

**Fraser River
Action Plan**



**Agricultural
Landuse
Survey in the
Sumas River
Watershed -
Summary
Report**

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**AGRICULTURAL LAND USE SURVEY IN
THE SUMAS RIVER WATERSHED
SUMMARY REPORT**

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Disclaimer

This publication and its accompanying supporting documentation contain the results of a project conducted under contract to Environment Canada. Ideas and opinions expressed herein do not necessarily reflect the opinions of Environment Canada, Department of Fisheries and Oceans, or BC

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EXECUTIVE SUMMARY

The Sumas River watershed is an economically important agricultural area located within the Lower Mainland area of the Fraser River basin. In 1991, the gross farm revenues were greater than 68 million dollars with expenses greater than 53.5 million. This watershed was selected as the study area. The goals of the study were to: (1) identify farms which followed the Code of Agricultural Practice for Waste Management and Agricultural Environmental Guidelines and (2) identify possible contaminant sources which could impact water quality. An inventory of the agrowaste facilities and management in the Sumas River watershed was carried out. This inventory included completing a telephone questionnaire followed by a farm visit - a process that should be updated within five years to document changes. The surface water quality was studied over a five month period and five fish species composition and relative abundance studies were conducted.

FARM SURVEYS

Based on this study, a total of 5693 hectares in the Sumas Prairie is used for agricultural purposes. Approximately 79% was dairy, 4.4% hog, 2.9% poultry and 17% produce and nursery farms. One small goat dairy farm was identified. The total daily dairy/hog/poultry manure production for the 118 farms studied was 1,238,360 L, with an overall loading rate of 262 L/hectare/day on the 4728 hectares of land utilized by livestock farms. Dairy producers generated 65% of the manure, hog producers 31% and poultry producers 4%. The mercator coordinates and photographs of the manure facilities were obtained during the site visits with the permission of the producers.

Ninety-four of the 107 dairy producers identified were surveyed. The average number of milking cow equivalents per farm was 111. Average manure storage time was 3.05 months with 51% of the storage facilities concrete and 19% of these were covered. Ninety percent of the producers spread manure on their own property. An Environmental Sustainability Parameter (ESP) was developed which quantified the potential for contamination of the surface and subsurface waters from a farming operation based on the Code of Agricultural Practice and the Environmental Guidelines for the Dairy Producers. Farms with an ESP greater than 80% were considered in this study to have a low potential for degrading water quality. Seven percent of the dairy producers had an ESP value of greater than 80% and 88% were between 40 and 80%, while 4% had an ESP value less than 40%.

Twelve of the 14 hog producers identified were surveyed (86%). The average number of sow equivalents per farm was 446. Fifty percent of the hog producers have greater than six months manure storage with 75% of storage concrete and covered. Eighty-three percent of the hog producers spread manure on their own land. Twenty-five percent of the hog producers had ESP values greater than 80% and twenty-five percent less than 40%.

Seventy percent (21 out of 30) of the poultry producers identified were contacted with 16 participating in the study. The average number of broiler equivalents per farm was 446,100. Thirty-one percent of the poultry producers exported their manure. Ninety-four percent of the producers have concrete manure storage facilities. Thirty percent of the producers had ESP values greater than 80% and a similar percentage less than 40%.

WATER QUALITY

Fecal coliform densities in some reaches of the Sumas River and Stewart Slough indicate that this water is not suitable to irrigate vegetables. Throughout the watershed, alkalinity exceeded the provincial criteria of 20 mg/L CaCO_3 . Individual pH readings ranged from 6.1 at the upper reach of the Sumas River to 7.6 downstream on the Sumas River. The overall watershed averaged pH was 7.0.

Total metal concentrations were measured twice during the winter of 1994. Total aluminum concentrations exceeded Canadian guidelines for the protection of aquatic life at all sites, except Stewart Slough, on both sampling occasions. After one week of steady rainfall, the criteria for total chromium for the protection of phyto- and zooplankton (2 µg/L) was exceeded at all except one site. Total chromium concentrations at two sites on the Sumas River also exceeded criteria of 20 µg/L for the protection of fish after a week of steady rain. The total copper criteria (2.0 µg/L @ 0 to 120 mg/L CaCO_3) was exceeded at all nine sampling locations on one day and at five sampling locations on both sampling days. Total iron concentrations exceeded the criteria of 300 µg/L for the protection of freshwater aquatic life throughout the watershed. The criteria for the protection of freshwater aquatic life for total nickel concentrations were exceeded at three sites after one week of steady rain. The surface waters are nutrient enriched.

At six of the nine water quality sampling sites, the dissolved oxygen concentrations were suitable for the designated fish habitat. The mean dissolved oxygen concentrations in Saar Creek, Arnold Slough and Marshall (Lonzo) Creek were suitable for the designated fish habitat, however, the minimum fall concentrations did not meet the criteria. The dissolved oxygen concentrations in the winter were acceptable throughout the watershed for the fish species identified.

FISH SURVEY

All reaches supported fish life and salmonids were found throughout the watershed except at the mid-reach on the Sumas River, the Sumas Drainage Canal at Barrowtown and Arnold Slough. The water quality in Saar Creek and the Arnold Slough in the fall was degraded and not considered suitable fish habitat for the identified fish species.

RECOMMENDATIONS

An on-going water quality program should be conducted in the Sumas River watershed. This program should consider and include the data required for dissolved oxygen water quality modelling of the system. The program should measure the dissolved oxygen process related parameters. Furthermore, this program should measure the runoff and dry weather concentrations of aluminium, chromium, copper, iron, nickel and indicator bacterial densities particularly during the late summer and fall periods.

Westwater Research are in the early stages of developing and conducting a GIS based assessment of agriculture and environmental issues in the Sumas River watershed. The information in this study should compliment that assessment. In addition, an agricultural land use survey should be repeated in two to three years to evaluate improvements in agricultural practices as indicated by changes in the ESP frequency distribution.

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1.0 INTRODUCTION

The Fraser River Action Plan (FRAP) was established to reduce the pollution inputs to the Fraser River and to restore the natural productivity of the Fraser River basin. The primary goal of the agricultural component of FRAP is to implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters. Targets and strategies for reduction are to be developed in consultation with stakeholders producer groups, the B.C. Ministry of Environment, Lands and Parks, B.C. Ministry of Agriculture, Fisheries and Food, the B.C. Federation of Agriculture, Department of Fisheries and Oceans and Environment Canada. The first step toward devising a strategy to achieve this goal is to identify current agricultural practices, contaminant sources and if necessary estimate the loadings of specific contaminants. The major non-point sources of potential contamination from rural areas are from agricultural operations.

The primary objective of this study was to develop an information base from which to assess whether the Code of Practice and the associated Environmental Guidelines are sufficient to protect surface and subsurface water quality in the lower Fraser Basins, which receives a greater amount of precipitation on an annual basis than other agricultural areas in B.C. Unlike some studies which make extensive use of runoff estimates, this project developed an initial detailed inventory of the manure handling and agrowaste practices on each individual farm. Nearly all (95%) of the individual farms were visited in the study area with the only exceptions being individual farmers who chose not to participate or could not be contacted. In addition, this project documented in a limited way the quality of the surface waters and the fisheries resource in a largely agricultural watershed. Irrigation is extensively used throughout the watershed. This document discusses the studies undertaken in the Sumas River watershed which is intensively used by dairy, hog and poultry producers as well as commercial crop producers. The methods used in the project are discussed as well as the findings.

2.0 LEGISLATION

In BC, legislative acts, regulations and guidelines that apply to agricultural operations include the federal Fisheries Act, the B.C. Waste Management Act, the Agricultural Waste Control Regulations and Code of Agriculture Practice for Waste Management, and the Environmental Guidelines for various producer groups developed by the B.C. Ministry of Agriculture, Fisheries and Foods and the producers groups.

The habitat section of the federal Fisheries Act prohibits the release of "deleterious substances" to waters frequented by fish. Deleterious substances are defined by this act as follows:

- ! any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or
- ! any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.

In BC, agricultural operations were recognized as a possible source of contamination to surface and subsurface waters, consequently, management guidelines were developed for agricultural producers. A Code of Agricultural Practice for Waste Management was developed by a committee including representatives from B.C. Ministry of Environment, Lands and Parks (MOELP), B.C. Ministry of Agriculture, Fisheries and Foods (MOAFF), B.C. Federation of Agriculture, the Department of Fisheries and Oceans (DFO) and the commodity group inspectors. All agricultural commodity groups had extensive input into development of the Code. The B.C. Federation of Agriculture actively supported enactment of the Code. This Code became part of the Agricultural Waste Control Regulation passed in 1992 under B.C.'s Waste Management Act.

The Code of Agricultural Practice for Waste Management was developed to reduce the export of substances from agricultural operations to the surface and subsurface waters by describing practices for using, storing, and managing agricultural wastes that will result in agricultural waste being handled in an environmentally sound manner. The Agricultural Code defines pollution as "the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment". The Agricultural Waste Control Regulation exempts waste management aspects of agricultural operations from the permit process if these operations conform to the Code.

The BC Ministry of Agriculture, Fisheries and Food in consultation with the BC Federation of Agriculture developed Environmental Guidelines for the various Commodity Groups including dairy (MOAFF, 1993a), hog (MOAFF, 1993b) and poultry producers (MOAFF, 1993c). These guidelines further amplify the Code and provide practical details for the implementation of the Code.

The Code of Agricultural Practice and the Environmental Guidelines describe methods of agrowaste management, facility construction and location which, if practised, will reduce the export of substances from the farm to the surface and subsurface waters. The environmental sustainability of the farming operation is

dependant on the proper construction and location of agrowaste facilities and management of these wastes through the implementation of the Code and Guidelines. These documents provide guidance to the producers so that the impacts of the individual farm operations on surface and subsurface water quality will be minimized.

3.0 STUDY AREA

The Sumas study area, shown in Figures 1 and 2 and is located between Sumas Mountain to the northwest and Vedder Mountain to the southeast, with the International Canada/U.S.A. border the south boundary and the Vedder Canal the eastern boundary. The Sumas prairie has an area of about 10,000 hectares. Drainage from the prairie flows to the Fraser River just east of Sumas Mountain. The basin is characterized by small gradients in the drainage system with resultant small velocities in the creeks and drainage canals.

The Sumas River watershed consists of the Sumas River and Sumas Drainage canal, Arnold and Stewart Sloughs, and Marshall (Lonzo) and Saar Creeks (see Figure 2). Sumas River, Arnold Slough and Saar Creek flow North from their head waters in the U.S.A. into B.C.. Approximately one-half of the 277 km² Sumas River watershed (30.5 km in length and 127 km²) is in British Columbia (Hutton, 1987). The Sumas River receives sewage treatment plant effluent from communities in Washington State, before entering Canada. A large portion of the of the Sumas River, from No. 2 Road to Hougen Park, is dyked (91%) and passes through agricultural land. Peak discharges at the International border occur in December/January and minimums in August/September. Sumas River stream gradients vary from 0.06% at the International border to 0.02% downstream (Hutton, 1987). The north side of Arnold Slough is dyked from Vye Road to the Saar Creek junction. From Saar Creek junction the North side of Saar Creek is dyked until it meets the Sumas River. The B.C. portion of Saar Creek is 6 km in length and has an approximate watershed area of 44.5 km² (Hutton, 1987).

In 1924, a shallow lake occupying part of Sumas Prairie was artificially drained after construction of the Sumas Drainage Canal (or Sumas Lake Canal) and exposed terraced beached sands around its perimeter (Halstead, 1986).

The level in the Sumas River is controlled by gravity drain floodgates for irrigation purposes at Barrowtown pump station (Hutton, 1987). Irrigation water is stored in the Sumas River from May 24 through to September 15 by closing the floodgates (Wright, F., personal communication). For the area West of the Sumas Drainage Canal, the water level in the Sumas River and its tributaries are controlled by three inlet valves (81 cm diameter valves and 91 cm diameter pipes) on the Sumas River which are opened from 35% to 50% of their maximums. Two of these valves are

operated by the District of Abbotsford and the third valve by a independent group of farmers known as the East Sumas Irrigation District. For the area East of the Sumas Drainage Canal, the water level is regulated by four lift pumps into the canal. Considerable seepage from the Vedder Canal into the Sumas watershed and land base around the Sumas Drainage Canal occurs. During the winter months the Sumas River floodgates can be closed to prevent flooding if the Fraser River rises above 4.5 to 5.0 m (Hutton, 1987). A large part of the Sumas Prairie has an elevation of less than 6 m (Halstead, 1986) and much of the Prairie is 1 or 2 meters below the Sumas Drainage Canal elevation. There are 212 kms of drainage/irrigation ditches and the Sumas Drainage Canal is 9 kms in length. For details on the hydraulics of the system see Klohn Leonoff (1989).

The most western portion of the Sumas study area (West of Sumas Way) has been developed for light industries. The remainder of the study area lies in the Sumas Prairie and is intensively used for agricultural production. Dairy, hog and poultry farms are scattered throughout this area, with the central northern portion (area bounded by McDermott Road, Campbell Road, Tolmie Road, No.3 Road and Hwy 1) being heavily used for rotation of vegetable crops such as cole crops and carrots. The northeast corner of the Sumas Prairie includes Yarrow in the District of Chilliwack and Stewart Slough which drains into the Sumas Drainage Canal. Stewart Slough provides irrigation for farms in this area.

Salmonid species have been reported in Saar Creek, Marshall (Lonzo) Creek, Stewart Slough and the Sumas River. Chum and coho salmon are present in the Sumas River from October to January, and spawning of salmonids have been recorded in Saar Creek and the Sumas River (Hutton, 1987). The floodgates at the Barrowtown Pump station are always opened by September 15 each year to allow passage of migrating salmon into the Sumas River and its tributaries.

4.0 METHODS

4.1 OVERVIEW

The methods for each of the project components are discussed in the following sections in the chronological order in which they were carried out. The questionnaire which documented all the features of a particular farming operation was developed in consultation with Environment Canada, Department of Fisheries and Oceans (DFO), BC Federation of Agriculture, BC Ministry of Agriculture, Fisheries and Food (MOAFF), and BC Ministry of Environment, Lands and Parks (MOELP). Once the questionnaire was developed, letters were sent to each individual producer to explain the purpose and objectives of this study. The letter was followed by a telephone interview to complete the questionnaire. During the telephone interview, permission was requested to visit the site. If a site visit was acceptable, the location

of the agrowaste storage facilities were determined using a Global Positioning System (GPS) and photographs of the farming operations related to the management of agrowastes were obtained. The methods used at each step are discussed below.

Independent of the interviews and site visits, water samples were collected at nine locations weekly for a two month period in the fall and over a two month period in the winter. These samples were analyzed for various chemical parameters.

Fish species composition and relative abundance were determined on five different days between October and March in the vicinity of the water quality sampling locations.

4.2 QUESTIONNAIRE

The main components in the telephone questionnaire were compiled by B.C. Environment based on a previous agricultural survey in the Sumas watershed (Hutton, 1987) and a recent agricultural survey in the Abbotsford aquifer (Meier, 1993). A first draft of the questionnaire was circulated to a review committee consisting of B.C. Ministry of Environment, Lands and Parks, B.C. Ministry of Agriculture, Fisheries & Food, B.C. Federation of Agriculture, Environment Canada and IRC for comments. After the first few interviews, it was apparent that a few minor changes to the telephone questionnaire would expedite the information gathering process. The site visit survey sheet that accompanies the telephone interview sheet was developed by IRC after the initial site visits to accommodate GPS information, observation and producer comments obtained on-site.

4.3 DEVELOPMENT OF CONTACT LISTS FOR LETTERS

The Ministry of Environment, Lands and Parks (Region 2) requested membership lists, including phone numbers and addresses, from the commodity groups listed in Table 1. From the farm addresses on these lists, producers in the Sumas basin were identified and notified of the Agricultural Land Use Survey by a letter from the Ministry of Environment, Lands and Parks which described the study (Appendix A). Not all producers in the Sumas study area were identified by the commodity lists because either they were not listed or the farm address was not given or the mailing address was not in the study area. Most hobby farms were not identified in this study since they are not associated with a commodity group.

4.4 TELEPHONE INTERVIEWS

Approximately one week after the mail-out of the letters, the producers were contacted by telephone. During the telephone call, the information for the questionnaire was obtained and an appointment to visit the farm was made. The interview questionnaire and site visit sheets used for this survey are attached in

Appendix A.

To determine the most time efficient method for collecting the questionnaire information, six producers were contacted initially using two different approaches. For three of the producers, the interview was conducted over the phone and a site visit was arranged at the end of the interview. The other three producers were contacted by telephone to arrange a site visit. The interview was conducted during the site visit. The approach of interviewing the producer on the telephone and then arranging for a site visit proved to be the most time efficient. Collecting general information about the farming operation prior to the site visit increased the effectiveness of the visit because more time could be spent by the interviewer touring the site, clarifying issues and points of concern identified during the telephone interview.

The remaining interviews were conducted by telephone with a site visit being requested at the end of the interview, unless the producer requested that the interview be done on site. The producer was at liberty to refuse to answer interview questions or to some or all components of the site visit. Interviewers exerted no pressure on those producers wishing not to participate in any part of the study.

The BC Chicken Marketing Board producers' list did not have contact telephone numbers and consequently, some producers could not be contacted. Difficulties were also experienced in contacting other commodity group producers, either because the telephone number provided by the commodity membership list was incorrect or the producer could not be reached after many attempts.

4.5 FARM VISITS

A time and date for the site visits was arranged during the telephone interview, if possible, as indicated in Section 4.4. The site visit consisted of a visual inspection of the outside agricultural waste handling practices relevant to a particular commodity; namely milk parlour waste, silage runoff, yard runoff, agricultural waste storage facility, disposal practices, location of domestic wells and any other issues identified during the telephone interview. The producer was asked to identify the farm property boundaries on municipal maps. The location of any surface water was visually identified or was noted as being within the property boundaries as indicated by the municipal map. With the permission of the producer, photographs were taken of all agricultural waste storage facilities and any other features that the interviewer considered relevant.

After the general inspection was completed, the producer was asked if GPS equipment (Trimble Pathfinder Basic Plus) could be used to locate their storage facilities. For each storage facility, a data rover file was created and the building/facility of interest circumnavigated. At many sites, it was not possible to

circumnavigate the structure and only two or three sides, or a portion thereof, could be travelled. During the circumnavigation, data was continuously recorded electronically at a preset time interval. Additional positional data were collected at the corners of an agricultural storage facility by pausing on the perimeters. Obstacles which could not be avoided were included in the circumnavigation track. The locations of the manure storage facilities were determined within an accuracy of 2 to 5 meters on a North American Datum 1983 (NAD 83) Universal Transverse Mercator (UTM) Grid using a Trimble Global Positioning System (GPS) Pathfinder system with base station corrections.

All field staff were given instructions and hands-on experiences in the use of GPS equipment and farm site visits over a period of a few days. Data sheets were developed for each individual farm which document the agrowaste operation and manure management on each farm. The manure storage capacities were determined by on site measurements wherever possible and a photographic library of the waste management operations on each farm was developed.

4.6 GPS/GIS MAPPING SYSTEM FOR MANURE STORAGE FACILITY

The general procedure for mapping manure facilities is provided in the following list.

- ! Field (rover) files were collected as described in Section 4.5.
- ! The field (rover) GPS data was downloaded to a personal computer via the program "Pfnder" provided by Trimble.
- ! The acquisition time, according to the GPS receiver clock (Greenwich) was retrieved from the data file via the "Pfnder" computer system.
- ! Base station data from Terra Pro's White Rock location were downloaded for the files identified in step 2 above via a modem. The base station data files were used to post-differentially correct field files. Without post-differential correction "GPS accuracy can range from 1 cm to 100 meters" (Trimble Navigation, 1992) depending on equipment, logging mode, clear view of the sky, if selective availability is activated, etc. With post-differential corrections, a Pathfinder GPS has an accuracy of two to five meters circular error probable (CEP). The CEP value is defined such that a circle of the radius will enclose exactly 50% of the data points. Thus, half the data point are within a CEP radius circle and half are outside the circle (Trimble Navigation, 1992).
- ! Each rover file was differentially corrected with a corresponding base station file using the "Pfnder" program.

- ! Each differentially corrected rover file was averaged to produce a mean coordinate (easting, northing and altitude) for the location of the agricultural waste handling facility surveyed (the centroid of the storage facility).
- ! A Geographic Information System (GIS) file was created for all the averaged GPS rover files. Identification numbers were added to the GIS ASCII files for the purpose of identifying corresponding survey information with the farms.

It was decided to provide the GIS data for the agricultural waste facilities as one averaged point, instead of all differentially corrected positions collected in the field for three main reasons.

- ! The physical perimeter dimensions of an agricultural waste facility are not large enough to be differentiated on a 1:20,000 map or a 1:50,000 map. Thus, giving all differentially corrected positions in the GIS file would not provide additional information.
- ! As mentioned in Section 4.5 Farm Visits, objects that were situated close to an agricultural waste storage facility were often included in the rover file positional data. By averaging all the differentially corrected rover positions the process of having to differentiate between the edge of the building/facility and the obstacle was avoided.
- ! In some cases, all GPS positions recorded in the field could not be differentially corrected by the base station data due to various differences in rover and base file parameter settings such as elevation mask heights, etc. If the number of correctable positions was low, then an adequate representation of the path transverse in the field would not be produced by the differentially corrected positions. In some cases, the corners and/or the general perimeter of the agricultural storage facility could not be determined. Averaging the differentially corrected positions eliminated the problem of providing partial paths for some storage facilities and complete circumnavigational paths for others. Consequently, each set of differentially corrected positional data was handled consistently from storage facility to storage facility.

4.7 SOIL MAP MOSAICS

The soil types are presented in Table 2 and Figure 3 as compiled from BC Ministry of Environment Assessment and Planning Division reports (Luttmerding, 1980 & 1981). The potential for drainage to surface waters or ground water can be inferred from the soil types, distribution and drainage ratings (Table 2).

4.8 SYNOPSIS SURFACE WATER QUALITY MONITORING

Nine water quality sampling sites were originally selected to define the longitudinal water quality gradients from the headwaters to the outlets of the Sumas River system as depicted in Figure 2 and described with GPS coordinates in Table 3. Three additional sites were added at the U.S.A./Canada border for one sampling day. These additional sampling locations have been identified by a letter "B" in the sampling number in Figure 2 and Table 3.

The water quality gradients from the headwaters to the outlet of the Sumas River watershed were measured for dissolved oxygen and total ammonia from October to December 1993. Additional parameters were measured from February to March. Table 4 summarizes the sampling dates, locations, and parameters for the fall sampling period (October to December) and the winter sampling period (February to March). Dissolved oxygen and 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 (Canlab Model 607) and conductivity (YSI Model 33) measurements were added to the winter survey. Water samples were not filtered or preserved in the field. The fall ammonia samples were delivered the same day to the B.C. Ministry of Environment, Lands and Parks, Region 2 office for transportation to the laboratory. The winter water samples were delivered directly to the laboratory the same day. The fall ammonia samples were analyzed by Zenon Laboratories, while the winter samples were analyzed by Elemental Research Inc. Analytical detection limits and duplicate analyses of the winter water samples by Elemental Research Inc. are presented in Appendix B.

4.9. FISH SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Fish were sampled on a presence/absence basis using a Smith Root backpack electroshocker at the nine locations used for the water quality sampling. The amount of shoreline area sampled at these locations ranged from about 20 to 60 m², depending on access at specific sites. Large differences in channel width between stations also increased variability in the efficiency of fish capture using this method. The best fish habitat available in the immediate area of each station was initially selected for sampling. The level of effort was standardized within sites, as much as possible, in terms of shocking time and area covered. However, flooding or freezing occasionally restricted access and reduced the fishable area during later visits.

Difficulties in recovering stunned fish in highly turbid conditions likely under-represented the overall presence of fish. During sampling, the capture of as many species as possible was emphasized over the tallying of more individuals of one species. In some cases, fish were observed only briefly before escaping the electric field; hence, the record of "trout" when species were not actually determined.

A description of physical habitat features was recorded at each location.

5.0 RESULTS AND DISCUSSION

5.1 INDIVIDUAL FARM DATA

The completed questionnaires and other information gathered during the site visits, including the photographs, were arranged in binders by commodity group for the watershed. Information was obtained from 96 dairy, 9 hog, 15 poultry, 3 nurseries and 11 vegetable/berry farms. The Ministry of Environment, Lands and Parks has all completed questionnaires and photographs.

5.2 DEVELOPMENT AND APPLICATION OF THE ENVIRONMENTAL SUSTAINABILITY PARAMETER (ESP)

In order to provide a method of comparing the potential for contamination of surface and ground water from agricultural operations in the Sumas River watershed, a farm ranking system was developed using the information from the completed questionnaires. This produces a single number called an Environmental Sustainability Parameter (ESP). Of the farm operations, the manure storage and disposal methods have the greatest potential for contaminating surface and ground waters. An evaluation of these manure management methods accounted for a large portion of the overall ESP value. The basis of the evaluation process are the methods recommended in the Code of Agricultural Practice and Environmental Guidelines. The ESP values were developed in consultation with B.C. Ministry of Environment, Lands and Parks, Environment Canada, B.C. Ministry of Agriculture, Fisheries and Foods, and the Dairy Producers Conservation Group.

Tables 5, 6 and 7 summarize questionnaire information for dairy, hog and poultry groups respectively. The acreage identified per farm was the total of owned and rented land available to the producer for the spreading of manure. The components of these tables (5, 6 and 7) which were used in the ESP are reported in Tables 8, 9 and 10 which depict the various factors, rating systems and weightings used to develop the ESP for the individual dairy, poultry and hog farms respectively. The factors considered in developing the ranking system are discussed in the Code of Agricultural Practice (1992) and the Environmental Guidelines for Dairy Producers in British Columbia (1993a), Poultry Producers in British Columbia (1993c) and Draft Environmental Guidelines for Hog Producers in British Columbia (1993b), respectively.

In Tables 8, 9 and 10, the ESP factors have been given numerical values from 0 to 5. Because not all of the factors have the same potential for the degradation of

surface and ground waters, the factors were weighted. A farmer must have both good manure storage capacity and small numbers of animals per hectare to have a high ESP value. If the recommendations in the Code or Guidelines are practised or bettered on an individual farm, a value of zero is assigned to that factor. By using a zero rating for the best operating practice for each factor, this factor is then not affected by any weighting system. All the individual factor ratings are added to define the ESP for a farm. An ESP value of 100% indicates complete adherence to the Code and Guidelines. A high ESP value (90%) indicates that the potential for the contamination of ground and surface waters is small. An ESP value of 80% is considered acceptable for the purpose of this analysis. While a farm may have a fairly high level of compliance with the Code and Guidelines, the ESP system evaluates other potential contaminant sources like silage storage drainage, poor yard drainage, septic system, woodwaste storage etc.

Tables 11, 12 and 13 illustrate the use of ESP from the information given in the questionnaire summary Tables 5, 6 and 7 and the weighted factors in Tables 8, 9 and 10 for dairy, hog and poultry respectively. An example of the how the ESP was calculated for poultry farm ID No. 410 is illustrated below. The ESP values for hog and dairy were calculated in a similar manner using a computational spreadsheet.

EXAMPLE

Farm ID 410, (Poultry - Layers)

<u>Summary Information</u>	<u>ESP Rank</u>
Acres = 33, Animals = 18000,	
Broiler Equivalents = $18000 \times 1.55 = 27900$	
BE/Hectare = $27900 / (33 / 2.47) = 2088$, (between 1900 to 2279)	42
Manure Disposal = on farm	14
Dry Manure Storage = concrete/covered	0
Woodwaste Storage = inside	0
Proximity of watercourse to storage facility = Not applicable	0
Tile field age - household domestic sewage = unknown	3
Ranking out of 119	59
ESP Percentage Ranking = $[(119-59)/119] \times 100 =$	50%

5.2.1 DAIRY ESP

Table 14 compares Ministry of Agriculture, Fisheries and Foods priority ratings of environmental concerns on dairy farms (Van Kleeck, 1994) with the priority rating used in the dairy ESP for this study. The order of magnitude for the factors is similar, however the ESP weights the manure storage time and application rates higher.

For dairy operations the revised median grass crop yield (12 tonnes/hectare) with a nitrogen application capacity of 360 kg/hectare was used to determine the allowable spreading rate of manure per hectare without supersaturating the soils with nitrogen (MOAFF, 1993a). This computation is based on an average manure yield of 77 L per day per milking cow (Ibid). Milking cow equivalents were determined as the total number of dairy animals divided by 1.52. Manure storage capacity was determined using the storage facilities dimension, a 77 L/d/MCE animal waste factor, a 27.3 L/d/MCE factor for milk parlour discharges to manure pits (Schmidt, personal communication) and rainfall input of 1091 mm/6 months when storage was uncovered. Storage facilities dimensions were taken from the questionnaire sheet as reported by the producer, where available. Reported dimensions were not verified by measurements during a site visit. If the questionnaire data did not contain storage facility dimensions, the GPS data were used to define the pit perimeter if available. A depth of 2.4 m (8 feet) was assumed for storage facilities when GPS dimensions were used. If there were no data on storage capacity a median ranking of 45 was used in the ESP computation.

The contribution of yard and/or silage drainages to a manure storage pit was not quantified in this survey and thus was not included in the pit storage time calculations. The yard drainage is related to rainfall events and silage storage drainage is seasonal. Consequently these two factors do not have the same potential impact as number of milking cow equivalents (MCE) per hectare or the manure storage capacity.

For the dairy farms in the lower mainland, a storage time of six months is desirable. This allows the manure to be stored during periods when spreading is not desirable in the winter rainy period because soil is saturated or frozen (MOAFF, 1993a). A manure pit storage time of equal to or greater than six months was given a ranking of zero, with less than six months storage receiving higher rankings from 1 to 5 (see Table 8). Covered concrete facilities were given a ranking of zero. Concrete uncovered and steel uncovered waste storage facilities were considered equivalent in their potential to prevent agricultural waste pollution and both received the same relative ranking of 5. Earthen pits were considered to be more of a risk because of the possibility of exfiltration in sandy soils and were given a ranking of 15. For future studies an additional ranking of 25 have been added for earthen lagoon where seepage can occur. This survey did not identify whether seepage from an earthen pit was occurring.

The Environmental Guidelines recommend that dry manure be stored in concrete covered facilities. Dairy farms which followed this recommendation or either had no dry manure to store, or disposed of the dry manure into the pit received a ranking of zero.

The recommended drainage from the milk parlour, the yard or the silage storage

should be to the manure pit (Ibid). No runoff from any of these three factors was given a ranking of zero. Runoff from any of these three factors to a ditch is the least desirable since this has the greatest potential for water contamination. Obviously dairy farms without milking cows would have no milk parlour drainage. Yard drainage refers to any paved area to which the cows have access. Not all dairy farms have yard drainage. Some dairy operations do not use silage or store silage in water tight plastic casings from which there is no runoff. As mentioned earlier, silage drainage is seasonal occurring after the silage is harvested.

Figure 4 shows the distribution of the ESP values for the dairy producers. Seven producers (7%) had ESP values greater than 80% and four producers (4%) were less than 40%. As agricultural practices change with implementation of the Environmental Guidelines a shift or skewness to the right should occur in this distribution. Thus it is important to repeat a survey of this nature in the future to show what improvements have occurred.

5.2.2 HOG ESP

There are three types of hog operations: farrow to finish, farrow to wean and finishers. In farrow to finish operations, sows farrow the piglets and they are raised on the farm to maturity (5 to 6 months old). On farrow to wean farms, sows farrow the piglets which are raised on the farm until they are weaned (6 to 8 weeks old). They are then sold as weaner pigs to finisher operations or to market. The finisher operations raise the weaner pigs to maturity for sale to market. For all three types of hog operations, the pigs are housed in barns for the duration of a cycle.

Similar to the dairy ESP, the median grass crop yield (12 tonnes/hectare) with a nitrogen removal capacity of 360 kg/hectare was used to determine the allowable spreading rate of manure per hectare without supersaturating the soils with nitrogen (MOAFF, 1993b). This computation is based on an average manure production of 72 L per day per sow called a sow equivalent (Ibid, Van Kleeck, personal communication). Manure storage capacity was determined using the storage facilities dimensions, a 72 L/d/SE animal manure production and rainfall input of 1091 mm/6 months when storage was uncovered. For finishers, which represent 12% of a sow equivalent, a animal waste production factor of 8.9 L/d was used (Van Kleeck, personal communication). Storage facilities dimensions were taken from the questionnaire sheet as reported by the producer, where available. Reported dimensions were not verified by measurements during a site visit. If the questionnaire data did not contain storage facility dimensions, the GPS data were used to define the manure pit perimeter if available. A depth of 2.4 m (8 feet) was assumed for storage facilities when GPS dimensions were used. If there was no data on storage capacity a average ranking was used in the ESP.

Unlike dairy farms yard drainage, milk parlour discharge and silage runoff are not

factors on a pig farm. The manure storage pit type for hog farms is ranked similarly as on dairy farms.

The relative magnitude of each of the factors in the ESP are presented in Table 9. The ESP values for the hog producers are presented in Table 12 and graphically in Figure 5. Three producers (25%) had ESP values greater than 80% and three producers (25%) had ESP values less than 40%. The remaining 50% of the hog operations surveyed had ESP values between 61% and 70%. As agricultural practices changes with implementation of the Environmental Guidelines a shift or skewness to the right should occur.

5.2.3 POULTRY ESP

The manure production for poultry is based on the number of broiler equivalents (BE) per cycle. For other poultry units, it was assumed that a layers = 1.55 BE, pullets = 0.94 BE and turkeys = 2.26 BE. The permissible manure loadings per hectare was based on a median grass crop yield (12 tonnes/hectare) with nitrogen removal capacity of 360 kg/hectare. The manure handling on poultry farms differs substantially from dairy farms due to the differences in the nature of the operations. Manure is normally cleared out of the barns at the end of a cycle (10 to 12 weeks for broilers/roasters and 12 months for layers). The manure is then removed within days because it must be removed before the next cycle can start.

Poultry manure spreading practices are also different than on dairy or hog farms. For example, dairy farms almost exclusively dispose of their manure on their own land. Eighty-seven percent of the poultry manure is disposed off the farm. Therefore manure disposal techniques were less of an environmental concern for the individual poultry farms. Since poultry manure storage was either piled on uncovered concrete slabs or in the field, the capacity of these two areas to store the manure was not limited by dimensions as is the case for the liquid dairy or hog manure. On poultry farms, yard drainage is not a factor since the birds are contained within the barns for the duration of a cycle for each type of poultry operation (i.e. layer, broiler, broiler hatching egg or turkey).

The relative magnitude of each of the factors in the ESP are presented in Table 10. The ESP values for the poultry producers are presented in Table 13 and graphically in Figure 6. Five of the producers (31%) had ESP values greater than 80% and four producers (25%) had ESP values less than 40%. As agricultural practices change with implementation of the Environmental Guidelines, a shift or skewness to the right should occur.

5.3 STATISTICAL SUMMARY OF FARM OPERATION BY COMMODITY GROUP

In 1991, 192 large farms in the Sumas River watershed had a gross revenue of 68.3 million dollars with 53.5 million dollars in expenses. A total of 167 producers were contacted by mail (Table 1). Approximately 65% of the producers identified were dairy, 7% hog, 16% poultry, 2% nurseries and 11% vegetable/berry producers. Eighty percent of the farms which received a letter participated in the study with varying levels of enthusiasm. Of the remaining 20%, 5% chose not to participate in the study and 15% could not be contacted.

Based on this study, a total 5693 hectares in the Sumas Prairie are used for agricultural purposes. Approximately 79% were dairy farms, 4.3% hog farms, 2.9% poultry farms and 17% produce and nursery farms. One small goat dairy was identified by this study. In the Sumas River watershed less than 30% of dairy/hog/poultry producers have manure storage facilities within thirty meters of a watercourse. The total amount of dairy/hog/poultry manure production in the Sumas River watershed was 1,238,360 L/day, with an overall loading rate of 262 L/hectare/day on land utilized by livestock producers (4728 hectares). Dairy producers generate 65% of the manure, hog producers 31% and poultry producers 4%. The statistical summary of the data for the different commodity groups is presented in Table 15.

DAIRY

Of the 107 dairy farms identified in the Sumas River watershed, partial or complete data were collected from 94 of them, with seven of the producers choosing only to participate in the telephone interview and not the site visit component. Data from these 94 surveys were used in the statistical data summarized in Table 15. Three dairy producers chose not to participate at all in the study and nine of the producers could not be contacted.

The total land base utilized by dairy producers in the Sumas River watershed was 4503 hectares, with 48 hectares available on average to a producer (includes owned and rented land). The total number of dairy animals (milk cows, dry cows, young stock and heifers) was calculated to be 15,725 animals, with 167 average number of dairy animals per farm. The average milking cow equivalent (MCE) was determined to be 111 (milking cow equivalents = total dairy stock/1.52) and the average MCE/hectare was calculated to be 2.51. The mean storage time for manure for the dairy producers was calculated to be 3.05 months, with a range from 0.21 months to 8.95 months. The desirable storage time is six months in order to eliminate the need for winter spreading from October to March. The most common manure storage facility type was concrete, 51% uncovered and 19% covered. One percent of the dairy producers did not have a permanent storage facility for manure and 32% of the producers had more than one storage facility. Four Sumas dairy

producers discharge directly from their manure storage area/facility into drainage ditches.

The dairy producers almost exclusively spread manure (90%) on their own land. The most common type of manure spreader used were splash plates (vacuum tankers, 90%) that broadcasts or sprays the liquid manure over the land or a mechanical (box spreader, 32%) for the dry manure. There are two dairy producers that currently use a solid/liquid separation system. The barns are equipped with a flush system that uses the water from a lagoon to flush the floors eight times a day, thus avoiding the need to mechanically collect the manure from the floor. Irrigation systems spread the wastewater from the pits onto the land. Using this technology supplementary chemical fertilizers are not required on these farms.

HOG

A total of 14 hog producers were identified in the Sumas study area. Two of these producers were also dairy producers, one was also a poultry producer and the remaining nine were solely hog producers. One hog producer chose not to participate in the study and another could not be contacted. Questionnaire data from the 12 hog producers participating in the study was used for the statistical summary in Table 15.

The total land base used by hog producers in the Sumas River watershed was 247 hectares, with an average of 33 hectares being utilized by a hog producer (includes owned and rented land). The average sow equivalents (SE) was 446. Farrow to finish operations usually reported the number of sows, while finishers would report the number of butcher hogs (finishers = SE x 0.12). The average SE/hectare was 13. The mean storage time for the hog producers is 8.0 months, ranging from 1 month to 19.5 months.

Three quarters of the storage facilities are concrete and covered (under barn) manure pits, and one quarter are concrete and uncovered manure pits. For the hog producers, about 33% of the producers spread manure on their own farms. The remaining 66% spread on their own property in addition to using neighbour's property or other means such as contractors to remove manure. Splash plates (vacuum tankers) are commonly used to spread the hog manure.

POULTRY

In total 30 poultry operations were identified in the Sumas River watershed. Of the 30 poultry producers, three were also dairy producers and one was also a hog producer. Nine of the poultry producers were not contacted, of which three were turkey producers and three were egg producers. Two poultry producers chose not to participate in the study. Data from 16 poultry producers have been used in the statistical summary in Table 15.

The total and average land base utilized by the study poultry producers was 163 hectares and 11 hectares respectively (including owned and rented land). The average number of birds per operation was 27,881. The average broiler equivalents (BE) and BE/hectare were 32,812 and 3,963 respectively. For the short period of time poultry producers have manure on their property, 86% of the operators use concrete storage, with 73% of the operators covering it, usually with a tarp, and 13% of the operators leaving the manure uncovered. The remaining 12% of the operators store the poultry manure in a field with half of the producers covering the manure. Approximately 13% of the poultry producers spread manure solely on their own land, while 53% spread on their own land and also on neighbouring land or have it removed by a contractor. About one third of the poultry producers do not spread manure on their own land and either have it removed by a contractor or taken to a neighbouring farm.

PRODUCE/NURSERIES

Twenty-two vegetable/berry/nursery producers were identified in the Sumas basin. Questionnaire data was obtained from three berry producers, seven vegetable producers and four nursery operations. The data from these 14 questionnaires have been summarized in Table 15. One mushroom operation was identified in the Sumas basin, however, the producer would not participate in the study. Seven producers were not contacted. The total land base used by produce growers/nurseries was 948 hectares, with an average of 68 hectares. More detail on irrigation and pesticide use is given in Section 5.4 below.

5.4 FERTILIZER, DOMESTIC SEWAGE, IRRIGATION AND PESTICIDE USE

Table 15 contains a summary of the chemical fertilizer, domestic sewage, irrigation and pesticide use for the four commodity groups: dairy, hog, poultry and vegetable/berry/nursery producers.

FERTILIZER USE

The dairy producers occupy 79% of the land base surveyed in the Sumas River watershed, and 84% of them use chemical fertilizers. The produce farms and nurseries occupy 17% of the agriculture land and all use chemical fertilizers.

Many of the producers base their chemical fertilization needs and application rates on soil tests, the results of which vary from year to year and depend on soil chemistry. Chemical fertilizers that are commonly reported by dairy and hog producers include; a side dressing formulation for corn, additional phosphorus and special blends. Fertilizer applications on hay or grass is usually in the spring and

repeated after each cut. For corn, the application occurs at planting and as a side dressing (an application approximately six weeks after planting). Information on the application of fertilizer varies each year.

DOMESTIC SEWAGE

Of the 133 producers contacted, less than 1 percent are on municipal sewage systems, the rest use septic tanks and tile fields. For the 118 producers managing livestock, 37% did not know the age of their septic tanks and fields. The average age of the remaining 72 septic tank and field systems was calculated to be 20 years. Reported age for domestic septic systems ranged from 76 years to one year old, with nine reported as less than five years old and 25 as greater than 20 years old.

IRRIGATION USE

The main source for irrigation water is the Sumas River drainage ditches. Other sources for irrigation consist of the Sumas River, Saar Creek, Stewart Slough and well water. Half the dairy producers are currently using various irrigation systems, such as reels and sprinklers. Four percent of the dairy producers use the waste water from their manure storage lagoons to irrigate the crops. Two thirds of the poultry producers and three quarters of the hog producers do not use any irrigation. Ninety-two percent of the produce farms and nurseries use an irrigation system.

PESTICIDE USE

The interview questionnaire used in this study required the producer to indicate if pesticides were used on the farm and method of disposal of the containers. The questionnaire did not require information on the pesticides used, nor the quantity. Only 7% of the poultry producers used pesticides, 42% of the hog producers used pesticides and 58% of the dairy producers used pesticides. For the dairy producers, 94% disposed of containers through the company contracted to apply the pesticide, while the remaining 6% of the dairy producers rinsed and crushed the containers before disposing of them at a landfill or a transfer station or returned them to the supplier. All of the poultry producers disposed of pesticide containers through the company contracted to apply the pesticide. For the 42% of the hog producers who used pesticides, 60% of them had contractors apply the pesticides with the contractor disposing of the containers. The remaining 40% of the hog producers who used pesticides did not answer the survey question regarding container disposal. Approximately 83% of the produce farms and nurseries surveyed reported that they use pesticides. Sixty percent 60% of the produce farms and nurseries reported that they sent the used pesticide containers to a landfill or transfer station, and the remaining 40% either incinerated the containers or had them removed by the contractors who applied the pesticides.

5.5 WATERSHED SURFACE WATER QUALITY

SURFACE WATER QUALITY

Table 16 summarizes the field measurements (temperature and dissolved oxygen) and ammonia analyses for the fall sampling period from October to December, 1993. Figure 7 shows the mean dissolved oxygen (mg/L and saturation) and total dissolved ammonia concentration for the fall sampling period as a bar graph. The dissolved oxygen and ammonia ranges are also indicated in Figure 7 by the vertical lines in the bar graph.

Table 17 summarizes the field and chemical analyses (outlined earlier in Table 4) for the February and March sampling period. Table 18 presents Canadian guidelines and provincial water quality criteria for some general parameters. As expected, the overall mean dissolved oxygen concentrations in February and March were higher than in the October to December sampling period and there was less variability in the winter (Table 19). In Saar Creek (Site 8) the mean dissolved oxygen concentrations were 125% higher in the winter and in Arnold Slough (Site 9) 70% higher in the winter. The provincial criteria of #200 FC/100 mL geometric mean of at least 5 samples for irrigation water used on vegetables/fruit which is eaten raw was not achieved in the Sumas River at Site 11 (GM=709, N=5) and Site 15 (GM=258, N=5). At all sites the alkalinity was greater than the provincial criteria of 20 mg/L CaCO_3 for the protection of freshwater aquatic life moderately sensitive to acid inputs. The individual pH data ranged from 6.1 at Site 7 (upper Sumas River) to 7.6 at Site 11 (downstream Sumas River) during the winter water quality survey, with an overall basin average of pH 7.0.

In Section 5.6, the water sampling sites were classified as category I to IV fish habitat based on the site inventories and the professional judgement of an experienced fisheries biologist. According to water quality criteria of the B.C. Ministry of Environment, Lands and Parks (MOELP, 1994) the minimum dissolved oxygen concentration to support these categories is as follows:

- ! Category I: Spawning and rearing of salmonids - 6 to 11 mg/L
- ! Category II: Year round habitat for at least three non-salmonid species and occasional salmonids - 3 to 8 mg/L
- ! Category III: Marginal habitat for any fish species in the fall but improved winter habitat suitable for at least one salmonid species in winter - 3 to 8 mg/L
- ! Category IV: Sparsely inhabited by only a few species in both seasons - 3 to 6 mg/L

The site classifications, dissolved oxygen concentrations and provincial water quality criteria (Ibid) have been summarized in Table 19. At all sites, except Sites 8 (Saar Creek), 9 (Arnold Slough), and 10 (Marshall Creek) dissolved oxygen concentrations in the fall were suitable for the designated fish habitat. At Sites 8, 9 and 10, the minimum dissolved oxygen concentrations in the fall were less than the criteria to support identified fish species. Sites 8 and 9 had the lowest mean dissolved oxygen concentrations in the fall and the largest variation with coefficients of variation of 61 and 76% respectively. The dissolved oxygen concentration in the winter were acceptable at all sites, with Site 9 (Arnold Slough) having the lowest mean dissolved oxygen concentrations in the winter. The mean ammonia concentrations at Saar Creek (Site 8) and Arnold Slough (Site 9) were also the highest in the fall. The water in Arnold Slough as it crossed the U.S. Canada border was sampled once (Site 9B) in the fall and had a dissolved oxygen value less than at Site 9 downstream on Arnold Slough, indicating that some of the BOD loadings are from United States sources. Even though the ammonia concentration in Arnold Slough at the border was high, it was lower than the average and same sampling day ammonia concentration at Site 9 downstream. Ammonia sources from the United States could likely cause some of the dissolved oxygen depletion measured at Site 9. The highest mean ammonia concentration in the winter water quality survey was found at Site 14 (Barrowtown Pump Station). Ammonia is a large oxygen demand, since the nitrification reaction requires two moles of oxygen for each mole of ammonium (Wetzel, 1983).

Table 20 presents the total metal concentrations for the winter sampling period and Table 21 presents water quality Canadian guidelines and provincial criteria for total metals. Total aluminum concentrations exceeded the Canadian guideline of 100 µg/L @ pH 6.5 (CCREM, 1987) for the protection of aquatic life at all sites, except Stewart Slough, on both sampling occasions. On March 3, after one week of steady rainfall, the Canadian guideline and provincial criteria for total chromium for the protection of phyto- and zooplankton (2 µg/L) was exceeded at all sites, except at Site 14 (Barrowtown Pump Station). Total chromium concentrations at Sites 7 and 11 on the Sumas River also exceeded 20 µg/L. The Canadian guideline for the protection of freshwater aquatic life for total copper concentration (2.0 µg/L @ 0 to 120 mg/L CaCO₃) was exceeded at Sites 7, 8, 9, 10 and 12 on February 22, and at all nine sampling locations on March 3. Total iron concentrations exceeded the Canadian guideline and provincial criterion of 300 µg/L throughout the watershed. The Canadian guidelines and the provincial criterion for the protection of freshwater aquatic life for total nickel concentrations were exceeded at Sites 7 (Sumas River), 8 (Saar Creek) and 11 (Sumas River) on March 3 after one week of steady rain. The total phosphorus concentrations exceeded the provincial criterion of <15 µg/L for the protection of aquatic life in lakes throughout the basin with the highest mean concentration of 265 µg/L in Arnold Slough. High concentrations of phosphorus indicates a nutrient enriched body of water.

SURFACE WATER QUALITY AND RAINFALL EVENTS

One of the objectives of the water quality sampling was to determine to what extent rainfall and the resulting runoff affect water quality in the Sumas River watershed. Other numerous studies on rainfall runoff in both urban and agricultural areas have indicated that water quality can be degraded after a rainfall event (Table 22). The fall water quality survey consisted of collecting water samples at nine sites on weekly basis for two months. This sampling program was not intentionally organized to collect samples after rainfall events. The winter sampling program in February and March was planned so that some sampling days were after rainfall events and some during dry periods. Rainfall was considered to be indicative of runoff. There are no data available on the rainfall-intensity-duration and time response characteristics of the waterways in the Sumas River watershed. This section discusses two methods for determining which sampling days were runoff events. These methods are required because no hydrograph data were available for the waterways during the sampling.

The distance from each sampling site to Site 15 on the Sumas River is presented in Table 23 as measured from a topographic map (Mission, 92 G/1, 5th Edition, Energy, Mines and Resources Canada, NAD27). There are no data on the time-of-travel in the Sumas River drainage system. We have estimated the rainfall response times for the runoff and dry condition, based on the assumption that typical dry and wet weather mean velocities for the Sumas River watershed would be approximately 0.15 m/s and 0.3 m/s respectively. These velocity estimated are based on experience with similar waterways. The travel-of-time from the sampling sites to Site 15 are also presented in Table 23. Using these assumed velocities, the travel time from Site 7 to Site 15 would be approximately 20 hours in wet weather and 40 hours in dry weather. This travel-of-time is probably less than the actual since the water level in the Sumas River watercourses can be controlled by drainage ditches, weirs and pumps as outlined in the description of the study area in Section 3.0. A more conservative estimate of a typical travel time for this basin would be about 48 hours in dry weather.

Daily rainfall data from Abbotsford Airport Station (Environment Canada, Atmospheric Environment Services) has been plotted in Figure 8 for the duration of water quality sampling period (October 1993 to March 1994). The rainfall data does not provide any information on the intensity/duration of the daily rainfall (i.e. 10 mm of rainfall in 3 hours or in 20 hours). Abbotsford Airport is located approximately 14 kms west of the Hougen Park in Sumas.

The water quality data were analyzed on a basin and on a site basis for the four upstream sampling sites (Sites 7, 8, 9, and 13) for differences between "wet" and "dry" sampling days. Basin averaged data require an estimate of the rainfall/runoff time response for interpretation. Site averaged data only require the date of rainfall

for interpretation. The basin averages for the wet and dry periods are discussed first, followed by the site averages in the upper reaches.

The following "wet" versus "dry" comparisons are based on crude time-of-travel estimates for the Sumas River watercourses and synoptic water quality monitoring. Detailed time-of-travel studies and modelling of the Sumas River watershed are needed before the impacts of rainfall events on water quality can accurately be assessed.

Watershed Averages for "Wet" and "Dry" Periods

The sampling days have been classified as "wet" and "dry" using a basin response time of 24 and 48 hours as presented below based on the rainfall distribution plotted in Figure 8. This classification system shows that November 15, December 15, February 22, and March 3 were wet days regardless of the response time due to rainfall distribution. October 12, 18, 25, November 1, 8, 24, February 10, and March 10 and 24 are classified as "dry" sampling days. The differences in surface water quality concentrations during wet and dry sampling days were determined.

24 hour Response Time		48 hour Response Time	
<u>"Wet" Days</u>	<u>"Dry" Days</u>	<u>"Wet" Days</u>	<u>"Dry" Days</u>
FALL			
Oct 6, 1993	Oct 12, 18, 25, 1993		Oct 6, 12, 18, 25, 1993
Nov 15, 1993	Nov 1, 8, 24, 1993	Nov 15, 1993	Nov 1, 8, 24, 1993
Dec 15, 1993		Dec 15, 1993	
WINTER			
Feb 22, 1994	Feb 10, 1994	Feb 22, 1994	Feb 10, 1994
March 3, 1994	March 10, 24, 1994	March 3, 1994	March 10, 24, 1994

Parameters were compared on a basin basis by averaging the data from all sampling sites for the "wet" and "dry" sampling days. Table 24 presents the basin averaged values for the parameters indicated earlier. The differences between the mean values were statistically tested using a "t" test.

For ammonia, the "dry" sampling days were slightly higher than the "wet" sampling days. Suspended solids and faecal coliforms concentrations tend to be higher during runoff periods. A decrease of a factor of three approximately in suspended solids was observed for the dry sampling days data (See Table 22). Table 24 shows that the "wet" basin averaged faecal coliform density is five times greater than the "dry" density. Statistically testing the differences between the "wet" and "dry" means ("t" test) showed that only suspended solids were different at the 99.9% confidence level.

Metal concentrations were determined on February 22, and March 3, 1994, both "wet" sampling days. During the week prior to March 3, approximately twice as

much rain fell (122.7 mm) compared to the week prior to February 22, 1994 (62.9 mm). Total aluminum concentrations were a factor of seven greater on a watershed basis on March 3 compared to February 22. Iron concentrations were approximately three times greater on March 3 than February 22. Selenium showed increased concentrations of a factor of 2.5 on a basin basis. For cadmium, mercury and selenium no difference was noted between February 22 and March 3. Total lead and total zinc concentrations increased by factors of 2 and 1.6 respectively on March 3 compared to February 22 sampling date.

Upper Reaches Averages for "Wet" and "Dry" Periods

The four upper-reach sites sampled in the Sumas River watershed were; Site 7 - Sumas River @ Vye Road, Site 8 - Saar Creek @ Vye Road, Site 9 - Arnold Slough @ Cole Road and Site 13- Stewart Slough @ Boundary Road. To investigate local runoff impacts, the sampling days were classified as "wet" if it rained the day of sampling (see Figure 8). Using this criterion, the "wet" and "dry" sampling days are:

<u>"Wet" Days</u>	<u>"Dry" Days</u>
FALL	
October 6, 12, 18, 1993	October 25, 1993
November 15, 1993	November 1, 8, 24, 1993
December 15, 1993	
WINTER	
February 22, 1994	February 10, 1994
March 3, 10, 1994	March 24, 1994

The "wet" and "dry" averaged water quality data for ammonia, suspended solids and faecal coliforms are presented in Table 25 for Sites 7, 8, 9, and 13. Metal concentration data were only available for "wet" days. For Sites 7, 8 and 9, the average ammonia concentration for "dry" sampling days were 1.2 to 1.5 times greater than the averaged "wet" concentrations. For Site 13 the averaged ammonia concentration for "wet" sampling days was approximately equal to the averaged "dry" concentration (Table 25). Suspended solids increased by a factor of four at Site 7 and by a factor of two at Sites 8 and 9 on the "wet" sampling days. No differences between "wet" and "dry" mean suspended solids concentrations were noted for Site 13. Faecal coliform concentrations were 1.8 times higher at Site 7, 2.7 times higher at Site 9 and 8.4 times higher at Site 13 on "wet" days compared to "dry" days. But none of the differences were statistically significant.

As discussed previously during the week prior to March 3, approximately twice as much rain fell (122.7 mm) compared to the week prior to February 22, 1994 (62.9 mm). From Table 20, aluminium concentrations were approximately three to five times greater on March 3 at Sites 7, 9, and 14 than on February 22. Sites 11 and 12 showed a nine and seven fold increase respectively, with Sites 8, 13 and 14 showing a 14, 11 and 21 fold increase respectively. Total iron concentrations were

less than two times higher on March 3 than on February 22 at Sites 9, 10 and 14. At Sites 7, 12, 13 and 15, the iron concentrations were approximately three times greater on March 3 than on February 22. Sites 8 and 11 had a five and seven fold increase respectively in total iron concentrations between February 22 and March 3. For total lead, Sites 7, 11 and 13 had less than two fold increase between the February 22 and March 3, while Sites 8, 9, and 10 showed a 3 to 5 fold increase between these two sampling dates. For total zinc, Sites 7, 8, 12, 13, and 14 showed approximately a 1.5 factor increase between February 22 and March 3, while Sites 10, 11 and 14 showed a 2.5 factor increase. For cadmium, mercury, and selenium no difference was noted between February 22 and March 3. This analyses shows that most metal concentrations are directly related to the amount at rainfall.

5.6 FISH SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Thirteen species of fish were collected or observed during the study. Their distribution and relative numbers between locations, for all five field survey days combined, are shown in Table 26. Table 27 presents the field survey information for the five sampling days individually. Stickleback represented 43% of the fish captured and sculpin 29%. The salmonids represented 9.3% of the fish captured and were found at least at all locations except at the Sumas Drainage Canal at Highway 1 West (Site 14), Arnold Slough (Site 9) and Sumas River at McDermott Road (Site 12).

All of the sites supported fish life. Based on site inventories and professional judgement, the locations were classified into four categories (I, II, III, IV) according to the relative quality and permanency of fish habitats.

Category I sites likely contain consistently good water quality and year round habitat for spawning or rearing salmonid species in most runoff conditions. These sites were smaller headwater streams in the study area like Stewart Slough (Site 13).

Category II sites likely contain consistent year-round habitat for at least three non-salmonid species and occasional salmonids. These sites were Sumas River at Vye Road (Site 7), Saar Creek (Site 8), Sumas River at McDermott Road (Site 12) and Sumas River near No. 1 Road (Site 15). However, Saar Creek would likely not rate this highly if sampling had been confined to upstream of the culvert; most species were collected downstream of the culvert where turbulence increased dissolved oxygen concentrations to tolerable levels in the autumn. Interestingly, adult chum salmon spawners were observed below the culvert on November 24; although their upstream passage appeared to be impeded by a temporary ice blockage, they may also have been trying to spawn in the sparse gravel pockets located below the culvert. Rocky rapids downstream of the bridge at Site 7 also probably increase dissolved oxygen concentrations in the downstream pool below.

Category III sites contained marginal habitat for any fish species in the fall season, but provided improved habitat in the winter season for at least one salmonid, or at least three non-salmonid, species in winter. Sumas River at South Parallel Road (Site 11) is Category III.

Category IV sites were sparsely inhabited by only a few species in both seasons. Arnold Slough (Site 9), Marshall (Lonzo) Creek (Site 10), and Sumas Drainage Canal (Site 14) are Category IV sites. Arnold Slough and Marshall Creek do not provide spawning or rearing habitat for salmonid fish habitat due to low gradient and poor water quality conditions that likely persist year round. However, the mainstem watercourse, namely Sumas River is important to local salmonid populations for brief periods each year as migratory routes. Anadromous stocks, although small in number, migrate through these polluted waters between the Fraser River and the headwater spawning areas each year. Gated dams at the mouth of the Sumas River physically restrict fish access and worsen stagnant water conditions at certain seasons. During the summer-fall, low flow period when water quality conditions are poorest, fish movements between the Fraser and the headwaters may be restricted until significant runoff events in the late fall flush the stagnant water in the respective mainstems. Changing the classification of reach from IV to III will provide fish habitat for non-salmonid species.

6.0 CONCLUSIONS

6.1 FARM INVENTORY

The process of sending an explanatory letter to each producer followed by a telephone interview then a site visit was found to be a very effective method for obtaining information on the operations of the individual farms. The site visits were an important component of the study. These visits not only provided personal contact with the farmer but permitted the farmer to ask questions about the study and farm management.

A common questionnaire form was used for all the producers in this project. The agrowaste management practices of the dairy, hog and poultry producers are very different consequently a different questionnaire format for the different producer groups would expedite the information gathering process and make it more direct. Different questionnaires are required for the different producer groups. Unfortunately, most producers do not have quantitative information on their manure production, spreading rates and frequencies, their chemical fertilizer spreading rates and frequencies, their crop yield and protein levels and their irrigation water usage.

All the project cooperating farms in the Sumas River watershed were visited and the

agrowaste management practices and facilities were documented and photographed. Using this process, it was possible to determine the extent of application of the Code of Agricultural Practice and the Environmental Guidelines for the various producer group operating farms in the watershed. The average storage capacity of manure in the basin is 3.05 months for the dairy producers and 8.0 months for hog producers. Seventy percent of the dairy producers have concrete manure storage facilities with 27% of these facilities covered. For the hog producers 75% of the manure storage is concrete and covered. Seventy-three percent of the poultry producers have covered concrete manure storage. Almost all of the dairy producers (90%) spread some or all of their manure on their own land with 90% using splash plate spreading techniques. Whereas only 33% of the hog producers spread their manure totally on their own land and 13% of the poultry producers use only their own land. There was no documentation on the final destination of the manure once it was removed from the producer's property.

Fifty-seven percent of the dairy farmers use pesticides and 94% of the pesticide containers are removed by contractors. For the hog producers 42% use pesticides and 60% of producers use contractors to remove the containers. Only 7% of the poultry producers use pesticides. Approximately 83% of the produce and nursery producers surveyed use pesticides. Sixty percent of these producers use landfilling to dispose of the pesticide containers.

All of the produce and nursery producers use chemical fertilizers and 84% of the dairy producers use chemical fertilizers. Only about 20% of the hog and poultry producers use chemical fertilizers.

Nearly all the producers have septic tanks and tile fields for the treatment of sanitary wastes. The average age of the septic tank and field systems was approximately 20 years old.

Ninety-two percent of the vegetable/berry producers and nurseries irrigate and 49% of the dairy producers irrigate. Only about 25% of the poultry and hog producers use irrigation. There is no information on the amount of water used in irrigation although the source of the irrigation water was identified in the survey.

ENVIRONMENTAL SUSTAINABILITY PARAMETER (ESP)

The average ESP value for the dairy producer was 64% with a range of 32% to 96%. Seven producers (7%) had ESP values greater than 80% and four producers (4%) were less than 40%. The average ESP value for hog producers was 65%, with a range of 24% to 97%. Three producers (25%) have ESP values greater than 80% and three producers (25%) have ESP values less than 40%. The average ESP value for poultry producers was 63%, with a range of 30% to 97%. Five of the producers (31%) have ESP values greater than 80% and four producers (25%) have ESP values

less than 40%. As agricultural practices changes with implementation of the Environmental Guidelines a shift or skewness to the right should occur for the frequency distributions developed during this study.

6.2 WATER QUALITY

The dissolved oxygen concentrations at the sampling sites on Saar Creek and Arnold Slough were, at times, less than the required provincial criteria to support the identified fish species in the fall. The minimum dissolved oxygen at Marshall (Lonzo) Creek in the fall was also less than the provincial criteria. The dissolved oxygen concentrations in the winter were acceptable throughout the basin. The faecal coliform densities in the Sumas River indicate that this water should not be used on vegetables that are eaten raw. At all sites the alkalinity was greater than the provincial criteria of 20 mg/L CaCO_3 for the protection of freshwater aquatic life moderately sensitive to acid inputs. The individual pH data ranged from 6.1 at Site 7 (upper reach of Sumas River) to 7.6 at Site 11 (Sumas River) during the winter water quality survey, with a watershed overall average of pH 7.0. The total phosphorus concentrations in the waterways throughout the basin exceeded the provincial criteria of 0.015 mg/L for lakes indicating nutrient enrichment.

Total aluminum concentrations exceeded Canadian guidelines for the protection of aquatic life at all sites, except in Stewart Slough, on both sampling occasions. After one week of steady rainfall, the criterion for total chromium for the protection of phyto- and zooplankton (2 µg/L) was exceeded at all sites, except at Site 14. Total chromium concentrations at two sites on the Sumas River also exceeded the criterion of 20 µg/L for the protection of fish after a week of steady rain. Total copper (2.0 µg/L @ 0 to 120 mg/L CaCO_3) exceeded the guideline at all nine sampling locations on one sampling day and at five sampling locations on both sampling days. Possible sources of copper could be present in runoff, herbicides and crop seed pesticide formulations. Total iron concentrations exceeded 300 µg/L throughout the watershed. Iron is ubiquitous in developed basins. Total nickel concentrations exceeded the criterion at three site after one week of steady rain.

6.3 FISHERIES

Fish were present at all the sampling locations although the fish species varied from site to site. Stewart Slough (Site 13) had the greatest number of individuals (84 fish in 5 surveys) with 12% of the 84 fish being salmonids. Saar Creek at Vye Road (Site 8) had the next highest number of individuals (30 fish in 5 surveys) with 23% of the 30 fish being salmonids. The Sumas River (Sites 11 and 12) and Sumas Drainage Canal had the least number of individual fish (5, 6 and 9 respectively) in 5 surveys which were primarily stickleback and sculpin.

7.0 RECOMMENDATIONS

7.1 FARM INVENTORY

Modification to the questionnaires should be made to account for the different producer groups because the agrowaste management practices vary.

Some documentation is required on manure that is exported from the farm. This documentation should include the name of the remover, quantity, date of removal and the destination of the manure.

More detailed information should be available to the farmer on the best days for spreading manure and on setting allowable spreading rates based on these conditions. This information should be available by telephone and be locally relevant. Consideration should be given to developing a spreading index (SI). Information such as soil moisture, rainfall, frozen ground, seasonal soil nitrate, weather predictions, fisheries sensitivity index, flows and dissolved oxygen in the Sumas River and Sumas Drainage Canal could be considered in developing a spreading index. A Victoria, B.C. company has developed and is marketing a soil moisture meter which could be useful. Combined with a "nitrometer" and a weather station forecast, this could generate the necessary data for the spreading index. If possible the spreading index would be modified locally by the individual farmer for the farm soil type and the nitrate levels determined by some method like a "nitrometer".

There appears to be little site specific information available on the export of material from the different farming operations. Some work on the presence of nitrate in tile drains in corn fields under different field management practices has been undertaken (Schmidt, 1993). However, the actual loadings based on rainfall were not included as part of this study. Consequently, there is a need for quantitative studies on the effect of milk parlour wastes, yard drainage, silage drainage, manure pit leachate and the effects of general crop manure spreading practices on surface and subsurface water quality.

7.2 WATER QUALITY

The water quality problems identified were low fall dissolved oxygen, faecal coliforms, total phosphorous, total aluminum, total chromium, total copper, total iron and total nickel. The concentrations of metals and bacterial densities should be monitored during dry periods and periods after rainfall events. The kinetics of the dissolved oxygen concentrations in the waterways is complicated by the small and variable times of travel in the watercourses. If the sources of oxygen demand are to be identified and the most cost effective remedial measures determined, it will be necessary to gather the data and apply conventional dissolved oxygen models like QUAL2. Because most of the processes determining the dissolved oxygen

concentration in the waterways are biological, a model is the only way to understand and predict the dissolved oxygen regime in the waterways and to make recommendations on how to improve the water quality. The model must include ground water flow, stagnation conditions, variable flows and sediment oxygen demand. An extensive data base will be required to apply the model with any degree of confidence. It is recommended that the model be developed and applied to a subcatchment like part of the Arnold Slough or Saar Creek so that the model can be modified to suit the Sumas River watershed.

Even with improvement in agricultural practices a lag phase in terms of improvement in water quality conditions would be expected. It will be important to develop and conduct an on-going water quality program over several years in order to demonstrate improvements and cause/effect relationships.

7.3 WATERSHED PLANNING

As watershed planning and land use planning become accepted practices (MEE, 1993 (a), (b), (c)), studies of this nature will be required to adequately demonstrate changes in land use practices and that can be used to demonstrate cause/effect environmental issues

8.0 ACKNOWLEDGMENTS

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9.0 GLOSSARY

ASCII	American Standard Code for Information Interchange
BE	Broiler Equivalents
CEP	Circular Error Probable
CCREM	Canadian Council of Resource and Environment Ministers
DFO	Department of Fisheries and Oceans
DO	Dissolved Oxygen
ESP	Environmental Sustainability Parameter
FRAP	Fraser River Action Plan
GIS	Global Information System
GPS	Global Positioning System
HP	Horse Power
MCE	Milking Cow Equivalents
MOAFF	Ministry of Agriculture, Fisheries and Foods
MOELP	Ministry of Environment, Lands and Parks
NAD27	North American Datum, 1927
NAD83	North American Datum, 1983
QUAL2	Stream Water Quality Model
SE	Sow Equivalents
UTM	Universal Transverse Mercator

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Table 1
Commodity Groups Membership Lists

Commodity Group	Address
B.C. Lawn Turf Farms	9010 192nd Street Surrey, B.C. V4N 3W9
B.C. Vegetable Marketing Commission	#201-7560 Vantage Way Delta, B.C. V4G 1H1
B.C. Broiler Hatching Egg Commission	464 Riverside Road S., RR2 Abbotsford, B.C. V2S 4N2
B.C. Mushroom Marketing Board	#201-7560 Vantage Way Delta, B.C. V4G 1H1
B.C. Pork	2010 Abbotsford Way, B.C. V2S 6X8
B.C. Egg Marketing Board	#22-34470 South Fraser Way Abbotsford, B.C. V2S 4P2
B.C. Chicken Marketing Board	#203 572 176 Street Surrey, B.C. V3S 4C8
B.C. Turkey Marketing Board	#218 17704 56th Avenue Surrey, B.C. V3S 1C7
Dairy Producers' Conservation Group	#205-33780 Laurel Street Abbotsford, B.C. V2S 1X4
Sustainable Poultry Farming Group	#302-34252 Marshall Road Abbotsford, B.C. V2S 5E4
Hog Producers' Sustainable Farming Group	2010 Abbotsford Way Abbotsford, B.C. V2S 6X8

Table 2
Sumas River Watershed Soils Map Legend ¹

MAP SYMBOL	SOIL NAME	SOIL MATERIAL	DRAINAGE	CLASSIFICATION
BK	BUCKERFIELD	Moderately fine textured lacustrine deposits	Poor to moderately poor; high ground water table	Orthic Humic Gleysol
BT	BATES	Medium-textured local stream deposits	Imperfect; fluctuating ground water table	Gleyed Eluviated Melanic Brunisol
DX	DIXON	15 to 50 cm of moderately fine to fine-textured lacustrine deposits over sand	Poor to very poor; high ground water table	Rego Gleysol
FD	FADDEN	Medium to moderately fine textured lacustrine deposits	imperfect	Gleyed Gray Brown Luvisol
KD	KENNEDY	Coarse-textured lacustrine beach deposits	Well to rapid	Brunisolic Gray Luvisol
LZ	LONZO CREEK	15 to 50 cm of medium-textured eolian deposits over moderately coarse textured glacial till	Moderately well to well	Orthic Humo-Ferric Podzol
MH	MARBLE HILL	More than 50 cm of medium-textured eolian deposits over gravelly glacial outwash deposits	Well	Orthic Humo-Ferric Podzol
PR	PREST	Medium to moderately fine textured floodplain deposits	Very poor; high ground water table	Rego Gleysol
SM	SUMAS	Coarse-textured lacustrine deposits	Very poor to poor; high ground water table	Rego Gleysol
VD	VEDDER	Moderately fine to fine-textured lacustrine deposits	Poor; high ground water table	Orthic Gleysol
VY	VYE	Moderately fine to fine-textured lacustrine deposits	Imperfect; fluctuating ground water table	Gleyed Gray Luvisol

1. Luttmerding, H.A., 1981. Soils of the Langley-Vancouver Map Area, Volume 3: Description of the Soils. RAB Bulletin 18.

Table 3
Surface Water Sampling Locations and Site Numbers
in the Sumas River Watershed

Site No.	Site Description	GPS Coordinates	
		Northing (metres)	Easting (metres)
7	Sumas River @ Vye Road	5429644	556907
7B	Sumas River @ U.S.A. border	-	-
8	Saar Creek @ Vye Road	5429665	559270
8B	Saar Creek @ U.S.A. border	-	-
9	Arnold Slough @ Cole Road	5430817	559671
9B	Arnold Slough @ U.S.A. border	-	-
10	Marshall Creek @ Sumas Mountain Road	5433704	558812
11	Sumas River @ South Parallel Road	5433245	558837
12	Sumas River @ McDermott Road	5436173	561106
13	Stewart Slough @ Boundary Road	5435416	567172
14	Sumas Drainage Canal @ Hwy 1 West	5440511	564897
15	Sumas River downstream of Barrowtown Pump Station	5440689	564883

Datum: NAD-83

Coordinate System: UTM-10M

Sites 7B, 8B and 9B do not have GPS coordinates since a water sample was collected only once from each of these three sites.

Table 4
Field Sampling Dates, Sites and Parameters Measured in the Sumas River Watershed

Sampling Dates	Site No.'s	Parameters											
		Field				Laboratory							
		Temp	D.O.	pH	Conductivity	pH	Conductivity	Ammonia-Nitrogen	Faecal Coliform	General ¹	Total Metals ²	Oil & Grease	Chloride
October 6, 12, 18, 25, 1993	9 to 15	X	X			X	X	X					
November 1, 8, 15, 24, 1993	9 to 15	X	X			X	X	X					
October 25, 1993	7B, 8B, 9B	X	X					X					
February 10, 1994	9 to 15	X	X			X	X	X	X	X			
February 22, 1994	9 to 15	X	X	X	X	X	X	X	X	X	X	X	X
March 3, 1994	9 to 15	X	X	X		X	X	X	X	X	X	X	X
March 10, 24, 1994	9 to 15	X	X	X	X	X	X	X	X	X			

1 General = Total Dissolved Solids, Total Suspended Solids, Turbidity, Alkalinity, Hardness, Total Organic Carbon, Nitrate-Nitrite, Total Kjeldahl Nitrogen, Total Nitrogen, Organic Nitrogen, ortho Phosphate, Total Dissolved Phosphate, Total Phosphorus

2 Aluminium, Arsenic, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Sodium, Strontium, Tin, Zinc

Table 5
Summary of Dairy Operations in the Sumas River Watershed

Farm ID	Acres ** (owned and rented)		Milking Cow Animals	Rate MCE per Hectare	Manure Pit Storage Time (months)	Dry Manure Storage	Main Manure Pit Facility Type	Second Manure Pit Facility Type	Third Manure Pit Facility Type	Fourth Manure Pit Facility Type	Woodwaste Storage	Milk Parlour Discharge	Yard Drainage	Silage Runoff	Proximity of Watercourse to Facility (meter)	Field Age Household Domestic Sewage	Spreading on				Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP * Percentage Ranking	
	Adjacent Farms (acres)	Type of Irrigation															Irrigation Source	Handling of Mortalities							
1	200	250	164	2.03	no data	none	earthen				none	manure	manure	surface	NA	?	splash plate		none	contractor	contractor	municipal		71	
2	200	200	132	1.63	no data	none	steel/unc				covered	manure			NA	?	splash plate	boom	Saar Crk.	contractor		municipal		76	
3	100	100	66	1.63	2.41	none	conc/unc				covered	tile	surface	none	NA	?	splash plate	wheel move	ditch	contractor		municipal		64	
4	115	250	164	3.53	4.24	conc/unc	steel/unc	conc/unc	conc/cov		inside	manure	none	manure	NA	37	spish/mech	none		contractor		municipal		67	
5	28	30	20	1.74	3.03	none	earthen				inside	ditch	manure	manure	NA	45	splash plate	hand move	ditch	contractor		municipal		65	
6	220	300	197	2.22	0.62	none	conc/cov				inside	manure	manure	surface	NA	?	splash plate	tractor/elec	ditches	contractor		municipal		65	
7	52	32	21	1.01	1.66	none	conc/unc				inside	manure	manure	none	35	17	splash plate	elec pump	ditch	contractor		municipal		65	
8	220	300	197	2.22	3.07	conc/unc	conc/unc	conc/unc			inside	manure	none	surface	NA	?	spish/mech	none		contractor	contractor	municipal		74	
9	160	300	197	3.05	3.09	conc/unc	conc/unc	conc/unc			inside	manure	none	surface	NA	?	spish/mech	elec pump	Arnold Slgh.	contractor	contractor	municipal		66	
10	28	45	30	2.66	2.83	field/unc	conc/unc				inside	manure	surface	manure	50	16	spish/mech	none	Saar Crk.	contractor	contractor	well	26.2	52	
11	351	700	461	3.24	1.87	conc/unc	conc/cov				inside	manure	manure	ditch	NA	5	spish/mech	wheel move	ditch	contractor		mountain		54	
12	100	150	99	2.44	2.05	none	conc/unc				inside	manure	manure	none	NA	14	splash/plate	yes	hand move	Saar Crk.	contractor		municipal		72
13	171	100	66	0.95	1.58	conc/unc	conc/unc				inside	manure	manure	manure	NA	76	splash plate	none		contractor		municipal		63	
14	20	35	23	2.84	3.66	none	conc/unc				uncovered	manure	tile	manure	NA	14	splash plate	none		contractor		municipal		65	
15	80	80	53	1.63	3.33	none	conc/unc				inside	manure	surface	surface	NA	?	splash plate	none		contractor		municipal		73	
16	100	180	118	2.93	no data	none	conc/cov				covered	manure	manure	surface	NA	?	splash plate	yes	none	contractor		municipal		68	
17	108	115	76	1.73	2.15	none	conc/unc				inside	surface	ditch	manure	NA	38	splash plate	40	none	contractor	contractor	municipal		61	
18	170	350	230	3.35	0.77	conc/unc	conc/cov	conc/cov			inside	manure	tile	surface	30	15	spish/mech	yes	wheel move	Sumas R.	contractor		municipal		44
19	55	110	72	3.25	3.22	conc/unc	conc/unc				inside	ditch	ditch	manure	NA	50	splash plate	none		contractor	contractor	municipal		55	
20	275	130	86	0.77	no data	none	conc/cov				inside	manure	ditch	none	NA	15	splash plate	yes	hand sprinkl	ditch	contractor	contractor	municipal		75
21	90	129	85	2.33	3.81	none	conc/cov	conc/cov			inside	manure	none	manure	NA	24	splash plate	12	none		contractor		municipal		81
22	22	35	23	2.59	5.09	conc/unc	conc/unc				none	manure	manure	manure	NA	?	spish/mech	2	elec pump	ditch	contractor		municipal		81
23	67	120	79	2.91	2.50	conc/unc	conc/unc	conc/unc			inside	manure	none	surface	NA	5	splash plate	yes	subirrigatn	ditch	contractor	contractor	municipal		59
24	41	60	39	2.41	4.32	none	earthen				inside	tile	ditch	surface	60	?	splash plate		shraiver	ditch	contractor		municipal		68
25	102	220	145	3.50	2.18	none	conc/unc				inside	manure	none	manure	NA	?	splash plate	5	none		contractor	contractor	municipal		56
26	44	78	51	2.88	1.46	conc/cov	conc/cov				inside	tile	ditch	surface	3	14	mechanical	30	elec pump	ditch	contractor	contractor	municipal		46
27	41	65	43	2.58	1.47	none	conc/cov	conc/cov			inside	manure	none	none	NA	44	splash plate		none		contractor		municipal		60
28	58	40	26	1.12	2.03	conc/cov	conc/cov				inside	tile	tile	none	15	8	mechanical		none		contractor		municipal		67
29	130	130	86	1.63	8.56	none	conc/cov	earth/unc	conc/cov		inside	manure	none	manure	10	?	splash plate	wheel move	Lonzo Crk.	contractor	contractor	municipal		97	
30	60	110	72	2.98	3.59	none	conc/unc				inside	ditch	manure	surface	NA	4	splash plate	hand move	ditch	contractor	contractor	municipal		58	
31	80	160	105	3.25	5.27	none	earthen	conc/unc	conc/cov		inside	manure	ditch	manure	10	?	splash plate	yes	reel	Sumas R.	contractor		municipal		71
32	58	130	86	3.64	4.21	conc/unc	steel/unc	conc/unc	conc/cov		inside	manure	none	none	NA	14	spish/mech	Arrow Franc	ditch	contractor	contractor	municipal		67	
34	75	120	79	2.60	2.46	none	conc/unc				inside	manure	ditch	manure	NA	34	splash plate	yes	none		contractor	contractor	mncpl/well	6.10	59
35	73	107	70	2.39	4.82	none	earthen	conc/unc	conc/unc		inside	manure	manure	none	NA	10	splash plate	50	none		contractor		municipal		81
36	200	500	329	4.06	7.29	conc/cov	earthen	conc/unc			inside	manure	none	none	NA	20	irrig/mech	yes	wheel move	lagoon	contractor		mncpl/well	9.14	70
37	105	200	132	3.10	7.31	none	conc/cov				inside	manure	none	none	NA	22	splash plate		none		contrator	contractor	municipal		92
38	200	400	263	3.25	2.31	none	conc/unc	conc/unc			inside	tile	none	none	NA	25	splash plate		none		contractor	contractor	municipal		61
39	36	40	26	1.81	1.78	none	conc/unc				inside	manure	none	none	NA	5	splash plate		hand move	ditch	contractor		municipal		65
40	90	150	99	2.71	1.32	none	conc/unc				inside	manure	manure	none	10	1	splash plate	wheel move	Saar Crk.	contractor	contractor	municipal		55	
41	60	100	66	2.71	5.73	none	conc/unc	conc/cov			inside	manure	ditch	none	28	?	splash plate		none		contractor	contractor	municipal		77
42	170	240	158	2.29	3.10	conc/cov	steel/unc				uncovered	manure	manure	surface	NA	19	spish/mech		reel	Lonzo Crk.	contractor	contractor	municipal		71
43	285	300	197	1.71	1.38	none	conc/unc				inside	manure	manure	none	NA	25	splash plate	wheel move	well		contractor	contractor	municipal		65
44	120	235	155	3.18	0.58	none	earthen				inside	manure	none	surface	NA	50	splash plate	yes	none		contractor	contractor	municipal		51
45	300	600	395	3.25	4.20	conc/cov	earthen	earthen	earthen	earthen	inside	manure	none	surface	NA	20	splash plate	yes	none		contractor	contractor	municipal		62
46	125	85	56	1.11	no data	none	earthen				inside	manure	none	none	NA	?	splash plate	yes	yes	?	contractor		municipal		74
48	21	60	39	4.64	no data	conc/unc	conc/unc				uncovered	manure	manure	manure	NA	?	spish/mech		none		contractor		municipal		48
49	78	285	188	5.92	0.96	conc/unc	conc/unc				inside	manure	none	none	60	10	spish/mech		none		contractor	contractor	municipal		39
50	140	230	151	2.67	3.98	none	conc/unc	conc/cov	conc/unc	conc/cov	inside	manure	manure	manure	60	12	splash plate	wheel move	ditch	contractor	contractor	municipal		70	

Notations Used: conc = concrete, cov = covered, mncpl = municipal, NA = Not Applicable, spish/mech = splash plate and mechanical spreaders, unc = uncovered

* See Tables 3 and 14. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 5 - continued
Summary of Dairy Operations in the Sumas River Watershed

Farm ID	Acres ** (owned and rented)	Animals	Milking Cow Equivs.	Spreading Rate MCE per Hectare	Manure Pit Storage Time (months)	Dry Manure Storage	Main Manure Pit Facility Type	Second Manure Pit Facility Type	Third Manure Pit Facility Type	Fourth Manure Pit Facility Type	Tile				Proximity of Watercourse to Storage Facility (meter)	Field Age Household Domestic Sewage (years)	Spreading on				Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP * Percentage Ranking	
											Woodwaste Storage	Parlour Discharge	Yard Drainage	Silage Runoff			Adjacent Farms (acres)	Type of Irrigation	Irrigation Source	Handling of Mortalities					
51	343	220	145	1.04	0.62	none	conc/unc				inside	manure	manure	none	45	5	splash plate	yes	overhead	ditch	contractor	contractor	mountain		65
52	90	175	115	3.16	5.04	none	steel/unc	conc/unc			inside	manure	none	none	NA	14	boom spread	40	wheel move	ditch	contractor	contractor	municipal		84
53	62	105	69	2.75	0.96	conc/unc	conc/cov				uncovered	ditch	surface	tile	NA	31	spish/mech		overhead	Saar Crk.	contractor	contractor	mncpl/well	14.50	41
54	74	105	69	2.31	3.38	conc/unc	conc/unc	conc/cov			covered	manure	ditch	surface	10	17	spish/mech		none		contractor		municipal		64
55	60	70	46	1.90	2.98	conc/unc	conc/unc				covered	manure	surface	none	NA	?	spish/mech	20	none		contractor		well	21 & 53	65
56	250	320	211	2.08	4.13	conc/unc	earthen	earthen	earthen	earthen	inside	surface	manure	none	NA	?	spish/mech		none		contractor		mncpl/well	5.18	73
58	100	76	50	1.24	2.80	field/unc	conc/unc				inside	manure	ditch	none	NA	40	spish/mech		none		contractor		municipal		58
59	29	36	24	2.02	0.25	none	none				none	manure	surface	none	NA	15	mechanical	1	overhead	Arnold Slgh.	contractor	landfill	municipal		65
60	240	260	171	1.76	3.58	conc/unc	earthen	conc/unc			inside	ditch	manure	manure	NA	?	splash plate		none		contractor		municipal		63
61	125	190	125	2.47	2.14	none	conc/unc				inside	manure	manure	surface	NA	?	splash plate		none		contractor	contractor	municipal		69
62	47	56	37	1.94	5.76	none	conc/unc				uncovered	tile	surface	surface	10	15	splash plate		none		contractor	contractor	municipal		76
63	35	50	33	2.32	4.20	none	conc/unc				none	manure	manure	surface	NA	?	splash plate		none		contractor	contractor	mncpl/well	?	82
64	70	124	82	2.88	3.26	none	conc/unc				inside	manure	none	manure	NA	12	splash plate		reel	Sumas R.	contractor	contractor	municipal		71
65	202	200	132	1.61	2.20	none	steel/unc				inside	manure	manure	manure	10	2	splash plate		none		contractor	contractor	municipal		69
66	26	130	86	8.13	1.50	conc/cov	conc/cov				inside	tile	none	none	20	10	mechanical		yes	ditch	contractor		municipal		39
67	30	50	33	2.71	4.77	none	conc/unc	conc/cov			inside	manure	surface	surface	NA	20	splash plate		tractor drive	ditch	contractor	contractor	municipal		72
68	55	90	59	2.66	3.26	conc/unc	conc/cov				none	manure	manure	surface	NA	14	spish/mech		none		contractor	contractor	municipal		68
69	52	80	53	2.50	4.42	none	conc/cov				none	tile	manure	surface	55	29	splash plate		none		contractor	contractor	municipal		80
70	255	140	92	0.89	8.95	none	steel/unc	conc/unc			inside	ditch	manure	surface	NA	14	splash plate	yes	none		contractor	contractor	mncpl/well	24.4	87
71	75	64	42	1.39	2.43	none	conc/unc				uncovered	manure	ditch	surface	NA	10	splash plate		hand move	ditch	contractor	contractor	municipal		60
72	93	150	99	2.62	1.16	none	earthen				inside	manure	none	manure	30	12	splash plate		overhead	Sumas R.	contractor		municipal		52
73	110	240	158	3.55	5.72	none	conc/cov				uncovered	manure	surface	manure	NA	13	splash plate		hand move	Saar Crk.	contractor	contractor	municipal		71
74	32	70	46	3.55	0.26	conc/unc	conc/unc				inside	ditch	ditch	none	40	?	mechanical	10	overhead	ditch	contractor		municipal		33
75	80	230	151	4.67	1.67	conc/unc	conc/unc				inside	manure	manure	manure	NA	15	splash plate	yes	hand move	Saar Crk.	contractor		municipal		40
76	100	165	109	2.68	2.23	conc/unc	conc/unc				inside	tile	manure	manure	NA	10	splash plate	yes	elec pump	ditch	contractor	contractor	municipal		58
77	76	125	82	2.67	2.23	none	steel/unc	conc/cov			inside	manure	ditch	surface	14	10	splash plate		none		contractor	contractor	municipal		54
78	381	290	191	1.24	2.84	none	conc/unc	conc/cov			inside	manure	manure	none	NA	14	splash plate	yes	hand move	Lonzo Crk.	contractor	contractor	municipal		72
79	75	95	63	2.06	0.78	none	conc/cov				inside	manure	surface	surface	NA	30	splash plate		reel	Sumas R.	contractor		municipal		62
80	105	132	87	2.04	2.80	none	conc/unc	conc/cov	conc/cov	conc/cov	inside	manure	manure	none	NA	?	splash plate		none		contractor		municipal		72
81	150	183	120	1.98	0.77	conc/unc	conc/unc				inside	tile	none	none	14	22	splash plate		none		contractor	contractor	mncpl/well	?	57
82	340	460	303	2.20	3.62	conc/unc	earthen	conc/unc	conc/cov	conc/unc	inside	manure	manure	ditch	NA	8	spish/mech		none		contractor	contractor	municipal		68
83	41	80	53	3.17	1.94	none	conc/unc				inside	manure	manure	manure	NA	10	splash plate		none		contractor	contractor	municipal		58
84	25	33	22	2.15	3.07	conc/unc	earthen				inside	ditch	manure	one	NA	?	spish/mech	yes	none		contractor	contractor	municipal		63
85	118	125	82	1.72	2.50	conc/cov	conc/unc	conc/cov			inside	manure	surface	none	NA	17	spish/mech	yes	overhead	ditch	contractor		municipal		69
86	165	320	211	3.15	5.24	none	earthen				inside	manure	manure	surface	5	10	splash plate		subirrigatn	Arnold Slgh.	contractor	landfill	municipal		74
87	125	190	125	2.47	3.30	conc/unc	conc/unc	conc/unc			uncovered	tile	none	surface	NA	40	spish/mech	yes	none		contractor	contractor	municipal		66
88	100	161	106	2.62	2.51	none	conc/cov	conc/cov	conc/cov	conc/cov	uncovered	manure	none	surface	NA	30	splash plate		none		contractor	contractor	municipal		59
89	40	33	22	1.34	3.73	conc/unc	earthen				inside	manure	surface	manure	30	48	spish/mech	yes	none		contractor		municipal		68
90	242	250	164	1.68	8.51	conc/unc	earthen	conc/cov	conc/unc		inside	tile	none	manure	NA	30	irrig/mech	yes	reel	lagoon	contractor	contractor	municipal		88
91	260	300	197	1.88	0.85	none	conc/unc	conc/unc			inside	tile	none	none	NA	60	splash plate	80	elec pump	ditch	contractor	returns	municipal		62
92	140	217	143	2.52	2.61	field/unc	earthen				inside	manure	surface	surface	NA	?	spish/mech		none		contractor	contractor	municipal		46
93	40	30	20	1.22	0.21	conc/unc	conc/unc				uncovered	tile	none	ditch	NA	18	mechanical	yes	none		contractor		mountain		52
94	21	29	19	2.24	3.42	conc/unc	conc/unc				inside	manure	tile	none	20	?	spish/mech	yes	none		contractor		municipal		73
95	70	80	108	3.81	1.69	none	conc/unc				inside	manure	none	surface	15	20	splash plate		elec pump	Stewart Crk.	contractor	contractor	municipal		45
96	190	350	230	2.99	4.26	none	steel/unc	conc/cov			inside	tile	ditch	tile	NA	18	splash plate		none		contractor	contractor	municipal		67
97	160	160	105	1.63	2.95	none	conc/unc				inside	manure	surface	surface	NA	?	splash plate	80	reel	well	contractor	contractor	municipal		67

Notations Used: conc = concrete, cov = covered, mncpl = municipal, NA = Not Applicable, splash/mech = splash plate and mechanical spreaders, unc = uncovered

* See Tables 6 and 14. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 6
Summary of Hog Operations in the Sumas River Watershed

Farm ID.	Acres ** (owned and rented)	Animals	Sow Equivs. (SE)	Spreading Rate SE/Hectare	Manure		Manure Disposal	Woodwaste Storage	Proximity of Field Age		Type of Irrigation	Irrigation Source	Handling Mortalities	Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP *
					Pit Storage Time (months)	Facility Type			Watercourse to Storage (meter)	Household Domestic Sewage (years)							Percentage Ranking
44	120	55	55	1.13	2.12	conc/unc	on farm	inside	NA	50	none		contractor	contractor	municipal		62
90	242	1200	144	1.47	2.88	conc/cov	two on farm	inside	NA	30	reel	Sumas R.	contractor	contractor	municipal		65
200	35	150	150	2.65	16.96	conc/cov	cont/on farm	inside	NA	1	gun	ditch	contractor	contractor	municipal		89
201	77	2000	300	4.81	10.94	conc/cov	on farm/ngbr	none	NA	?	none		contractor		municipal		68
202	77	2700	324	5.20	12.06	conc/cov	on farm/ngbr	none	NA	25	none		contractor	unknown	municipal		68
203	42	140	140	8.23	3.46	conc/unc	on farm	none	300	1	none		contractor	unknown	municipal		39
204	10	2000	240	59.28	7.44	conc/cov	neighbour	none	32	?	none		contractor		municipal		99
205	31.5	5000	600	23.53	19.48	conc/cov	four on farm/ngbr	none	32	?	none		contractor		municipal		67
206	75	296	270	8.89	1.06	conc/cov	neighbour	inside	32	?	none		burial		municipal		99
207	210	2800	2800	16.47	14.98	conc/cov	seven on farm/ngbr	none	NA	?	none		contractor		municipal		68
208	44	2000	240	13.47	1.28	conc/cov	on farm	inside	NA	?	gun	ditch	contractor		municipal		24
209	10	700	84	10.38	3.60	conc/unc	on farm/ngbr	inside	NA	?	none		contractor		municipal		39

Notation Used: conc = concrete, cov = covered, NA = Not Applicable, ngbr = neighbour, unc = uncovered

* See Table 9. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 7
Summary of Poultry Operations in the Sumas River Watershed

Farm ID.	Acres ** (owned and rented)	Animals	Broiler Equivs. (BE)	Spreading Rate BE/Hectare	Manure Disposal	Dry Manure Storage	Woodwaste Storage	Proximity of Watercourse to Storage Facility (meter)	Tile Field Age Household Domestic Sewage (years)	Type of Irrigation	Irrigation Source	Handling of Mortalities	Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP * Percentage Ranking
35	72.9	7300	11315	383	contractor	conc/cov	uncovered	NA	3	none		incineration		municipal		91
94	21	25000	38750	4558	contractor	conc/cov	inside	20	?	none		contractor		municipal		97
203	42	10000	15500	912	on farm	conc/unc	none	306	1	none		contractor		municipal		79
400	19	50000	50000	6500	neighbour	conc/cov	inside	NA	?	unknown		composting		municipal		100
401	36	6800	10540	723	on farm	conc/unc	inside	NA	?	none		incineration		municipal		79
402	20	40000	40000	4940	on farm	conc/unc	inside	NA	?	big gun	Stewart Crk					31
403	35	20000	31000	2188	on farm	conc/cov	inside	NA	?	sprinklers	ditch	composting	unknown	municipal		52
404	36	16000	24800	1702	on farm	conc/cov	inside	30	?	none		composting		well	18.3	60
405	8.5	10000	15500	4504	on farm	conc/cov	inside	31	?	unknown		composting		municipal		38
406	20	40000	40000	4940	neighbour	conc/cov	uncovered	NA	NA	unknown		incineration		municipal		91
407	25	26000	28750	2841	on farm	conc/cov	inside	NA	5	none		composting		municipal		40
408	22	76000	76000	8533	on farm	conc/cov	inside	4	?	overhead	ditch	incineration		municipal		34
409	10.7	32000	49600	11450	neighbour	field/cov	inside	NA	?	none		incineration		municipal		83
410	33	18000	24240	1814	on farm	conc/cov	inside	NA	24	above grnd	ditch	incineration		municipal		64
412	19	16000	16000	2080	on farm	conc/cov	inside	NA	?	none		composting	contractor	municipal		52
413	24.5	53000	53000	5343	on farm	conc/cov	inside	NA	?	none		composting		municipal		40

Notation Used: conc = concrete, cov = covered, grnd = ground, NA = Not Applicable, unc = uncovered

* See Table 10. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 8
Environmental Sustainability Factors and Factor Ranges for
Dairy Operations in the Sumas River Watershed

Factor	Range	Rank	Weighting	Weighted Ranks	Relative % or Priority ²
Manure Pit Storage Time ¹	> 6 months 5 - 6 months 4 - 5 months 3 - 4 months 2 - 3 months < 2 months	0 1 2 3 4 5	15	0 15 30 45 60 75	32.5%
Milking Cow Equivalents ³ (MCE) Per Hectare	≤ 2.5 2.5 to 3.25 3.25 to 4 > 4	0 1 2 3	18	0 18 36 54	23.4%
Dry Manure Storage	none concrete/covered concrete/uncovered field/covered field/uncovered	0 0 1 2 4	5	0 0 5 10 20	10.8%
Manure Pit Facility Type	concrete/covered concrete/uncovered steel/uncovered earthen earthen/seepage	0 1 1 3 5	5	0 5 5 15 25	8.7%
Woodwaste Storage	none inside covered outside uncovered	0 0 1 2	5	0 0 5 10	8.7%
Milk Parlour Discharge	none manure pit tile field field surface ditch	0 0 2 3 5	4	0 0 8 12 20	5.2%
Yard Drainage	none manure pit tile field field surface ditch	0 0 1 2 4	3	0 0 3 6 12	4.3%
Silage Runoff	none manure pit tile field field surface ditch	0 0 1 2 3	3	0 0 3 6 9	3.9%
Proximity of Watercourse to Storage Facility	> 60 m 30 to 60 m 15 to 30 m < 15 m	0 1 2 3	2	0 2 4 6	2.6%
Total				231	100%

1. Manure Pit Storage Times were calculated allowing a one foot freeboard and using factors of 77 L/d/MCE for animal wastes, 27.3 L/d/MCE for milk parlour discharges to the manure pit and 1091 mm/6 months for rainfall for uncovered facilities
2. Calculated from Factor Maximum Priority/Overall Total Priority
3. Milking Cow Equivalents = Total number of dairy animals/1.52

Table 9
Environmental Sustainability Factors and Factor Ranges for
Hog Operations in the Sumas River Watershed

Factor	Range	Rank	Weighting	Weighted Ranks	Relative % or Priority ²
Manure Pit Storage Time ¹	contract or neighbour > 6 months 5-6 months 4-5 months 3-4 months 2-3 months < 2 months	0 0 1 2 3 4 5	15	0 0 15 30 45 60 75	44.1%
Sow Equivalents (SE) ³ Per Hectare	contract or neighbour <2.1 2.1 to 2.7 2.7 to 3.3 > 3.3	0 0 1 2 3	18	0 0 18 36 54	31.8%
Manure Pit Facility Type	concrete/covered concrete/uncovered steel/uncovered earthen earthen/seepage	0 1 1 3 5	5	0 5 5 15 25	14.7%
Woodwaste Storage	none inside covered outside uncovered	0 0 1 2	5	0 0 5 10	5.9%
Proximity of Watercourse to storage facility	> 60 m 30 to 60 m 15 to 30 m < 15 m	0 1 2 3	2	0 2 4 6	3.5%
Total				170	100%

1. Manure Pit Storage Times were calculated allowing a one foot freeboard and using factors of 72 L/d/SE for animal wastes and 1091 mm/6 months for rainfall for uncovered facilities.
2. Calculated from Factor Maximum Priority/Overall Total Priority
3. Finisher = 0.12 Sow Equivalents

Table 10
Environmental Sustainability Factors and Factor Ranges for
Poultry Operations in the Sumas River Watershed

Factor	Range	Rank	Weighting	Weighted Ranks	Relative % or Priority ²
Broiler Equivalents (BE) Per Hectare ¹	contract haulier/neighbour	0	14	0	48.3%
	≤ 1130	0		0	
	1131 to 1514	1		14	
	1515 to 1899	2		28	
	1900 to 2279	3		42	
	> 2280	4		56	
Manure Disposal	contract haulier	0	14	0	12.1%
	neighbouring farms	0		0	
	on farm ³	1		14	
Dry Manure Storage	none	0	10	0	25.9%
	concrete/covered	0		0	
	concrete/uncovered	1		10	
	field/covered	2		20	
	field/uncovered	3		30	
Woodwaste Storage	none	0	5	0	8.6%
	inside	0		0	
	covered outside	1		5	
	uncovered	2		10	
Proximity of Watercourse to Storage Facility	> 60 m	0	2	0	5.1%
	30 to 60 m	1		2	
	15 to 30 m	2		4	
	< 15 m	3		6	
Total				116	100%

1. Broiler Equivalents; layers x 1.55, pullets x 0.94, and turkeys x 2.26
2. Calculated from Factor Maximum Priority/Overall Total Priority
3. Manure storage in longer for on farm disposal with potential for contamination

Table 11
Environmental Sustainability Parameter Factors and Rankings
for Dairy Operations in the Sumas River Watershed

Farm ID.	Manure Pit Storage Time Rank	MCE per Hectare Rank	Dry Manure Storage Rank	Manure Pit Facility Type Rank	Woodwaste Storage Rank	Milk Parlour Discharge Rank	Yard Drainage Rank	Silage Runoff Rank	Proximity of Watercourse to Storage Facility Rank	Ranking Out of 231	ESP * Percentage Ranking
1	45	0	0	15	0	0	0	6	0	66	71
2	45	0	0	5	5	0	0	0	0	55	76
3	60	0	0	5	5	8	6	0	0	84	64
4	30	36	5	5	0	0	0	0	0	76	67
5	45	0	0	15	0	20	0	0	0	80	65
6	75	0	0	0	0	0	0	6	0	81	65
7	75	0	0	5	0	0	0	0	2	82	65
8	45	0	5	5	0	0	0	6	0	61	74
9	45	18	5	5	0	0	0	6	0	79	66
10	60	18	20	5	0	0	6	0	2	111	52
11	75	18	5	0	0	0	0	9	0	107	54
12	60	0	0	5	0	0	0	0	0	65	72
13	75	0	5	5	0	0	0	0	0	85	63
14	45	18	0	5	10	0	3	0	0	81	65
15	45	0	0	5	0	0	6	6	0	62	73
16	45	18	0	0	5	0	0	6	0	74	68
17	60	0	0	5	0	12	12	0	0	89	61
18	75	36	5	0	0	0	3	6	4	129	44
19	45	18	5	5	0	20	12	0	0	105	55
20	45	0	0	0	0	0	12	0	0	57	75
21	45	0	0	0	0	0	0	0	0	45	81
22	15	18	5	5	0	0	0	0	0	43	81
23	60	18	5	5	0	0	0	6	0	94	59
24	30	0	0	15	0	8	12	6	2	73	68
25	60	36	0	5	0	0	0	0	0	101	56
26	75	18	0	0	0	8	12	6	6	125	46
27	75	18	0	0	0	0	0	0	0	93	60
28	60	0	0	0	0	8	3	0	6	77	67
29	0	0	0	0	0	0	0	0	6	6	97
30	45	18	0	5	0	20	0	6	0	94	59
31	15	18	0	15	0	0	12	0	6	66	71
32	30	36	5	5	0	0	0	0	0	76	67
34	60	18	0	5	0	0	12	0	0	95	59
35	30	0	0	15	0	0	0	0	0	45	81
36	0	54	0	15	0	0	0	0	0	69	70
37	0	18	0	0	0	0	0	0	0	18	92
38	60	18	0	5	0	8	0	0	0	91	61
39	75	0	0	5	0	0	0	0	0	80	65
40	75	18	0	5	0	0	0	0	6	104	55
41	15	18	0	5	0	0	12	0	4	54	77
42	45	0	0	5	10	0	0	6	0	66	71
43	75	0	0	5	0	0	0	0	0	80	65
44	75	18	0	15	0	0	0	6	0	114	51
45	30	36	0	15	0	0	0	6	0	87	62
46	45	0	0	15	0	0	0	0	0	60	74
48	45	54	5	5	10	0	0	0	0	119	48
49	75	54	5	5	0	0	0	0	2	141	39
50	45	18	0	5	0	0	0	0	2	70	70

* The ESP was developed by IRC.

Table 11 - continued
Environmental Sustainability Parameter Factors and Rankings
for Dairy Operations in the Sumas River Watershed

Farm ID.	Manure Pit Storage Time Rank	MCE per Hectare Rank	Dry Manure Storage Rank	Manure Pit Facility Type Rank	Woodwaste Storage Rank	Milk Parlour Discharge Rank	Yard Drainage Rank	Silage Runoff Rank	Proximity of Watercourse to Storage Facility Rank	Ranking Out of 231	ESP * Percentage Ranking
51	75	0	0	5	0	0	0	0	2	82	65
52	15	18	0	5	0	0	0	0	0	38	84
53	75	18	5	0	10	20	6	3	0	137	41
54	45	0	5	5	5	0	12	6	6	84	64
55	60	0	5	5	5	0	6	0	0	81	65
56	30	0	5	15	0	12	0	0	0	62	73
58	60	0	20	5	0	0	12	0	0	97	58
59	75	0	0	0	0	0	6	0	0	81	65
60	45	0	5	15	0	20	0	0	0	85	63
61	60	0	0	5	0	0	0	6	0	71	69
62	15	0	0	5	10	8	6	6	6	56	76
63	30	0	0	5	0	0	0	6	0	41	82
64	45	18	0	5	0	0	0	0	0	68	71
65	60	0	0	5	0	0	0	0	6	71	69
66	75	54	0	0	0	8	0	0	4	141	39
67	30	18	0	5	0	0	6	6	0	65	72
68	45	18	5	0	0	0	0	6	0	74	68
69	30	0	0	0	0	8	0	6	2	46	80
70	0	0	0	5	0	20	0	6	0	31	87
71	60	0	0	5	10	0	12	6	0	93	60
72	75	18	0	15	0	0	0	0	4	112	52
73	15	36	0	0	10	0	6	0	0	67	71
74	75	36	5	5	0	20	12	0	2	155	33
75	75	54	5	5	0	0	0	0	0	139	40
76	60	18	5	5	0	8	0	0	0	96	58
77	60	18	0	5	0	0	12	6	6	107	54
78	60	0	0	5	0	0	0	0	0	65	72
79	75	0	0	0	0	0	6	6	0	87	62
80	60	0	0	5	0	0	0	0	0	65	72
81	75	0	5	5	0	8	0	0	6	99	57
82	45	0	5	15	0	0	0	9	0	74	68
83	75	18	0	5	0	0	0	0	0	98	58
84	45	0	5	15	0	20	0	0	0	85	63
85	60	0	0	5	0	0	6	0	0	71	69
86	15	18	0	15	0	0	0	6	6	60	74
87	45	0	5	5	10	8	0	6	0	79	66
88	60	18	0	0	10	0	0	6	0	94	59
89	45	0	5	15	0	0	6	0	4	75	68
90	0	0	5	15	0	8	0	0	0	28	88
91	75	0	0	5	0	8	0	0	0	88	62
92	60	18	20	15	0	0	6	6	0	125	46
93	75	0	5	5	10	8	0	9	0	112	52
94	45	0	5	5	0	0	3	0	4	62	73
95	75	36	0	5	0	0	0	6	6	128	45
96	30	18	0	5	0	8	12	3	0	76	67
97	60	0	0	5	0	0	6	6	0	77	67

* The ESP was developed by IRC.

Table 12
Environmental Sustainability Parameter Factors and Rankings for
Hog Operations in the Sumas River Watershed

Farm ID.	Manure Pit Storage		Manure Pit Facility		Proximity of Watercourse to Storage		ESP *	
	Time	SE/Hectare	Type	Woodwaste Storage	Facility	Ranking	Percentage	
	Rank	Rank	Rank	Rank	Rank	(out of 170)	Ranking	
44	60	0	5	0	0	65	62	
90	60	0	0	0	0	60	65	
200	0	18	0	0	0	18	89	
201	0	54	0	0	0	54	68	
202	0	54	0	0	0	54	68	
203	45	54	5	0	0	104	39	
204	0	0	0	0	2	2	99	
205	0	54	0	0	2	56	67	
206	0	0	0	0	2	2	99	
207	0	54	0	0	0	54	68	
208	75	54	0	0	0	129	24	
209	45	54	5	0	0	104	39	

* The ESP was developed by IRC.

Table 13

**Environmental Sustainability Parameter Factors and Rankings for
Poultry Operations in the Sumas River Watershed**

Farm ID.	BE per Hectare Rank	Manure Disposal Rank	Dry Manure Storage Rank	Woodwaste Storage Rank	Proximity of Watercourse to Storage Facility Rank	Ranking (out of 116)	ESP *
							Percentage Ranking
35	0	0	0	10	0	10	91
94	0	0	0	0	4	4	97
203	0	14	10	0	0	24	79
400	0	0	0	0	0	0	100
401	0	14	10	0	0	24	79
402	56	14	10	0	0	80	31
403	42	14	0	0	0	56	52
404	28	14	0	0	4	46	60
405	56	14	0	0	2	72	38
406	0	0	0	10	0	10	91
407	56	14	0	0	0	70	40
408	56	14	0	0	6	76	34
409	0	0	20	0	0	20	83
410	28	14	0	0	0	42	64
412	42	14	0	0	0	56	52
413	56	14	0	0	0	70	40

* The ESP was developed by IRC.

Table 14
Comparison of Ministry of Agriculture, Fisheries and Foods and ESP
Priority Ratings of Environmental Concerns on Dairy Farm Operations

Ministry of Agriculture, Fisheries and Food ¹			Integrated Resource Consultants		
Factor	Priority ²	Relative % of Priority	Factor	Maximum Priority ²	Relative % or Priority ³
Winter Spreading (Lack of Enough Manure Storage)	10	23.8%	Manure Pit Storage Time (5 x 15)*	75	32.5%
Over Application on Manure	8	19.0%	Milking Cow Equivalents (MCE/hectare) (3 x 18)*	54	23.4%
Yard Runoff that Pollutes	7	16.7%	Manure Pit Facility Type (5 x 5)*	25	10.8%
Milkhouse Effluent to Ditches	6	14.3%	Dry Manure Storage (4 x 5)*	20	8.7%
Silage Effluent to Ditches	5	11.9%	Milk Parlour Discharge (5 x 4)*	20	8.7%
Fall Spreading of Manure on Bare Soils	4	9.5%	Yard Drainage (4 x 3)*	12	5.2%
Milkhouse Effluent to Tile Field Without a Permit	2	4.8%	Woodwaste Storage (2 x 5)*	10	4.3%
			Silage Runoff (3 x 3)*	9	3.9%
			Proximity of Watercourse to Storage Facility (3 x 2)*	6	2.5%
			Overall Total	231	100%

1. Van Kleeck, 1994, 26th Annual Dairy Producers' Short Course Presentation
 2. A high priority number has the largest negative impact, a low priority number has the smallest negative impact
 3. Calculated from Factor Maximum Priority/Overall Total Priority
- * Values from Table 8

Table 15

Statistical Summary of Farm Types and Operating Conditions for the Sumas River Watershed

	COMMODITY GROUP			
	DAIRY	HOG	POULTRY	PRODUCE/ NURSERIES
Number of Survey Participants	94	12	16	14
Total hectares	4503	247	163	948
Average hectares	48	33	11	68
Range	8.1 to 154.3	4.0 to 98	2.9 to 7.7	4 to 275
Total Animals	15725	19041	446100	
Average Animals	167	1586	27881	
Range	29 to 700	55 to 5000	6800 to 76000	
Average Animal Equivalents*	111 MCE	446 SE	32812 BE	
Average Animal Equivalents/Hectare	2.51 MCE/Hectare	13 SE/Hectare	3963 BE/Hectare	
Average liquid manure storage capacity (months)	3.05	8.0	(1)	
Range	0.21 to 8.95	1 to 19.5		
Main Storage Facility Type	51% conc/unc 19% conc/cov 19% earth/unc 9.6% steel/unc 1.1% none	75% conc/cov 25% conc/unc	73% conc/cov 13% conc/unc 6.7% field/cov 6.7% field/unc	
Farms that have more than one storage facility	32%	25%		
Farms that have a storage facility within 30m of a natural watercourse	287%	25%	27%	
Spreading Practice	90% splash plate 32% mechanical 2.1% irrigation 38% on farm/neighbour	42% on farm/neighbour 33% on farm 17% neighbour 8.3% contractor/on farm	40% on farm/neighbour 20% neighbour 13% on farm 13% on farm/contractor 13% contractor	
Percent of farms using irrigation	49%	25%	27%	92%
Irrigation source	52% Irrigation ditch 15% Saar Creek 11% Sumas River 7% Arnold Slough 7% Lonzo Creek 4% Well water 4% Manure Lagoon 2% Stewart Creek	67% ditch 33% Sumas River	75% ditch 25% Stewart Creek	55% ditch 18% Sumas River 9.1% Canal 9.1% pond 9.1% Stewart Creek
Percent of farms using pesticides	58%	42%	6.7%	83%
Disposal of containers	94% contractor 4% landfill or transfer station 2% return to supplier	60% contractor 40% unknown	100% contractor	60% landfill or transfer station 30% contractor 10% incinerate
Percent of farms using chemical fertilizers	84%	21.4%	20%	100%
Total hectares	2874	10	11	562
Domestic Sewage	100% tile fields	100% tile fields	93% tile fields 6.7% municipal	

Notation Used: conc = concrete, cov = covered, earth = earthen, unc = uncovered

* See Table 8 for MCE, Table 9 for SE and Table 10 for BE.

(1) Poultry operations do produce liquid manure, they just produce dry manure

Table 16

Sumas River Watershed Surface Water Quality Data - Fall Sampling 1993

Site 7: Sumas River @ Vye Rd.					Site 7B: Sumas River @ U.S.A. Border			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.3	9.7	91	0.085				
Oct 12	11.7	10.1	93	0.056				
Oct 18	12.0	9.9	92	0.043				
Oct 25	8.7	10.1	87	0.093	8.4	9.8	84	0.007
Nov 1	7.8	10.2	86	0.055				
Nov 8	4.5	10.8	83	0.059				
Nov 15	5.6	10.0	80	0.056				
Nov 24	-0.8	12.2	82	0.167				
Dec 15	7.2	9.0	75	0.110				
Average	7.7	10.2	85	0.080	8.4	9.8	84	0.007
Std Dev.	4.2	0.9	6	0.039				
Minimum	-0.8	9.0	75	0.043	8.4	9.8	84	0.007
Maximum	12.3	12.2	93	0.167	8.4	9.8	84	0.007

Site 8: Saar Creek @ Vye Rd.					Site 8B: Saar Creek @ U.S.A. Border			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.1	3.3	31	0.611				
Oct 12	11.8	1.1	10	0.962				
Oct 18	11.8	0.8	7	1.300				
Oct 25	8.1	6.8	58	0.179	8.0	7.6	64	0.117
Nov 1	6.8	2.6	21	2.460				
Nov 8	2.7	5.5	41	1.820				
Nov 15	5.8	5.6	69	0.877				
Nov 24	-1.0	NA	NA	0.132				
Dec 15	7.0	8.8	72	0.269				
Average	7.2	4.3	39	0.957	8.0	7.6	64	0.117
Std Dev.	4.4	2.8	26	0.791				
Minimum	-1.0	0.8	7	0.132	8.0	7.6	64	0.117
Maximum	12.1	8.8	72	2.460	8.0	7.6	64	0.117

NA = Dissolved oxygen data not available. Cold weather caused the panel meter to stick.

* Detection Limit 0.005 mg/L

Table 16 - continued

Sumas River Watershed Surface Water Quality Data - Fall Sampling 1993

Site 9: Arnold Slough @ Cole Rd.					Site 9B: Arnold Slough @ U.S.A. Border			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.9	1.1	10	0.296	7.5	2.5	21	0.727
Oct 12	11.6	1.1	10	1.380				
Oct 18	11.9	3.7	34	1.110				
Oct 25	10.4	5.7	51	1.260				
Nov 1	7.0	1.4	12	1.030				
Nov 8	3.4	2.6	20	1.180				
Nov 15	6.9	9.7	80	0.846				
Nov 24	-1.5	NA	NA	1.090				
Dec 15	8.4	3.7	32	0.724	7.5	2.5	21	0.727
Average	7.9	3.6	31	0.991				
Std Dev.	4.6	2.9	24	0.328				
Minimum	-1.5	1.1	10	0.296				
Maximum	12.9	9.7	80	1.380	7.5	2.5	21	0.727

NA = Dissolved oxygen data not available. Cold weather caused the panel meter to stick.

Site 10: Marshall Creek @ Sumas Mtn Rd.					Site 11: Sumas River @ South Parallel Rd.			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.2	5.8	54	0.030	13.1	10.6	100	0.054
Oct 12	12.3	6.9	64	0.056	13.0	9.8	100	0.025
Oct 18	12.1	7.2	67	0.025	13.0	10.6	100	0.050
Oct 25	9.7	2.3	20	0.234	11.0	10.1	92	0.064
Nov 1	8.9	3.7	32	0.192	9.2	10.4	90	0.079
Nov 8	5.4	4.8	38	0.005	4.4	11.8	91	0.076
Nov 15	6.9	5.3	44	< 0.005	5.5	11.4	90	0.048
Nov 24	-0.5	8.3	56	0.249	1.0	11.8	83	0.150
Dec 15	8.0	6.4	54	0.315	7.8	9.4	79	0.126
Average	8.3	5.6	48	0.123	8.7	10.7	92	0.068
Std Dev.	4.1	1.9	15	0.123	4.3	0.9	8	0.040
Minimum	-0.5	2.3	20	< 0.005	1.0	9.4	79	0.025
Maximum	12.3	8.3	67	0.315	13.1	11.8	100	0.150

* Detection Limit 0.005 mg/L

Table 16 - continued

Sumas River Watershed Surface Water Quality Data - Fall Sampling 1993

Site 12: Sumas River @ McDermott Rd.					Site 13: Stewart Slough @ Boundary Rd.			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	13.8	7.6	73	0.086	12.1	5.6	52	0.089
Oct 12	12.2	5.7	53	0.190	12.0	5.8	54	0.086
Oct 18	13.0	7.6	72	0.310	12.3	6.4	60	0.110
Oct 25	10.4	0.4	4	0.007	9.2	8.5	74	0.114
Nov 1	9.0	7.9	68	0.268	8.6	7.0	60	0.102
Nov 8	5.4	8.5	67	0.318	6.6	8.0	65	0.018
Nov 15	5.3	10.3	81	0.156	8.0	8.2	69	0.117
Nov 24	-0.5	11.6	78	0.259	3.0	9.9	74	0.190
Dec 15	7.8	8.6	72	0.234	8.5	8.8	75	0.132
Average	8.5	7.6	63	0.203	8.9	7.6	65	0.106
Std Dev.	4.6	3.2	24	0.105	3.0	1.5	9	0.045
Minimum	-0.5	0.4	4	0.007	3.0	5.6	52	0.018
Maximum	13.8	11.6	81	0.318	12.3	9.9	75	0.190

Site 14: Sumas Drainage Canal @ Hwy 1 West					Site 15: Sumas River downstream of Barrowtown Pump Station			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	15.0	4.5	45	0.382	15.4	5.8	58	0.329
Oct 12	13.2	6.1	58	0.917	13.0	6.5	62	0.479
Oct 18	14.2	5.1	50	0.708	14.0	4.6	45	0.690
Oct 25	10.4	6.8	61	0.536	10.6	10.1	91	0.176
Nov 1	9.3	6.4	56	0.852	9.0	7.2	62	0.583
Nov 8	5.9	6.7	54	0.875	5.6	9.4	75	0.233
Nov 15	5.5	9.3	74	0.687	5.0	11.6	91	0.171
Nov 24	-0.5	9.6	65	0.311	0.5	11.6	80	0.895
Dec 15	8.6	6.7	57	0.713	7.8	6.9	58	0.462
Average	9.1	6.8	58	0.665	9.0	8.2	69	0.446
Std Dev.	4.9	1.7	8	0.215	4.8	2.6	16	0.247
Minimum	-0.5	4.5	45	0.311	0.5	4.6	45	0.171
Maximum	15.0	9.6	74	0.917	15.4	11.6	91	0.895

* Detection Limit 0.005 mg/L

Table 17
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

	Site 7: Sumas River @ Vye Road								
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	3.9	4.0	9.8	8.0	7.5	6.6	2.3	3.9	9.8
Dissolved Oxygen (mg/L)	12.0	11.2	7.8	9.1	10.2	10.1	1.5	7.8	12
% Saturation Dissolved Oxygen	91%	85%	69%	77%	85%	81%	8%	69%	91%
pH (field)	no data	7.3	6.1	7.3	7.1	6.9	0.5	6.1	7.3
pH (lab)	7.5	7.1	7.3	7.2	7.4	7.3	0.1	7.1	7.5
Conductivity (field) (umhos/cm)	no data	150	no data	220	200	190	29	150	220
Conductivity (lab) (umhos/cm)	320	200	220	310	260	262	47	200	320
Total Dissolved Solids (mg/L)	200	180	140	190	190	180	21	140	200
Total Suspended Solids (mg/L)	18	130	130	25	28	66	52	18	130
Turbidity (NTU)	13.0	65.0	86.0	15.0	17.0	39.2	30.4	13.0	86.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	120	95	82	120	110	105	15	82	120
Hardness - CALC (mg/L)	110	76	96	110	130	104	18	76	130
Total Organic Carbon (mg/L)	2.76	6.80	7.60	5.05	4.10	5.26	1.76	2.76	7.60
Faecal Coliform (MPN/100 ml)	23	70	500	220	500	155	204	23	500
Free Ammonia (mg NH3-N/L)	0.160	0.119	0.190	0.487	0.153	0.222	0.135	0.119	0.487
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	2.980	4.970	4.640	3.360	3.330	3.856	0.793	2.980	4.970
Total Kjeldahl Nitrogen (mg/L)	0.49	0.73	1.14	0.82	0.41	0.72	0.26	0.41	1.14
Total Nitrogen (mg/L)	3.47	5.70	5.78	4.18	3.74	4.57	0.98	3.47	5.78
Organic Nitrogen (mg/L)	0.33	0.61	0.95	0.33	0.26	0.50	0.26	0.26	0.95
Ortho Phosphate (mg P/L)	0.031	0.052	0.137	0.103	0.032	0.071	0.042	0.031	0.137
Total Dissolved Phosphate (mg P/L)	0.064	0.058	0.142	0.106	0.035	0.081	0.038	0.035	0.142
Total Phosphorus (mg P/L)	0.091	0.168	0.308	0.132	0.096	0.159	0.080	0.091	0.308
Chloride (mg/L)		17.0	10.0			13.5	3.5	10.0	17.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

	Site 8: Saar Creek @ Vye Road								
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	4.0	3.5	8.1	8.0	6.0	5.9	1.9	3.5	8.1
Dissolved Oxygen (mg/L)	8.8	11.0	9.1	9.1	10.7	9.7	0.9	8.8	11.0
% Saturation Dissolved Oxygen	67%	83%	77%	77%	86%	78%	6%	67%	86%
pH (field)	no data	no data	6.2	6.6	6.7	6.5	0.2	6.2	6.7
pH (lab)	7.0	6.9	7.1	6.8	6.9	6.9	0.1	6.8	7.1
Conductivity (field) (umhos/cm)	no data	90	no data	120	100	103	12	90	120
Conductivity (lab) (umhos/cm)	200	140	130	170	130	154	27	130	200
Total Dissolved Solids (mg/L)	130	110	96	98	100	107	13	96	130
Total Suspended Solids (mg/L)	14	20	42	14	9	20	12	9	42
Turbidity (NTU)	19.0	11.0	32.0	13.0	11.0	17.2	8.0	11.0	32.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	78	51	40	60	56	57	12	40	78
Hardness - CALC (mg/L)	71	50	51	57	56	57	8	50	71
Total Organic Carbon (mg/L)	2.80	4.70	5.20	4.32	3.00	4.00	0.95	2.80	5.20
Faecal Coliform (MPN/100 ml)	N/A	50	130	240	2	42	90	2	240
Free Ammonia (mg NH3-N/L)	0.790	0.403	0.270	0.450	0.262	0.435	0.192	0.262	0.790
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.330	4.510	4.740	2.410	2.260	3.050	1.340	1.330	4.740
Total Kjeldahl Nitrogen (mg/L)	1.10	1.21	0.91	1.00	0.43	0.93	0.27	0.43	1.21
Total Nitrogen (mg/L)	2.43	5.72	5.65	3.41	2.69	3.98	1.43	2.43	5.72
Organic Nitrogen (mg/L)	0.31	0.81	0.65	0.55	0.17	0.50	0.23	0.17	0.81
Ortho Phosphate (mg P/L)	0.064	0.044	0.073	0.102	0.039	0.064	0.023	0.039	0.102
Total Dissolved Phosphate (mg P/L)	0.119	0.053	0.081	0.112	0.040	0.081	0.031	0.04	0.119
Total Phosphorus (mg P/L)	0.169	0.122	0.173	0.125	0.092	0.136	0.031	0.092	0.173
Chloride (mg/L)		9.9	6.5			8.2	1.7	6.5	9.9
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

	Site 9: Arnold Slough @ Cole Road								
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	6.4	4.5	8.7	10.0	6.0	7.1	2.0	4.5	10
Dissolved Oxygen (mg/L)	6.2	7.8	5.4	4.2	6.8	6.1	1.2	4.2	7.8
% Saturation Dissolved Oxygen	50%	60%	46%	37%	55%	50%	8%	37%	60%
pH (field)	no data	6.3	6.3	6.7	6.8	6.5	0.2	6.25	6.8
pH (lab)	7.0	6.7	6.8	6.7	6.9	6.8	0.1	6.7	7.0
Conductivity (field) (umhos/cm)	no data	170	no data	200	200	190	14	170	200
Conductivity (lab) (umhos/cm)	300	210	200	280	250	248	39	200	300
Total Dissolved Solids (mg/L)	210	210	160	180	180	188	19	160	210
Total Suspended Solids (mg/L)	30	34	54	32	14	33	13	14	54
Turbidity (NTU)	40.0	33.0	80.0	27.0	25.0	41.0	20.2	25.0	80.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	110	95	64	100	100	94	16	64	110
Hardness - CALC (mg/L)	100	82	82	110	100	95	11	82	110
Total Organic Carbon (mg/L)	2.80	6.70	9.50	4.08	4.00	5.42	2.41	2.80	9.50
Faecal Coliform (MPN/100 ml)	50	140	350	23	30	70	123	23	350
Free Ammonia (mg NH3-N/L)	0.700	0.468	0.240	0.720	0.483	0.522	0.176	0.240	0.720
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	0.762	5.470	5.620	1.460	1.870	3.036	2.079	0.762	5.620
Total Kjeldahl Nitrogen (mg/L)	1.15	1.21	0.90	1.57	0.63	1.09	0.31	0.63	1.57
Total Nitrogen (mg/L)	1.91	6.68	6.52	3.03	2.50	4.13	2.05	1.91	6.68
Organic Nitrogen (mg/L)	0.45	0.74	0.66	0.85	0.15	0.57	0.25	0.15	0.85
Ortho Phosphate (mg P/L)	0.015	0.018	0.101	0.029	0.016	0.036	0.033	0.015	0.101
Total Dissolved Phosphate (mg P/L)	0.073	0.028	0.118	0.029	0.016	0.053	0.038	0.016	0.118
Total Phosphorus (mg P/L)	0.285	0.265	0.325	0.180	0.172	0.245	0.060	0.172	0.325
Chloride (mg/L)		20.0	12.0			16.0	4.0	12.0	20.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

Site 10: Marshall Creek @ Sumas Mtn Road

Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	5.9	5.0	8.8	9.0	9.5	7.6	1.8	5.0	9.5
Dissolved Oxygen (mg/L)	8.1	9.2	7.2	7.8	9.0	8.3	0.7	7.2	9.2
% Saturation Dissolved Oxygen	65%	72%	62%	67%	79%	69%	6%	62%	79%
pH (field)	no data	6.7	6.6	6.7	7.0	6.7	0.1	6.6	7.0
pH (lab)	7.1	6.7	6.7	6.8	7.0	6.9	0.2	6.7	7.1
Conductivity (field) (umhos/cm)	no data	155	no data	170	200	175	19	155	200
Conductivity (lab) (umhos/cm)	470	240	200	230	270	282	97	200	470
Total Dissolved Solids (mg/L)	280	200	150	160	190	196	46	150	280
Total Suspended Solids (mg/L)	11	22	33	12	16	19	8	11	33
Turbidity (NTU)	16.0	26.0	49.0	15.0	15.0	24.2	13.1	15.0	49.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	76	60	48	68	80	66	11	48	80
Hardness - CALC (mg/L)	97	64	75	85	100	84	13	64	100
Total Organic Carbon (mg/L)	2.22	6.70	8.90	4.08	3.70	5.12	2.38	2.22	8.90
Faecal Coliform (MPN/100 ml)	50	70	240	900	300	187	309	50	900
Free Ammonia (mg NH3-N/L)	0.240	0.220	0.300	0.270	0.396	0.285	0.062	0.220	0.396
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	4.680	6.290	5.210	3.520	4.280	4.796	0.929	3.520	6.290
Total Kjeldahl Nitrogen (mg/L)	0.60	1.20	1.82	0.71	0.73	1.01	0.45	0.60	1.82
Total Nitrogen (mg/L)	5.28	7.49	7.03	4.23	5.01	5.81	1.24	4.23	7.49
Organic Nitrogen (mg/L)	0.36	0.98	1.52	0.44	0.33	0.73	0.46	0.33	1.52
Ortho Phosphate (mg P/L)	0.015	0.042	0.107	0.040	0.038	0.048	0.031	0.015	0.107
Total Dissolved Phosphate (mg P/L)	0.058	0.050	0.112	0.040	0.044	0.061	0.026	0.04	0.112
Total Phosphorus (mg P/L)	0.088	0.175	0.282	0.090	0.132	0.153	0.072	0.088	0.282
Chloride (mg/L)		21.0	15.0			18.0	3.0	15.0	21.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

	Site 11: Sumas River @ South Parallel Road								
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	4.6	3.5	9.2	9.0	8.0	6.9	2.4	3.5	9.2
Dissolved Oxygen (mg/L)	8.8	11.4	7.5	9.2	10.6	9.5	1.4	7.5	11.4
% Saturation Dissolved Oxygen	68%	86%	65%	80%	90%	78%	10%	65%	90%
pH (field)	no data	7.0	7.3	7.3	7.3	7.2	0.1	7.0	7.3
pH (lab)	7.6	7.3	7.4	7.2	7.4	7.4	0.1	7.2	7.6
Conductivity (field) (umhos/cm)	no data	160	no data	220	210	197	26	160	220
Conductivity (lab) (umhos/cm)	320	370	210	300	280	296	52	210	370
Total Dissolved Solids (mg/L)	200	190	140	190	180	180	21	140	200
Total Suspended Solids (mg/L)	10	72	71	14	17	37	28	10	72
Turbidity (NTU)	13.0	48.0	75.0	17.0	15.0	33.6	24.4	13.0	75.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	120	99	82	120	110	106	14	82	120
Hardness - CALC (mg/L)	110	86	89	130	130	109	19	86	130
Total Organic Carbon (mg/L)	2.56	6.00	7.50	4.57	4.20	4.97	1.67	2.56	7.50
Faecal Coliform (MPN/100 ml)	240	4000	1600	900	130	709	1415	130	4000
Free Ammonia (mg NH3-N/L)	0.195	0.163	0.190	0.270	0.195	0.203	0.036	0.163	0.270
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	2.720	5.310	4.580	3.060	3.190	3.772	0.997	2.720	5.310
Total Kjeldahl Nitrogen (mg/L)	0.55	1.15	1.43	0.74	0.50	0.87	0.36	0.50	1.43
Total Nitrogen (mg/L)	3.27	6.46	6.01	3.80	3.69	4.65	1.32	3.27	6.46
Organic Nitrogen (mg/L)	0.36	0.99	1.24	0.47	0.30	0.67	0.37	0.30	1.24
Ortho Phosphate (mg P/L)	0.014	0.068	0.149	0.040	0.039	0.062	0.047	0.014	0.149
Total Dissolved Phosphate (mg P/L)	0.069	0.075	0.153	0.040	0.041	0.076	0.041	0.04	0.153
Total Phosphorus (mg P/L)	0.092	0.181	0.229	0.122	0.095	0.144	0.053	0.092	0.229
Chloride (mg/L)		15.0	10.0			12.5	2.5	10.0	15.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0	0	< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

Site 12: Sumas River @ McDermott Road

Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	3.7	4.0	9.0	9.0	8.0	6.7	2.4	3.7	9
Dissolved Oxygen (mg/L)	10.6	11.0	8.0	7.8	11.0	9.7	1.5	7.8	11
% Saturation Dissolved Oxygen	80%	84%	69%	67%	93%	79%	9%	67%	93%
pH (field)	no data	7.1	7.1	7.0	7.2	7.1	0.1	7.0	7.15
pH (lab)	7.4	7.2	7.2	7.1	7.3	7.2	0.1	7.1	7.4
Conductivity (field) (umhos/cm)	no data	145	no data	200	185	177	23	145	200
Conductivity (lab) (umhos/cm)	310	240	190	270	260	254	39	190	310
Total Dissolved Solids (mg/L)	200	170	120	170	180	168	26	120	200
Total Suspended Solids (mg/L)	13	33	58	21	17	28	16	13	58
Turbidity (NTU)	17.0	32.0	66.0	19.0	19.0	30.6	18.5	17.0	66.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	100	84	68	100	94	89	12	68	100
Hardness - CALC (mg/L)	110	73	77	110	110	96	17	73	110
Total Organic Carbon (mg/L)	2.50	6.10	7.10	4.32	8.80	5.76	2.18	2.50	8.80
Faecal Coliform (MPN/100 ml)	0	900	1600	240	170	492	594	0	1600
Free Ammonia (mg NH3-N/L)	0.290	0.247	0.210	0.540	0.302	0.318	0.116	0.210	0.540
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	2.630	5.120	4.640	2.690	3.030	3.622	1.047	2.630	5.120
Total Kjeldahl Nitrogen (mg/L)	0.67	1.04	1.21	1.07	0.46	0.89	0.28	0.46	1.21
Total Nitrogen (mg/L)	3.30	6.16	5.85	3.76	3.49	4.51	1.23	3.30	6.16
Organic Nitrogen (mg/L)	0.38	0.79	1.00	0.53	0.16	0.57	0.30	0.16	1.00
Ortho Phosphate (mg P/L)	0.014	0.056	0.140	0.118	0.035	0.073	0.048	0.014	0.140
Total Dissolved Phosphate (mg P/L)	0.069	0.065	0.145	0.120	0.040	0.088	0.039	0.04	0.145
Total Phosphorus (mg P/L)	0.085	0.190	0.283	0.130	0.104	0.158	0.072	0.085	0.283
Chloride (mg/L)		16.0	10.0			13.0	3.0	10.0	16.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0	0	< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

Site 13: Stewart Slough @ Boundary Road									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	6.3	5.5	7.9	8.5	8.0	7.2	1.1	5.5	8.5
Dissolved Oxygen (mg/L)	10.6	10.8	8.8	9.6	10.8	10.1	0.8	8.8	10.8
% Saturation Dissolved Oxygen	86%	86%	74%	82%	91%	84%	6%	74%	91%
pH (field)	no data	6.4	6.5	7.0	6.9	6.7	0.2	6.4	7.0
pH (lab)	7.2	7.0	6.9	6.9	7.1	7.0	0.1	6.9	7.2
Conductivity (field) (umhos/cm)	no data	85	no data	90	90	88	2	85	90
Conductivity (lab) (umhos/cm)	140	130	120	120	110	124	10	110	140
Total Dissolved Solids (mg/L)	99	93	69	80	87	86	10	69	99
Total Suspended Solids (mg/L)	11	7	12	7	9	9	2	7	12
Turbidity (NTU)	4.9	2.5	4.2	3.8	2.2	3.5	1.0	2.2	4.9
Alkalinity to pH 4.5 (mg (CaCO ₃ /L)	60	50	46	42	50	50	6	42	60
Hardness - CALC (mg/L)	57	42	44	50	56	50	6	42	57
Total Organic Carbon (mg/L)	0.79	1.70	2.10	1.40	1.30	1.46	0.43	0.79	2.10
Faecal Coliform (MPN/100 ml)	50	2400	130	240	50	180	916	50	2400
Free Ammonia (mg NH ₃ -N/L)	0.101	0.109	0.118	0.105	0.092	0.105	0.009	0.092	0.118
Nitrate+Nitrite ((NO ₃ -N+NO ₂ -N)mg/L))	1.230	1.710	1.930	1.410	1.370	1.530	0.254	1.230	1.930
Total Kjeldahl Nitrogen (mg/L)	0.32	0.36	0.50	0.34	0.32	0.37	0.07	0.32	0.50
Total Nitrogen (mg/L)	1.55	2.07	2.43	1.75	1.69	1.90	0.32	1.55	2.43
Organic Nitrogen (mg/L)	0.22	0.25	0.38	0.24	0.23	0.26	0.06	0.22	0.38
Ortho Phosphate (mg P/L)	0.012	0.023	0.031	0.025	0.017	0.022	0.007	0.012	0.031
Total Dissolved Phosphate (mg P/L)	0.023	0.026	0.034	0.030	0.018	0.026	0.006	0.018	0.034
Total Phosphorus (mg P/L)	0.043	0.049	0.048	0.042	0.033	0.043	0.006	0.033	0.049
Chloride (mg/L)		5.0	4.5			4.8	0.3	4.5	5.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

Site 14: Sumas Drainage Canal @ Hwy 1 West									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	2.1	4.5	8.3	9.0	8.0	6.4	2.6	2.1	9
Dissolved Oxygen (mg/L)	8.2	9.4	7.6	8.2	10.4	8.8	1.0	7.6	10.4
% Saturation Dissolved Oxygen	59%	73%	65%	71%	88%	71%	10%	59%	88%
pH (field)	no data	7.1	6.9	6.8	7.1	6.9	0.1	6.8	7.1
pH (lab)	7.1	6.9	6.8	6.9	7.0	6.9	0.1	6.8	7.1
Conductivity (field) (umhos/cm)	no data	140	no data	155	180	158	16	140	180
Conductivity (lab) (umhos/cm)	210	220	200	230	210	214	10	200	230
Total Dissolved Solids (mg/L)	140	150	130	140	150	142	7	130	150
Total Suspended Solids (mg/L)	11	18	23	8	18	16	5	8	23
Turbidity (NTU)	16.0	24.0	34.0	23.0	21.0	23.6	5.9	16.0	34.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	84	88	78	96	96	88	7	78	96
Hardness - CALC (mg/L)	78	68	79	82	95	80	9	68	95
Total Organic Carbon (mg/L)	2.02	3.50	3.50	4.35	2.90	3.25	0.77	2.02	4.35
Faecal Coliform (MPN/100 ml)	17	900	1600	130	110	204	613	17	1600
Free Ammonia (mg NH3-N/L)	0.890	0.825	0.660	0.900	1.30	0.915	0.211	0.660	1.300
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.210	1.560	1.880	1.330	1.290	1.454	0.243	1.210	1.880
Total Kjeldahl Nitrogen (mg/L)	1.20	1.26	1.27	1.35	1.47	1.31	0.09	1.20	1.47
Total Nitrogen (mg/L)	2.41	2.82	3.15	2.68	2.76	2.76	0.24	2.41	3.15
Organic Nitrogen (mg/L)	0.31	0.43	0.61	0.45	0.17	0.39	0.15	0.17	0.61
Ortho Phosphate (mg P/L)	0.006	0.013	0.050	0.012	0.024	0.021	0.016	0.006	0.050
Total Dissolved Phosphate (mg P/L)	0.049	0.019	0.051	0.012	0.025	0.031	0.016	0.012	0.051
Total Phosphorus (mg P/L)	0.073	0.177	0.172	0.099	0.140	0.132	0.041	0.073	0.177
Chloride (mg/L)		12.0	10.0			11.0	1.0	10.0	12.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 17 - continued
Sumas River Watershed Surface Water Quality - Winter Sampling 1994

Site 15: Sumas River downstream of Barrowtown Pump Station									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	1.5	4.0	9.1	9.0	8.5	6.4	3.1	1.5	9.1
Dissolved Oxygen (mg/L)	9.2	10.6	7.7	9.4	10.6	9.5	1.1	7.7	10.6
% Saturation Dissolved Oxygen	66%	81%	67%	81%	91%	77%	10%	66%	91%
pH (field)	no data	no data	6.8	7.1	7.1	7.0	0.1	6.8	7.1
pH (lab)	7.2	7.1	7.0	7.2	7.2	7.1	0.1	7.0	7.2
Conductivity (field) (umhos/cm)	no data	140	no data	180	175	165	18	140	180
Conductivity (lab) (umhos/cm)	240	230	170	250	230	224	28	170	250
Total Dissolved Solids (mg/L)	160	160	110	160	170	152	21	110	170
Total Suspended Solids (mg/L)	11	22	47	16	23	24	12	11	47
Turbidity (NTU)	17.0	24.0	60.0	18.0	22.0	28.2	16.1	17.0	60.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	92	82	64	94	86	84	11	64	94
Hardness - CALC (mg/L)	87	73	69	110	100	88	16	69	110
Total Organic Carbon (mg/L)	2.34	4.60	6.00	3.84	4.00	4.16	1.18	2.34	6.00
Faecal Coliform (MPN/100 ml)	50	900	500	300	170	258	298	50	900
Free Ammonia (mg NH3-N/L)	0.790	0.384	0.620	0.250	0.039	0.417	0.265	0.039	0.790
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.540	3.140	3.730	2.830	2.440	2.736	0.732	1.540	3.730
Total Kjeldahl Nitrogen (mg/L)	1.15	1.00	1.75	0.70	0.84	1.09	0.36	0.70	1.75
Total Nitrogen (mg/L)	2.69	4.14	5.48	3.53	3.28	3.82	0.95	2.69	5.48
Organic Nitrogen (mg/L)	0.36	0.62	1.13	0.45	0.80	0.67	0.27	0.36	1.13
Ortho Phosphate (mg P/L)	0.008	0.022	0.099	0.105	0.033	0.053	0.041	0.008	0.105
Total Dissolved Phosphate (mg P/L)	0.046	0.027	0.100	0.108	0.039	0.064	0.033	0.027	0.108
Total Phosphorus (mg P/L)	0.084	0.143	0.226	0.140	0.130	0.145	0.046	0.084	0.226
Chloride (mg/L)		14.0	10.0			12.0	2.0	10.0	14.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0	0	< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 18
Water Quality Canadian Guidelines and Provincial Criteria for General Parameters

Parameter	CCREM Guidelines ¹				Provincial Criteria ² (Maximum Concentration)			
	Irrigation (all soils)	Live Stock Watering	Drinking Water (Raw)	Freshwater Aquatic Life	Irrigation (all soils)	Live Stock Watering	Drinking Water (Raw)	Freshwater Aquatic Life
Alkalinity, mg/L CaCO ₃								10 to 20, moderate sensitivity to acid inputs > 20, low sensitivity to acid inputs
Ammonia mg/L-N				pH 6.5/10°C = 2.2				pH 7.0/7°C = 21.1 ⁴ pH 7.0/7°C (Avg 30 day Conc. = 1.90 ⁴)
Chloride, mg/L	100 to 700				100 to 700 (Diss.)			
Dissolved Oxygen mg/L				4.0, 1 day minimum for cold water, other life stages				
Faecal Coliforms / 100 mL	100		0		≤200 GM ³		0	
Nitrate mg/L		100	10			100	10	200
Nitrite mg/L			1			10	1	0.06
pH				6.5 to 9.0	4.5 to 9.0			6.5 to 9.0
Total Dissolved Solids mg/L	500 to 3500	3000			500 to 3500	1000 to 3000		

Diss = Dissolved. GM = geometric mean.

¹ CCREM, 1987, Canadian Water Quality Guidelines.

² MOELP, 1994. Approved and Working Criteria for Water Quality - 1994.

³ For crops eaten raw.

⁴ pH 7.0 and 7°C approximates winter conditions in Table 17

Table 19
Fish Habitat Classification and Measured Dissolved Oxygen in the Sumas River Watershed

Site	Site Description	Fish Habitat Category	Dissolved Oxygen (mg/L)						
			Provincial Criteria ¹	Minimum		Mean		Coefficient of Variance ² %	
				Fall	Winter	Fall	Winter	Fall	Winter
7	Sumas River @ Vye Road	II	3 to 8	9	7.8	10.2	10.1	8	15
8	Saar Creek @ Vye Road	II	3 to 8	0.8	8.8	4.3	9.7	61	9
9	Arnold Slough @ Cole Road	IV	3 to 6	1.1	4.2	3.6	6.1	76	20
10	Marshall Creek @ Sumas Mountain Road	IV	3 to 6	2.3	7.2	5.6	8.3	31	9
11	Sumas River @ South Parallel Road	III	3 to 8	9.4	7.5	10.7	9.5	8	25
12	Sumas River @ McDermott Road	II	3 to 8	5.7	7.8	7.6	9.7	40	15
13	Stewart Slough @ Boundary Road	I	6 to 11	5.6	8.8	7.6	10.1	18	8
14	Sumas Drainage Canal @ Hwy 1 East	IV	3 to 6	4.5	7.6	6.8	8.8	24	12
15	Sumas River downstream of Barrowtown Pump Station	II	3 to 8	4.6	7.7	8.2	9.5	30	11

1 MOELP, 1994. Approved and Working Criteria for Water Quality - 1994, Table 17

2 Coefficient of variance = standard deviation/mean

Table 20

**Sumas River Watershed Surface Water Quality for Total Metals
Winter Sampling 1994**

Total Metals (ug/L)	Site 7: Sumas River @ Vye Road			Site 8: Saar Creek @ Vye Road			Site 9: Arnold Slough @ Cole Road		
	Feb 22	March 3	Average	Feb 22	March 3	Average	Feb 22	March 3	Average
Aluminium	610	2700	1655	190	4000	2095	540	2800	1670
Arsenic	1.40	1.70	1.55	0.49	1.20	0.85	0.85	1.40	1.13
Cadmium	0.05	0.05	0.05	0.04	< 0.03	< 0.03	0.06	0.06	0.06
Calcium	15000	20000	17500	8200	14000	11100	16000	22000	19000
Chromium	11.0	41.0	26.0	1.9	14.0	8.0	2.0	6.2	4.1
Cobalt	3.00	13.00	8.00	0.43	3.80	2.12	1.10	2.70	1.90
Copper	2.8	11.0	6.9	3.0	12.0	7.5	5.3	16.0	10.7
Iron	1900	6100	4000	1200	5700	3450	2600	4200	3400
Lead	0.62	0.88	0.75	0.29	1.10	0.70	0.40	1.10	0.75
Magnesium	23000	46000	34500	8500	16000	12250	17000	19000	18000
Manganese	56	220	138	33	180	107	120	130	125
Mercury	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	0.70	0.71	0.71	0.45	0.51	0.48	0.81	1.10	0.96
Nickel	73.0	250.0	161.5	8.5	36.0	22.3	26.0	34.0	30.0
Phosphorus	150	400	275	100	350	225	200	400	300
Potassium	5800	9700	7750	2800	5900	4350	7500	11000	9250
Selenium	0.27	0.16	0.22	0.25	0.22	0.24	0.55	0.45	0.50
Sodium	6600	6700	6650	3900	5600	4750	7600	7100	7350
Strontium	110	110	110	72	90	81	150	140	145
Tin	0.03	< 0.03	< 0.02	< 0.03	< 0.03	< 0.03	0.04	< 0.03	< 0.027
Zinc	13.0	20.0	16.5	14.0	23.0	18.5	24.0	25.0	24.5

Table 20 - continued

**Sumas River Watershed Surface Water Quality for Total Metals
Winter Sampling 1994**

Total Metals (ug/L)	Site 10: Marshall Creek @ Sumas Mtn Road			Site 11: Sumas River @ S. Parallel Road			Site 12: Sumas River @ McDermott Road		
	Feb 22	March 3	Average	Feb 22	March 3	Average	Feb 22	March 3	Average
Aluminium	400	2000	1200	240	2100	1170	320	2200	1260
Arsenic	1.70	2.00	1.85	1.40	4.10	2.75	1.10	1.50	1.30
Cadmium	0.07	< 0.03	< 0.04	0.03	0.06	0.05	0.06	0.07	0.07
Calcium	18000	27000	22500	13000	19000	16000	13000	19000	16000
Chromium	0.6	5.2	2.9	2.8	29.0	15.9	4.2	17.0	10.6
Cobalt	0.72	2.40	1.56	0.86	7.00	3.93	0.92	4.60	2.76
Copper	4.2	12.0	8.1	1.2	9.5	5.4	2.6	9.5	6.1
Iron	1200	3100	2150	680	4700	2690	1200	4000	2600
Lead	1.10	1.00	1.05	0.34	0.85	0.60	0.31	0.81	0.56
Magnesium	8700	13000	10850	18000	37000	27500	14000	26000	20000
Manganese	70	180	125	27	130	79	47	120	84
Mercury	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	0.73	1.10	0.92	0.64	0.81	0.73	0.62	0.72	0.67
Nickel	17.0	29.0	23.0	29.0	140.0	84.5	24.0	86.0	55.0
Phosphorus	100	350	225	180	300	240	100	300	200
Potassium	4300	7300	5800	5400	9700	7550	4900	9300	7100
Selenium	0.25	0.23	0.24	0.27	0.18	0.23	0.25	0.26	0.26
Sodium	11000	11000	11000	6700	6900	6800	7100	7300	7200
Strontium	120	120	120	100	96	98	100	100	100
Tin	< 0.03	< 0.03	< 0.03	0.06	0.06	0.06	0.04	< 0.03	< 0.027
Zinc	12.0	30.0	21.0	7.7	20.0	13.9	12.0	18.0	15.0

Table 20 - continued

**Sumas River Watershed Surface Water Quality for Total Metals
Winter Sampling 1994**

Total Metals (ug/L)	Site 13: Stewart Slough @ Boundary Road			Site 14: Sumas Drainage Canal @ Hwy 1 West			Site 15: Sumas River down- stream of Barrow- town Pump Station		
	Feb 22	March 3	Average	Feb 22	March 3	Average	Feb 22	March 3	Average
Aluminium	29	320	175	160	530	345	130	1800	965
Arsenic	0.39	0.47	0.43	2.00	2.10	2.05	1.30	1.70	1.50
Cadmium	0.04	0.07	0.06	< 0.03	< 0.03	< 0.03	0.03	< 0.03	< 0.023
Calcium	14000	24000	19000	17000	30000	23500	15000	21000	18000
Chromium	< 0.2	3.0	< 1.5	< 0.2	< 0.2	< 0.2	0.2	11.0	5.6
Cobalt	0.17	0.56	0.37	0.54	2.30	1.42	0.53	3.50	2.02
Copper	0.5	3.8	2.2	1.3	5.3	3.3	1.0	8.3	4.7
Iron	380	1200	790	2300	4400	3350	1300	4200	2750
Lead	< 0.05	0.33	< 0.17	0.17	0.48	0.33	0.12	0.70	0.41
Magnesium	3600	6300	4950	9500	15000	12250	12000	19000	15500
Manganese	22	87	55	200	400	300	82	190	136
Mercury	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	0.39	0.42	0.41	0.45	0.74	0.60	0.59	0.79	0.69
Nickel	2.2	2.7	2.5	4.7	11.0	7.9	13.0	58.0	35.5
Phosphorus	< 20	< 20	< 20	180	200	190	140	300	220
Potassium	1400	3400	2400	4800	7000	5900	4400	8600	6500
Selenium	0.12	0.12	0.12	0.11	0.11	0.11	0.16	0.18	0.17
Sodium	2800	5300	4050	4900	7000	5950	5800	7100	6450
Strontium	100	110	105	130	140	135	110	100	105
Tin	< 0.03	< 0.03	< 0.03	0.03	< 0.03	< 0.02	< 0.03	< 0.03	< 0.03
Zinc	10.0	15.0	12.5	9.7	13.0	11.4	7.1	18.0	12.6

Table 21
Water Quality Canadian Guidelines and Provincial Criteria for Metals

Parameter	CCREM Guidelines ¹			Provincial Criteria ² (Maximum Concentration)		
	Irrigation (all soils)	Live Stock Watering	Freshwater Aquatic Life	Irrigation (all soils)	Live Stock Watering	Freshwater Aquatic Life
Aluminum µg/L	5000	5000	100 @ pH ≥ 6.5 5 @ pH < 6.5	5000	5000	100 (Diss.) @ pH ≥ 6.5 52 to 74 for pH 6.1 to 6.4 ³
Arsenic µg/L	100	500	50	100 to 2000	500	50
Cadmium µg/L	10	20	0.2 @ 0 to 60 mg/L CaCO ₃ 0.8 @ 60 to 120 mg/L CaCO ₃	10	20	0.2 @ 0 to 60 mg/L CaCO ₃ 0.8 @ 60 to 120 mg/L CaCO ₃
Calcium mg/L		1000				4 to 8, moderate sensitivity to acid inputs > 8, low sensitivity to acid inputs
Chromium µg/L	100	1000	2, phyto- & zooplankton 20, fish	100	1000	2, phyto- & zooplankton 20, fish
Cobalt µg/L	50	1000		50	1000	50
Copper µg/L	200 - 1000	1000	2.0 @ 0 to 120 mg/L CaCO ₃	200	300	2 to 14.2 for 0 to 130 mg/L CaCO ₃
Iron µg/L			300	5000		300
Lead µg/L	200	100	1.0 @ 0 to 60 mg/L CaCO ₃ 2.0 @ 60 to 120 mg/L CaCO ₃	200	100	3 to 114 for 0 to 130 mg/L CaCO ₃
Manganese µg/L	200			200		100 to 1000
Mercury µg/L		3.0	0.1	2.0	3.0	0.1
Molybdenum µg/L	10 to 50	500		50	50 to 80	2000
Nickel µg/L	200	1000	25 @ 0 to 60 mg/L CaCO ₃ 65 @ 60 to 120 mg/L CaCO ₃	200	1000	25 @ 0 to 60 mg/L CaCO ₃ 65 @ 60 to 120 mg/L CaCO ₃
Phosphorus µg/L						5 to 15 (lake)
Selenium µg/L	20 to 50	50	1.0	20 to 50	50	1.0
Zinc µg/L	1000 @ pH < 6.5 5000 @ pH > 6.5	50000	30	1000 @ pH < 6.5 5000 @ pH > 6.5	50000	30

Notes: All water quality guidelines concentrations are for total metals, unless indicated otherwise. Diss = Dissolved.

For winter survey the hardness ranged from 50 to 130 mg/L CaCO₃.

¹ CCREM, 1987, Canadian Water Quality Guidelines.

² MOELP, 1994. Approved and Working Criteria for Water Quality - 1994.

³ For the winter survey the pH ranged from 6.1 to 7.6.

TABLE 22
RUNOFF CHARACTERISTICS ¹

Parameter	Seattle ² Washington	Lake Ellyn ³ Michigan	Peak Conc ⁴ USA	Alberta Surface ⁵ Water Quality Objectives
Conductivity, µohm/cm	12.9			
Turbidity, JTU	7.0			25
Dissolved Oxygen, mg/L	9.0			5.0
Biochemical Oxygen Demand, mg/L	30.4	18.0		
Chemical Oxygen Demand, mg/L	99.0			
Chloride, mg/L	11.6	34.7		
Sulphate, mg/L	20.0			
Nitrogen, mg/L				1.0
Organic	1.71			
Ammonia	0.35	0.18		
Nitrite	0.13			
Nitrate	0.74			
Phosphorus, mg/L				0.15
Hydrolyzable	0.36	0.08		
Ortho	0.11			
Lead, µg/L	360	224	460	50
Iron, mg/L	1.99			0.3
Mercury, µg/L	0.17			0.1
Arsenic, µg/L			50.5	10
Copper, µg/L		41	100	20
Cadmium, µg/L	15.0		14	10
Zinc, µg/L	120	171	2,400	50
Phenols, µg/L			115	5
Solids, mg/L				
Settleable	121			
Suspended	160	196		Background + 10
Total Dissolved Solids, mg/L	144			
Coliforms, org./100mL				
Total	26,000			2,400
Fecal	1,200			200

Notes: 1. Alberta Environment, 1987. Stormwater Management Guidelines.

2. Kibler, 1982. Urban Stormwater Hydrology.

3. Hey and Schaefer, 1984. An Evaluation of the Water Quality Effects of Detention Storage and Source Control.

4. Cole *et al*, 1984. Preliminary Findings of the Priority Pollutant Monitoring Program.

5. Alberta Environment, 1977.

Table 23
Time of Travel Estimates from Water Quality Sampling Sites
to Site 15 on the Sumas River

Site No.	Site Description	Distance of Sampling Site to Site 15 on the Sumas River * (km)	Time-of-Travel (hours)	
			Dry Velocity (0.15 m/s)	Wet Velocity (0.3 m/s)
7	Sumas River @ Vye Road	21.75	40.0	20.0
7B	Sumas River @ U.S.A. border	25.50	47.2	23.6
8	Saar Creek @ Vye Road	15.00	28.0	14.0
8B	Saar Creek @ U.S.A. border	17.50	32.4	16.2
9	Arnold Slough @ Cole Road	13.75	25.0	12.5
9B	Arnold Slough @ U.S.A. border	16.75	31.0	15.5
10	Marshall Creek @ Sumas Mountain Road	10.25	19.0	9.5
11	Sumas River @ South Parallel Road	11.00	21.0	10.5
12	Sumas River @ McDermott Road	6.75	12.5	6.25
13	Stewart Slough @ Boundary Road	9.50	17.6	8.8
14	Sumas Drainage Canal @ Hwy 1 West	0.5	0.9	0.5

* As measured from a topographic map (Mission, 92 G/1, 5th Edition, Energy, Mines and Resources Canada, NAD 27)

Table 24
Comparison of "Wet" versus "Dry" Watershed Averaged Water Quality Data

Parameter	"Wet" Sampling Days	"Dry" Sampling Days
Ammonia (mg/L)	0.327	0.446
Suspended Solids (mg/L)	46	16
Total Aluminum (µg/L)	1171	----
Total Cadmium (µg/L)	0.040	----
Total Iron (µg/L)	2877	----
Total Lead (µg/L)	0.60	----
Total Mercury (µg/L)	< 0.05	----
Total Selenium (µg/L)	0.300	----
Total Zinc (µg/L)	16	----
Faecal Coliforms (MPN/100 mL)	438	86

Note: Metals were sampled on February 22, and March 3, 1994, both which are classified as "wet" sampling days.

Table 25
Comparison of "Wet" versus "Dry" Site Averaged Water Quality Data

Parameter	Site 7		Site 8		Site 9		Site 13	
	Sampling Days		Sampling Days		Sampling Days		Sampling Days	
	"Wet"	"Dry"	"Wet"	"Dry"	"Wet"	"Dry"	"Wet"	"Dry"
Ammonia (mg/L)	0.143	0.115	0.643	0.939	0.723	0.957	0.108	0.103
Suspended Solids (mg/L)	95	23	25	12	40	22	9	10
Faecal Coliforms (MPN/100 mL)	197	107	116	2	104	39	421	50

Table 26
Relative Abundance of Fish Species at Water Quality Sites in the Sumas River Watershed

SITE	coho salmon	chinook salmon	chum salmon	rainbow/steelhead trout	cutthroat trout	"trout" (unidentified)	northern squawfish	redside shiner	goldfish	"cyprinid"	largescale sucker	3 spine stickleback	coastrange sculpin	lamprey ammocoete	TOTALS:
Sumas River Watershed															
7 (Sumas River at Vye Rd)															
OCT18													4		4
NOV24															0
DEC15							1						2	1	4
FEB10					1		5								6
MAR03													2		2
8 (Saar Creek at Vye Road)															
OCT18								2				5		2	9
NOV24			5												5
DEC15											3	2	1		6
FEB10	1										3	3			7
MAR03	1											2			3
9 (Arnold Slough at Cole Road)															
OCT18												2			2
NOV24															0
DEC15											1	2			3
FEB10								3				2			5
MAR03															0
10 (Marshall Creek at Sumas Mtn. Road)															
OCT18												5			5
NOV24															0
DEC15												1			1
FEB10					1							10			11
MAR03															0
11 (Sumas River at S. Parallel Road)															
OCT18										1			2		3
NOV24															0
DEC15				1				1							2
FEB10															0
MAR03															0
12 (Sumas River at McDermott Road)															
OCT18													2		2
NOV24															0
DEC15												1			1
FEB10												3			3
MAR03															0
13 (Stewart Slough at Boundary Road)															
OCT18	1			2				1				10		1	15
NOV24	1					2	1	1		1	1	5	2		14
DEC15	1						1					20	5		27
FEB10	1			1			6				1	7	4		20
MAR03	1						1	1				3	2		8
14 (Sumas Drainage Canal at Hwy 1 West)															
OCT18												5	2		7
NOV24															0
DEC15												2			2
FEB10															0
MAR03															0
15 (Sumas River near No. 1 Road)															
OCT18													20		20
NOV24															0
DEC15			1										10		11
FEB10															0
MAR03	1											2	3		6
Estimated Total Captures	8	1	5	4	2	2	15	9	0	2	9	92	61	4	214
Percent Composition =	3.7%	0.5%	2.3%	1.9%	0.9%	0.9%	7.0%	4.2%	0.0%	0.9%	4.2%	43.0%	28.5%	1.9%	100%
Ranking =	6	13	7	8	10	10	3	4	14	10	4	1	2	8	

Table 27
Sumas River Watershed Fisheries Survey Results

Date: October 18, 1993

Weather: overcast, cool most of day

Site	Location	Fish Captured	Notes
7	Sumas River at Vye Road	Four large sculpin (to 110 mm)	Bottom under bridge was broken rock leading to a riffle and deep pool. D.O. 9.9 mg/L
8	Saar Creek at Vye Road	Stickleback only above Vye Road culvert. Below culvert and cascade, stk., red side shiner, lamprey	D.O. 0.9 mg/L above culvert, floating orange colored islands, and strong animal urine odor
9	Arnold Slough at Cole Road	2 stickleback	Oil slick nearly continuous above bridge and partly broken in flowing water below
10	Marshall Creek at Sumas Mtn Road	A few stickleback, potential coho rearing habitat	Muskrat observed below bridge. D.O. 7.2 mg/L
11	Sumas River at South Parallel Road	Sculpin, unidentified small cyprinid, crayfish	sand gravel substrate, high D.O. (10.6 mg/L) strong "farm odor" in air
12	Sumas River at McDermott Road	2 sculpin captured, one 150 mm squawfish dead on bank (angled and abandoned)	High densities of mysid shrimp in evidence
13	Stewart Slough at Boundary Road	80 mm coho, two 160 mm rainbow, plus redbside shiner, stickleback, and lamprey	D.O. 6.4 mg/L. Abundant luxuriant submerged vegetation still in evidence
14	Sumas Drainage Canal at Hwy 1 West	Sculpin and a few stickleback. D.O. = 5.1 mg/L	Sampled near broken rock border to large pool below pump house
15	Sumas River near No 1 Road	Abundant small sculpin on gravel/broken rock slope.	Abundant mysid shrimp. D.O. 4.6 mg/L

Table 27 - continued
Sumas River Watershed Fisheries Survey Results

Date : November 24, 1993

Weather : sunny; cold (below 0) - variable wind

Site	Location	Fish Captured	Notes
7	Sumas River at Vye Road	Ice cover greater than 90% - No fish captured	D.O. =12.2mg/L. - T = -0.8 C
8	Saar Creek at Vye Road	5+ CM spawners in pool below culvert - north side of Vye Road. electroshocker not used - ice dam reduced in height	T = -1.0 C - D.O. meter needle stuck due to low air temperature
9	Arnold Slough at Cole Road	Thick ice - elctroshocker not used	T = -1.5 C - D.O. meter needle stuck due to low air temperature
10	Marshall Creek at Sumas Mtn Road	No fish captured - minimal ice	D.O. =8.3mg/L. - T = -0.5 C
11	Sumas River at South Parallel Road	95% ice cover - not shocked	D.O. =11.8mg/L. - T = 1.0 C
12	Sumas River at McDermott Road	95% ice cover - not shocked	D.O. =11.6mg/L. - T = -0.5 C
13	Stewart Slough at Boundary Road	1 redbside shiner, sculpin, stickleback, squawfish, chub coho, "trout", sucker	D.O. =9.9mg/L. - T = 3.0 C
14	Sumas Drainage Canal at Hwy 1 West	Ice too thick - not shocked	D.O. =9.6mg/L. - T = -0.5 C
15	Sumas River near No 1 Road	Ice too thick - not shocked	D.O. =11.6mg/L. - T = 0.5 C

Table 27 - continued
Sumas River Watershed Fisheries Survey Results

Date : December 15, 1993

Weather : sunny; mild; no wind

Site	Location	Fish Captured	Notes
7	Sumas River at Vye Road	1 squawfish juv., 2 sculpin, 1 lamprey (smaller area shocked due to high water)	D.O. =7.2mg/L. - T = 9.0 C hi turbidity, hi velocity
8	Saar Creek at Vye Road	3 juv. suckers; 1 sculpin, 2 stickleback (all below road) (smaller area shocked due to high water)	D.O. =7.0mg/L. - T = 8.8 C hi turbidity, hi veloc.; culvert not a barrier
9	Arnold Slough at Cole Road	1 juv. sucker, 2 stickleback	D.O. =8.4mg/L. - T = 3.7C hi turbidity, hi water level
10	Marshall Creek at Sumas Mtn Road	1 adult stickleback	D.O. =8.0mg/L. - T = 6.4 C mod. turb.& veloc.; new creek enters just d/s
11	Sumas River at South Parallel Road	1 rainbow ~200 mm, 1 redbreasted shiner (RSS) (smaller area shocked due to high water)	D.O. =7.8mg/L. - T = 9.4 C hi turbidity, hi water level
12	Sumas River at McDermott Road	1 juv. stickleback (smaller area shocked due to high water)	D.O. =7.8mg/L. - T = 8.6 C hi turbidity, hi water level
13	Stewart Slough at Boundary Road	coho presmolt 65mm, 1 squawfish 200mm, 5 adult sculpin, ~20 stickleback adult+fry	D.O. =8.5mg/L. - T = 8.8 C mod turbidity, mod. velocity
14	Sumas Drainage Canal at Hwy 1 West	2 juv. stickleback	D.O. =8.6mg/L. - T = 6.7 C hi turbidity, hi water level
15	Sumas River near No 1 Road	1 chinook fry, ~10 juv. sculpin	D.O. =7.8mg/L. - T = 6.9 C hi turbidity, hi water level

Table 27 - continued
Sumas River Watershed Fisheries Survey Results

Date : February 10, 1994

Weather : overcast/drizzle in AM; sunny breaks in PM: no wind; snow on ground

Site	Location	Fish Captured	Notes
7	Sumas River at Vye Road	1 CT 60mm, 5 squawfish ~120mm	D.O. =3.9mg/L. - T = 12.0 C brown turbidity mod level
8	Saar Creek at Vye Road	1 CO pre-smolt 90+mm, 3 stik, 3 LSSK	D.O. =4.0mg/L. - T = 8.8 C brown turbidity, mod level, (above culvert)
9	Arnold Slough at Cole Road	3 juv. RSS, 2 stik in normal area; at d/s corner of bridge, ~20 RSS, ~20 squawfish, ~6 LSSK together	D.O. =6.4mg/L. - T = 6.2 C brown turbidity lo level
10	Marshall Creek at Sumas Mtn Road	1 CO presmolt 90mm, 10 juv. stickleback	D.O. =5.9mg/L. - T = 8.1 C brown turbidity mod level
11	Sumas River at South Parallel Road	0 (one 7" squawfish dead on bank) 2 fishermen caught one 12" CT there last week	D.O. =4.6mg/L. - T = 8.8 C brown turbidity lo level
12	Sumas River at McDermott Road	3 stickleback	D.O. =3.7mg/L. - T = 10.6 C mod clear ice along edge
13	Stewart Slough at Boundary Road	1 CO presmolt 70mm, 6 squawfish, 4 adult sculpin, 7 stickleback, 1 RB 250mm, 1 LSSK 250mm	D.O. =6.3mg/L. - T = 10.6 C mod. clear, mod. level
14	Sumas Drainage Canal at Hwy 1 West	0 - mostly ice-covered	D.O. =2.1mg/L. - T = 8.2 C mod clear, hi turbidity, hi water level
15	Sumas River near No 1 Road	0 - ice-covered except boat launch	D.O. =1.5mg/L. - T = 9.2 C mod clear

Weather: overcast, calm AM; rain beginning 11:00;

Table 27 - continued
Sumas River Watershed Fisheries Survey Results

Date : March 3, 1994

sunny PM (heavy rain earlier in week)

Site	Location	Fish Captured	Notes
7	Sumas River at Vye Road	2 sculpin	D.O. =9.8mg/L. - T = 7.8 C - pH = 6.1 v. turbid, v. high
8	Saar Creek at Vye Road	1 CO 60mm, 2 stickleback	D.O. =8.1mg/L. - T = 9.1 C - pH = 6.2 v. turbid, v. high (above culvert)
9	Arnold Slough at Cole Road	0 fish; limited area sampled	D.O. =8.7mg/L. - T = 5.4 C - pH = 6.3 v. turbid, v. high
10	Marshall Creek at Sumas Mtn Road	0 fish	D.O. =8.8mg/L. - T = 7.2 C - pH = 6.6 turbid, high level
11	Sumas River at South Parallel Road	0 fish; limited area sampled	D.O. =9.2mg/L. - T = 7.5 C - pH = 7.3 v. turbid, v. high
12	Sumas River at McDermott Road	not sampled - flooded out	D.O. =9.0mg/L. - T = 8.0 C - pH = 7.1 v. turbid, v. high
13	Stewart Slough at Boundary Road	1 Coho 65mm, 1 squawfish, 2 sculpin, 3 stickleback, 1 redbreast shiner	D.O. =7.9mg/L. - T = 8.8 C - pH = 6.5 rel. clear, high level
14	Sumas Drainage Canal at Hwy 1 West	0 fish	D.O. =8.3mg/L. - T = 7.6 C - pH = 6.9 turbid, high level
15	Sumas River near No 1 Road	1 Coho 85mm; 2 stickleback, 3 sculpin	D.O. =9.1mg/L. - T = 7.7 C - pH = 6.8 v. turbid, high level

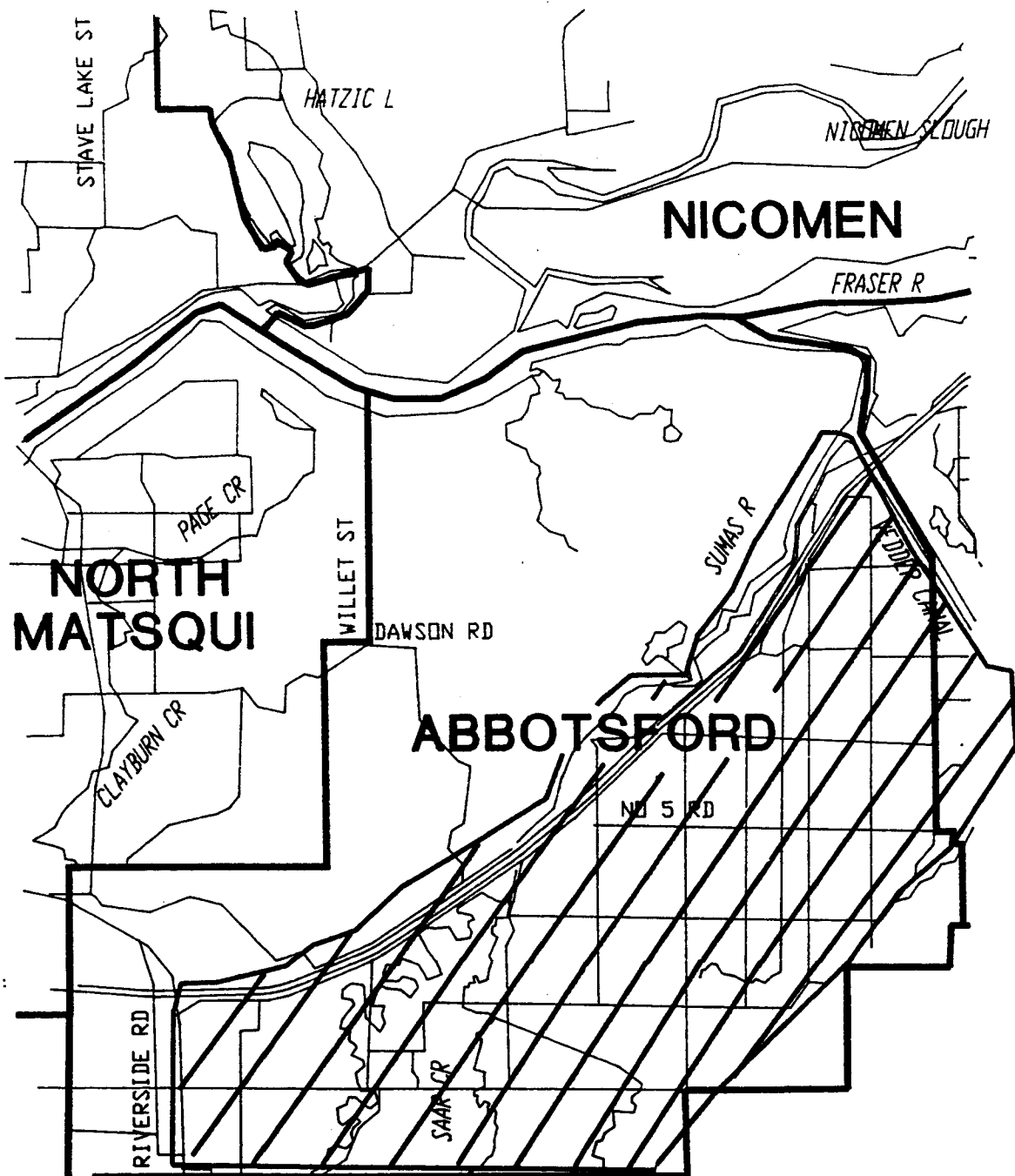
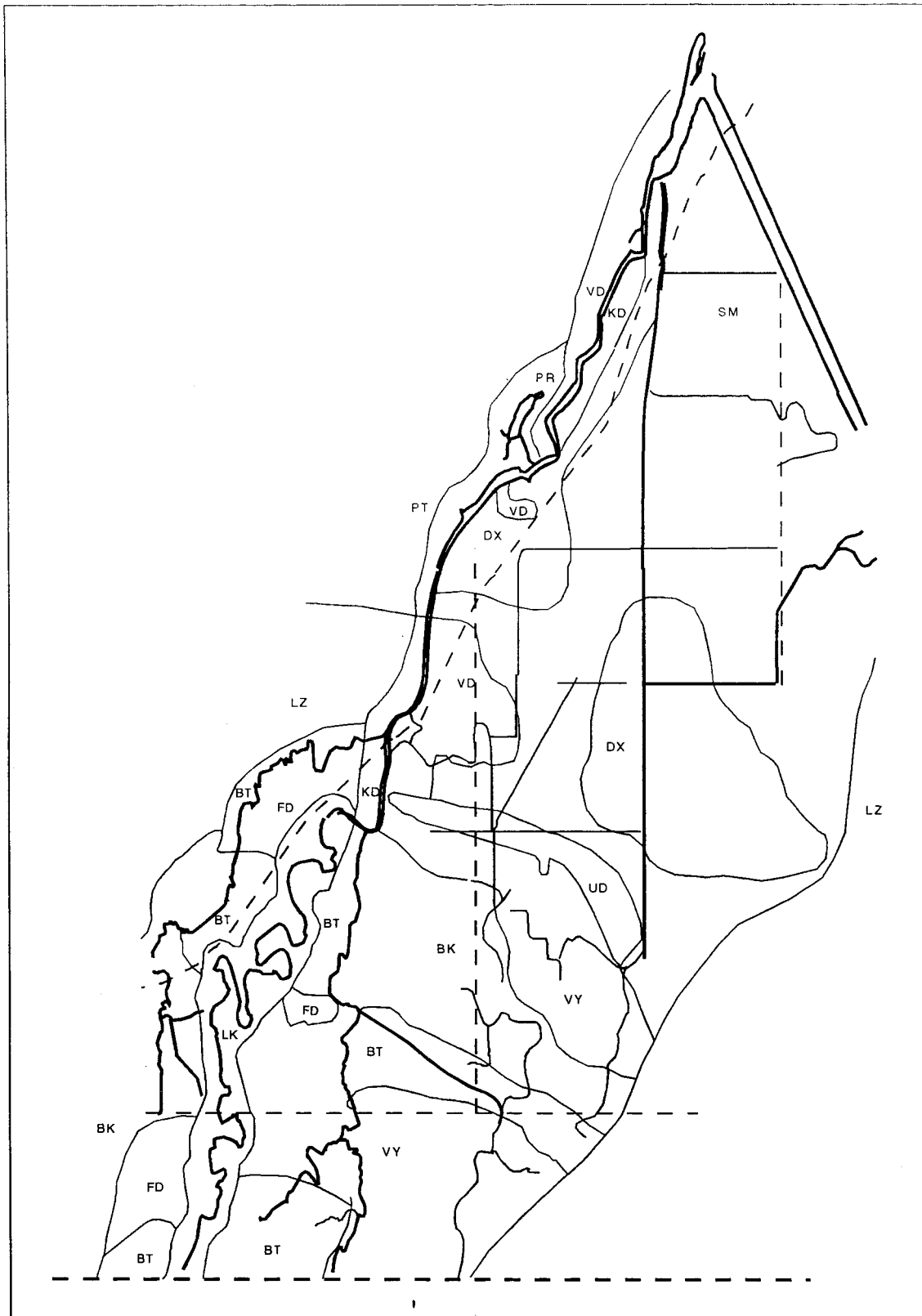


Figure 1
Sumas River Watershed Study Area
within Abbotsford Zone

MOAFF, 1994. Study Zones of the Agricultural Inventory Project for the Lower Fraser Valley

Figure 3

Sumas River Watershed and Soil Map



Luttmerding, H.A., 1980. Soils of the Langley-Vancouver Map Area,
Volume 1: Soil Map Mosaics and Legend, Lower Fraser Valley.

Figure 4
Sumas River Watershed Dairy ESP Frequency Distribution

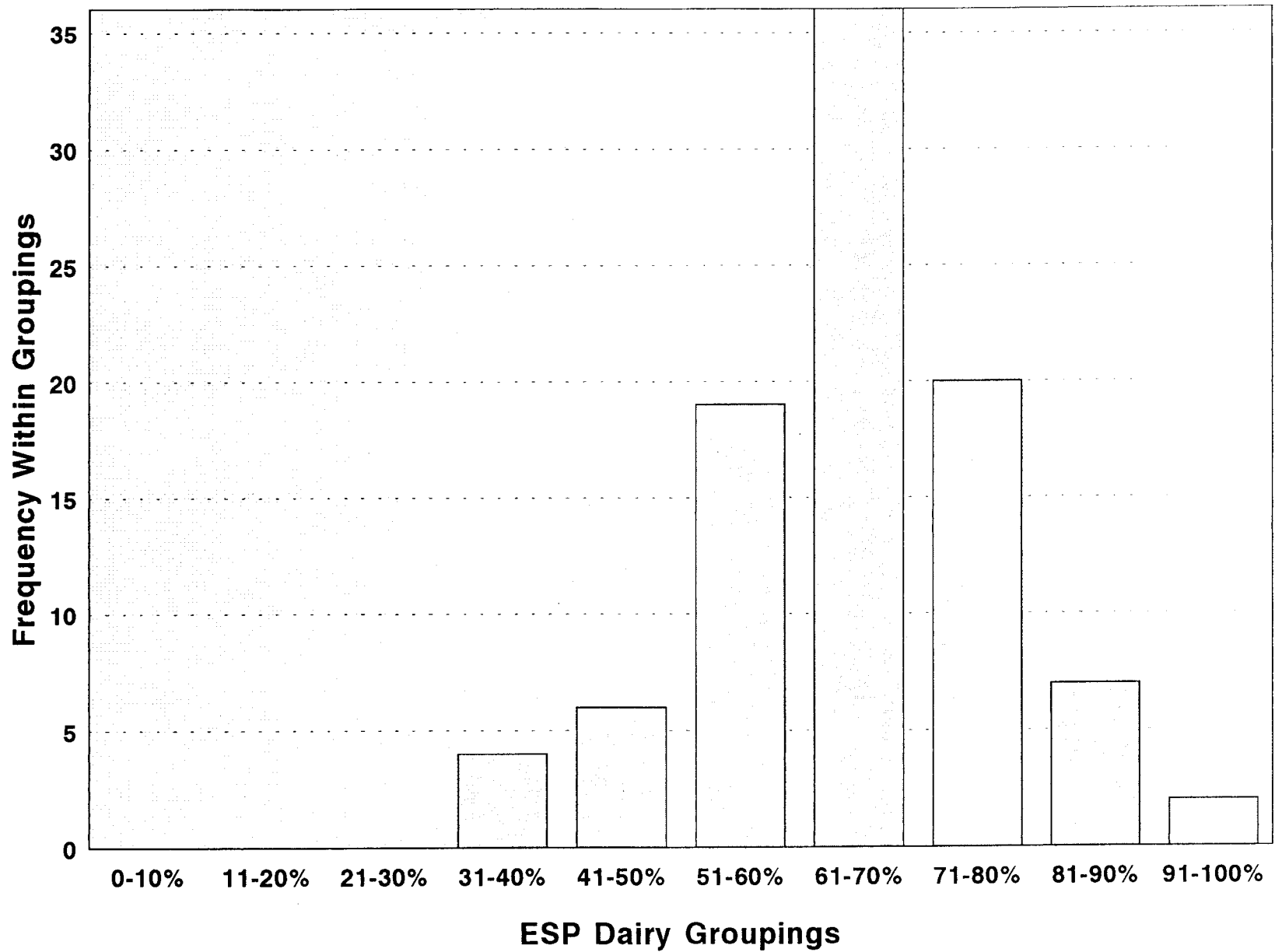


Figure 5
Sumas River Watershed Hog ESP Frequency Distribution

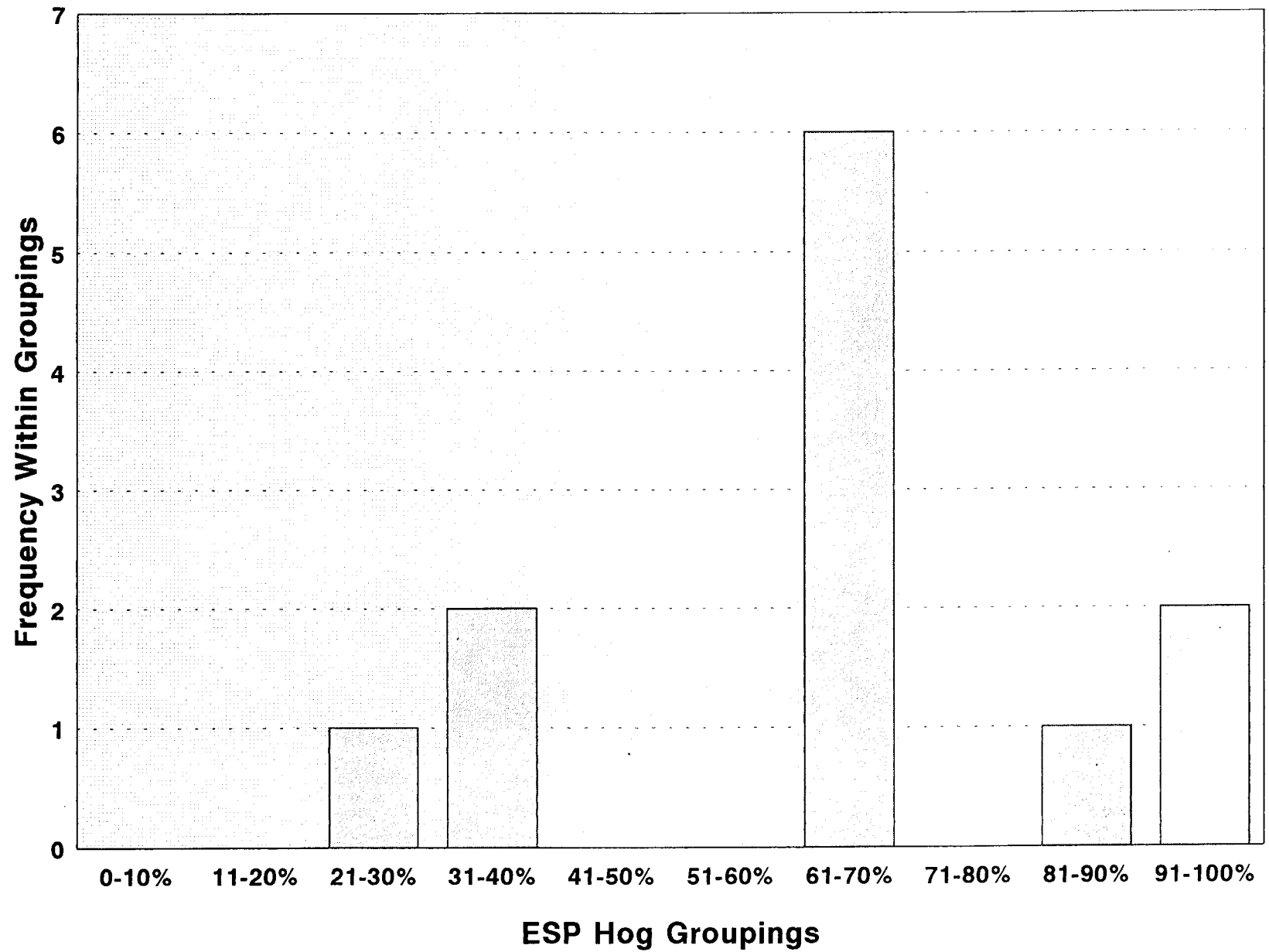


Figure 6
Sumas River Watershed Poultry ESP Frequency Distribution

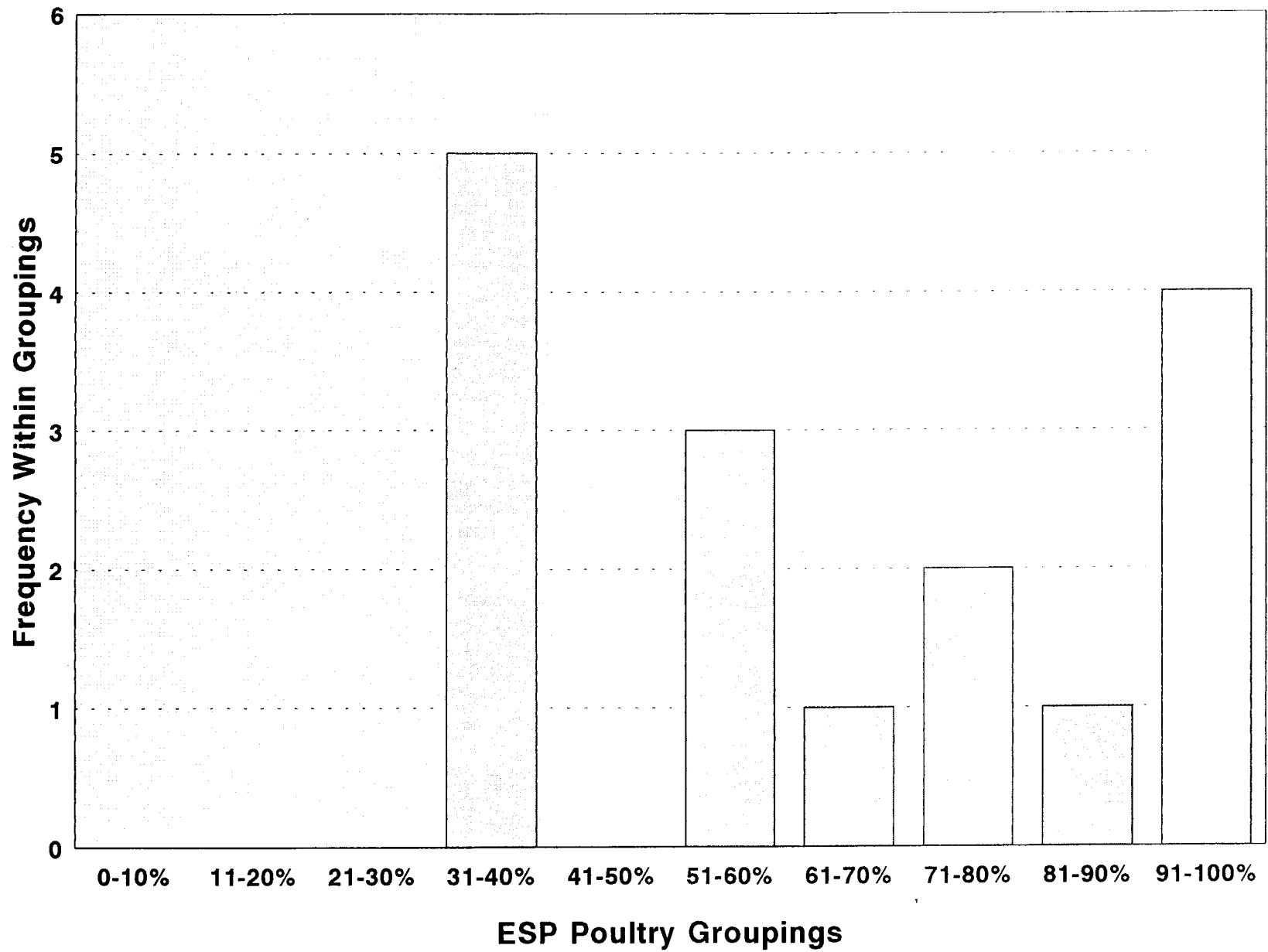


Figure 7

Sumas Basin Surface Water Quality Data: Ranges and Means for Fall 1993

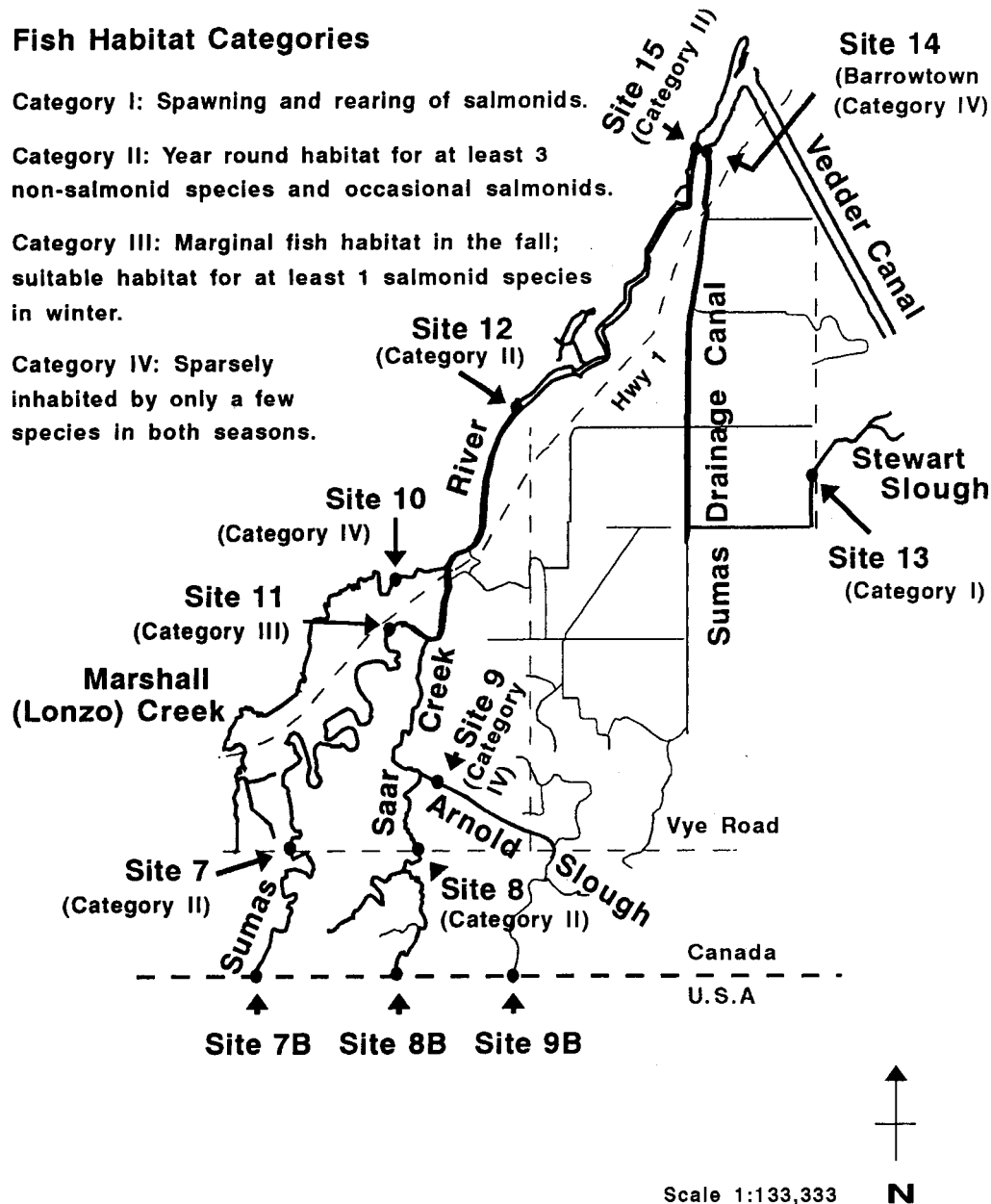
Fish Habitat Categories

Category I: Spawning and rearing of salmonids.

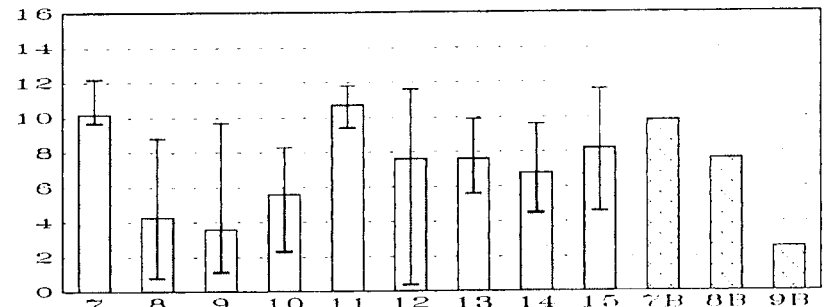
Category II: Year round habitat for at least 3 non-salmonid species and occasional salmonids.

Category III: Marginal fish habitat in the fall; suitable habitat for at least 1 salmonid species in winter.

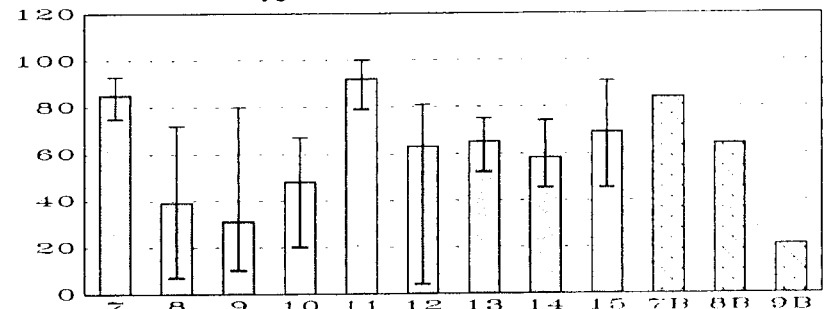
Category IV: Sparsely inhabited by only a few species in both seasons.



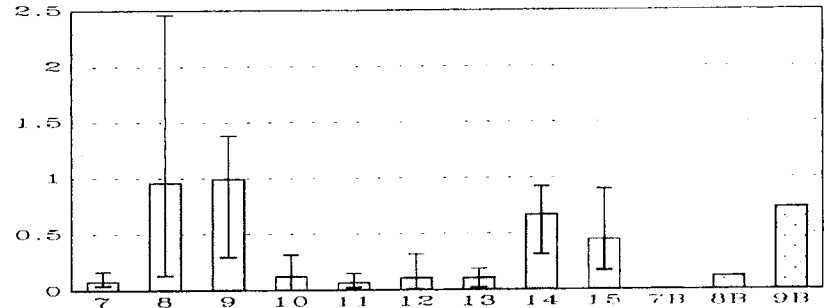
Dissolved Oxygen (mg/L)



Dissolved Oxygen % Saturation

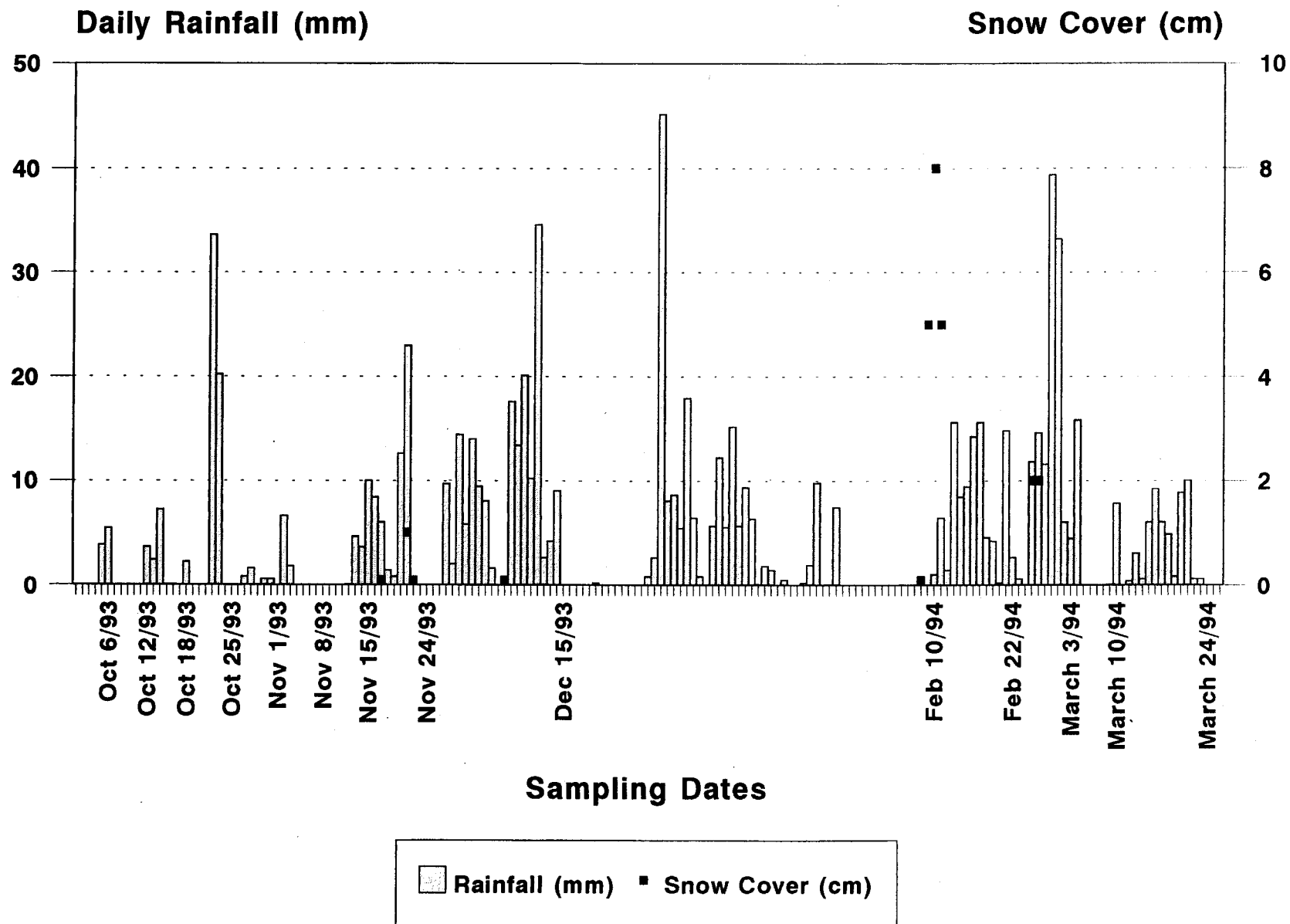


Total Ammonia Dissolved (mg/L)



Sampling Sites

Figure 8
Daily Rainfall (mm) from October 1993 to March 1994
Abbotsford Airport Station *



* Environment Canada Atmospheric Environment Service

APPENDIX A
SAMPLE NOTIFICATION LETTER, TELEPHONE INTERVIEW AND SITE VISIT SHEETS



Province of
British Columbia

MINISTRY OF ENVIRONMENT, LANDS AND PARKS
and MINISTRY RESPONSIBLE FOR
MULTICULTURALISM AND HUMAN RIGHTS

BC
Environment

Environmental Protection
15326 - 103A Avenue
Surrey, British Columbia
V3R 7A2
Telephone: (604) 582-5200
Fax: (604) 584-9751

File No. 43050-01

Attention:

On behalf of the Ministry of Environment, Lands and Parks, Integrated Resource Consultants (IRC) are conducting an Agricultural Land Use Inventory in the Matsqui Slough and Sumas River watersheds. This work is part of the Fraser River Action Plan (Green Plan) initiative in which industrial and other potential pollutant sources to the Fraser River system are catalogued.

The objective of this inventory is to identify farm management practices which could reduce the discharge of agricultural waste runoff to groundwater and surface waters. During the survey groundwater and surface water samples will be collected at a limited number of stations in both watersheds. The study will hopefully show that compliance with the existing Agricultural Waste Control Regulation and associated Code of Agricultural Practice will adequately protect the quality of the receiving environment.

It is our intention to work with the B.C. Federation of Agriculture in resolving concerns that are identified by the survey. Stakeholder groups could be formed in each watershed to discuss issues involving agricultural waste management and receiving environment impacts. The information collected during the survey could be presented in meetings with the local producers.

As part of this project, details on farm operations will be collected by telephone interviews with individual producers and site visits. Your co-operation in providing this information would be appreciated. If you have any questions please contact IRC (Karen Moore or Merv Palmer at 278-7714) or the Ministry of Environment, Land and Parks (Brent Moore at 582-5246 or Liz Freyman at 582-5318).

Sincerely,

M.C. Gow,
Head, Environmental Impacts Section

FRASER VALLEY WATER QUALITY SURVEY
AGRICULTURAL INVENTORY - TELEPHONE INTERVIEW

WATERSHED: MATSQUI _____ SUMAS _____ DATE: _____

GENERAL DATA:

FARM NAME: _____

ADDRESS: _____

TELEPHONE NO.: _____

OWNER: _____

OPERATOR: _____

TYPE OF OPERATION: _____

TOTAL SIZE: _____ ACRES

LEASES _____ ACRES TO _____

RENTS _____ ACRES FROM _____

AREA USED FOR -CROP PRODUCTION (SPECIFY CROPS):
YIELD AND PROTEIN LEVELS

_____ ACRES _____

_____ ACRES _____

_____ ACRES _____

-GRAZING: _____ ACRES - FEEDLOTS: _____ ACRES - BUILDINGS _____ ACRES

NO. OF ANIMALS: (BY TYPE - ANNUAL RANGE OR AVERAGE)

COMMENTS: _____

MANURE DATA:

MANURE PRODUCTION PER YEAR: _____

IMPORT OF MANURE PER YEAR: _____

EXPORT OF MANURE PER YEAR: _____

MANURE STORAGE: _____ PERMANENT

_____ COVERED _____ UNCOVERED

_____ CONCRETE _____ EARTHEN

_____ UNDER-CAGE STORAGE _____ UNDER-PEN STORAGE

CAPACITY OF FACILITY (TONS OR MONTHS): _____

PHYSICAL DIMENSIONS _____

_____ FIELD STORAGE _____ COVERED _____ UNCOVERED

APPLICATION: (SPECIFY AMOUNT, AREA, METHOD AND CROP)

DISPOSAL SEASON: _____

_____ ON-FARM _____

_____ OFF-FARM (SPECIFY LOCATION): _____

_____ CONTINGENCY SITE: (SPECIFY LOCATION): _____

WOODWASTE DATA:

TYPE: _____ SAWDUST _____ HOG FUEL _____ CHIPS _____ OTHER

USES: _____

STORAGE AND DISPOSAL PRACTICES: _____

MISCELLANEOUS:

HANDLING OF MORTALITIES: _____ ON-FARM _____ OFF-FARM (SPECIFY LOCATION)

LOCATION: _____

METHOD: _____

COMPOSTING FACILITY: _____ COVERED _____ UNCOVERED

MATERIALS COMPOSTED (LIST THEM) _____

SILAGE, MILK PARLOUR AND YARD RUNOFF:

TO TILE FIELD
TO MANURE PIT
TO SURFACE (NO COLLECTION)
TO DRAINAGE DITCH

CHEMICAL FERTILIZER APPLICATION -TYPE _____

-FREQUENCY _____ -AMOUNT _____

-CROPS _____

PESTICIDE APPLICATION _____ YES _____ NO

DISPOSAL OF CONTAINERS _____

IRRIGATION SYSTEM: TYPE: _____

WATER SOURCE: _____

NO. OF ACRES IRRIGATED: _____ FREQUENCY: _____

SEWAGE DISPOSAL: _____ SEWER CONNECTION _____ TILE FIELD - DATE INSTALLED: _____

DRINKING WATER: _____ MUNICIPAL _____ WELL

- DEPTH AND LOCATION _____

FUEL TANKS: _____ ABOVE GROUND _____ UNDERGROUND

YEAR OF INSTALLATION _____ REGISTERED WITH FIRE DEPARTMENT? _____

IF UNDERGROUND, IS IT >250 L VOLUME? _____

FRASER VALLEY WATER QUALITY SURVEY

AGRICULTURAL INVENTORY - SITE VISIT

DATE: _____

MUNICIPAL MAP: _____

PLAN NUMBER: _____

TRIMBLE GPS DATA FILES

FILE NAME	DESCRIPTION

PROXIMITY OF MANURE FACILITY TO WATER COURSE: _____

COMMENTS: _____

APPENDIX B
ELEMENTAL RESEARCH INC. ANALYTICAL DETECTION LIMITS AND DUPLICATES
ANALYSES FOR WINTER WATER QUALITY SAMPLES

ERI Ref: C0-001

Summary of Results of Duplicate Analysis - February 10, 1994 Sampling

Sample		Stn. 6	dup Stn. 6	Stn. 7	dup Stn. 7	Stn. 9	dup Stn. 9	Stn. 10	dup Stn. 10	Stn. 15	dup Stn. 15	Stn. 13	dup Stn. 13	Stn. 1	dup Stn. 1
Parameter	Units														
Alkalinity	mg CaCO3/L	130	130									60	58		
Hardness	mg/L			110	120										
pH	units			7.5	7.6										
Specific conductance	umhos/cm			320	320										
Total Organic Carbon	mg/L									2.3	2.3				
Turbidity	NTU			13	13										
Total Sus. Solids	mg/L			18	20										
Total Diss. Solids	mg/L			200	200										
Total Kjeldahl Nitrogen	mg/L					1.15	1.20								
Ortho Phosphate	mg P/L													0.007	0.007
Total Diss. Phosphate	mg P/L							0.058	0.063						
Total Phosphorous	mg P/L					0.285	0.228								

dup : duplicate sample

Summary of Results of Duplicate Analysis - February 22, 1994 Sampling

Sample		Stn. 1	dup Stn. 1	Stn. 2	dup Stn. 2	Stn. 6	dup Stn. 6	Stn. 10	dup Stn. 10	Stn. 11	dup Stn. 11
Parameter	Units										
Alkalinity	mg CaCO3/L					77	72				
Hardness	mg/L					58	63				
pH	units							6.7	6.9		
Specific conductance	umhos/cm							240	240		
Total Organic Carbon	mg/L			1.9	1.8			6.7	7.0		
Turbidity	NTU							26	26		
Total Sus. Solids	mg/L									72	74
Total Diss. Solids	mg/L									190	180
Free Ammonia	mg NH3-N/L			<0.005	<0.005			0.220	0.203		
Nitrate + Nitrite	(NO3+NO2)mg/L			1.84	1.75			6.29	5.58		
Total Kjeldahl Nitrogen	mg/L			0.36	0.33			1.20	1.20		
Total Nitrogen	mg/L			2.20	2.08			7.49	6.78		
Total Organic Nitrogen	mg/L			0.36	0.33			0.98	1.00		
Ortho Phosphate	mg P/L			0.005	0.002			0.042	0.041		
Total Diss. Phosphate	mg P/L			0.007	0.003			0.050	0.042		
Total Phosphorous	mg P/L			0.023	0.021			0.175	0.165		
Total Aluminum	ug/L	180	150								
Total Arsenic	ug/L	4.0	3.6								
Total Calcium	ug/L	13000	14000								
Total Cadmium	ug/L	0.11	0.09								
Chloride	mg/L							21	24		
Total Chromium	ug/L	7.1	6.2								
Total Cobalt	ug/L	0.24	0.20								
Total Copper	ug/L	2.3	1.9								
Total Iron	ug/L	720	640								
Total Potassium	ug/L	1200	1200								
Total Magnesium	ug/L	3400	3100								
Total Manganese	ug/L	100	87								
Total Mercury	ug/L	<0.05	<0.05								
Total Molybdenum	ug/L	0.73	0.70								
Total Nickel	ug/L	2.0	1.8								
Total Lead	ug/L	1.0	1.4								
Total Phosphorous	ug/L	<20	<20								
Total Sodium	ug/L	9000	8700								
Total Selenium	ug/L	<0.05	0.05								
Total Strontium	ug/L	84	76								
Total Tin	ug/L	0.04	0.04								
Total Zinc	ug/L	19	15								

dup : duplicate sample

Summary of Results of Duplicate Analysis - March 3, 1994 Sampling

Sample		dup Stn. 1 Stn. 1		dup Stn. 2 Stn. 2		dup Stn. 4 Stn. 4		dup Stn. 5 Stn. 5		dup Stn. 10 Stn. 10		dup Stn. 13 Stn. 13		dup Stn. 9 Stn. 9		dup Stn. 7 Stn. 7	
Parameter	Units																
Alkalinity	mg CaCO3/L	34	38									46	42				
Hardness	mg/L	39	37													96	89
pH	units			6.3	6.5							6.9	6.9				
Specific conductance	umhos/cm			49	51							120	120				
Total Organic Carbon	mg/L							5.7	5.5	8.9	7.7						
Turbidity	NTU			15	18							4.2	4.8				
Total Sus. Solids	mg/L					35	31							54	57		
Total Diss. Solids	mg/L					70	71							160	160		
Free Ammonia	mg NH3-N/L							0.260	0.260	0.300	0.240						
Nitrate + Nitrite	(NO3+NO2)mg/L							1.95	2.00	5.21	5.33						
Total Kjeldahl Nitrogen	mg/L							1.00	1.16	1.82	1.69						
Total Nitrogen	mg/L							2.95	3.16	7.03	7.02						
Total Organic Nitrogen	mg/L							0.74	0.90	1.52	1.45						
Ortho Phosphate	mg P/L							0.078	0.078	0.107	0.108						
Total Diss. Phosphate	mg P/L							0.082	0.081	0.112	0.109						
Total Phosphorous	mg P/L							0.148	0.120	0.282	0.273						
Total Aluminum	ug/L	330	320													2700	2900
Total Arsenic	ug/L	2.6	2.6														
Total Calcium	ug/L	15000	14000													20000	20000
Total Cadmium	ug/L	0.05	<0.03													0.050	0.050
Chloride	mg/L			3.0	3.5							4.5	5.0				
Total Chromium	ug/L	4.1	4.1													41	43
Total Cobalt	ug/L	0.41	0.39													13	12
Total Copper	ug/L	3.8	3.0													11	10
Total Iron	ug/L	890	850													6100	6600
Total Potassium	ug/L	2200	2100													9700	10000
Total Magnesium	ug/L	4600	4300													46000	47000
Total Manganese	ug/L	160	150													220	220
Total Mercury	ug/L	<0.05	<0.05													<0.05	<0.05
Total Molybdenum	ug/L	0.70	0.87													0.71	0.76
Total Nickel	ug/L	1.8	1.7													250	240
Total Lead	ug/L	0.96	0.93													0.88	0.91
Total Phosphorous	ug/L	80	60													400	350
Total Sodium	ug/L	6900	7300													6700	7700
Total Selenium	ug/L	<0.05	<0.05														
Total Strontium	ug/L	78	71													110	100
Total Tin	ug/L	0.11	0.10													<0.03	<0.03
Total Zinc	ug/L	16	12													20	18

dup : duplicate sample

ERI Ref: C0-001

Summary of Results of Duplicate Analysis - March 10, 1994 Sampling

Sample		dup Stn. 1		dup Stn. 13		dup Stn. 15	
Parameter	Units						
Alkalinity	mg CaCO ₃ /L			42	44		
Hardness	mg/L	27	32				
pH	units	6.3	6.6				
Specific conductance	umhos/cm	81	86				
Total Organic Carbon	mg/L	3.60	2.87			3.84	4.32
Turbidity	NTU	29	30				
Total Sus. Solids	mg/L	71	83				
Total Diss. Solids	mg/L	51	48				
Free Ammonia	mg NH ₃ -N/L	0.33	0.34			0.250	0.240
Nitrate + Nitrite	(NO ₃ +NO ₂)mg/L	1.14	1.20			2.83	3.03
Total Kjeldahl Nitrogen	mg/L	1.33	1.36			0.70	0.75
Total Nitrogen	mg/L	2.47	2.56			3.53	3.78
Total Organic Nitrogen	mg/L	1.00	1.02			0.45	0.51
Ortho Phosphate	mg P/L	0.022	0.022			0.105	0.105
Total Diss. Phosphate	mg P/L	0.022	0.022			0.108	0.110
Total Phosphorous	mg P/L	0.127	0.098			0.140	0.123

dup : duplicate sample

ERI Ref: C0-001

Summary of Results of Duplicate Analysis - March 24, 1994 Sampling

Sample		Stn. 1	dup Stn. 1	Stn. 2	dup Stn. 2	Stn. 5	dup Stn. 5	Stn. 9	dup Stn. 9	Stn. 10	dup Stn. 10	Stn. 4	dup Stn. 4	Stn. 11	dup Stn. 11
Parameter	Units														
Alkalinity	mg CaCO ₃ /L									80	82				
Hardness	mg/L	70	70												
pH	units			6.9	6.8										
Specific conductance	umhos/cm	180	180												
Total Organic Carbon	mg/L											4.2	4.5	4.2	5.4
Turbidity	NTU	5.3	4.9												
Total Sus. Solids	mg/L			5	7										
Total Diss. Solids	mg/L			53	50										
Free Ammonia	mg NH ₃ -N/L											0.127	0.124	0.195	0.192
Nitrate + Nitrite	(NO ₃ +NO ₂)mg/L											1.95	1.96	3.19	3.12
Total Kjeldahl Nitrogen	mg/L											0.51	0.49	0.50	0.45
Total Nitrogen	mg/L											2.46	2.45	3.69	3.57
Total Organic Nitrogen	mg/L											0.38	0.37	0.30	0.26
Ortho Phosphate	mg P/L							0.016	0.014						
Total Diss. Phosphate	mg P/L			0.006	0.005										
Total Phosphorous	mg P/L					0.066	0.065								

dup : duplicate sample