Water Quality Unit

Ambient Water Quality Objectives For The Peace River Mainstem

Overview Report

Resource Quality Section
Water Management Branch
Ministry Of Environment And Parks

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

Original Signed By T. R. Johnson
Deputy Minister
Ministry Of Environment and Parks
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TABLE OF CONTENTS

- **Figure 1** Peace River sub-basin showing effluent discharges, receiving water sites and water withdrawals
- **Tables**
  - **Table 1.** Provisional Water Quality Objectives for the Peace River Mainstem sub-basin
  - **Table 2.** Average 30-day Concentration of Total Ammonia Nitrogen for Protection of Aquatic Life.
  - **Table 3.** Maximum and 30-day average Allowable Nitrite (N) Concentration
  - **Table 4.** Recommended Routine Effluent and Receiving Water Monitoring Programs for the Peace River Mainstem sub-basin.
- **Summary**
- **Preface**
- **Introduction**
- **Hydrology and Oceanography**
- **Water Uses**
- **Waste Discharges**
- **Water Quality**
- **Provisional Water Quality Objectives**
- **Monitoring Recommendations**

SUMMARY
This report assesses the water quality of the Peace River between the Bennett Dam and the BC-Alberta border. Water quality objectives are set to protect its use for drinking water, aquatic life, recreation, wildlife, livestock and irrigation.

River water is used, after partial treatment, to supply the Village of Taylor and the District of Hudson's Hope. The river is also important for sports fish, recreation and some irrigation.

The main discharges to the river are secondary-treated effluent from the City of Fort St John and treated effluent plus cooling water from the Petro-Canada oil and gas plant at Taylor. The municipal effluent contributes to downstream fecal coliform levels and there is a possibility that certain hydrocarbons from the refinery complex could have some effect on aquatic life. A pulp mill is being built at Taylor for completion in late 1988. Its possible impact on the river has yet to be assessed.

The water quality of the Peace River is, generally, in a natural state. Provisional water quality objectives set for fecal coliforms, dissolved oxygen and turbidity to protect recreation are being met, although fecal coliforms sometimes exceed drinking eater objectives in the river. More data are needed to ascertain whether objectives set for trace metals and certain organic and inorganic contaminants are being met. A comprehensive monitoring program is therefore proposed.

Return To The Table of Contents

Figure 1a. Peace (east) Peace River sub-basin showing effluent discharges, receiving water sites and water withdrawals (east half of map)

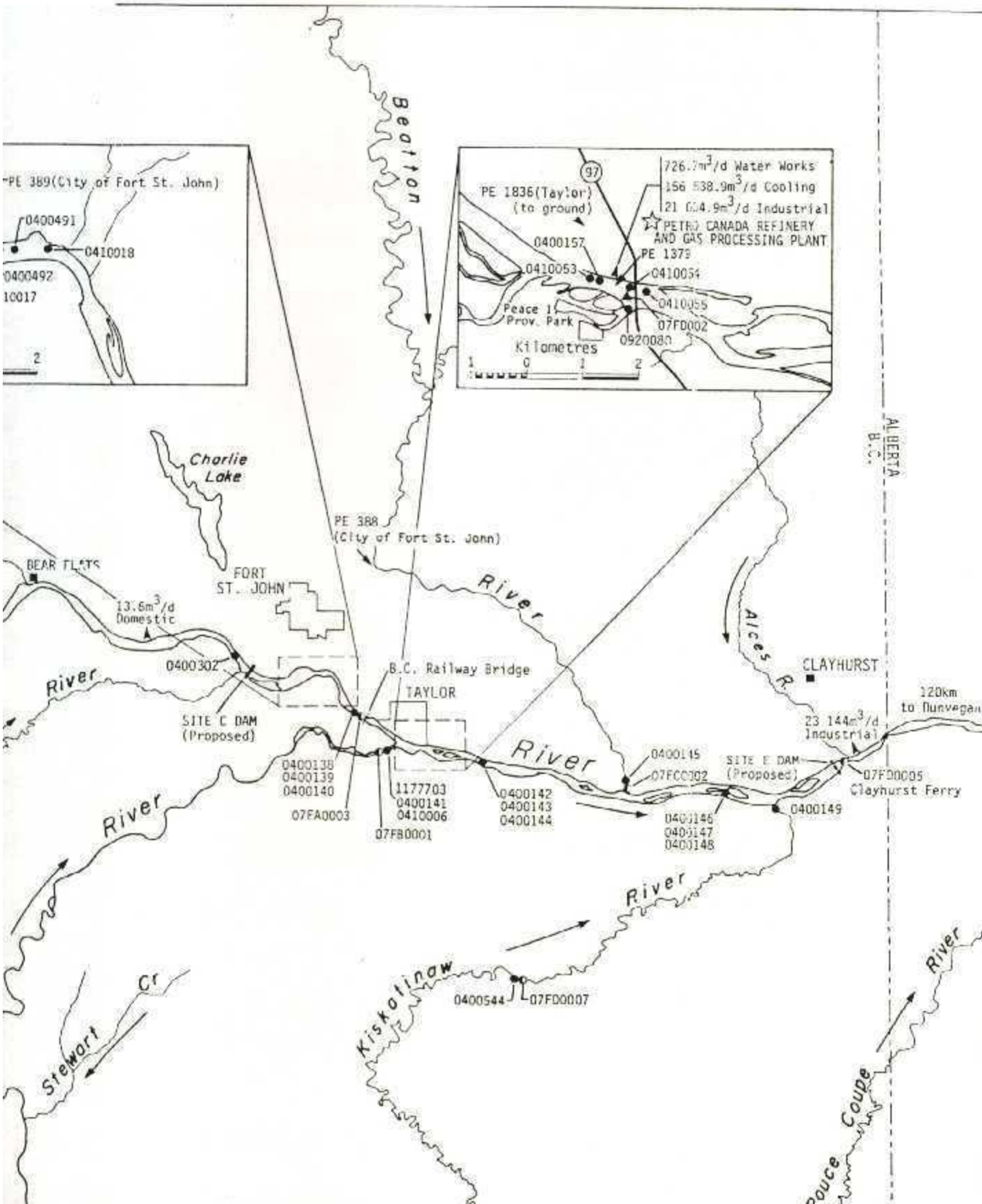
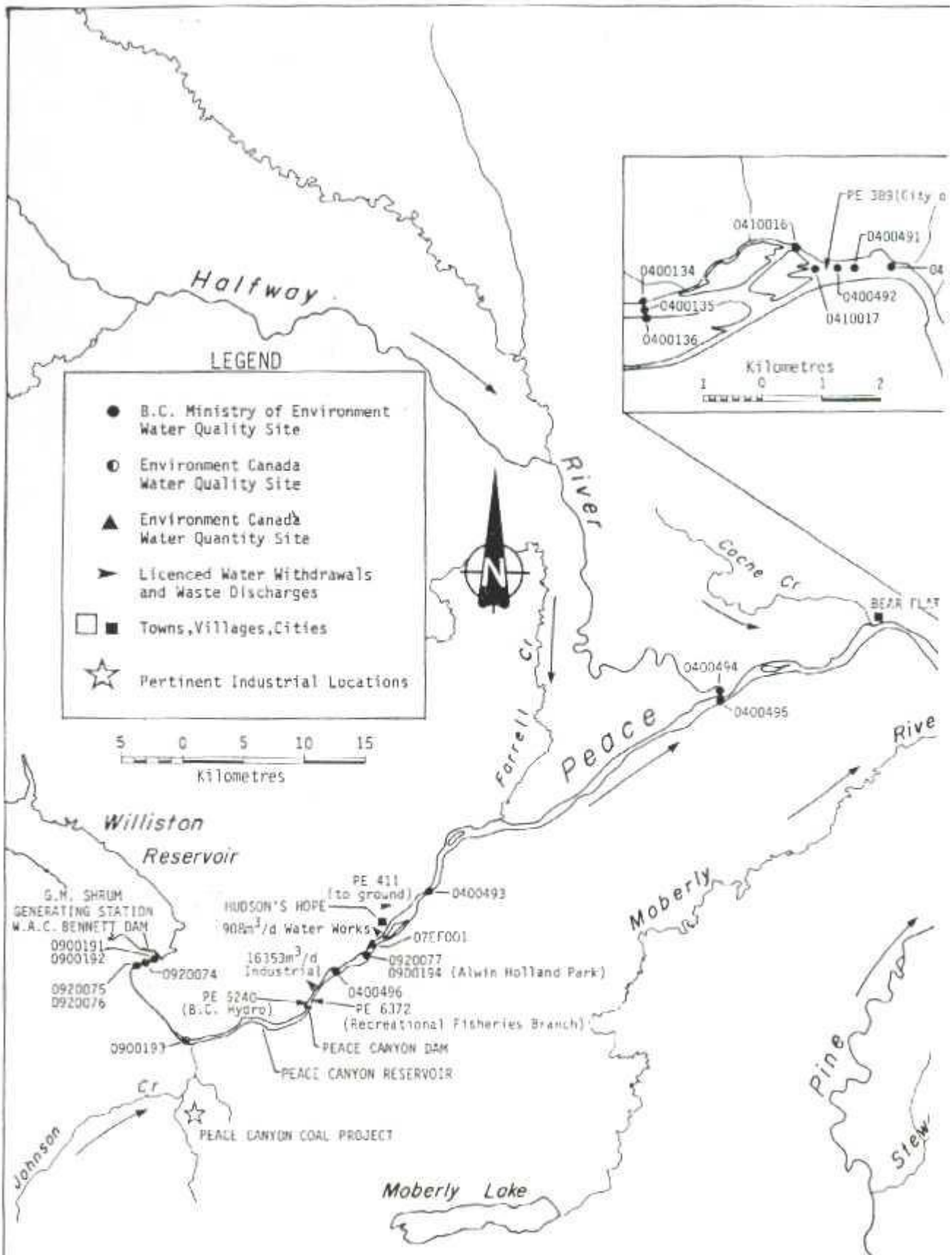

PE 389(City of Fort St. John)
0400491
0410018
0400492
10017
2
PE 1836(Taylor)
(to ground)
97
726.7m³/d Water Works
156 538.9m³/d Cooling
21 004.9m³/d Industrial
PETRO CANADA REFINERY
AND GAS PROCESSING PLANT
0400157
PE 1379
0410053
0410054
0410055
Peace 1
Prov. Park
07FD002
0920080
Kilometres
1 0 1 2
Beatton
River
Charlie
Lake
PE 388
(City of Fort St. John)
BEAR FLATS
FORT
ST. JOHN
13.6m³/d
Domestic
0400302
River
SITE C DAM
(Proposed)
B.C. Railway Bridge
TAYLOR
0400138
0400139
0400140
07FA0003
1177703
0400141
0410006
07FB0001
0400142
0400143
0400144
0400145
07FC0002
SITE E DAM
(Proposed)
07FD0005
Clayhurst Ferry
0400146
0400147
0400148
0400149
River
Alces R.
CLAYHURST
120km
to Dunvegan
23 144m³/d
Industrial
ALBERTA
B.C.
River
Kiskatinaw
0400544
07FD0007
River
Stewart
Cr
Coupe
River

Figure 1b. Peace (west) Peace River sub-basin showing effluent discharges, receiving water sites and water withdrawals (west half of map)


LEGEND
B.C. Ministry of Environment Water Quality Site
Environment Canada Water Quality Site
Environment Canada Water Quantity Site
Licenced Water Withdrawals and Waste Discharges
Towns, Villages, Cities
Pertinent Industrial Locations
5 0 5 10 15
Kilometres
Halfway
River
Cache Cr
BEAR FLAT
0400494
0400495
Farrell Cr
Peace
Rive
Williston Reservoir
G.M. SHRUM GENERATING STATION
W.A.C. BENNETT DAM
0900191
0900192
0920074
0920075
0920076
PE 411 (to ground)
0400493
HUDSON'S HOPE
908m³/d Water Works
07EF001
16353m³/d Industrial
0920077
0900194 (Alwin Holland Park)
0400496
PE 5240 (B.C. Hydro)
PE 6372 (Recreational Fisheries Branch)
0900193
PEACE CANYON DAM
PEACE CANYON RESERVOIR
PEACE CANYON COAL PROJECT
Johnson Cr
Moberly
Moberly Lake
Pine
Stew
0410016
PE 389(City o
0400491
0400134
0400135
0400136
0400492
0410017
Kilometres
1 0 1 2

Return To The Table of Contents

PREFACE
Purpose of Water Quality Objectives

Water quality objectives are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the near future.

How Objectives Are Determined

Water quality objectives are based the BC approved and working criteria as well as national water quality guidelines. Water quality criteria and guidelines are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the criteria by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- 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 routinely provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licences and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular waterbody can be checked, and help to determine whether basin-wide water quality studies should be initiated.

Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses. While water quality objectives have no legal standing and are not directly enforced, these objectives become legally enforceable when included as a requirement of a permit, licence, order, or

regulation, such as the Forest Practices Code Act, Water Act regulations or Waste Management Act regulations.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a waterbody. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time 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 the critical time, then they also will be protected at other times when the threat is less.

The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water.

For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (*i.e.*, mean value, maximum value).

Return To The Table of Contents

INTRODUCTION

This assessment deals with the water quality of the Peace River mainstem and input from its major tributaries between the W.A.C. Bennett Dam and the BC-Alberta border (Figure 1). It is one of five priority assessments being carried out for the Peace River area. A detailed technical appendix to this report was prepared and forms the basis for the conclusions presented in this summary.

This report is the product of data assessments undertaken during 1983 to 1985. In general, the study was designed to analyze the status of existing and future water quality with respect to all waste discharges. Assessment of ground water quality is outside the scope of this study, although reference may be made on occasion to land discharges where there is reason to expect some impact on surface water quality. Included in this report are provisional water quality objectives to protect designated water uses and a recommended monitoring program. The goal of this assessment is to guide water and waste management in the Peace River mainstem.

Return To The Table of Contents

HYDROLOGY

Streamflow regulation of the Peace River began in 1967 with the completion of the WAC Bennett Dam. Since 1970, water has been released from the Williston Reservoir, formed by the dam, at a relatively uniform rate throughout the year in keeping with the demands of the electrical power production. Located 23 km downstream from the WAC Bennett Dam is the Peace Canyon Dam which was completed in 1980. This is a run-of-the-river hydroelectric facility with small storage. It thus has little effect on the streamflow regulation by the WAC Bennett Dam.

The major tributaries of the Peace River downstream from the Peace Canyon Dam contribute approximately 24 percent of the mean annual flow of the Peace River near the BC-Alberta border. The largest tributaries (in descending order of importance) are the Pine River from the south, the Halfway River from the north, the Beatton River from the north, the Moberly River from the south and the Kiskatinaw River from the south (see Figure 1). These tributaries can be expected to have a greater effect on the Peace River water quality during the spring when their flows are high and Peace River flows are low relative to pre-regulated conditions.

The altered flow regime of the Peace River is characterized by mean winter flows approximately 2-5 times greater than those before regulation and by elimination of the former spring-melt discharge peaks. Lowest minimum flows occur presently during the late summer. The minimum flow to be released from the WAC Bennett Dam, as required by BC Hydro's water licence is 283 m^3/s (at Hudson's Hope about 35 km downstream from the dam). Only since since construction of the dam (June 1980) have flows at Hudson's Hope been lower than this value.

Return To The Table of Contents

WATER USES

Present licenced water withdrawal from the Peace River represents only one percent of the minimum river flow permitted by the BC Hydro water licence for the WAC Bennett Dam. Neither present nor anticipated future withdrawals would have a significant effect on downstream flows. Present licenced water uses are for drinking, industrial and livestock watering. Unlicenced water use for irrigation also occurs. There are two existing withdrawals with the potential of being adversely affected by upstream waste discharges: one is Hudson's Hope's water supply which is downstream from two BC Hydro sewage discharges (30 km and 6 km upstream); the other is Taylor's water supply which is 12.5 km downstream from the City of St John's treated sewage discharge. Both of these water supplies receive treatment (filtration or settling plus disinfection) prior to distribution to consumers.

Within a regional context, fisheries values are high in the Peace River and its tributaries, which provide spawning/rearing, migration and over-wintering habitat for seven sportfish species, including salmonids. Sports fishing is the most significant water-based recreation and wading and boating are conducted over the entire length of the Peace River in BC.

Return To The Table of Contents

WASTE DISCHARGES

Non-point Sources

Agricultural fertilizers, pesticides, suspended solids and hydrocarbons from farming, logging, petroleum production and storm drains probably constitute the most significant (and presently unquantified) diffuse waste loading to the Peace River.

Point Sources

The largest point waste sources in this sub-basin are the City of Fort St John and the Petro-Canada refinery at Taylor. All other point discharges to the Peace River are small and receive high dilution after mixing in the Peace River with no consequent effect on water quality. These minor discharges include: two treated sewage discharges at the GM Shrum Hydroelectric Generating Station; a small Recreational Fisheries Branch rainbow trout hatchery at the Peace Canyon Dam; and a treated sewage discharge at Peace Canyon Hydroelectric Generating Station. The Village of Taylor and the District of Hudson's Hope discharge their municipal effluent to the ground. The Peace Canyon Coal Project, a small open-pit coal mine proposed for the Johnson Creek area, has been put on indefinite hold due to depressed market conditions.

The City of Fort St John discharges 65 percent of its treated effluent to the Peace River on a year round basis. The existing treatment system consists of one aerobic cell, three anaerobic /aerated cells and two facultative lagoons followed by year-round chlorination. Discharge is to the mid-channel of the Peace River through a diffuser outfall. Monitoring data show that effluent quality deteriorated after the treatment system switched from seasonal to continuous year-round in 1980. However, effluent quality improved after redesign of the treatment system in 1983 (permit amendment). Dilution in the Peace River is expected to be greater than 6600:1 after complete mixing during the August low flow. Fecal coliform levels downstream from the discharge are predicted to be not more than 200 MPN/100 ML.

Increases in nitrogen and phosphorus levels were predicted to have no measurable effect on downstream water quality, although there have been insufficient receiving water data to verify such predictions.

Approximately 35 percent of the Fort St John effluent is discharged to the Beatton River during the period May 1 to June 30. Treatment of this effluent is through a separate system consisting of four aerobic and four anaerobic lagoons. The effluent is not chlorinated. At the permitted effluent flow, effluent dilution is expected to be 292:1 during the mean low-river flow for the spring discharge period. In adequate receiving water data have prevented an accurate assessment of actual downstream water quality. However, it is expected that there would be increased levels of phosphorous and fecal coliforms.

Petro-Canada discharges combined refinery and natural gas processing/extraction plant effluent to the north shore of the Peace River through a 1 m diameter pipe placed into the main river current. The discharge pipe has no diffuser. The effluent includes storm run-off, cooling water used on a once-through basis, process effluent from a number of refinery sources and gas process and extraction plant effluent. The gas plant effluent treatment includes oil separation, aeration and biological treatment before it is mixed with the cooling water and storm runoff and then discharged to the Peace River.

The combined refinery and natural gas processing/extraction plant effluent receives a theoretical dilution of greater than 15,000:1 after complete mixing in the Peace River during mean low flow periods. The cooling water component of the discharge receives greater than 350:1 dilution at low river flow. However, before complete mixing occurs, the initial dilutions would be considerably less. The size of the mixing zone is unknown, but is expected to be relatively long (in the several kilometer range) since the outfall has no diffuser and the river is wide (420 m) at the point of discharge.

Static bioassays conducted on the process effluent gave results ranging from non-toxic to very toxic (bioassay results for 1984-1986) were all non-toxic). Extrapolation of these bioassay toxicity data to conditions in the Peace River indicates that receiving water concentrations would be 50 to 500 times lower than the safe levels recommended for persistent and cumulative toxicants after complete mixing. However, three aromatic hydrocarbons have been analyzed in the effluent. These include two polycyclic aromatic hydrocarbons (PAH), phenanthrene and methyl phenanthrene and one bicyclic aromatic hydrocarbon, naphthalene. Two of these, anphthalene and phenanthrene, are on the EPA list of Priority Pollutants because of their potential carcinogenicity. More recent analysis of the process effluent (1985) did not detect polycyclic aromatic hydrocarbins, but did detect benzene, another suspected carcinogen. Until further data show otherwise, these toxicants should be regarded with concern. Benzene has also been detected in ground seepage springs discharging on the river bank below the refinery/gas plant complex.

It was not possible to determine whether there were any contaminant additions to the cooling water before it was mixed with process effluent and discharged. Elevations in the receiving water temperatures as a result of heated effluent discharge were predicted and have been observed to exceed the 1 degree Celcius increase recommended by the pollution control objectives.

A pulp mill is under construction at Taylor by Fibreco Export Inc. and is to be completed in late 1988. The mill will have a daily capacity of 600 Tonnes of pulp and will use chemi-thermomechanical pulping with hydrogen peroxide bleaching. Although the mill's impact on the river has yet to be assessed, several water quality objectives (suspended solids, dissolved oxygen, pH, etc.) developed in this report will apply to its operation.

Return To The Table of Contents

WATER QUALITY

Upstream from Fort St John, the water quality of the Peace River is in a near-natural state, reflecting the quality of water released by the WAC Bennett Dam. Anthropogenic point-source waste discharges are small and dilution is large. The major tributaries in the reach, the Halfway River and Moberly River, contribute only 8.3 percent of the Peace River mean annual flow (at Hudson's Hope) and have no significant effect on downstream Peace River quality. Throughout this reach, the water can be characterized as alkaline, moderately hard, well-oxygenated, colored and variably turbid. Color and turbidity have seasonally exceeded the acceptable limits for drinking water, necessitating filtration (or equivalent treatment) prior to drinking water use. Dissolved copper, lead, mercury and zinc have occasionally exceeded working criteria for aquatic life, but not for public water supplies. These metal levels reflect natural background concentrations. Nutrient loading is not a significant factor and algal

growth is phosphorus-limited. Dissolved gas supersaturation, sometimes a problem downstream from hydroelectric dams, has not been measured at levels unsafe for aquatic life. Fecal contamination from unidentified diffuse non-point sources has resulted in fecal coliform levels in excess of the BC Ministry criteria for raw drinking water receiving only disinfection, but did not exceed its criteria for contact recreation. Filtration (or equivalent) and disinfection may be necessary prior to drinking use.

Between Fort St John and Taylor, the water quality is influenced by the City of Fort St John municipal discharge and inflow from the Pine River. Water quality data for the Pine River upstream from its mouth indicates general similarity to Peace River water quality except for higher maximum levels of nutrients, fecal coliforms and certain total metals (iron and manganese). The Fort St John discharge may have increased the downstream fecal coliform levels in excess of levels considered safe for water-contact recreation in the past. However, since redesign of the treatment system in 1983, fecal coliform levels in the discharge have improved markedly and downstream waters are considered safe for recreation use. Complete water treatment plus disinfection may be necessary prior to downstream drinking water use. The available data show that this discharge is not altering the downstream water quality relative to alkalinity, pH, dissolved oxygen, hardness, color, turbidity, suspended solids, metals or nutrients. Dissolved copper, lead, mercury, zinc and cadmium have been in excess of working criteria for aquatic life, but reflect background concentrations.

From Taylor to the Beatton River, water quality is influenced by combined upstream effluent sources and the effluent discharge from the Petro-Canada refinery and a natural gas processing/extraction plant. Receiving water quality has improved since 1983 when effluent treatment system modifications were completed. Actual water quality data and/or worst-case concentration projections have indicated no significant increases for the following variables downstream from the refinery (outside the initial dilution zone): BOD_5, pH, cyanide, phenol, ammonia, sulphide and nutrients. Fecal coliform bacteria have been measured downstream from the refinery at levels that would necessitate more treatment and disinfection of the water prior to drinking; however, these are related to high upstream levels allowed by the Pollution Control Objectives. Elevated oil and grease levels in surface films have also been detected downstream from the Petro-Canada outfall. The benthic invertebrate community downstream from the refinery was found to be lower in diversity and density and different in taxonomic composition (ie, more pollution-tolerant organisms) compared to sites upstream from the refinery in 1980. However, study of the benthic community since improvement of the effluent quality in 1983 has shown no evidence of adverse impact.

From the Beatton River to the Alberta border, Peace River water quality is influenced by combined upstream sources and tributary input from the Beatton River and Kiskatinaw River. The most significant anthropogenic waste source in this reach is the City of Fort St John's discharge of treated sewage to the Beatton River during the period April-June. Assessment of its effect on water quality was hampered by an absence of data from sites both upstream and immediately downstream. Worst-case projections indicate no impairment of downstream water quality (outside the initial dilution zone) relative to dissolved oxygen, suspended solids, ammonia-N or nutrients. However, elevated fecal coliform concentrations could result, necessitating filtration and disinfection prior to any future drinking water use. Tributary input from the Beatton River and to a lesser extent, the Kiskatinaw River, contributed to significant elevations in Peace River concentrations of turbidity, suspended solids, color, nutrients and certain metals (iron, manganese, selenium and mercury). Metals in excess of the working criteria for aquatic life in this reach of the Peace River included copper, lead, mercury and cadmium, as well as three others (iron, manganese and selenium) which were not found to be in excess of the criteria upstream from the Beatton River. Iron and manganese have also been measured in excess of their respective drinking water criteria.

Between the BC-Alberta border and Dunvegan, Alberta, a distance of 120 km, there are no anthropogenic point-source waste discharges. The water quality site at Dunvegan has the largest data base over the longest period of record for the Peace River. These data were reviewed to check the water quality at the border. The data do not show significant impairment relative to water quality upstream from the BC-Alberta border. As could be expected for a downstream site, variables such as color, turbidity, suspended solids and dissolved phosphorus show higher seasonal maximum levels. Metals in excess of the working criteria for aquatic life at Dunvegan include all the metals found in excess at sites upstream in British Columbia, plus silver. The list of metals in excess of the working criteria for drinking water is similar to that for upstream reaches, except for inclusion of cadmium. Fecal coliform levels indicate the need for filtration (or equivalent) and disinfection of raw water supplies prior to drinking water use. Thirty-eighth separate pesticides, including herbicides and insecticides, were tested for in samples from this site. Most of the pesticides were not detected and those that were detected did not exceed any published water quality criteria. Polychlorinated biphenyls were not detected in water at Dunvegan.

Return To The Table of Contents

PROVISIONAL WATER QUALITY OBJECTIVES

Designated uses of the Peace River mainstem and the lower Beatton River include drinking water supplies, water-contact recreation, irrigation, livestock watering, industrial use, use by wildlife and use by aquatic life, including salmonid fishes. Provisional water quality objectives, shown in Table 1, Table 2 and Table 3, are proposed to protect these uses. The objectives apply to discrete samples outside the initial dilution zones of waste discharges. They apply on a year-round basis except the fecal coliform objectives in the Beatton River which apply only during the recreation season. These excluded dilution zones are defined as extending 100 m downstream from the discharge point and no more than 25 percent across the width of the river, from the surface to the substratum.

The objectives are based on approved and working criteria for water quality and on available data on ambient water quality, waste discharges, water uses and river flows. The objectives will remain provisional until receiving water monitoring programs provide adequate data and the Ministry has established approved water quality criteria for all of the characteristics of concern.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. They will guide the evaluation of water quality, the issuing of permits, licences and orders, the management of the fisheries and of the Province's land base. They will also provide a reference against which the state of water quality in a particular water body can be checked and serve to make decisions on whether to initiate basin-wide quality studies.

Depending on the circumstances, water quality objectives may already be met in a water body, 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 man's activity, now and in the foreseeable future.

The provisional objectives for fecal coliforms are not being met in reaches of the Peace River and Beatton River. Sufficient receiving water data exist to show that the objectives for total dissolved gases, dissolved oxygen, turbidity and suspended solids are presently being met in the Peace River and Beatton River. Actual receiving water data for the following characteristics are presently too sparse or ambiguous to state whether or not the objectives are being met: ammonia-N, nitrite-N, total chlorine residual, periphyton growth, pH, temperature, total sulphide, total cyanide (as CN), dissolved flouride, total copper, total chromium, total lead, total nickel, total zinc, sulphide (as un-ionized H_2S), phenol, chlorinated phenols and 2, 4-D. Further receiving water monitoring is required to determine unambiguously whether the latter characteristics are meeting the objectives.

These objectives are proposed to protect water use within the British Columbia portion of the Peace River and are without prejudice to any objectives that may be subsequently developed between the provinces of Alberta and British Columbia as a result of future agreement on transboundary water quality objectives.

Return To The Table of Contents

MONITORING RECOMMENDATIONS

Recommendations for effluent and receiving water monitoring in the Peace River mainstem sub-basin are summarized in Table 4. The monitoring recommendations were made from a technical perspective and the extent to which the receiving water monitoring is conducted will depends on the overall priorities and monitoring resources available for the Region and Province. Effluent monitoring required of a discharger is determined by the Regional Waste Manager on a site-specific basis.

It should be noted that the Peace River above Alces River (Clayhurst) is a federal-provincial water quality monitoring station implemented in 1985-86. Sampling is conducted 26 times/year (bi-weekly) for measurement of approximately 40 key variables to detect any changes in these variables and to contribute to the development of water quality objectives for some of these variables.

Once the higher priority monitoring program recommended in this report is implemented, a study of non-point source loading to the Peace River should be conducted. This study would add the pertinent water quality variables and monitoring sites which could evaluate diffuse pollution loads from certain land use practices. These include the use of agricultural pesticides and fertilizers, runoff from logged and cleared areas, municipal storm-sewers, the oiling of rural roads for the purpose of dust suppression and the input of fecal coliform bacteria from the cattle watering sites and feedlots. A special monitoring program will also be required to assess the possible impact of the pulp mill now being built in Taylor.

Return To The Table of Contents

TABLES

Table 1 Provisional Water Quality Objectives for the Peace River Mainstem sub-basin

Water Bodies	**Peace River from the W. A. C. Bennett Dam to the Alberta border**	**Beatton River d/s from Fort St. John**
designated water uses	**drinking water (after filtration or the equaivalent and disinfection), aquatic life, recreation, livestock watering, industrial, wildlife and irrigation**	**drinking water (after complete treatment and disinfection), aquatic life, recreation, livestock watering, industrial, wildlife and irrigation**
fecal coliforms	**less than or equal to 100 MPN/100 mL 90th percentile**	**less than or equal to 200 MPN/100 mL geometric mean from April 1 to October 31**
turbidity	**5 NTU maximum increase when u/s is less than or equal to 50 NTU 10% maximum increase when u/s is over 50 NTU**	
suspended solids	**10 mg/L maximum increase when u/s is less than or equal to 100 mg/L 10% maximum increase when u/s is over 100 mg/L**	
total chlorine residual	**0.002 mg/L maximum**	**not applicable**
dissolved fluoride	**1.0 mg/L maximum**	**not applicable**
weak acid dissociable cyanide	**0.01 mg/L maximum less than or equal to 0.005 mg/L 30-day mean**	**not applicable**
periphyton standing crop	**50 mg/m^2 chlorophyll-*a* maximum**	
total ammonia-nitrogen	**Average 30-day Concentration of Total Ammonia Nitrogen for Protection of Aquatic Life**	
nitrite-nitrogen	**Maximum and 30-day average Allowable Nitrite (N) Concentration**	

dissolved oxygen	**7.25 mg/L minimum**	
pH	**range 6.5 to 9.0 less than or equal to a 0.5 pH unit change within this range less than or equal to a 0.1 pH unit change outside this range**	
total dissolved gases	**up to 110% saturation maximum**	**not applicable**
temperature	**1 degree Celcius maximum increase**	**not applicable**
total copper	**less than or equal to [0.04 (mean hardness)] 30-day average [0.094 (hardness) +2] maximum 20% maximum increase when u/s exceeds these values**	**not applicable**
chlorinated phenols	**0.2 micrograms/L (total of all tri-, tetra- and pentachlorophenols) maximum**	**not applicable**
total lead	**less than or equal to 3.31 + exp [1.273 ln (mean hardness) - 4.705] 30-day average exp [1.273 ln (hardness) - 1.46] maximum 20% maximum increase when u/s exceeds these values**	**not applicable**
total nickel	**0.025 at hardness less than 60 mg/L 0.065 for hardness 60 to 120 mg/L 0.11 mg/L for hardness 120 to 180 mg/L 0.15 mg/L for hardness over 180 mg/L**	**not applicable**
total zinc	**0.03 mg/L maximum 20% maximum increase when u/s exceeds 0.03 mg/L**	**not applicable**
phenol	**less than or equal to 0.002 mg/L**	**not applicable**

	mean **20% maximum increase when u/s exceeds 0.002 mg/L**	
un-ionized H_2S	**0.002 mg/L maximum** **20% maximum increase when u/s exceeds 0.002 mg/L**	**not applicable**
2,4-D ester	**0.004 mg/L maximum**	**not applicable**

Note: The objectives apply to discrete samples from all parts of the water body except from initial dilution zones of effluents. These excluded dilution zones are defined as extending 100 m downstream from the discharge point and no more than 2 percent across the width of the stream, from the surface to the bottom.
1. The fecal coliform geometric mean, median and 90th percentile are calculated from at least 5 weekly samples taken in a period of 30 days. The Peace River objective applies year-round. The Beatton River objective applies only during the open-water recreation season, but should be extended to year-round if there are future year-round drinking water withdrawals.
3. The periphyton standing crop is calculated by averaging the results from at least 5 samples collected randomly from natural substrates.
4. Since the total chlorine residual objective is less than the minimum detectable concentration, it may be necessary to estimate the receiving water concentration using effluent loading and streamflow.
5. For turbidity, suspended solids, total copper, chromium, lead and zinc, phenol and un-ionized hydrogen sulphide the increase or decrease (in NTU, mg/L, pH, % or degrees Celcius) 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 levels.
6. For weak acid dissociable cyanide, total ammonia nitrogen, nitrite nitrogen, phenol and total lead and copper the average is calculated from at least 5 weekly samples taken in a period of 30 days.
7. Measurements of strong acid dissociable cyanide should also be made to check whether the possible photolysis of iron-cyanide complexes may produce unacceptable levels of weak-acid dissiociable cyanide.
8. Lead and copper values are in micrograms/L.
9. Hardness as mg/L $CaCO_3$

Table 4 Recommended Routine Effluent and Receiving Water Monitoring Programs for the Peace River Mainstem sub-basin.

Sites	Frequency and Timing	Characteristics to be Measured
G.M.Shrum Hydroelectric Generating Station effluent	quarterly (record daily flow once per month)	flow, BOD_5, suspended solids, fecal coliforms, chlorine residual
Peace Canyon Coal Project receiving waters (if project is reactivated)	monthly, more frequently for suspended solids and turbidity during freshet and rains	pH, alkalinity, turbidity, suspended solids, total phosphorus, dissolved orthophosphorus, sulphate, oil and grease, nitrate-nitrogen, ammonia nitrogen, total and dissolved copper, total and dissolved zinc, total and dissolved cadmium, total mercury
Recreational Fisheries Branch hatchery (PE 6372) effluent	2 times per year	flow, BOD_5, suspended solids, total phosphorus, ammonia-nitrogen, nitrite/nitrate-nitrogen
Peace Canyon Hydroelectric Generating Station (PE 5240) effluent	quarterly	flow, BOD_5, suspended solids, chlorine residual
Fort St. John, Peace River discharge (PE 389) effluent	monthly, record effluent flow daily	flow, BOD_5, suspended solids, chlorine residual, fecal coliforms, total phosphorus, dissolved orthophosphorus, ammonia-nitrogen, pH, nitrate-nitrogen, nitrite-nitrogen, oil and grease
Peace River u/s and d/s from Fort St. John discharge at sites 0400134, 0400135, 0400136, 0400491, 0400138, 0400139, 0400140	to begin: 3 times per year during spring to late fall low flows (coincide with effluent monitoring)	flow (Water Survey of Canada data), fecal coliforms, total and dissolved copper, zinc and lead, suspended solids, pH, total mercury, ammonia, nitrate and nitrite-nitrogen, dissolved oxygen, temperature, oil and grease, total phosphorus, dissolved orthophosphorus, turbidity
Fort St. John Beatton River discharge (PE 388) effluent	monthly (May 1 to June 30) record	flow, BOD_5, suspended solids, chlorine residual, total phosphorus,

	daily flow once per week	dissolved orthophosphorus, fecal coliforms, ammonia, nitrite and nitrate-nitrogen, pH, oil and grease
Beatton River u/s and d/s from Fort St. John discharge, site 0400145 plus u/s control site and 3 new d/s sites	to begin: twice during discharge period (May 1 to June 30)	flow (Water Survey of Canada data), fecal coliforms, total and dissolved copper, zinc and lead, suspended solids, pH, total mercury, ammonia, nitrate and nitrite-nitrogen, dissolved oxygen, temperature, oil and grease, total phosphorus, dissolved orthophosphorus, turbidity
Petro-Canada Refinery PE 1379, process effluent	weekly for all except monthly for bioassays and dissolved phosphorus (record daily discharge volumes)	flow, BOD_5, bioassay, fluoride, suspended solids, phenol, total sulphide, ammonia-nitrogen, cyanide, temperature, oil and grease, total phosphorus, dissolved orthophosphorus, hydrocarbons
Petro-Canada Refinery PE 1379, cooling water inflow and outflow	weekly for flow, pH and temperature (record daily discharge volumes), monthly to begin for all others	flow, fluoride, pH, phenol, sulphide, ammonia-nitrogen, cyanide, temperature, total phosphorus, dissolved orthophosphorus, hydrocarbons
Petro-Canada Refinery PE 1379, storm runoff	monthly during periods of storm runoff (record daily discharge volumes)	flow, pH, suspended solids, phenols, sulphide, ammonia, nitrite and nitrate-nitrogen, oil and grease, total phosphorus, dissolved orthophosphorus, hydrocarbons
Petro-Canada Refinery PE 1379, combined effluents	annually to begin)	organic contaminants-alkyl and dialkyl benzenes, aromatic and polynuclear aromatic hydrocarbons, heterocyclic compounds
Peace River u/s and d/s from Petro-Canada	to begin: 3 times per year, spring to	fecal coliforms, turbidity, suspended solids, fluoride,

discharge, receiving water sites 0400138, 0400139, 0400140, 0400157, 0410054, 0410055, 0400142, 0400143, 0400144 and 3 new sites	**fall low flows (to coincide with effluent monitoring)**	**cyanide, ammonia, nitrite and nitrate-nitrogen, dissolved oxygen, pH, temperature, total and dissolved cadmium, chromium, copper, lead, iron, nickel and zinc, total mercury, hydrocarbons, PAHs, colour, specific conductance, total and dissolved hardness, oil and grease, total phosphorus and sulphide, dissolved orthophosphorus, surface film hydrocarbons, flow (Water Survey of Canada data)**
Peace River u/s and d/s from Petro-Canada discharge, u/s and d/s sites at discretion of the sampler	**annually to begin**	**benthic fauna (identified to the lowest possible taxa); sediment and surface film analysis for hydrocarbons including polynuclear aromatics such as benzo(a)pyrene; fish neoplasia (incidence of epidermal papilloma, fin erosion, gonadal and hepatic tumours and histopathological effects; fish hydrocarbon contamination (induction of liver enzyme aryl hydrocarbon hydroxylase)**
Peace River W.A.C. Bennett Dam to the Alberta border (sites at the discretion of the sampler)	**once**	**fish tissue mercury levels (confined to food fish species); fish tainting (taste testing of sport species)**

Note: the amount of sampling carried out will depend on funding and regional program priorities.

Return To The Table of Contents

George Butcher
Resource Quality Section
Water Management Branch
Ministry of Environment and Parks