasonal Variation in Total Phosphorus





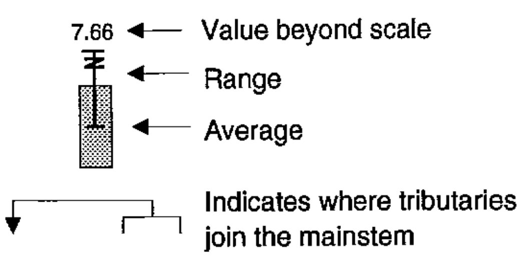
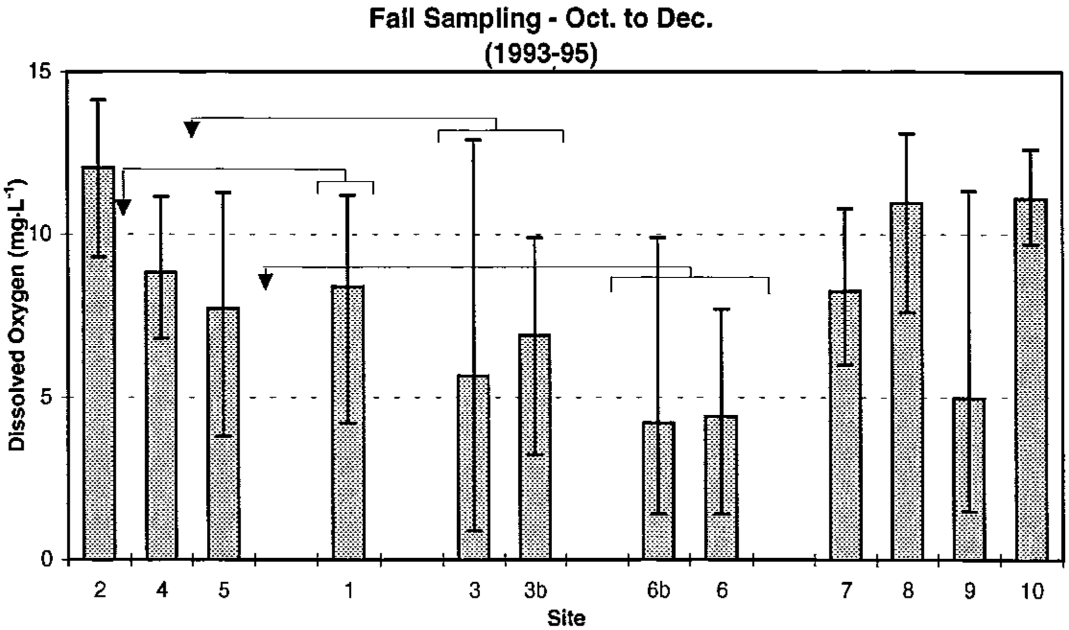
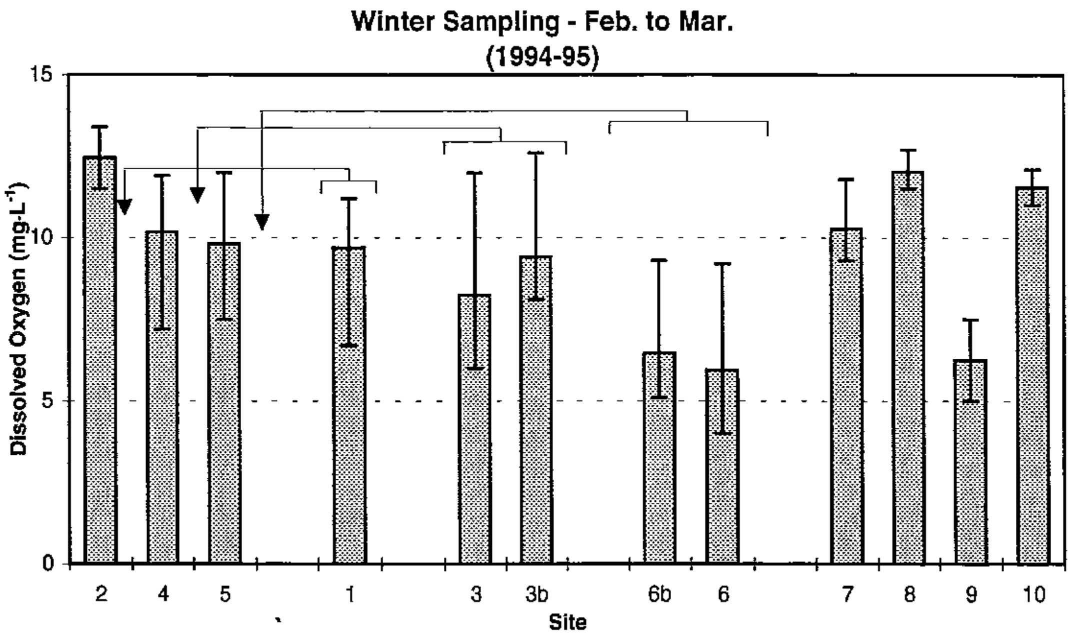


Figure 5 Spatial and Seasonal Variation of Dissolved Oxygen





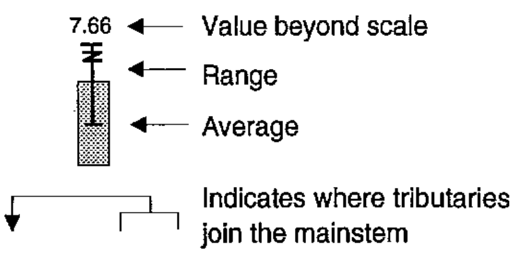
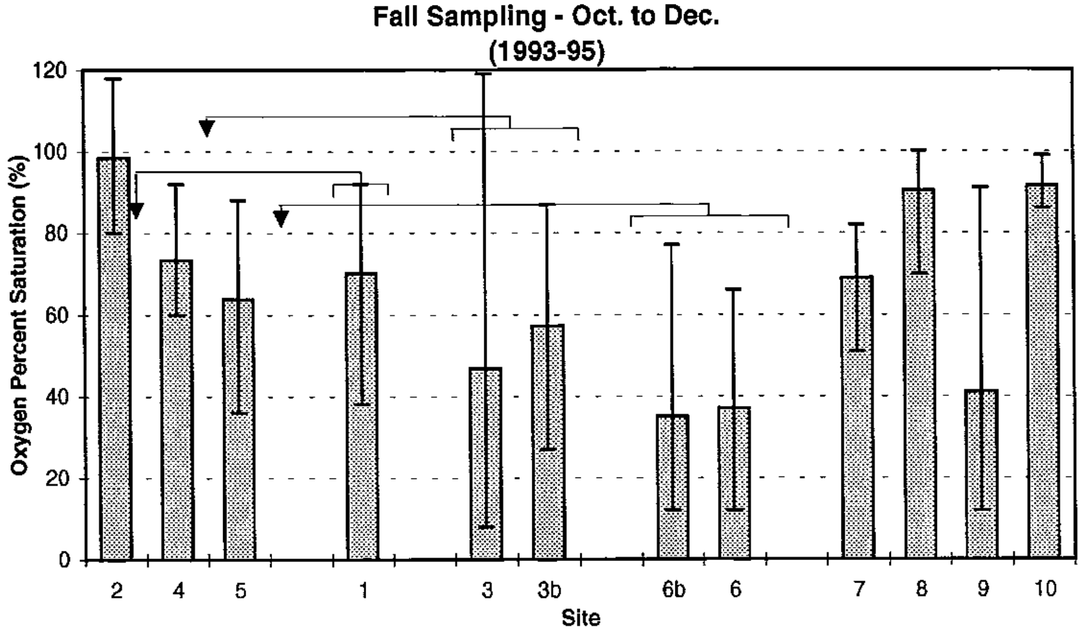
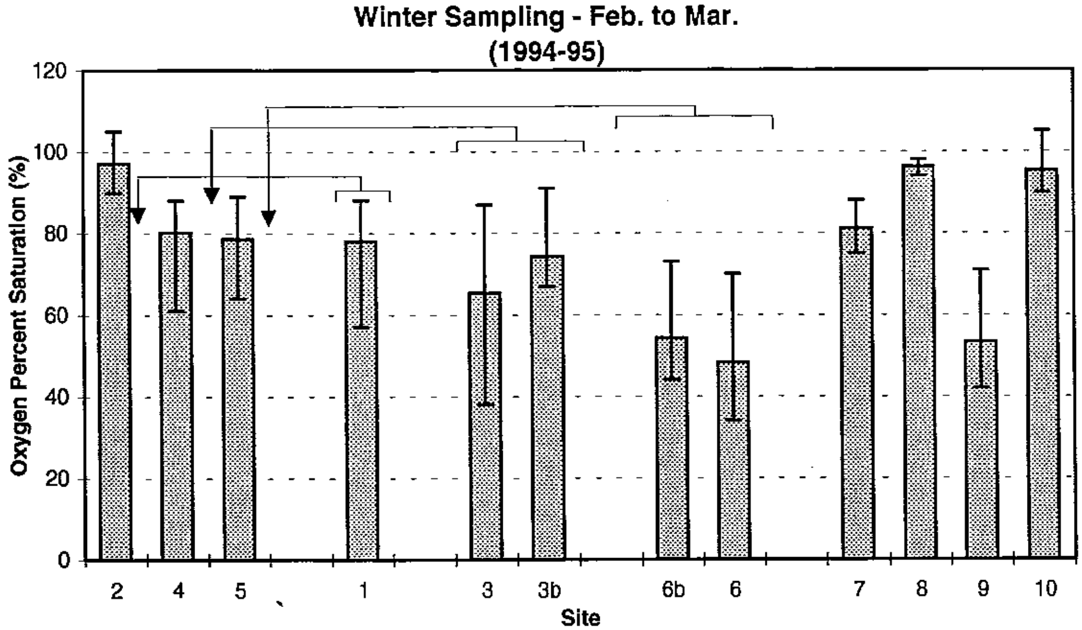


Figure 6 Spatial and Seasonal Variation in Oxygen Percent Saturation





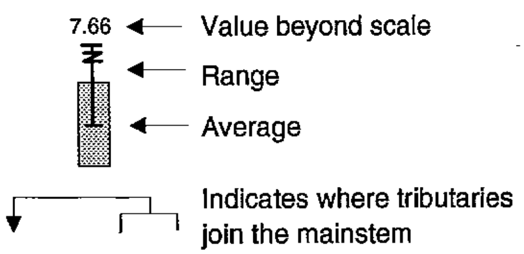
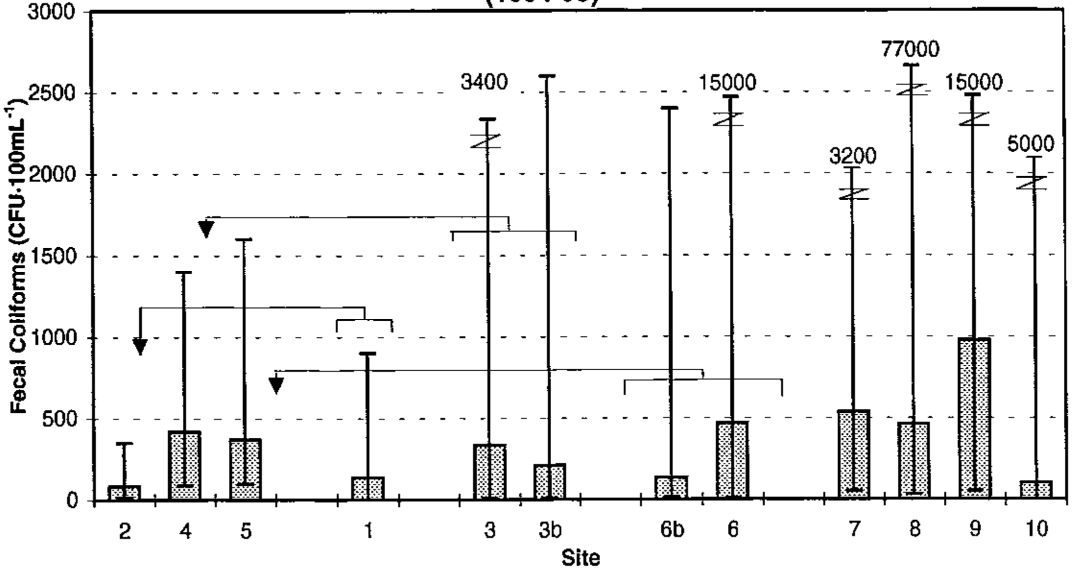
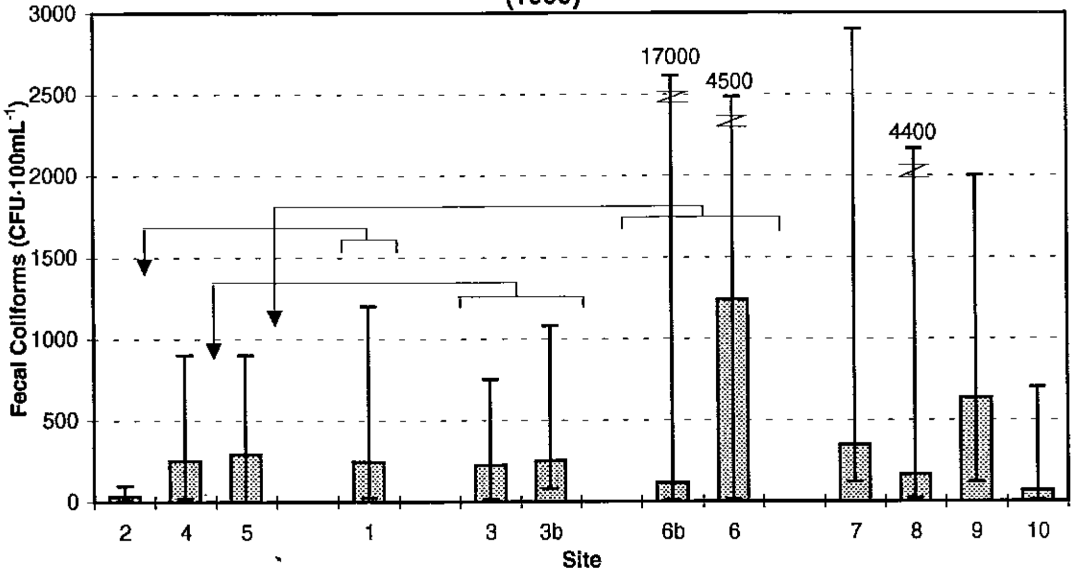


Figure 7 Spatial and Seasonal Variation in Fecal Coliforms

Fall Sampling - Oct. to Dec.
(1994-95)



Winter Sampling - Feb. to Mar.
(1995)



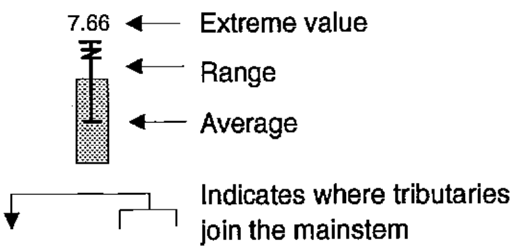
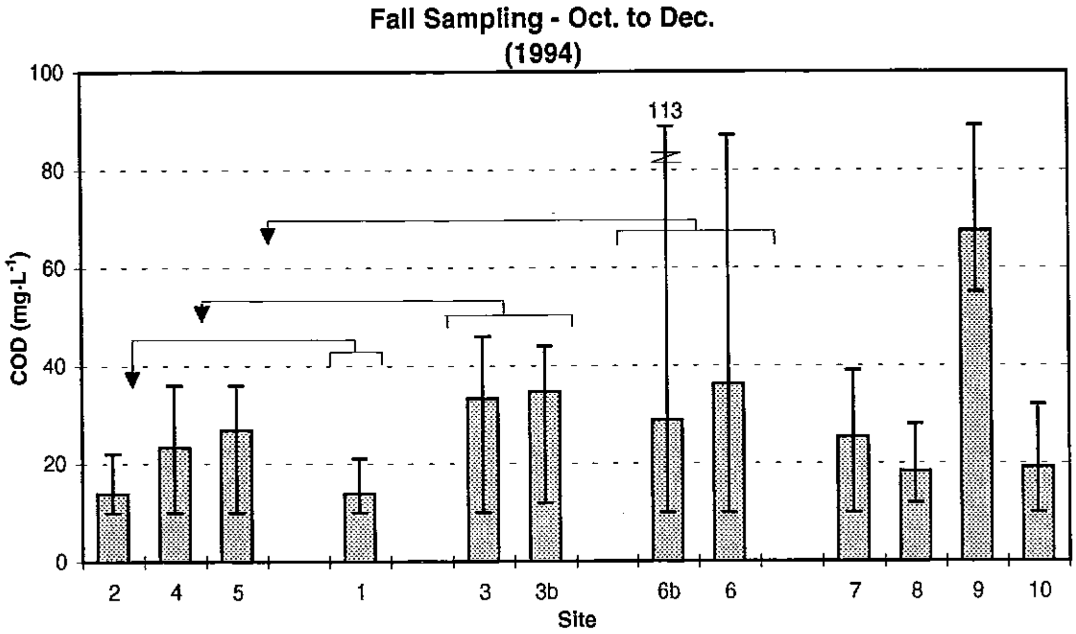


Figure 8 Spatial Variation in Chemical Oxygen Demand



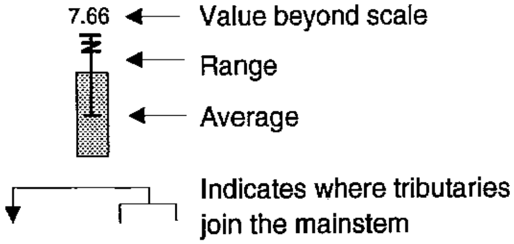


Figure 9 Spatial and Seasonal Variation in Total Organic Carbon

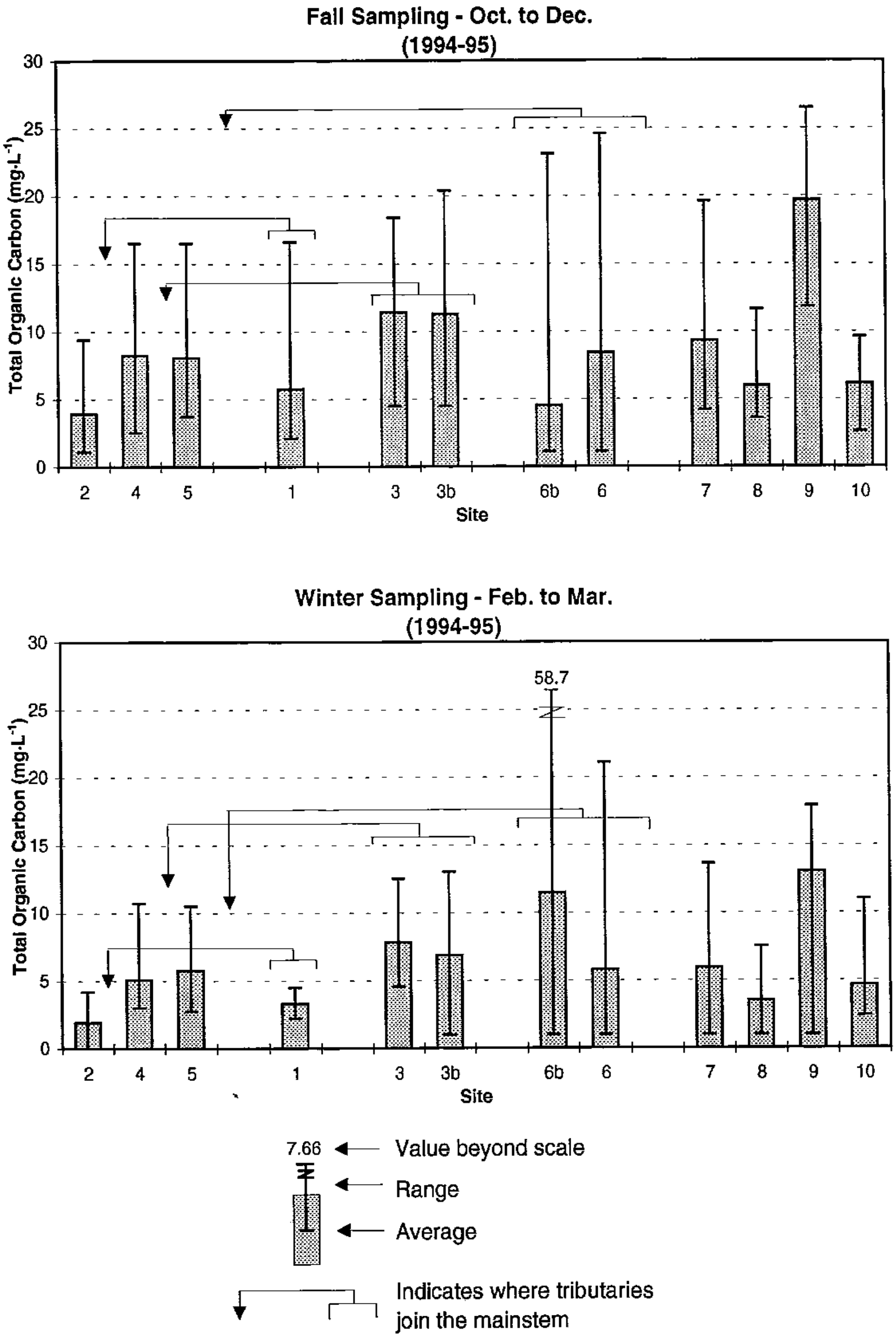
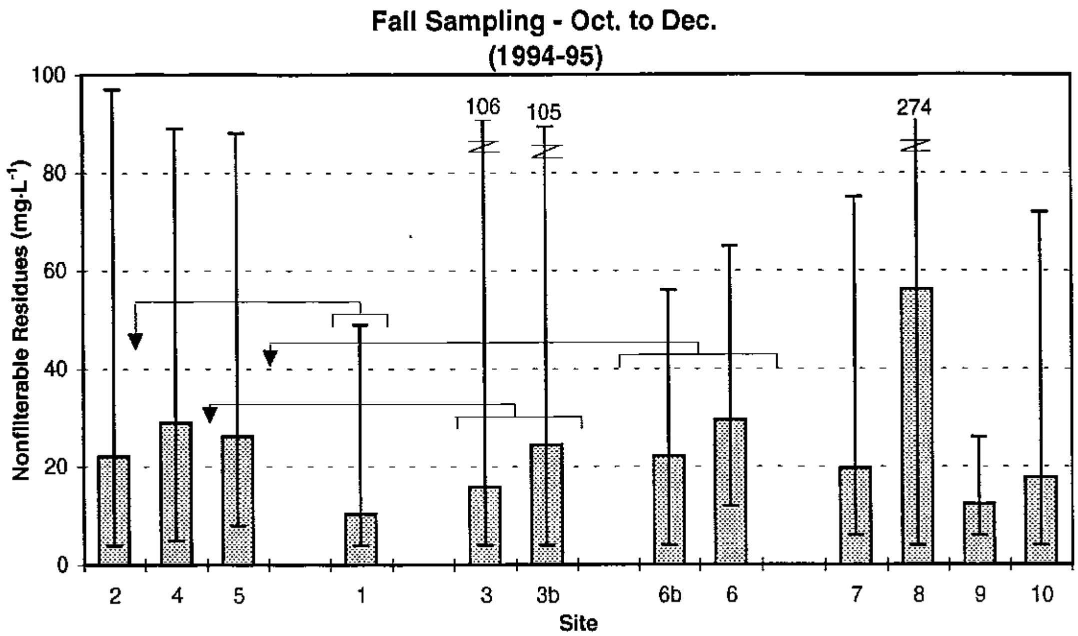
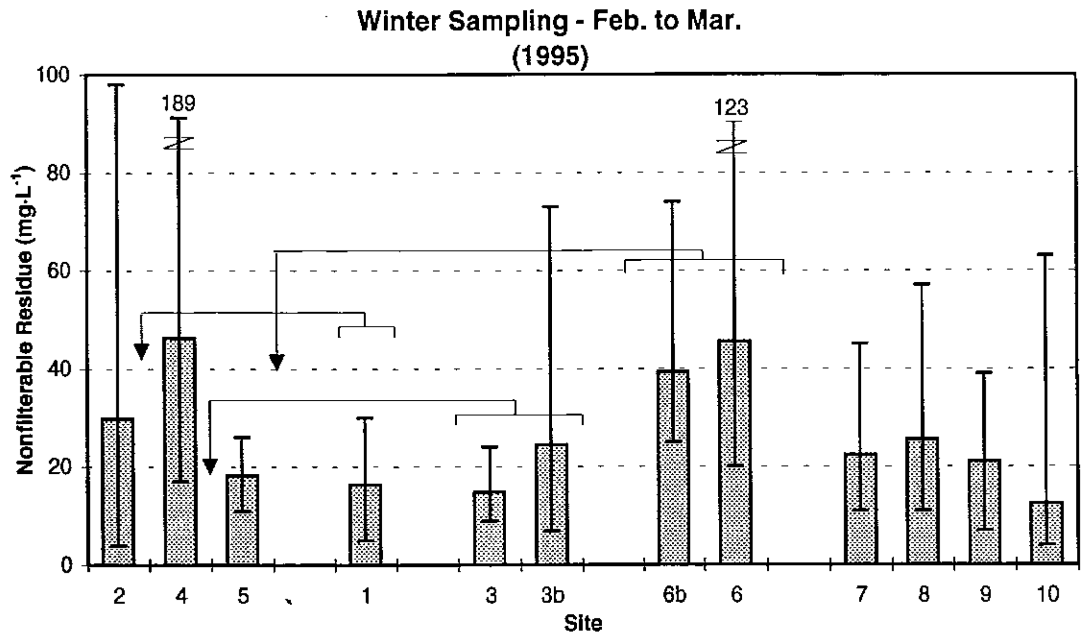


Figure 10 Spatial and Seasonal Variation in Nonfilterable Residue





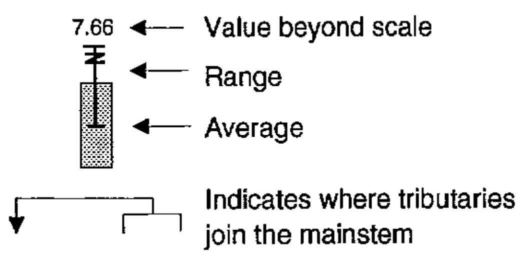
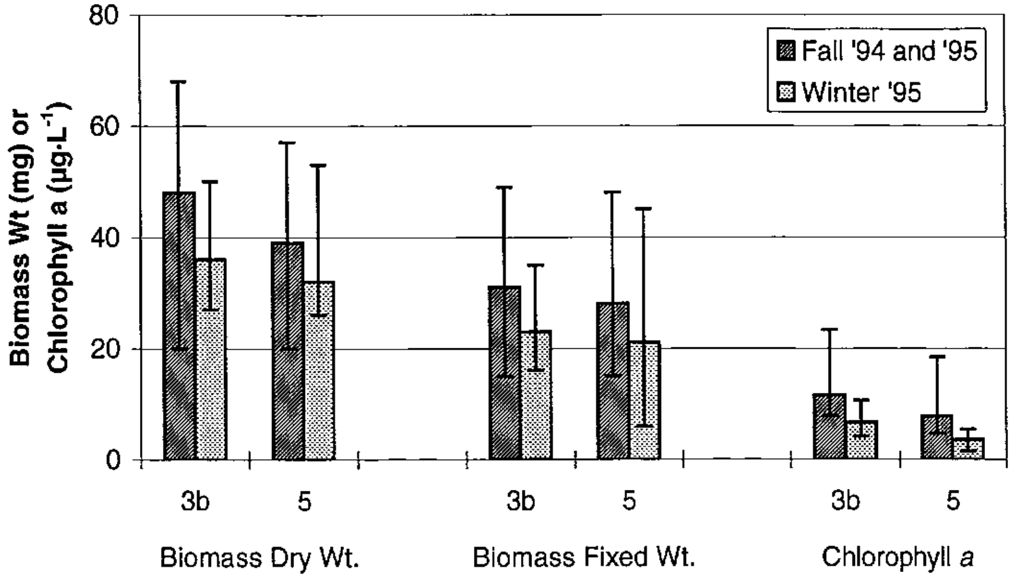


Figure 11 Spatial and Seasonal Variation in Biomass and Chlorophyll *a*



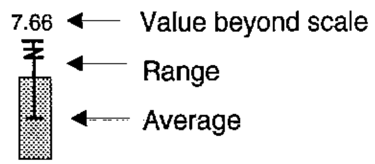
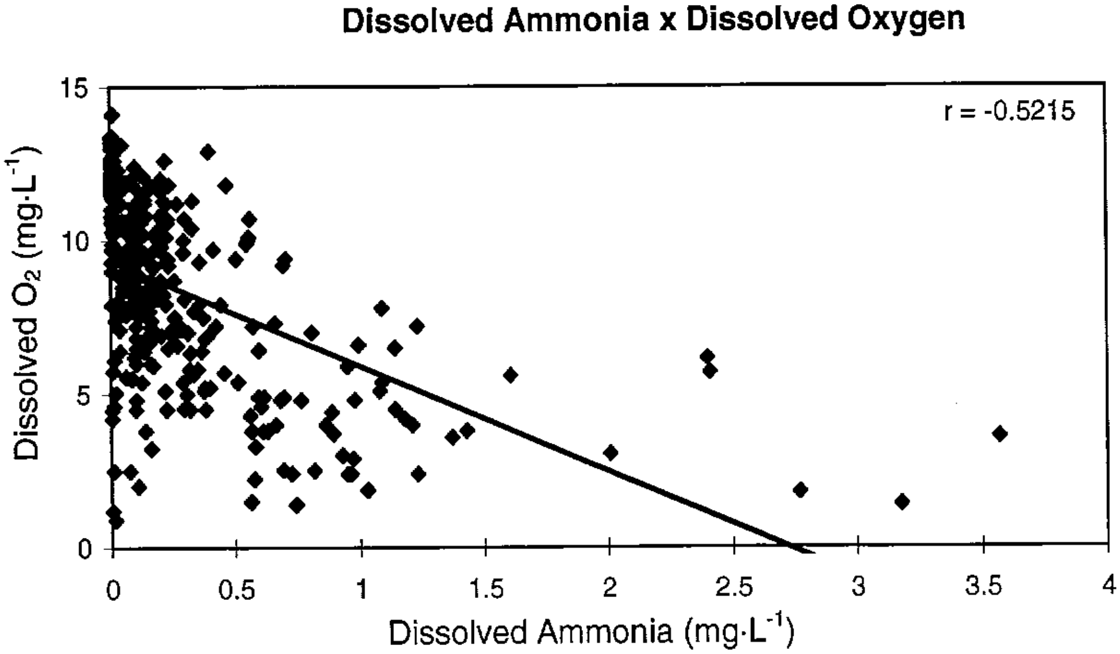


Figure 12 Significant Relationships Between Selected Parameters Sampled in the Matsqui Slough Watershed (p = 0.05)



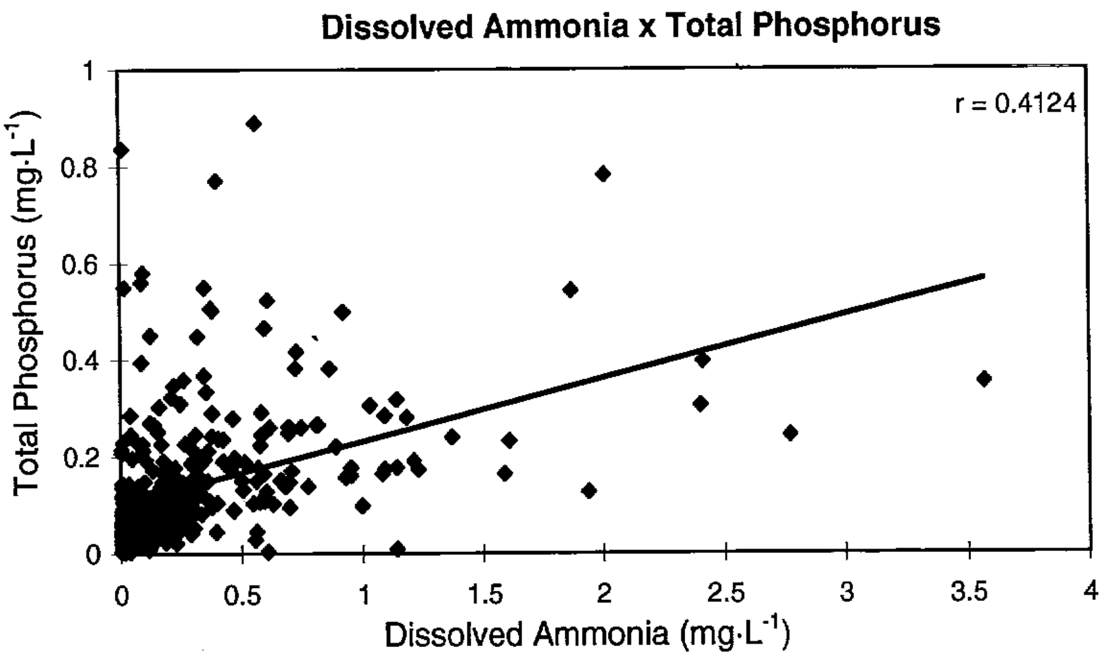
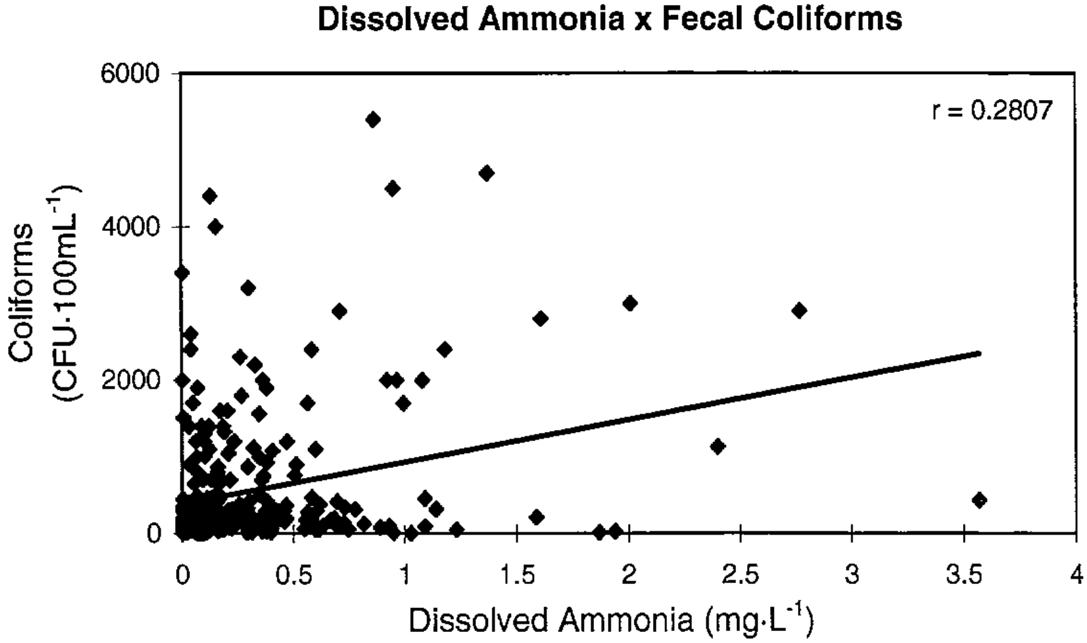


Figure 12 (cont) Significant Relationships Between Selected Parameters Sampled in the Matsqui Slough Watershed (p = 0.05)



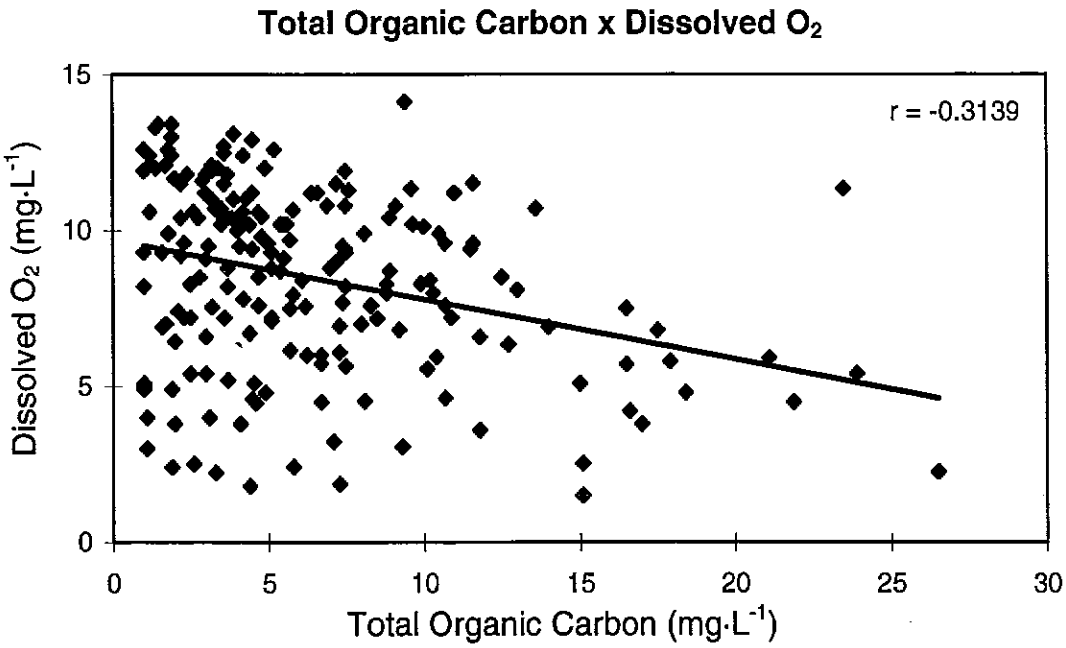


Figure 12 (cont) Significant Relationships Between Selected Parameters Sampled in the Matsqui Slough Watershed (p = 0.05)