Water Quality

Water Quality Assessment And Objectives For The Fraser River From Moose Lake To Hope

Summary Report

Water Management Branch
Environment And Resource Division
Ministry Of Environment, Lands And Parks

Prepared Pursuant To Section 2(E) Of The
Environment Management Act, 1981

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August, 1997.

DISCLAIMER

This report is part of the British Columbioa Ministry of Environment, Lands and Parks' *Water Quality Assessment and Objectives* series. It has received formal review and approval from the Ministry. Environment Canada's Fraser River Action Plan provided funds for the production of this report. Its contents do not necessarily reflect the views and policies of Environment Canada.

Canadian Cataloguing in Publication Data
Swain, L. G. (Leslie Grant), 1950-
Water quality assessment and objectives, for the Fraser River
from Moose Lake to Hope

Consists of two parts: An overview and a report,
of which the overview is also available as a separate document.
Includes bibliographical references: p.

ISBN 0-7726-7726-3415-7

1. Water quality - British Columbia - Fraser River.
I. Walton, Douglas George, 1953- ., II. Obedkof, W.
III. BC Environment. Water Management Division. IV. Title

TD227.F7S927 1997 363.739'42'097113 C97-960321-

SUMMARY

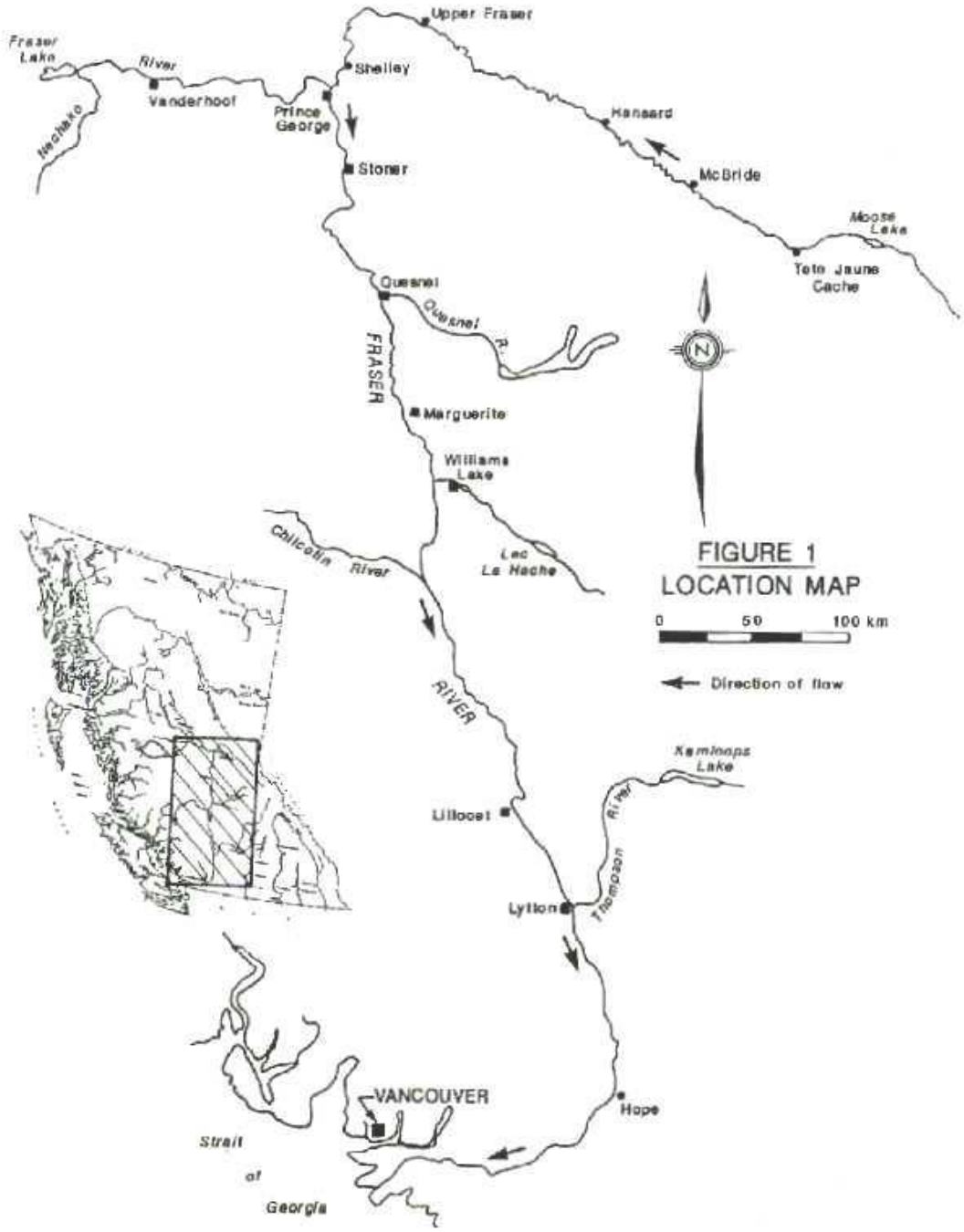
This document is one in a series that describes ambient Water Quality Objectives for British Columbia. It has two parts: the following overview and a technical appendix which is available as a separate document. The overview provides general information about water quality in the main stem of the Fraser River from Moose Lake to Hope in three main River reaches. These reaches are from Moose Lake to Tete Jaune Cache, from Tete Jaune Cache to the Nechako River confluence, and from the Nechako River confluence to Hope. The technical appendix presents details of a recent water quality assessment for these reaches and forms the basis for recommendations and objectives presented in the overview. The overview is intended for both technical readers and others who may not be familiar with the process of setting water quality objectives. Separate tables listing water quality objectives and monitoring recommendations are included for those readers requiring data about these waterbodies. A separate report will be published on water quality objectives for the Fraser River from Hope to Sturgeon and Roberts Banks.

The Fraser River is home to both resident and anadromous species of fish. There are 26 species of resident fish documented as being in the Fraser River above Hope, with most species being in the river as far north as the Chilcotin River. Salmonid species are present in large numbers and make the Fraser River a world-class system for these fish species. Runs have increased during the 1980s for all species of salmon in the River. This same decade had the largest average runs for chinook, chum, and sockeye salmon. Consistent achievement of water quality objectives in the Fraser River is critical for the continued success and sustainability of the Fraser's salmon resource.

Most water contamination in the River above Hope is related to treated wastewater discharges from pulp and paper mills located at Prince George and Quesnel as well as treated municipal sewage discharges from Prince George, Williams Lake, Quesnel, Lytton, and Lillooet. Flows from the Thompson River, a tributary to the Fraser, carry the treated wastewater from a pulp mill and a municipal sewage discharge from the City of Kamloops.

This report describes the specific Water Quality Objectives recommended to protect aquatic life, wildlife, livestock watering, irrigation, and drinking water supplies in all three reaches of the Fraser River Basin from Moose Lake to Hope. The objectives have been prepared for Environment Managers for use in determining the effectiveness of different pollution prevention controls which are being used.

Figure 1. The Fraser River from Moose Lake to Hope: Location Map



PREFACE

Purpose of Water Quality Objectives

Water quality objectives are tools that support the effective management of water resources. They describe conditions that water managers have agreed should be met in order to protect the most sensitive designated uses of freshwater, estuarine, and coastal marine ecosystems. They are used in conjunction with other management tools, such as effluent controls, best management practices, and best available or best practicable wastewater treatment technology (BAT/BPT), to achieve high standards of water quality.

Water quality objectives are being jointly prepared by Environment Canada and the Ministry of Environment, Lands, and Parks, as part of their respective mandates for responsible water resource management. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity, either now or in the future.

How Objectives Are Determined

Water quality objectives are based on water quality guidelines and criteria. The Canadian water quality guidelines, which are developed by the Canadian Council of Ministers of the Environment (CCME), are numerical concentrations or narrative statements for chemical, physical, radiological, and biological variables that are recommended to support and maintain designated water uses. Like water quality guidelines, water quality criteria also relate the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment to their effects on water use, but differ in that they are developed by the Ministry of Environment, Lands and Parks.

Water quality objectives are numerical concentrations or narrative statements which have been established to support and protect the most sensitive designated use of water at a specified site (BCMOELP 1986; CCREM 1987). They are derived from the guidelines and criteria by considering local water quality, water uses, water movement, waste discharges and other factors.

Water quality objectives are based on the best scientific information available at the time the objectives are developed. When insufficient information exists, provisional water quality objectives may be applied until the data required to develop permanent water quality objectives are available. Provisional objectives are deliberately conservative. To facilitate the establishment of permanent objectives, a monitoring or study program is usually recommended to fill any data gaps that are identified.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. Designated uses of water include the following:

- raw drinking water, public water supply, and food processing;
- fish, other aquatic life, and wildlife;
- agriculture (livestock watering and irrigation);
- recreation and aesthetics; and,
- industrial water supplies.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical, or biological characteristics affecting that waterbody.

How Objectives Are Used

Water quality objectives have no legal standing at this time and, therefore, cannot be directly enforced. In British Columbia, water management objectives are achieved through the issuance of permits for effluent discharges, monitoring of the volumes and concentrations of contaminants discharged, inspection of farms, streambank restoration, erosion control, and enforcement of environmental legislation when violations occur. The limits on effluent discharges are generally based upon the best available technology for wastewater treatment; however, the objectives have also been used to support the permitting process in recent years.

Water quality objectives are important water management tools because they provide policy direction for resource managers with respect to the protection of water uses in specific waterbodies. Objectives provide benchmarks for evaluating water quality, issuing wastewater discharge permits, dispersing water withdrawal licences and orders, and managing fisheries and the province's land base. They also provide reference points against which the state of water quality can be checked and help to determine whether additional management actions are needed to protect and/or restore the designated water uses in a particular waterbody.

Objectives and Monitoring

Water quality objectives are established to protect all the uses which take place in a water body. To determine if the objectives are being met and if the water uses are being protected, monitoring programs are usually specified along with the objectives. Monitoring should take place at critical times when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at critical times, then they will also be protected at other times when the threat is less severe. The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as average, conditions in the water. For some water bodies, the monitoring period and frequency will vary with the nature of the problem, the severity of threats to designated water uses, and the way the objectives are expressed (*i.e.*, mean value, maximum value, etc.).

INTRODUCTION

The Fraser River drains about one-quarter of the Province of British Columbia, and extends from the Alberta-British Columbia border in the north and east, to the estuary and the River confluence with the Strait of Georgia, in the south and west of the Province (see Figure 1). The purpose of this report was to develop Water Quality Objectives in the Fraser River from Hope to Moose Lake to provide policy direction to resource and environment managers for the protection of designated uses of waterbodies within the stretch of the waterbody defined by this report. Others that may find the information useful include environmental scientists and other agency staff including regulators, habitat biologists, and water quality specialists. The public will also find the Water Quality Objectives useful for assessing the health of their environment, articulating concerns about existing uses of resources in their environment, and monitoring the performance of various government agencies cooperating to maintain acceptable high levels of water quality in the Fraser River Basin.

Profile of the Fraser River from Moose Lake to Hope

HYDROLOGY

The Fraser River exhibits a classic perpetual annual snow melt hydrograph pattern due to its extensive snow pack and massive basin storage. High flows take place from May to August, with 64% of the annual volume runoff taking place during this time. Low flow months are consistently between November and April. The extreme lowest mean monthly discharges (ten year, seven-day low flows in parentheses) have ranged from 4.06 (4.10) m^3/s at Red Pass, to 20.6 (21.0) m^3/s at McBride, to 97 (110) m^3/s at Shelley (just upstream from Prince George), to 218 (232) m^3/s at Marguerite (downstream from Quesnel), to 482 (563) m^3/s at Hope. These compare to extreme high flows at the same stations of 235 m^3/s, 918 m^3/s, 3470 m^3/s, 5390 m^3/s, and 10800 m^3/s, respectively.

WATER USES

Water uses in each of the three reaches of the Fraser River designated in this document are similar. Consumptive water uses include domestic water supply (including livestock watering) withdrawals in all three reaches, and irrigation water supplies below Prince George. Fisheries values are considered to be high, with 26 resident species using the river upstream from Hope, and five salmon species migrating to and spawning in tributaries upstream from Hope. The returns of these five species increased during the 1980's, with the largest average runs for the decade being recorded in the 1980's for chinook, chum, and sockeye salmon.

Recreational water use along the Fraser River is generally limited, since the precipitous geography of the upper and middle Fraser reaches allows for only a low to moderate recreational use. Primary-contact recreation does not normally occur along the Fraser River itself, since the tributaries are generally warmer and less turbid. River rafting (secondary-contact) is popular, with over 60 companies using the Fraser River or 36 of its tributaries.

WASTE WATER DISCHARGES

There are no significant direct discharges of wastewater to the Fraser River between Moose Lake and Tete Jaune Cache. The most significant discharges to the Fraser River between Tete Jaune Cache and the Nechako River confluence are from the Northwood Pulp Mill and the Prince George Pulp and Intercontinental Mills at Prince George. Significant improvements to effluent quality have been made at all pulp mills since 1991. Downstream from the Nechako River confluence are municipal-type discharges from the Prince George area, treated sewage discharges from Williams Lake, Lytton, and Lillooet, as well as discharges from the two pulp mills (and the municipal-type discharge) at Quesnel.

Non-point sources are also impacting water quality, especially forestry operations, in every major tributary entering the mainstem Fraser. Studies performed on the impacts of forestry on fish habitat or

water quality indicate that historically, there has been severe sedimentation of stream gravel used for salmonid spawning and greatly increased sediment and nutrient loadings which have reduced light penetration. This type of degradation should be improved significantly when future forest practices are undertaken in compliance with the new Forest Practices Code of BC Act.

Agricultural inputs to the Fraser River are likely greatest downstream from Hope. In this reach of the river, considerably more land is in agricultural use, more fertilizers are used, and more livestock are housed. These activities lead to increased ammonia, nutrient, oxygen-demanding and bacteriological loadings to the river. In the urbanized areas of the watershed, stormwater runoff increases concentrations of metals, nutrients, and suspended solids.

Water Quality Assessment and Objectives

WATER QUALITY ASSESSMENT

The data examined in the present assessment indicate that the water quality of the Fraser River was generally fair to good in all reaches. Information on water and sediment quality, contaminants in fish tissues, and the abundance and diversity of benthic invertebrate populations near the major effluent discharges were evaluated. The River was generally well-buffered to acidic inputs, with moderate water hardness. Metal concentrations generally met guidelines to protect aquatic life. Dissolved oxygen concentrations were occasionally below the guidelines for minimum concentrations to protect aquatic life. Colour was generally below guidelines for drinking water supplies but turbidity and suspended solids concentrations were such that water would require filtration for drinking water supplies. Bacteriological concentrations were generally below guidelines for drinking water supplies.

The highest concentrations of organochlorine compounds in sediments were found at sites downstream from Hope, likely due to slower river velocities in this area. Reduced flow allows finer sediment particles, which adsorb higher concentrations of organics, to settle out.

Resident fish from Moose Lake had the highest lead and molybdenum concentrations in muscle along the length of the river. Fish from McBride had the highest concentrations in muscle of cadmium, copper, chromium, and nickel. Fish collected near Lillooet had the highest concentrations of arsenic, cadmium, copper, and zinc in livers. Dioxins and furans in fish collected upstream from Prince George and upstream from the Nechako River confluence were low compared to fish collected from below the pulp mills at Prince George and Quesnel. Mountain whitefish collected downstream from Quesnel had the highest dioxin and furan concentrations. It is important to note that levels of dioxins and furans have declined dramatically over the past few years. None of these levels were sufficiently high to be of concern from the perspective of human consumption, and no fisheries closures took place as a result.

WATER QUALITY OBJECTIVES

Water Quality Objectives proposed for the three reaches of the Fraser River from Moose Lake to Hope are summarized in Table 1. The objectives are based on BC approved and working criteria, the Canadian Water Quality Guidelines developed by the Canadian Council of Ministers of the Environment for water quality, and on available data on ambient water quality, waste discharges, water uses, and stream flows.

Where insufficient information exists, provisional Water Quality Objectives may be applied until the data required to develop formal, definitive Water Quality Objectives are available. Provisional objectives are deliberately conservative, and a monitoring or study program is specified that will lead to the establishment of permanent objectives. Permanent objectives are established when the information available about the local conditions and water quality guidelines is complete.

Depending on the circumstances, Water Quality Objectives may already be met in a waterbody, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by human activity now and in the foreseeable future.

Designated water uses for all three reaches of the Fraser River from Moose Lake to Hope are for the protection of aquatic life, wildlife, recreation, livestock watering, and drinking water supplies. Irrigation water is to be protected downstream from Prince George.

Water Quality Objectives which are based on approved or draft BC water quality guidelines include those for dioxins and furans, chlorophenols, microbiological indicators, ammonia, nitrite, nitrate, and pH. The objectives are required to ensure that inputs from non-point source discharges, pulp and paper mills, and the sewage treatment plants do not impair water uses. An objective is proposed for pH as a range of values. The upper value will control the formation of toxic quantities of ammonia. Different dissolved oxygen levels, based on the Ministry's modification of the CCREM (now known as the CCME) guidelines in the Technical Appendix, are proposed for the waterbodies.

MONITORING RECOMMENDATIONS

Monitoring programs should be designed and coordinated to determine the degree to which Water Quality Objectives are being met. Monitoring of ecosystem responses will provide a means of identifying situations where more restrictive effluent standards may be required or where Water Quality Objectives need to be adjusted to meet water management goals.

The long-term purpose of monitoring is to detect a pre-determined degree of change at a significant frequency when monitoring is performed at a level of effort to confer reliable information. If a parameter is consistently within one order of magnitude of the Water Quality Objective, monitoring should be continued at the same frequency. If the objective is exceeded, the monitoring effort should be increased to determine the extent the objective is exceeded. The actual monitoring undertaken will depend upon regional resources.

A recommended monitoring design is included as Table 6. Should the objectives be exceeded, some water uses may be threatened at some time in the future.

WATER QUALITY OBJECTIVES AND MONITORING TABLES
The following tables provide a summary of the objectives data and monitoring recommendations.

To protect water uses in a waterbody, objectives specify a range of values for characteristics (variables) that may affect these uses. These values are maximum and/or minimum values that are not to be exceeded.

Some readers may be unfamiliar with terms such as: maximum concentration, 30-day average concentration, 90th percentile, and not applicable (NA). Maximum concentration means that a value for a specific variable should not be exceeded; 30-day average concentration means that a value should not be exceeded during a period of 30 days, when five or more samples are collected at approximately equal time intervals. The term 90th percentile indicates that 9 out of 10 values should be less than a particular value. Not applicable (NA) means that water uses are not threatened for that particular variable.

Table 1. Water Quality Objectives for the Fraser River from Moose Lake to Hope.

Designated Water Uses: aquatic life, wildlife, livestock watering, irrigation, secondary-contact recreation, drinking water (partial treatment)

Table 1a. Water Quality Objectives for the Fraser River from Moose Lake to Tete Jaune Cache.

Characteristics	Fraser River from Moose Lake to Tete Jaune Cache
suspended solids	10 mg/L maximum increase when u/s background is less than 100 mg/L ..... 10% maximum increase when u/s background is greater than 100 mg/L
turbidity	5 NTU maximum
true colour	15 TCU maximum
pH	6.5 to 8.5

total lead	**0.8 microgram/g maximum in edible fish muscle**
total PCBs	**2.0 microgram/g maximum in edible fish muscle** **.....** **0.1 microgram/g maximum in whole fish**

Table 1b. Water Quality Objectives for the Fraser River from Tete Jaune Cache to Hope.

Characteristics	**Fraser River from Tete Jaune Cache to Hope**
suspended solids	**10 mg/L maximum increase** **when u/s background is less than 100 mg/L** **.....** **10% maximum increase** **when u/s background is greater than 100 mg/L**
turbidity	**1 NTU maximum increase when the u/s control is less than 5 NTU** **.....** **5 NTU maximum increase when the u/s control is between 5 and 50 NTU** **.....** **10% maximum increase when the u/s control is over 50 NTU**
true colour	**15 TCU maximum from June to September** **.....** **75 TCU maximum from October to May** **.....** **10% maximum increase over the u/s control** **when the u/s control exceeds 15 or 75 NTU, respectively**
pH	**6.5 to 8.5**
total lead	**0.8 microgram/g maximum in edible fish muscle**
total PCBs	**2.0 microgram/g maximum in edible fish muscle** **.....**

	0.1 microgram/g maximum in whole fish
fecal coliforms	less than or equal to 100/cL 90th percentile
enterococci	less than or equal to 25/cL 90th percentile
total chlorine residual	average less than or equal to 2 micrograms/L
temperature	maximum change 1 degree Celcius
total ammonia-N	AMMONIA TABLE
nitrite-N	NITRITE TABLE
Nitrite-N + Nitrate-N	10 mg/L maximum
Periphyton Chlorophyll-a	50 mg/m^2 maximum
Dissolved oxygen	the higher of 80% saturation or 8.0 mg/L minimum ... 11.0 mg/L when salmonid embryos and larvae are present from November to April
Chlorophenols	CHLOROPHENOL TABLE
AOX	no increase at the 95% confidence level
Dehydroabietic acid	maximum 8 micrograms/L at pH 7.0 ..... maximum 12 micrograms/L at pH 7.5
Total resin acids	maximum 25 micrograms/L at pH 7.0 ..... maximum 145 micrograms/L at pH 7.5
Dioxins and Furans 2,3,7,8-T_4CDD equivalents	maximum 0.06 pg/L dissolved in water ..... maximum 0.25 pg/g normalized to 1% organic carbon in

	sediments **.....** **maximum 50 pg/g wet weight in lipids of fish muscle or fish eggs**

Note: While water quality objectives do not apply in initial dilution zones where acutely toxic conditions are not permitted, they do apply to discrete samples of water and sediment from all other parts of the Fraser River from Moose Lake to Hope. In practice, the extent of the initial dilution zone is defined on a site specific basis, with due regard to water uses, aquatic life, including migratory fish, and other waste discharges. However, where sufficient site-specific data is not available for defining initial dilution zones for the objectives established, provisional initial dilution zones will be defined as extending up to 100 metres downstream from a discharge, and occupying no more than 25% of the stream width around the discharge point, from the bed of the stream to the surface. It is also important to note that objectives for fish apply to all parts of the river, including fish in the initial dilution zone.
-Not Applicable means no water quality objective is recommended.
-For fecal coliforms and enterococci the 90th percentiles are calculated from at least five weekly samples collected in a period of thirty days. For values recorded as less than the detection limit, the detection limit itself should be used in calculating the statistic. The 90th percentile can be extrapolated by graphical methods when fewer than ten samples are collected.
-For turbidity and suspended solids the increase in mg/L or NTU is over levels measured at a site upstream from a discharge or series of discharges and as close to them as possible, and applies to downstream values.
-The maximum chlorophyll-a is based on an average calculated from at least five randomly located samples from natural substrates at each site on any sampling date.
-For pH measurements may be made in situ but must be confirmed in the laboratory if the objective is not achieved.

Table 6. Recommended Water Quality Monitoring for the Fraser River from Moose Lake to Hope.

Site and Location	Sampling Frequency and Dates	Variables
new site	**5 times weekly**	**suspended solids, turbidity**

Fraser River at outlet from Moose lake	**in 30 days ..... May to June**	
new site Fraser River at Red Pass		
E206580 Fraser River at Hansard	**5 times weekly in 30 days ..... January to March ..... except sediment Dioxins and Furans which are only sampled once with 3 replicates per site**	**suspended solids, turbidity, dissolved oxygen, pH, temperature, MF fecal, enterococci, *Escherichia coli*, residual chlorine, ammonia-N, nitrate-N, nitrite-N, true colour, AOX, dehydroabietic acid, total resin acids, dioxins and furans in the water column and in the sediments**
new site Fraser River above the Nechako River confluence and below the mills outfalls		
new site Fraser River above Quesnel		
0600011 Fraser River below Quesnel (Marguerite)		
E206581 Fraser River at Hope		
E206580 Fraser River at Hansard	**once ..... July to September**	**periphyton chlorophyll-a on suitable natural substrates, 5 replicates ..... lead, PCBs, Dioxins and Furans in a minimum of 3 species of fish with at least 5 specimens of each species at each site**
E206580 Fraser River at Stoner		
new site Fraser River above Quesnel		
0600011 Fraser River below Quesnel (Marguerite)		
E206581 Fraser River at Hope		

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