MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

PEACE RIVER AREA

PINE RIVER SUB-BASIN
WATER QUALITY ASSESSMENT AND OBJECTIVES

TECHNICAL APPENDIX

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1. INTRODUCTION

The Pine River sub-basin is one of seven priority sub-basins in the Peace River area for which water quality assessments are being conducted. The location of the Peace River Planning Unit is shown in Figure 1, and Figure 2 shows the area and its seven priority sub-basins.

The Pine River originates near Pine Pass in the Rocky Mountains and flows eastward past Chetwynd and East Pine (Map, Figures 1-3). From East Pine it flows northward and enters the Peace River at Taylor. The two largest tributaries of the Pine River are the Sukunka River and the Murray River.

The Pine River crosses three physiographic regions. The Rocky Mountains Region, which comprises the headwaters of the Pine River west of Lemoray, rises to elevations of up to 2000 m. The Rocky Mountain Foothills region extends downstream to Chetwynd and is characterized by ridges and valleys with an elevation between 600 and 1800 m. This region is underlain by faulted and folded shales and sandstones. From Chetwynd to its confluence with the Peace River, the Pine River passes through the flat-to-rolling upland topography of the Alberta Plateau Plains region (E.L.U.S.C., 1977).

The Village of Chetwynd, a forestry, transportation, and service center, is the largest settlement in the sub-basin with an estimated 1982 population of 2 596 (Stone, 1982). Forestry is presently the main industry and dominant employer in this sub-basin, followed by the oil and gas industry. Agriculture follows in economic importance, and consists of livestock and grain production in the Pine River Valley. As a result of the proximity of Chetwynd to Tumbler Ridge and the Northeast Coal Development, both the population and amount of industrial activity are expected to increase dramatically over the next 10 years. The main effluents presently entering the Pine River are treated sewage effluents from the Village of Chetwynd and from the Westcoast Transmission Co. Ltd. subdivision at Willow Flats.

2. HYDROLOGY

The Pine River experiences low flows during the winter months under ice cover, November to April, and peak flows during the early summer, May to August (Hydrograph, Figure 4). Flows decline in late summer to a minimum in early September, followed by a rise in October due to rain and snow events. Combined rain-on-snow events are not uncommon in the Pine River watershed.

The seven-day average low flow (10-year return period) expected during the October-April period, is 2.6 m^3/s at Willow Creek and 4.7 m^3/s near Chetwynd at Twidwell Bend (Obedkoff, 1982). The mean seven-day average low flow for this period is 4.1 m^3/s at Willow Creek and 7.4 m^3/s at Twidwell Bend. The late summer low flow is less severe: the seven-day low flows (10-year return period) in August expected for Willow Creek and Twidwell Bend are 12 m^3/s and 21 m^3/s, respectively. The mean seven-day average August low flow is 18 m^3/s at Willow Creek and 32 m^3/s at Twidwell Bend.

Water Survey of Canada (Environment Canada) has maintained a flow gauge (station 07FB001) on the Pine River at East Pine continuously since 1961.

3. WATER USES

A summary of licenced water usage for the Pine River is contained in Table 1. There are no licenced water withdrawals for the purpose of agriculture or forestry. The largest withdrawal is from the Pine River for the water works of the Village of Chetwynd. Chetwynd's licenced withdrawal is less than 1% of the 7-day, 10-year low flow in the Pine River at Willow Creek, and thus has a negligible effect on downstream flows. The Chetwynd withdrawal is downstream from the existing waste discharge at Willow Flats (PE 410, Westcoast Transmission Co. Ltd.) and downstream from the proposed waste discharges of the Willow Creek Coal Project (see map, Figure 3). Neither of these waste discharges is likely to have an effect on the domestic water supply for Chetwynd, because both are approximately 50 km upstream, are small discharges, and are to contain no toxic contaminants (see Section 5.2).

No new large withdrawals are projected over the next 10 years, although Chetwynd's withdrawal will increase in relation to population growth. With a doubling of population by 1992 (Section 4.1a), actual present water consumption (1 773 m^3/d) should also double. Although, this would mean a 50 percent increase in the present licenced withdrawal, it would continue to have a negligible effect on downstream flows.

Recreationally significant sportfish that are known to occur in the Pine River include: Dolly Varden char, Arctic grayling, Rocky Mountain whitefish, northern pike, and rainbow trout. Within a regional context, the relative abundance of these species in the Pine River is considered high upstream from Stewart Creek near East Pine (Kumka, 1982). From Stewart Creek to the confluence with the Peace River, the fish population density is rated as medium to low. There is, however, no specific creel census analysis which would provide data on the rate of exploitation and relative significance to anglers.

The importance of the Pine River mainstem as fish habitat for game fish is related to its use for migration, overwintering, and feeding. Spawning and fry rearing activities for these species are generally limited to the tributary streams.

Recreational use (apart from angling) of the Pine River mainstem is concentrated downstream from Twidwell Bend where canoeing, kayaking, and riverboating occur. Intermediate whitewater kayaking occurs between Chetwynd and Twidwell Bend (B. Fuhr, 1982; personal communication). Significant recreational swimming is not known to occur in the river.

WASTE DISCHARGES

The most important waste discharge to the Pine River sub-basin is the sewage effluent from the Village of Chetwynd (PE 1167). Of less importance, but considered in this report is the small discharge of sewage from the Westcoast Transmission Co. subdivision at Willow Flats (PE 410). A natural gas processing plant at Hasler Flats (Westcoast Transmission Co. Ltd., PA 5151) contributes acidic contaminants to the air with the potential of rain-out into aquatic systems in the Peace River area. Details of the permits issued by the Waste Management Branch for the Pine River Sub- basin are summarized in Table 2. The locations of important waste discharges are shown in Figure 3.

4.1 THE VILLAGE OF CHETWYND

a) DESCRIPTION OF DISCHARGE

Chetwynd had an estimated 1982 population of 2 596. The population is projected to increase to 3 880 in 1987 and up to 5 200 in 1992 (Stone, 1982). This expected doubling of the population in 10 years will be largely due to worker settlement from the Northeast Coal Projects. The source of municipal effluent will continue to be from the residential and commercial sector as well as light industrial, e.g., sawmilling and warehousing.

Prior to 1973, Chetwynd discharged its sewage into a 3.0 ha stabilization lagoon which emptied via an excavated ditch into Centurion Creek, a tributary of the Pine River. Permit PE 1167 was issued to the Village, July 30, 1973, after the system was modified to include a mechanical aeration cell, two polishing cells and chlorination facilities. The permit authorized a year-round discharge of 908 m^3/d with BOD_5 of 45 mg/L and suspended solids of 60 mg/L. The permit was amended June 15, 1982, increasing the maximum discharge to 3 000 m^3/d, and requiring construction of a pipeline and outfall to the Pine River by December 31, 1982. The new outfall was completed in September, 1982. The Pine River outfall was necessary since Centurion Creek did not provide 20:1 dilution on a year-round basis. The amended permit waived effluent chlorination until high coliform counts in the receiving waters require its reinstitution.

b) PRESENT WASTE LOADS

Effluent monitoring data for the period 1972 to 1983 are summarized in Table 3. This table includes effluent data for the period 1972 to 1982 when the effluent was discharged to Centurion Creek and for the period, September 1982 to September 1983, which is after the start-up of the Pine River outfall. The results indicate that the aerated basin system provided good effluent treatment and generally met permit conditions.

Flow. Although only five measurements were recorded between 1972 and 1977, all values were less than the previous permitted daily maximum of 908 m^3/d (346-691 m^3/d). Of 272 flow measurements taken in 1982, only two exceeded the amended permit limit of 3 000 m^3/d. One occurred in January (3 283 m^3/d) and one in August (3 006 m^3/d). The mean effluent flow recorded after installation of the Pine River outfall was 1 799 m^3/d. During the period September 1982 to September 1983, effluent flow exceeded the permitted level 8 times for 395 measurements (2 percent). Flows above permitted levels occurred during January and February, 1983. The maximum effluent flow recorded was 4 024 m^3/d on January 30, 1983.

BOD_5 Eighty-three percent of the BOD_5 measurements recorded before the installation of the outfall were less than the permitted level of 45 mg/L. Of those measurements which exceeded this level, the majority (82 percent) occurred during the winter months, December to March, a period of low stream flow. The maximum daily BOD_5 load projected to have occurred between 1972 and 1982 was estimated to be 220 kg/d (Table 4). This estimate is high and may represent an upper limit since it was calculated from a maximum effluent flow value and a maximum concentration which are unlikely to coincide.

Of the 16 BOD_5 measurements recorded since the installation of the Pine River outfall, only one measurement (51 mg/L) in November, 1982, exceeded the permitted level of 45 mg/L. The maximum actual BOD_5 loading for the new outfall was recorded on May 10, 1983 (63 kg/d). This loading is approximately half the permitted loading of 135 kg/d (Table 4).

<u>Suspended Solids</u>. The majority of suspended solids measurements (50 out of 66) recorded between 1972 and 1982 have conformed to the permit limit of 60 mg/L. The permit limit was exceeded mainly during the high run-off months of May-July, possibly due to algal growth in the stabilization lagoon. The maximum daily suspended solids loading was estimated to be 404 kg/d, approximately double the permitted level.

The mean level of effluent suspended solids measured after the installation of the Pine River outfall was 31 mg/L. Two of the 16 suspended solids measurements exceeded the permit level of 60 mg/L (122 mg/L on Feb. 7, 1983; 64 mg/L on July 18, 1983). After installation of the new outfall, a maximum actual loading of 212 kg/d occurred on February 7, 1983.

<u>Fecal Coliforms</u>. Fecal coliform levels prior to September, 1982, ranged from 2 to 790 000 MPN/100 mL. The geometric mean was 3 162 MPN/100 mL. Since the Pine River outfall was installed, fecal coliform levels appear to have decreased: range of 2-54 000 MPN/100 mL; geometric mean of 1 047 MPN/100 mL.

<u>Nitrogen and Phosphorus</u>. Ammonia-N levels in the effluent during the period 1972-1982 averaged 14.8 mg/L. Since Centurion Creek did not consistently provide 20:1 effluent dilution, receiving water concentrations of un-ionized ammonia-N likely exceeded the safe level (7 μg/L average; 30 μg/L maximum) as recommended by Pommen (1983). Ammonia-N levels have not been measured since the Pine River outfall was put into operation. Nitrite/nitrate levels in the effluent discharged via Centurion Creek were not high (0.1-0.3 mg/L) although only three samples were taken. Only one

measurement (0.07 mg/L) of the nitrite/nitrate levels in the effluent has been recorded since start-up of the new outfall. Dissolved and total phosphorus levels in the effluent discharged via Centurion Creek averaged 3.1 and 4.4 mg/L, respectively. Too few data (n=3) were recorded to establish significance or seasonal trends. Total phosphorus levels in the effluent discharged to the new outfall averaged 3.3 mg/L.

c) FUTURE WASTE LOADS

Projected future waste loadings to 1992 for BOD_5 and suspended solids are presented in Table 4. These were calculated given a doubling of population over 1982 estimates, and assuming that the permitted constituents of the new discharge to the Pine River will be in compliance with permit conditions.

Future maximum BOD_5 loadings are projected to be 362 kg/d. Maximum suspended solids loadings are projected to be 482 kg/d in 1992.

4.2 WESTCOAST TRANSMISSION CO. LTD. (WILLOW FLATS)

a) DESCRIPTION OF DISCHARGE

Permit PE 410 was issued to Westcoast Transmission June 16, 1971, for an aerated lagoon treatment system discharging chlorinated sewage effluent into the Pine River (Figure 3). The source of the effluent is a company subdivision consisting of 15 houses. There are no industrial or commercial waste discharges to the system. The lagoon system replaced individual septic tanks. The permit authorizes a year-round discharge of 31.8 m^3/d with BOD_5 of 50 mg/L and suspended solids of 60 mg/L.

From 1971 to 1983, there was no discharge of effluent from the lagoon. For most of the past 10 years, only eight houses were occupied and the lagoon handled the effluent through evaporation and exfiltration without direct discharge. Recently, the subdivision became fully occupied and the amount of incoming effluent exceeded the rate of exfiltration. As a result, the lagoon discharged effluent during May, 1983, for the first time since construction.

b) PRESENT WASTE LOADS

Effluent monitoring data, available for the period 1975-1980, are summarized in Table 5. Generally, monitored characteristics exceeded permitted levels, although the number of samples was small.

Flow. No effluent was discharged from the lagoon until May 1983, and no flow data are available. The design flow for the treatment system was 32 m^3/d. This is a small discharge relative to the flow in the Pine River: at a severe Pine River low flow (October-April, 10 year return period) effluent dilution will exceed 7 000:1.

BOD_5. Only nine BOD_5 measurements have been recorded, five of which exceeded the permit level of 50 mg/L. The maximum daily BOD_5 load was estimated to be approximately 2.8 kg/d.

Suspended Solids levels averaged 86 mg/L. Five out of nine samples exceeded the permit limit of 60 mg/L. The maximum daily suspended solids load was estimated to be 6.9 kg/d.

Fecal Coliforms. Only two samples were taken (2 400 and 5 400 MPN/100 mL), preventing any analysis of fecal contamination problems.

Nitrogen and Phosphorus. The one ammonia-N measurement taken October, 1980 (1.8 mg/L) was low. The sample taken in October, 1980, for nitrite/nitrate and dissolved phosphorus measured 12.5 and 4.3 mg/L respectively.

c) FUTURE WASTE LOADS

Future waste load projections for this discharge have not been made because no expansion of the Willow Flats subdivision is expected in the near future.

4.3 WESTCOAST TRANSMISSION CO. LTD. (HASLER FLATS)

a) DESCRIPTION OF DISCHARGE

The natural gas processing plant at Hasler Flats (Figure 3) emits contaminated by-products from the sweetening of natural gas into the air. These contaminants include NO_X, H_2S, and SO_X which can produce acidic precipitation, affecting aquatic systems. At full operating capacity, the total sulphur emission from this plant is approximately 18-20 tonnes per day after passing sour gas through a sulphur recovery plant with a minimum sulphur recovery rate of 99.0%. However, since issuance of the permit in May, 1979, the processing plant has been operating at approximately one third of its capacity and total sulphur emissions have averaged 7 tonnes per day (Kotturi, 1982).

b) PRESENT WASTE LOADS

SO_2 was continuously monitored by the company at five locations in the Hasler Flats-Chetwynd area. As of February, 1983, there were four stations. Data presented by Kotturi (1982) show that the Provincial level A objective of 0.17 ppm for a one-hour average was occasionally exceeded at only one site between February 1980 and July 1982. The Provincial level A objective of 0.005 ppm of H_2S for a one-hour average was exceeded for 151 hours during nine months in 1980, for 29 hours in 1981, and for 12 hours during six months in 1982. Kotturi concluded that air quality in the vicinity of Hasler Flats has been acceptable to date.

Precipitation pH has been monitored in the area, but the available data are unreliable (Kotturi, personal communication). The monitoring methodology is currently being corrected and reliable data will be available in the future. Westcoast Transmission Co. Ltd. is presently installing two acid precipitation stations downwind from the plant. Once reliable precipitation pH data become available, it will be possible to assess more fully whether acid precipitation is a regional problem. At this time, the pH of regional waterbodies does not indicate a trend towards acidification (Swain, 1983). Review of the surficial materials of the area suggests that the acid precipitation impact of this source upon regional water quality can be expected to be low. The geology of the area is characterized by calcareous minerals and consequently, the water is very hard, alkaline, and high in dissolved calcium. This type of carbonate-containing terrain has a high capability to buffer hydrogen ion input. Review of the Ministry's preliminary acid rain lake sensitivity maps (Swain, 1983) also indicates that the Peace River area has a low sensitivity to (i.e., a high tolerance to) acidic precipitation (based upon pH, dissolved calcium, and alkalinity data; Figure 5). Further study of precipitation pH is necessary to determine the effects of the SO_2 emissions.

c) FUTURE WASTE LOADS

It is expected that if natural gas demand increases over the next 10 years, the Hasler Flats plant will reach capacity and future emission rates may be double or treble present rates.

4.4 DAVID MINERALS LTD., WILLOW CREEK COAL PROJECT

David Minerals Ltd. has proposed to develop an underground coal mine, producing up to 0.6 million tonnes per year, located east of Willow Creek, a tributary of the Pine River (Figure 3). Construction of the mine has been delayed indefinitely as a result of depressed market conditions. The environmental impact assessment of this mine has been reported in a Stage II submission prepared by I.E.C. Consultants Ltd., and Kilborn Engineering (B.C.) Ltd. (1982).

The proposed mine is a relatively simple operation from the standpoint of water quality. Being a small underground mine, it does not entail radical watershed disturbance. Additionally, there will be no preparation, washing, or processing of the coal other than separation and stockpiling for rail shipment. Since coal excavation will occur without blasting, nitrogen enrichment of receiving waters due to explosives use is not a concern.

Potential sources of wastewater include:

- sediment-laden runoff from construction disturbance,
- groundwater from the underground mine workings,
- coal pile storage runoff,
- waste rock dump runoff and,
- surface runoff from buildings, roads and parking lots.

Mine groundwater is not expected by the consultants to be contaminated with heavy metals. Drainage from the waste rock dump and coal storage piles is also expected to be free of heavy metals as the rock and coal are low sulphur, non-acid generating materials. The only constituent expected to be of concern in water discharged to the Pine River is suspended solids arising from surface erosion and waste rock runoff. To minimize the sediment load, a water management plan has been designed so that all runoff will be collected by diversion ditches and conveyed to three settling ponds. The waste water collected in this manner is expected to meet Provincial effluent objectives before being discharged to the Pine River (e.g. 25-75 mg/L suspended solids). The wastewater settling ponds have been designed to permit effective settling at flows up to the 10-year, 24-hour flood flow with a minimum retention time of 10 hours. The total design flow for the settling ponds is 0.17 m^3/s. The suspended solids load in the outflow, at a concentration of 75 mg/L, would be 1 102 kg/d. Assuming that such loading occurred during an extreme low flow (2.6 m^3/s for the October-April, seven-day average low flow with a 10-year return period) the concentration of suspended solids that would be contributed to ambient levels after complete mixing would be:

$$\frac{1102\ \text{kg/d}}{2.6\ \text{m}^3/\text{s} \times 86.4} = 4.9\ \text{mg/L}$$

This value is highly conservative since it assumes maximum loading during minimum streamflow. A suspended solids concentration of 75 mg/L and maximum settling pond outflow are highly unlikely during low flow periods. Thus, if this mine is built, its water quality impact is expected to be low.

4.5 DIFFUSE AND UNPERMITTED WASTE DISCHARGES

Most of the Pine River watershed is in a natural state with minimal land disturbance. Agriculture and logging occur more extensively in the lower part of the basin, and contribute to the sediment load of the river. These additions are masked by the naturally high suspended solids load during spring flood and summer rain events. Suspended solids are also contributed from Hart Highway (#97) culverts and Chetwynd storm sewers.

Agriculture is limited to hay and cereal crop production and some cattle grazing. Fertilizers and pesticides are not believed to be used in sufficient quantities to warrant pollution concern (R. Girard, 1983; personal communication).

5. WATER QUALITY

5.1 PINE RIVER

There are six Ministry of Environment water quality sites on the Pine River relevant to the effluent discharges. Three of these sites (0400562, 1177704, and 0400561) have data for the years 1976-1977, which is before the installation of Chetwynd's Pine River outfall, and the others (0410027, 0410028, and 0410029) were established in 1983 after the outfall began operating. The locations of these are shown in Figure 3 and site descriptions are given in Table 7 and Table 8 along with a summary of the water quality data. Environment Canada (Water Quality Branch) sampled the Pine River in 1966, 1967, and 1969. These data are presented in Table 9. Water quality data collected by the consultants for the proposed Willow Creek Coal Project are shown in Table 10.

Analysis of the water quality of the Pine River was hampered by a small number of samples, a limited sampling period, and for some characteristics, a lack of sampling at all monitoring sites on the same day. Site 0400561 (Twidwell Bend) was too far downstream to demonstrate the effects of the treated sewage discharge via Centurion Creek. There are presently too few data for the new sites in the vicinity of Chetwynd's Pine River outfall to provide a meaningful analysis. There were also too few fecal coliform bacteria data for meaningful analysis, and concentrations projected from effluent loadings had to be calculated.

Review of available data indicates that water in the Pine River is alkaline (pH 6.8-8.4, total alkalinity 70-198 mg/L), moderately hard (75-205 mg/L), low in nutrients, colored (3-35 T.A.C.Units), and turbid (1.7-88 NTU). Pine River water at all of the sites can be described as of good quality, although it exceeds drinking water criteria for turbidity, total iron, and total manganese (B.C. Ministry of Health, 1982). The high levels of these constituents are attributable to the high levels of suspended solids arising largely from natural erosion processes during spring melt and rain events (the river is clear during the winter and most of the late summer and autumn). The high values recorded for these characteristics do not affect the safety of the water for domestic use or its aesthetic acceptability by consumers. The high concentrations are due to the iron and manganese content of the suspended sediment, since removal of the suspended solids prior to distribution of the water to Chetwynd consumers reduces total iron and total manganese to acceptable levels (i.e. 0.4 mg/L and 0.09 mg/L total iron; and 0.02 mg/L and 0.01 mg/L total manganese on April 19, 1977 and March 26, 1980, respectively). Settling of the water prior to distribution eliminates potential problems with unpalatable tastes, scaling of pipes, or fabric staining.

Dilution

Year-round discharge of Chetwynd's treated sewage to the Pine River has eliminated the effluent dilution problems that occurred during discharge to Centurion Creek. Effluent dilution at present maximum discharge and minimum streamflows ranges from 124:1 during the winter 10-year low flow to 842:1 during the mean August low flow (Table 11). Effluent dilution ratios are expected to decrease by 1992 as a result of increased effluent flow: the projected minimum dilution ratios will range from 62:1 during the winter 10 year low flow to 421:1 during the mean August low flow (Table 11). From the few data available at this time, it is not possible to calculate accurately the zone of influence downstream from Chetwynd's outfall.

BOD and Suspended Solids

The available receiving water data for dissolved oxygen and suspended solids are few, but they do not indicate water quality degradation downstream from the Chetwynd outfall. Similarly, the predicted concentrations attributable to sewage input under conditions of minimum streamflow (Oct.-April 10-year low flow), maximum present effluent loading, and complete mixing are low: BOD_5 = 0.5 mg/L; suspended solids = 1.0 mg/L (Table 6).

During the mean August low flow, the expected increase in receiving water concentrations would be even lower: BOD_5 = 0.08 mg/L; suspended solids = 0.15 mg/L (Table 6). This is a result of the high dilution available in the Pine River even during extreme low flow periods (Table 11). With twice the daily discharge volume expected in 1992, the concentrations of BOD_5 and suspended solids attributable to sewage input are predicted to be only 1.0 mg/L and 2.0 mg/L, respectively, and would have no significant effect on Pine River water quality.

Nutrients

There is evidence that sewage input from Chetwynd is altering the natural nutrient balance in the Pine River (Table 12; Girard, 1981), although nuisance algal growth is not presently a problem in the Pine River downstream from the outfall. N/P ratios for sites upstream from Chetwynd range from 19:1 to 20:1, indicating phosphorus-limited primary production. Downstream from Chetwynd (site 0400561), elevated dissolved phosphorus values have reduced the N/P ratio to 14:1. This is approaching a situation where neither phosphorus nor nitrogen would be limiting algal growth. Using the projected increases in concentrations of nitrogen and phosphorus (Table 6), the N/P ratio becomes 5:1 under worst-case conditions of maximum permitted effluent flow and minimum streamflow (Table 12). At these levels the Pine River nutrient balance would be nitrogen limited: algal blooms could possibly occur in the future for an extensive distance downstream from the outfall.

The level of dissolved phosphorus in Pine River which would be attributable to the Chetwynd outfall at maximum permitted loading (and October-April 10-year low flow) is high (0.03 mg/L), and is responsible for this reduced N/P ratio. This level is 10 times ambient concentrations. The resultant receiving water concentration of dissolved phosphorus would be 0.033 mg/L (Table 12). However, since the expected increase was calculated using the 10-year winter low flow estimate it does not represent a realistic value for the growing season. Using the mean low flow estimate for August, the increase in dissolved phosphorus concentration attributable to the outfall is projected to be 0.004 mg/L (Table 6). This level is low, but when added to ambient concentrations (0.003 mg/L), it represents a doubling of phosphorus downstream from Chetwynd (Table 12). During the mean August low flow, under conditions of maximum permitted loading, the N/P ratio is estimated to be 5:1 (Table 12).

Actual measurements of dissolved phosphorus downstream from the new outfall do indicate an increase over background levels. On September 20, 1983, dissolved phosphorus was found to be 0.003 mg/L at site 0410028 (100 m downstream from the outfall) and 0.008 mg/L at site 0410029 (800 m downstream from the outfall). At site 0410027, 100 m upstream from the outfall, the background dissolved phosphorus level was 0.004 mg/L (Table 8). To determine whether such an increase over ambient levels is a consistent result of the discharge requires further sampling.

Many authors have reported that nuisance algal blooms and plant growth in lakes can occur when biologically available phosphorus concentrations exceed the 0.010-0.015 mg/L range (Carlson, 1977; Sawyer, 1947; Vollenweider, 1976). It is not known if this range of phosphorus concentrations is applicable to rivers where other factors, such as temperature, light, turbidity, and water movement play important roles. By 1992, the dissolved phosphorus concentration increase attributable to the outfall is projected to be 0.008 mg/L or twice the present concentration (assuming a 100% increase in daily discharge volume by 1992). In combination with ambient phosphorus concentrations, the level of phosphorus downstream from Chetwynd in 1992 could be in this 0.010-0.015 mg/L range.

Fecal Coliforms

On September 20, 1983, fecal coliform levels downstream from the new outfall were found to be <2 MPN/100 mL at 100 m downstream and 5 MPN/100 mL at 800 m downstream. The fecal coliform level 100 m upstream from the outfall was <2 MPN/100 mL (Table 8). On this particular day, the outfall discharged 2 040 m^3 of effluent, only slightly higher than the average daily discharge recorded since the new outfall was installed. Further fecal coliform sampling is required to verify these low downstream levels.

In the absence of sufficient coliform bacteria data for the Pine River, projected concentrations were calculated and are presented in Table 13. Fecal coliform levels were calculated for three low flows at present and maximum permitted effluent discharge levels. At present maximum effluent flows and maximum effluent fecal coliform concentrations, fecal coliform concentrations in the Pine River are expected to range from 26 MPN/100 mL during mean August low flows to 4 000 MPN/100 mL during the winter 10-year low flow. Under conditions of future maximum permitted effluent flow, fecal coliform concentrations are projected to range from 684 to 4 654 MPN/100 mL for the same low flow periods.

There is significant water-based recreation on the Pine River downstream from Chetwynd: canoeing and kayaking. High fecal coliform concentrations during the summer could indicate a health hazard for participants in these activities. At maximum permitted effluent flow (3000 m^3/d) and maximum effluent fecal coliform concentrations, receiving water concentrations of fecal coliform bacteria (684 MPN/100 mL) would exceed the B.C. Health Ministry (Richards, 1983) criterion for primary contact recreational waters (geometric mean 200 MPN/100 mL and 90th percentile of 400 MPN/100 mL). However, summer fecal coliform concentrations in the effluent can be expected to be far lower than the maximum concentrations recorded in winter. Using the maximum effluent concentration recorded during summer (24 000 MPN/100 mL) we arrive at a more realistic summer value of 26 MPN/100 mL for the receiving waters. This is approximately one order of magnitude lower than the B.C. criterion for primary contact recreational use. More receiving water fecal coliform data are required to decide whether summer chlorination of the effluent is necessary.

5.2 WATER QUALITY OBJECTIVES

The water quality of the Pine River upstream from Willow Creek is in a natural state, and water quality objectives need not be set for this reach. However, water quality objectives are currently needed for the Pine River between Willow Creek and Chetwynd, and for the Pine River downstream from Chetwynd's municipal effluent discharge.

Upstream from Chetwynd, there is the potential for elevated levels of suspended solids and turbidity originating from the Willow Creek Coal Project, and for elevated levels of fecal coliform bacteria from the Westcoast Transmission Co. Ltd. Willow Flats subdivision effluent. Although it is unlikely that either discharge would impact the Pine River water quality (Sections 4.2, 4.4), it is proposed that the following designated water uses be protected: drinking water supplies (Westcoast Transmission Co. Ltd. Willow Flats subdivision; Village of Chetwynd); water-contact recreation (i.e., canoeing, swimming, angling); and aquatic life.

Downstream from the Chetwynd municipal discharge there is the potential for depressed levels of dissolved oxygen and for elevated levels of suspended solids, turbidity, un-ionized ammonia-N, fecal coliform bacteria, and nutrients. Although there is high effluent dilution available even during low flow periods, significant increases in the above constituents are possible outside the initial dilution zone, before complete mixing occurs. Water quality objectives are recommended to protect the following designated water uses: water-contact recreation (i.e., canoeing, swimming, angling); and aquatic life.

At present, the Ministry of Environment is still developing water quality criteria, and there are insufficient receiving water quality data for the Pine River. Consequently, permanent water quality objectives for the Pine River sub-basin will not be proposed at this time. The objectives will remain provisional until receiving water monitoring programs provide adequate data, and the Ministry has established approved water quality criteria for the characteristics of concern.

The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. For example, they can be used to draw up waste management permits and plans, regulate water use, or plan fisheries management. They can also provide a reference against which the state of water quality in a particular water body can be checked.

Water quality objectives have no legal standing and their direct enforcement would not be practical. Hence, although water quality objectives should be used when determining effluent permit limits, they should not be incorporated as part of the conditions in a waste management permit.

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.

Provisional water quality objectives are summarized below. They apply to discrete samples taken at any time, at any point in the river, either upstream or downstream from Chetwynd, but outside the initial dilution zone of a waste discharge. The objectives apply year-round, except for the fecal coliform objectives downstream from Chetwynd, which apply only during the recreation season (June to September inclusive).

Samples to check coliform and nitrogen objectives are taken over a 30-day period at weekly intervals. This frequency would only be used if less frequent routine monitoring or other factors suggested that the objectives may be exceeded. Background turbidity and suspended solids in the following objectives are defined as the levels measured upstream from a waste discharge at the time when downstream levels are measured.

a) WILLOW CREEK TO CHETWYND

Turbidity

- induced turbidity should not exceed 5 NTU when background turbidity is less than or equal to 50 NTU, nor should induced turbidity be more than 10 percent of background when background is greater than 50 NTU (Singleton, 1983).

This objective applies on a year-round basis, to protect aquatic life.

Suspended Solids

- induced suspended solids (nonfilterable residue) should not exceed 10 mg/L when background suspended solids is less than or equal to 100 mg/L, nor should induced suspended solids be more than 10 percent of background when background is greater than 100 mg/L (Singleton, 1983).

This objective applies on a year-round basis, to protect aquatic life.

Fecal Contamination

- the fecal coliform content shall not exceed 10 MPN/100 mL in 90 percent of river water samples taken in any consecutive 30-day period (B.C. Ministry of Health, 1982).

This objective applies on a year-round basis, to protect drinking water supply.

b) DOWNSTREAM FROM CHETWYND

Turbidity

- induced turbidity should not exceed 5 NTU when background turbidity is less than or equal to 50 NTU, nor should induced turbidity be more than 10 percent of background when background is greater than 50 NTU (Singleton, 1983).

This objective applies on a year-round basis, to protect aquatic life and aquatic habitat.

Suspended Solids

- induced suspended solids (nonfilterable residue) should not exceed 10 mg/L when background is less than or equal to 100 mg/L, nor should induced suspended solids be more than 10 percent of background when background is greater than 10 mg/L (Singleton, 1983).

This objective applies on a year-round basis, to protect aquatic life and aquatic habitat.

Total Chlorine Residual

- not to exceed 0.002 mg/L (E.P.A., 1976)

This objective would be necessary to protect downstream aquatic life in the event that chlorination of Chetwynd's effluent is implemented, and would apply 100 m downstream from the Chetwynd municipal discharge, on a year-round basis. This objective level cannot be measured directly because it is lower than current minimum detectable limits for routinely used methods. Levels may have to be estimated from effluent concentrations and river flow.

Fecal Contamination

- the fecal coliform content shall not exceed a running log mean of 200 MPN/100 mL for a minimum of five weekly samples during the recreation season. No more than 10 percent of total samples during any thirty day period shall exceed 400 MPN/100 mL (Richards, 1983).

This objective applies during the summer, June 1 to September 30, to protect water-contact recreation.

Periphyton Growth

- total periphyton growth 100 m downstream from the Chetwynd municipal discharge is not to exceed the upstream periphyton growth by more than 25 percent. This objective is based on a minimum increase in periphyton growth that could likely be detected. The periphyton growth should be measured as biomass per unit area at sites subject to similar light and water flow conditions.

This objective is designed to prevent summer oxygen depletions in the water column, loss of aquatic habitat, and aesthetic problems, and thus protect aquatic life and recreation. Nitrogen and phosphorus values cannot be specified above which nuisance growth of periphyton would occur. Ambient nutrient concentrations and periphyton growth would require further documentation before specific objectives could be set.

Un-ionized Ammonia-N

- un-ionized ammonia-N is not to exceed an average of 7 µg/L calculated from at least 5 weekly samples taken in a period of 30 days, and is not to exceed a maximum of 30 µg/L at any time (Pommen, 1983).

This objective applies on a year-round basis, to protect aquatic life from toxic levels of un-ionized ammonia-N.

Nitrite-N

- nitrite-N is not to exceed an average of 20 µg/L calculated from at least 5 weekly samples taken in a period of 30 days and is not to exceed a maximum of 60 µg/L at any time (Pommen, 1983).

This objective applies on a year-round basis, to protect aquatic life.

Dissolved Oxygen

- a minimum of 7.75 mg/L (Davis, 1975).

This level is one standard deviation above the mean incipient oxygen response level for freshwater salmonids. This corresponds to the Davis level A of protection and assures a high degree of protection for the important salmonid sports fish species in the Pine River.

This objective applies on a year-round basis.

6. CONCLUSIONS AND MONITORING RECOMMENDATIONS

Treated sewage from the Village of Chetwynd has been the only major permitted discharge to the Pine River. Most of the Pine River watershed is in a pristine natural state with minimal land disturbance. The resulting water quality is good with the exception of seasonally high suspended sediment loads. This is accompanied by levels of turbidity, total iron, and total manganese in excess of Provincial drinking water quality standards. The high values for these constituents do not affect the safety of the water for drinking since treatment (settling) eliminates the problem before distribution to the Village of Chetwynd.

Effluent and receiving water monitoring recommendations are given in the following sections and in Table 15. These recommendations are made from a technical perspective and the extent to which monitoring is conducted will depend on the overall priorities and monitoring resources available for the province. The recommended monitoring program is the "minimum" program. The "optimum" program would be to increase the frequency of sampling as well as to add water quality variables which could evaluate diffuse loadings. Monitoring resources surplus to the achievement of the "minimum" program should be directed toward the "optimum" program.

At present, there are inadequate data regarding fish species distribution and fish habitat use in the Pine River for the purpose of assessing any impacts of effluent discharges. A fisheries program capable of obtaining such data is required. Fish sampling should be concentrated in the mainstem and associated side-channels in the vicinity of the present and potential discharges outlined in this report.

6.1 CHETWYND

The Pine River outfall for the Chetwynd sewage has been put into operation only recently, and there are few data analyzing its direct effect. Review of available water quality data for six sites on the Pine River has not shown any serious impairment of water quality as a result of the sewage discharge, although the water quality data base was not adequate to provide a good analysis of the situation. A program designed to measure the direct effect of effluent on the Pine River has begun (R. Girard, 1983; personal communication).

The existing receiving environment and effluent monitoring programs are outlined in Table 14. A new receiving environment program and modifications to the effluent monitoring are recommended in Table 15.

Year-round discharge of Chetwynd sewage to the Pine River has significantly improved the effluent dilution problems which occurred in Centurion Creek. The dilution range of between 20 and 200:1 can be met at a permitted discharge rate of 3 000 m^3/d during all minimum flow periods. Effluent dilution at present discharge levels is not expected to be less than 124:1. With increasing discharge levels over the next 10 years effluent dilution should remain above 60:1 even during severe winter low flow.

The water quality effects of Chetwynd's effluent were calculated using regionalized streamflow estimates and require verification with actual data. It is recommended that a gauging station be established on the Pine River at the Chetwynd outfall to substantiate the low flow estimates used here to predict effluent dilution ratios. David Minerals Ltd., should the project proceed, will be establishing a gauging station on the Pine at the E-Z Bridge. The data generated there should be used with occasional measurements at the proposed Chetwynd gauging station to produce more reliable low flow estimates at Chetwynd.

BOD_5 and suspended solids concentrations in the receiving waters, attributable to Chetwynd's effluent, are predicted to be negligible after complete mixing. However, higher orthophosphorus levels could alter the nutrient balance of the river, and fecal contamination is expected during minimum streamflows. A systematic water quality monitoring program will be required to verify the predictions made in this report. Monitoring should occur four to six times a year initially, during the mid-summer and winter low flow periods at the established sites 1177704 and 0400561 as well as at the newly created sites: 0410027 (100 m upstream from the outfall), 0410028 (100 m downstream from the outfall), and 0410029 (800 m downstream from the outfall). The monitoring downstream from the outfall will aid in determining the extent of the zone of influence, i.e., that reach of river experiencing less than maximum effluent dilution. Characteristics to be monitored are shown in Table 15. It is important that all effluent and river monitoring occur on the same day. Visual observations of algal growth and aquatic macrophyte growth should be recorded and compared to upstream conditions.

Provisional water quality objectives have been recommended for the Pine River downstream from Chetwynd (Section 5.2). The future need for phosphorus removal and chlorination for the Chetwynd effluent will be assessed by the monitoring for fecal contamination and algal growth.

6.2 WILLOW FLATS

Although Westcoast Transmission Co. Ltd. has been permitted since 1971 to discharge domestic sewage from its company subdivision to the Pine River, actual discharge has occurred only once (May, 1983). Effluent quality should be monitored for:

BOD_5
Suspended Solids (Residue, nonfilterable)
Fecal coliform density
Flow

Effluent monitoring should occur at the outlet of the sewage lagoon to coincide with the intermittent discharge regime. Receiving water monitoring will depend on effluent quality and quantity.

6.3 HASLER FLATS

Since issuance of Permit PA 5151 in May, 1979, the Westcoast Transmission Co. Ltd. natural gas processing plant has been operating at less than one third of its capacity. Total sulphur emissions have averaged 7 tonnes per day. Future emission rates may be double or treble present rates. However, the acid precipitation impact upon regional water quality is expected to be low since the surrounding watersheds drain carbonate-containing terrain with a large capability of buffering hydrogen ion input. Water quality monitoring for this discharge is not deemed necessary at this time. However, further study of precipitation pH is recommended.

6.4 WILLOW CREEK COAL PROJECT

If the project proceeds, the underground coal mine proposed by David Minerals Ltd. is not expected to impact the Pine River, seriously. There is no coal preparation or washing, and no radical watershed disturbance. Groundwater and stockpile runoff are not expected to be contaminated with heavy metals, and coal extraction will occur without blasting agents (potential nitrogen contributors). The only constituent expected to be of concern in the discharges is suspended sediments from surface erosion and waste rock runoff. A series of settling ponds will be included in the project so that discharged wastewater will meet Provincial effluent objectives for suspended solids.

It is recommended that the settling pond effluent be monitored a minimum of four times per year for:

pH	Mercury, Total
Sulphate	Cadmium, Total
Suspended solids (Residue, nonfilterable)	Zinc, Total
Alkalinity, Total	Flow
Turbidity	Ammonia-N
Phosphorus, Diss.	Nitrite
	Nitrate

Suspended solids, turbidity, and flow should be sampled more frequently than the other characteristics (e.g., weekly during spring freshet and during rain events).

It should also be necessary for the proponent to establish the level of effluent dilution afforded by spring streamflows. Receiving water monitoring is recommended if permit effluent quality limits cannot be met.

LITERATURE CITED

B.C. Ministry of Health. 1982. British Columbia drinking water quality standards 1982. Victoria, B.C. 18 pp.

Carlson, R.E. 1977. A trophic state index for lakes. Limnol. Oceangr. 22:361-369.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. J. Fish. Res. Board. Can. 32: 2295-2332.

E.L.U.S.C. (Environment and Land Use Sub-Committee on Northeast Coal Development). 1977. Preliminary environmental report on proposed transportation links and townsites. Victoria, B.C. 141 pp. + 4 App.

E.P.A. (U.S. Environmental Protection Agency). 1976. Quality criteria for water. E.P.A. - 440/9-76-023. Washington, D.C.

Fuhr, B. (Surveys and Resource Mapping Branch, Victoria). 1982. Personal communication, November 22, 1982.

Girard, R. 1981. Nutrient status of Pine River. Memorandum to Pollution Control Permit PE-1167 File, Waste Management Branch, Ministry of Environment, Prince George, B.C. 5 pp.

Girard, R. (Head, Environmental Section, Waste Management Branch). 1984. Personal Communication, February 17, 1984.

I.E.C. International Environmental Consultants Ltd., and Kilborn Engineering (B.C.) Ltd. 1982. Willow Creek project stage II submission. Volume 1. Environmental and socio-economic impact assessment. Prepared for David Minerals Ltd. 236 pp.

Kotturi, M.S. (Air Studies Branch, Victoria). 1982. Emissions and air quality in the Peace River strategic planning unit. Draft Report. Prepared for Planning and Assessment Branch, Ministry of Environment, Victoria, B.C. 14 pp.

Kotturi, M.S. (Air Studies Branch, Victoria). 1983. Personal communication, January 13, 1983.

Obedkoff, W. (Water Management Branch, Victoria). 1982. Peace River strategic plan; peak and low flow estimates. Memorandum to J. Bernard, Planning Branch, October 15, 1982. File 1E-4.1 Hy.

Pommen, L.W. 1983. The effect on water quality of explosives use in surface mining. Volume 1: Nitrogen sources, water quality, and prediction and management of impacts. B.C. Ministry of Environment Technical Report 4, Victoria, B.C. 149 pp.

Richards, H.M. 1983. Memorandum from Provincial Health Officer, Preventive Services Branch, Ministry of Health to R.J. Buchanan, Resource Quality Section, Water Management Branch, Ministry of Environment. May 20, 1983. Water Quality Unit File No. 64.15. 1 p.

Sawyer, C.N. 1947. Fertilization of lakes by agricultural and urban drainage. J. New England Water Works Assn. 61:109-27.

Singleton, H.J. 1983. Water quality criteria for particulate matter. Draft manuscript. B.C. Ministry of Environment, Water Management Branch, Victoria, B.C. 76 pp.

Stone, M. (Planning and Assessment Branch, Victoria). 1982. Peace River planning unit population projections 1987 and 1992. Memorandum to L. Pommen, Aquatic Studies Branch, October 8, 1982. File 64.0307.

Swain, L. 1983. Preliminary acid rain lake sensitivity maps. Folio of four draft maps. Water Management Branch, Ministry of Environment, Victoria, B.C.

Vollenweider, R.A. 1976. Advances in defining critical loading levels for phosphorus in lake eutrophication. Mem. Inst. Ital. Idrobiol. 33:53-83.

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Figure 1.

STRATEGIC ENVIRONMENTAL PLANNING UNITS

- Strategic Planning Unit Boundary
- Resource Management Region Boundary
- • Designated Regional Centre

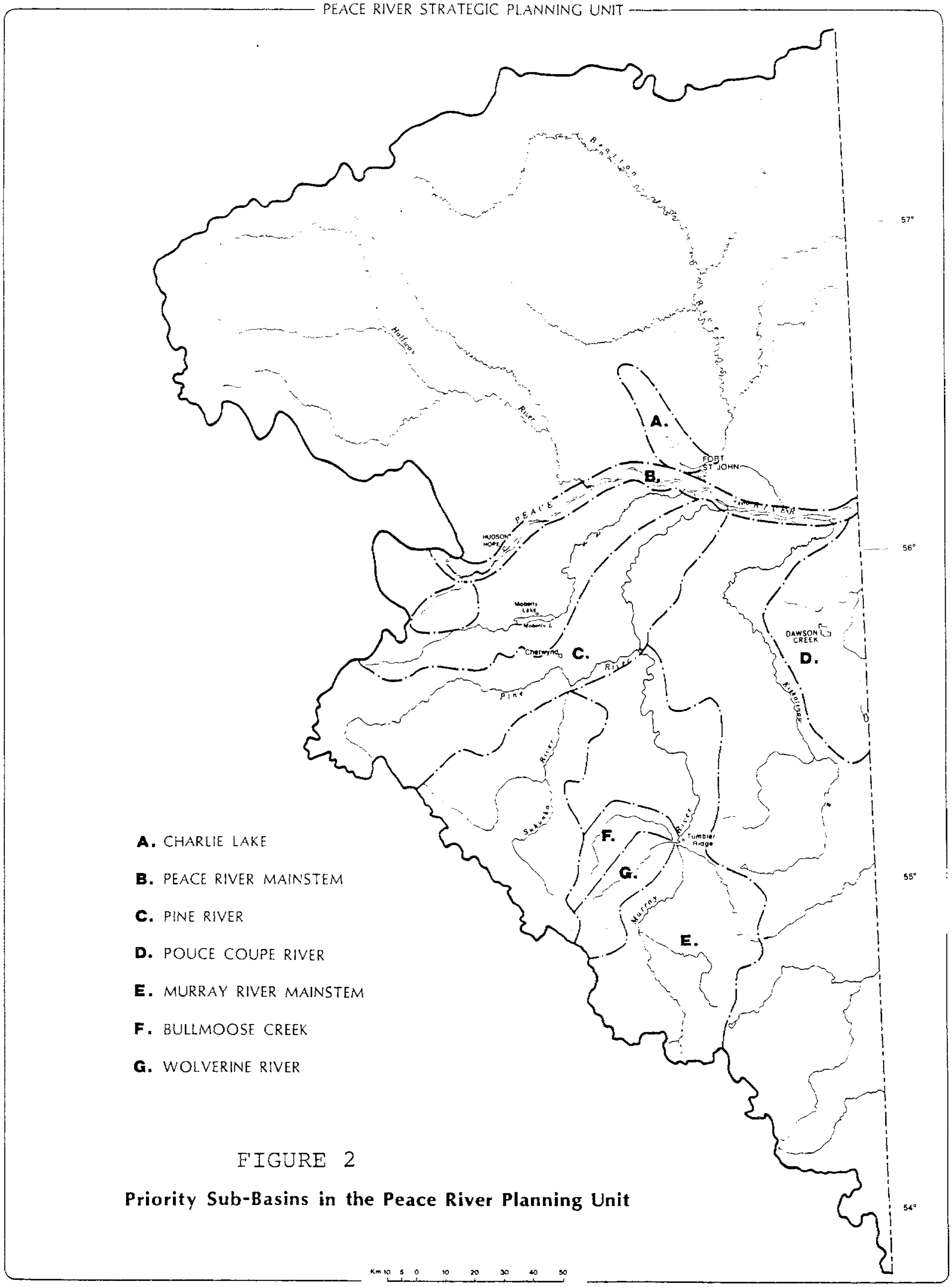
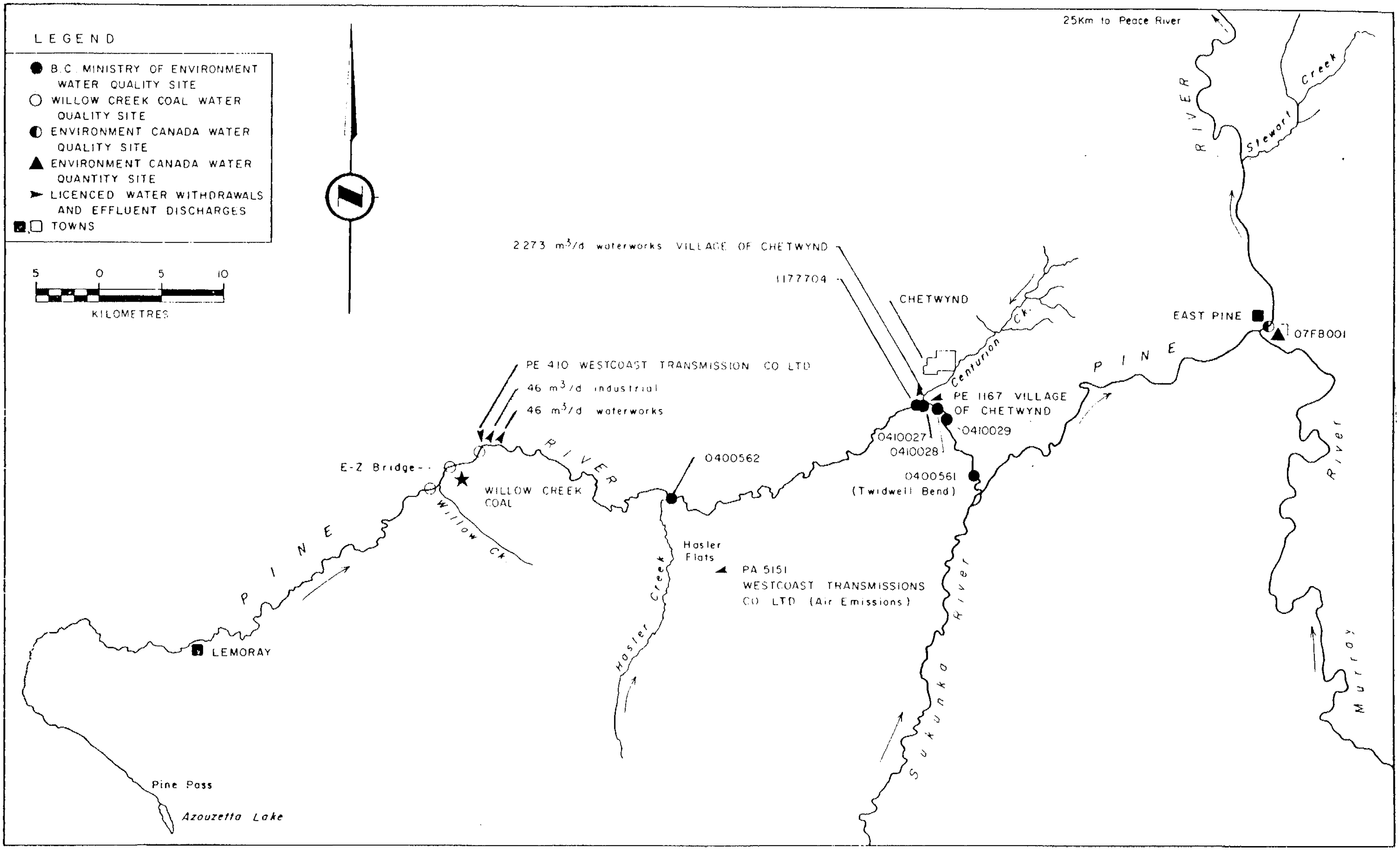


FIGURE 2

Priority Sub-Basins in the Peace River Planning Unit

Figure 2:

MAP OF THE PINE RIVER SUB-BASIN SHOWING EFFLUENT DISCHARGES, RECEIVING WATER SITES AND WATER WITHDRAWALS



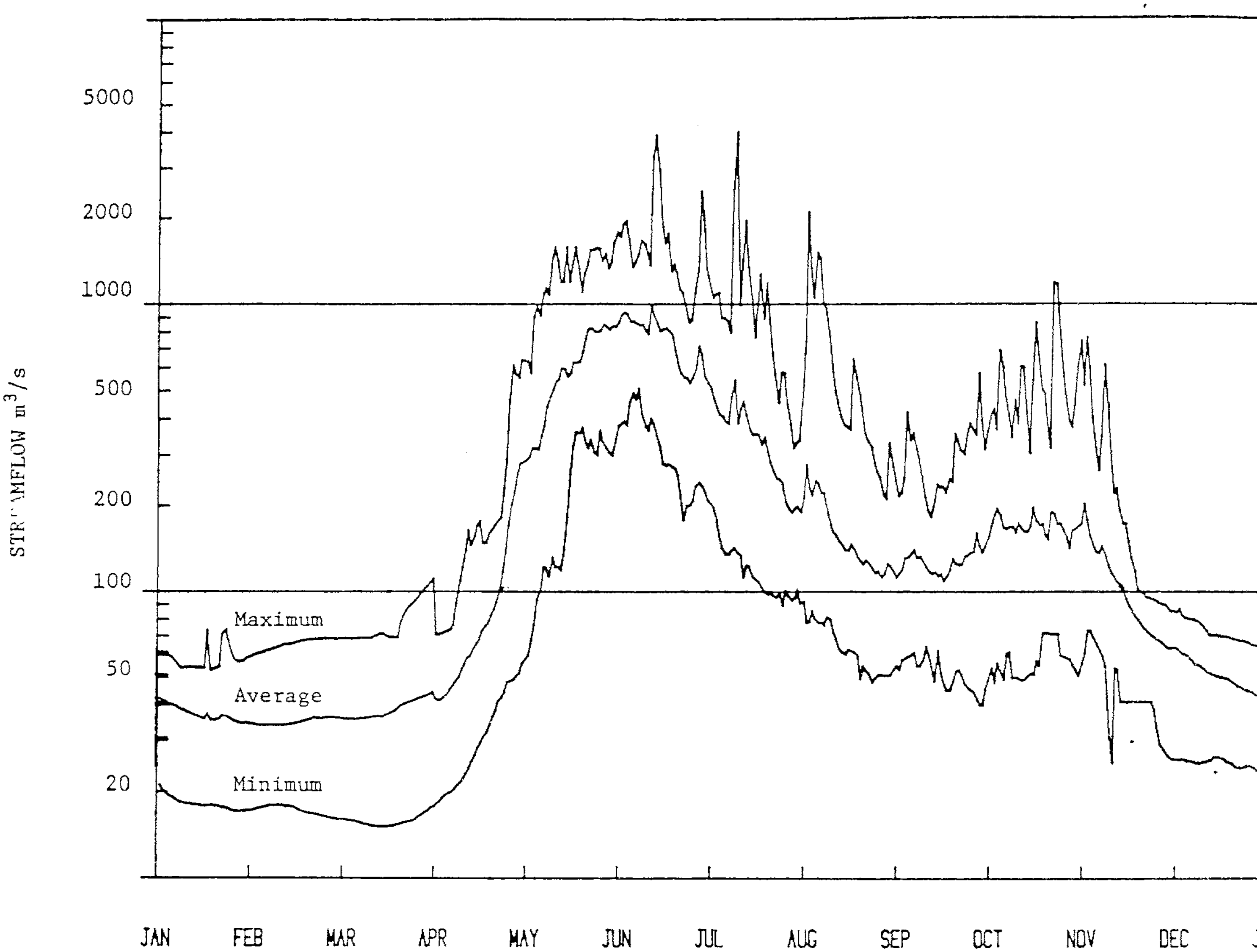
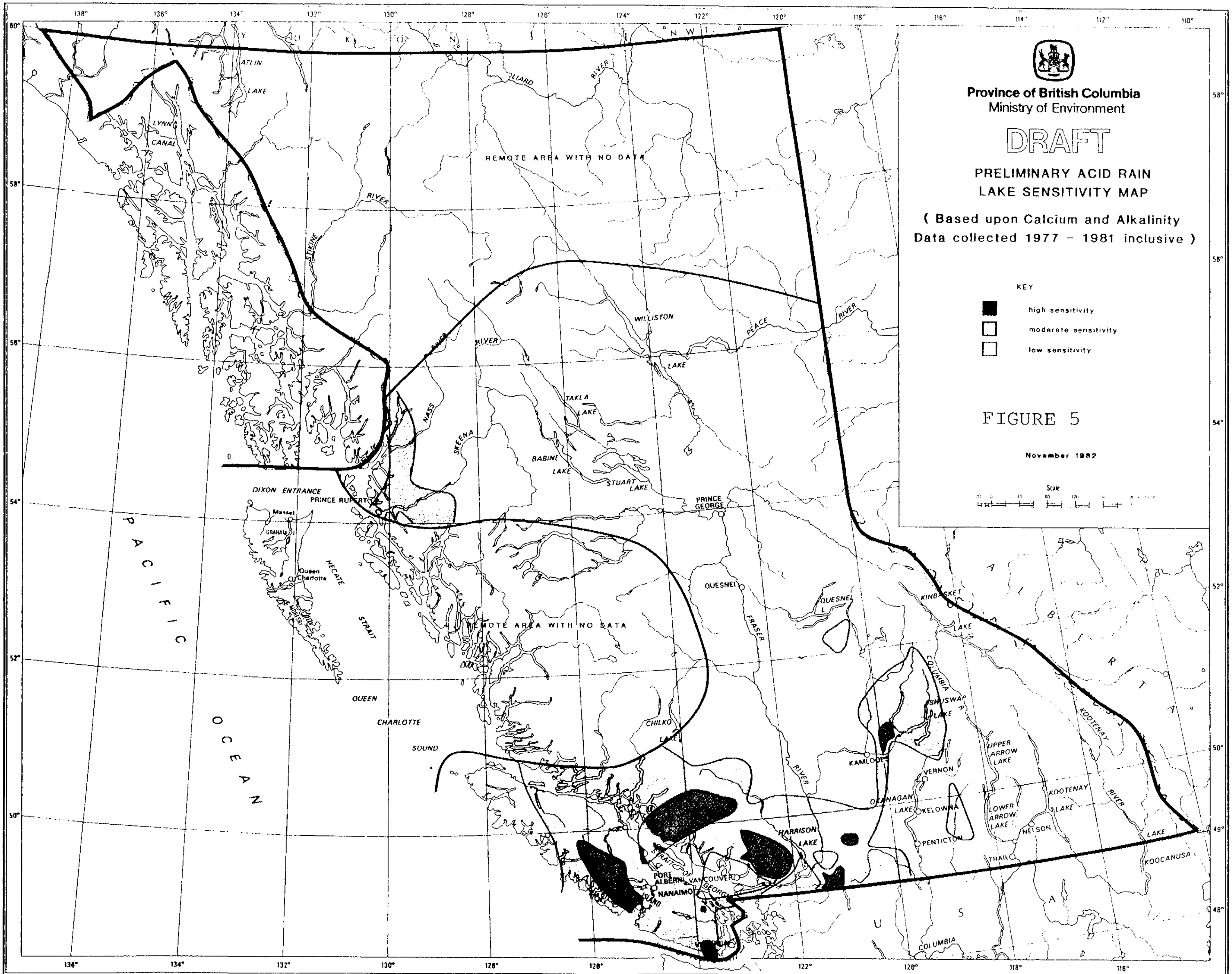


FIGURE 4 Hydrograph for Pine River near East Pine (Water Survey of Canada Station 07FB001) Showing Maximum, Minimum and Average Daily Flows for the Period 1961-1981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DRAFT
PRELIMINARY ACID RAIN
LAKE SENSITIVITY MAP
(Based upon Calcium and Alkalinity
Data collected 1977 - 1981 inclusive)
KEY
high sensitivity
moderate sensitivity
low sensitivity
FIGURE 5
November 1982
Scale
REMOTE AREA WITH NO DATA
REMOTE AREA WITH NO DATA
PACIFIC OCEAN
DIXON ENTRANCE
PRINCE RUPERT
HECATE STRAIT
QUEEN CHARLOTTE SOUND
WILLISTON LAKE
PEACE RIVER
TAKLA LAKE
BABINE LAKE
STUART LAKE
PRINCE GEORGE
QUESNEL
FRASER RIVER
CHILKO LAKE
KAMLOOPS
VERNON
OKANAGAN LAKE
KELOWNA
PENTICTON
HARRISON LAKE
VANCOUVER
NANAIMO
PORT ALBERNI
STRAIT OF GEORGIA
SHUSWAP LAKE
COLUMBIA
UPPER ARROW LAKE
LOWER ARROW LAKE
KOOTENAY LAKE
KOOTENAY RIVER
NELSON
TRAIL
KOOCANUSA LAKE
KINBASKET LAKE
ALBERTA
U S A
ATLIN LAKE
LYNN CANAL
STIKINE RIVER
LIARD RIVER
NASS
SKEENA RIVER
YUKON
N W T
Masset
GRAHAM
Queen Charlotte
MORESBY

TABLE 1
SUMMARY OF IMPORTANT WATER WITHDRAWALS
FOR THE PINE RIVER SUB-BASIN

SOURCE	NO. OF LICENCES	QUANTITY	PURPOSE
Pine River	2	2273 m^3/d*	Water works - Village of Chetwynd
Pine River	1	46 m^3/d	Water works - Westcoast Transmission Co. Ltd.
Pine River	1	46 m^3/d	Industrial - Westcoast Transmission Co. Ltd.

* actual use (1981) for Village of Chetwynd = 1773 m^3/d.

TABLE 2

PINE RIVER SUB-BASIN

SUMMARY OF PERMITS FOR WASTE DISCHARGE

PERMIT HOLDER	PERMIT NUMBER	DISCHARGE TO	MAXIMUM WASTE DISCHARGE FLOW (m^3/d)	TYPE OF DISCHARGE
Village of Chetwynd	PE 1167*	Pine River	3000	treated municipal sewage
Westcoast Tranmission Co. Ltd.	PA 5151*	air	--	sour gas flaring
Westcoast Transmission Co. Ltd.	PE 410	Pine River	32	treated sewage effluent
Village of Chetwynd	PR 2896	ground	--	refuse landfill
Peace-Liard Regional District (Willow Flats)	PR 2377	ground	--	refuse landfill

*priority permits as determined by the regional Waste Management Branch.

TABLE 3
VILLAGE OF CHETWYND
SAMPLING OF TREATED EFFLUENT BY PERMITTEE AND PROVINCE

CHARACTERISTICS		DISCHARGE TO CENTURION CREEK NOVEMBER 1972 - JUNE 1982			DISCHARGE TO PINE RIVER SEPTEMBER 1982 - SEPTEMBER 1983		
		MEAN	RANGE OF VALUES	NUMBER OF VALUES	MEAN	RANGE OF VALUES	NUMBER OF VALUES
BOD_5	mg/L	33	15-67	63	26	14-51	16
Coliforms, Fecal	MPN/100 mL	3162*	2-790 000	46	1047*	<2-54 000	19
, Total	MPN/100 mL	-	-	-	4726*	200-160 000	3
Conductance	uS/cm	-	-	-	685	593-739	3
Flow	m^3/s	0.023	0.004-0.038	272	0.021	0.005-0.046	395
	m^3/d	1987	346-3283	272	1799	455-4024	395
Nitrogen, Ammonia	mg/L	14.8	10.9-18.5	4	-	-	-
Nitrite/nitrate	mg/L	0.2	0.1-0.3	3	-	0.07	1
Total	mg/L	20.8	20-22	4	-	27	1
Kjeldahl	mg/L	20.8	20-22	4	-	27	1
pH		8.1	7.2-10.4	37	7.3	6.5-9.4	16
Phosphorus, Dissolved (Orthophosphate)	mg/L	3.1	2.3-3.5	3	-	-	-
Phosphorus, Total	mg/L	4.4	3.9-5.0	4	3.3	0.01-4.8	18
Solids, Suspended	mg/L	38.8	2-123	66	31.3	<5-122	16
, Dissolved	mg/L	-	-	-	350	300-400	2

* geometric mean

TABLE 4

SUMMARY OF PERMITTED, ACTUAL, AND PROJECTED FUTURE WASTE LOADS FOR PE 1167, VILLAGE OF CHETWYND AND PE 410, WESTCOAST TRANSMISSION CO. LTD.

PE 1167 VILLAGE OF CHETWYND

CHARACTERISTICS	PERMIT CONDITIONS		CONDITIONS PRIOR TO PINE RIVER OUTFALL		PRESENT CONDITIONS (SEPT. 1982 - SEPT. 1983)		MAXIMUM PROJECTED LOADING FOR 1992*[1] kg/d
	Level or Concentration	Loading kg/d	Maximum Level or Concentration	Maximum Loading*[2] kg/d	Maximum Level or Concentration	Maximum Actual Loading*[3] kg/d	
Flow	3000 m^3/d		3283 m^3/d		4024 m^3/d		8048
BOD_5	45 mg/L	135	67 mg/L	220	51 mg/L	63 May 10/83	362
Solids, Suspended	60 mg/L	180	123 mg/L	404	122 mg/L	212 Feb. 7/83	482
Phosphorus, Diss.	-	-	3.5 mg/L	12	-	-	-
, Total	-	-	-	-	4.8 mg/L	8.6 June 13/83	-
Nitrogen,							-
Ammonia-N	-	-	18.5 mg/L	61	-	-	
Nitrite/nitrate	-	-	0.3 mg/L	1	0.07 mg/L	0.1 Feb. 15/83	-

PE 410 WESTCOAST TRANSMISSION CO. LTD.

CHARACTERISTICS	PERMIT CONDITIONS		PRESENT CONDITIONS 1975 - 1980		PROJECTED LOADING FOR 1992 kg/d
	Level or Concentration	Loading kg/d	Maximum Level or Concentration	Maximum Loading kg/d	
Flow	32 m^3/d				
BOD_5	50 mg/L	1.6	89 mg/L	2.8	-
Solids, Suspended	60 mg/L	1.9	217 mg/L	6.9	-

*[1] based on a projected 1992 population of 5 201, a 100% increase over the 1982 population estimate (Stone, 1982). Assumes a doubling of present maximum effluent flows and permit compliance for permitted constituents.
*[2] calculated by multiplying maximum flow by maximum concentration, thereby providing a conservative estimate of actual loadings.
*[3] calculated by using flow and concentration data for the same date.

TABLE 5
WESTCOAST TRANSMISSION CO. LTD. (PERMIT PE 410)
SAMPLING OF TREATED EFFLUENT BY THE PROVINCE
BETWEEN JANUARY 1975 AND OCTOBER 1980

CHARACTERISTICS			MEAN	RANGE OF VALUES	NUMBER OF VALUES
BOD_5		mg/L	57.2	32-89	9
Coliforms, Fecal		MPN/100 mL	3900	2400-5400	2
Nitrogen,	Ammonia	mg/L	1.8	-	1
	Kjeldahl	mg/L	8.0	-	1
	Nitrite/Nitrate	mg/L	12.5	-	1
	Total	mg/L	21.0	-	1
pH			8.1	7.4-9.5	9
Phosphorus, Dissolved (Orthophosphorus)		mg/L	4.3	-	1
Solids, Suspended		mg/L	86	11-217	9
Solids, Total		mg/L	505	448-538	5

TABLE 6

PREDICTED INCREASES IN CONCENTRATIONS OF KEY CHARACTERISTICS IN PINE RIVER, CONTRIBUTED FROM THE CHETWYND OUTFALL DURING MINIMUM STREAMFLOW*1 AND MAXIMUM EFFLUENT LOADING

CHARACTERISTICS	MAXIMUM PRESENT LOADING*2 kg/d	INCREASE IN RECEIVING WATER CONCENTRATION (mg/L)*3	
		at max. present loading and Oct.-April 10-year low flow*1	at max. present loading and mean August low flow*1
Ammonia-N	61	0.15	0.02
BOD_5	220	0.50	0.18
Suspended Solids	404	1.0	0.15
Phosphorus, dissolved	12	0.03	0.004
NO_3/NO_2 -N	1	0.002	0.0004

*1 The 10-year low flow estimate (7-day average discharge) for Pine River at Twidwell Bend is 4.7 m^3/s. The mean August 7-day average low flow estimate is 32 m^3/s.

*2 From Table 4.

*3 Assuming complete mixing of effluent and river water.

TABLE 7

WATER QUALITY OF THE PINE RIVER AS MEASURED BY THE PROVINCE (MARCH 1976 TO SEPTEMBER 1977)

CHARACTERISTICS		0400562 AT HASLER CREEK CONFLUENCE			1177704 50m UPSTREAM FROM CENTURION CREEK CONFLUENCE			0400561 AT TWIDWELL BEND		
		Mean	Range of Values	No. of Values	Mean	Range of Values	No. of Values	Mean	Range of Values	No. of Values
Aluminum, Total	mg/L	<0.01	--	3	0.17	<0.01-1.1	7	0.014	<0.01-0.02	5
Arsenic, Total	mg/L	<0.005	--	4	<0.005	--	7	<0.005	--	6
Cadmium, Total	µg/L	<0.5	--	4	<0.5	--	6	0.7	<0.5-1.2	6
Calcium, Dissolved	mg/L	32.9	23.4-43	4	34.6	25.6-54.6	17	38.3	25.8-58.4	6
Carbon, Organic	mg/L	2.3	1-5	4	4.2	1-11	9	2.7	1-8	7
Chromium, Total	mg/L	0.007	<0.005-0.014	4	0.01	<0.005-0.02	7	0.009	<0.005-0.018	6
Chloride	mg/L	--	--	--	1.9	--	1	4.1	--	1
Coliform, Fecal	MPN/100 mL	--	--	--	2	--	2	--	--	--
, Total	MPN/100 mL	--	--	--	12.5	8-17	2			
Color	T.A.C. Units	7.8	3-12	4				12	3-35	6
Copper, Total	mg/l	0.003	<0.001-0.005	4	0.004	<0.001-0.01	11	0.004	<0.001-0.007	6
, Dissolved	mg/L	--	--	--	<0.001	--	7	--	--	--
Fluoride	mg/l	<0.1	--	3	0.11	<0.1-0.12	6	0.102	<0.10-0.11	5
Iron, Total	mg/l	1.0	0.2-2.0	4	2.3	0.1-7.3	11	1.4	0.3-4.3	5
, Dissolved	mg/l	--	--	--	0.1	0.1-0.2	7	--	--	--
Lead, Total	mg/L	0.002	<0.001-0.004	4	0.003	<0.001-0.006	11	0.003	<0.001-0.007	6
, Dissolved	mg/L	--	--	--	0.001	--	7	--	--	--
Magnesium, Total	mg/L	9.8	--	1				8.8	7.5-10.1	2
, Dissolved		6.6	3.8-9.6	4	7.4	5-12	17	8.3	4.6-13.2	6
Manganese, Total	mg/L	0.03	<0.02-0.04	4	0.05	<0.02-0.13	10	0.05	<0.02-0.11	6
Mercury, Total	µg/L	<0.05	--	4	<0.05	--	7	<0.05	--	6
Molybdenum, Total	mg/L	0.001	0.0007-0.002	4	0.0012	0.001-0.002	7	0.0011	0.0008-0.0017	6

TABLE 7 (Continued)

CHARACTERISTICS		0400562 AT HASLER CREEK CONFLUENCE			1177704 50m UPSTREAM FROM CENTURION CREEK CONFLUENCE			0400561 AT TWIDWELL BEND		
		Mean	Range of Values	No. of Values	Mean	Range of Values	No. of Values	Mean	Range of Values	No. of Values
Nickel, Total	mg/L	<0.01	--	4	<0.01	--	9	<0.01	--	6
Nitrogen, Ammonia	mg/L	0.008	<0.005-0.01	4	0.018	<0.005-0.09	10	0.025	<0.005-0.112	7
Kjeldalhl	mg/L	0.26	0.03-0.64	4	0.22	0.03-0.44	14	0.20	0.06-0.33	7
Nitrite/Nitrate	mg/L	0.05	<0.02-0.09	3	0.05	<0.02-0.14	14	0.05	<0.02-0.1	6
Organic	mg/L	0.25	0.02-0.63	4	0.2	0.07-0.34	8	0.18	0.05-0.31	7
Total	mg/L	0.18	0.07-0.37	3	0.24	0.08-0.48	7	0.19	0.07-0.37	4
Oxygen, Dissolved	mg/L	--	--	--	10.9	8.7-15.9	10	10.5	10.4-10.6	2
pH		8.0	7.6-8.3	4	8.2	7.8-8.4	15	8.1	7.8-8.4	7
Phenol	mg/L	--	--	--	0.002	<0.002-0.003	6	--	--	--
Phosphorus, Dissolved (Orthophosphorus)	mg/L	<0.003	--	4	<0.003	<0.003-0.04	10	0.005	<.003-.014	6
, Total	mg/L	0.03	0.005-0.05	4	0.07	0.004-0.24	16	0.003	--	1
Potassium, Dissolved	mg/L	--	--	--	0.7	--	1	1.0	--	1
Sodium, Dissolved	mg/L	--	--	--	3.1	--	1	5.2	--	1
Solids, Dissolved	mg/L	110	--	1	143	102-204	16	178	118-240	4
, Suspended	mg/L	29.5	2-63	4	55	--	1	60	5-200	7
, Total	mg/L	156	150-164	3	200	156-300	16	233	162-366	6
Sulphate	mg/L	11.6	5.8-19.7	4	14.1	5.9-23.4	6	17.6	7.3-38.8	6
Turbidity	NTU	12.5	1.7-23	4	27	2.4-88	16	27	4.2-80	7
Vanadium, Total	mg/L	0.003	0.002-0.003	2	0.005	<0.001-0.01	6	0.003	<0.001-0.006	4
Zinc, Total	mg/L	0.008	<0.005-0.012	4	0.012	<0.005-0.05	11	0.02	<0.005-0.06	6
, Dissolved	mg/L	--	--	--	<0.005	0.005-0.006	7	--	--	--

TABLE 8

WATER QUALITY OF THE PINE RIVER AFTER THE INSTALLATION OF THE NEW CHETWYND OUTFALL
(JUNE TO OCTOBER, 1983)

CHARACTERISTICS		0410027 100 m upstream from outfall			0410028 100 m downstream	0410029 800 m downstream	0400561 at Twidwell Bend		
		Mean	Range of Values	No. of Values	Values	Values	Mean	Range of Values	No. of Values
Carbon, Organic	mg/L	2.5	1-4	2	1	1	-	-	-
Chloride	mg/L	1.3	0.8-1.8	2	1.8	1.8	-	1.9	1
Coliform, Fecal	MPN/100 mL	-	<2	1	<2	5	-	-	-
Conductivity	µS/cm	271	211-330	2	330	331	309	279-338	2
Nitrogen, Ammonia	µg/L	<5	<5	2	<5	6	-	<5	1
, Kjeldahl	mg/L	0.15	0.03-0.26	2	0.02	0.04	0.075	0.07-0.08	2
, Nitrate	mg/L	0.025	0.02-0.03	2	0.02	0.02	<0.02	<0.02	2
, Nitrite	µg/L	<5	<5	2	<5	<5	<5	<5	2
, Nitrite/nitrate	mg/L	0.025	0.02-0.03	2	0.02	0.02	<0.02	<0.02	2
, Organic	mg/L	0.15	0.03-0.26	2	0.02	0.03	0.075	0.07-0.08	2
, Total	mg/L	0.17	0.05-0.29	2	0.04	0.06	0.075	0.07-0.08	2
pH		8.1	8.0-8.2	2	8.2	8.2	8.35	8.3-8.4	2
Phosphorus, Total	µg/L	42	7-77	2	7	8	9	9	2
, Dissolved	µg/L	4.5	4-5	2	3	8	4	4	2
, Orthophosphorus	µg/L	<3	<3	2	<3	<3	<3	<3	2
Solids , Total	mg/L	-	190	1	186	192	180	170-190	2
, Suspended	mg/L	-	62	1	-	-	-	4	1
, Dissolved	mg/L	161	134-188	2	184	190	177	166-188	2
Turbidity	N.T.U.	-	32	1	-	-	-	-	-

TABLE 9

WATER QUALITY DATA FOR PINE RIVER COLLECTED BY ENVIRONMENT CANADA AT HIGHWAY #97 BRIDGE, EAST PINE, BRITISH COLUMBIA - 1966, 1967, 1969

		Aug. 1966	Sep. 1967	Aug. 1969	Average	Standard Deviation
Temperature (°C)	°C	15.6	14.4	12.8	14.3	1.40
pH		8.1	8.1	7.9	8.0	0.16
Colour	Rel. Units	5.0	L 5.0	L 5.0	1.5	2.50
Turbidity	JTU	1.9	1.8	9.6	4.3	4.47
Specific con.	µhmo/cm	264.0	235.0	214.0	237.7	25.11
Total diss. solids	mg/L	147.0	124.0	89.0	120.0	29.21
Hardness	mg/L	NT	118.0	-	-	-
Dissolved calcium	mg/L	40.4	33.3	31.0	34.9	4.90
Dissolved magnesium	mg/L	NT	8.5	NT	8.5	0.00
Dissolved potassium	mg/L	0.6	0.5	0.4	0.5	0.10
Dissolved sodium	mg/L	2.1	2.0	1.6	1.9	0.26
Total alkalinity	mg/L	132.0	107.0	97.0	112.0	18.03
Bicarbonate	mg/L	161.0	130.0	119.0	136.7	21.78
Carbonate	mg/L	0.00	0.00	0.00	0.00	0.00
Dissolved chloride	mg/L	0.9	0.9	0.5	0.77	0.23
Dissolved fluoride	mg/L	0.10	0.08	L	0.06	0.05
Reactive silica	mg/L	2.7	3.6	1.9	2.70	0.85
Dissolved sulfate	mg/L	11.7	11.5	11.5	11.57	0.12
Total organic carbon	mg/L	NT	NT	L	0.00	0.00
Nitrogen (NO_2/NO_3)	mg/L	L 0.005	L 0.005	L 0.005	L 0.005	0.00
Total phosphorus	mg/L	NT	L 0.005	0.016	0.008	0.01
Total inorg. phos.	mg/L	NT	NT	L 0.005	L 0.005	0.00
Suspended iron	mg/L	NT	0.11	NT	0.11	0.00
Extractable lead	mg/L	NT	L 0.01	L 0.01	L 0.01	0.00
Extractable manganese	mg/L	NT	L 0.01	NT	L 0.01	0.00
Extractable copper	mg/L	NT	L 0.01	L 0.01	L 0.01	0.00
Extractable zinc	mg/L	NT	L 0.01	L 0.01	L 0.01	0.00
Free CO_2	mg/L	2.0	1.6	2.4	2.0	0.40
Saturation index		0.4	0.2	-0.1	0.17	0.25
Stability index		7.3	7.7	8.0	7.6	0.35
Sodium absorption ratio (Rel. Units)		0.08	0.08	0.21	0.12	0.08
Filterable residue	mg/L	152.0	NT	NT	152.0	0.00
Nonfilterable residue	mg/L	NT	NT	42.0	42.0	0.00
Nonfilter. fixed. res.	mg/L	NT	NT	38.0	38.0	0.00
Filter. fixed res.	mg/L	98.0	NT	NT	98.0	0.00

L = less than detection limit
NT = not tested
Detection limits were not listed

TABLE 10
WATER QUALITY OF PINE RIVER AS MEASURED BY THE CONSULTANTS (I.E.C., 1982)
TO THE PROPOSED WILLOW CREEK COAL PROJECT

	UPSTREAM FROM MINE				AT THE 'EZ'BRIDGE	DOWNSTREAM FROM MINE		
	02/05/81	05/02/82	03/06/82	29/07/82	03/06/83	05/02/82	03/06/82	29/07/82
PHYSICAL TESTS								
pH	8.00	8.30	6.80	8.10	7.00	8.25	7.00	8.10
Conductivity (micromhos/cm)	285.0	363.0	140.0	280.0	150.0	373.0	150.0	280.0
Turbidity (JTU)	8.0	0.75	21.00	2.6	30.0	0.78	36.00	2.7
Hardness (mg/L) as $CaCo_3$	136.0	202.0	75.0	140.0	78.0	205.0	75.0	140.0
SOLIDS (mg/L)								
Total Dissolved	232.0	322.0	94.0	162.0	110.0	326.0	100.0	170.0
Total	260.0	345.0	170.0	172.0	220.0	328.0	270.0	178.0
Suspended	28.0	23.0	76.0	10.0	110.0	2.0	170.0	8.0
ANIONS (mg/L)								
Total Alkalinity	161.0	198.0	70.0	130.0	70.0	193.0	71.0	130.0
Sulfates	13.0	39.5	10.0	17.0	14.0	49.0	16.0	17.0
NUTRIENTS (mg/L)								
Total Phosphates	0.208	0.021	0.140	0.015	0.170	0.010	0.190	0.019
Dissolved Phosphates	NT	0.004	0.003	0.004	L 0.003	0.004	L 0.003	0.003
Total Kjeldahl Nitrogen	NB	0.06	0.58	0.32	0.61	L 0.05	0.60	0.32
Ammonia Nitrogen	0.12	L 0.05	L 0.01	0.01	L 0.01	L 0.05	L 0.01	0.03
Nitrates/Nitrites Nitrogen	0.024	L 0.012	0.02	0.04	0.01	0.10	0.01	0.05
Dissolved Metals (mg/L)								
Aluminum	L 0.15	L 0.15	0.1	0.50	0.08	L 0.15	0.1	0.05
Barium	0.074	0.12	0.1	0.10	0.1	0.10	0.1	0.1
Cadmium	L 0.025	L 0.025	L 0.001	L 0.001	L 0.001	L 0.025	L 0.001	L 0.001
Chromium	L 0.03	L 0.03	L 0.025	L 0.025	L 0.025	L 0.03	L 0.025	L 0.025
Copper	0.015	L 0.005	L 0.001	0.001	L 0.001	0.05	L 0.001	0.002
Iron	0.079	0.044	0.195	0.028	0.500	L 0.068	0.140	0.028
Lead	L 0.08	L 0.001	0.003	0.001	0.004	L 0.001	0.002	0.001
Zinc	L 0.015	L 0.015	0.001	L 0.001	0.002	0.015	0.002	0.003
TOTAL METALS (mg/L)								
Aluminum	0.49	L 0.15	1.70	0.15	2.0	L 0.15	2.20	0.20
Barium	0.089	0.12	0.15	0.10	0.15	0.10	0.15	0.15
Cadmium	L 0.025	L 0.025	L 0.001	L 0.001	L 0.001	L 0.025	L 0.001	L 0.001
Chromium	L 0.03	L 0.03	L 0.025	L 0.025	L 0.025	L 0.03	L 0.025	L 0.025
Copper	0.026	0.005	0.004	L 0.001	0.005	0.004	0.005	L 0.001
Iron	0.86	0.20	3.900	0.225	4.7	0.14	5.250	0.240
Lead	L 0.08	L 0.001	0.003	0.001	0.004	L 0.001	0.004	L 0.001
Mercury	NT	L 0.00005	**	**	**	L 0.00005	**	**
Zinc	0.46	L 0.015	0.022	L 0.003	0.022	L 0.015	0.026	0.003

L = Less than.

NB = No results due to loss of sample during testing, insufficient volume to rerun test.

NT = Not tested.

** = Contaminated sample.

TABLE 11

EFFLUENT DILUTION RATIOS FOR THE CHETWYND DISCHARGE TO PINE RIVER, AT VARIOUS LOW FLOW ESTIMATES (MINIMUM 7-DAY AVERAGE DISCHARGE FOR MEAN AND 10-YEAR RETURN PERIODS AT TWIDWELL BEND)

	PRESENT*[1]		1992*[2]	
	October-April	August	October-April	August
Streamflow (Mean) Dilution Ratio	7.4 m^3/s 195:1	32 m^3/s 842:1	7.4 m^3/s 97:1	32 m^3/s 421:1
Streamflow (10-Year) Dilution Ratio	4.7 m^3/s 124:1	21 m^3/s 553:1	4.7 m^3/s 62:1	21 m^3/s 276:1

*[1] present maximum daily effluent flow = 3283 m^3/d.

*[2] projected maximum daily effluent flow = 6566 m^3/d.

TABLE 12
NUTRIENT CONCENTRATIONS AND N:P RATIOS
FOR THE PINE RIVER (AFTER GIRARD, 1981)

CHARACTERISTICS	CONCENTRATIONS*[1] AND N:P RATIOS						
	site 0400562 near Hasler Creek	site 1177704 upstream from Centurion Creek	site 0400561 at Twidwell Bend	Increase in Receiving Water Concentrations*[4]		Resultant Receiving Water Concentrations*[3,4]	
				(assuming max. present loading and Oct.-Apr. 10-year low flow)	(assuming max. present loading and mean August low flow)	(assuming max. present loading and Oct.-Apr. 10-year low flow)	(assuming max. present loading and mean August low flow)
NH_3-N mg/L	0.008	0.018	0.025	0.150	0.02	0.176	0.046
NO_2/NO_3-N mg/L	0.050	0.042	0.045	0.002	0.0004	0.044	0.042
$NO_2/NO_3 + NH_3$ mg/L	0.058	0.06	0.070	0.152	0.02	0.22	0.09
P, dissolved mg/L	0.003	0.003	0.005	0.030	0.004	0.033	0.007
N:P ratio*[2]	19:1	20:1	14:1			5:1	5:1

*[1] concentrations are given as mean values.
*[2] NO_2/NO_3-N + NH_3-N: P, dissolved.
*[3] sum of predicted increases in concentration and ambient concentrations at site 1177704.
*[4] assuming complete mixing of effluent and river water.

TABLE 13
PROJECTED FECAL COLIFORM CONCENTRATIONS IN THE PINE RIVER
DUE TO EFFLUENT FROM CHETWYND

ASSUMED CONDITIONS	PROJECTED FECAL COLIFORM LOADINGS MPN/d	PROJECTED RECEIVING WATER FECAL COLIFORM CONCENTRATIONS* MPN/100 mL		
		WINTER LOW FLOW 10-year Return	AUGUST LOW FLOW 10-year Return	Mean
At Maximum Permitted Effluent Flow (3000 m^3/d) and maximum fecal coliform concentration (630 000 MPN/100 mL) recorded post 1973 (March, 1982).	18.9×10^{12}	4654	1041	684
Present Conditions i WINTER - maximum effluent flow (2568 m^3/d) recorded March, 1982, and maximum fecal coliform concentration (630 000 MPN/100 mL) recorded March, 1982.	16.2×10^{12}	4000		
ii SUMMER - maximum effluent flow (3006 m^3/d) recorded August, 1982, and maximum fecal coliform concentration 24 000 MPN/100 mL) recorded June, 1982.	7.2×10^{11}		40	26

*assuming complete mixing of effluent and river water.

TABLE 14
SUMMARY OF THE EXISTING SAMPLING AND MONITORING PROGRAM FOR PE 1167
(VILLAGE OF CHETWYND) DATED MARCH 24, 1982

DISCHARGE MONITORING

1. Sampling - obtain every month composite samples of the discharge. The samples shall each consist of four consecutive grab samples taken at hourly intervals and mixed to form a single sample for subsequent analysis.

2. Analysis - obtain analysis of the sample as follows:

BOD_5	(mg/L)
Suspended solids	(mg/L)
Fecal coliforms	(MPN/100 mL)
Total phosphorus	(mg/L)
pH	

3. Effluent Flow Measurement - record weekly the effluent discharge for a 24-hour period.

RIVER MONITORING

1. River Gauging - gauge the river upstream from the outfall once every three months and record the dilution ratio each time the river flow is recorded.

2. Sampling - obtain every three months, coinciding with the effluent sampling frequency, grab samples of the river. The samples shall each consist of four grab samples taken across the river to form a single sample for subsequent analysis.

3. Analysis - obtain analysis of the samples as follows:

Total phosphorus	(mg/L)
Fecal coliforms	(MPN/100 mL)

TABLE 15
SUGGESTED REVISIONS TO THE PRESENT SAMPLING AND MONITORING PROGRAM FOR PE 1167 (VILLAGE OF CHETWYND) DATED MARCH 24, 1982

DISCHARGE MONITORING

1. Sampling - no change (monthly composite samples)

2. Analysis - no change

3. Effluent Flow Measurement - effluent sampling to coincide with timing of effluent flow measurement.

RIVER MONITORING

1. River Gauging - change the frequency of river gauging from once every three months to -"the permittee shall gauge the river once per month".

2. Sampling

   - in lieu of combining four samples taken across the river to form one sample for analysis, determine the location of the effluent plume (at the 10 m and 200 m downstream sites), and submit one surface sample from the middle of the plume. If the extent of the plume cannot be determined, submit three separate equidistant surface samples taken across the river.
   - change from quarterly sampling to 4-6 samplings per year (initially) during the mid-summer and winter low flow periods.
   - change the location of the sampling sites as follows: retain the 2 upstream control sites 0410027 and 1177704 (since considerable data already exist for this latter site); retain the two new downstream sites 0410028, 0410029 (100 m and 800 m downstream from outfall); and add one more downstream site, the present Twidwell Bend site (0400561).

3. Analysis - add the following:

Ammonia	(mg/L)
Oxygen, dissolved	(mg/L)
Residue, non-filterable	(mg/L)
pH	
Temperature	(°C)
Nitrite-N	(mg/L)
Nitrate-N	(mg/L)
Phosphorus, dissolved	(mg/L)
Turbidity	NTU
Chlorine, Total Res.	(µg/L) (if effluent chlorination is instituted).
Specific Conductance	(µS/cm)
Fecal Coliforms	(MPN/100 mL)

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