Willow Creek Final Project Report

Pine Valley Coal Ltd.

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EXECUTIVE SUMMARY

PROJECT BACKGROUND

Pine Valley Coal Ltd. (PVC) intends to develop an open pit coal mining operation 45 km west of Chetwynd in the northeast coal block of British Columbia. PVC is a joint venture formed from Falls Mountain Coal Inc. (subsidiary of Globaltex Industries Inc.), BCR Ventures Ltd. (subsidiary of BC Rail Ltd.) and Mitsui Matsushima Canada Ltd. (subsidiary of Mitsui Matsushima of Japan). The operator is PVC.

The PVC properties are located within the Pine Pass area in the Peace River District of northeast British Columbia. Primary road access to the general area is via the John Hart Highway, Highway 97, which is an all-weather paved highway connecting the Peace River District with the central interior city of Prince George, B.C. BC Rail operates a rail line through the Pine River Valley to service the Peace River District. The rail provides direct access to the port of Vancouver, B.C. or indirect access, via Canadian National Railway at Prince George, to the Ridley Island Coal Port at Prince Rupert, B.C. In the vicinity of the Willow Creek portion of the property, the line lies on the south side of the Pine River, immediately adjacent to sites suitable for plant and shop facility construction. Natural gas supply is available about 2 km from the property and a connection to an electric power supply can be made about 2 km from the proposed site of surface facilities; the powerline from Hasler to Willow Flats requires upgrading from single-phase to three-phase. Potable water supply would be readily available through wells cored in the gravels in the alluvial fan of Willow Creek. The Peace River District is serviced by daily commercial airline flights to the cities of Dawson Creek and Fort St. John.

The property is forested by jackpine and minor spruce. Poplar stands occur in low areas such as the Pine River Valley, and in wet areas adjacent to creeks and seepages. Most of the forested terrain may be classified as open forest i.e., with little or no underbrush. The exceptions are the wet areas where willows and devil's club are common. Wildlife noted in the area consist of grizzly bear, black bear, moose, caribou, deer and wolves. Fish present in the area have been reported to include dolly varden, northern pike, forage fish, mountain whitefish, Arctic grayling, and rainbow trout. Bull trout, a species related to dolly varden, has also been reported from this area. On the Willow Creek Block these species are found in the Pine River. Some species, namely dolly varden (bulltrout), rainbow trout, mountain whitefish and forage fish, are also present in the lower reaches of Willow Creek, for about 3.4 km, to a point where their upstream progress is impeded by a waterfall.

The climate of the region may be classified as northern temperate. Daily temperatures range from an annual mean maximum of 7·C to an annual mean minimum of minus 6·C, with a mean daily temperature of 1·C. Extreme temperatures range from a maximum of 32·C to a minimum of minus 48·C. The mean total precipitation in the region is approximately 425 mm, which includes the rainfall equivalent of a mean snowfall of 165 cm.

PROJECT ECONOMICS AND SCHEDULE

Coal production will be in the order of 900,000 metric tonnes per year with a mine life (projected from 1997 reserves) of 15 years. The number of employees required for construction will be 50 to 70 and for operation 100 to 120. Economic benefits will include capital spending of approximately $20 million to build the mine, plant and infrastructure, total taxes payable over the projected mine life of $57 million, employment of 2502 person years, and gross revenues of approximately $270 million.

The project development schedule calls for project approval by February of 1998, preliminary timber removal during winter of 1998 (February - March), pre-stripping for open pit operation and construction of the wash plant in spring and summer of 1998. Operation is targeted to begin prior to the end of 1998. Mine life is presently estimated at 15 years, with potential to extend.

GEOLOGY

The Pine Valley Property covers a series of large-scale, northwesterly trending anticlines and synclines that expose the coal seams of the Gething Formation. The Pine Valley Property is centred around the

Pine River Anticline and the Fisher Creek Syncline, a pair of large-scale, southwesterly plunging concentric folds. These folds, and the subsidiary folds on their flanks, bring the coal seams of the Gething Formation to the surface in the various mining areas. In northeastern British Columbia, the Gething Formation coals, particularly those in the upper part of the Formation, are generally suitable for use as metallurgical (coking) coals. The rank of the Gething Formation coals range from low-volatile to high-volatile A bituminous, determined by vitrinite reflectance and proximate analysis of coal samples. For most of the coal seams, the sulphur content of 1.7 SG floats is between 0.5% and 0.75%.

MINING

Mining will be conducted in two areas, designated north and central. Open pit methods will be used. Results from the block modelling process indicated the Willow Creek project, including both the North and Central mining regions, has a mineable reserve of 15,652,000 run-of-mine tonnes (romt) of coal with 58,810,000 banked cubic metres (bcm) of rock. The resulting average run of mine (ROM) coal stripping ration is 3.76:1 (bcm:romt). Typically the proposed sequence of mining within each mining phase will be from north to south. This is to take advantage of gravity with respect to the waste haul, and to maximize internal backfilling opportunities. Internal backfilling of mined-out pits during the scheduling of waste disposal has been maximized. For those areas where internal backfilling is either not possible or practical, external dumping areas have been identified. Wherever possible, these external dumping areas have been utilized for access purposes in order to prevent unnecessary road construction and to minimize the total disturbance area.

PROCESSING

The plant will employ a partial washing process. The partial washing concept entails dry screening the ROM coals at 6 mm, and then washing all the coarse (oversize) material. This concept removes the plus 6 mm visible rock impurities and upgrades this portion of the product(s). Any minus 6mm coal bypassing the plant will have a lower moisture content than the washed coal, and the overall product moisture specifications can be achieved without thermal drying. The proposed stockpiling system is a single radial stacker conveyor capable of forming stockpiles having total capacity in the order of 70,000 ROM total tonnes. The two stockpiles allow for the segregation of the coking and thermal grades of raw coal. As a result, the stockpiles can be sized so that more room is allotted for the higher throughput of coking coal required to produce the product split of coking/thermal coal. Reclaiming ROM coal to feed the wash plant will be done via a front end wheel loader tramming from the segregated coking and thermal stockpiles to a hopper mounted at the tail end of the ROM reclaim conveyor. The plant design criteria required the capability to process 900,000 clean tonnes per year. Two clean coal stockpiles will be utilized. They are designed and sized to provide up to 20,000 tonnes storage each. The thermal product may require the addition of dust suppressants to the coal at the top of the thermal coal stacking tube and/or other belt transfer points from time to time. It is unlikely the coking product will need the addition of a dust suppressant as the bulk of the fines (- 6mm) will be washed, and hence already wetted. Loading of unit trains will be done in eight to ten hours. At the 900,000 tonne-per-year level a unit train would need to be loaded about every three to four days. Pumps will be installed to remove and deliver the tailings from the thickener to the pond, located approximately 1,000 m from the washery.

MINE SERVICES

An administration building will be integrated with a shop and warehouse. Power will be supplied from B.C. Hydro lines, 2 km distant. Fresh water will be supplied by well(s) situated at the plant site.

ENVIRONMENTAL BASELINE

The objective of environmental baseline work was to document conditions at the Willow Creek site prior to construction of the mine. This report builds on information provided in the David Minerals' Stage II report prepared in 1982 and additional information obtained by Globaltex in 1994. This report evaluates previousl information where appropriate. Information was collected in 1996 and 1997 on: climate and air quality, surface water quality, stream sediments, hydrology, groundwater quality, fisheries, attached algae (periphyton), soils, vegetation and wildlife. Surface and groundwater both show low levels of most parameters with only occasional natural exceedances of criteria established by Ministry of Environment, Lands and Parks for the protection of freshwater aquatic life. Stream sediments showed no metals anomalies and are similar in that respect to those measured at existing northeast coal mining operations. Fish use of area streams is limited to the Pine River, lower 3.6 km of Willow Creek and mouths of other streams. Much of the upland area is in early to mid successional stages as a result of logging. Presently wildlife habitat is modified by this previous disturbance. Logged areas are in various stages of revegetating.

LAND USE

The project site is not used for agricultural purposes as soils are unsuitable for agriculture, although farming is carried out in the region. A number of timber licences and forestry tenures are held around the project area. Forestry related activity in the Willow Creek area is high. Both oil and gas leases and mining claims are held in and adjacent to the Project area. There are five property owners nearby to the site. The lands surrounding the proposed Willow Creek Project are held under various tenures. There are privately and publicly owned properties, as well as other land interests. The interests include various forestry designated areas, provincially designated areas and reserves, right of ways, licenses and tenures. Under Bylaw 1086-1977, an area surrounding the mine site has been incorporated into the District of Chetwyd.

ACID GENERATION POTENTIAL AND METAL LEACHING

Low total sulphur contents and high neutralization potentials due to the presence of carbonate (ie. visible calcite) in the rocks have resulted in high NP/AP ratios which indicate that the Willow Creek mining operation will be acid consuming and not produce acidity. The results for the Moosebar shale samples also indicated that this marine unit will be net acid consuming and also not produce acidity when exposed during mining. Coarse reject samples of coal and in-seam waste report NP/AP ratios which are generally low and often have values less than 2.0. Evidence indicates that most of the sulphur occurs in the coal seams and in-seam waste as organic sulphur and not as pyrite. Results indicate that little acid will be generated from the oxidation of this material when exposed during mining activities. Apart from lower NP/AP ratios in coarse reject samples the evidence indicates that the risk of ARD is very low for this project. Coal mines in the northeast coal mining area have not released ARD in the past.

SOCIO-ECONOMIC BASELINE

The largest community close (45 km east) to the Project area is Chetwynd with a population of under 3000. Several smaller communities are located between Chetwynd and the Project area, the closest being the gas pumping station at Willow Flats approximately 4 km to the east. The predominant employment activities in the area are resource-based (forestry, mining, energy). The area has a history of relatively stable employment.

Chetwynd is served by three levels of government. Local government consists of a mayor and council. A number of provincial government offices are also located in the District including Ministries of Attorney General, Environment, Health and Human Resources. Federal government services are limited to the RCMP.

ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION

Air Quality

Air emissions from coal mining and processing will be predominantly dust; emissions from mobile equipment will also be dust and, additionally, those associated with diesel internal combustion engines (NOx, CO, CO2, VOCs). The most significant potential impacts may be from dust emissions from coal stockpiles (predominantly from thermal coal as previously discussed) and to a lesser extent from mobile sources such as vehicles. Dust suppression will be employed to the greatest extent practical to mitigate these sources of impact.

Water Quality

Limited impacts to water quality are likely from mine development because of the management measures to be employed to control the principal addition to water from mining activities: sediment. The coal and other associated strata are not acid generating, based on acid-base accounting tests, and metals leaching is highly unlikely based on the experience of other northeastern coal mines.

Water will be recycled to the greatest extent possible and any water discharged will be treated for sediment removal. Nitrogen levels are calculated to be low. Phosphorus addition will be limited to the extent possible through use of a holding tank system for sewage disposal.

Fisheries

Fisheries values of Project area streams are limited. The Pine River is considered to be good habitat and the lower 3.4 km of Willow Creek provides habitat for fish. Passage of fish up Willow Creek is blocked near the mouth during low water due to subsurface water flow during those times. Fish, however, were found in the Creek up to a falls at 3.4 km upstream. Other Project area streams were found not to have any fish present, except in areas of the Pine River floodplain. Impacts to fish and habitat will be minimized through use of recommended construction practices for roads and mine facilities.

Vegetation

Only small proportions of most vegetation associations found in the Project area will be affected by the proposed mine activities. No rare, threatened or endangered plant species will be affected.

Wildlife

Some temporary loss of habitat will occur from mine development. Progressive reclamation will not only enhance habitat for some species, such as deer and moose, but will ensure that disturbance of habitat is kept to the shortest time possible. Few areas will be permanently alienated, e.g. pit highwalls, and loss of this habitat will be offset in the short and medium term by enhancement of some habitat through a revegetation program with commercial agronomic species and the planting of trees and shrubs. Disturbances caused by mining will affect only a small part of the available range for most species known or suspected to be present in the Project area.

SOCIO-ECONOMIC IMPACTS

The potential for both positive and negative socio-economic impacts from the Willow Creek project is influenced by a number of important features of the project: The project is relatively small in capital cost and total workforce. However, there is the potential for long term benefits, primarily to nearby communities. The operating workforce is estimated at 100 to 120 people. The mine will be located 45 km west of the District of Chetwynd, and there is good existing road and rail access. Chetwynd and the surrounding areas provide adequate and readily available infrastructure for housing the workforce. Chetwynd's growth has been based upon industrial developm/ent of the forest, oil and gas and mining industries. A significant number of Chetwynd's residents presently work in the mining industry, commuting to the Bullmoose and Quintette mines. Chetwynd is interested in diversification and growth of the District by the Willow Creek project. The Quintette and Bullmoose mines are expected to significantly reduce their present work forces over the next year. The timing of this workforce reduction, with the planned startup of the Willow Creek project, should mitigate some of the loss of these existing mining jobs, and provide a trained workforce for the Willow Creek project.

There are a number of families located close to the Willow Creek project area that could be potentially impacted by project development.

The mine life used in the feasibility analyses is 15 years, with the potential for extending the coal reserve and mine life indefinitely. Known coal measures with economic potential are located to the south and to the west of the Project area.

Secondary benefits will accrue to the community and surrounding areas by the mine development. The jobs created in the area will increase the local purchasing power and the demand for goods and services. The mine area has been incorporated into the District of Chetwynd for tax purposes to further support the District of Chetwynd. Additional taxes will accrue to the Provincial and Federal governments as previously discussed.

FIRST NATIONS

The Willow Creek Project area is within lands covered by Treaty #8, with Treaty rights ensuring traditional hunting, fishing and trapping for Treaty 8 First Nations peoples. Consultation is on-going with the two First Nations in the area to try to minimize impacts on traditional use, and cultural values, and to provide opportunities and economic benefits with mine development.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

Pine Valley Coal Ltd. (PVC) is a joint venture formed from Falls Mountain Coal Inc. (subsidiary of Globaltex Industries Inc.), BCR Ventures Ltd. (subsidiary of BC Rail Ltd.) and Mitsui Matsushima Canada Ltd. (subsidiary of Mitsui Matsushima of Japan). The operator is PVC. Exploration for coal in the general project area dates from construction of the John Hart Highway (Highway 97) through Pine Pass. The first serious attempt to develop coal at the Willow Creek site was made in the early 1980s by

David Minerals Limited. David Minerals obtained an approval for an underground coal mine on the northern part of the project area through submission of a Stage II report. In 1994, Globaltex Coal Corporation (subsidiary of Globaltex Industries Inc.) began exploration efforts directed toward a relatively small open-pit mining operation. The exploration and study work has continued from that time to the present.

1.2 PROPERTY LOCATION, SERVICE FEATURES AND PHYSIOGRAPHY

The Pine Valley Coal properties are located within the Pine Pass area in the Peace River District of northeast British Columbia (Figure 1.2-1). The coal licenses flank the Pine River Valley approximately 45 km west of the town of Chetwynd, with the majority of the licenses situated on the south side of the Pine River. The approximate centre of the license area is located on NTS Map 93O/9 at longitude 122· 17' west and latitude 55· 36' north.

Primary road access to the general area (Figure 1.2-2) is via the John Hart Highway (Highway 97) which is an all-weather paved highway connecting the Peace River District with the central interior city of Prince George, B.C. Near the property, the highway is located along the north bank of the Pine River Valley, with secondary and tertiary roads that branch off and provide ground access to most of the license area. During the early 1980s, a bridge was constructed over the Pine River providing access to the coal reserve areas now referred to as the Willow and Falling Creek Blocks. This bridge may require some upgrading to serve the mining operations. Access within the Willow Creek portion of the property is currently via the Willow Creek Forestry road, as well as exploration roads. The forestry road will be upgraded to service mining operations.

BC Rail operates a rail line through the Pine River Valley to service the Peace River District. The rail provides direct access to the port of Vancouver, B.C. or indirect access, via Canadian National Railway at Prince George, to the Ridley Island Coal Port at Prince Rupert, B.C. In the vicinity of the Willow Creek portion of the property, the line lies on the south side of the Pine River, immediately adjacent to sites suitable for plant and shop facility construction.

Natural gas supply is available about 2 km from the property and a connection to an electric power supply can be made about 2 km from the proposed site of surface facilities; the powerline requires upgrading from single-phase to three-phase from Hasler to the site along Highway 97. Potable water supply would be readily available through wells drilled in the gravels that lie in the valley adjacent to the Pine River.

The Peace River District is serviced by daily commercial airline flights to the cities of Dawson Creek and Fort St. John. These services have respective road distances to the Willow Creek Project Properties of roughly 148 km and 203 km.

The property is situated in the Rocky Mountain Inner Foothills physiographical region. It is characterized by relatively low, rounded, northwest southeast-trending ridges and valleys, and is dissected by the 1.5 km wide Pine River Valley. The elevation difference relative to the Pine River Valley, within the license area, is approximately 670 m. Elevations ranging from 630 m along the Pine River Valley to 1300 m along the eastern property limits. The Pine River watershed cuts across and drains the property. In addition, glaciation appears to have had a large influence in shaping the topography of the license areas.

The property is forested by jackpine and minor spruce. Poplar stands occur in low areas such as the Pine River Valley, and in wet areas adjacent to creeks and seepages. Most of the forested terrain may be classified as open forest i.e., with little or no underbrush. The exceptions are the wet areas where willows and devil's club are common.

Wildlife noted in the area consist of grizzly bear, black bear, moose, caribou, deer and wolves. Fish present in the area have been reported to include dolly varden, northern pike, forage fish, mountain whitefish, Arctic grayling, and rainbow trout. Bull trout, a species related to dolly varden, has also been reported from this area. On the Willow Creek Block these species are found in the Pine River. Some species, namely dolly varden (bulltrout), rainbow trout, mountain whitefish and forage fish, are also present in the lower reaches of Willow Creek, for about 3.4 km, to a point where their upstream progress is impeded by a waterfall.

The climate of the region may be classified as northern temperate. Daily temperatures range from a mean maximum of 7·C to a mean minimum of minus 6·C, with a mean daily temperature of 1·C. Extreme temperatures range from a maximum of 32·C to a minimum of minus 48·C. The average annual number of days with frost is 210.

The mean total precipitation in the region is approximately 425 mm, which includes the rainfall equivalent of a mean snowfall of 165 cm. The average annual number of days, with measurable precipitation is 95. The greatest recorded rainfall in 24 hours is 66.5 mm.

1.3 HISTORY

Coal was discovered in the Peace River District during Alexander Mackenzie's overland journey to the Pacific some 200 years ago. The first coal licenses were granted in 1908, but owing to the remoteness of the area, it was not until the 1940s that the coals were exploited.

From 1946 to 1951, the Coal Division of the British Columbia Department of Lands and Forests conducted coal exploration in the Pine River area of the Peace River District in anticipation of the construction of another major rail route through the Rockies. The work concentrated on two areas: Willow and Noman Creeks.

As a result of the work completed by the British Columbia Department of Lands and Forest in the 1940s and 1950s, which included trenching and 39 diamond drillholes, the Willow Creek area has been the subject of various exploration programs in the 1970s and 1980s. In 1973, the Pine Pass Coal Company drilled 5 diamond holes at the headwaters of Willow and Johnson Creeks. Although the drilling confirmed the presence of thick coal seams in the Gething Formation at this locale, the perceived structural and stratigraphic problems precluded further drilling in the area. In addition to the Pine Pass Coal Company, the only company to test drill the Gething Formation in the Willow Creek area was Semper Resources/David Minerals in 1980 and 1981.

The Semper Resources/David Minerals Ltd. exploration program at Willow Creek comprised 42 trenches and 46 diamond drillholes. In 1981, Semper Resources amalgamated with David Minerals Ltd. to further develop the Willow Creek Project. Subsequent to this, Kilborn Engineering Ltd. was commissioned to complete an underground mine engineering feasibility study. Environmental studies were completed and the project progressed to Stage 2 of the Mine Development Review process.

In 1992, Globaltex Industries Inc. acquired the original 14 coal licenses comprising the Willow Creek Coal Project and proceeded with a surface mining review. Globaltex continued from that time to expand and develop the property. The property size was also increased to its present status of 33 coal licenses.

In 1996, Globaltex (through its wholly owned subsidiary, Falls Mountain Coal Inc.) was joined by Mitsui Matsushima Canada Ltd. and BCR Ventures Ltd. in ongoing efforts to develop the property. Pine Valley Coal Ltd. was formed to represent the collective interests of the participants and to act as operator. A major drillhole exploration program was conducted in 1996, culminating in a feasibility study in 1996/97 which was completed in July 1997.

1.4 KEY PROJECT DATA

Mine Operator:

Pine Valley Coal Ltd.

501 - 1200 West Pender Street

Vancouver, British Columbia

V6E 2S9

Contact:

Mr. David Fawcett

Chief Operating Officer

Phone:604-687-5833

Fax: 604-682-4698

Mine Location:

45 km west of Chetwynd, British Columbia, south of the John Hart Highway

Coal Production:

In the order of 900,000 metric tonnes per year

Mine Life (projected from 1997 reserves):

15 years

Workforce:

Construction: 60 to 70

Mine Development:40 to 60

Operation: 100 to 120

Economic Benefits:

Capital Cost:

$20 million

Annual Purchases of Goods (projected from 1997 information):

$12 million

Annual wages and benefits (direct, indirect, induced)

$9.2 million

Annual Taxes (projected from 1997 information):

Federal: $2.3 million

Provincial:$2.0 million

Total $4.3 million

Gross Value of the Deposit to BC's Economy (based on a 15 year mine life):

$270 million

Employment (person years - 15 year mine life):

Direct:1542

Indirect: 960

Total: 2502

Power:

B.C. Hydro transmission grid

2000 kw maximum requirement

1.5 CONCEPTUAL DEVELOPMENT SCHEDULE

Figure 1.5-1 is a conceptual schedule for mine approval based on information available in early 1997. Figure 1.5-2 is a similar schedule for mining the deposit(1).

1.6 ENVIRONMENTAL ASSESSMENT TERMS OF REFERENCE

The scope of this report covers requirements of the 1994 terms of reference (TOR) prepared for Globaltex Coal Corporation (Pine Valley Coal Ltd.) by Ministry of Environment, Lands and Parks (MOELP) and amended as indicated in Appendix 1.6-1. MOELP TOR are attached for reference in Appendix 1.6-1. The project was grandfathered under the former Mine Development Assessment Process as per the letter attached in Appendix 1.6-1. Table 1.6-1 summarizes requirements under the Terms of Reference and amendments.

TABLE 1.6-1 Environmental Assessment Office Terms of Reference	
Study Element	**Report Section**
Hydrology	Section 4.5
Aquatic Baseline	Section 4
Water Quality Sites	Section 4.4
Sediment Quality	Section 4.4.4
Periphyton	Section 4.8
Data Quality Assurance	Section 4.4.2.5
Data Review	
Mass Loadings to Water	Section 6.4
Operational Monitoring Program	Section 18
Groundwater Effects	
Baseline	Section 4.4.3
Soil data	Section 4.3
Impacts	Section 6.5
Waste Management Planning	Section 7.2

Water Management Planning	Section 7.3
Acid Mine Drainage	Section 4.15
Air Emissions	Section 4.2 Section 6.1 Section 7.2
Environmental Safety	Section 12
Sanitary Sewage	Section 2.4.3
Refuse Management	Section 7.2
Fisheries	
Baseline	Section 4.6
Impacts	Section 6.6
Management	Section 7.4
Wildlife	
Baseline	Section 4.12
Impacts	Section 6.8
Management	Section 7.5
Soil Conservation	Section 7.1

Visual Impacts	Section 6.3
Reclamation	Section 7.1

The original terms of reference were for a 500,000 tonnes per annum (tpa) production rate. Change to a 900,000 tpa production rate will not result in any additional disturbance to the environment, i.e. the footprint of the mine which is determined by the pits and plant site are the same. The wash plant, because of sizes available, was oversized for the production required under the 500,000 tpa production rate. The increase in production will be accommodated in the coal handling operation by operating additional time. The major impacts from a shift to 900,000 tpa will be positive, i.e., increased taxes and increased jobs accruing the people of British Columbia.

Except for grandfathered projects, a Project Report under the *British Columbia Environmental Assessment Act* (BCEAA) must meet certain requirements as set out in the Guide to the Environmental Assessment Process (1995, and amendments). In recognition of changes in environmental assessment requirements since the TOR were set, Pine Valley Coal Ltd. expanded scope of environmental studies to reflect BCEAA requirements, specifically the public consultation and First Nations studies scope were expanded and a Traditional Use study undertaken in cooperation with the two principal First Nations in the area.

Under the *Canadian Environmental Assessment Act* (CEAA) (1992), any project falling within federal government jurisdiction may be subject to review under the Act. Reference to the *Comprehensive Study List Regulations* indicates the Willow Creek Project falls within requirements for a screening review if a federal agency deems the Project reviewable under the Act. The federal agency most likely to be involved with the project is the Department of Fisheries and Oceans, since there is some potential to affect fish habitat as defined under the *Fisheries Act*.

Under the recently signed *Canada and British Columbia Cooperation Agreement on Environmental Assessment* (1997) (the "Harmonization Agreement"), the province is responsible for joint assessments and the Project Report prepared for BCEAA approval will serve for federal screening purposes. However, under the Harmonization Agreement, assessments conducted for provincial approval must also meet federal assessment objectives. *Canadian Environmental Assessment Act* screening requirements are set out in Section 16(1) of the Act and these requirements are summarized in Table 1.6-2.

TABLE 1.6-2 Screening Requirements under the Canadian Environmental Assessment Act	
Requirement	**Project Report Section**
Consider the environmental effects of the project, including accidents	6, 12
Consider cumulative effects	13
Significance of effects	6, 12, 13
Public comments	16
Mitigation and Management of Effects	7
Project alternatives	9, 10

1.7 PERMIT REQUIREMENTS

Table 1.7-1 lists the permits required for mine operations for a typical mine in British Columbia. Actual permit requirements for the Willow Creek project may vary from those listed.

TABLE 1.7-1

ENVIRONMENTAL PERMITS FOR MINING IN BRITISH COLUMBIA

Permit	Legislation
Waste Management Mine/Plant Effluent	Waste Management Act

Environmental Monitoring Program Approval	Waste Management Act
Water Licence	Water Act
Water Approvals	Water Act
Land Improvement Licence - Water Storage, Tailings Pond	Water Act
Licence to Cut	Forest Act
Permit Approving the Mine Plan and Reclamation Program	Mines Act
Licence of Occupation	Land Act
Potable Water Approval	Water Act
Septic System Approval	Health Act
Refuse Permit	Waste Management Act
Highways Act Approvals	Transportation Act
Waste Management, Air Emissions - Plant	Waste Management Act
Transportation of Dangerous Goods	Transportation of Dangerous Goods Act
Special Use Permit - Gravel Pit	Mines Act
Class A Burning Permit	Forest Act

Explosives Manufacture	Explosives Act

1.8 REPORT ORGANIZATION

The report is organized in chapters to facilitate reference to specific topics. The text of the report is contained in this volume (1); most tables and figures are contained in Volume 2 and appendices are contained in Volume 3. Chapters are organized to address all of the major topics required under the *British Columbia Environmental Assessment Act* Guidelines for a Project Report. Reference to the Table of Contents (above) will provide guidance to the specific location of the various topics as follows:

TABLE 1.8-1 **Project Report Organization**			
Section	**Topics Discussed**	**Section**	**Topics Discussed**
VOLUME 1			
1	Project background, key data, permit requirements, report organization	10	Assessment of alternative effects
2	Project description, geology	11	Assessment of effects on Aboriginal Peoples
3	Site selection	12	Safety and contingency response

4	Biophysical baseline • air/climate • aquatic • terrestrial • aboriginal traditional use • land use • acid producing potential	13	Cumulative impacts assessment
5	Socio-economic baseline	14	Potential cross boundary effects
6	Biophysical impact assessment	15	Energy efficiency and conservation
7	Mitigation and environmental management • reclamation • waste management • water management • fish and wildlife • dust, noise and visual quality	16	Public consultation
8	Socio-economic impact assessment	17	First Nations consultation
9	Project alternatives	18	Operational monitoring
		Refs	
VOLUME 2			
Figures + tables			
VOLUME 3			

Appendices

(1)To be updated

2.0 PROJECT RATIONALE AND DESCRIPTION

2.1 GEOLOGY

2.1.1 Introduction

This section of the report includes a description of various aspects of the geology; the material presented is not intended to constitute a definitive treatise on the geology of the region or even the Willow Creek Property. The geological data provided is concerned with the determination of the reserves, definition of geological properties that affect engineering design of mining operations to extract the coal.

The topics addressed include stratigraphy, geological structure and a description of the field exploration that has been conducted to date, and which provides the source of data for the current study. Related topics that address in-place minable coal reserves and resources are also included in this section.

TABLE 2.1-1

TABLE OF FORMATIONS

SERIES	GROUP	FORMATION	APPROX. THICKNESS (m)	LITHOLOGY
L o w e r C r e t a c e o u s	Fort St. John	Hulcross Boulder Creek Gates Moosebar	90-120 80-110 80-200 150-300	Grey marine mudstone with interlaminated Fine-grained marine sandstone toward the top. Nonmarine sandstone and massive conglomerate; siltstone, sandstone and coal in upper part. Sandstone; siltstone, conglomerate; marine and nonmarine mudstone; COAL; seams are generally thin in Pine River area. Dark grey marine mudstone, minor siltstone. Thin bed of conglomeratic sandstone and mudstone, usually glauconitic, at base (Bluesky Member).

Transitional				
	Bullhead	**Gething** Cadomin	**350-550** 125-250	**Mudstone, siltstone, sandstone, carbonaceous mudstone; coalified plant debris, minor bentonite, minor conglomerate, occasional thin tuffs in upper part; COAL; coal seams are well developed in Pine River area.** Medium to very coarse sandstones, grits and conglomerate; discontinuous coal seams.
	MInnes	Bickford Monach Beattie Peaks Monteith	300 - 500 150 - 225 250 - 300 350 - 450	Lithic sandstone, siltstone, mudstone, carbonaceous mudstone, minor coal. Marine lithic & quartzose sandstone, with minor siltstone and conglomerate. Sandstone, thinly bedded mudstone, siltstone, minor ironstone bands. Sandstone, quartzite, minor mudstone, siltstone, and thin conglomerate.

Jurassic	Fernie	Fernie	Incomplete section	Dark grey to black marine mudstone, minor siltstone.

2.1.2 Stratigraphy

The Cretaceous sediments of the northern Foothills were deposited along the western margin of the Western Canada Basin in a series of transgressive-regressive cycles during the Columbian Orogeny. Environments of deposition varied laterally and vertically from marine through prodeltaic and near shore, to delta plain and alluvial. Lithologies include mudstone, siltstone, sandstone, conglomerate and coal.

The Pine Valley Property is underlain by the Jurassic-Cretaceous Minnes Group, and the Lower Cretaceous Bullhead and Fort St. John Groups. A table of formations is presented in Table 2.1-1. The Geological Survey of Canada (G.S.C.) classification of the upper Jurassic, Lower Cretaceous strata has been adopted in this report.

The oldest unit mapped on the property to date is the Cadomin Formation which, further to the south, has a distinct lithology that allows it to be formally referred to as the Cadomin Conglomerate. Conformably overlying this formation is the principal unit of economic significance, the Gething Formation. This formation contains the nine seams that are the subject of the present study, Seam Nos. 1 through 8 and Seam A. Both of the previously mentioned formations constitute the Bullhead Group.

Overlying the Gething Formation is the Moosebar Formation which is marine and the youngest unit of the Fort St. John Group. This is a thick and prominent marine shale unit which is a glauconite rich, sometimes conglomeratic or sandy member, named the Bluesky. Conformably overlying this are the other formations of the Fort St. John Group which, in this area, include in succeeding order, the Gates, Hasler and Boulder Creek Formations. Coal seams occur in the Boulder Creek Formation, but the development of these seams is not as significant as that of the Gething Formation. They have not yet been studied in sufficient detail to determine if they have economic significance for this coal property.

2.1.3 Structural Geology

Tectonic Environment

In the Pine Valley area, the coal bearing strata are exposed in a series of northwesterly trending folds that are cut by thrust faults. Deformation during early Campainian to late Eocene time was characterized by high lateral compressive stresses that had a near-horizontal orientation. Depth of burial was not excessive, resulting in brittle to semi-brittle styles of deformation.

Large sheets of strata became detached during deformation and were displaced to the northeast along thrust faults. These thrusts generally have a staircase geometry, with wide flats almost parallel to bedding, connected by narrow ramps oblique to bedding, that cut up-section toward the northeast. The tendency is for the faults to be subparallel to bedding in incompetent rocks such as coal, mudstone and shale, and to be more oblique to bedding in competent lithologies such as sandstone.

Deformation tended to migrate northeastward across the region, and as a rule, the lower or more external of any two thrusts is the younger. Comparatively little folding preceded faulting; consequently thrusts tended to develop in essentially horizontal strata. As movement occurred along a thrust, its staircase geometry caused folding in the overlying strata and older thrust faults. Because of this folding, an older thrust may dip either southwest or northeast, although the over-all movement of the plate of strata remains northeastward.

Concentric folds, angular folds and box folds are typical fold geometries. The dip of fold limbs can vary from nearly horizontal to overturned, but is usually in the range of 20º to 50º. Fold axes trend northwesterly. Plunge oscillates between northerly and southerly over the length of a large-scale fold and is usually shallow, but can steepen locally to as much as 35º. The major folds persist for large distances, in several cases more than 50 km, and usually have an *en echelon* alignment.

Concentric folds are roughly U-shaped, and in concentric folding both the competent and incompetent layers can maintain a constant thickness throughout the structure.

Chevron folds are V-shaped, with relatively short hinge areas and straight limbs. Strain in the hinge zone is usually accommodated by limb faults, the development of bulbous hinge zones, or boudinage of incompetent layers. The latter can produce localized tectonic thickening and thinning of coal seams. Examples of all of these features have been found associated with chevron folds on the Pine Valley Property, but have been simplified for portrayal on the cross-sections.

Box folds are characterized by a broad, nearly flat crest, flanked by steeply dipping limbs. The plates of strata that form the top and limbs tend to be largely undeformed, but the abrupt hinge zones often exhibit some of the small-scale structures that are associated with the hinge zones of chevron folds.

Structure Of The Pine Valley Property

The Pine Valley Property covers a series of large-scale, northwesterly trending anticlines and synclines that expose the coal seams of the Gething Formation. The larger folds, such as the Fisher Creek Syncline and the Pine River Anticline, persist throughout the length of the property, and extend to the northwest across the Pine River. They are broken in places by northeasterly dipping thrust faults, some of which have displacements of 20m or more. The folds may be displaced along a cross-trending structure in the Pine River Valley, but the evidence is not conclusive, and the displacement, if any, is small.

The Pine Valley Property is centred around the Pine River Anticline and the Fisher Creek Syncline, a pair of large-scale, southwesterly plunging concentric folds. These folds, and the subsidiary folds on their flanks, bring the coal seams of the Gething Formation to the surface in the various mining areas.

The Willow Anticline is a broad concentric fold on the northeast limb of the Pine River Anticline. Its limbs dip to the northeast and southwest at angles of 30º to 35º. In the Willow North Block, its crest is complicated by few smaller folds and northeasterly dipping thrust faults in the area where the North A Seam Pit will be located. To the southeast in the Willow Central Block, the Willow Anticline becomes an overturned chevron fold, with its crest broken by a fault, the Willow Thrust, a northeasterly dipping thrust fault.

The northeast limb of the Willow Anticline, away from the axial region, is a largely undeformed plate of strata that underlies the ridge along the northeastern edge of the property. It dips to the northeast at angles of about 30º to 35º. With the exception of the structures at the crest of the fold, exploration to date has found no evidence of major folds or faults affecting this limb in the Willow North Block, where the North 1 to 4 Seam Pit (4N) will be located. In the Willow Central Block, where the 1 to 4 Seam, Pit 4C will be located, a northeasterly dipping thrust fault, or fault zone, associated with some local concentric folds has been identified.

The Willow Syncline lies southwest of the Willow Anticline. Like the Willow Anticline, the Willow Syncline is a fairly broad fold in the north, becoming tight and asymmetrical in the Willow Central Block.

The major fault in the mining area is the Willow Thrust, a northeasterly dipping thrust fault. It cuts the northeast limb of the Willow Syncline, which is the southwest limb of the Willow Anticline, in the north near the Pine River working its way into the crest of the Willow Anticline in the Willow Central Block. The Willow Thrust generally appears to have a displacement of about 15 to 20m.

The Spruce Anticline and Syncline lie southwest of the Willow Syncline in the southern part of the Willow Central Block. The Spruce Anticline is a tight, sometimes asymmetrical chevron fold developed between the Willow and Spruce Synclines. The Spruce Anticline becomes smaller and tighter to the north where it probably dies out, so that the Spruce Syncline merges into the Willow Syncline.

In the southwestern part of the Willow Central Block, the Spruce Syncline is flanked to the southwest by a small box anticline and a small concentric syncline. Southwest of these lies a large box anticline termed the Peninsula Anticline. The broad crest of this structure is formed by an essentially undeformed, nearly flat-lying plate of strata. Seam 7 lies at very shallow depths at the crest of this structure, and will be mined as part of Pit 7C.

The Willow South Block lies immediately southeast of the Willow Central Block. It covers the continuation of the same sequence of Gething Formation coal seams, but has not yet been subjected to detailed drilling.

The Willow West Block is located on the southwest limb of the Pine River Anticline, which is the northeast limb of the Fisher Creek Syncline. The Pine Pass and Falling Creek Licenses are located farther to the west, on the southwest limb of the Fisher Creek Syncline. Like the Willow South Block, these areas have not yet been explored in detail, but Gething coal seams are known to be present.

2.1.4 Geological Interpretation

The Pine Valley Property is characterized by geology that is complex, both with respect to stratigraphy and structure. This complexity is not an impediment to mining; indeed it is the cause for the seams to be surface minable in this location.

The stratigraphic complexity is evident in the number of splits of minable thickness that may be present in any given coal seam, and the degree to which these may persist laterally throughout the property, or die out or coalesce with other coal units. The structural complexity is evident in several ways such as the fact that the important thrust faults dip easterly in this area, as opposed to the westerly dip more commonly found for the thrust faults in the Canadian Rocky Mountain foothills. It is also seen in the tendency of these structures to cut down through the stratigraphic sequence along strike; for small-scale structures to contribute to the minability of various structures; for a variety of fold styles to be present in close proximity to each other; and various other geological features.

2.1.5 Coal Quality

Introduction

In northeastern British Columbia, the Gething Formation coals, particularly those in the upper part of the Formation, are generally suitable for use as metallurgical (coking) coals. The description of regional trends in their raw coal quality presented below is based on data available from the British Columbia government and other coal projects in the Pine River area.

Regional Coal Quality Trends

In this section some of the quality characteristics of Gething Formation seams on a Regional basis, are discussed. The region under consideration extends from as far south as the Monkman Pass and as far north as the Peace River Canyon. The following discussion is confined to the Willow Creek area.

The rank of the Gething Formation coals range from low-volatile to high-volatile A bituminous, determined by vitrinite reflectance and proximate analysis of coal samples. The rank of the coal is mostly a function of the stratigraphic position of the seams. The Upper Gething seams generally fall into the medium-volatile bituminous category; and the Middle Gething seams generally fall into the low-volatile bituminous category.

Within the Rocky Mountains, there is an abrupt westward decrease in rank after peaking at a low-volatile bituminous to semi-anthracite level. This trend is supported by Gething Formation coals found at the Goodrich Property, which lies in a tectonic slice immediately west of the Willow Creek area and where the rank is described as medium volatile (Ryan 1997). The Gething coals at Goodrich have a greater volatile matter content than those at Willow Creek and are thus lower in rank.

The westward change in rank is also evident on the Pine Pass Licenses west of Willow Creek. Equivalent seams at Pine Pass have volatile matter contents which are greater than those at Willow Creek. Thus the coals at Pine Pass are likely to be lower rank coals similar to those of the Goodrich coals. The Falling Creek Property is located to cover Gething Formation seams of the Goodrich tectonic slice and the seams on this property can thus be expected to display similar characteristics to those of the “Goodrich” type.

Free-swelling index (FSI) values are measured on a scale of 0 to 9. Traditionally an index value of 3.5 was considered the lower limit of a coking coal. However, with changes in blast furnace technology, a broader range of FSI values can now be used. For example, the lower limit of semi-soft coking coals is now considered to be an FSI of 2. Typical FSI values for Upper Gething seams and Middle Gething seams range from 1½ to 8½, and 0 to 2, respectively. The Upper Gething seams have FSIs in the range required for coking coals and the low FSIs of the Middle Gething indicate some potential for use as semi-soft coking coals, PCI coals, or high-heat thermal coals.

Within the region under discussion, some of the Gething Formation coal seams are low in ash. On an air-dried basis, raw ash values from Gething Formation coal seams range from less than 2.5% up to 30%, with an average of about 14%. The lowest values reflect a lack of bone coal and carbonaceous partings within some of the coal seams and suggest potentially high washplant recoveries. In conjunction with this and the rank of the coal, Gething Formation coals have high calorific values.

The Hardgrove Grindability Index (HGI) is a general measure of the hardness or friability of coal, determined by the ease with which it can be ground into powder. Coals with HGI values of less than 50 are considered to be hard coals, whereas coals with values above 80 are considered soft coals. Gething coals are generally soft coals.

Sulphur Content

For most of the coal seams, the sulphur content of 1.7 SG floats is between 0.5% and 0.75%. Seam 8 has a relatively high level of 1.1%. Work performed as part of the 1994 program indicates that (for Seams 1, 4, 6 and 7) most of the sulphur is present in organic form. With the possible exception of Seam 8, which forms a small proportion of the total reserves, all seams can be classified as low in sulphur, i.e. less than 1%. Assuming that the other seams are similar to those tested, there would appear to be no potential for reducing sulphur in the coal processing plant. The sulphur content of the product coals should be low enough to have full market acceptability.

2.2 MINING

2.2.1 Introduction

Mine plans were developed for the Willow Creek North and Central mining regions. The plans provide the flexibility to accommodate a variety of pit sequencing options in order to achieve a coal release schedule to meet changing demand. A single schedule, averaging approximately 900,000 clean tonnes per annum, is described within this document.

The Willow Creek mining situation is typical of those found in other mines in Western Canada. Topography is steep but not severe and is favourable from both a drainage and haulage viewpoint. The geology is complex with respect to stratigraphy and structure, but is not an impediment to mining. Bedding dips are usually shallow making coal cleaning and recovery the major consideration for mine planning and equipment selection. The plunge of the coal structure is generally to the north, which is similar to topography, permitting the initial phases of the pits to be opened at the lower elevations and to utilize downhill haulage to an external dump. Subsequent phases of the pits will then have downhill or flat haulage to internal backfill areas. Water intercepted in the pit will require minimal head pumping and surface waters will be easily intercepted. Gravity flow ditches will carry water to the treatment areas.

Rock types in the Willow Creek area are not expected to cause unusual operating difficulties. They are similar to those found in other regional mines, are easily blasted, and do not create exceptional wear on tracked equipment, rolling stock, ground engaging tools and tires. They are also competent for road construction projects and surfacing. Rock properties were given no special consideration in the equipment selection process.

2.2.2 Mining Methodology

The objective of the mine plan was to provide a continuous source of coal throughout the mine life, in an economic manner. Target coking and thermal coal quantities for this plan are 500,000 and 400,000 clean metric tonnes, respectively, once full production levels are achieved, targeted for the year 2000. In order to meet the clean coal specifications of the customer, a flexible mining system capable of servicing alternate working faces over short periods of time is required. This is also needed to appropriately blend the coal.

2.2.3 Production Levels and Stripping Ratios

Results from the mine modelling process determined that the Willow Creek project, including the North and Central mining regions, has a recoverable reserve of 15,652,000 run-of-mine tonnes (romt) of coal, with waste totalling 58,810,000 banked cubic metres (bcm) of rock. The resulting average raw coal stripping ration is 3.76:1 (bcm:romt). To minimize mining equipment requirements, the pit sequencing was scheduled to equalize rock stripping requirements, by maintaining a relatively constant, although slightly increasing, stripping ratio over the life of the project.

2.2.4 Mine Design and Layout

The Willow Creek North and Central mining regions are separated by an east-west trending slope, producing a vertical separation of approximately 100 m. This topographical feature prevents the continuation of the mining pits between the two regions, and also places significant constraints on the accessibility of the Central mining zone. An overall plan view of the mining region is provided in Figure 2.1-1. Figures 2.2-1 through 2.2-3 show representative pit cross sections. Refer to Section 2.1 for a discussion of the geological structures shown on the cross sections. In Willow Creek North, the mining region is constrained by the subcrop of the lower seams to the west, and Far East Creek to the east. As indicated, the topographic ridge limits extension to the south, while the Pine River floodplain restricts further development of the seams to the north.

The same east-west constraints that constrain the Willow Creek North region, also influence the Central mining zone. The slope between the regions controls the northern extent of the Central pits. For the purposes of this study, the southern end of the mine development area has been truncated by the drainage referred to as Tributary 2. The area south of the drainage is known locally as Willow South. At the present time there is insufficient drilling information to warrant the preparation of a detailed geologic model, and individual pit designs.

The overall development plan is predicated on the following criteria, ranked by priority:

- Release required volumes of raw coal, by seam, to ensure flexibility in blending to meet clean coal customer specifications, and optimize plant yield.
- Maximize in-pit backfilling, and ultimately achieve a reclaimed ecosystem, which adds value to the land.
- Minimize haulage distance to optimize mining costs.
- Produce a flexible mining schedule, which will provide the operator with mining options (multiple faces) in the relatively confined individual mining areas. This is critical for optimization of the coal cleaning operation and internal project economics.
- Schedule mine development for progressive reclamation, gaining visual credibility with local stakeholders and minimizing reclamation materials handling costs by direct placement.
- Develop the lease so water management is a closed loop to minimize the potential for environmental impacts.

A bench height of 10 m was selected based on coal seam thickness, equipment and topographical constraints. There may be areas within the project, such as the Peninsula Pit, where the bench height may be increased on a site specific basis. These decisions would be made during the operating stages of the project. Top and bottom waste wedge handling will be required because of the relatively shallow dip of multiple coal seams. The volume of this material increases as a function of bench height, as will coal cleaning requirements. However, mining costs for rock and coal increases as bench height decreases. Based on a review of the geometry of the deposit, a bench height of 10m is also expected to maximize coal recovery. There may be areas where the shallow dip of the coal seams will require bench height to be reduced. The loading equipment selected for the project will comfortably work with 10 m benches without the need to use additional equipment to reduce the face height.

Ultimate Pit Boundaries

Willow North

The terrain in the Willow North Area has a moderate to steep slope, in a northerly direction, to the Pine River valley. The north facing slope is interrupted by relatively deep drainage channels trending north-south. There are four pits proposed for the Willow North mining region; namely the Pit 8N, the Pit 6N, the AN Pit and the Pit 4N. The 8N and the 6N pits are essentially a small open cut excavated along the coal seam outcrops, extending some 30 to 40 m in depth. As pit bottom coal will be extracted by a hydraulic backhoe, vehicular traffic in the pit bottom will be eliminated, and no safety berms were needed in the ultimate pit designs. To make allowance for any surficial weathering of the bedrock materials, the overall highwall slope angle of both pits was limited to 55·.

The AN Pit is defined by a continuous footwall slope along the west side of the pit, which rolls into a shallow bottomed syncline at a depth of approximately 60 to 70 m, to form the pit bottom. A north-south striking thrust fault interrupts this structure near the centre of the AN Pit. Because of this fault, an additional series of benches must be incorporated into the plan to minimize rock handling. On the east side of these benches, the pit is also defined by an easterly dipping footwall slope, which is followed to the depth at which the economic mining limit is reached.

The west side of 4N Pit is comprised of the continuous 4 Seam footwall slope, which extends to an approximate depth of 65 m. A series of benches connects the west and east sides of the pit at the intersection of the 2 Seam footwall. The slope of 2 Seam footwall is extended to the economic mining limit of the pit, except in areas which are constrained by the Far East Creek drainage channel to the east.

Willow Central

The Central mining region is situated on a plateau parallelling the Willow Creek drainage channel to the west. Topographic relief in the area ranges from 990 to 1160 m elevation. The western portion of Willow Central is bisected by the Tributary 1 drainage channel. The three pits comprising the Central mining region are: The Peninsula Pit, Pit 7C, and Pit 4C. The Peninsula Pit is located in the south end of Willow Central. The economic viable coal reserves of the Peninsula Pit have been eroded to the north. The pit contains only Seams 7 and 8, which are relatively flat lying over much of the area, but have been folded into a syncline-anticline sequence at the east side of the pit. For the purposes of this study, the Seam 8 reserves are only mined along a crescent shaped area on the north side of the Peninsula. The Seam 8 deposits situated underneath Seam 7 throughout the Peninsula area significantly exceed the economic strip ratio limit imposed for standard loader/truck mining methods in this study. Future consideration will be given to other mining applications such as throw blasting or dozer mining. There is potential for a Seam 8 Pit north of the Tributary 1 area, with possible recoverable reserves of 70,000 tonnes.

The west footwall of the Pit 7C is comprised of a benched wall following bedding beneath the Seam 7. In the south end of the pit, the benched slope intersects the Seam 7 footwall at the eastern edge of the Peninsula Pit. The primary structure encountered in the Pit 7C is a north striking syncline-anticline-syncline fold sequence. At the present time, only the reserves in the western syncline and anticline portion of the sequence have been scheduled for mining.

Pit 4C is similar in design to the Pit 4N in that the Seam 4 footwall forms the west wall of the pit and an intermediate highwall runs through the centre of the pit, connecting the Seam 4 footwall to the Seam 2 footwall. The eastern side of the pit follows the Seam 2 footwall to the economic limit in the south end of the pit, but extends to elevation 1000 m in the north. This elevation coincides with available access to this area of the pit.

Pit Phasing

Many of the pit areas discussed in the previous section were phased during the mine scheduling process in order to maximize the potential for internal backfilling of waste material and to provide an opportunity for the direct placement of topsoil/subsoil materials on reclaimed dump and pit areas.

For example, the Pit 4N has been subdivided transversely into three phases with the intersection between Phases 1 and 2 situated near Section 17,000, and the Phase 2 and 3 intersection near Section 16,200. Steep topographical locations on the north facing slope were used as the break lines between the individual phases. Use of the steep slopes eliminates rehandle of the internal backfill material as access to the lower benches of the subsequent phase of the pit is established. The AN Pit has also been subdivided, with Phase I comprising the lower area from approximately Section 17,000 to the northern subcrop, and Phase 2 comprising the southern portion of the pit.

In Willow Central, Pit 4C was divided into three phases near Sections 15,400 and 14,800. Pit 7C could not be subdivided transversely because access to the bottom of the Seam 7 syncline requires the entire length of the pit to achieve acceptable operating grades for the mining equipment. The upper benches at the south end of the pit can be phased separately making it possible to backfill the south end of the pit where pit bottom elevation exceeds 980 m.

2.2.5 Mining Sequence And Development Plan

Typically the proposed sequence of mining within each mining area will be from north to south. This is to take advantage of gravity with respect to waste haul, and to maximize internal backfilling opportunities. The moderate to steep topographical relief, and the corresponding access problems, were a major factor when developing the mining sequence. Other factors having a significant influence on the sequence were:

- the coal release schedule particularly with respect to the AN Pit;
- ability to meet blending requirements for raw coal feed to the plant to achieve customer needs;
- backfill availability;
- surface water management; and
- the average stripping ratio of the individual pits.

During scheduling of the mining sequence, the coal release from the AN Pit was extended for as long as practical to reduce the impact of its less desirable cleaning properties; the annual release of this coal was held near constant, until Seam A mining was completed. As a result of this constraint, product coal characteristics were controlled, and plant operating hour requirements were normalized. Similarly, the average annual stripping ratios were kept as nearly constant as possible; this was done in order to prevent large changes in the annual waste volumes once the mine was operating at full capacity. Scheduling strategy was based on minimizing the pre-stripping investment to meet coal release requirements, at approximately the average ratio of the minable reserve.

The proposed mining sequence is sensitive to the timing of the various pit/phase developments. The major advantages of the proposed development plan are as follows:

- External dumping requirements are minimized;
- Reclamation can proceed in a progressive manner; and
- Haulage distances for waste are kept relatively short.

This approach minimizes the overall mining disturbance requirements and enables the creation of a post-mining landform which meets the objectives of the proposed end land-use for the project area. By phasing the pit developments within the Willow North and Central regions, components of the mine within each area are released for final reclamation in a progressive manner, throughout the mine life.

In general the sequence involves mining in the North Area in the initial years for production of coking coals, with Central Area mining in the Peninsula Area to produce thermal coals. Once the pits producing coking coals in the North Area are completed, mining shifts to the Central Area specifically to Pit 4C to allow continued coking coal production. This approach enables both areas to be developed in a manner consistent with the dumping/backfilling plan for the overall project.

Although complex, the mining sequence has inherent flexibility beyond the detail of an annualized mine schedule; this results from the on-going release of coal within the individual phases. Owing to the relatively tight mining conditions within the individual pits/phases, it will be necessary for the operator to have this flexibility to maintain efficient operations. It is anticipated that opportunities will present themselves to improve the mining/dumping plan, while achieving the final reclamation landform objectives.

Although operations in Willow North and Central are on-going in each area concurrently for most of the mine life, the two areas are operationally discreet from the point of view of access and material movement.

2.2.6 Main Access And Haul Road Options

Permanent haul roads for the Willow Creek mining areas were designed at maximum grades of 8%, with infrequent short lengths of road which reach 10%. The running surface width of all haul roads was designed at 18 m with an additional width allowance for 2 m high berms along the outside edge. Vehicle runaway lanes will be provided wherever necessary on long

downhill grades. It is assumed that the roads will be constructed by building single lane temporary accesses to the mining area along the design route with dozers and then widening them to final design utilizing waste from the active mining area. This is standard practise in many Western Canadian Coal Operations.

Construction

Roads will be built according to *Mines Act* requirements. The following general sequence will be followed (modified as required to suit site-specific circumstances).

- top soil will be removed;
- soft (weak) and organic soils will be removed; and
- cuts and fills will be constructed as required.

Fill material will be from on site cuts or from pit rock.

North Area Access

Access to the Willow North mining region will be gained through a switchback road climbing from the valley at 635 m elevation and winding through the 8N and 6N Pit areas to the southern end of the mining area. The switchbacks were included to minimize the disturbance area and to provide access to the intermediate benches for all of the North pits. The bottom switchback is situated at 685 m elevation where access to the upper benches of Phase I of AN and 4N Pits will be gained. The southern portion of the road continues winding up the north facing slope to provide access to 840 m bench in 6N Pit and the 830 m bench in 8N Pit.

Central Area Access

Two separate options to provide access to the Central area pits were evaluated; upgrading the existing Forestry road, or continuing upwards from the 840 m elevation of the North area haul road. The Forestry upgrade is the preferred route for a number of reasons:

- the road alignment is safer for operations;
- trucks will not be driving under the active north-central dump;
- the access is independent of north area blasting delays; truck traffic and associated noise and dust will be out of public view; and
- the underlying landowner receives an improved road at project completion.

From a mining and aesthetics point-of-view, there are no advantages to the alternate route.

Forestry Road Upgrade

The existing Forestry road runs southward along the east slope of the Willow Creek drainage. It is relatively narrow and contains portions which are too steep to operate mining equipment. The first segment with an excessive grade comprises the northern portion of the road from elevation 750 m at local grid 17,230N and extends southwards a distance of approximately 500 m. This segment needs to be replaced with a portion of road constructed at 8% to 10% grade and includes one switchback.

The second portion of road exhibiting excessive grades is the segment near Tributary 1 from local grid 15,400N to 14,900N. This section of road has an average grade of 12% with a maximum grade of 14% to 15%. From elevation 880 m the road can be rebuilt at a grade of 8% to 9% up to 940 m elevation. At this location it will be necessary to increase the grade to 10% to elevation 1030m south of Tributary 1 and to elevation 1060m in the region north of Tributary 1. Beyond this point roads can be built to satisfy the development needs of the Central mining area.

In addition to the reduction in maximum slope of the above areas, the road will have to be widened over the entire length that will be utilized for the mine. To accomplish the road widening, for the majority of the route, the inside edge of the road will remain relatively unchanged and mine waste will be used as fill to extend the road to the outside. One noticeable exception to this procedure is a 200 m length section situated near the north end of the road where the close proximity to Willow Creek makes it necessary to widen the road by cutting into the slope.

Upgrading of the Forestry road is the preferred option for the provision of access; it maintains flexibility for the independent development of the North and Central mining regions. The advantage of keeping the two areas independent is that scheduling of both waste disposal and coal release is simplified and it allows the amount of internal backfill to be maximized. Another important advantage of utilizing the Forestry road upgrade is that there will be reduced dust, noise and visual disturbance along the north slope of the mine property. Fill roads of this type are common in Western Canadian Coal Operations and have proven to be stable and acceptable to the regulatory agencies concerned.

2.2.7 Rock Dumping/Backfilling

As mentioned previously, internal backfilling of mined-out pits during the scheduling of waste disposal has been maximized. For those areas where internal backfilling is either not possible or practical, external dumping areas have been identified. Wherever possible, these external dumping areas have been utilized for access purposes in order to prevent unnecessary road construction and to minimize the total disturbance area. External dump areas will be located so as not to sterilize coal resources consistent with requirements of the *Mines Act*. A location map for the external dumping areas is shown on Figure 2.1-1.

Figure 2.1-1 also shows the lower portion of the north slope designated as an external dump area for the Willow North pits. Internal backfilling will take place in Phases I and II of the AN Pit, and all three phases of Pit 4N, as well as Pits 6N and 8N.

In Willow Central, external dumping is proposed as a starter dump for the Peninsula Pit. The location is shown on Figure 2.1-1 west of Pit 7C. Once sufficient floor area is opened in the peninsula area, all material from peninsula mining will be placed internally. Internal backfill will be placed in the Peninsula Pit, all three phases of Pit 4C, and the south end of Pit 7C.

2.2.8 Geotechnical Criteria

A preliminary geotechnical assessment of the Willow Creek area was conducted by Piteau Associates Ltd. in the report entitled “Willow Creek Project - Preliminary Geotechnical Review of Open Pit Slopes” (June 1996). Included in the report is a review of the proposed footwall slopes, highwalls and endwalls, and overburden slopes. Based on Piteau’s experience with footwalls at similar projects, they suggest that unbenched footwall slopes are feasible up to a critical limiting height. This height is dependent on the dip of the slope, the nature and spacing of jointing, and the effects of potential water pressures. Highwall and endwall stability is likely controlled by the development of planar slabs, wedges and/or rockfalls. Overburden slopes are generally not a concern due to the limited thickness but diversion ditches are recommended to avoid water flow in the overburden soils. Geotechnical engineering is continuing. Any changes in criteria will be recognized in detailed designs and possible changes can be accommodated in the mine design. For mine design purposes for this report, the following geotechnical design criteria were utilized:

- Continuous footwall slopes were limited to 60 m in vertical height above the last truck/loader bench.
- Interbench face angles were projected at 68·.
- Highwall catchment berms, 8 m in width, were installed at 20 m intervals.
- Overall highwall slope angles were designed at 50·.
- An overburden swell factor of 1.3 was used for truck and bucket loads, while 1.25 was used for dumped material.
- The coal swell factor was assumed to be 1.25.
- Angle of repose of dumped waste material was assumed to be 37·.

2.2.9 Recoverable And Product Reserves

Methodology and Reserve Calculation Criteria

Recoverable reserves for the various pits were determined from the computer generated block model. The recoverable reserves are the tonnages of coal that are expected to be extracted from the minable reserve in place during the mining process. The calculation of these tonnages takes into account various mining parameters such as any coal losses that might occur during mining; the introduction of in-seam and out-of-seam dilution; provision for oxidation; and thickness and depth limits for mining. These reserves apply to the design of pits that include infrastructural elements, such as benches and in-pit roads. Oxidation effects on the coking coal seams take into account by the generation of an oxidation surface 5 m vertically below the subcrop. Any tonnage for the seams that are considered for the extraction of coking coal and which fall between the subcrop surface and the oxidation surface were considered to be thermal coal. It should be noted that this is a provision for oxidation, rather that a physical limit that has been determined in the field.

The calculation of recoverable reserves also involves consideration of dilution since this material forms part of the run-of-mine tonnage. In general, both in-seam and out-of-seam dilution are included in the recoverable reserve tonnages. Provision has also been made for mining losses. Thus, there is the provision for the overall loss during mining of a full sequence of the seams of about 1 m.

Generally, coal to a true thickness of an individually mined seam greater than or equal to 1 m is included in reserves.

Finally, the product coal reserves were determined from the recoverable or run-of-mine tonnage. This calculation was made using wash plant yields that were determined by the coal processing evaluation.

Recoverable and Product Coal Reserve Results

Table 2.2-1 shows the results of the calculation of the reserves of recoverable (ROM) coal. Similarly, Table 2.2-2 shows the results of calculation of the product reserves of coking and thermal coals.

TABLE 2.2-1

PINE VALLEY COAL LTD.

RECOVERABLE COAL RESERVES

WILLOW CREEK PROPERTY

SEAM	COAL TYPE		PIT_4N		PIT_AN		PIT_6N	PIT_8N		PIT_4C			PIT_7C		PIT_8C	SUB-TOTAL	TOTAL
		PHASE 1	PHASE2	PHASE 3	PHASE 1	PHASE 2			PHASE 1	PHASE 2	PHASE 3	PENINSULA	UPPER	LOWER			
SEAM 1	COKING	84,264	206,915	316,481					309,533	54,237	377,437					1,348,867	
	THERMAL	20,030	19,871	24,195					21,164	12,951	57,599					155,810	1,504,677
		0	0	0													
SEAM 2	COKING	9,750	59,030	95,231					185,260	71,764	282,416					703,449	
	THERMAL	5,596	11,916	12,510					16,037	6,730	25,503					78,291	781,740
		0	0	0													
SEAM 3	COKING	26,884	46,526	3,901						55,995	386,464					519,770	
	THERMAL	3,950	5,681	562						5,931	39,457					55,581	575,351
		0	0	0													
SEAM 4	COKING	416,111	416,203	394,554					436,517	271,339	645,152					2,579,875	

	THERMAL	39,680	25,430	22,208					18,578	15,173	36,597					157,667	2,737,541
SEAM A	COKING				962,657	1,397,563										2,360,220	
	THERMAL				60,895	84,163										145,058	2,505,278
SEAM 5	COKING															0	
	THERMAL						35,582						115,145	299,112		449,839	449,839
SEAM 6	COKING															0	
	THERMAL						280,019						195,091	750,347		1,225,457	1,225,457
SEAM 7	COKING															0	
	THERMAL							78,572				1,546,255	844,214	3,150,410		5,619,452	5,619,452
SEAM 8	COKING															0	
	THERMAL							108,589							144,929	253,518	253,518
SUB-TOTAL	COKING	537,008	728,673	810,166	962,657	1,397,563	0	0	931,309	453,335	1,691,469	0	0	0	0	7,512,181	
	THERMAL	69,256	62,897	59,475	60,895	84,163	315,601	187,161	55,779	40,784	159,157	1,546,255	1,154,450	4,199,870	144,929	8,140,672	
TOTAL BY PHASE	COAL	606,264	791,571	869,642	1,023,552	1,481,726	315,601	187,161	987,088	494,118	1,850,626	1,546,255	1,154,450	4,199,870	144,929		15,652,853
	WASTE (CU.M.)	2,471,157	3,354,691	3,721,411	5,055,058	4,069,309	1,165,963	884,896	6,320,678	3,099,836	5,542,739	3,226,528	5,508,008	13,808,086	582,053		58,810,410
	RATIO (CU.M./T)	4.08	4.24	4.28	4.94	2.75	3.69	4.73	6.40	6.27	3.00	2.09	4.77	3.29	4.02		3.76
TOTAL BY PIT	COKING		2,075,848		2,360,220					3,076,113			0				7,512,181
	THERMAL		191,629		145,058		315,601	187,161		255,719			6,900,575		144,929		8,140,672
																	0

COAL	2,267,477	2,505,278	315,601	187,161	3,331,832	6,900,575	144,929	15,652,853
								0
WASTE	9,547,259	9,124,367	1,165,963	884,896	14,963,252	22,542,621	582,053	58,810,410
RATIO	4.21	3.64	3.69	4.73	4.49	3.27	4.02	3.76

TABLE 2.2-2

PINE VALLEY COAL LTD.

PRODUCT COAL RESERVES

WILLOW CREEK PROPERTY

SEAM	**COAL TYPE**	**YIELD (%)**		**PIT_4N**		**PIT_AN**		**PIT_6N**	**PIT_8N**		**PIT_4C**			**PIT_7C**		**PIT_8C**	**SUB-TOTAL**	**TOTAL**
			PHASE 1	**PHASE2**	**PHASE 3**	**PHASE 1**	**PHASE 2**			**PHASE 1**	**PHASE 2**	**PHASE 3**	**PENINSULA**	**UPPER**	**LOWER**			
SEAM 1	**COKING**	**80.8**	68,085	167,187	255,717	0	0	0	0	250,103	43,824	304,969	0	0	0	0	**1,089,885**	
	THERMAL	**85.0**	17,026	16,890	20,565	0	0	0	0	17,989	11,008	48,959	0	0	0	0	**132,438**	**1,222,323**
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEAM 2	**COKING**	**80.8**	7,878	47,696	76,946	0	0	0	0	149,690	57,985	228,192	0	0	0	0	**568,387**	
	THERMAL	**85.0**	4,756	10,128	10,633	0	0	0	0	13,631	5,720	21,677	0	0	0	0	**66,547**	**634,934**
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEAM 3	**COKING**	**80.8**	21,722	37,593	3,152	0	0	0	0	0	45,244	312,263	0	0	0	0	**419,974**	
	THERMAL	**85.0**	3,358	4,829	478	0	0	0	0	0	5,041	33,539	0	0	0	0	**47,244**	**467,218**
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEAM 4	**COKING**	**80.8**	336,217	336,292	318,799	0	0	0	0	352,705	219,242	521,282	0	0	0	0	**2,084,539**	

	THERMAL	**85.0**	33,728	21,616	18,877	0	0	0	0	15,791	12,897	31,108	0	0	0	0	**134,017**	**2,218,555**
SEAM A	**COKING**	**67.3**	0	0	0	647,672	940,275	0	0	0	0	0	0	0	0	0	**1,587,947**	
	THERMAL	**85.0**	0	0	0	51,761	71,539	0	0	0	0	0	0	0	0	0	**123,299**	**1,711,246**
SEAM 5	**COKING**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
	THERMAL	**85.0**	0	0	0	0	0	30,245	0	0	0	0	0	97,873	254,245	0	**382,363**	**382,363**
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEAM 6	**COKING**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
	THERMAL	**85.0**	0	0	0	0	0	238,016	0	0	0	0	0	165,828	637,795	0	**1,041,639**	**1,041,639**
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEAM 7	**COKING**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
	THERMAL	**85.0**	0	0	0	0	0	0	66,787	0	0	0	1,314,317	717,582	2,677,849	0	**4,776,534**	**4,776,534**
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEAM 8	**COKING**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
	THERMAL	**85.0**	0	0	0	0	0	0	92,300	0	0	0	0	0	0	123,190	**215,490**	**215,490**
SUB-TOTAL	**COKING**		433,903	588,768	654,614	647,672	940,275	0	0	752,498	366,294	1,366,707	0	0	0	0	**5,750,731**	
	THERMAL		58,868	53,463	50,554	51,761	71,539	268,261	159,087	47,412	34,666	135,283	1,314,317	981,283	3,569,889	123,190	**6,919,571**	
TOTAL BY PHASE	**COAL**		**492,770**	**642,231**	**705,168**	**699,433**	**1,011,813**	**268,261**	**159,087**	**799,910**	**400,961**	**1,501,990**	**1,314,317**	**981,283**	**3,569,889**	**123,190**		**12,670,302**
	WASTE (CU.M.)		**2,471,157**	**3,354,691**	**3,716,462**	**5,055,058**	**4,145,407**	**1,165,929**	**884,896**	**6,320,678**	**3,099,836**	**5,529,754**	**3,226,528**	**5,508,008**	**13,724,413**	**582,053**		**58,784,867**

	RATIO (CU.M./T)	**5.01**	**5.22**	**5.27**	**7.23**	**4.10**	**4.35**	**5.56**	**7.90**	**7.73**	**3.68**	**2.45**	**5.61**	**3.84**	**4.72**	**4.64**
TOTAL BY PIT	**COKING**		**1,677,285**		**1,587,947**					**2,485,499**			**0**			**5,750,731**
	THERMAL		**162,885**		**123,299**		**268,261**	**159,087**		**217,361**			**5,865,489**		**123,190**	**6,919,571**
																0
	COAL		**1,840,170**		**1,711,246**		**268,261**	**159,087**		**2,702,860**			**5,865,489**		**123,190**	**12,670,302**
																0
	WASTE		**9,542,310**		**9,200,465**		**1,165,929**	**884,896**		**14,950,267**			**22,458,948**		**582,053**	**58,784,867**
	RATIO		**5.19**		**5.38**		**4.35**	**5.56**		**5.53**			**3.83**		**4.72**	**4.64**

2.2.10 Material Balance

The rock and coal release volumes are summarized in Table 2.2-3. The table outlines the material movement quantities by year, for each phase of the individual pits. Also included on the table are annual average stripping ratios and summary totals for life of mine coal and waste volumes. These are presented on a by phase and by pit basis.

Table 2.2-3

VOLUMES AND TONNAGES

	YEAR	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
PIT 1-4	**PHASE 1 WASTE**	397,387	1,342,779	732,752									
NORTH	**PHASE 2 WASTE**			446,023	1,187,500	1,023,086	717,228						
	PHASE 3 WASTE					699,416	639,772	2,208,229	153,086				
	PHASE 1 COAL	77,931	296,875	234,618									
	PHASE 2 COAL			62,257	296,875	296,875	136,932						

	PHASE 3 COAL						159,943	610,366	94,804				
	TOTAL WASTE REMOVED	397,387	1,342,779	1,178,775	1,187,500	1,722,502	1,357,000	2,208,229	153,086	0	0	0	0
	ROM COAL	77,931	296,875	296,875	296,875	296,875	296,875	610,366	94,804	0	0	0	0
A PIT	**PHASE 1 WASTE**	428,289	1,665,559	1,602,486	1,318,101								
NORTH	**PHASE 2 WASTE**				736,632	1,720,614	1,599,600	53,086					
	PHASE 1 COAL	40,597	491,604	491,604	382,028								
	PHASE 2 COAL				109,576	491,604	491,604	6,661					
	TOTAL WASTE REMOVED	428,289	1,665,559	1,602,486	2,054,733	1,720,614	1,599,600	53,086	0	0	0	0	0
	ROM COAL	40,597	491,604	491,604	491,604	491,604	491,604	6,661	0	0	0	0	0
PIT 5-6	**WASTE**												
NORTH	**COAL**												
	TOTAL WASTE REMOVED	0	0	0	0	0	0	0	0	0	0	0	0
	ROM COAL	0	0	0	0	0	0	0	0	0	0	0	0
PIT 7-8	**WASTE**												
NORTH	**COAL**												
	TOTAL WASTE REMOVED	0	0	0	0	0	0	0	0	0	0	0	0
	ROM COAL	0	0	0	0	0	0	0	0	0	0	0	0
PENINSULA	**8 SEAM WASTE**												
CENTRAL	**7 SEAM WASTE**		267,552	1,066,496	654,437	721,086	265,792	265,791					
	8 SEAM COAL												
	7 SEAM COAL		198,235	374,706	374,706	374,706	374,706	369,461					
	TOTAL WASTE REMOVED	0	267,552	1,066,496	654,437	721,086	265,792	265,791	0	0	0	0	0

	ROM COAL	0	198,235	374,706	374,706	374,706	374,706	369,461	0	0	0	0	0
PIT 1-4	**PHASE 1 & 2 WASTE**						639,938	963,268	2,320,086	2,475,086	2,593,086	459,272	
CENTRAL	**PHASE 3 WASTE**											2,192,086	2,993,344
	PHASE 1 & 2 COAL							49,086	580,196	634,743	643,743	148,299	
	PHASE 3 COAL											487,190	625,000
	TOTAL WASTE REMOVED	0	0	0	0	0	639,938	963,268	2,320,086	2,475,086	2,593,086	2,651,358	2,993,344
	ROM COAL	0	0	0	0	0	0	49,086	580,196	634,743	643,743	635,489	625,000
PIT 5-7	**UPPER BENCH WASTE**						453,086	312,086	1,689,505	1,763,870	1,511,141	751,086	
CENTRAL	**LOWER PIT WASTE**											912,792	1,496,245
	UPPER BENCH COAL							55,245	414,706	454,963	445,963	344,875	
	LOWER PIT COAL											109,342	464,706
	TOTAL WASTE REMOVED	0	0	0	0	0	453,086	312,086	1,689,505	1,763,870	1,511,141	1,663,878	1,496,245
	ROM COAL	0	0	0	0	0	0	55,245	414,706	454,963	445,963	454,217	464,706
TOTAL	**TOTAL WASTE REMOVED**	825,675	3,275,890	3,847,757	3,896,670	4,164,202	4,315,416	3,802,460	4,162,677	4,238,956	4,104,227	4,315,236	4,489,589
	ROM COAL	118,528	986,714	1,163,185	1,163,185	1,163,185	1,163,185	1,090,819	1,089,706	1,089,706	1,089,706	1,089,706	1,089,706
	CLEAN COAL PRODUCTION	89,583	750,000	900,000	900,000	900,000	900,000	900,000	900,000	900,000	900,000	900,000	900,000
	CLEAN COAL STRIP RATIO	9.22	4.37	4.28	4.33	4.63	4.79	4.22	4.63	4.71	4.56	4.79	4.99
	RAW COAL STRIP RATIO	6.97	3.32	3.31	3.35	3.58	3.71	3.49	3.82	3.89	3.77	3.96	4.12
a	Coal is listed in tonnes; waste as bank cubic metres (BCM). An approximate equivalency can be obtained by assuming a waste specific gravity of 2.4.												

Topsoil/Subsoil

Topsoil/subsoil volumes were calculated after determining the disturbance areas for the pits, external waste dumps, road, and infrastructure. Thickness of the topsoil/subsoil horizons were provided from data collected from soil surveys. The total volume of this material, listed by location, is provided in Table 2.2-4. Topsoil and subsoil horizons will be salvaged from the proposed pit and dumping areas in phases to minimize the amount of time areas are to be disturbed, and to maximize opportunities for direct placement of the material. Topsoil and subsoil is projected to be salvaged in a single lift, by either dozer and/or loader truck operation. In relatively flat and dry regions push dozer and scraper can be employed. Salvage operations will be conducted in all areas, except for localized regions of steep terrain.

Stockpile locations have been sited in both the North and Central mining areas, as well as near the plant site. These stockpiles have been sized to accommodate the topsoil/subsoil volumes that cannot be transported directly to a reclaimed area.

TABLE 2.2-4

POTENTIAL TOPSOIL/SUBSOIL VOLUMES

LOCATION	**THICKNESS (m)**	**VOLUME (m3)**
Pit 4N	2.3	260,000
Pit AN	1.5	339,000
Pit 6N	0.9	78,000
Pit N	1.0	59,000
North Area External Dumps	0.9	263,000
Pit C	0.8	375,000
Pit C	0.8	398,000
Peninsula Pit	0.8	225,000
Central Area External Dumps	1.5	294,000`
Plant Site and Tailings Pond	2.5	225,000
Mine Infrastructure*	1.6	675,000
Total Volume		**3,191,000**

* Includes sedimentation ponds and haul roads.

Rock

As discussed previously, the waste rock volumes were equalized as much as possible to minimize fluctuations in equipment operating hours and manpower requirements. The volumes were calculated for each mining phase so that both internal and external dumps could be sized to accommodate the resulting rock.

Coal

Table 2.2-3 provides the coal release schedule from each of the mining areas. Owing to differences in the plant yields for thermal and coking coal production, the raw feed requirements to produce 400,000 tonnes of thermal coal and 500,000 tonnes of coking coal, is not a linear function. Annual production was scheduled on a clean coal basis for both product types.

2.2.11 Mine Equipment

The rock and coal volumes, determined from geological data and computer modelling, were utilized for the selection and sizing of the major mining equipment. It is assumed that during the equipment selection process, the equipment type and sizing outlined in this report will only be used as a guideline; specified make and model number actually employed may differ from these.

Equipment Specification

A primary consideration associated with specification of the major mining equipment, was the requirement of the equipment to selectively mine the moderately to steeply dipping, multi-seam, thinly bedded coal deposit. In addition to the configuration of the coal seams, the production levels, topography of the mining region, and the surface area of the individual pit benches, were important factors affecting the specification process. Since there are no plans to provide electricity to the mining areas, all of the mobile equipment listed in the following paragraphs is diesel powered. Owing to the confined working area and multiple working faces, the utilization of electrical powered equipment is not thought practical.

Sizing of the major mining equipment was based on the assumption that the truck fleet would haul both coal and waste. Productivities, breakout force per inch of bucket lip and the ability to selectively mine coal and parting material indicate the choice of a 7.0 m3 backhoe for coal and a 10.7 m3 front end loader for waste as the best loading options. Haulage requirements indicated 97-tonne trucks were the most economical fleet option. Drilling will require a diesel unit capable of producing a 270 mm blasthole.

The selection of a loader for use in the rock removal operation was based on the need to relocate from pit area to pit area. It also provides back-up for the loader at the plant for such functions as coal feed to the plant and train loading. The loader is ideal for towing disabled trucks to the shop.

Support Equipment

The support equipment required to service the production fleet was specified according to the type and magnitude of the anticipated work requirements. Compatibility with the major production fleet, was also an important factor in the specification process.

Projected dozer work in the mining process will include, dump and road construction and maintenance, ripping of frost and hard materials, coal cleaning and parting sorting, drill pad preparation, and backhoe working pad levelling. Use of a wheel loader and backhoe for waste and coal loading will minimize the amount of dozer work for loading area maintenance. Reclamation work will require dozers for topsoil/subsoil salvage and spreading, as well as dump and haul road resloping. Finally, dozers will be required to assist train loading and for minor site maintenance. Scheduling of this work has indicated the requirement for both a 300 kW and 425 kW. sized track dozer.

Road and site maintenance work will require the use of a large mining sized grader. It is recommended that a 335 kW. sized scraper and accompanying 20,000 L water bowl be acquired for dust control, road sanding, and topsoil/subsoil salvage and spreading.

A used 10.7 m3 sized wheel loader was specified for plant feed, coarse reject loading, and associated plantsite maintenance work.

Owing to the relatively large distances between active mining areas, all tracked equipment, including the 7.0 m3 backhoe will need to be hauled between job sites. Consequently, a 120 tonne lowboy tractor/trailer was included in the equipment specifications.

2.2.12 Mine Maintenance

On-site mine maintenance will consist of a full scale preventative maintenance program for all production and support equipment. It is envisioned that all servicing, as well as component change-outs will be conducted at the mine site, with assistance being provided by external contractors. Tire maintenance and replacement has been assumed to be contracted out, and accordingly, no allowance has been made for a tire shop, equipment, or for tire inventory.

In addition to the maintenance shop complex, mine maintenance will provide in-pit fuel and lubrication services, utilizing a self contained lube truck. Minor field repairs will be conducted by a shift mechanic, equipped with a service truck.

Preventative maintenance will be conducted according to a predetermined schedule. In order to increase component life and assist with warranty claims, a full scale oil analysis program will be implemented.

2.2.13 Drilling and Blasting

Production and wall control blasting criteria for the proposed mine, were designed based on a combination of Norwest's experience with blasting for loader/truck waste operations and from input from the geotechnical consultant as to the rock mass strength and material properties. It should be noted that the blasting criteria outlined in the following sections are "rule of thumb" design techniques, which provide sufficient detail for costing purposes. As is the case for any blasting program, once operations commence, the blasting program may be enhanced through experience gained under actual mining conditions.

Production Blasting

Design specifications for production blasting provide the following blasting criteria for typical operating conditions:

- Pattern size: 7.6 m equilateral pattern
- Powder factor: 0.52 kg/bcm
- Subdrill depth: 2.0 m
- Blasting agent: ANFO and ANFO based emulsions
- Accessories: Nonel noiseless trunkline and downlines

Through consultation with coal mine operators and explosive manufacturers operating in the Chetwynd area, it was determined that plastic borehole liners would be required in 50% of the ANFO holes, and that water resistant blasting agents (emulsions) would be required for approximately 10% of the holes. Should the same explosive manufacturer utilized at the Quintette and Bullmoose operations be selected to supply explosives to Pine Valley, ANFO based emulsions can be supplied in bulk from the Quintette mine as opposed to purchasing packaged products.

During the first few years of mining at Pine Valley, the pit benches can be opened up along free faces, due to the site's topographical setting. It is only in the later years of operations that benches will have to opened via centre cuts or "V" notches. Design of these specialized blasts, will be completed at the time they are needed, after gaining actual operating experience at the minesite.

2.3 COAL PROCESSING

Figure 2.3-1 is a site arrangement of the processing plant area.

2.3.1 Introduction

For design purposes, the coal handling and processing systems have been developed based on the following:

Semi-soft coking coal: 500,000 tonnes

Thermal coal: 400,000 tonnes

Total annual coal sales: 900,000 tonnes

This annual production equates to an average of 2570 tonnes per day, assuming a 350 day-per-year operation of the wash plant.

Clean coal production specifications are subject to further refinements based on contracts with potential customers, and have been targeted as follows:

Table 2.31

Specifications:

	Semi-Soft Coking Coal	Thermal Coal
Sources	unoxidized Seams 1 to 4, A	Seams 5 to 8, & oxidized Seams A,1 to 4
Product ash	9% Air Dried	10 - 12% Air Dried
Volatile Matter	20 - 24% db	15 - 20% db
FSI	> 3 -	

		~ 8,600 kcal/kg daf.
Heat Value	-	~15,500 BTU/lb daf.

2.3.2 General Approach

Data collected in the 1996 drilling program was used in conjunction with previous data for the Plant/Process Evaluation. A partial washing concept was assessed, incorporating:

- the integration of washability data obtained for all seams from both drill cores and the 1994 bulk sample; and
- the proportioning of all coal seams to be washed based on a mining schedule coal release.

The partial washing concept entails dry screening the ROM coals at 6 mm, and then transferring all the coarse (oversize) material to the wash plant. This concept removes all of the plus 6 mm visible rock impurities and upgrades this portion of the product(s). Any minus 6 mm coal bypassing the plant will have a lower moisture content than the washed coal, and the overall product moisture specifications can be achieved without thermal drying.

2.3.3 Raw Coal

Raw Coal Specifications

Coal is to be mined from nine different seams. The raw coals from these seams fall broadly into two high rank categories: coking and low volatile thermal. The upper seams, 1 through 4 and A, are generally medium to low volatile bituminous coking coals, with a dry mineral matter free volatile range of 20% to 24%. The lower seams, 5 through 8, have high carbon content, are low volatile bituminous coals, with a dry mineral matter free volatile range of 15% to 17%. It should be noted that the total reserve in the North and Central mining blocks has only minor differences in quality.

The lower seams, 5 through 8, are suited to sectors of the thermal market, to PCI use, and to other specialty markets requiring high-thermal, high-carbon content coals.

The plant and handling facilities designs have incorporated predictable variations in the mined coal quality, specifically variances in size consist and amounts of dilution.

Dilution Levels

Dilution is rock material that is mined in conjunction with the coal; it thus forms part of the run-of-mine tonnage and is included in the recoverable reserve. Dilution occurs in two forms, in-seam and out-of-seam, each of which is treated separately in the calculations and analyses of this study. In-seam dilution is the component rock bands that occur within any mining section. Investigations in the field provide information concerning the typical character of the in-seam dilution material. Core samples demonstrate that it normally consists, particularly for thinner bands, of carbonaceous mudstone or mudstone. Less commonly, siltstone or fine grained sandstone may be present.

An allowance was made for out-of-seam dilution quantities introduced as a result of mining contamination. Overall dilution is expected to be approximately 10% by weight.

ROM Coal Stockpiling

Stockpiling of ROM coal ahead of the washing facility provides the following operational controls:

- prevention of interruption of plant production;
- segregation of ROM coking and thermal coals; and
- provision of adequate blending of seams within each of the coking, and thermal product groups.

The proposed stockpiling system is a single radial stacker conveyor capable of forming two stockpiles sized at 35,750 tonnes each, or any two pile combination, totalling 71,500 tonnes. The two stockpiles allow for the segregation of the coking and thermal grades of raw coal. As a result, the stockpiles can be sized so that more room is allotted for the higher throughput of coking coal required to produce the product split of 500,000/400,000 coking/thermal coal.

As multiple seams are being washed to produce two products, blending ahead of the washery is used for the efficient operation of the jig plant. The automatic nature of the jig, coupled with feedback information from the on-stream ash analyser, generally eliminates any concern relative to ash quality. Each of the seams are relatively low in near gravity material, and display similar washability curves.

The stockpiling operation is shown schematically in DWG 1942-SC-06.

2.3.4 Coal Preparation Plant

Overview

Analysis of the washability data obtained from the 1996 drilling program, and the bulk samples of 1994, indicates that all seams have very low proportions of near-gravity material, at the cut points in the 1.5 to 1.8 s.g. range, and hence are relatively easy to clean. This suggests that a jig and spirals can be used for beneficiating raw coal. Further, the jig and spirals are traditionally easy to operate, low in maintenance, and have very high mechanical availability.

The washability data suggests that partial washing, employing dry screening techniques is applicable. This is desirable for the following reasons:

- yields can be maximized;
- lower product moistures are achieved, as some or all smaller sizes of the coal are bypassed and are not wetted; and
- a smaller sized plant is required.

The plant design criteria required the capability to process 900,000 clean tonnes per year. To attain 900,000 tonne per year output, a two shift operation is required. Based on Norwest's experience, a mechanical availability of 92% was utilized for design specifications and scheduling purposes.

ROM Coal Dry Screening

Dry screening of the ROM coal upstream of the wash plant allows raw minus 6 mm coal to bypass the plant during events when product upgrading is unnecessary. The bypassed fine raw coal is then mixed with the wash plant output. The blend reports to a specific product stockpile.

The dry ROM coal screen is located at the point where raw coal enters the preparation plant; it is situated directly in-line with the Baum jig, thus enhancing the operational performance of the jig.

Development Of Flowsheet

A conceptual flow sheet is provided in DWG 1942-SC-01. The flow sheet also contains materials and water balances.

All raw coal not bypassed will be fed into a jig. The minus 0.15 mm fraction (approximately 4% of feed) reports to tailings, as it would not be economically viable to attempt to beneficiate this size fraction. Handling problems would also occur with this size fraction unless some form of thermal drying was implemented. The recovery of the minus 0.15 mm fraction will be assessed on an ongoing basis, as experience is gained during operation of the mine.

Analysis of the 1996 and 1994 washability data indicates that a significant portion of the minus 6 mm raw semi-soft coking coal (upper seams 1 through 4 and A), will need washing to meet the desired product specification of 9.0% air dried ash. To meet the maximum ash specifications of the thermal market, washability data analysis and computer modelling indicate that the minus 6 mm raw coal will be bypassed. Higher system throughput is achieved when processing thermal coal, as less fines (minus 6 mm) are washed.

Process Yields, Wash Plant Capacity & Scheduling

The capacity of the wash plant is dependent on product yield, annual tonnage requirements, and the mining release schedule of the nine seams. The annual clean coal production is nominally 500,000 and 400,000 tonnes per year of coking and thermal coal each, respectively.

The above schedule addresses the reserves within the Willow North and Central mining regions. Table 2.3-1 reflects the expected yields of the partial washing, for the coking and thermal coals.

Table 2.3-1

Product Yields

Years	Coking Yield1 As Received	Thermal Yield1 As Received
1998 - 2005	72.3%	85.1%
2006 - 2013	80.8%	85.0%

1 Adjusted

Assuming a 92% mechanical availability factor, the coal preparation plant operating schedule is based on about 3000 operating hours per year, utilizing 12 hour shifts per day.

2.3.5 Clean Coal Handling

Clean Coal Stockpile

The two clean coal stockpiles are designed and sized to provide up to 20,000 tonnes storage each. Stacking tubes will be used for these facilities.

The thermal product may require the addition of dust suppressants to the coal at the top of the thermal coal stacking tube and/or other belt transfer points. This could add 0.5% moisture to the product. It is unlikely the coking product will need the addition of a dust suppressant as the bulk of the fines (- 6 mm) will be washed, and hence already wetted.

In addition to the on-stream ash analyzer, a mechanical sampler is located on the clean coal conveyor reporting to the product stackers.

Clean Coal Reclaim

The particular coal product, thermal or coking, will be reclaimed from the respective product stockpile when a unit train arrives. This will be accomplished by a front end loader and/or dozer made available by mine operations.

2.3.6 Train Loadout

Design Criteria

Loading of unit trains will be done in eight to ten hours. At the 900,000 tonne-per-year level unit train would be loaded every three to four days.

Loadout Design

Conceptually, the following will be used to load the rail cars:

- clean coal reclaim hopper;
- load out conveyor;
- a 200t capacity surge bin;
- weigh/feeder;
- a traveling/telescoping (depending on car type) car loading chute; and
- an operator’s control panel located at top of rail car elevation.

Loadout Operation

Train loading is expected to occur every four to five days, depending on unit train cycle times, length of unit train, and availability. Train loading time has been targeted at ten hours or less. The proposed loadout system is similar to the ROM coal reclaim, i.e. from the stockpile by a front end loader onto the tail end of the loadout bin feed conveyor. Dozer assist of the front end loader may be required.

2.3.7 Plant Refuse Disposal

Coarse Refuse Disposal

The coarse reject disposal site will be a dump or waste backfilling location which is within the catchment area of a sedimentation pond. For design purposes it has been assumed that the coal haul fleet will collect a load of coarse rejects as required and detour to the reject disposal area, on the return haul to the coal face.

Slurry Refuse Disposal & Ponds

When washing coking coal the amount of tailings will increase to approximately twice the volume produced by the thermal coal washing operations. Therefore, two underflow pumps will be installed to remove and deliver the tailings from the thickener to the pond, located approximately 1,000 m from the washery. The availability of two pumps will also provide the following benefits:

- the flexibility of the installed equipment available to meet the total system requirements which will vary from seam to seam;
- the availability of at least one delivery pump in the event of a pump failure, which will allow either full or reduced washing to be maintained; and
- the availability of two pipelines to provide an alternative for continuity operation under sand-out or frozen line conditions

The two pumps will be complimented by two high density polyethylene (HDPE) tailings delivery lines, which will provide the benefits of choice in the event of a problem with one of the lines. Clarified water will be available via suitable valved piping connections for the periodic flushing of each line routinely performed at the completion of pumping operations.

A third HDPE pipeline will be installed alongside the tailings disposal lines to bring recovered pond water back to the washery’s clarified water sump. During the early period of washery operations, recovered pond water will not be available for several weeks, and make-up water will have to provide for this shortfall. It is envisioned that during this period a sump will be excavated within the tailings area to provide a source of water.

All three pipelines will be buried below the frostline to prevent cold weather freezing problems. The location of the tailings pond is shown on Figure 2.3-1. All lines will be graded such that they are free draining to prevent sand-out or freeze up in the event of a power failure.

The tailings pond is designed to accommodate 200,000 m3 of tailings. It is expected that during the initial years of the project when A Seam coal is being processed that 98,000 m3 of tailings material will be produced, reducing to 53,000 m3 when Seam A is depleted. These volumes are based on the mine producing at the 900,000 tonne per year rate. Tailings material will be hauled from the pond and disposed of in the same manner as the coarse refuse, as described previously.

2.3.8 Coal Quality Laboratory

The laboratory will consist of two separate areas located in the preparation plant and office/shop complex. The room situated in the plant will be the “dirty” sample receiving area, where samples are crushed, riffled, gross weighed, etc. The “clean” room, where analytical tests and measurements are carried out, and computations and report generation, take place, will be located in the office/shop complex.

2.4 SITE INFRASTRUCTURE

2.4.1 Introduction

Site infrastructure and services were evaluated based on preliminary design work, and discussions with numerous suppliers and/or manufacturers. The type and size of the facilities were determined primarily by the scale of the mine operation and length of the mine life. Based on this criteria, the facilities and services outlined in the following sections were selected for the Willow Creek application.

2.4.2 Maintenance, Warehouse & Administration Facilities

Shop/Office Complex

For the purpose of this study, it was assumed that a shop/office facility was required to conduct preventive and breakdown maintenance. Equipment servicing and component changeout work would be conducted on site, however component and/or equipment rebuilds, would be contracted to external shops. As a cost reduction and efficiency measure, it was decided to include the administration offices and warehouse in the same facility as the maintenance shop. This should also promote excellent employee interaction and communication.

The magnitude of the structure was determined from the type, size and number of pieces of mining equipment to be maintained, as well as an estimate of the overall fleet mechanical availability. Based on this criteria, a six-bay shop was selected, comprised of four repair bays, a steam bay, and a service bay. Included in the shop are separate areas for the steam cleaner, lube equipment, and a lunch room.

The office portion of the facility includes four private offices, a general reception area and a conference room. The main floor also includes a first-aid room, ambulance bay, and men's and women's change/shower facility. There is a second floor above the main office area, comprised of a training room and staff lunch room, as well as the plant laboratory. Finally, the warehouse area, complete with a separate loading dock will be included in the facility.

2.4.3 Utilities

Fuel Storage and Supply

Fuel will include diesel and gasoline. Fuel will be stored in approved above-ground storage tanks in accordance with BC and National Fire Codes. All tanks will have secondary containment. Spill kits and fire suppression equipment will be located in the area and clearly marked. Any drains required at the fuel storage or fuelling station locations will be routed to approved oil-water separators and the water then routed to the tailings pond or discharged if of acceptable quality based on MOELP criteria. Fuel delivery systems will be lockable and fuel delivery hoses will be equipped with approved, spring activated nozzles that cannot be locked in the open position. If required, fuel delivery hoses will be equipped with break away valves to prevent accidental spill of fuel from hose breakage during fuelling operations.

Heat

Heat for the proposed processing plant and shop/office complex is expected to be provided by propane, however the use of natural gas will be evaluated. Based on the predicted consumption levels, a 68,000 litre (18,000 US gal) tank is recommended., which is suitable to service both facilities. Estimated consumption of propane is 330,000 litres per annum.

Power

As discussed previously, the mining regions will not be provided with electrical power. Discussions with B.C. Hydro have indicated that service can be provided to the site facilities, with the preferred voltage being 347/600 three phase to the process plant, 120/208 to the shop and 120/240 single phase to the office. The demand and energy charge will be based on a 1500kw maximum power requirement, with the largest motor being 150hp.

Water Supply

Fresh water will be supplied by well(s) situated at the plant site. Based on Norwest’s experience at other mine sites, well productivity of approximately 90 litres/min (20 gpm) is sufficient to supply potable water to an operation of this size, when operated in conjunction with a storage reservoir of 9,000 litres (2,000 gals). Potable water will be required for a staff of approximately 20.

It is assumed that the plant makeup water, estimated at 50 m3/hr, will be obtained from the tailings pond and makeup wells, and will not rely on the fresh water system. The potential of obtaining make-up water from the North area sedimentation pond will be evaluated. To provide makeup water during the early stages of the plant operation, a relatively large sump will be excavated within the tailings pond area.

2.5 SURFACE WATER MANAGEMENT

During development of the mining areas, surface water will be diverted by ditching outside of the future mining disturbance. This will minimize water volumes entering the mining areas and requiring treatment. Water that is intercepted by the mining operation will be directed to settling facilities situated in both the Willow North and Willow Central mining areas. When mining is completed in the North Area in early 2005 this area will become the main sedimentation pond for the remainder of the mine life.

Surface water handling including sedimentation pond location and sizing, is discussed in detail in Section 7.3.

2.6 RECLAMATION PLAN

As described earlier, the mining sequence has been phased to exploit the opportunity for internal backfilling of pits and to minimize the area of disturbance for the project. Upon completion of an area of mining, the waste dumps will be resloped and the topsoil/subsoil will be spread on the recontoured land. These areas will be seeded and planted with native species of grasses and trees, after the resloping and topsoil replacement operations have been completed. Reclamation activities will be kept current as the mine development schedule allows, to minimize the amount of disturbed area exposed.

All waste dump slopes will be regraded from angle of repose to a maximum of 27·. Dumps will generally be constructed in relatively low lifts, with lower “wrap-around” terraces being added from subsequent phases. This construction procedure will result in terraced dump faces, and will reduce the amount of dozer work required for resloping. It will also provide access for topsoil replacement, as well as seeding and planting equipment.

All haulroads will be resloped to a maximum of 27·, have topsoil replaced, and be seeded and planted as with the waste dumps. The upgraded Forestry Road will remain in its upgraded state and be available for public use.

The plantsite area will be reclaimed following the removal of all buildings, equipment, concrete slabs, and footings. All earthworks will be resloped to a maximum of 27. Topsoil will be replaced and the area will be seeded and planted as with the reclaimed dumps.

Reclamation planning is discussed in detail in Section 7.1.

3.0 SITE SELECTION

Selection of the site was based on exploration results by David Minerals and others in the early 1980s. Further exploration by Globaltex and Pine Valley Coal Ltd. aided in outlining a potentially economic coal deposit in the Willow Creek area. Additional exploration and an engineering feasibility study were conducted to confirm the economic viability of the deposit.

Siting of infrastructure for the proposed mine is largely driven by the location of the deposit, access to the site and the existing BC Rail line. Further details concerning location of the plant and soil stockpiles are discussed in Section 2.0 under Project Description and Section 6.0 under environmental impact assessment. Pits are located where economic coal reserves dictate. The wash plant and floodplain infrastructure are located so as to minimize to the greatest extent possible disturbance of this area.

Specific alternatives examined are discussed in Section 9.0

4.0 ENVIRONMENTAL BASELINE

4.1 SCOPE AND OBJECTIVES

The objective of environmental baseline work reported here is to document baseline conditions at the Willow Creek site prior to construction of the mine. This report builds on information provided in the David Minerals' Stage II report prepared in 1982. This report evaluates the 1982 information where appropriate.

Baseline information addressed in this report include:

- climate and air quality;
- soils;
- vegetation;
- wildlife;
- water quality;
- groundwater;
- sediments;
- hydrology;
- fisheries populations and habitat;
- benthic invertebrates;
- periphyton;
- land use; and
- acid generation potential.

4.2 CLIMATE AND AIR QUALITY

The Willow Creek Project is located in the Pine River drainage basin, 45 km west of Chetwynd south of Highway 97. Climate is influenced by mountainous topography (orographic uplift) and two principal air masses: the maritime Pacific which is moist, unstable and mild; and the continental Arctic which is dry, stable and subject to extreme temperatures. Except during winter, the Pacific air mass dominates, moving generally eastward across the Project area and produces moist conditions. During winter, Arctic air moves westward across the Project area until being blocked by the Rocky Mountains to the west.

The major local topographic features are the Pine Valley which trends northeast-southwest, and tributary valleys/gulleys (principally Willow Creek) trending north-south and rising generally in a southerly direction. The Pine valley is relatively flat, sloping gently northeast and is approximately 2 to 3 km wide. Local mountain peaks reach over 1500 m; the Pine River valley floor at Willow Creek is 630 m elevation. The highest elevation within the proposed mine area is 1150 m.

4.2.1 Wind

The 1996/97 wind velocity and direction data collection commenced in September. Data indicate instantaneous wind direction is highly variable, but data are consistent with expected patterns: prevalent wind direction is along the Pine Valley. During nighttime, winds drain down the mountainsides and continue downvalley eastward or slightly south of west (Figure 4.2-1). During the daytime in the summer, winds are expected to flow up tributary valleys. During the winter, periodic chinooks may flow downvalley, north down tributaries and then northeast down the main Pine River valley.

Data obtained by IEC Beak (1982) for the Pine VB station 13 km east of the project site and data for the Pine Willow Flats (Hasler) Gas Plant, 15 km east of the project site are attached here in Tables 4.2-1 and 4.2-2, respectively. Winds at the Pine VB station were predominantly from the WSW to WNW with a secondary maximum in the E to ESE quadrant, or along the Pine River valley, or essentially similar to the Willow Creek data for wind direction frequency which were collected over a much shorter period. Winds at the Gas Plant were most frequently from the SE to SW and secondarily from the SW to NW, or the reverse of the Pine VB station. The gas plant is at a higher elevation than the proposed plant site as well as at some distance, but has an excellent long-term meteorological record. Results from the two stations quoted suggest winds are highly variable from location to location in the Pine River valley.

TABLE 4.2-1

WIND DIRECTIONAL FREQUENCIES (OCCURRENCES)

FOR THE PINE VB STATION

PERIOD 1978 FREQUENCY: days

:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	%
NNE	1	0	1	4	6	6	0	0	2	2	4	1	27	0.3
NE	11	3	14	12	1	3	2	1	5	2	7	6	54	0.6
ENE	31	31	21	37	5	7	17	2	19	1	30	9	227	2.7
E	125	110	48	93	32	16	34	21	46	10	58	42	640	7.5
ESE	97	80	73	77	22	39	70	40	37	15	33	38	621	7.6
SE	53	34	43	36	24	16	34	34	37	12	26	28	382	4.5
SSE	42	32	27	33	16	19	27	28	25	21	17	23	310	3.6
S	40	33	35	26	20	18	24	34	28	42	23	24	337	3.9
SSW	34	41	37	35	26	26	56	58	62	91	48	30	458	5.3
SW	61	55	56	61	64	41	62	85	93	210	136	90	1014	11.8
WSW	79	77	113	119	146	87	115	112	142	183	114	151	1438	16.8
W	86	78	125	73	225	198	160	191	140	107	129	181	1693	19.8
WNW	44	82	96	81	109	105	102	75	59	29	70	99	951	11.1
NW	13	14	50	29	33	64	37	40	23	0	11	21	335	5.9

NNW	0	2	4	1	17	13	5	13	0	0	14	0	69	0.8
N	0	0	0	2	2	0	0	0	1	1	0	0	6	0.1
Source: IEC 1982														

TABLE 4.2-2

MONTHLY AND ANNUAL AVERAGE WIND DIRECTION FREQUENCIES AND

WIND SPEED FOR PINE RIVER GAS PLANT

PERIOD: FREQUENCY: %

WIND SPEED: km/h

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
N	3.4	1.5	2.0	2.2	3.9	4.7	2.8	3.3	3.5	1.3	0.9	0.5	2.5
NE	1.7	2.8	1.8	3.7	5.3	5.2	5.2	10.3	7.6	5.3	4.5	6.4	5.0
E	15.7	13.4	12.8	8.9	10.8	9.5	12.4	18.7	13.4	11.7	15.3	21.2	13.7
SE	36.0	17.7	20.4	20.8	26.5	18.6	15.6	19.5	31.6	33.1	18.1	24.6	23.5
S	8.1	12.7	4.2	8.4	10.5	7.3	4.9	14.0	17.6	15.6	23.9	22.0	12.4
SW	6.9	9.9	16.3	14.0	15.5	17.1	25.1	15.3	8.8	9.3	12.6	3.6	12.8
W	11.1	23.7	19.2	25.3	17.8	24.0	19.0	9.0	10.8	17.9	17.7	11.6	16.8
NW	15.1	15.2	15.1	11.3	13.2	10.3	8.7	8.3	6.3	5.5	5.6	7.8	10.2

Calm	2.0	3.0	8.2	5.4	2.5	3.4	6.5	1.7	0.5	0.4	1.5	2.3	3.1
Avg Vel	6.3	8.0	7.2	8.3	6.3	6.8	7.1	3.6	4.7	6.0	5.8	6.4	6.4
Source: Westcoast Energy Co. Ltd.													

Wind velocities recorded from September 1996 through July 21, 1997 were predominantly in the 0 to 20 kmph range, analyzed either as average or maximum velocities (Figure 4.2-2). Brief gusts (less than 15 minutes duration) up to 40 kmph occurred 30% of the time, or on 106 days of the year. Longer duration gusts up to 40 kmph occurred much less frequently, only 8% of the time or 30 days a year. The maximum wind velocity measured at the weather station on Willow Creek during the period of record was 74.5 kmph. Maximum wind velocities measured over 60 kmph occurred 5% of the time, or 18 days per year, for the period of record. Wind velocities were measured over a 15 minute period. Average wind velocities over 60 kmph for the same period, which provide a more realisitic estimate of wind conditions, occurred 0.13% of the time or 0.5 days. The following table provides a listing of a frequency analysis performed on wind velocities recorded at the weather station at Willow Creek.

Willow Creek Wind Velocity Frequency					
Average Wind Velocity			**Maximum Wind Velocity**		
Velocity (kph)	**% Freq**	**No. Days/Yr**	**Velocity (kph)**	**% Freq**	**No. Days/Yr**
<0 (1)	0.13%	0.5	<0 (1)	0.11%	0.4
<20	91.53%	334	<20	65.53%	239

<40	8.21%	30	<40	29.05%	106
<60	0.13%	0.5	<60	4.99%	18

(1)Station not operating

The stability of the lowest levels of the atmosphere influences the intensity of turbulence and, consequently, the ability of the atmosphere to disperse pollutants. Effects of air-borne substances are determined by dispersion as well as wind direction. Atmospheric turbulence varies with thermal forces induced by solar insolation, the strength of the wind and the roughness of the underlying surface. Turbulence from thermal effects is at a maximum in the early afternoon, and at a minimum near sunrise, when the earth's surface is coolest. Mechanical turbulence is induced by differential changes in wind speed near the ground. Its extent is dependent on wind speed and the roughness of the underlying surface.

Regional data assembled by IEC Beak (1982) and site-specific data for the Pine Gas Plant suggest that dispersion is poorest during winter months. Other than during spring and summer, low level temperature inversions tend to occur during mornings throughout the year. Afternoon mixing height, wind speed and ventilation coefficients for the Project area presented by IEC Beak are attached in Table 4.2-3. Percent frequency of climatological air pollution potential classes for Dawson Creek and Prince George (where radiosond data exist) are attached in Table 4.2-4. The Pine Gas Plant median mixing heights by month data obtained by IEC Beak are listed in Table 4.2-5.

TABLE 4.2-3

AFTERNOON MIXING HEIGHTS, MIXING SPEEDS AND VENTILATION

COEFFICIENTS ESTIMATED FOR PROJECT AREA

	Mixing Height	**Mixing Wind Speed**	**Ventilation Coefficient**
	(m)	**(m/s)**	**(m2/s)**
Spring	1500	5.5	8500
Summer	1800	4.5	8000

Fall	700	5.0	4000
Winter	300	4.0	1500
Annual	1100	4.5	6000
Source: IEC 1982			

TABLE 4.2-4

PERCENTAGE FREQUENCY OF OCCURRENCE OF SELECTED CLIMATOLOGICAL

AIR POLLUTION POTENTIAL (CAPP) CLASSES

CAPP	**None**		**Moderate**		**Severe**	
CLASSES	**Ventilation Index**		**Ventilation Index**		**Ventilation Index**	
	Greater Than		**1000 to 6000 m2/s**		**Less Than**	
	6000 m2/s				**1000 m2/s**	
STATION	SUMMER	WINTER	SUMMER	WINTER	SUMMER	WINTER
Prince George	17	2	68	53	15	45
Dawson Creek Beacon	43	11	52	32	5	57

Dawson Creek Airport	22	4	55	22	23	74

Source: IEC 1982

TABLE 4.2-5

PINE RIVER HASLER RIDGE GAS PLANT MEDIAN MIXING HEIGHTS BY MONTH

(m)

	SUNRISE	AFTERNOON
Dec	0	90
Jan	0	210
Feb	105	420
Mar	0	200
Apr	180	210
May	0	350
Jun	0	435
Jul	0	745
Aug	210	950
Sep	0	180

Oct	0	210
Nov	0	160

Period of Record: December 1977 to December 1979

Source: IEC 1982

4.2.2 Air Quality

Data are collected by Westcoast Energy for ambient sulfur dioxide and hydrogen sulphide at their Willow Flats gas pumping station, but there are no other ambient air monitoring stations near the Project site; data monitored at the pumping station are for sulphur emissions and are not relevant to the proposed mining operation.

Baseline total suspended particulate (TSP) air quality data were collected by Quintette Coal Ltd. prior to start up, in 1977 at a site referred to as the Wood Preservers Camp, and in 1981 at Kiskat and Tumbler Ridge. In 1977, prior to developments at the Quintette Mine, TSP was collected over a 24-hour period using high-volume samplers on 11 separate occasions. The results ranged from 8 to 38 mg/m3 (20·C), with a geometric mean of 21 mg/m3 (20·C). Measurements in 1982 yielded TSP in Kiskat, which is near Heritage Highway, of 2.3 to 89.5 mg/m3 (20·C) and geometric means of (mg/m3) :

August	52.3
September	13.4
October	7.7

Measurements in Tumbler Ridge ranged from 10.6 to 69.4 mg/m3 (20·C) and had geometric means of (mg/m3):

October	20.5

November	30.6
December	19.2
January	13.1

August values for Kiskat were elevated by construction activities. The observed values are typical of a semi-remote area with construction activity. Tumbler Ridge has higher average wind velocities than the proposed mine site at Willow Creek and therefore potentially higher background dust levels.

Dustfall measurements were made in Tumbler Ridge in 1977 and 1981. Dustfall was measured for 30-day periods using dustfall sampling jars. In 1977, dustfall was measured at 2.1 g/m2/30d in August/September and 3.4 g/m2/30d in September/October. In 1981 dustfall levels measured were 15.6, 2.0, 6.8, 6.9 and 10.6 g/m2/30d over the September to December period. Elevated dustfall in October and November 1977 in Tumbler Ridge was attributed to construction activities. Dustfall levels in 1981 were significantly higher than preconstruction levels.

A limited amount of dustfall data were collected by IEC for the David Minerals Stage II submission. Six stations were established; data for spring and summer 1982 are shown in Table 4.2-6. Total solids ranged from 1.5 to 3.2 mg/dm2/day and were judged to be representative of pristine areas.

TABLE 4.2-6

DUSTFALL MONITORING RESULTS, 1982

		Soluble		**Insoluble**	
		Soluble	**Solids**	**Insoluble**	**Solids**
Station	**Exposure Period**	**Solids**	**Ashed**	**Solids**	**Ashed**
		(mg/m2/day)			
Off Hart Hwy 1.5 km	April 24 to June 3	1.46	0.006	0.028	0.006

west of EZ bridge	June 3 to July 14	2.11	0.048	0.045	<0.003
Willow Creek 150 m	April 24 to June 3	2.45	0.133	0.002	0.006
above railway bridge	June 3 to July 14	1.73	0.039	0.057	0.006
100 m NE of EZ bridge	April 24 to June 3	1.64	0.009	0.028	0.006
	June 3 to July 14	3.16	0.069	0.057	<0.003
150 m from railroad tracks	April 24 to June 3	1.43	0.133	0.012	<0.003
adjacent to proposed plant	June 3 to July 14	1.46	0.003	0.030	<0.003
150 m from railway tracks at	April 24 to June 3	1.74	0.117	0.019	<0.003
Middle Creek culvert	June 3 to July 14	1.28	0.027	0.048	<0.003
On gravel bar adjacent to	April 24 to June 3	2.67	0.130	0.022	0.009
Far East Creek	June 3 to July 14	2.13	0.298	0.051	0.006

Source: IEC 1982

In the spring of 1996, two dust monitoring stations were established to build the dustfall database for the present project. Sites were established just west of the proposed mill site (Site 'C') and, initially, at the proposed north pit location near Far East Creek. The Far East Creek site was moved after one month to the Sheen residence on Highway 97 and Pine River. Results to July 1997 are listed in Table 4.2-7. Results from the 1996 monitoring study are somewhat lower but similar in magnitude to those reported by IEC. Current MOELP ambient air control objectives for dustfall are 1.7 to 2.9 mg/dm2/day.

TABLE 4.2-7

1996/1997 DUSTFALL MONITORING RESULTS

			Particulate		
	Date		Total	Insoluble	Soluble
Station	From	To	(mg/dm2/d)		
Mill Site C	96/07/16	96/08/15	0.34	0.09	0.25
Far East Creek	96/07/16	96/08/15	0.53	0.24	0.29
Mill Site C	96/08/15	96/09/12	0.69	<0.05	0.14
Pine River (Sheen residence)	96/08/15	96/09/12	1.45	0.14	1.31
Mill Site C	96/09/12	96/10/09	0.58	0.14	0.44
Pine River (Sheen residence)	96/09/12	96/10/09	0.81	0.06	0.75
Mill Site C	96/10/09	96/11/06	0.17	0.07	0.10
Pine River (Sheen residence)	96/10/09	96/11/06	0.18	0.08	0.10
Mill Site C	96/11/06	96/12/11	0.22	0.07	0.15
Pine River (Sheen residence)	96/11/06	96/12/11	0.29	0.06	0.23
Mill Site C	96/12/11	97/01/15	0.24	0.07	0.17
Pine River (Sheen residence)	96/12/11	97/01/15	0.29	<.05	0.29

Mill Site C	97/01/15	97/02/12	<0.26	<.05	0.21
Pine River (Sheen residence)	97/01/15	97/02/12	<0.10	<.05	<.05
Mill Site C	97/02/12	97/03/18	0.28	<0.05	0.28
Pine River (Sheen residence)	97/02/12	97/03/18	<0.27	<0.05	0.22
Mill Site C	97/03/18	97/04/15	<0.28	<0.05	0.23
Pine River (Sheen residence)	97/03/18	97/04/15	<0.11	<0.05	0.06
Mill Site C	97/04/15	97/05/21	<0.13	<0.05	0.08
Pine River (Sheen residence)	97/04/15	97/05/21	1	0.27	0.73
Mill Site C	97/05/21	97/06/11	1.48	0.29	1.19
Pine River (Sheen residence)	97/05/21	97/06/11	4.28	0.43	3.85
Mill Site C	97/06/11	97/07/21	0.61	0.18	0.43
Pine River (Sheen residence)	97/06/11	97/07/21	2.76	0.66	2.10

4.2.3 Temperature and Precipitation

Regional Canadian Climate Normals data were provided at two stations for the period 1950 through 1981 (Environment Canada 1982) for the Chetwynd British Columbia Forest Service (BCFS) (Table 4.2-8) and for Pine Pass (Mt. Lemoray) (Table 4.2-9) 15 km west of Willow Creek. Stations were no longer listed in the 1960 to 1990 Climate Normals (Environment Canada 1993). These regional data were summarized by IEC for David Minerals as part of the Stage II submission for the Willow Creek coal project (IEC 1982). Climate is characterized by cold winters and cool summers. Maximum precipitation occurs in the summer (June to August); snowfall maxima are January through March. Table 4.2-10 provides a summary of Pine Pass and Chetwynd data presented by IEC. Comparative rainfall intensity data for regional stations are provided in Table 4.2-11.

TABLE 4.2-8

SUMMARY OF TEMPERATURE AND PRECIPITATION DATA FOR CHETWYND

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
CHETWYND B.C. Forest Service													
55.42 N 121.37 W 660 m													
Daily Maximum Temperature	22.0	4.7	0	9.7	16.1	19.8	22.0	21.0	15.5	9.5	-0.5	-7.5	7.5
Daily Minimum Temperature	-19.2	15.4	-9.4	-2.9	2.4	6.6	8.6	7.8	3.5	-0.5	-8.4	-14.7	-3.5
Daily Temperature	-15.1	-10.1	-4.7	3.4	9.3	13.2	15.4	14.4	9.5	4.5	-4.4	-10.9	2.0
Standard Deviation, Daily Temperature	5.0	7.2	3.8	2.5	1.0	1.4	1.5	1.7	1.7	2.0	4.7	4.7	1.2
Extreme Maximum Temperature	10.0	11.5	19.4	24.5	31.1	33.3	34.4	34.4	28.3	26.0	18.9	12.0	34.4
Years of Record	10	8	9	9	11	11	11	10	11	11	11	11	11
Extreme Minimum Temperature	-38.3	-42.8	-36.7	-23.3	-5.0	-2.8	0	-0.6	-13.3	-15.0	-33.9	-37.2	
Years of Record	10	7	9	9	11	11	11	10	11	11	11	11	11

Rainfall (mm)	0	0	0.8	5.8	34.4	66.1	59.8	53.0	32.1	12.9	3.1	0	268.0
Snowfall	37.1	23.2	26.3	10.9	5.0	0	0	0	1.4	18.1	30.4	36.1	188.5
Total Precipitation	37.9	24.3	30.0	17.5	40.3	65.6	59.8	52.1	32.3	33.1	36.3	37.9	467.1
Standard Deviation, Total Precipitation	26.0	27.0	15.6	10.4	33.9	38.2	30.8	34.4	24.8	24.6	17.5	28.3	103.9
Greatest Rainfall in 24 Hours	T	T	5.1	9.9	31.2	37.1	34.8	66.8	17.0	13.5	12.7	0.3	66.8
Years of Record	10	8	8	9	11	11	10	11	11	10	11	11	
Greatest Snowfall in 24 Hours	24.9	20.3	18.8	13.7	T	0	0	0	7.7	19.1	19.3	27.9	27.9
Years of Record	8	8	8	7	11	11	11	11	10	10	10	10	
Greatest Precipitation in 24 Hours	24.9	20.3	18.8	13.7	31.2	37.1	34.8	66.8	17.0	19.6	19.3	27.9	66.8
Days with Rain	0	0	1	2	8	12	13	10	11	5	1	0	63
Days with Snow	10	7	8	3	0	0	0	0	1	2	6	9	46
Days with Precipitation	10	7	8	5	9	12	13	10	11	7	7	9	108
Source: Environment Canada 1982 (No record of this station in the 1990 Climate Normals for British Columbia.)													

TABLE 4.2-9

SUMMARY OF TEMPERATURE AND PRECIPITATION DATA FOR PINE PASS

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Year

PINE PASS													
55.21 N 122.36W 945 m													
Daily Maximum Temperature	-11.5	-4.4	-0.9	6.1	12.0	17.2	19.7	17.8	12.6	6.1	-3.1	-7.3	5.4
Daily Minimum Temperature	-17.9	-12.3	-9.5	-3.8	1.4	4.6	7.3	6.9	3.3	-1.1	-7.8	-13.3	-7.5
Daily Temperature	-15.1	-1	-5.7	1.1	6.5	11.1	13.5	12.5	8.1	2.7	-6.1	-10.5	0.8
Years of Record	8	8	8	9	9	9	11	9	7	8	7	9	
Rainfall (mm)	2.9	4.0	24.3	16.4	77.9	117.4	236.9	87.1	205.2	87.3	33.6	7.7	700.7
Snowfall	215.1	208.7	129.5	64.9	8.7	0.1	0	0.2	1.3	52.1	194.6	200.3	1075.5
Total Precipitation	252.0	235.9	171.1	90.3	87.6	119.5	136.9	86.3	103.0	142.5	249.1	241.8	1916.0
Greatest Rainfall in 24 Hours	10.2	20.3	26.7	30.5	30.7	60.7	204.0	36.3	47.0	46.7	43.2	16.0	204.0
Years of Record	8	8	8	8	9	9	9	9	8	8	8	8	
Greatest Snowfall in 24 Hours	62.2	67.3	51.3	66.0	17.8	1.3	0	1.8	5.8	48.3	48.3	77.5	77.5

Years of Record	8	8	7	8	9	9	11	9	8	8	7	8	
Greatest Precipitation in 24 Hours	62.2	67.3	51.3	66.0	30.7	60.7	204.0	36.3	47.0	48.3	48.3	77.5	204.0
Years of Record	8	8	7	8	9	9	9	9	8	8	7	8	
CHETWYND B.C. Forest Service													
55.42 N 121.37 W 660 m													
Daily Maximum Temperature	22.0	4.7	0	9.7	16.1	19.8	22.0	21.0	15.5	9.5	-0.5	-7.5	7.5
Daily Minimum Temperature	-19.2	15.4	-9.4	-2.9	2.4	6.6	8.6	7.8	3.5	-0.5	-8.4	-14.7	-3.5
Daily Temperature	-15.1	-10.1	-4.7	3.4	9.3	13.2	15.4	14.4	9.5	4.5	-4.4	-10.9	2.0
Rainfall (mm)	0	0	0.8	5.8	34.4	66.1	59.8	53.0	32.1	12.9	3.1	0	268.0
Snowfall	37.1	23.2	26.3	10.9	5.0	0	0	0	1.4	18.1	30.4	36.1	188.5
Total Precipitation	37.9	24.3	30.0	17.5	40.3	65.6	59.8	52.1	32.3	33.1	36.3	37.9	467.1
Greatest Rainfall in 24 Hours	T	T	5.1	9.9	31.2	37.1	34.8	66.8	17.0	13.5	12.7	0.3	66.8
Years of Record	10	8	8	9	11	11	10	11	11	10	11	11	

Greatest Snowfall in 24 Hours	24.9	20.3	18.8	13.7	T	0	0	0	7.7	19.1	19.3	27.9	27.9
Years of Record	8	8	8	7	11	11	11	11	10	10	10	10	
Greatest Precipitation in 24 Hours	24.9	20.3	18.8	13.7	31.2	37.1	34.8	66.8	17.0	19.6	19.3	27.9	66.8

Source: Environment Canada 1982

TABLE 4.2-10

CLIMATE SUMMARY - PROJECT AREA

Chetwynd BCFS	**660 m**
Annual Mean Temperature	2.0·C
Annual Average Maximum Temperature	7.5·C
Annual Average Minimum Temperature	-3.5·C
Total Annual Rainfall	268.0 mm
Total Annual Snowfall	188.5 mm
Total Annual Precipitation	467.1 mm
Pine Pass	**945 m**
Annual Mean Temperature	0.8·C

Annual Average Maximum Temperature	5.4·C
Annual Average Minimum Temperature	-7.5·C
Total Annual Rainfall	700.7 mm
Total Annual Snowfall	1076.0 mm
Total Annual Precipitation	1916.0 mm

TABLE 4.2-11

COMPARATIVE RAINFALL DATA

Parameter	**Chetwynd (BCFS)**	**MacLeod Lake**	**MacKenzie Airport**
Elevation (m)	660	704	700
Mean Annual Rainfall (mm)	268.0	419.4	375.1
2-Year, 60 Min. Intensity (mm/hr)	11.4	7.3	11.2
5-Year, 60 Min. Intensity (mm/hr)	18.6	9.4	17.5
10-Year, 60 Min. Intensity (mm/hr)	23.5	11.0	19.5
10-Year, 24 Hr Intensity (mm/hr)	2.5	2.1	1.7

Source: IEC 1982

Mean elevations of the north and central mining areas are approximately 750 m and 1050 m, respectively. The Pine Pass temperature and precipitation regimes are likely closer to the proposed mine area than that of Chetwynd, whereas the reverse may be true for the plant site.

Precipitation data were collected manually just west of the proposed plant Site C from July to September; a recording tipping bucket rain gauge was installed in September 1996 and removed October 9, 1996 due to freezing conditions. It was re-installed at the end of May 1997.

Snowfall

Snowfall accumulation records have been kept for Pine Pass (Station 4A02, 1430 m elevation) for 24 years. Based on that record, the minimum snow accumulation recorded was 408 mm and the maximum 1168 mm (both water equivalent). Snow cover has as great, or greater correlation with elevation than temperature and precipitation and therefore different elevations on the project site can be expected to have quite different snow accumulations. Data collected during the Northeast Coal Study (1977, 78) indicated more than 4 m accumulation at 1600 m elevation versus 0.2 m at 660 m. Snow cover may persist at higher elevations until nearly June. As previously noted, the proposed mine site (central area) average elevation is 1050 m and the proposed plant is at 640 m. Snow cover at the proposed mine site central area has not exceeded 2 m depth during the past 3 years' exploration activities.

Snowfall accumulation has several physical affects, principal of which is affects on spring runoff levels. As well, some avalanche potential is possible along the corridors (stream gullies) that traverse higher terrain in the Project area.

As part of 1996 baseline data collection, a snow gauge was installed in the fall of 1996 at the Project meteorological station west of the proposed plant site (forestry road near Willow Creek).

4.3 SURFICIAL GEOLOGY AND SOILS

Surficial geology was mapped by IEC Beak for the area in 1981 (Appendix 4.3-1). A summary of their findings reported in the David Minerals' 1982 Stage II report follows:

- IEC Beak carried out field mapping in the summer of 1982. Representative samples of fine-grained soils were collected and analyzed for grain size distribution. 1969 and 1976 aerial photography was used for interpretation. Results were also based on terrain mapping by Reinchen in 1968 and summarized in unpublished Geological Survey of Canada notes.
- The Willow Creek coal seams are within cretaceous sandstones, shales and conglomerates of the Foothills Belt Province. Strata are flat to steeply dipping and exposed along the flanks and tops of mountains. Shallow colluvial sediments (to less than 1 m deep) cover rocks. Glacial erosion of sedimentary rocks has produced sand, silt and clay. Coarser fragments of conglomerate limestone, quartzite and igneous rocks provide coarse superficial deposits.
- Within the Willow Creek area, prominent ridges and mountain tops are composed of sandstone. Less resistant shales are found near valley bottoms. In the Pine River valley, fine-grained floodplain sands and silts are interbedded with coarser sands and gravels.

- The flood plane is subject to active stream erosion and flooding. The John Hart Highway (Highway 97) and BC Rail railbed control channel migration and flooding in the Willow Creek area. Relatively recent imposition of these controls has lead to rapid changes in stream position in several areas.

Additional information on surficial deposits can be found in Section 4.9 under bioterrain mapping.

4.4 WATER QUALITY

4.4.1 Scope and Objectives of Studies

The scope of the water quality study was to supplement previous studies conducted by IEC Beak (1982) and NDM (1994). For the current study, all project area streams were monitored from spring 1996 through March 1997 (limit of reporting in this document); sampling is on-going.

The objectives of the surface water quality program were to:

- establish a baseline background level for metals, nutrients and physical parameters in project area streams prior to commencement of mine construction and operation;
- provide a basis for estimation of assimilative capacity of receiving waters for use in environmental impact assessment; and
- establish sampling sites that could be used for on-going monitoring once mine operation began.

4.4.2 Surface Water Quality

The surface drainages of interest for the Willow Creek Project include:

- Pine River;
- Willow Creek;

- Tributary 1

- Tributary 2 (extent of presently proposed development);
- Tributary 3;

· Middle Creek (will be eliminated by mining the north pit);

· Far East Creek (mostly east of proposed mining; affected, if at all, by the north pit)

Middle and Far East Creeks have intermittent flows and are subsurface in the floodplain; the lower end of Willow Creek is also subsurface during all but high flow periods.

Surface water quality data collected previous to the 1996 studies included:

- Environment Canada 1966, 1967, 1969;
- Ministry of Environment 1976;
- David Minerals 1982; and
- Globaltex 1994.

Table 4.4-1 lists the locations sampled. Environment Canada data were collected for the Pine River. The David Minerals' data (IEC 1982) and 1994 Globaltex data were collected for Willow, Middle and Far East creeks and the Pine River. A location map showing IEC sampling locations is attached in Appendix 4.4-1; 1996 sample locations are shown on Figure 4.4-1. Results of previous (to 1996) studies are summarized in Appendix 4.4-1 (Tables A to E). Summary data also include groundwater (discussed in the next section).

TABLE 4.4-1

WATER QUALITY STATION LOCATIONS

Sampling Organization	Location	Stn No.
Environment Canada	East Pine at Highway 97 Bridge	none
MOE 1976	Pine River at Hasler Creek	none
IEC 1982	Willow Creek, BC Rail bridge west of mine site	none
	Middle Creek, u/s of BC Rail tracks	none
	Far East Creek, u/s of BC Rail tracks	none
	Pine River, u/s of Willow Creek	none
	Pine River at EZ Bridge d/s of Willow Creek	none
	Pine River, d/s of site 3 km east of EZ Bridge	none
NDM 1994	Pine River, d/s of Willow Creek	PR-3
	Willow Creek above the BC Rail bridge	WC-1
	Tributary 1 near its confluence with Willow Creek	TRIB-1
	Middle Creek, u/s of the BC Rail tracks	MC-1
	Far East Creek, u/s of the BC Rail tracks	FEC-1
NDM 1996	Pine River, d/s of Willow Creek	PR-1
	Pine River, u/s of Far East Creek	PR-2
	Willow Creek, u/s of mill site C (approx. 1 km above mouth)	WC-1
	Willow Creek, u/s of Tributary 3	WC-2
	Tributary 1, at the forestry road	TRIB-1
	Tributary 2, at the forestry road	TRIB-2
	Tributary 3, at the forestry road	TRIB-3
	Middle Creek, at access road (approx. 1.5 km above mouth)	MC-1

	Far East Creek, at access road (approx. 1.5 km above mouth)	FEC-1

Historical data were collected on a seasonal basis (refer to appendix tables for details), whereas the 1996 data were collected on a monthly basis from May 1996 (sampling is on-going). In addition, weekly data were collected for the months of June (to represent spring freshet) and August/September (to represent summer low flows) in order to determine short-term variability in critical water quality parameters (pH, conductivity [summer low flows only], total dissolved solids, chloride, nitrate, nitrite and ammonia). Weekly data are summarized in Table 4.4-2 and monthly data in Table 4.4-3. Complete data to March 1997 are attached in Appendix 4.4-2, Table A. Copies of original analyses sheets for 1996/97 are available upon request. Data were transferred electronically from data sheets into tables to eliminate transcription errors.

TABLE 4.4-2

PINE VALLEY COAL WILLOW CREEK PROJECT

WEEKLY WATER QUALITY SUMMARY

						STATIONS				
Parameter	**Summary**	**FEC1**	**MC1**	**PR1**	**PR2**	**TRIB 1**	**TRIB 2**	**TRIB 3**	**WC1**	**WC2**
Spring Freshet										
pH	Arithmetic Mean	8.20	8.18	8.00	8.02	8.07	8.02		8.07	7.88
	Standard Deviation	0.04	0.04	0.04	0.08	0.12	0.14		0.10	0.13
	Coefficient of Variation	0.48%	0.51%	0.51%	1.03%	1.50%	1.77%		1.18%	1.70%
Conductivity	Arithmetic Mean									
	Standard Deviation									
	Coefficient of Variation									
Total Dissolved Solids	Arithmetic Mean	163	195	107	105	145	146		149	99
	Standard Deviation	57	23	24	31	50	35		40	48
	Coefficient of Variation	34.94%	12.02%	22.68%	29.14%	34.28%	24.18%		26.76%	48.53%
Cl	Arithmetic Mean	0.63	0.60	0.9	1.14	0.6	0.55		0.55	<0.02
	Standard Deviation	0.05	0.08	0.22	0.57	0.10	0.10		0.10	

	Coefficient of Variation	8.00%	13.61%	24.00%	49.85%	16.67%	18.18%		18.18%	0.00%
NO3	Arithmetic Mean	<0.05	<0.05	0.17	0.16	<0.05	<0.05		0.22	0.20
	Standard Deviation			0.02	0.02				0.03	0.04
	Coefficient of Variation	0.00%	0.00%	8.81%	12.69%	0.00%	0.00%		13.68%	18.13%
NO2	Arithmetic Mean	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002
	Standard Deviation									
	Coefficient of Variation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%
NH3	Arithmetic Mean	<0.02	0.04	0.04	0.03	<0.02	0.06		0.04	<0.02
	Standard Deviation		0.02	0.01	0.01		0.04		0.01	
	Coefficient of Variation	0.00%	50.00%	35.36%	17.32%	0.00%	70.71%		35.36%	0.00%
Summer Low Flows										
pH	Arithmetic Mean	8.40	7.95	8.21	8.24	8.23	8.35	8.25	8.47	8.23
	Standard Deviation	0.02	0.05	0.03	0.02	0.05	0.02	0.06	0.04	0.24
	Coefficient of Variation	0.18%	0.59%	0.30%	0.26%	0.62%	0.25%	0.74%	0.51%	2.95%
Conductivity	Arithmetic Mean	421	449	283	284	372	352	303	362	311
	Standard Deviation	13	7	15	17	7	6	8	9	11
	Coefficient of Variation	3.09%	1.52%	5.44%	5.90%	1.94%	1.74%	2.47%	2.35%	3.53%
Total Dissolved Solids	Arithmetic Mean	243	242	159	154	220	199	185	203	192
	Standard Deviation	20	9	3	15	20	7	17	24	12
	Coefficient of Variation	8.28%	3.84%	1.67%	9.87%	9.07%	3.58%	9.28%	11.80%	6.12%
Cl	Arithmetic Mean	0.50	0.47	1.53	1.58	0.60	0.47	0.45	0.48	0.55
	Standard Deviation	0.18	0.23	0.13	0.05	0.00	0.23	0.24	0.21	0.07

	Coefficient of Variation	36.51%	49.49%	8.25%	3.17%	0.00%	49.49%	52.90%	43.40%	12.86%
NO3	Arithmetic Mean	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Standard Deviation									
	Coefficient of Variation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NO2	Arithmetic Mean	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Standard Deviation									
	Coefficient of Variation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NH3	Arithmetic Mean	0.06	0.09	0.12	0.09	0.07	0.08	0.08	0.10	0.08
	Standard Deviation	0.03	0.05	0.08	0.06	0.03	0.01	0.03	0.04	0.04
	Coefficient of Variation	47.89%	62.16%	68.00%	62.86%	38.72%	16.24%	35.28%	44.24%	49.83%

4.4.2.1 Weekly Variability

Variables for analyses were chosen because they are the most likely to be influenced by mining activities (nitrogen species), afford aquatic life protection against effects of ammonia (chloride) or are indicative of general water quality (the remaining parameters). The parameters of most interest (nitrate, nitrite) were almost all below detection and therefore a measure of short-term variability was not obtained. Examination of the coefficient of variation data (standard deviation divided by the arithmetic mean expressed as a percentage) of data listed in Table 4.4-2 indicates that, other than total dissolved solids in the spring, no parameter was highly (variation > 20%) variable at all but Middle Creek in the spring, but not during the summer. Some variation in the spring was also shown by chloride (in the Pine River) and ammonia concentrations were highly variable at four sites (Middle Creek, the upper Pine River site, Tributary 2 and the lower Willow Creek). During the summer low period, TDS was not highly variable, but both chloride and ammonia were variable at a greater number of sites:

Chloride: Far East, Middle, lower Willow, Tribs 2 & 3.

Ammonia: all sites but Trib 3.

Much of the variability in ammonia is an artifact of analysis and is due to the parameter being near or at detection for most sampling events. Because of the uncertainty of analyses around detection, no feasible amount of replication is likely to reduce variability to below 20%. The variability in TDS in the spring may be a reflection of the varying importance of the groundwater, or base flow, contribution to flows in the spring compared to low summer flows which would likely have a higher component of groundwater, depending on the precipitation regime around the time samples were collected.

Variation in parameters above detection was in the order: NH3 > Cl > TDS > Conductivity > pH. Of those parameters that were above detection, total dissolved solids exhibited more variability during spring freshet than during summer low flows. The pH, chloride ion and ammonia weekly variations were about the same during both measurement periods.

Table 4.4-3 provides a summary.

4.4.2.2 Seasonal Variability

Monthly sampling provided a measure of seasonal variability of the parameters measured. The parameter used to measure variability was the coefficient of variation (standard deviation divided by the arithmetic mean) among monthly samples. Table 4.4-3 provides a comparison by site and parameter analyzed for the 9 stations sampled. The mean coefficient of variation for all parameters measured for the measurement period (May through January) range from 8 to 31%. At all stations, total metals accounted for more variability than dissolved metals (from 56 to 77%).

4.4.2.3 Spatial Variability of Seasonal Data

Across all sites, by parameter, total aluminium had the highest variability (124%) whereas a number of parameters consistently below detection, e.g. mercury, had zero detectable variability. The most highly variable parameters are listed below.

Parameter	**Coefficient of Variation**	**Parameter**	**Coefficient of Variation**
Total Aluminum	124	Total Manganese	73
Total Iron	94	Ammonia Nitrogen	64
Turbidity	85	Fluoride	63
Total Zinc	78	Dissolved Aluminum	62
Total Copper	73	Dissolved Zinc	60

Natural variability in parameters, both temporal and spatial, will tend to mask changes that occur when the mine is operating if the changes are less than or about equal to the variability of the parameter. Natural variability is an important measure for other reasons. All natural systems are subject to variability; change is constant. Natural variability in the absence of man-made alterations is a key measure of how wide the range of parameters can be and allow the system to remain stable. Any variability introduced by outside forces, such as that introduced by man’s activities, which is within natural variability will be unlikely to result in destabilization of the natural system.

4.4.2.4Summary Water Quality Characteristics of Area Streams

Table 4.4-3 provides a summary of mean monthly water quality by station. The statistical summary includes arithmetic mean, standard deviation and coefficient of variation. Table 4.4-4 provides a summary of key characteristic ranges. Pine River had a higher sediment load than its tributaries in the Project area, but otherwise the average water quality of all streams was very similar: moderately alkaline, low concentrations of all parameters, with a few exceptions. The pH ranged from 7.5 to 8.4, hardness from 70 to 258, with pine river water on average, softer than Project area streams and Far East and Middle creeks being the highest. Total suspended solids ranged from below detection (1 mg/L) in Tributary 3 to 52 mg/L in the Pine River. Chloride ranged from 0.2 to 2.2 mg/L and was most variable in Far East Creek and then the Pine River. Chloride levels were generally low and, at the lower concentrations, would not provide significant protection to fish from nitrite levels (but see nitrite below). Nitrate concentrations ranged from below detection (0.05 mg/L) to 0.22 mg/L with the widest range in the Pine River, followed closely by Far East Creek. Nitrate levels were all low. Nitrite levels were all below detection (0.002 mg/L). Ammonia concentrations ranged between 0.03 and 0.24 mg/L(1). Ammonia concentrations reported were all below MOELP criteria for the protection of freshwater aquatic life at the temperature and pH of the water collected.

TABLE 4.4-4

KEY PARAMETER SUMMARY - PROJECT AREA WATER QUALITY

	Pine	**Willow**	**Trib 1**	**Trib 2**	**Trib 3**	**Far East**	**Middle**
	River	**Creek**				**Creek**	**Creek**
Parameter	**Range (mg/L, except pH)**						
pH	7.5 - 8.3	7.6 - 8.4	7.9 - 8.3	7.5 - 8.4	8.1 - 8.3	7.9 - 8.4	7.8 - 8.4
Hardness	77 - 183	70 - 203	128 - 222	100 - 202	124 - 159	147 - 243	196 - 258
Total Suspended Solids	2 - 52 mean 30	2 - 45 mean 8	6 - 9	3 - 5	ND	3	2
Cl	0.8 - 2.2	0.2 - 0.7	0.2 - 0.6	0.3 - 0.7	0.4 - 0.6	0.3 - 2.8	0.3 - 0.6
NO3	0.08 - 0.17	0.05 - 0.22	0.07 - 0.13	0.05 - 0.13	0.13 - 0.16	0.11 - 0.21	ND
NO2	ND	ND	ND	ND	ND	ND	ND
NH3	0.03 - 0.24a	0.03 - 0.12	0.02 - 0.14	0.02 - 0.14	0.02 - 0.13	0.02 - 0.08	0.02 - 0.13
Metals	ND to low	ND to low	ND to low	ND to low	ND to low	ND to low	ND to low

ND: Not Detected

a - High concentration suspected analytical error.

The mean and range of parameters that ranged above MOELP criteria for the protection of freshwater aquatic life are graphed in Figure 4.4-2 on a site by site basis. Very few parameters ever exceeded criteria; those that did were not consistently high nor at all stations. Parameters included chromium, copper, iron and zinc.

Table 4.4-5 lists the minimum, maximum and mean concentrations for several parameters measured during the present and past studies. Data from the 1996 monthly sampling also are summarised in this table. The British Columbia Criteria for the Protection of Aquatic Life (Nagpal *et al*. 1995) are listed for comparison. The criteria for copper, which are hardness-dependent, have been calculated using the average hardness measured in each stream in 1996. The criteria for ammonia, which depend upon pH and temperature, are based on the ranges of pH and temperature measured in 1996. Table 4.4-5 shows that several metals in the project area streams periodically have exceeded their average or maximum criteria.

Chromium levels above the 0.002 mg/L criterion for plankton have been recorded at the Pine River and Willow Creek stations. Chromium periodically exceeded 0.002 mg/L during all years it was measured in the Pine River (except for 1981-82 when the detection limit was above the criterion level). Chromium has not exceeded the criterion for fish (0.02 mg/L) at any of the stations. However, since the detection limits in 1981-82 were above the criteria levels, and all samples taken were below the detection limits, it is not known if any of the samples exceeded either criterion level.

The maximum copper concentration at the Pine River exceeded the criterion for a maximum value in the 1981-82 sampling and the 1996 sampling. Only the mean of the 1996 sampling at the Pine River exceeded the 30-day criterion (defined as an average of five measurements over five weeks, thus not strictly applicable to the 1996 sampling mean or to individual measurements), and some maximum values exceeded this level for the Pine River and Willow Creek sites. For this comparison, the criteria levels for copper were calculated using the hardness of each creek during 1996, which would not be identical to hardness during the past studies but should be similar.

Iron concentrations have been consistently above the criterion level of 0.3 mg/L in the Pine River. Maximum levels were above 0.3 mg/L during both the 1994 and 1996 studies at Willow Creek and all samples exceeded this level in 1981-82 at Willow Creek. The maximum level was above 0.3 in 1981-82 at Middle Creek. All samples in 1981-82 and the maximum level in 1994 had iron levels above 0.3 mg/L at Far East Creek.

Some samples have exceeded the criterion of 0.03 mg/L for zinc at the Pine River, Willow Creek, and Far East Creek sampling stations. All means of zinc concentrations were below the criterion level.

There are no Fresh Water Criteria for Aquatic Life set for total phosphorous. Phosphorous concentrations were the highest at the Pine River site (0.005 mg/L to 0.09 mg/L). The maximum (0.09 mg/L) and the mean (0.07 mg/L) concentrations recorded in 1996 were higher than the levels measured historically.

Since the fresh water criteria for ammonia is calculated using the temperature and pH of the water at the time of sampling, the lowest and highest temperature and pH measurements of the 1996 samples were used to calculate a range for the criteria. Only the 30-day average criteria were calculated. Individual measurements are more appropriately compared with the maximum criteria, but exceedence of the average criteria would suggest elevated baseline ammonia levels. None of the values recorded at all four stations during any of the studies exceeded the lowest value in the average criteria range.

There are no Fresh Water Criteria for Aquatic Life set for total nitrogen (nitrate + nitrite). Nitrogen concentrations were below or at the detection limit of 0.02 mg/L for all four sites during the present study. Concentrations as high as 0.09 mg/L in the Pine River and 0.05 mg/L in Willow Creek have been recorded historically.

The Fresh Water Criterion for Total Suspended Solids (TSS) is stated as an acceptable increase over the background level. It is not applicable to the current data set since the sampling was done to determine baseline TSS levels. The measured TSS levels at all sites were below 50 mg/L, except during 1981-82 when IEC reported a range of 56 mg/L to 118 mg/L in Middle Creek and a maximum 170 mg/L in the Pine River.

4.4.2.5 QA/QC

Duplicate samples were collected each month. As well, a trip blank (DI water from the lab, kept sealed throughout) and a field blank (DI water added in the field) were prepared each month; data are summarized in Appendix 4.4-2, Table B. Blanks were mostly below detection for all parameters (except pH). A summary of the repeatability in duplicate samples is listed in Table 4.4-6. Appendix 4.4-2, Table C contains the complete comparison data set by sample date, duplicate set and analysis parameter. Data are also summarized graphically in the appendix. Repeatability varied considerably and tended to be the less on low detection limit parameters where the absolute difference was very small but the relative difference large, e.g. 1 ppb at a 2 ppb concentration.

TABLE 4.4-6

REPEATABILITY OF FIELD DUPLICATES

Sampling Date	Average	Maximum	Minimum

96/05/14	95.0%	100.0%	46.4%
96/06/12	93.3%	100.0%	25.0%
96/07/10	93.3%	100.0%	25.0%
96/08/07	87.7%	100.0%	1.7%
96/09/11	93.5%	100.0%	25.0%
96/10/09	93.8%	100.0%	38.5%
96/11/06	94.8%	100.0%	40.0%
96/12/11	96.7%	100.0%	42.9%
97/01/15	94.5%	100.0%	16.1%
Average	**93.6%**		
Maximum		**100.0%**	
Minimum			**1.7%**

4.4.2.6 Low Level Metals

At the request of MOELP, one set of samples (August 1996) was pre-concentrated prior to analysis by the laboratory to provide a measure of low-level concentrations for metals normally below detection in sampling. Complete results are listed in the water quality tables in Appendix 4.4-2, Table A. The data serve to confirm that results at or near detection using higher level detection limits were valid within an order of magnitude. All metals/metaloids except beryllium and mercury were detected in total metals analyses on some streams during some periods; cadmium and chromium were rarely above detection. Of note is that selenium was below or near detection in all samples. Selenium has been found to be problematic in some coal deposits.

4.4.3 Groundwater

IEC 1982

IEC groundwater samples were taken from a coal seam and drill hole in the presently proposed north pit area. Samples were collected at low flows and represent base flow quality.

Seam samples were collected from near the top of the seam where it outcropped on a ridge; it was likely representative if shallow groundwater. The second sample was taken from an artesian drill hole and probably was more representative of a deeper aquifer.

Groundwater was similar to surface water, moderately hard, moderately alkaline, relatively high in calcium and magnesium, but relatively low in other major ions. Metals levels, including iron, were low and similar to surface water.

NDM 1996

Three drill holes had flowing water (artesian) during the 1996 field season and were sampled for groundwater quality (location shown on Figure 4.4-1). Sampling was conducted during base flow conditions, as was done by IEC. Results are listed in Table 4.4-7.

TABLE 4.4-7

WILLOW CREEK PROJECT GROUNDWATER QUALITY - 1996

		QA/QC			SAMPLES						
		Trip Blank	**Field Blank**	**DUPLICATE (DDH81-28/GW2)**	**DDH81-28/GW1**	**DDH81-28/GW2**	**DDH81-28/GW3**	**Arithmetic Mean**	**Geometric Mean**	**Standard Deviation**	**% Variance**
Date Sampled		8/16/96	8/16/96	8/16/96	8/16/96	8/16/96	8/16/96	-	-	-	-
pH	pH units	-	-	7.15	7.1	7.16	7.38	7.21	7.21	0.15	2.04%
Conductivity	uS/cm	-	-	778	862	779	653	765	760	105	13.76%
Turbidity	NTU	-	-	12	5.5	12	22.5	13	11	9	64.34%
Hardness CaCO3	mg/L	-	-	306	257	310	316	294	293	32	11.03%
Total Suspended Solids	mg/L	-	-	2	< 1	2	23	13	7	15	118.79%
Total Alkalinity CaCO3	mg/L	-	-	424	507	432	356	432	427	76	17.49%
Fluoride F	mg/L	-	-	0.18	0.18	0.19	0.35	0.24	0.23	0.10	39.75%
Chloride Cl	mg/L	-	-	0.9	1.1	0.9	0.8	0.9	0.9	0.2	16.37%
Nitrate N	mg/L	-	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-
Sulphate SO4	mg/L	-	-	12	6.1	12	4.6	7.6	7.0	3.9	51.70%

Total Organic Carbon C	mg/L	-	-	2.4	1.4	3.4	3.7	2.8	2.6	1.3	44.13%
Ammonia Nitrogen N	mg/L	-	-	1.2	0.95	1.2	0.97	1.04	1.03	0.14	13.36%
Ortho Phosphorus P	mg/L	-	-	< 0.02	< 0.02	< 0.02	0.03	0.03	0.03	-	-
Total Phosphorus P	mg/L	-	-	0.03	0.02	0.03	0.04	0.03	0.03	0.01	33.33%
Total Aluminum Al	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2	0.2	0.2	-	-
Total Antimony Sb	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-	-
Total Arsenic As	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-
Total Barium Ba	mg/L	< 0.001	< 0.001	0.2	0.29	0.21	0.58	0.36	0.33	0.19	54.08%
Total Beryllium Be	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	-	-
Total Boron B	mg/L	< 0.01	< 0.01	0.32	0.27	0.32	0.14	0.24	0.23	0.09	38.18%
Total Cadmium Cd	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-
Total Calcium Ca	mg/L	0.03	0.03	86	76.9	89.7	95	87.2	86.9	9.3	10.67%
Total Chromium Cr	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	-
Total Cobalt Co	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-

Total Copper Cu	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-
Total Iron Fe	mg/L	< 0.03	< 0.03	0.28	0.2	0.29	4.78	1.76	0.65	2.62	149.07%
Total Lead Pb	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-
Total Magnesium Mg	mg/L	< 0.05	< 0.05	22.1	16.3	22.6	28.8	22.6	22.0	6.3	27.70%
Total Manganese Mn	mg/L	< 0.003	< 0.003	0.033	0.024	0.035	0.11	0.06	0.05	0.05	83.08%
Total Mercury Hg	ug/L	-	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-
Total Molybdenum Mo	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-
Total Nickel Ni	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	-
Total Phosphorus PO4	mg/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	-	-
Total Potassium K	mg/L	0.01	< 0.01	1.41	1.15	1.47	1.42	1.35	1.34	0.17	12.78%
Total Selenium Se	mg/L	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	0.001	0.001	-	-
Total Silicon SiO2	mg/L	0.1	< 0.1	5.5	5.1	5.6	6.5	5.7	5.7	0.7	12.37%
Total Silver Ag	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-
Total Sodium Na	mg/L	< 0.1	< 0.1	53.2	95.3	55.8	9.8	53.6	37.4	42.8	79.78%
Total Strontium Sr	mg/L	< 0.001	< 0.001	0.11	0.072	0.11	0.16	0.11	0.11	0.04	38.72%

Total Tin Sn	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	-
Total Titanium Ti	mg/L	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	-	-
Total Uranium U	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-	-
Total Vanadium V	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-	-
Total Zinc Zn	mg/L	0.03	< 0.02	< 0.02	0.08	< 0.02	< 0.02	0.08	0.08	-	-
Total Zirconium Zr	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-
Dissolved Aluminum Al	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-	-
Dissolved Antimony Sb	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	-	-
Dissolved Arsenic As	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-
Dissolved Barium Ba	mg/L	< 0.001	< 0.001	0.2	0.28	0.2	0.51	0.33	0.31	0.16	48.77%
Dissolved Beryllium Be	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	-	-
Dissolved Boron B	mg/L	< 0.01	< 0.01	0.31	0.25	0.31	0.12	0.23	0.21	0.10	42.85%
Dissolved Cadmium Cd	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-
Dissolved Calcium Ca	mg/L	0.02	< 0.01	85.9	76	87.3	84.2	82.5	82.4	5.8	7.08%
Dissolved Chromium Cr	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	-

Dissolved Cobalt Co	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-
Dissolved Copper Cu	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	-
Dissolved Iron Fe	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	-
Dissolved Lead Pb	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-
Dissolved Magnesium Mg	mg/L	< 0.05	< 0.05	21.9	16.2	22.3	25.7	21.4	21.0	4.8	22.49%
Dissolved Manganese Mn	mg/L	< 0.003	< 0.003	0.033	0.02	0.034	0.08	0.04	0.04	0.03	70.28%
Dissolved Mercury Hg	ug/L	-	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-
Dissolved Molybdenum Mo	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	-
Dissolved Nickel Ni	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	-
Dissolved Phosphorus PO4	mg/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	-	-
Dissolved Potassium K	mg/L	< 0.01	< 0.01	1.39	1.01	1.37	1.09	1.16	1.15	0.19	16.34%
Dissolved Selenium Se	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-
Dissolved Silicon SiO2	mg/L	< 0.1	< 0.1	5.3	4.7	5.2	4.9	4.9	4.9	0.3	5.10%
Dissolved Silver Ag	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-
Dissolved Sodium Na	mg/L	< 0.1	< 0.1	52.4	95.1	53.4	8.6	52.4	35.2	43.3	82.61%

Dissolved Strontium Sr	mg/L	< 0.001	< 0.001	0.11	0.07	0.11	0.14	0.11	0.10	0.04	32.92%
Dissolved Tin Sn	mg/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	-	
Dissolved Titanium Ti	mg/L	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	-	
Dissolved Uranium U	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-	
Dissolved Vanadium V	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-	
Dissolved Zinc Zn	mg/L	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	
Dissolved Zirconium Zr	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-	

Overall, quality was similar to IEC samples. Water was harder (principally due to the higher calcium content; sodium was also considerably higher than IEC samples). Results tend to confirm IEC conclusions that the groundwater quality is similar to surface water on the site, although somewhat harder and more alkaline due to dissolution of calcium. Variation in parameters among samples was likely due to somewhat different lithologies in the path lengths of the different aquifer(s) sampled.

QA/QC

Reproducibility of the duplicate sample was good, with almost all parameters above detection identical or nearly identical to each other. The trip blank (DI water shipped in a sample bottle from the lab and returned to test bottle storage contamination) and field blank (bottle filled with DI water at the site) had almost all parameters below detection.

4.4.4 Stream Sediments

Stream sediments were not collected by IEC for the David Minerals Stage II study. Stream sediments were collected at, or near, the water quality sites by NDM in September 1996.

Methods

Samples were pre-screened in the field to remove the +20 mesh (+0.84 mm) coarse fraction. Approximately 5 kg of sediment were collected in the active stream channel from among boulders at each site. Water quality sample locations are shown in Figure 4.4-1. Samples were collected by placing stream sediment in a large screen in an aluminum pan and washing the -20 mesh fraction through into the pan. Water was then decanted off. Sediment was scooped into plastic bags. The remainder in the pan from the first scooping was washed down to the bottom of the pan and the water again decanted off. A small amount of water was then used to wash the remainder of the sediment into the sample bag. In this manner, the sample collection was not biased against the heaviest sediment fraction (containing most metals).

In the laboratory the sediment samples were screened to -200 mesh (-75 mm) and dried at < 100·C. Five replicate samples were drawn from each sample and analyzed by inductively coupled argon plasma (ICAP).

Results

Summary results (means and variability) are listed in Table 4.4-8. Complete results are listed in Appendix 4.4-3. Replicate variability (based on the standard deviation percent of the mean) was low (typically between 2 and 8% for parameters above detection). Arsenic, thorium and boron tended to be more variable within sites than other metals; lead variability was higher than average at Trib 2 and Trib 3 sites.

Organic carbon levels in all samples was low (<1 to 2.25%), with Willow Creek tributaries and the small streams, Middle and Far East Creek, having the highest concentrations which is consistent with their smaller size and location in a forested watershed.

Selenium, which can be a problematic metal in coal deposits, was below detection (<5 ppm) at all sites. Mercury levels were also low (70 to 176 ppb). As well most of the mercury would not be mobile but complexed with sulphur (as the mineral cinnibar).

Metals levels in Pine River sediments upstream of the site were slightly elevated over those at downstream. Considering the relatively short distance between sites (7 km along the river course) and the lack of anomalously high concentrations of metals in tributary streams (principal of which in the Project area is Willow Creek), the differences seen are likely due to slight differences in the stream bed where the two samples were collected.

Metals levels in Pine River sediments were slightly elevated over those of Willow Creek, downstream site (WC1), except for barium, boron and mercury. The same relationship held with upper Willow Creek (WC2), with the additional exceptions of manganese and chromium. These results indicate that exogenous sediment metal sources for most metals detected are as, or more, important contributors to Pine River metals sediment loads than its principal tributary in the Project area. Far East and Middle creeks enter the Pine River through low water velocity wetlands where most suspended sediments would settle and cannot therefore be significant sources of sediment loads to the River. As well, for much of the year, both these streams go underground upslope of the Pine River.

4.5 HYDROLOGY

4.5.1 Background

Stream flow data were obtained previously at the Willow Creek site in 1981 by IEC and in 1994 by B. Guy. IEC measured discharges at Willow Creek, Pine River, Middle and Far East creeks from May 1981 to July 1982. Guy established stations at upper and lower Willow, Tributary 1, Far East and Middle creeks and measured flows and discharges from 30 May 1994 to 5 November 1994. IEC and B. Guy data are appended in Appendices 4.5-1 and 4.5-2, respectively.

4.5.2Objectives and Scope of the 1996/97 Program

The objective of the 1996/97 hydrology program was to augment data previously collected at the site, to collect stream flow information on site streams to calibrate long-term data from Water Survey of Canada to local conditions and to establish a baseline for relatively undisturbed conditions which operational monitoring can be compared, to provide information necessary for prediction of potential impacts from discharges to water, and to assist development of management strategies to mitigate impacts and manage water at the site. Hydrological information was used in the impact assessment to predict concentrations of substances that could be released to water bodies from discharge treatment facilities and not exceed assimilative capacities or discharge permit limits. Data will also be used by MOELP to set allowable discharge limits to protect water quality.

Major tributaries draining the project site were the targets of the study. Pine River hydrology was extensively discussed by IEC Beak in

1982.

4.5.3 NDM Methods

Stations were established on tributary water bodies in the Project area as described in Table 4.5-1 (the table also shows locations for IEC and B. Guy studies). Stations were chosen to coincide with those established by B. Guy where possible and in consultation with an MOELP hydrologist from Prince George. As well as stations listed, the depth of water at the forestry road bridge across lower Willow Creek was also periodically measured. Stream discharge measurement dates are listed in Table 4.5-2.

TABLE 4.5-1

HYDROLOGY STATION LOCATIONS - 1996 PROGRAM

Willow Creek, u/s of mill site C (approx. 1 km above mouth)	WC-1
Willow Creek, u/s of Tributary 3	WC-2
Tributary 1, at the forestry road	TRIB-1
Tributary 2, at the forestry road	TRIB-2
Tributary 3, at the forestry road	TRIB-3
Middle Creek, at access road (approx. 1.5 km above mouth)	MC-1
Far East Creek, at access road (approx. 1.5 km above mouth)	FEC-1

HYDROLOGY STATION LOCATIONS - 1994 PROGRAM

Willow Creek below BCR Bridge

Willow Creek, u/s of mill site C (approx. 1 km above mouth)

Middle Creek at BCR Culvert

Far East Creek at BCR Culvert

HYDROLOGY STATION LOCATIONS - 1981 PROGRAM

Willow Creek below BCR Bridge	na
Willow Creek at continuous recorder (u/s of BCR Bridge)	na
Pine River at Hasler Bridge	na
Pine River at EZ Bridge (downstream E of Willow Creek)	na

Middle Creek at BCR Culvert	na
Far East Creek at BCR Culvert	na

na: Not available

TABLE 4.5-2

STREAM DISCHARGE MEASUREMENT DATES

Date				**Station**				
	WC11	**WC2**	**WCbr**	**TRIB 1**	**TRIB 21**	**TRIB 3**	**MC1**	**FEC1**
5-Jun-96	D	D		D	D		D	D
12-Jun-96	D	D		D	D		D	D
18-Jun-96		D						
19-Jun-96	D				D			
28-Jun-96	D	D		D	D		D	D
10-Jul-96		D		D	D		D	D
11-Jul-96	D							
17-Jul-96		D		D	D	D	D, W	D
23-Jul-96							W	
24-Jul-96	D	D		D	D	D	D, W	D
1-Aug-96	D	D		D	D	D		
2-Aug-96			H				D, W	D
7-Aug-96								
13-Aug-96		D		D	D			
14-Aug-96	D							

15-Aug-96				D			D, W	
16-Aug-96								W
1-Sep-96			H					W
4-Sep-96								W
10-Sep-96			H					
11-Sep-96		D		D	D	D	D, W	D, W
12-Sep-96	D		H					
18-Sep-96			H				W	W
25-Sep-96			H				W	W
9-Oct-96		D		D	D	D	D, W	D, W
10-Oct-96	D		H					
6-Nov-96		D				D		
7-Nov-96				D	D			
8-Nov-96	D						D,W	D,W
12-Dec-96	D	D		D	D	D	D,W	W
16-Jan-97				H	H		D,W	H
13-Feb-97	D			D	H		D	
19-Mar-97					D		D,W	
15-Apr-97		H			H	H	D	H
16-Apr-97				D	H			
21-May-97		D		D	D	D	D,W	D
12-Jun-97	D	D		D	D	D	D,W	D

22-Jul-97	D	D		D	D	D	D,W	D
1 Continuous height recorder								
WC1	Lower Willow Creek		TRIB2	Tributary 2		D	Discharge	
WC2	Upper Willow Creek		TRIB3	Tributary 3		H	Height	
WCbr	Willow Creek @ BCR		MC1	Middle Creek		W	Weir Discharge	
TRIB1	Tributary 1		FEC1	Far East Creek				

Continuous height recorders were installed on lower Willow Creek (at WC1, June 21, 1996), and at Tributary 2 below the Forestry Road (at TRIB 2, June 21, 1996) (Figure 4.4-1). Stream heights were recorded every hour. Data to July 1997 were evaluated for this report; data were still being collected at the time of this report. Most streams could not be gauged in January or February, 1997 due to heavy ice; only the existence of flows was noted.

Either a Price AA or a pigmy current meter were used together with a top setting wading rod to measure water flows. Cross sections were taken at established points at each hydrology station. Flow meters were purchased new for the project and factory calibrated. Hydrology stations were not surveyed in with respect to the established property grid in 1996; surveying is scheduled for 1997.

V-notch weirs were constructed on Far East Creek and Middle Creek. Height of water through the weirs was measured each time the staff gauges at these sites were read, once weir construction was completed. Discharge through the weirs was calculated and compared to the discharge measured by means of the current meter and wading rod. The following relationship was used (Hewlett 1982):

$Q = Ch^{5/2}$ . . . . (1)

where Q = discharge in m^3/s

h = height of water through weir, or head

C = coefficient for sharp edge, 90 degree V-notch weir (= 1.38 for SI units)

Stage discharge curves were calculated for each of the streams metered; a best-fit curve fitting algorithm on an HP48 calculator was used to determine the best-fit regression line for the gauge height and discharge data. From 10 to 13 discharge measurement points were used to calculate the stage discharge. Stream discharges were measured from spring flood flows through December lows in the 1996 season and up to July 1997 for evaluation in this report.

Statistical relationships between watershed area and peak floods were developed for the Omineca-Peace Region by Chapman et al. (1991). Chapman et al.'s regression relationship for Zone 21 (which encompasses the project area) was used to check discharge maxima predicted from field-derived stage discharge relationships (discussed in the previous paragraph) which were outside the range of discharges actually measured in the field. Chapman et al.'s relationships were also used to predict return period flood events for Willow Creek and tributaries. Chapman et al.'s relationships for Zone 21 is as follows:

Mean Annual Daily Peak Flow = 200 $l/s/km^2$

Prediction Equation based on watershed area

$\log q = 2.746 - 0.1813 \log A$ A = watershed area (km^2)

$\log Q = -0.7033 + 0.9695 \log A$q = Flow (l/s/km2)

$R10 = 2.76 - 0.293 \log A$ Q = Flow (m3/s)

$R25 = 5.02 - 0.73 \log A$

$R50 = 7.34 - 1.204 \log A$

$R100 = 10.42 - 1.855 \log A$

$R200 = 14.67 - 2.78 \log A$

The drainage areas for each of the streams in the Project Area (other than the Pine River, which is supplied by Water Survey of Canada) were measured on a 1:50,000 scale NTS map by means of a CAD program and reported in km2. From ground observation, the NTS map appears to have overestimated the drainage basin area of Middle Creek and Tributary 1.

4.5.4 IEC 1982 Results

IEC conducted hydrologic investigations of the Pine River in 1981-82 for David Minerals as part of Stage II studies for coal mine approval. We have summarized their studies here and provided pertinent data tables in Appendix 4.5-2.

The closest Water Survey of Canada (WSC) hydrometric station to the project site is Pine River at East Pine, 80 km downstream. The Pine River at this station drains an area 10 times that of the River at the project site. Table 3.7-1 from the IEC Beak report lists WSC stations in east central British Columbia and is attached in Appendix 4.5-2.

IEC hydrology sites are listed in their Table 3.7-3, attached in Appendix 4.5-2. They established a continuous recorder on lower Willow Creek above the BCR Bridge at the point where Willow Creek enters the Pine River floodplain.

Pine River Hydrology

Pine River flood flows are of interest since floods may result in water backing up in back channels behind (south of) the BC Rail tracks. Low flows in the Pine River are of interest since they set the minimum level for receiving environment assimilative capacity for area stream discharges.

Mean, maximum and minimum annual runoff, mean daily discharge, 200 year maximum discharge, mean annual 7-day low flow and 200 year 7-day low flows were calculated for the Pine River by IEC Beak. Their data are attached in Appendix 4.5-2. Calculations were provided for East Pine and the EZ Bridge (IEC Beak designation for the existing forestry road bridge across the Pine River). Monthly and annual mean discharges for the Pine River were also calculated and are attached in Appendix 4.5-2; data for Pine River at East Pine and at the EZ Bridge were provided. Maxima and minima for Pine River at EZ Bridge were made more extreme (by 4%) than at East Pine to account for the smaller drainage basin.

IEC Beak discussed the problem with statistical estimation of flood events for rivers like the Pine. Statistical procedures assume a single cause, i.e. rainfall or snowmelt, but not both acting simultaneously. Flood frequency distributions for rivers such as the Pine show several points of anomalously high recurrence intervals and most frequently used procedures underestimate discharges of high recurrence intervals. IEC Beak used the Gumbel Type I and maximum daily discharge to calculate peak flows. The mean annual maximum daily discharge for the Pine River at EZ Bridge was calculated using a relationship determined by MOE (1981) for northeast coal area streams. The 200 year maximum daily discharge was determined: Gumbel Type I, fitted graphically; Gumbel Type I, maximum likelihood; and Log-Pearson Type III. The most conservative estimate (Log-Pearson) was chosen.

Low flows were derived by means of a frequency distribution from flow records for Pine River at East Pine. Mean annual and 200-year, 7-day low flows were calculated. Relationships determined for East Pine were reduced for the smaller drainage area subtended by the Pine River at EZ Bridge and prorated for the smaller drainage area to produce low flow estimates.

Pine River Floodplain Delineation

The 200-year flood line was determined by IEC Beak empirically as follows:

· discharges were calculated for various water surface elevations using the hydraulic characteristics of the Pine River and Mannings Equation: Q = (A/n)R2/3S1/2

where Q = discharge, A = cross sectional area, R = hydraulic radius,

S = longitudinal slope, n = roughness (Mannings) coefficient;

- stream cross sections were field-determined;
- n was chosen on the basis of stream characteristics observed in the field;
- the cross sectional area was split into in-stream and over-bank flows; and
- the area south of the railway was not included since the railway acts as a 3 m high berm whereby water likely slowly floods through culverts. The estimated extent of the floodplain was illustrated on Figure 3.7-8 of the IEC Beak report and is attached in Figure 4.5-1.

4.5.5 B. Guy 1994 Results

Hydrology stations on lower Willow, Far East and Middle Creeks were subject to subsurface flows in 1994. Discharge ranges measured were as follows:

Drainage	**Discharge**	**Drainage**	**Discharge**
Willow Creek	0.008 to 0.687 m3/s	Tributary 1	0.002 to 0.051 m3/s
Middle Creek	0 to 0.02 m3/s	Far East Creek	0 to 0.046 m3/s

Minimum discharges reported for Willow Creek and Tributary 1 are at variance with the results obtained by NDM in 1996 which indicated minimum flows in Willow Creek of 0.08 m3/s and in Tributary 1 of 0.01 m3/s.

4.5.6 NDM 1996 Results

Stream Flows and Discharge

Stream discharges were measured at approximately weekly intervals during the summer (June through August) and monthly thereafter. Continuous records provide the best insight into behaviour of site streams and data for Tributary 2 (TRIB 2) and lower Willow Creek (WC1) were evaluated. Willow Creek was chosen as it is the principal tributary draining the site; Tributary 2 was selected as being representative of first order streams(2) draining the site into Willow Creek. Discharges were calculated in a spreadsheet for each hourly stream height record using the stage discharge relationships. Figure 4.5-2 graphically represent daily discharges calculated from stream heights for Willow Creek at WC1 and Tributary 2, respectively.

Willow Creek and the Pine River will receive water discharged from the site. Tributaries 1, 2 and 3 flow into Willow Creek which flows into the Pine River. Far East, Middle and Unnamed creeks flow directly into backwaters of the Pine River. Far East and Middle creeks are intermittent and only flow below the surface much of the summer. Unnamed Creek is a dry gully, except for brief periods at spring runoff, as are the unnammed east bank tributaries to Willow Creek north of Tributary 1.

Stage Discharge Relationships

Data used to develop stage discharge relationships for site streams are provided in Table 4.5-3. These relationships were used to predict discharges for a given flood or low flow event for impact assessment.

TABLE 4.5-3

SITE STREAM STAGE DISCHARGE RELATIONSHIPS

Willow Creek at WC1 (Lower)					**Willow Creek at WC2 (Upper)**				
Regression Curve		power curve (y=a*xe)			Regression Curve		power curve (y=a*xe)		
a	24.441				a	43.820			
e	2.090				e	3.340			
r2	0.919				r2	0.951			
n	12				n	12			
		Discharge					**Discharge**		
Date	**Stf Ht**	**(m3/s)**		**(l/s/km2)**	**Date**	**Stf Ht**	**(m3/s)**		**(l/s/km2)**
	(m)	**Measured**	**Calc**			**(m)**	**Measured**	**Calc**	
5-Jun-96	0.355	3.123	2.807		12-Jun-96	0.235	0.322	0.348	
12-Jun-96	0.270	1.459	1.584		18-Jun-96	0.315	0.973	0.925	
19-Jun-96	0.295	1.940	1.906		28-Jun-96	0.250	0.424	0.427	
28-Jun-96	0.243	1.019	1.271		10-Jul-96	0.209	0.243	0.235	
11-Jul-96	0.220	0.866	1.033		17-Jul-96	0.278	0.563	0.609	
24-Jul-96	0.272	1.551	1.609		24-Jul-96	0.250	0.386	0.427	
1-Aug-96	0.196	1.796	0.811		1-Aug-96	0.181	0.157	0.145	
14-Aug-96	0.144	0.354	0.426		13-Aug-96	0.155	0.055	0.087	

12-Sep-96	0.102	0.168	0.207	
10-Oct-96	0.153	0.376	0.483	
8-Nov-96	0.110	0.239	0.243	
12-Dec-96	0.080	0.161	0.125	
Tributary 1 at TRIB 1				
Regression Curve		exponential (a*ex)		
a	0.00014			
e	26.812			
r2	0.839			
n	10			
		Discharge		
Date	**Stf Ht**	**(m3/s)**		
	(m)	**Measured**	**Calc**	**(l/s/km2)**
5-Jun-96	0.240	0.133	0.086	
12-Jun-96	0.225	0.064	0.057	
28-Jun-96	0.216	0.046	0.045	
10-Jul-96	0.216	0.046	0.045	
24-Jul-96	0.233	0.070	0.071	
1-Aug-96	0.216	0.036	0.045	
15-Aug-96	0.206	0.031	0.035	
9-Oct-96	0.210	0.021	0.038	
7-Nov-96	0.178	0.023	0.016	

11-Sep-96	0.129	0.043	0.047	
9-Oct-96	0.178	0.241	0.137	
6-Nov-96	0.150	0.068	0.078	
12-Dec-96	0.120	0.040	0.037	
Tributary 2 at TRIB 2				
Regression Curve		Linear (b+mx)		
b	0.078			
m	0.376			
r2	0.907			
n	13			
		Discharge		
Date	**Stf Ht**	**(m3/s)**		
	(m)	**Measured**	**Calc**	**(l/s/km2)**
5-Jun-96	0.482	0.255	0.259	
12-Jun-96	0.266	0.2	0.178	
19-Jun-96	0.257	0.18	0.174	
28-Jun-96	0.168	0.152	0.141	
10-Jul-96	0.136	0.149	0.129	
17-Jul-96	0.333	0.19	0.203	
24-Jul-96	0.244	0.169	0.169	
1-Aug-96	0.114	0.125	0.121	
13-Aug-96	0.122	0.093	0.124	

12-Dec-96	0.158	0.010	0.010

11-Sep-96	0.087	0.08	0.111
9-Oct-96	0.039	0.099	0.092
7-Nov-96	0.020	0.084	0.085
12-Dec-96	0.006	0.09	0.080

Tributary 3 at TRIB 3				
Regression Curve		exponential (a*ex)		
a	0.00002			
e	35.389			
r2	0.848			
n	6			
		Discharge		
Date	**Stf Ht**	**(m3/s)**		
	(m)	**Measured**	**Calc**	**(l/s/km2)**
24-Jul-96	0.255	0.275	0.193	
13-Aug-96	0.222	0.058	0.060	
11-Sep-96	0.182	0.025	0.015	
9-Oct-96	0.222	0.052	0.060	
6-Nov-96	0.210	0.020	0.039	
12-Dec-96	0.180	0.013	0.014	

Middle Creek at MC1				
Regression Curve		exponential (a*ex)		
a	0.00019			
e	16.758			
r2	0.798			
n	6			
		Discharge		
Date	**Stf Ht**	**(m3/s)**		
	(m)	**Measured**	**Calc**	**(l/s/km2)**
12-Jun-96	0.300	0.051	0.029	
28-Jun-96	0.279	0.036	0.020	
10-Jul-96	0.275	0.034	0.019	
17-Jul-96	0.300	0.033	0.029	
24-Jul-96	0.371	0.069	0.095	
2-Aug-96	0.333	0.040	0.050	
15-Aug-96	0.277	0.020	0.020	
11-Sep-96	0.212	0.005	0.007	
9-Oct-96	0.248	0.007	0.012	

				8-Nov-96	0.216	0.006	0.007
Far East Creek at FEC1							
Regression Curve		exponential (a*ex)					
a							
e							
r2							
n							
		Discharge					
Date	**Stf Ht**	**(m3/s)**					
	(m)	**Measured**	**Calc**	**(l/s/km2)**			

Flood Flows

Flood events are a concern for design of water handling structures and for determining maximum volumes of discharge required from sedimentation ponds. The flow rates of receiving water bodies combined with substance loading factors (such as sediments and nitrogen compounds) also determine the concentrations of substances released to them.

Data obtained in 1996 and 1997 confirm that the behaviour of site streams was typical for headwater drainages, that is, discharges increase rapidly upon onset of rain storms and drop rapidly thereafter.

The calculated peak discharge at lower Willow Creek (using the stage discharge relationship empirically determined from site discharge measurements) was 8.52 m3/s over a maximum one-hour period in response to July 1996 rains at the site. Calculated discharges in Willow Creek over the period of record in 1996 and 1997 ranged from 0.095 m3/s to the above- referenced discharge(3).

Using the regression relationships of Chapman et al., predicted return floods for Willow Creek at WC1, and Tributaries 1, 2 and 3 were calculated and are presented in Table 4.5-4. Chapman et al's predicted instantaneous 10 year peak flood for Willow Creek would be 13.192 m3/s, or over 1.5 times the peak flood measured in July 1996.

TABLE 4.5-4

CALCULATED RETURN FLOODS FOR MAJOR PROJECT AREA STREAMSa

		Average Annual	**Return Period Flood (Years)**				
	Drainage Area	**Daily Peak**	**10**	**25**	**50**	**100**	**200**

Stream	(km2)	(m3/s)	(m3/s)				
Willow Creek at WC1	26	4.661	10.933	11.952	11.447	11.394	11.420
Trib 1 at mouth	1.6	0.312	0.843	0.908	0.869	0.866	0.868
Trib 2 at mouth	3.6	0.686	1.780	1.925	1.842	1.835	1.839
Trib 3 at mouth	3.4	0.649	1.689	1.826	1.747	1.740	1.744

a Pine River return floods provided by IEC Beak (1982).

Return floods are daily peak flows; to obtain instanteous peak flows multiply by 1.2.

Flood peaks in smaller tributary streams were likely much less pronounced than Willow Creek, based on continuous flows available for Tributary 2. The calculated peak discharge for Tributary 2 for the same July 1996 storm event was 0.192 m3/s. Tributary 2 discharges through the period of record ranged from 0.08 m3/s to 0.192 m3/s(4). Other small tributaries would be expected to have similar discharges patterns, proportional to their drainage areas.

Some smaller streams at the site may be modified by mining activities, e.g. Tributary 1, Middle and Far East creeks) and runoff will be handled through ditches and sedimentation ponds where that occurs.

Snow Melt/Spring Freshet

Snow melt will add to runoff volumes and the amount of flow augmentation will depend on the rate of snow melt. Snow melt combined with rainfall will increase flow rates even more. The effects of snow melt augmenting spring rainstorm events will likely be much more pronounced for larger drainage basins, such as the Pine River and much less a contributing factor for small basins such as Willow Creek and tributaries. As discussed previously, the amount of the snow pack at the site is expected to be highly variable. However, making a number of assumptions, it is possible to derive an estimate of runoff due to snow pack melting. What is important for calculating flow augmentation is the rate of snow melting, rather than the total accumulation. A worst case assumption is that snow pack melts at the maximum credible rate when the ground is frozen and all water enters the stream. We provide this calculation for Willow Creek, including Tributaries 2 and 3, since other tributaries will be altered and flows controlled during mine operation.

Total area: 2700 ha

Maximum snow melt rate (water equivalent),

assuming no rain and heavy forest cover

(Wanielista, et al. 1996): 10 mm/24 hr

Runoff (assuming all melted snow

reaches Willow Creek):3.6 m3/s

(This does not include contributions from Tributaries 1, 2, or 3 nor from rain.)

Once snow melt from the farthest point away reaches the stream (time of concentration), maximum flows will be attained. Time of concentration for water to reach Willow Creek will be highly variable. It will be higher per unit distance for areas subject to overland flow into the creek and lower for areas feeding into first order streams. The longest distance to any Willow Creek first order tributary is approximately 500 m and to Willow Creek up to 1 km. Therefore time of concentration is dependent on the greater distance. Using the Soil Conservation Service (1975) (now Natural Resources Conservation Service) nomogram and assuming an average 20% slope, produces an estimate of approximately one hour (assuming 0.3 m/s overland flow) for time of concentration; actual times will likely vary between less than one half hour to one hour. This time is short enough that maximum snow melt runoff could be expected for at least a portion of daylight hours (typically 1400 to 1600 hours on sunny days).

The estimated value of 3.6 m3/s increment from snow melt for Willow Creek is well below the calculated peak runoff for the July 18, 1996 storm of 8.5 m3/s, but consistent with spring runoff discharge measurements made in 1994 and 1996. Snow melt from areas where tree cover is removed will be much greater. As well, runoff will be faster (shorter times of concentration), both of which will lead higher snow melt runoff rates. Even with these two considerations, snow melt contributions to flood flows will not approach high summer storm runoff.

Low Flows

Low flows are of interest because they are the major factor in determining the resultant concentration of substances released to receiving waters through discharge from water control structures. The statistically derived value for a 7-day low flow is normally used as a predictor of minimum flows. For Project area streams which are subject to prolonged winter freezing, base flows in winter are likely the controlling factor for minimum flows. Base flows are determined by the amount of groundwater discharging into a stream when runoff is zero for a prolonged period.

We discuss Willow Creek and the Pine River (IEC Beak data) in this report, since other, smaller, drainages will be altered significantly when mining disturbances affects them, and low flows are not an issue for these streams. With reference to the Pine River, minimum annual flows at the EZ Bridge reported by IEC (1982) average 3.7 m3/s in January, or 14% of average annual flows (26.3 m3/s at EZ Bridge). The mean annual 7 day low flow for the Pine River at the EZ Bridge was reported to be 2.8 m3/s and the 200 year, 7 day low flow to be 0.9 m3/s.

Long-term data are not available for Willow Creek, or other similar streams in the area. If the discharge relationships developed for Pine River at EZ Bridge are used, the annual 7 day low flow would be 10% and the 200 year, 7 day low flow would be 5% of average annual flows. Mean annual flows for Willow Creek are not available. However the 1996/97 mean flow for the period of record (June 5 through July 1997) was 0.627 m3/s. Using this average, the annual 7 day low flow would be 0.063 m3/s and the 200 year, 7 day low flow would be 0.032 m3/s at WC1. During such extreme low flow events, discharges from the site sedimentation ponds are unlikely because such flows occur in January and February when water control structures will be ice-covered and at low levels.

Pine River Floodplain Back Channels and Wetlands

Pine River floodplain back channels and wetlands exist south and north of the B.C. Rail tracks at the site (Figure 4.5-1). The area is a mixture of water channels (river back channels), marsh areas and mixed forest. The approximate floodplain areas are as follows:

- south of the B.C. Rail tracks (Willow to Far East Creek):48 ha;
- north of the B.C. Rail tracks (Willow to Far East Creek):190 ha.

During flood conditions, water would be expected to have a net flow into the wetlands and back channels, while at other times water will flow slowly out of these areas into the Pine River. Water from Far East and Middle Creeks flows (underground in the summer) into the wetland area south of the railway tracks. Reference to Figure 4.5-1 shows that Far East Creek flows eastward and roughly parallel to the Pine River before entering the river approximately 1 km east of the Project area. Runoff from the proposed north rock dump and coarse rejects dump will be into the wetland area south of the tracks.

4.5.7 Groundwater

Groundwater occurrence and flows were investigated by IEC Beak (1982). A summary of their findings follows:

- Groundwater flows within the overburden and bedrock. Groundwater within the overburden occurs principally east of the ridge east of Middle Creek. Shales of the Moosebar Formation have been found to form a relatively impervious barrier to groundwater flow. Precipitation accumulating within this area will discharge through the overburden deposits of colluvium and glacial outwash or within the upper weathered zones of bedrock. Most of the bedrock groundwater flows are within the Gething Formation underlying the Moosebar Formation.
- Flow of groundwater within bedrock is along fracture planes with major fracture zones occurring within the coal sequences. However calcite precipitation in recent geologic history prevents groundwater flows within fractures. IEC Beak found groundwater flows were predominantly north and northeast from the easternmost drainage divide on the property (east side of Far East Creek) and is controlled by topography.

4.6 FISHERIES

Fisheries studies were conducted in the Willow Creek area by Beak (1982), MarLim Ecological Consultants Ltd. (1994; reported in 1996) and by NDM for the study reported here. Previous results are discussed with NDM's where appropriate.

4.6.1 Globaltex 1994

MarLim Ecological Consultants Ltd. conducted habitat studies in the project area on Pine River and Willow Creek from its mouth to upstream of Tributary 3. A summary of their report is attached as Appendix 4.6-1 and results discussed in general in the following section.

4.6.2 NDM 1996

4.6.2.1 Introduction

Study Objectives

According to the Project TOR prepared by EAO, the fisheries component of the environmental assessment report "should identify the potential impacts of the mine development and operation on fish habitat and populations, along with the identification of any measures proposed to mitigate these impacts." Fish species presence and abundance, as well as fish habitat in all fish-bearing reaches were to be described and mapped.

The report was also to map the streams in relation to the proposed mine layout and associated works, and to provide a fish/habitat conservation (protection) plan. All potential impacts, direct and indirect (i.e. downstream), were to be identified. The project report was also to identify and detail impact avoidance and mitigation measures to minimize potentially adverse effects on the aquatic environment.

Project Area

The tributary creeks draining the project area include parts of Willow Creek and two unnamed creeks referred to locally as Middle Creek and Far East Creek (Figure 4.6-1), which flow northward from elevations of up to 1130 m asl to the Pine River at approximately 630 m asl.

4.6.2.2 Study Methods

Review of Existing Information

Previous studies in the general area, including MarLim (1996), NDM (1994), IEC (1982) and Shultz (1977), were reviewed, as well as SISS/FISS data that includes DFO, BC Environment and consultants' file data on parts of the general area. The Pine River in the vicinity of the PVC project is known to support Arctic grayling (*Thymallus arcticus*), Dolly Varden char (*Salvelinus malma*), Rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsoni*) and northern pike (*Esox lucius*), as well as several forage species (Table 4.6-1). The rainbow trout were introduced to the area (Hasler Creek) by local residents and the stocks are protected by angling closures in April-June each year.

TABLE 4.6-1

FISH SPECIES COLLECTED FROM THE PEACE RIVER AND ITS TRIBUTARIES

			Peace Rb	Pine Rc	Sukunka Rd	Murray Re
Common Namea	**Scientific Name**	**Classification**	**& Tribs**	**& Tribs**	**& Tribs**	**& Tribs**
Arctic grayling	*Thymallus arcticus*	S	O	O	O	O
Dolly Varden	*Salvelinus malma*	S	O	O	O	O
Rainbow trout	*Onchorhynchus mykiss*	S	O	O	O	O
Mountain whitefish	*Prosopium williamsoni*	S	O	O	O	O
Northern pike	*Esox lucius*	S	O	O	O	O
Goldeye	*Hiodon alosoides*	S	O			
Yellow walleye	*Stizostedion vitreum vitreum*	S	O			O
Lake whitefish	*Coregonus clupeaformis*	C	O			
Largescale sucker	*Catotomus macrocheilus*	F	O			
Longnose sucker	*Catostomus catostomus*	F	O		O	O
White sucker	*Catosomus commersoni*	F	O			
Burbot	*Lota lota*	F	O			O
Flathead chub	*Playtgobio garcilius*	F	O			
Lake chub	*Couesium plumbeus*	F	O			
Redside shinner	*Richardsonius lateatus*	F	O			
Spoonhead sculpin	*Cottus recel*	F	O			
Slimy sculpin	*Cottus cognatus*	F	O		O	O
Prickly sculpin	*Cottus asper*	F	O			
Largenose dace	*Rhinichthys cataraciae*	F	O		O	
Trout-perch	*Percopsis omiscomaycus*	F	O			

Northern squawfish	*Ptychocheilus oregonensis*	F	O			
Pygmy whitefish	*Prosopium coulteri*	F				
Lake trout	*Salvelinus namaycush*	F				
Northern redbelly dace	*Chrosomus eos*	F				O

O: denotes presence

S: sports fish

C: commercially valuable species

F: forage species

a: species list based on Scott and Crossman, 1973 and McPhail and Lindsey, 1970

b: B.C. Hydro and Power Authority, 1979

c: Westcoast Energy, 1977

d: Stuart, K.M., and G.R. Chislett, 1979

e: Denison Mines Ltd., 1980

Source: IEC 1982

The streams show a diversity of habitat types from confined and unconfined channels, side channels, back channels, islands, bars and smaller tributary streams. The lowermost reaches of Willow Creek were found by IEC to contain mountain whitefish (*Prosopium williamsoni*) and forage species (mainly Cyprinids - minnows) below the canyon/falls (located just downstream of Tributary 1), while Dolly Varden char (*Salvelinus malma*) were also thought to inhabit the creek below the falls. This was confirmed by NDM and MarLim's sampling in that area that also showed rainbow trout (*Oncorhynchus mykiss*) in the lower reaches of Willow Creek. The only other creek in the immediate area that was found to contain fish was the lowermost reach of Far East Creek, which contained forage species (sculpins). The other creeks have fish migration barriers just upstream of their confluences with the Pine River, as well as in several locations farther upstream.

Field Work

Field work by IEC for the previously proposed David Minerals property included considerable fish sampling and detailed habitat surveys in Willow, Middle and Far East Creeks in the periods 7-10 May and 27-30 July, 1982. MarLim completed their very detailed habitat assessments and photographic coverage of the streams in October, 1994.

More recently, NDM conducted additional fisheries field work for the proposed Pine Valley Coal (PVC) development in the period 12-30 August, 1996. Fish sampling dates are listed in Table 4.6-2. Methods included electrofishing and minnow (Gee) trapping, as well as detailed habitat surveys using standard DFO/BC Environment Stream Survey Forms and methods (as had the previous field crews for IEC and MarLim). The focus of the NDM work was to confirm previous findings and, particularly, to study areas not previously assessed in detail. Copies of the completed Stream Survey Forms, including information on biophysical features, fish catches and cross-sectional sketches, are included in Appendix 4.6-1 for the MarLim work and in Appendix 4.6-2 for the NDM work. Photographs are also included in those appendices that show the stream habitat characteristics in many parts of the study area (also

Appendix 4.6-3).

TABLE 4.6-2

PINE VALLEY COAL WILLOW CREEK PROJECT FISH SAMPLE LOCATIONS, DATES AND METHODS

Location	Date		Time		Total Time	Site	Gear	Fish
	Start	Stop	Start	Stop	(hrs)			
Willow Creek								
Trib 2 to 250m u/s on Willow Creek	30-Aug-96				1680 sec		ES	0
near WC2, 80m u/s of road	12-Aug-96	13-Aug-96	12:00 PM	12:00 PM	24	30 to 80 cm pool	GT	0
near WC2, 80m u/s of road	13-Aug-96	15-Aug-96	12:00 PM	1:10 PM	49		GT	0
near WC2, road to 100m u/s	29-Aug-96	29-Aug-96			409 sec		ES	0
near WC2, 100m d/s of road	12-Aug-96	13-Aug-96	12:30 PM	12:30 PM	24	30 to 70 cm pool	GT	0
near WC2, 100m d/s of road	13-Aug-96	15-Aug-96	12:30 PM	1:10 PM	49		GT	0
near WC2, road to 100m d/s	29-Aug-96	29-Aug-96			454 sec		ES	0
60m u/s of falls	12-Aug-96	13-Aug-96	2:00 PM	2:00 PM	24	30 to 50 cm pool	GT	0
60m u/s of falls	13-Aug-96	15-Aug-96	2:00 PM	3:00 PM	49		GT	0
200m u/s of falls	12-Aug-96	13-Aug-96	2:30 PM	2:30 PM	24	30 to 50 cm pool	GT	0
150m u/s of falls	13-Aug-96	15-Aug-96	2:30 PM	3:00 PM	48	large pool	GT	0

falls to 330m u/s of falls, site 4	28-Aug-96	29-Aug-96	3:00 PM	10:25 AM	2443 sec		ES	0
135m d/s of falls	26-Aug-96	28-Aug-96	2:30 PM	3:00 PM	48.5		GT	0
135m d/s of falls	28-Aug-96	29-Aug-96	3:00 PM	9:00 AM	1.8		GT	0
135m d/s of falls	29-Aug-96	31-Aug-96	9:00 AM	9:00 AM	48		GT	0
200 m d/s of falls	26-Aug-96	28-Aug-96	2:30 PM	3:00 PM	48.5		GT	0
200 m d/s of falls	28-Aug-96	29-Aug-96	3:00 PM	9:00 AM	18		GT	RB
falls to 120m d/s	28-Aug-96		3:00 PM		1117 sec		ES	0
60m u/s of staff gauge at WC1	12-Aug-96	13-Aug-96	3:30 PM	5:20 P[M	26	20 to 50 cm pool	GT	0
60m u/s of staff gauge at WC1	13-Aug-96	14-Aug-96	5:20 PM	3:30 PM	22		GT	0
60m u/s of staff gauge at WC1	14-Aug-96	15-Aug-96	3:30 PM	7:00 PM	27.5		GT	9 RB, 4 DV
80m d/s of road bridge	12-Aug-96	13-Aug-96	4:20 PM	5:40 PM	25	30 to 100 cm pool	GT	0
80m d/s of road bridge	13-Aug-96	14-Aug-96	5:40 PM	4:00 PM	22.5		GT	0
80m d/s of road bridge	14-Aug-96	15-Aug-96	4:00 PM	7:30 PM	27.5		GT	0
50 to 200m d/s of road bridge, site 2	28-Aug-96				2319 sec		ES	7 RB, 1 SC
50m u/s of Pine River	12-Aug-96	13-Aug-96	4:45 PM	4:45 PM	24	small pool at bank undercut	GT	0

50m u/s of Pine River	13-Aug-96	14-Aug-96	4:45 PM	6:50 PM	26		GT	1 MW
50m u/s of Pine River	14-Aug-96	15-Aug-96	6:50 PM	7:00 PM	24		GT	2 SC
70m u/sa of Pine River	13-Aug-96	14-Aug-96	5:00 PM	1:00 PM	20	30 to 80 cm pool	GT	0
mouth to 145m u/s of log bridge, reach 1, site 1	26-Aug-96	26-Aug-96			293 sec		ES	12 MW, 3 SC
mouth to 145m u/s of log bridge, reach 1, site 1	27-Aug-96	27-Aug-96			536 sec		ES	3 SC, 10 MW, 1 RB
	30-Aug-96	31-Aug-95			24		GT	0
road to 50m u/s	30-Aug-96	30-Aug-96			213 sec		ES	0
250m d/s of forestry road	26-Aug-96	30-Aug-96	12:15 PM		96	pool	GT	0
250m d/s of forestry road	30-Aug-96	31-Aug-95			24		GT	0
road to 100m d/s	30-Aug-96	30-Aug-96			485 sec		ES	0
Tributary 1								
30m u/s of forestry road	26-Aug-96	30-Aug-96	1:15 PM	3:45 PM	98.5	pool	GT	0
30m u/s of forestry road	30-Aug-96	31-Aug-95	3:45 PM		24		GT	0
road to 50m u/s	30-Aug-96	30-Aug-96			182 sec		ES	0
100m d/s of forestry road	26-Aug-96	30-Aug-96	1:15 PM	4:15 PM	99	pool	GT	0
100m d/s of forestry road	30-Aug-96	31-Aug-95	4:15 PM		24		GT	0

road to 120m d/s	30-Aug-96	30-Aug-96			233 sec		ES	0
Tributary 2								
40m u/s of forestry road	26-Aug-96	30-Aug-96	12:15 PM		96		GT	0
Tributary 3								
60m u/s of forestry road	26-Aug-96	29-Aug-96	10:30 AM	6:00 PM	80	pool	GT	0
60m u/s of forestry road	29-Aug-96	31-Aug-95	6:00 PM		40		GT	0
road to 60m u/s	29-Aug-96	29-Aug-96			256 sec		ES	0
60m d/s of forestry road	26-Aug-96	29-Aug-96	10:30 AM	6:00 PM	80	pool	GT	0
road to 60m d/s	29-Aug-96	29-Aug-96			463 sec		ES	0
Pine River								
60m d/s of Willow Creek	12-Aug-96	13-Aug-96	5:00 PM	5:00 PM	24	undercut bank	GT	0
60m d/s of Willow Creek	13-Aug-96	15-Aug-97	5:00 PM	7:30 PM	50.5		GT	0
60m u/s of forestry road bridge, site 1	26-Aug-96	26-Aug-96			966 sec		ES	1 RB, 2 MW, 1 WS?
d/s of Willow Creek, site 2	27-Aug-96	27-Aug-96			249 sec		ES	2 SALMONIDS, 1MW, 1GR, 18SC
Middle Creek								
Wetland near creek at BC Rail	12-Aug-96	13-Aug-96	5:30 PM	7:25 PM	26	40 cm water	GT	3RSS?
Wetland near creek at BC Rail	13-Aug-96	14-Aug-96	7:25 PM	2:30 PM	19		GT	5RSS?

Wetland near creek at BC Rail	14-Aug-96	16-Aug-96	2:30 PM	2:30 PM	48		GT	61RSS?
40m u/s of where creek goes underground (150m d/s of road)	26-Aug-96	30-Aug-96	3:30 PM	5:30 PM	98		GT	
40m u/s of where creek goes underground (150m d/s of road)	30-Aug-96	31-Aug-95	3:30 PM		24		GT	
road to 50m u/s	30-Aug-96	30-Aug-96	5:30 PM		139 sec		ES	
road to 150m d/s	30-Aug-96	30-Aug-96			207 sec		ES	
margin of wetland 70m d/s of where creek goes underground	30-Aug-96	30-Aug-96			269 sec		ES	
Far East Creek								
80m u/s of where creek goes underground (50m u/s of BCR bridge)	12-Aug-96	14-Aug-96	6:30 PM	4:30 PM	22		GT	
250m d/s of weir (FEC1)	26-Aug-96	30-Aug-96	4:15 PM	5:15 PM	97	pool	GT	
250m d/s of weir (FEC1)	30-Aug-96	31-Aug-95	5:15 PM		24		GT	
wier to 80m d/s and to 50m u/s	30-Aug-96	30-Aug-96			266 sec		ES	
ES:electroshocker, GT: gee trap								
GR: Arctic Grayling, MW: Mountain Whitefish, RB: Rainbow Trout, RSS: Redside Shiner, SC: Sculpin, WS: White Sucker								

Habitat Surveys

Intensive habitat surveys were completed over extended lengths of each of the creeks in the Project area using hip-chain measurements to reference habitat measurements, descriptions and photographs at known distances from the stream mouths. DFO/BCE Stream Survey Forms were completed for each sampling station and reach in the project area. The methods used were identical to those used by IEC and MarLim for habitat surveys. The results of all three assessments provide a complete inventory of habitat features in the project streams.

There are three unnamed "streams" marked on topographic maps for the Project area which carry water only during storm events and spring runoff which were not sampled. Two are located north of Tributary 1 on the east bank of Willow Creek and one is located west of Middle Creek and connects with the Pine River floodplain (Figure 4.6-2).

Hydrological measurements were completed using staff gauges, a V-notch weir and a data logger (in Willow Creek) that recorded continuous stage measurements and determined the flow rates (discharges).

Water quality measurements included *in situ* determinations of water temperature, pH, conductivity and dissolved oxygen, and water sampling for an array of parameters, including metals, nutrients, trace elements and general characteristics (e.g. hardness, total dissolved and suspended solids).

Fish Sampling

The fish sampling methods of IEC included beach seines, gillnets, minnow traps, electrofishing and snorkel dives. They concentrated their sampling on the mainstem Pine River, including 17 beach seine sites, 9 minnow trapping sites and 4 gillnet sites. They electroshocked Willow Creek near the mouth, and set traps and gillnets in lower Far East Creek.

MarLim's work was primarily for habitat assessment and did not include fish sampling. Some fish were observed incidentally during the habitat work that add to the data base.

NDM's fish sampling included primarily electrofishing in the Pine River at the mouth of Willow Creek and at 9 locations upstream, including above and below the falls. Electrofishing was also conducted in Middle Creek and lower Far East Creek. In each case, extensive electrofishing was undertaken to confirm the presence, or absence, of fish in each area (see Stream Survey Forms in Appendix 4.6-2).

4.6.2.3 Baseline Environment

The area does not contain pristine, undisturbed habitat. Extensive forestry activities have taken place throughout the proposed area to be mined. As well a forest service road traverses the entire length of Willow Creek and crosses the creek near Tributary 3 at the southwest corner of the project area.

Habitat Conditions

The Stream Survey Forms completed by NDM contract personnel in 1996 for each stream reach in the vicinity of the project area are contained in Appendix 4.6-2. Appendix 4.6-1 includes the Stream Survey Forms completed by MarLim in 1994. Photographs of typical stream reaches and/or particular features are also included in those appendices. The complete results of a previous habitat assessment by MarLim Ecological Consulting Ltd in the fall of 1994 are also included here as Appendix 4.6-1. Previous reports by IEC International Environmental Consultants Ltd (1982), based on 1981 field work (habitat surveys and fish sampling), included both the Stage I and Stage II assessments under the B.C. Coal Development Guidelines. Also included is a letter from the BC Ministry of Environment (Ableson 1982) noting the importance of the fishery resources in the Pine River, much less importance in Willow Creek, and almost no value in Middle and Far East Creeks.

The photographs by NDM and in the MarLim report are good representations of the habitat conditions in the subject streams and include all of the reaches in each creek. The MarLim report also provides a reach-by-reach description of each stream.

Below is a summary of all of the habitat and fisheries information currently available on the study streams. The key fish presence and habitat information is also shown on Figure 4.6-2, which shows habitat features in the format of the Resources Inventory Committee (RIC) as described in "Standards for Aquatic Mapping" (Draft 1997), as well as the "Lake and Stream Inventory Manual" (RIC 1995 draft). The map legend shows the meanings of the different symbols. The figures for stream gradients and channel widths shown on the maps are approximated from the field data provided by MarLim (1994) and by NDM's field work, as the stations sampled were not exactly the same in each case. Also, in some cases, words were inserted in the symbol text where there are no symbols in the references for particular conditions (e.g. step/pool habitat in organic substrate materials, or dry channel conditions. The companion manual to the Standards for Aquatic Mapping (RIC 1995 draft) is the "Reconnaissance Fish and Fish Habitat Inventory Manual", which was not yet available from RIC at the time of this writing.

Pine River

The Pine River is part of the Sukunka/Murrary/Peace river system, which connects to the Slave and MacKenzie River system. The Pine River in the project area is approximately 100 m wide (channel width) and, at the time of the surveys (late August, 1996), had a wetted width of about 30 m. The river meanders slightly and shows a predominantly glide-over-cobble habitat type with extensive bars at low water. There are pools up to 1.5 m deep (at low water) and riffle areas up to 45 cm deep. The substrate is comprised of 40-50% gravels, up to 20% fines and the remainder is boulders. There is little cover from large woody debris (LWD), deep pools, or overhanging riparian vegetation. The river flows between the BCR line on the south side and Highway 97 on the north, and there are several areas where these linear developments have encroached on the floodplain with rip-rap armouring. In some cases, oxbow ponds (old river bends) have been partially isolated from the river by the road or railway. There is also a bridge crossing of the Pine River for the access road to the Willow Creek area.

The mainstem river, while providing little covered spawning habitat in this area, does provide good rearing habitat in the oxbow ponds and sloughs, and in some deep pools and undercut banks at bends in the river. The river in this section is primarily a migration route for adult fish, but may provide important nursery habitat for juvenile fish and feeding areas for adults.

Pine River Oxbows/Back Channels

Pine River back channels in the area of the project are cut off from the mainstem by the BC Rail track. The wetlands in this area are a combination of trees (predominantly willow) and sedges (short and tall) together with open water. The surface water connection to the Pine River is through one or more culverts in the railway bed with the principal exit being on the eastern side of open water. Water interchange will also be by seepage as the railway bed is composed of gravel and therefore porous. As discussed under hydrology, water from this area will flow slowly out during part of the year, depending on the relative water levels on either side of the main connecting culvert. At flood, Pine River water backs into the back channel area. When water levels are equal on both sides of the railway bed culvert, no flow occurs (most of the open water season) and when Pine River levels are low (typically late summer), flows will be out from the back channel pond. The area of open water in this back channel pond is approximately 48,000 m2.

The pond has a very organic bottom and thus does not provide suitable spawning habitat for salmonids. However, open water areas may provide rearing and feeding habitat for juvenile and perhaps adult fish. Based on IEC Beak (1982) results for the Pine River, the back water pond populations are likely dominated by suckers (*Catostomus* spp.) which tend to favour muddy habitats (except for spawning where gravels are required).

The project will not directly affect open water habitat in this area as sediment control structures and runoff will be to adjacent (upland) willow areas.

Willow Creek

Willow Creek is by far the largest tributary creek in the Project area running from elevation 1,130 m and flowing for some 10 km to join the Pine River at approximately 630 m asl. There is a large (4-5 m) falls (rock chute - Photo 4) at the upper end of Reach 4 approximately 3.4 km from the mouth, or below Tributary 1, that forms a fish migration barrier. No fish have been found in Willow Creek above the falls after extensive electrofishing.

Lower Willow Creek has a channel width of approximately 8 m and an overall gradient of 2.2 percent. The substrate is comprised of approximately 50% gravels, 40% cobbles and 10% fines, according to the habitat mapping of IEC (1982). The second reach from the mouth, above the road and rail crossings, has an average channel width of 12 m, gradient 2.4% and substrate composition of 50% boulders, 40% gravels and 10% fines. The third reach upstream (still below the falls) is in the more steeply sided creek valley above the ancient floodplain (valley bottom) of the Pine River. The creek is approximately 10 m wide, has a slope of 5% and substrate comprised of 70% boulders, 20% gravels and 10% fines (IEC 1982).

At low summer flows, the lowermost reach of Willow Creek (Site 1 on Figure 4.4-1) flows subsurface (Photos 1 and 2) such that fish cannot move upstream or downstream (to and from the Pine River) at those times. The subsurface flow condition is likely the result of substrate transport and deposition during high flow periods. A pool approximately 7 m long and 30 cm deep just upstream of the deposition area contained numerous fish in late August, 1996, that were effectively stranded in the pool until the water level rose. Farther upstream at NDM Sites 2 and 3, the creek has sufficient depth for fish (Photos 3 and 4). Site 3 includes the base of the falls (bedrock chute) shown in Photo 4.

Just upstream of the falls below Tributary 1, Willow Creek is approximately 4 m wide with largely boulder substrate and has glide/run, shallow pool and some riffle flow types. There are patches of gravels associated with some of the boulders (Photos 5 and 6). Farther upstream, above the second tributary that drains the Project Area, Willow Creek shows a relatively wide (15 m) floodplain strewn with boulders and LWD, and including debris jams that would be fish migration barriers (Photos 9 and 10). After extensive electrofishing, no fish were found in Willow Creek upstream of the main falls shown in Photo 4.

The small (1-2 m wide) secondary tributaries that drain the Project area are steep, rocky and overgrown with riparian vegetation and windfall (Photos 13-32). They also have several rock chutes and debris jams that would be fish migration barriers. The culvert under the forestry road on the second stream (Site 6) would be a definite fish migration barrier (if there were fish in this area). The farthest upstream tributary to Willow Creek (Tributary 3) is 5-6 m wide and shows a mix of habitat types from pools to riffles and small cascades, and good riparian/LWD cover (Photos 33-38). The Ministry of Forests (MOF) recently decommissioned the road in this area by removing the culvert and regrading the creek channel.

Far East Creek

Far East Creek (Photos 39 and 40) has a fish migration obstruction (bedrock undercut falls) just upstream of the Pine River (Photo 39). It also has beaver dams and a culvert at the BCR crossing and flows subsurface in its large fan area in the trees near the BCR tracks. Much of the flow downstream of the railway line appears to enter a wetland area approximately 150 m to the northeast. Upstream, the creek is approximately 2 m wide on average and has a mix of pool, riffle and glide habitat over cobble and boulder, with good riparian cover. Non-salmonid fish were found below the falls and no fish upstream. The creek was judged by IEC (1982) "to have very little fisheries potential due to its intermittent nature, low flow, and the presence of beaver dams. A flow measurement weir (Photo 40) was installed in this creek above the falls.

Middle Creek

Middle Creek, which is only 1.75 km long and approximately 1 m wide (Photo 42), flows subsurface approximately 70 m upstream and 3 m higher in elevation from a ponded wetland immediately upstream of the culvert under the BCR line (further discussed under Pine River Oxbows). No flow was observed through the culvert by IEC in 1981 and 1982. Downstream of the railway line, Middle Creek also showed little flowing water and was judged as poor fish habitat. At higher flows, the creek flows in several small channels visible in the area above the wetland. No fish were captured by IEC in Middle Creek above or below the BCR line in either 1981 or 1982.

Fish Stocks

The historical data and the field work by NDM in 1996, MarLim in 1994 and IEC in 1981-82 indicate that the primary fish populations inhabiting the Pine River system include (in approximate order of relative abundance, based on catch data):

- slimy sculpins (*Cottus cognatus*);

- cyprinids, including suckers (*Catostomus* spp) and redside and/or spottail shiners;
- mountain whitefish (*Prosopium williamsoni*);
- Dolly Varden char (*Salvelinus malma*) or bull trout (*Salvelinus confluentus*);
- rainbow trout (*Oncorhynchus mykiss*); and
- northern pike (*Esox lucius*).

The field work by IEC in July 1981, and May and July 1982, showed only mountain whitefish (*Prosopium williamsoni*) and forage species (sculpins - *Cottus* sp) in the lower reaches of Willow Creek below the falls. No fish were found in the lowermost reaches of the other study creeks (Middle and Far East creeks), both of which have very little available habitat below fish migration barriers. Historical information (e.g. SISS) and IEC sampling also showed the above salmonid species in the Pine River.

NDM's 1996 field work found mountain whitefish, as well as char, which were tentatively identified as bull trout (*Salvelinus confluentus*), but may be Dolly Varden char (*S. malma*) and rainbow trout (*Oncorhynchus mykiss*) in the Pine River and in Willow Creek above the dry Reach 1 and below the waterfall between Reaches 4 and 5. Arctic grayling (*Thymallus arcticus*) were also caught in the Pine River. Non-salmonids, including sculpins and minnows (Cyprinidae) were also found in those areas. The beaver pond just above the BC Rail tracks in Middle Creek produced samples of cyprinids tentatively identified as redside shiners (*Balteatus richardsoni*), or spottail shiners (*Notropis hudsonius*). The fish catch results for all areas sampled are summarized in Table 4.6-3 and by area caught in Table 4.6-4.

TABLE 4.6-3

PINE VALLEY COAL WILLOW CREEK PROJECT

SUMMARY OF 1996 FISH CATCHES BY STREAM

Stream	**Species**	**Number**
Pine River	Arctic Grayling	1
Pine River	Mountain Whitefish	3
Pine River	Rainbow Trout	1
Pine River	salmonids	2
Pine River	Sculpin	18
Pine River	White Sucker	1
Willow Creek	Dolly Varden Char	4
Willow Creek	Mountain Whitefish	47
Willow Creek	Rainbow Trout	19
Willow Creek	Sculpin	11

Tributary One	no fish caught	0
Tributary Two	no fish caught	0
Tributary Three	no fish caught	0
Middle Creek	Redside Shiner ?	70
Far East Creek	no fish caught	0

TABLE 4.6-4

PINE VALLEY WILLOW CREEK PROJECT 1996 FISH CATCHES

Location	**Date**	**Method**	**Species**	**Frk. Ln. (mm)**
Willow Creek				
confluence with Pine Creek	14-Aug-96	GT	MW	90
confluence with Pine Creek	15-Aug-96	GT	SC	15
confluence with Pine Creek	15-Aug-96	GT	SC	35
reach 1, site 1	26-Aug-96	ES	MW	28
reach 1, site 1	26-Aug-96	ES	MW	35
reach 1, site 1	26-Aug-96	ES	MW	30
reach 1, site 1	26-Aug-96	ES	MW	52
reach 1, site 1	26-Aug-96	ES	MW	43
reach 1, site 1	26-Aug-96	ES	MW	48
reach 1, site 1	26-Aug-96	ES	MW	50
reach 1, site 1	26-Aug-96	ES	MW	48
reach 1, site 1	26-Aug-96	ES	MW	30
reach 1, site 1	26-Aug-96	ES	MW	40

reach 1, site 1	26-Aug-96	ES	MW	35
reach 1, site 1	26-Aug-96	ES	MW	33
reach 1, site 1	26-Aug-96	ES	SC	30
reach 1, site 1	26-Aug-96	ES	SC	40
reach 1, site 1	26-Aug-96	ES	SC	45
mouth to 145m u/s	26-Aug-96	ES	12 MW	20 to 52
mouth to 145m u/s	26-Aug-96	ES	3 SC	30 to 45
mouth to 145m u/s	27-Aug-96	ES	3 SC	26 to 60
mouth to 145m u/s	27-Aug-96	ES	22 MW	30 to 50
mouth to 145m u/s	27-Aug-96	ES	RB	155
site 2	28-Aug-96	ES	RB	87
site 2	28-Aug-96	ES	RB	93
site 2	28-Aug-96	ES	RB	103
site 2	28-Aug-96	ES	RB	140
site 2	28-Aug-96	ES	RB	145
site 2	28-Aug-96	ES	RB	152
site 2	28-Aug-96	ES	RB	165
site 2	28-Aug-96	ES	RB	90
site 3, falls to 120m d/s	28-Aug-96	ES	RB	190
site 3, falls to 120m d/s	28-Aug-96	ES	RB	190
site 3, falls to 120m d/s	28-Aug-96	ES	RB	193
site 3, falls to 120m d/s	28-Aug-96	ES	RB	196

site 3, falls to 120m d/s	28-Aug-96	ES	RB	200
site 3, falls to 120m d/s	28-Aug-96	ES	RB	205
site 3, falls to 120m d/s	28-Aug-96	ES	RB	210
site 3, falls to 120m d/s	28-Aug-96	ES	RB	220
site 3, falls to 120m d/s	28-Aug-96	ES	RB	230
site 3, falls to 120m d/s	28-Aug-96	ES	DV	222
site 3, falls to 120m d/s	28-Aug-96	ES	DV	240
site 3, falls to 120m d/s	28-Aug-96	ES	DV	240
site 3, falls to 120m d/s	28-Aug-96	ES	DV	330
135m d/s of falls	28-Aug-96	GT	RB	128
Pine River				
60m u/s of forestry bridge, South bank	27-Aug-97	ES	RB	90
60m u/s of forestry bridge, South bank	27-Aug-97	ES	WS	195
60m u/s of forestry bridge, South bank	27-Aug-97	ES	MW	180
60m u/s of forestry bridge, South bank	27-Aug-97	ES	MW	220
d/s of Willow Creek confluence, South bank	27-Aug-97	ES	MW	40
d/s of Willow Creek confluence, South bank	27-Aug-97	ES	GR	37
d/s of Willow Creek confluence, South bank	27-Aug-97	ES	18 SC	25 to 75
Middle Creek				
wetland below where creek goes underground	13-Aug-96	GT	RSS ?	60
wetland below where creek goes underground	13-Aug-96	GT	RSS ?	65
wetland below where creek goes underground	13-Aug-96	GT	RSS ?	75

wetland below where creek goes underground	14-Aug-96	GT	RSS ?	40
wetland below where creek goes underground	14-Aug-96	GT	RSS ?	45
wetland below where creek goes underground	14-Aug-96	GT	RSS ?	50
wetland below where creek goes underground	14-Aug-96	GT	RSS ?	55
wetland below where creek goes underground	14-Aug-96	GT	RSS ?	55
wetland below where creek goes underground	14-Aug-96	GT	RSS ?	60
wetland below where creek goes underground	16-Aug-96	GT	61 RSS ?	25 to 90

ES:electroshocker, GT: gee trap

GR: Arctic Grayling, DV: Dolly Varden Char, MW: Mountain Whitefish, RB: Rainbow Trout,

RSS: Redside Shiner, SC: Sculpin, WS: White Sucker

The key life cycle information for the fish species known to inhabit the Pine River in the general project area is summarized in Table 4.6-5. Mountain whitefish and Dolly Varden char (or bull trout) are fall spawners, while rainbow trout, Arctic grayling and northern pike spawn in the spring, as do the cyprinids and cottids (sculpins).

TABLE 4.6-5

KEY LIFE CYCLE INFORMATION OF LOCAL FISH SPECIES

Fish Species	Spawning Period	Egg Incubation to Fry Emergence
Arctic Grayling	April to June (when the ice breaks up)	eggs hatch 13 to 18 days after fertilization and the young spend 8 more days in the gravel
Dolly Varden/ Bull Trout	September to early November	eggs hatch 4.5 months after fertilization (March to May), and the fry emerge after 18 more days
Mountain Whitefish	late fall to early winter	eggs hatch 4 months after fertilization (spring) and the fry spend a few weeks in the stream shallows
Rainbow Trout	March to August (mainly mid-April to late June	eggs hatch from April to October (4 to 7 weeks after fertilization) and the fry spend a few more weeks in the gravel

Redside Shiner	May to early August	eggs hatch from May to early August (3 to 15 days after fertilization) and the young spend a week in the gravel
Slimy Sculpin	spring	eggs hatch several weeks after fertilization
White Sucker	early May to early June	eggs hatch 2 weeks after fertilization, and the fry emerge from the gravel 1 to 2 weeks later

For the spring spawning species, the critical egg incubation and early fry rearing period is in late spring and through to late summer. The typical window of reduced risk to fish from instream disturbances is in the mid to late summer period, as the fry will have emerged from the stream gravels and are less vulnerable to sedimentation or direct disturbance as they are then mobile.

For the fall spawners, the eggs and alevins (yolk-sac-fry) are in the gravels as early as August and do not emerge until the following spring. This includes species such as the Pacific salmon, char (Dolly Varden, or bull trout) and the whitefishes. Generally, no instream construction work is allowed by the regulatory agencies during the fall months for that reason.

Fish Diets

The IEC studies included detailed analyses of the stomach contents of Pine River mountain whitefish categorized by fish age classes. The 1+ and 2+ fish ate primarily (86-87%) chironomids, while stoneflies, caddisflies and mayflies made up increasing proportions of the diets of older fish, such that the 6+, 7+ and older fish showed only 4-6% chironomids and large proportions of the larger insects. A similar pattern, plus fish-eating, would likely occur in the other salmonids in the area (i.e. eating larger food items with increasing age and size).

4.7 BENTHIC INVERTEBRATES

Aquatic invertebrate sampling was conducted by IEC in the Pine River, Willow and Far East creeks in July 1981; Middle Creek was not sampled due to the absence of water. Seven sites were sampled as follows:

- Pine River: 3 sites;
- Willow Creek: 3 sites;
- Far East Creek: 1 site.

Triplicate samples were collected at each site with a Surber sampler with a 0.093 m2 area and 253 mm mesh net. Results were tabulated by IEC Beak in Table 3.8-2 of their report; the table is attached for reference in this report, Appendix 4.7-1.

IEC Beak divided benthic invertebrates into three groups (1 through 3) based on their known stress tolerance: Group 1, most stress tolerant through Group 3, least stress tolerant. Groups were as follows:

Class	**Stress Tolerance Group**

Ephemeroptera Trichoptera Plecoptera Hemiptera Coleoptera Odonata	Group III
Diptera	Group II
Hymenoptera Hirudinea Mollusca	Group I

IEC Beak provided the following summary of results:

Stream	Pine River		Willow Creek		Far East Creek	
Biotic Group	Total No. Organisms	% of Total No.	Total No. Organisms	% of Total No.	Total No. Organisms	% of Total No.
1	1	0.1	1	0.1	14	38.9
2	438	60.7	417	44.1	20	55.6
3	282	39.1	528	55.8	2	5.6
Total	**721**	**99.8**	**946**	**99.9**	**36**	**100.1**

Far East Creek had the lowest numbers of organisms and taxa. It also had a higher proportion of Group 1 organisms and fewer Group 3. IEC Beak concluded this creek's benthic communities were under more stress than Willow Creek or Pine River's. The most likely reason was seen to be the intermittent nature of the creek, the impoundment of water behind beaver dams and the greater percentage of fines in the sediment due to intermittent flows.

4.8 PERIPHYTON

4.8.1 Methods

Attached algae, particularly epilithic algae growing on rocks (periphyton) and including primarily single-celled diatoms as well as filamentous green (Chlorophyta) and blue-green (Crysophyta) algae) were sampled from two (2) locations in the Pine River - upstream and downstream of the project area, as well as at five (5) sites in Willow Creek (see Figure 4.8-1) in late August, 1996.

The periphyton sampling sites corresponded to the water quality stations and were often near the hydrology staff gauge sites. At each station five (5) rocks with periphyton cover were selected for each of five (5) samples. The samples were taken with a stainless steel razor blade from a 5 cm by 5 cm (25 cm2) area on each rock and composited in a wide mouth glass jar. Thus, five (5) samples were taken at each station, each comprised of algae from five different rocks. Each of the five replicate samples from each station was filtered separately onto acetate filters and each filter cut into three (3) approximately equal parts for biomass, chlorphyll *a* and taxonomic analyses.

The five (5) samples at each site for biomass and taxonomy were further composited prior to analysis, while those for chlorophyll *a* were each analyzed separately. Those filter sections for chlorophyll *a* analysis were dry filtered, preserved with magnesium carbonate, placed in petri dishes with a tight fitting lids, labelled and wrapped in aluminum foil to keep them dark, and frozen. The filter section for biomass determination was treated similarly, except no magnesium carbonate was used. The filter section for taxonomic identification was washed off the filter with distilled water, preserved and stained with acid Lugol's solution, labelled and shipped to the taxonomic laboratory (Zenon Environmental Laboratories).

Biomass (ash-free dry weight) was determined in the following manner. Each sample was thawed, homogenized and evaporated in a platinum crucible over a steam bath. The residue was then dried in an oven at 105oC to constant weight (dry weight biomass). The crucible was then placed in a muffle furnace at 550oC for 30 minutes until desiccated, and weighed for fixed weight (ash-free) biomass.

The chlorophyll *a* content of the periphyton samples, also a measure of biomass, was determined by Zenon by extracting the chlorophyll pigments from the filters using an aqueous solution of acetone and magnesium carbonate and grinding. The extract was centrifuged and the absorbance of the extract measured by light spectroscopy (Hewlett Packard 8452A Diode Array Spectrophotometer) at 750, 663, 645 and 630 nanometres (nm) wavelength light.

In the taxonomic laboratory, each periphyton sample was sub-sampled according to the standard methods of APHA (1989). For each sub-sample of 100 mls with a 5X dilution factor, 10 fields

were analyzed under 1,000 power. The numbers of the different taxa were calculated for each square centimetre of original sampling area. Quality control included recounts of 10% of the sub-samples by independent taxonomists. Following the taxonomic analysis, representative portions of the samples were archived as a reference collection.

4.8.2 Trophic Status

4.8.2.1 Sampling Sites

The upper Willow Creek (WC1) sampling station, located just above the hydrology staff gauge, showed abundant brown algal scum on the rocks with sediments entrapped in the algae. There was also submergent moss and green filamentous algae evident at this site. Numerous larval insects and egg masses of snails were also observed on the rocks. Three (3) samples of "brown scum" (diatomaceous material) and two (2) samples of lime green material (green algae - Chlorophyceae) were composited for taxonomic analysis.

Tributary 3 in upper Willow Creek had moderate amounts of brown algae, some green communal algae and egg masses. Benthic invertebrates also appeared to be plentiful. Four (4) samples of primarily diatomaceous material were composited for taxonomic analysis.

Far East Creek (FEC1) near the staff gauge showed little evidence of brown or green algae. There was abundant moss cover on the stream bed and benthic invertebrates were evident. No periphyton samples were taken on Far East Creek.

Middle Creek (MC1) approximately 80 m upstream of the staff gauge has relatively small and unstable substrate sizes such that periphyton growth is inhibited by substrate movement. Little evidence of periphyton was found, including no brown scum (diatoms) and very little green material (filamentous algae). Molluscan egg masses were observed on some rocks. No periphyton samples were taken on Middle Creek.

Pine River upstream of the Project site (PR1) had heavy sediment loads in bed cobbles both upstream and downstream of the water quality site. All rocks sampled had to be rinsed in the river prior to sampling. Only diatoms were collected at this site.

Pine River downstream of the Project site (PR2) had moderately heavy sediment loads nearshore. Samples were collected 3 to 5 m from shore. Diatoms accounted for approximately 75% of cover and green algae about 25%.

Lower Willow Creek (WC2) near the road bridge showed abundant brown algal material, some green algae and considerable moss. A large community of lime green filamentous algae was found on cobble substrate below a pool. Three (3) samples of diatomaceous material and two (2) samples of green algae (Chlorophyceae) were composited separately for taxonomic analysis.

Tributary 2 near the staff gauge and data logger showed relatively little attached algae, except some green material evenly coated on a few rocks. Egg masses of gastropods were abundant. Tributary 2 above the road crossing also showed little brown "scum" (green diatoms with silt)

and very little green filamentous algae, particularly as the creek becomes steeper farther upstream. Benthic invertebrates were evident in the substrates. Five (5) samples of periphyton were taken and composited for taxonomic analysis.

Tributary 1 had abundant aquatic moss near the staff gauge with filamentous green algae growing on the moss. Very little periphytic algae was found, especially on the steeper gradients. Egg masses were evident on many rocks. Five (5) samples were taken of the brown scum (primarily diatoms) and composited for taxonomic analysis.

4.8.2.2 Taxonomy

The relative abundance of the different taxonomic groups of attached algae are shown in tables and schematically in Appendix 4.8-1, while the percentage abundance data are summarized in Table 4.8-1.

TABLE 4.8-1

PINE VALLEY WILLOW CREEK PROJECT SUMMARY OF PERIPHYTON BY STATION

Station	**Biomass Dry Wt (mg)**		**Biomass Fixed Wt (mg)**		**Chlorophyll A (ug/cm2)**		**Three most Commonly**
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Found Species**
PR1		291		240		7.75	*Achnanthas minutissima*
							Stigeoclonison lubricum
							Chroomonas acuta
PR2	38 to 195	116.5	34 to 165	99.5	4.08 to 4.16	4.12	*Stigeoclonium lubricum*
							Achnanthes minurissima

							Achnanthes minutissima
WC1	26 to 70	48	18 to 39	57	0.35 to 2.36	0.83	*Stigeoclonium lubricum*
							Achnanthes minutissima
							Cocconeis placentula
WC2	57 to 90	73.5	39 to 68	53.5	2.06 to 4.70	3.01	*Stigeoclonium lubricon*
							Navicula spp.
							Oscillatoria tenuis
TRIB 1		36		24		3.57	*Stigeoclonium lubricum*
							Chroomonas acuta
							Oscillatoria sp.
TRIB 2		35		21		2.83	*Srigeoclonium lubricum*
							Oseillatoria tenuis
							Chroomonas acuta
TRIB 3		103		62		6.23	*Stigeoclonium lubricion*
							Cocconois placennula
							Achnanthes minutissima

The primary periphyton taxa typically included:

- the green algae (Chlorophyta) of the Class Chlorophyceae and Order Chaetophorales, particularly the species *Stigeoclonium lubricum*;
- blue-green algae (Division Cyanophyta; Class Cyanophyceae; Order Oscillatoriales; Genus and Species *Oscillatoria tenuis*)
- brown algae of the Division Pyrrophyta, Class Cryptophyceae (cryptomonads), Order Cryptomonadales, particularly *Chroomonas acuta*; and
- diatoms of the Division Chrysophyta, Class Bacillariophyceae (diatoms), Order Pennales, especially the species *Cocconeis placentula* and/or *Achnanthes minutissima*.

By sampling areas, the Pine River mainstem, both above and below the project area, showed primarily the diatom *A. minutissima* and the green filamentous from *S. lubricum*. The latter alga (green filamentous) was relatively abundant at all stations sampled, including mainstem and tributary sites.

The numbers of different taxa (Genera used here) at each station provides a relative comparison of species diversity, or richness, at the different stations. A rigorous statistical comparison is not necessary, as there is no relevant reason to compare stations in the baseline work, and as many of the species listed at each site are shown only as "present" if they represented very small proportions (<<1%) of the algal communities in each case (see laboratory results in Appendix 4.8-1).

The range in numbers of genera of periphyton found in the project area was 21-34, the highest number of taxa being at the lower station in Willow Creek and the lowest at the upper station in Willow Creek and the lower station in the Pine River. The upstream station in the Pine River showed 28 periphyton genera.

Tributaries 1, 2 and 3 in the Willow Creek drainage showed intermediate numbers of taxa in the epilithiphyton and the same dominant forms as in the larger streams.

Numerous other studies of periphyton in north temperate waters have found similar total numbers and community structures (e.g. Perrin et al. 1987; Deniseger et al. 1986; Shortreed and Stockner 1983; Crossey and LaPointe 1988). The diatom *Achnanthes* is often dominant, including in acidic and high metal ion conditions. It was also often found in other studies cited in these papers that filamentous algae increase at times of low flow, high light irradiance and high nutrient concentrations.

Chadwick and Canton (1983) found in a study of periphyton, benthos and fish in a creek adjacent to an active coal mine in northwest Colorado that the creek supported 107 species of periphyton, with less than 30% of the same species at all stations, and that the Bacillariophyta (diatoms) were consistently the dominant periphyton group. The periphyton community downstream of the mine showed slightly lower diversity (numbers of species), but similar to a clean water community. They also found no significant differences in fish abundance upstream and downstream of the mine.

In a study by Crossey and LaPointe (1988) of the effects of heavy metals on periphyton in Prickly Pear Creek, Montana, 89 algal taxa were identified in the creek, 79 were diatoms, while only 6 were Cyanophytes (blue-green algae) and four were Chlorophyta. The green alga *Ulothrix* sp. and the blue-green *Chroococcus* sp. were relatively abundant in the impact zone, while not found at the control sites (Crossey and Lapointe 1988).

In Myra Creek on Vancouver Island a lead-zinc-copper mine began operating in 1966-67. Significant increases in copper, zinc and cadmium were detected at the downstream monitoring station just above Buttle Lake. Nitrate, nitrite, ammonia and silica concentrations were also slightly elevated at the lower site. At the upstream control site, a total of 61 species of periphytic algae were found, while 38 species were found at the downstream station. Sixty-four (64) algal species in total were found in Myra Creek. Forty-five of the 61 species at the upstream station were diatoms, 12 were chlorophytes, 2 were chrysophytes and there was one species each of cyanophytes and pyrrophytes. At the downstream station, 31 of the 38 algal species were diatoms, while 5 were chlorophytes and one each of chrysophytes and pyrrophytes. Cell densities ranged from 211.4 to 2246.42 cells/mm2. In July-September, the dominant species were *A. minutissima, A. microcephala* and *Eunotia serra* and others. In summer, the filamentous green algae such as *Ulothrix* spp., *Zygnema, Spprirogyra, Mougeotia and Cladophora* increased in relative abundance.

Perrin et al. (1987) studied the Keogh River on the Queen Charlotte Islands and found that diatoms comprised most of the biomass of the attached algae. *Tablellaria* and *Synedra* were most common, and *Achnanthes* spp. showing up to 50% of the numbers in some samples. *Fragilaria* and *Diatoma* were also present as minor components.

The baseline data on periphyton community structure in the Project area will be used for comparison to future monitoring results. The upstream station in Willow Creek and in the Pine River will also provide reference/control sites for same-time comparisons with the potentially affected sites. Periphyton are communities of interacting organisms; some are sensitive, some resistant and some in between. The differences can provide a measure of natural perturbations from anthropogenic influences (Genter et al. 1987).

4.8.2.3 Biomass

Biomass, measured as the ash-free dry weight of periphyton, was determined for composited samples at each water quality station. The results (Table 4.8-1) suggest slightly higher standing crops of periphyton per unit area in the larger system (Pine River mainstem) than in the smaller creeks. The upstream station on Willow Creek (WC1) showed 18-39 mg/cm2, Tributary 1 showed 24 mg/cm2, while the mainstem river had 291 mg periphyton/cm2 at the upstream station and 38-195 mg/cm2 at the downstream site.

Shortreed and Stockner (1983) studied periphyton biomass, species composition and accumulation rates on plexiglass plates in Carnation Creek, Vancouver, Island. The study was part of a multidisciplinary study of the effects of logging on a coastal stream ecosystem. They found that periphyton biomass was highest during periods of low/stable flows, high light intensity, relatively high temperatures. Light was not a limiting factor, nor was water temperature. Phosphorus (P) was considered the limiting factor to periphyton production in the logged and unlogged parts of the creek system. They concluded that logging had little effect on the periphyton community and any changes to the fish and/or invertebrate populations in the creek were due to physical habitat changes. However, they also concluded that "In nutrient-limited, fast-flushing coastal streams such as Carnation Creek, the efficacy of nutrient enrichment in stimulating autotrophic production and providing an increased food resource for stream benthos should be investigated. If such experiments were successful the negative effects of logging on the stream ecosystem could be considerably reduced."

Bothwell (1985) found that P content limits algal growth in the Thompson River and that soluble reactive phosphate (SRP) concentrations of 3-4 mg/l are sufficient to saturate P-limited growth rates. Stockner and Shortreed (1978) found that, in Carnation Creek, chlorophyll *a* levels increased by more than 10 times with increases in SRP levels from <1 to 8-10 mg/l. By adding inorganic N, as well as P, a further doubling of biomass to >200 mg chlorophyll *a*/m2. "Nuisance" levels of algae are often defined as 100-150 mg chlorophyll *a*/m2. The mean weights of juvenile salmonids in the experiment increased by up to 80% over controls due to the nutrient treatments.

Perrin et al. (1987) concluded that "grain additions significantly increased mean weights of coho fry by up to 58% over fry weights in the control reach. By comparison, juvenile coho growth increased rapidly with the onset of fertilizer additions, resulting in up to an 82% gain in mean weights in the same growing season. Mean weights of juvenile steelhead trout were not significantly different between the control and T1 but were 67% heavier in fertilized reaches compared with the control. Hence, while grain additions can increase insect standing crop in nutrient-replete streams (Mundie et al. 1983), increased autotrophic production by nutrient addition results in greater benefit for growth of salmonids in a nutrient-deficient stream."

4.8.2.4 Chlorophyll a Content

The results of the periphyton sample analysis from the Pine Valley Coal project area summarized in Table 4.8-1. The chlorophyll *a* content of the periphyton at the farthest upstream station on Willow Creek (Water Quality Station WC2 just above Tributary 3) showed values for the five samples ranging from 2.06 to 4.70 micrograms per square centimetre (mg/cm2), while the lowermost station in Willow Creek showed chlorophyl *a* content of 0.35 to 2.36 mg/cm2 (Table 4.8-1). The chlorophyll *a* content in periphyton from Tributary 1 was 3.57 mg/cm2. The chlorophyll *a* content of the periphyton samples from the Pine River above and below the project area was 7.75 mg/cm2 at PR1 upstream and 4.08 and 4.16 downstream (Table 4.8-1).

Boston and Hill (1991) found that biomass, as measured by chlorphyll *a* content in periphyton, tended to increase with increasing incident light (though not a strong correlation) and that most of the photosynthesis occurs in the upper layers of a periphyton community. Increasing biomass of periphyton can become a limiting factor to overall photosynthetic productivity due to shading of lower layers in the algal matrix. Sloughing of periphyton from rocks may also be due to poor condition of the cells in the lowermost layers of periphyton patches (Boston and Hill 1991). They also found a lower reaction to increases in nutrient content in the water for periphyton than for phytoplankton, again due to the matrix formations that occur with periphyton populations.

Biomass estimates are also often confounded by the different grazing/cropping rates of invertebrate organisms, which can, in turn be affected by the fish populations that prey upon the invertebrates (e.g. Perrin et al. 1987). Also, in some of the diatoms and green algae, chlorophyll *a* may be masked by carotenoid pigments (carotene *a* and *b*), while others have no pigments. The pennate diatoms are also motile and able to move using a whip-like raphe (Scagel et al. 1965).

As noted above, however, where periphyton growth is limited by low nutrient concentrations (especially P as orthophosphate, or SRP) significant gains in primary production can be achieved through nutrient additions. The increases in primary production can, in some circumstances, be reflected in increases in benthic invertebrate and fish biomass. Where it is possible to increase fish production by increasing primary production, that option may be a viable fisheries enhancement measure.

4.9 BIOTERRAIN AND SOILS

4.9.1 Introduction

This section describes the terrain analysis and soil classification component of the Terrestrial Ecosystem Mapping (TEM) carried out in the Willow Creek drainage, approximately 45 kilometres west of Chetwynd, B.C.

Terrain mapping was carried out following the Terrain Classification System for British Columbia (Section 4.9.2.1). Mapping was done on large scale colour air photos by air photo interpretation, followed by extensive field checking by means of ground traverses. Physical conditions that influence ecosystems were taken into account whilst mapping ("bioterrain

mapping"). Identification of soil types was completed to the Subgroup level according to the Canadian System of Soil Classification (Section 4.9.2.2). Soil classification was completed for each polygon during terrain field checking.

This section augments the information shown on the bioterrain maps (Figures 4.9-1 and 4.9-2) and map legend. It includes descriptions of the methodology used for terrain mapping and soil classification, and provides a general overview of the physiography of the project area. Additional information about surficial materials, geomorphological processes, and soil classes is given in Sections 4.9.4 to 4.9.6.

4.9.2 Methods

4.9.2.1 Terrain Mapping and Mapping Reliability

Terrain mapping was carried out following the Terrain Classification System for British Columbia (Howes and Kenk, 1988; RIC, 1995). Preliminary terrain mapping was done by interpretation of large scale air photos (approximate scale 1:20,000). On the photos, the area was examined closely and terrain polygons were delineated, based primarily on surficial material characteristics, topography, and other geomorphological patterns, such as gullying. Polygon boundaries were also drawn to take account of aspect, drainage conditions, and where possible, vegetation types cover, in order to provide a basis for the ecological mapping. Air photo interpretation was done by J. Barraclough, and checked by T. Randall, both prior to and following field work. The overall reliability of terrain symbols, however, is based primarily on ground observations.

Mapping on air photos was confirmed during field work carried out between September 18-25, 1996. Terrain characteristics were checked by means of extensive ground traverses, carried out in conjunction with the ecological and wildlife surveys. The field work resulted in the field checking of 68 of 124 polygons initially delineated in the study area, or 55% of the polygons. Thus mapping in the area was conducted at Terrain Survey Intensity Level (TSIL) B. Of these polygons, 17 were delineated based solely on a change in vegetation and/or aspect rather than a change in surficial material. Additional polygons were delineated during ecosystem mapping, largely due to the addition of biogeoclimatic lines.

It should be kept in mind that terrain mapping was carried out at an air photo scale of approximately 1:20 000. Thus local variations in terrain conditions over distances less than about 100 m (0.5 cm on the photos) were usually not mapped. Therefore, there are within-polygon variations in slope steepness, material characteristics and soil moisture, as well as local inclusions of materials other than those mapped.

4.9.2.2 Soil Classification

A major component of the field work was to identify the soil type at each ecological plot where detailed or visual forms were completed, based on the Canadian System of Soil Classification (Expert Committee on Soil Survey, 1987). Terrestrial ecosystem mapping requires that the soil

class be determined to the subgroup level. Soil pits were dug to a depth of approximately 60 centimetres at roughly the centre of the plot or visual site. (This pit was also used to verify the air photo interpretation of surficial materials). Criteria used for soil classification include presence of diagnostic horizons, and horizon thickness. Other soil characteristics, such as texture, coarse fragments, soil structure and soil drainage were also noted.

Similar to terrain mapping, one must be aware that there are variations in soil type within polygons. Soil characteristics are determined by the five factors of soil formation: climate, aspect, parent material, drainage, and topography. While factors such as aspect and climate are relatively constant within a polygon, factors such as parent material, slope steepness, slope position and hence soil drainage, may vary slightly or substantially over a distance of only a few metres. The result is that although the plot is completed at a representative site, there are variations in soil class that are not recorded.

4.9.3 Results

4.9.3.1 Physiography

General Topography and Bedrock Geology

The Willow Creek project area drains into the Pine River within the Rocky Mountain Foothills physiographic region (Holland, 1976). The foothills are at their widest extent at the latitude of Willow Creek, approximately 72 kilometres. The tallest peaks surrounding the study area reach an elevation of nearly 1425 m, while the Pine River floodplain is at an elevation of approximately 630 m. This order of relief, about 800 m, is typical for the foothills in the vicinity of Pine Valley.

In general, the bedrock of the foothills is folded along northerly to northwesterly-trending axes and cut by southwesterly-dipping thrust faults, resulting in a complex mixture of rock types. The greater relief of the Foothills near Willow Creek, as compared to that further east, can be directly attributed to geology. Increased intensity of folding and faulting to the west has resulted in a generally more rugged topography. The vicinity of the study area is underlain by Triassic limestones, siltstones, and sandstones, while the eastern Foothills are composed of Cretaceous sandstones and shales.

Often the underlying bedrock geology can have profound effects on the texture and composition of the surficial material found above it. However, this was not the case as a correlation between texture of soils and bedrock was not determined. This may be the result of the small size of the Willow Creek valley leading to mixing of locally derived materials. Furthermore, the area may be dominated by till transported from outside the study area.

Bedrock geology is further discussed in Section 2.1 and surficial geology in Section 4.3, which see.

Evolution of the Landscape: Glacial and Postglacial History

Most terrain characteristics date from events of the past 30,000 years, including Fraser Glaciation and postglacial time. Prior to Fraser Glaciation, the general topography of the study area likely was very similar to that of the present. The major valley glacierss, tributaries, and mountains appeared much the same as they do today, the result of a dozen or more previous glaciations, presumably similar in nature to the Fraser Glaciation.

At the onset of Fraser Glaciation, cirque and valleys glaciers developed in the Rocky Mountains west of the project area. Ice expanded eastward and flowed through the valleys of the Rocky Mountain Foothills. Easterly trending valleys, such as Pine Valley, were widened and deepened, while those trending to the northwest, like Willow Creek, generally were not eroded to the same extent. However, an extensive mantle of till was deposited in the Willow Creek valley, as in all valleys of the area (Holland, 1976). This deposition of material is the most significant impact of the Fraser Glaciation on the study area.

The last 11,000 years have produced mainly cosmetic changes to the landscape. These modifications are the product of processes such as weathering of the till surface to produce a mineral soil, and frost shattering of rock faces and local rock outcrops resulting in rockfall. Further processes of degradation have included: flowing water, debris flows, landslides, and wind. Streams have eroded into drift and bedrock, and fluvial gravels have been deposited in fans and floodplains along the major streams.

4.9.3.2 Surficial Materials and Associated Landforms

The following descriptions are based on observations of materials exposed in road cuts, stream cuts, tree-throw hollows, and soil pits. Material characteristics were recorded at specific sites, and general observations were made continuously during traverses.

Till (M)

Till (morainal material) was deposited directly by glacier ice. Typically, it is a massive (non-stratified), poorly-sorted material with clasts (particles >2mm) supported by a fine-grained matrix of sand and silt, and in some places, a small amount of clay. Till is usually the most highly consolidated (densest) and strongest of all the surficial materials. Permeability of till is generally low.

Till is common throughout the project area and appears to be either a dominant or a subdominant component in many terrain symbols. Till blankets (Mb) and veneers (Mv) are restricted mainly to smooth, gentle to moderately steep slopes. On slopes mapped as till blanket, till is thicker than 1 or 2 m; thinner till was mapped as a veneer. Mantle of variable thickness (Mw) is shown on hummocky and/or undulating slopes where till fills depressions in an irregular bedrock surface; till thickness varies continuously from zero to several metres, and rock outcrops may be common. Till is thin or absent on rises and ridges, and thicker in depressions.

Within the project area, there is some variability in the relative amounts of sand, silt and clay in the till matrix. Till at the northwest end of the study area is generally of a silty sand texture, with

some polygons characterized by a sandy silt texture. However, as one moves toward the southeast portion of the area, the texture tends to become finer. For example, till in the centre of the area is generally dominated by a sandy silt matrix, while in the southeast, the matrix is predominantly a sandy mud; (“mud” is a mixture of silt and clay). Soil drainage is relatively poor for finer-textured tills, and this may encourage sloughing of roadcuts and soil creep.

Clasts in the local till are chiefly subangular and subrounded pebbles and cobbles consisting predominantly of sandstone and siltstone. Other rock types identified include conglomerate, limestone, quartzite, and shale. Generally, till in the study area had a clast content between 20 and 30%. Till is moderately consolidated where unmodified by the surface environment. It is usually dark grey in colour, and grades to browner tones where modified by weathering and soil-forming processes. Due to its typically low permeability, soils derived from till are commonly wet and unstable on steep slopes.

Colluvium ©

Colluvium is material that has moved downslope due to any of a variety of gravitational processes, including rockfalls, debris flows, and snow avalanches. The physical characteristics of colluvium are closely related to its site and mode of accumulation, as well as its source material. Thus, the texture and other characteristics of colluvium vary widely.

In the study area, colluvium is only a minor component in most terrain polygons where it was mapped. It is derived from the fractured rock of bedrock outcrops and from the downslope movement of till and other materials. Generally, colluvium contains a wide range of sizes of sub-angular to angular fragments (rubble and blocks) with interstitial silty sand or sand (e.g., sxCv). Colluvium is typically loose, non-cohesive, highly porous and permeable, and thus typically gives rise to relatively well-drained sites.

Fluvial Materials (F, FA)

Fluvial materials have been transported by flowing water. Fluvial gravels and sands are loose, non-cohesive, and highly porous and permeable. Associated terrain that is close to stream-level, such as floodplains and parts of fans, has a high water table and is moderately to imperfectly drained. In soil pits excavated on the Pine River floodplain, only silts, sands, and fine gravels were observed. Old borehole data near Hasler Creek to east indicates thick fluvial valley fill on the order of 300 m, suggesting that coarser fluvial materials (cobbles, boulders) may be present at depth (David Minerals, pers. comm., quoted in IEC Beak 1982).

Near the northwest corner of the study area, a large fluvial fan has been deposited by Willow Creek. This landform has many of the same characteristics as the floodplain, but it is better drained due to its gradient and lower water table. Although, fluvial materials make excellent aggregate sources for road construction, extraction should be avoided on floodplains because of their ecological significance as riparian areas.

Glaciolacustrine Materials (LG)

Glaciolacustrine (or glacial lake) sediments consist of fine sand, silt, and clay carried by meltwater streams and settled out in temporary, ice-dammed lakes. If these sediments contain even a modest proportion of silt and clay, they are only slowly permeable, or effectively impermeable. Thus the presence of a thin layer of silty or clayey material is sufficient to cause impeded drainage, perched water tables, and surface seepage. All these conditions promote instability and soil creep. Also, these materials are susceptible to surface erosion by running water.

Glaciolacustrine sediments were mapped in only one polygon, in a scarp presently undercut by the Pine River at the northern corner of the TEM study area(5) and outside the Project area. Development in this polygon, whether it be road construction or mining excavation, could result in increased sediment release to Pine River. Where glaciolacustrine materials underlie other surficial materials they are very hard to identify unless exposed in roadcuts, slide scarps or stream cutbanks. Consequently the extent of glaciolacustrine material in the study area, especially near the Pine River, may be under-represented by the mapping.

Organic Materials (O)

Organic materials (peat, muck) accumulate where decomposition of decaying vegetation is slow due to waterlogging and cold ground temperatures. In this area, organics tend to be limited to sites on the Pine River floodplain and to sites in the southeastern part of the project area. The project has been designed to minimize disturbance of organic materials.

4.9.3.3 Active Geomorphological Processes

Debris Slides, Debris Flows, and Rock Fall (-R”s, -Rs, -R”d, Rd, -R”b, -Rb)

Rapid mass movement includes falling, bouncing, rolling, sliding, or flowing of dry, moist or saturated debris derived from surficial material or bedrock. Initiation zones, indicated by **-R”**, are unstable slopes that may be further destabilized by logging or mining. Runout zones, indicated by **-R**, are affected by processes such as debris flows that may be hazardous to people and equipment, but human activities are unlikely to significantly aggravate the basic problem.

Debris slides (**-Rs, -R”s**) are a variety of small landslide. They occur when a mass of glacial drift or weathered bedrock becomes detached from a hillside and moves rapidly downslope by sliding along a shear plane. Slides are triggered by heavy rain onto ground that is already saturated, and result from loss of soil strength due to high pore water pressure. During wet conditions, slides are also triggered by wind stress on trees, tree-throw, impact of falling rocks from upslope, and vibrations due to earthquakes or human activity. If the sliding debris is saturated, or if debris falls into a steep stream and becomes saturated, it will be transformed into a debris flow (**-Rd, -R”d**). A debris flow is the rapid flow of a mass of viscous material, consisting of mud, sand, stones, and organic debris. Erosion by debris flows results in loss of soil and vegetation cover, and the development and enlargement of gullies.

Debris slides and flows can be significant potential source of stream sediment, and may pose a hazard to people and structures (roads, culverts) located downslope. Debris slides and flows are found throughout the project area, but not in great numbers. Most of the slides are along gully sidewalls above Willow Creek itself or along the slope forming the northeast TEM study boundary east of Far East Creek.

Further upslope, surficial materials are thinner and rockfall becomes a more common process than debris slides. Rockfall involves the release of relatively small masses of rock (e.g., a single block or a few cubic metres) and movement downslope by free fall, rolling and bouncing. Rockfall is a hazard beneath rock outcrops on open slopes and in gullies. On the terrain maps, symbols such as Rs-**R”b** are used to indicate source areas for rockfall. Rockfall is not widespread within the project area.

Slow Mass Movement (-F, -F”)

Failing (**-F”**) is used to describe areas subject to enhanced soil creep where soils are moving away from upslope obstacles (e.g., roots, boulders) or where materials have travelled a short distance downslope. Small slumps and slides in till along gully sidewalls, and unstable bedrock with tension cracks are included in this category. Once exposed, slumped sediments and the scar are then subjected to surface erosion. Recognition of slow slumping in the field is based upon exposed surficial material and the presence of tension cracks and tilted or toppled trees. Slow mass movement is found on the steep gully walls of Far East Creek along the northeast edge of the project area. This polygon, with slopes commonly greater than 70%, is subject to slow failure in till and weathered bedrock fragments (colluvium). However, failing (**-F”**) is not a widespread process in the Willow Creek TEM study area.

Gully Erosion (-V)

Gullies are small ravines with a V-shaped cross-section formed in drift and/or bedrock. The symbol is usually applied to terrain polygons where more than one gully is present, or to an individual gully large enough to delimit as a separate terrain polygon. Gullies are formed by the erosive effects of debris flows, small streams, snow avalanches, and rockfall. Once formed, gullies contain permanent or ephemeral streams and they focus upslope drainage and increase rates of run-off.

Throughout the project area, gullies of various depths have developed in till and bedrock. Gully headwalls and side walls are commonly unstable or potentially unstable, thus development in such areas must take this into account where appropriate, e.g. for road development.

River Behaviour (-J, -M, -I)

Process symbols that describe stream behaviour are attached to terrain symbols for floodplains and fans. Most of the Pine River floodplain is mapped as having anastamosing, irregularly sinuous and/or meandering channels. The anastamosing channel pattern (e.g., FAp-**J**) has multiple channels that split and rejoin around forested islands. These islands are reasonably stable, although avulsions (abrupt shifts in channel position) are possible. In areas where the pattern of a stream course is a regular series of bends, river behaviour is described as meandering (FAp-**M**). Meandering streams flow on very low gradients and are often associated with relatively fine sediments, and poorly or imperfectly drained floodplains with boggy areas. Floodplains with irregularly sinuous channels (e.g., FAp-**I**) tend to have active channel zones that are narrower than those of anastamosing streams of similar size, but are subject to similar flood regimes.

Rivers and streams rarely demonstrate one class of behaviour along their entire length, and often, two (or more) behaviour classes may be used to describe a particular reach

(e.g., FAp-**IJ**).

4.9.3.4 Soil Classes and Distribution

Brunisolic Order

The Brunisolic Order categorizes soils with weakly developed B horizons that do not display the characteristics of the diagnostic horizons of another order. That is to say, these soils have been only slightly modified by pedogenic processes.

Orthic Eutric Brunisols (along with Orthic Grey Luvisols) comprise the majority of the soils found in the study area. They are widely distributed and found on slopes of all gradients and aspects with loamy materials. The Orthic subgroup indicates that the soil has no characteristic modifying it from the Eutric Great Group. This Great Group is characterized by a pH of 5.5 or higher and lacks a well developed organic-enriched mineral horizon. In several places, Eluviated Eutric Brunisols were identified. These soils possess all the characteristics of the Eutric Great Group, but in addition have an eluviated A Horizon at least 2 cm thick. Orthic Melanic Brunisols are characterized by the presence of a dark coloured Ah horizon and a pH greater than 5.5. These soils were identified at several locations, both on slopes with gradients less than 10% with imperfect to poor drainage, and on a small floodplain.

Luvisolic Order

In forested regions, leaching commonly has resulted in significant translocation of clay from the A to the B horizon, producing an eluviated Ae horizon. The clay-enriched B horizon is referred to as a Bt horizon, and is the diagnostic horizon for a Luvisol.

Orthic Grey Luvisols are found throughout the study area, and are nearly as widespread as the Eutric Brunisols. Grey Luvisols may or may not have a Ah or Ahe horizon, and are found in areas with a mean annual soil temperature less than 8¡C. Luvisols are usually found on medium to fine grained parent materials. It is for this reason that Grey Luvisols are common in the Willow Creek study area: the till has a high percentage of silt and at some sites contains a moderately high amount of clay.

Organic Order

Organic soils are composed dominantly of materials containing more than 17% organic carbon, and they have a thickness of at least 60 cm for fibric materials and 40 cm for humic and mesic materials. Most Organic soils are saturated with water for prolonged periods of the year.

The Humisol Great Group contains organic material that is highly decomposed and contains few recognizable fibres. This, a Typic Humisol, was the only organic soil found in the TEM study area and only at one site. This site is a bog situated in the southeast one-third of the Project area. The distribution of Humisols and for that matter other organic soils, was limited by the lack of bogs and other poorly drained sites.

4.9.4Summary

The Willow Creek study area, located west of Chetwynd, B.C., is underlain by sandstones, shales, conglomerates, and coal. Bedrock was covered with a mantle of fine- to medium-grained till during the Fraser Glaciation, which, along with colluvium from mass wasting processes, has weathered to produce loamy and clay loam soils, predominantly Eutric Brunisols and Grey Luvisols.

The terrain and soils component of terrestrial ecosystem mapping shows the distribution of surficial materials, active geomorphological processes, and soil classes. Physical characteristics of the land surface, such as steepness, slope shape, soil moisture, and parent material, can vary locally over distances of a few metres to several tens of metres, giving rise to related variations in soil classes. Such local differences are not shown in the mapping due to restrictions imposed by scale.

4.10 TERRESTRIAL ECOSYSTEM MAPPING

4.10.1 Background

The objective of this project component was to map ecosystem units of the proposed Pine Valley mine at a scale of 1:5,000 and 1:20,000 in portions of map sheets 93O.059, 93O.060, 93O.069 and 93O.070(6). This mapping is to support interpretations regarding wildlife use in the project area.

The proposed mine is located on the east side of the Hart Ranges, Rocky Mountains in the Hart Foothills in northeastern British Columbia. The site is situated on the south side of the Pine River valley and the east side of Willow Creek. Chetwynd is located approximately 45 km east along the Pine River.

4.10.2 Objectives

Ecosystem mapping of the Project area was completed as a component of the environmental impact assessment of the proposed mine.

The objectives were to:

- produce bioterrain information with polygons coincidental to ecosystem polygons;
- produce 1:5,000 and 1:20,000 scale ecosystem maps with Ecosection, Biogeoclimatic, and Ecosystem Units (with site series, site modifiers and structural stage) to support wildlife interpretations; and
- produce wildlife capability and suitability ratings for red and blue listed wildlife and identified wildlife species (Dawson Creek Forest District).

4.10.3 Methodology

Field work was conducted during September 18 to 25, 1996. Sampling was completed along transects accessed by logging and exploration roads.

Mapping was completed according to the methodology outlined in *Standards for Terrestrial Ecosystem Mapping in British Columbia* (Resources Inventory Committee, 1995) and Addenda to Terrestrial Ecosystem Mapping Standards (RIC, 1996) at survey intensity level 2. Bioterrain units form the basic framework for the ecosystem mapping. The ecosystem mapping is based on the three level ecosystem classification framework, which includes ecoregion units, biogeoclimatic units and ecosystem units. Ecosystems units are developed from the site series defined within the existing Ministry of Forests biogeoclimatic ecological classification system (Prince George Forest Region) with the addition of site modifiers and structural stage. Site modifiers further defined the physical conditions of the ecosystem unit and are used to describe characteristics (site, soil and terrain) that are not typical for the site series. Up to two site modifiers may be used in defining ecosystem units. Structural stage defines the current development stage of the plant community.

Ecosystem units of mine Project area were mapped at a scale of 1:5,000 (547 ha). Ecosection, Biogeoclimatic, and Ecosystem Unit lines were mapped on digital topographic mapping developed for the site. Polygons were numbered and labelled with Ecosystem Units.

Information is present on separate 1:5,000 scale maps for bioterrain (Figures 4.9-1 and 4.9-2) and ecosystem unit (Figures 4.10-1 and 4.10-2). Twenty-one full ecological plots (site, soil, vegetation and wildlife forms) and forty-nine visual inspections were completed. Photographs were taken of the soil and site at each full plot; photographs were also taken at several other locations.

4.10.4 Description of Map Units

4.10.4.1 Ecoregions

The project area is located within the Sub-boreal Interior Ecoprovince. It lies within the Hart Foothills (HAF) Ecosection of the Central Canadian Rocky Mountain Ecoregion. Topography within the Hart Foothills consists of low, rounded mountains and wide valleys; relief in the project area ranges from about 630 m along the Pine River to approximately 1400 m at Falls Mountain to the south. The HAF extends from the headwaters of Wapiti River in the south to the Moberly River in the north. The Hart Ranges (Central Rocky Mountains Ecoregion) lie to the west. Mountains in this range are generally lower than found in Rocky Mountain ranges to the south and north. However, the mountains provide a barrier to the southward movement of cold Arctic air and the eastward movement of Pacific air mass (Campbell et al., 1990).

The biogeoclimatic units found in the Hart Foothills Ecosection include the Peace Variant of the Boreal White and Black Spruce Moist Warm subzone (BWBSmw1), the Finlay - Peace Variant of the Sub-Boreal Spruce Wet Cool subzone (SBSwk2) and the Bullmoose Variant of the Engelmann Spruce - Subalpine Fir Moist Very Cold subzone (ESSFmv2).

4.10.4.2 Biogeoclimatic Units

Peace Variant of the Boreal White and Black Spruce Moist Warm Subzone (BWBSmw1)

The BWBS covers the northeast corner of British Columbia. It generally experiences a northern continental climate characterized by very long, cold winters and short, warm summers. Within the BWBS zone, the BWBSmw1 is found on the rolling plains from a point near where the Rocky Mountains intersect the Alberta border, north to the Beatton River. It fingers into the Hart Foothills along major river valleys. It typically ranges in elevation from 750 to 1150 m (DeLong et al., 1990). The BWBSmw subzones experience climates which are warmer and of intermediate moisture levels as compared to other BWBS subzones. Mean annual snowfall is 190 cm, while annual mean temperature is +1.1 in the BWBSmw1 (DeLong et al., 1990). Trembling aspen is the dominant tree species in BWBSmw1 forests. Balsam poplar is common on wetter sites and white spruce is the common climax species on moist to wetter sites that have experienced limited fire. Lodgepole pine is found on sites with drier moisture and poorer nutrient regimes.

Finlay - Peace Variant of the Sub-Boreal Spruce Wet Cool Subzone (SBSwk2)

The SBS zone occurs in the central interior of the province, primarily on gently rolling plateaus. The SBSwk2 is found at elevations below 1100 m in the following locations: along Williston Lake; in the valleys between and side valleys within the Rocky and Omineca Mountains; and in the valleys of the western Omineca and eastern Skeena Mountains (MacKinnon et al., 1990). Within the study area the SBSwk2 generally occurs above the BWBSmw1 and below the ESSFmv2 biogeoclimatic units.

The SBSwk2 experiences a wet, cool climate; mean annual precipitation is 824 mm, while mean annual temperature is +0.7 C (MacKinnon et al., 1990). Hybrid white spruce and subalpine fir

are dominant in climax forests. Lodgepole pine occurs as a seral species on mesic and drier sites and as a climax species on very dry sites. Trembling aspen is also found as a seral species.

Bullmoose Variant of the Engelmann Spruce - Subalpine Fir Moist Very Cold Subzone (ESSFmv2)

The Engelmann Spruce - Subalpine Fir zone occurs at high elevations throughout much of the interior of B.C. The ESSFmv2 primarily occurs on the east side of the Rocky Mountain divide from a point near where the Rocky Mountains intersect the Alberta border, north to the Peace Arm of Williston Reservoir (DeLong et al., 1994). The ESSFmv2 generally occurs above the SBSwk2 at elevations ranging from about 1000 to 1400 m. Mean annual precipitation and temperature are 780.4 mm and -0.3 C, respectively. Due to its position on the lee side of the Rocky Mountains, the ESSFmv2 is drier than other ESSF variants (for which there are data) in the Prince George Forest Region.

Engelmann spruce and subalpine fir are dominant in climax forests. Lodgepole pine is common in many stands due to the greater incidence of fire that occurs in the ESSFmv2 than most ESSF forests.

4.10.4.3 Ecosystem Units

Site Series

Ecosystem units incorporate site series, site modifiers and structural stage. Site series have been developed to describe variation at the site level within the biogeoclimatic units (RIC, 1995). The site series “describe all land areas capable of supporting a specific climax plant association and reflecting a specified range of soil moisture and nutrient regimes within a subzone or variant” (RIC, 1995). A two letter symbol has been assigned to all defined site series. Site series are further described through the use of site modifiers and structural stage. Site modifiers refine site series by describing specific site, soil or terrain characteristics of the ecosystem unit. They generally denote site conditions that differ from typical conditions for a site series. Structural stages describe the existing dominant stand appearance or physiognomy of the ecosystem unit.

The following site series have been mapped:

Map SymbolBiogeoclimatic unit/Name

Site series

AM BWBSmw1/01SwAt - Step moss

SC BWBSmw1/03Sw - Wildrye - Peavine

SO BWBSmw1/05Sw - Currant - Oak fern

SC BWBSmw1/06Sw - Currant - Bluebells

SH BWBSmw1/07Sw - Currant - Horsetail

AS BWBSmw1/00SwAt - Soopolallie

SE BWBSmw1/00Sedge Fen

WH BWBSmw1/00Willow - Horsetail -Sedge Riparian Wetland

LH SBSwk2 Pl - Huckleberry - Cladina

SO SBSwk2/01 Sxw - Oak fern

SC SBSwk2/03 Sxw - Huckleberry - Highbush-cranberry

SD SBSwk2/05 Sxw - Devil’s club

SH SBSwk2/06 Sxw - Horsetail

WS SBSwk2/00 Willow - Sedge Fen

FR ESSFmv2/01 Bl - Rhododendron - Feathermoss

FL ESSFmv2/02 Bl - Lingonberry

BT ESSFmv2/03 BlSb - Labrador tea

FO ESSFmv2/04 Bl - Oak fern - Knight’s plume

FH ESSFmv2/06 Bl - Alder - Horsetail

SE ESSFmv2/00 Sedge Fen

WS ESSFmv2/00 Willow - Sedge Fen

UNC ESSFmv2/00 Unclassified forb meadow

A summary of the ecosystem units mapped is provided in Table 4-10-1. This table provides a brief description of the ecosystem units’ key site, soil and terrain characteristics, a list of all the modifiers and structural stages mapped and a list of the dominant plant species for each ecosystem unit.

Table 4.10-1

Ecosystem Units of Willow Creek Site

Map Symbol	Site Series	Name	Description	Site Modifiers & Structural Stage	Dominant Plants	Land Position	Slope position	Parent Material	Drainage
ESSFmv2									
FR	ESSFmv2/01	Bl - Rhododendron - Feathermoss	Typically occurs on gentle to moderate sloping, medium textured morainal material. Also occurs on shallow soils, and steep slopes (warm and cool aspects).	FR6, FRs6, FRk6, FRks6, FRw6, FRsw6	lodgepole pine, Engelmann spruce, white-flowered rhododendron, black huckleberry, black gooseberry, bunchberry, stiff clubmoss, one-sided wintergreen, knight's plume, red-stemmed feathermoss		mid (variable)	till	
				FR5	lodgepole pine, Engelmann spruce, white-flowered rhododendron, black huckleberry, bunchberry, one-sided wintergreen				

				FR3, FRs3	lodgepole pine, white-flowered rhododendron, red raspberry, five-leaved bramble, fireweed		
				FR2	fireweed, bluejoint, five-leaved bramble, bunchberry		
FL	ESSFmv2/02	Bl-Lingonberry	Typically occurs on flat to gently sloping coarse textured material. Mid to upper slope position. Also occurs on very shallow to shallow soils and warm aspects.	FLs6, FLsw6, FLvw6	lodgepole pine, Engelmannn spruce, white-flowered rhododendron, Sitka and mountain alder, black huckleberry, bunchberry, twinberry, red-stemmed feathermoss, knight's plume		mid - upper
				FLvw5	lodgepole pine, white-flowered rhododendron, Sitka and mountain alder, bunchberry, red-stemmed feathermoss		

BT	ESSFmv2/03	BlSb - Labrador tea	Typical;y found on gently sloping, or depressional sites with fine-textured morainal or lacustrine material	BTm6	lodgepole pine, black spruce, white-flowered rhododendron, Labrador tea, bunchberry, lingonberry, knight's plume, step moss, red-stemmed feathermoss
FO	ESSFmv2/04	Bl - Oak fern - Knight plume	Typically occurs on deep medium-textured soils on gently sloping moisture receiving sites. Also occurs on steep slopes, lower slope positions.	FO6, FOk6, FOw6	Engelmann spruce, lodgepole fir, white-flowered rhododendron, black huckleberry, black gooseberry, oak fern, five-leaved bramble, one-sided wintergreen, knight's plume, red-stemmed feathermoss
				FO2	fireweed, bluejoint, five-leaved bramble
FH	ESSFmv2/06	Bl - Alder - Horsetail	Typically occurs on level to depressional subhygric to hygric sites with coarse textured material. Also occurs on medium - textured material, and on organic veneers over	FHm6, FHp6	lodgepole pine, Engelmann spruce, white-flowered rhododendron, black twinberry, mountain alder, black gooseberry, trailing raspberry, oak fern, five-leaved

			mineral soils.		bramble, common and meadow horsetail, knight's plume, ragged mosses, leafy mosses
				FH2	fireweed, bluejoint, five-leaved bramble, common and meadow horsetail
UNC	ESSFmv2/00	Unclassified forb meadow	Steep, upper slopes on warm aspects. Medium - textured soils. Does not fit existing MOF classification.	Unclassified	kinnickinnick, poa sp., fuzzy-spiked wildrye, alpine sweet-vetch, locoweed, three-toothed saxifrage
SE	ESSFmv2/00	Sedge fen wetland	Level to depressional water collecting sites. Organic soils or organic veneers over fluvial material.	SE2	soft-leaved sedge, bluejoint, fowl managrass, drepanocladus sp.
WS	ESSFmv2/00	Willow - Sedge fen wetland	Level to depressional water collecting sites. Organic soils or organic veneers over fluvial material. Shrub - herb wetland.	WS3a	Athabasca-willow, willow spp., scrub birch, soft-leaved sedge, bluejoint, drepanocladus sp.

SBSwk2					
SO	SBSwk2/01	Sxw - Oak fern	Typically found on gently sloping, medium textured morainal material. Also occurs on steep slopes (warm and cool aspects) with shallow and deep soils.	SO6, SOk6, SOks6, SOw6, SOsw6	hybrid white spruce, highbush-cranberry, black gooseberry, black huckleberry, bunchberry, oak fern, five-leaved bramble, palmate coltsfoot, red-stemmed feathermoss, knight's plume, step moss
				SO5, SOk5, SOw5	trembling aspen, highbush-cranberry, thimbleberry, bunchberry, oak fern, five-leaved bramble, palmate coltsfoot
				SOsw3	trembling aspen, highbush-cranberry, thimbleberry, bunchberry, fireweed

LH	SBSwk2/02	Pl - huckleberry - Cladina	Typically found on flat to gently sloping coarse-textured glacio-fluvial material. Mapped on shallow soils along ridge crests.	LHrs6	lodgepole pine, Sitka alder, black huckleberry, bunchberry, one-sided wintergreen, red-stemmed feathermoss, knight's plume
SC	SBSwk2/03	Sxw - Huckleberry - Highbush cranberry	Typically found on steep warm aspects on coarse-textured soil developed on various parent materials. Also occurs on shallow soils on gentle and steep slopes, very shallow soils on steep slopes, and medium-textured soils on gentle and steep slopes.	SCs6. SCk6, SCks6, SCw6, SCsw6, SCvw6, SCm6, SCkm6, SCmw6	hybrid white spruce, lodgepole pine, highbush-cranberry, birch-leaved spirea, Sitka alder, black huckleberry, bunchberry, twinflower
				SCw5, SCsw5	trembling aspen, lodgepole pine, highbush-cranberry, birch-leaved spirea, bunchberry, twinflower

				SCks3, SCsw3, SCvw3	trembling aspen, lodgeploe pine, highbush-cranberry, birch-leaved spirea, bunchberry, fireweed, twinflower
SD	SBSwk2/05	Sxw - Devil's club	Typically found on gently sloping, moisture receiving sites. Also occurs on steeply sloping (warm and cool) aspects.	SD6, SDw6, SDk6	hybrid white spruce, thimbleberry, devil's club, bunchberry, five-leaved bramble, trailing raspberry, sweet-cicely, oak fern, knight's plume, red-stemmed feathermoss, leafy mosses
SH	SBSwk2/06	Sxw - Horsetail	Typically occurs on coarse - textured material on flat to depressional sites; toe of slopes. Seepage is common. Also mapped on medium - textured soils.	SH6, SHm6	hybrid white spruce, subalpine fir, black twinberry, black gooseberry, highbush-cranberry, trailing raspberry, horsetails, tall bluebells, five-leaved bramble, red-stemmed feathermoss, knight's plume, leafy mosses

				SHm3	hybrid white spruce, willow spp., black twinberry, red-osier dogwood, fireweed, bluejoint, horsetails
WS	SBSwk2/00	Willow - Sedge fen wetland	Flat to depressional water collecting sites. Shrub - herb wetland.	WS3a	willow spp., scrub birch, soft-leaved sedge, bluejoint, drepanocladus sp.
BWBSmw1					
AM	BWBSmw1/01	SwAt - Step moss	Typically occurs on gentle slopes, with fine-textured morainal or lacustrine material. Mesic sites. Mapped on medium and coarse - textured material on fluvial fans, medium - textured soils on cool aspects.	AMcn6, AMkm6, AMm6, AMmn6	trembling aspen, lodgepole pine, white spruce, highbush-cranberry, prickly rose, creamy peavine, fireweed, bunchberry, tall bluebells, trailing raspberry, twinflower, step moss, red-stemmed feathermoss, knight's plume

AM:ap	BWBSmw1/01-$	At - creamy peavine	Seral stages of AM ecosystem units.	AMcn6:ap, AMm6:ap	trembling aspen, highbush-cranberry, prickly rose, saskatoon, creamy peavine, fireweed, bluejoint, showy aster, trailing raspberry, twinflower, bunchberry, palmate coltsfoot, American vetch, tall bluebells, pink wintergreen
				AMcn3:ap	trembling aspen, highbush-cranberry, prickly rose, saskatoon, creamy peavine, fireweed, bluejoint, showy aster, trailing raspberry, American vetch, tall bluebells
SW	BWBSmw1/03	Sw - Wildrye - Peavine	Typically occurs on gentle slopes, deep, coarse - textured soils. Mapped on medium - textured soils on gentle and steep slopes, with soils depths ranging from	SWmw6, SWmv6, SWsw6, SWk6, SWks6, SWkm6, Swkv6, Swvw6	trembling aspen, lodgepole pine, white spruce, highbush-cranberry, prickly rose, soopolallie, birch-leaved spirea, twinflower, fuzzy-spiked wildrye,

			very shallow to deep.		creamy peavine, showy aster, trailing raspberry, step moss, red-stemmed feathermoss, knight's plume
				SWsw5	trembling aspen, lodgepole pine, white spruce, highbush-cranberry, prickly rose, soopolallie, birch-leaved spirea, fireweed, fuzzy-spiked wildrye, creamy peavine, showy aster, trailing raspberry
				SWm3, SWms3, SWmw3, SWsw3, SWvw3	trembling aspen, lodgepole pine, white spruce, saskatoon, prickly rose, soopolallie, fireweed, fuzzy-spiked wildrye, creamy peavine, showy aster, trailing raspberry

SW:as	BWBSmw1/03-$	At - Soopolallie	Seral stages of SW ecosystem units.	SWm6:as, SWkm6:as, SWmw6:as	trembling aspen, highbush-cranberry, prickly rose, saskatoon, soopolallie, fuzzy-spiked wildrye, creamy peavine, fireweed, showy aster, trailing raspberry, twinflower, bunchberry, palmate coltsfoot, American vetch, pink wintergreen, bluejoint
				SWsw5:as	trembling aspen, highbush-cranberry, prickly rose, saskatoon, soopolallie, fuzzy-spiked wildrye, creamy peavine, fireweed, showy aster, trailing raspberry, twinflower, bunchberry, palmate coltsfoot, American vetch, pink wintergreen, bluejoint

SO	BWBSmw1/05	Sw - Currant - Oak fern	Typically found on gently sloping, moisture receiving sites. Mapped on medium - textured soils on gentle and steep slopes. Lower slope positions.	SOm6, SOkm6, SOmw6	trembling aspen, white spruce, highbush-cranberry, prickly rose, black twinberry, black gooseberry, devil's club, fireweed, bluejoint, creamy peavine, showy aster, tall bluebells, trailing raspberry, oak fern, step moss, red-stemmed feathermoss
SC	BWBSmw1/06	Sw - Currant - Bluebells	Gently sloping, mositure receiving sites. Mapped on medium and coarse - textured fluvial soils, and active fluvial sites.	SCm7	white spruce, highbush-cranberry, prickly rose, black twinberry, red swamp currant, bluejoint, creamy peavine, bunchberry, tall bluebells, trailing raspberry, step moss, red-stemmed feathermoss, knight's plume

SCm6	white spruce, baslam popolar, highbush-cranberry, prickly rose, black twinberry, red swamp currant, bluejoint, creamy peavine, showy aster, tall bluebells, trailing raspberry, bunchberry, step moss, red-stemmed feathermoss, knight's plume
SCm5	balsam poplar, white spruce, highbush-cranberry, prickly rose, black twinberry, red swamp currant, bluejoint, creamy peavine, showy aster, tall bluebells, trailing raspberry
SCm3	balsam poplar, white spruce, highbush-cranberry, prickly rose, black twinberry, bluejoint, creamy peavine, showy aster,

					tall bluebells, trailing raspberry
SC: ab	BWBSmw1/06-$	At - black twinberry	Seral stages of SC ecosystem units.	SCm6:ab, SCac6:ab, SCam6:ab	balsam poplar, highbush-cranberry, prickly rose, black twinberry, red raspberry, saskatoon, creamy peavine, showy aster, trailing raspberry, twinflower, bunchberry, palmate coltsfoot, common mitrewort, tall bluebells, pink wintergreen
				SCac5:ab, SCam5:ab	balsam poplar, highbush-cranberry, prickly rose, black twinberry, red raspberry, saskatoon, creamy peavine, showy aster, cow parsnip, trailing raspberry, twinflower, bunchberry, palmate coltsfoot, common mitrewort, tall bluebells

				SCam3:ab, SCa3:ab	balsam poplar, highbush-cranberry, black twinberry, red raspberry, saskatoon, creamy peavine, fireweed, bluejoint, showy aster, cow parsnip, trailing raspberry, twinflower, bunchberry, tall bluebells
SH	BWBSmw1/06	Sw - Currant - Horestail	Typically occurs on flat, hygric sites on fluvial material (moderately coarse). Also mapped on medium - textured soils and active floodplains.	SHm7	white spruce, highbush-cranberry, prickly rose, black twinberry, red swamp currant, horsetails, trailing raspberry, tall bluebells, bunchberry, common mitrewort, step moss, knight's plume, red-stemmed feathermoss
				SHa6	white spruce, balsam poplar, highbush-cranberry, prickly rose, black twinberry, red swamp currant, horsetails, trailing raspberry, tall

					bluebells, bunchberry, common mitrewort
				SH5	white spruce, balsam poplar, willow spp., highbush-cranberry, prickly rose, black twinberry, bluejoint, horsetails, tall bluebells, bunchberry
				SHa3	white spruce, balsam poplar, willow spp., highbush-cranberry, prickly rose, black twinberry, bluejoint, horsetails, tall bluebells, fireweed
SH: ac	BWBSmw1/06-$	Ac- cow parsnip	Seral stages of SH ecosystem units.	SHmn6:ac, SHa6:ac, SHam6:ac	balsam poplar, prickly rose, highbush-cranberry, black twinberry, red raspberry, red-osier dogwood, trailing raspberry, bluejoint, wood horsetail, tall bluebells, showy aster, fringed aster, palmate coltsfoot, cow parsnip

SH5:ac, SHam5:ac	balsam poplar, prickly rose, highbush-cranberry, black twinberry, red raspberry, red-osier dogwood, trailing raspberry, fireweed, bluejoint, wood horsetail, tall bluebells, showy aster, fringed aster, palmate coltsfoot, cow parsnip
SHa3:ac, SHam3:ac, SH3:ac	balsam poplar, prickly rose, highbush-cranberry, black twinberry, red raspberry, red-osier dogwood, trailing raspberry, fireweed, bluejoint, wood horsetail, tall bluebells, showy aster, fringed aster, cow parsnip

AS	BWBSmw1/00	SwAt - Soopolallie	Typically occurs on significant slopes on warm aspects. Sites with xeric - submesic moisture regimes. Mapped on sites with shallow to very shallow soil. Sites in this unit also had lodgepole pine canopies.	ASsw6, ASvw6	lodgepole pine, trembling aspen, saskatoon, soopolallie, birch-leaved spirea, fuzzy-spiked wildrye, creamy peavine, asters, kinnicknnick
				ASvw5	lodgepole pine, trembling aspen, saskatoon, soopolallie, birch-leaved spirea, fuzzy-spiked wildrye, creamy peavine, asters, kinnicknnick
				ASvw3	willow spp., saskatoon, soopolallie, birch-leaved spirea, fuzzy-spiked wildrye, creamy peavine, asters, kinnicknnick (trembling aspen, lodgepole pine)

SE	BWBSmw1/00	Sedge Wetland	Sedge wetland found in back channels (fluvial sites). Water collecting sites with organic soils.	SE2	turned sedge, water sedge, beaked sedge, common horsetail
WH	BWBSmw1/00	Willow - Sedge - Horsetail Riparian Wetland	Riparian wetland found in back channels (fluvial sites). Water collecting sites with organic soils.	WH3a, WH3b	mountain alder, felt-leaved willow, willow spp., red-osier dogwood, turned sedge, water sedge, common horsetail

The following units are not further described in this report.

OW Shallow open water

Table 4.10-2 contains a list of full ecological plots correlated to Ministry of Forest site series.

Table 4.10-2

Willow Creek Plots Correlated to Ministry of Forest Sites Series

Plot	Visual	Ecosection	BGC Zone	Site	Map	Site Series	Ecosystem	Terrain	Elev	Slope	Aspect
				Series	Symbol	Name	Unit				
1		HAF	ESSFmv2	00	UNC	Unclassified herb meadow	UNC	srCvb/Rk	1375	50	220
2		HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRw6	szMv/xszCv	1285	32	260
3		HAF	ESSFmv2	02	FR	Bl - Lingonberry	FLsw6	dszMw	1175	45	220
4		HAF	ESSFmv2	04	FO	Bl - Oak fern - Knight's plume	FOw6	dszMbw	1150	30	205

5		HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dszMbw	1145	15	000
6		HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR2	dzsMvb	1170	3	000
7		HAF	SBSwk2	01	SO	Sxw - Oak fern	SOk6	dszMw/Cv	1045	25-30	326
8		HAF	ESSFmv2	06	FH	Bl - Alder - Horsetail	FHp6	Ov/szFp	1100	3	000
9		HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCsw6	sxCv	1075	80	250
10		HAF	ESSFmv2	02	FL	Bl - Lingonberry	FLs6	srCv/Rur	1050	5	
11		HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRks6	dszMv/Cv	1065	65	27
12		HAF	ESSFmv2	02	FL	Bl - Lingonberry	FLs6	dszMv/Rum	1125	5	
13		HAF	BWBSmw1	00	AS	SwAt - Soopolallie	ASvw6	srCv-Rsk-R"b	1030	70	227
14		HAF	BWBSmw1	03	SW	Sw - Wildrye - Peavine	SWsw5:as	dszM	840	60	230
15		HAF	SBSwk2	01	SO	SBSwk2/01	SO6	dszMb	890	25	360
16		HAF	BWBSmw1	05	SO	Sw - Currant - Oak fern	SOkm6	dszMv - V	670	50	8
17		HAF	BWBSmw1	01	AM	SwAt - Step moss	AMm6:ap	zFp	625	0	999
18		HAF	SBSwk2	01	SO	Sxw - Oak fern	SOk6	/Cw/Mw	815	34	28
19		HAF	ESSFmv2	00	WS3a	Willow - Sedge wetland	WS3a	Op	1110	1	999
20		HAF	BWBSmw1	06	SC	Sw- Currant - Bluebells	SCm7	gszFp	628	2	999
21		HAF	BWBSmw1	00	WH	Willow - Horsetail Sedge Riparian Wetland	WH	0v/Fp	625	1	999
	1	HAF	ESSFmv2	00	SE	Sedge wetland	SE2	cszMvb	1340	0	99
	2	HAF	ESSFmv2	02	FL	Bl - Lingonberry	FLrv6	Rrj	1365	20	0

3	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dszMb	1235	15	230
4	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dszMbv	1125	5	280
5	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRk6	dszMvb	1090	37	320
6	HAF	SBSwk2	06	SH	Sxw - Horsetail	SHm6	Ov/gzsFp	1065	25	180
7	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dszMbv	1175	16	230
8	HAF	SBSwk2	06	SH	Sxw - Horsetail	SH6	dszMw/Fpj	1040	8	190
9	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCks3a	dzsMv	1070	28	110
10	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRks6	dzsMv	1155	60	32
11	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRks6	rzsCv	1080	75	38
12	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dsMw	1100	20	240
13	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dzsMb	1115	20	270
14	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRks6	rzsCv	1095	65	305
15	HAF	BWBSmw1	03	SW	Sw - Wildrye - Peavine	SWmw3	/rCv/dzsMvw	915	32	235
16	HAF	SBSwk2	02	LH	Pl - Huckleberry - Cladina	LHrs6	srCv	985	18	325
17	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCks6	rsCv	950	70	290
18	HAF	SBSwk2	05	SD	Sxw - Devil's club	SDk6	dszMbv - V	900	30	355
19	HAF	SBSwk2	01	SO	Sxw - Oak fern	SOk6	rzsCv	855	46	42

20	HAF	SBSwk2	01	SO	Sxw - Oak fern	SOw5	dszMbv	865	25-30	274
21	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCkm6	dszMbv	905	30	300
22	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCvw3	srCv - VR"sF"	860	95	238
23	HAF	SBSwk2	01	SO	Sxw - Oak fern	SOks6	srCv - VF"	855	95	60
24	HAF	SBSwk2	01	SO	Sxw - Oak fern	SOk6	dzsMw	915	50	45
25	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCks6	srCv-V	930	65	42
26	HAF	SBSwk2	05	SD	Sxw - Devil's club	SD6	dszMb	915	23	10
27	HAF	BWBSmw1	05	SO	Sw - Currant - Oak fern	SOm6	dzMw	730	10	350
28	HAF	SBSwk2	01	SO	Sxw - Oak fern	SO6	dszMw	735	18	350
29	HAF	BWBSmw1	01	AM	SwAt - Step moss	AMm6	dszMw	760	12	245
30	HAF	BWBSmw1	03	SW	Sw - Wildrye - Peavine	SWmw6:as	Cv/Raj	745	26	250
31	HAF	BWBSmw1	01	AM	SwAt - Step moss	AMm6:ap	dzsMw	705	23	310
32	HAF	BWBSmw1	03	SW	Sw - Wildrye - Peavine	SWkm6:as	rzsCvb	650	40	295
33	HAF	SBSwk2	06	SH	Sxw - Horsetail	SHm6	szFj	1040	18	180
34	HAF	ESSFmv2	03	BT	BlSb - Labrador tea	BTm6	dsmMwb	1075	180	15
35	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FR6	dszMbw	1100	19	195
36	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCmw6	dzmMks	1135	60	255
37	HAF	ESSFmv2	04	FO	Bl - Oak fern - Knights plume	FOk6	dsmMbw	1115	33	342
38	HAF	SBSwk2	06	SH	Sxw - Horsetail	SHm3	dzmMb	1125	8	260

39	HAF	ESSFmv2	01	FR	Bl - Rhododendron - Feathermoss	FRw6	dszMwb	1150	35	285
40	HAF	ESSFmv2	06	FH	Bl - Alder - Horsetail	FHm6	dsmMb	1090	5	215
41	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCmw6	dsmMb	1070	40	215
42	HAF	SBSwk2	03	SC	Sxw - Huckleberry - Highbush-cranberry	SCsw6	srCv	1025	54	224
43	HAF	BWBSmw1	03	SW	Sw - Wildrye - Peavine	SWsw6	zrsCv	950	70	225
44	HAF	BWBSmw1	06	SC	Sw - Currant - Bluebells	SCac6:ab	gszF(A)p	625	1	999
45	HAF	BWBSmw1	01	AM	SwAt - Step moss	AMm6:ap	Mb	650	8	310
46	HAF	BWBSmw1	01	AM	SwAt - Step moss	AMcn6:ap	gsFf	660	3	355
47	HAF	BWBSmw1	00	AS	SwAt-Soopalallie	ASvw5	rCv-R"b	680	62	275
48	HAF	BWBSmw1	07	SH	Sw - Currant - Horsetail	SHam5:ac	zFp	625	1	999
49	HAF	BWBSmw1	06	SC	SC - Currant - Bluebells	SCac5:ab	zsgFp	625	0	999

Site Modifiers

Site modifiers are used to further described site series. Site modifiers refine site series by describing specific site, soil or terrain characteristics of the ecosystem unit. They generally denote site conditions that differ from typical conditions for a site series. Up to two site modifiers can be used with an ecosystem unit.

The following site modifiers have been used:

c coarse textured soils (includes sandy loam, loamy sand, sand textures, fine matrix with over 70% coarse fragments and medium matrix with over 35 % coarse fragments)

f fine textured soils (heavy clay, silty clay, clay and sandy clay textures)

j gentle slopes (less than 25% slope)

k cool, northerly or easterly aspect (285 - 135 degrees, slopes greater than 25%)

m medium textured soils (includes silty clay loam, clay loam, silt, silt loam, loam, and sandy clay loam textures)

n fan (colluvial, or fluvial) or cone

r ridge or crest

w warm, southerly or westerly aspect (135 - 285 degrees, slopes greater than 25%)

p peaty soil

s shallow soil (25-100cm to bedrock)

v very shallow soil (less than 25cm mineral soil over bedrock)

Structural Stages

Structural stages describe the existing dominant stand appearance or physiognomy of the ecosystem unit. One of seven structural stage categories describing the current development stage is assigned to each ecosystem unit.

Symbol Description

1a Non-vegetated: less than 5% vegetation cover

1b Sparse: less than 10% vegetative cover

2 Herb: early successional stage disclimax or climax, dominated by herbaceous vegetation

(tree cover <10%, herb cover >25% or >=33% of total cover)

3 Shrub/Herb: early successional stage disclimax or climax communities dominated by shrub vegetation < 10 m in height (tree cover <10%, shrub cover >25% or >= 33% of total cover). Used for communities that will be forested at climax.

3a Low Shrub: early successional stage disclimax or climax communities dominated by shrub cover <2m in height (tree cover <10%, shrub cover >25% or >= 33% of total cover)

3b Tall Shrub: early successional stage disclimax or climax communities dominated by shrub cover 2 to 10 m in height (tree cover <10%, shrub cover >25% or >= 33% of total cover)

4 Pole/Sapling: Trees > 10 m tall that have over topped the shrub and herb layers. Stands are typically dense.

5 Young Forest: Self thinning is usually evident and the forest canopy has begun differentiation into distinct layers (40-80 yrs).

6 Mature Forest: Trees that were established after the last disturbance have matured and a second cycle of shade tolerant trees may have established (80 - 250 yrs for ESSFmv2; 80 - 140 yrs for BWBSmw1 and SBSwk2).

7 Old Forest: Old structurally complex stands (>250 yrs ESSFmv2; >140 yrs for BWBSmw1 and SBSwk2).

Description of Ecosystem Units

A description of each of the ecosystems mapped in the study area is provided by biogeoclimatic zone in Appendix 4.10-1 (Tables A to U). These tables include a description of the site, soil and terrain characteristics, a list of each all the site modifiers used for each unit, and a list of plant species for each potential structural stage of the ecosystem unit.

4.11 VEGETATION

4.11.1 Background

Vegetation resources were assessed as a component of terrestrial ecosystem mapping. A description of the ecsosection, biogeoclimatic units and ecosystem units mapped in the project area are provided in section 4.10.

Rare vascular fauna and rare plant community tracking lists for the Dawson Creek Forest District (FD#47) were obtained from the B.C. Conservation Data Centre (1996).

4.11.2 Methodology

Field work was conducted during September 18 to 25, 1996. Plant species found on the site were recorded during sampling completed for ecosystem mapping. Plant communities were also determined from data collected during mapping transects using descriptions contained in Prince George Forest Region Field Guides (DeLong et al., 1990; MacKinnon et al., 1990; and DeLong et al., 1994).

4.11.3 Results

A list of ecosystem units (site series or plant communities) mapped for the project site are provided in section 4.10.4.3. A total of twenty-one plant communities were identified. One of these units, the Subalpine fir/Black spruce - Labrador tea community (ESSFmv2/03) is blue - listed (provincial rank S3). This unit is mapped in the southern portion of the project area (Figure 4.10-2). This plant community is also found in the ESFFmv3, and ESSFmv4 biogeoclimatic units.

A list of plant species observed during field surveys is included in Table 4.11-1. No red or blue - listed vascular plant were identified at the project site.

TABLE 4-11.1

PLANT SPECIES OBSERVED AT THE PINE VALLEY COAL PROJECT AREA

Trees

Common Name	Scientific Name
Balsam poplar	Populus balsamifera ssp. balsamifera
Engelmann spruce	Pices engelmannii
Hybrid white spruce	Pices glauca x engelmannii
Lodgepole pine	Pinus controta var. latifolia
Paper birch	Betula papyrifera
Subalpine fir	Abies lasiocarpa

Trembling aspen	Populus tremuloides
White spruce	Pices glauca

Shrubs

Common Name	Scientific Name
Athabasca willow	Salix athabascensis
Balck twinberry	Lonicera involucrata
Birch-leaved spirea	Spiraea betuliflia
Black gooseberry	Ribes lacustre
Black huckleberry	Vaccinium membranaceum
Common snowberry	Symphoricarpos albus
Common juniper	Juniperus communis
Devil's club	Oplopanax horridus
Douglas maple	Acer glabrum
Dwarf blueberry	Vaccinium caespitosum
Felt-leaved willow	Salix alaxnsis
Highbush-cranberry	Vibrunum edule
Labrador tea	Ledum groenlandicum
Mountain alder	Alnus incana ssp. tenuifolia
Prickly rose	Rosa acicularis
Red elderberry	Sambucus racemosa
Red raspberry	Rubus idaeus
Red swamp currant	Ribes triste

Red-osier dogwood	Cornus stolonifera
Saskatoon	Amelanchier alnifolia
Scrub birch	Betula glandulosa var. glandulosa
Sitka alder	Alnus viridis ssp. sinuata
Skunk currant	Ribes glandulosum
Soopolallie	Shepherdia canadensis
Thimbleberry	Rubus parviflora
Western mountain-ash	Sorbus scopulina
Willow	Salix spp.
White-flowered rhododnedron	Rhododendron aldiforum

Forbs (and dwarf shrubs)

Common Name	**Scientific Name**
Crowberry	Empetrum nigrum
Five-leaved bramble	Rubus pedatus
Kinnikinnick	Arctostaphylos uva-ursi
Lingonberry	Vaccinium vitis-idaea
Trailing raspberry	Rubus pubescens
Twinflower	Linnaea borealis
Alpine sweet-vetch	Hedysarum alpinium
American vetch	Vicia americana
Arrow-leaved groundsel	Senecio triangularis
Baneberry	Actaea rubra

Bracted lousewort	Pedicularis bracteosa
Bunchberry	Cornus canadensis
Clasping twistedstalk	Streptopus amplexifolius
Clovers	Trifolium spp.
Common red paintbrush	Castilleja miniata
Common mitrewort	Mitella nuda
Cow parsnip	Heracleum lanatum
Creamy peavine	Lathyrus ochroleucus
Cut-leaf anenome	Anemone multifida
False Solomon's-seal	Smilacina racemosa
Field mint	Mentha arvensis
Field pussytoes	Antennaria neglecta
Fireweed	Epilobium angustifolium
Fringed aster	Aster ciliolatus
Great northern aster	Aster modestus
Hawkweed	Hieracium sp.
Heart-leaved twayblade	Listera cordata
Heart-leaved arnica	Arnica cordifolia
Hooker’s fairybells	Disporum hookeri
Indian hellebore	Veratrum viride
Kneeling angelica	Angelica genuflexa
Lance-leaved stonecrop	Sedum lanceolatum
L. round-leaved rein orchid	Platanthera orbiculata

Large-leaved avens	Geum macrophyllum
Locoweed	Oxytropis campestris
Meadowrue	Thalictrum sp.
Mitrewort	Mitella sp.
Mountain monkshood	Aconitum delphiniifolium
Northern bedstraw	Galium boreale
One-sided wintergreen	Orthilia secunda
Orange-foot lichen	Cladonia ecmocyna
Orchid	Platanthera sp.
Palmate coltsfoot	Petasites palmatus
Pearly everlasting	Anaphalis margaritacea
Pink wintergreen	Pyrola asarifolia
Purple sweet-cicely	Osmorhiza purpurea
Purple-leaved willowherb	Epilobium ciliatum
Queen's cup	Clintonia uniflora
Rattlesnake-plantain	Goodyera oblongifolia
Rough-fruited fairybells	Disporum trachycarpum
Showy aster	Aster conspicuus
Sitka valerian	Valeriana sitchensis
Small bedstraw	Galium trifidum
Small-flowered penstemon	Penstemon procerus
Spreading dogbane	Apocynum androsaemifolium
Sweet-scented bedstraw	Galium triflorum

Tall bluebells	Mertensia paniculata
Three-leaved foamflower	Tiarella trifoliata
Water avens	Geum rivale
Wild strawberry	Fragaria virginiana
Wild sarsparilla	Aralia nudicaulis
Wild lily-of-the-valley	Maianthemum canadense
Yarrow	Achillea millefolium
Yellow monkey-flower	Mimulus guttatus
Dwarf rattlesnake-plantain	Goodyera repens

Ferns and Horsetails

Common Name	Scientific Name
Common horsetail	Equisetum arvense
Dwarf scouring-rush	Equisetum scirpoides
Lady fern	Athyrium filix-femina
Meadow horsetail	Equiseteum pratense
Oak fern	Gymnocarpium dryopteris
Ostrich fern	Matteucia struthiopteris
Spiny wood fern	Dryopteris expansa

Grasses, Sedges

Common Name	Scientific Name
Bluegrass	Poa sp.

Bluejoint	Calamagrostis canadensis
Columbia brome	Bromus vulgaris
Fowl managrass	Glyceria elata
Fuzzy-spiked wildrye	Elymus innovatus
Rough leaved ricegrass	Oryzopsis asperifolia
Beaked sedge	Carex utriculata
Soft-leaved sedge	Carex disperma
Turned sege	Carex retorsa
Water sedge	Carex aquatilis

Clubmosses

Common Name	Scientific Name
Stiff clubmoss	Lycopodium annotinum

Mosses and Lichens

Common Name	Scientific Name
Dicranum sp.	Dicarnum spp.
Drepanocladus sp.	Drepanocladus sp.
Haircap moss	Polytrichum sp.
Knight's plume	Ptilium crista-castrensis
Leafy mosses	Plagiomnium sp.
Ragged moss	Brachythecium sp.
Red-stemmed feathermoss	Pleurozium schreberi

Sphagnum moss	Sphagnum sp.
Step moss	Hylocomium slendens
Cladonia lichens	Cladonia spp.
Freckled lichen	Peltigera aphthosa
Pelia	Pelia sp.
Peltigra sp.	Peltigera sp.
Pixie cup-lichens	Cladonia pyxidata
Reindeer lichens	Cladina sp.
Toad pelt	Peltigera scaborosa

4.12 WILDLIFE

4.12.1 Methodology

Wildlife and wildlife habitats were assessed between 18 and 25 September 1996 during terrestrial ecosystem mapping of the subject property. The wildlife assessment focused on species of regional concern (i.e., grizzly bear, elk, moose, mountain caribou, mule and white-tailed deer, marten, fisher and northern goshawk) and species that are blue or red-listed by the B.C. Ministry of Environment (MOELP 1996) and which may occur within the subject property (i.e., broad-winged hawk, trumpeter swan, Cape May warbler, black-throated green warbler, Connecticut warbler, Philadelphia vireo and Canada warbler). The Conservation Data Centre was contacted regarding rare wildlife occurrences for the area.

The primary objective of the wildlife component of terrestrial ecosystem mapping was to generate habitat capability and suitability ratings for the wildlife species of concern, to provide an overview of all wildlife species utilizing the study area, to identify valued ecosystem components (VECs) including nest sites, wildlife trees and feeding areas, and to identify environmentally sensitive areas. A survey of raptor nests (e.g., bald eagle and northern goshawk) was not conducted. Nests identified in the following report were encountered during terrestrial ecosystem mapping activities.

Wildlife presence was determined by direct contacts and evidence of wildlife occurrence (i.e., ?sign’ such as scats, tracks, trails, burrows, nests, bones, feathers, and various kinds of feeding sign). Wildlife were observed with the aid of 8X36 binoculars. The potential occurrence of wildlife not observed during the site visit was inferred from habitat availability, known distributions, and local information.

4.12.3 Results

4.12.3.1 Birds

A number of bird species were recorded during the field survey of the Willow Creek subject property. Because of the timing of the survey (i.e., mid to late September) only year-round residents or fall migrants were observed. Table 4.12-1 summarizes all bird species recorded during the field survey. A complete list of bird species including species expected to occur (inferred from habitats available on the site) with scientific names is provided in Appendix 4.12-1 (also summarizes the apparent status of each bird species).

TABLE 4.12-1

Relative abundance of bird species observed on a proposed coal mine at Willow

Creek, west of Chetwynd, during a late September field survey.

Bird Species	Relative Abundance During Field Survey
American Crow	Uncommon - most prevalent in Pine R. floodplain
American Robin	Common - in Pine R. floodplain and clearcuts
Black-backed Woodpecker	Rare - one seen in Pine R. floodplain
Bohemian Waxwing	Uncommon - migrant in clearcut
Boreal Chickadee	Common - throughout forested areas
Brown Creeper	Rare - in forested areas
Common Raven	Uncommon - throughout subject property
Dark-eyed Junco	Common - throughout
Golden-crowned Kinglet	Common - throughout coniferous forested areas
Golden Eagle	Rare - one immature observed
Gray Jay	Common - throughout
Hairy Woodpecker	Rare - one heard calling
Mallard	Uncommon - four seen in Pine R. oxbow
Northern Flicker	Rare - one observed at edge of clearcut
Northern Pygmy-Owl	Rare - one in upland forest and one in floodplain
Northern Shrike	Rare - one perched on snag in clearcut
Pine Grosbeak	Rare - four observed in upland forest

Pine Siskin	Uncommon - throughout
Red-breasted Nuthatch	Uncommon - throughout
Red-tailed Hawk	Rare - one migrant observed soaring above ridge
Ruby-crowned Kinglet	Common - observed in small numbers throughout
Ruffed Grouse	Uncommon - throughout
Sharp-shinned Hawk	Uncommon - throughout
Steller's Jay	Uncommon - throughout
Three-toed Woodpecker	Common - sign and individuals observed throughout
Townsend's Solitaire	Rare - three observed in clearcut
Varied Thrush	Uncommon - throughout
White-throated Sparrow	Rare - one heard singing in Pine R. floodplain
Winter Wren	Rare - in forests with well developed understorey
Yellow-rumped Warbler	Rare - two individuals (migrants) observed
Total Number of Species	**30**

From Appendix 4.12-1 it is apparent that a large diversity of birds breeds on the subject property. Habitats of particular importance are riparian zones, floodplain habitats of the Pine River, creeks and ravines, old growth and mature upland forests, upland willow wetlands and deciduous dominated forests.

Red- and Blue-Listed Bird Species

Bird species which are blue and red-listed by the B.C. Ministry of Environment (MOELP 1996) and which may occur on the subject property are described in more detail below.

Bay-breasted Warbler (red-listed)

Bay-breasted warblers are known to occur regularly as close to Moberley Lake Provincial Park near Chetwynd (Enns and Siddle 1996; C. Siddle, pers. comm., 1996). Coniferous forest and occasionally adjoining deciduous second growth forest appear to be the preferred nesting habitat (Ehrlich *et al.* 1988). All six birds reported by Enns and Siddle (1996) occurred in mixed wood stand types dominated by tall, close-canopied large spruce. The shrubby understorey tended to be dominated by highbush cranberry, red-osier dogwood and Sitka alder. The associated deciduous tree species was aspen although birch was also common. Other associated plant species included wintergreen, bunchberry, baneberry, rose, northern bedstraw, willow, bluegrass, twinflower, bluejoint, soopalallie, fireweed, American vetch and purple peavine. Habitats of this description are not widespread, but do occur in the Pine River floodplain.

Black-throated Green Warbler (red-listed)

Black-throated blue warblers are at the extreme western end of their North American breeding range in the vicinity of the Willow Creek study area. They are known to breed at nearby Moberley Lake (Enns and Siddle 1996) and along Brazion Creek (Strom *et al.* 1995). The Conservation Data Centre (1996) lists nine records of black-throated green warblers in the vicinity of the study area. Preferred habitats appear to be coniferous and deciduous mixed wood forests where stands of mature spruce still remain (Salt and Salt 1976; Ehrlich *et al.* 1988). Of 50 individuals recorded by Enns and Siddle (1996), 90% were in either white spruce/trembling aspen forest or riparian white spruce/balsam poplar forest. These stands tended to be dominated by understorey vegetation such as rose, baneberry, highbush cranberry, bunchberry, fireweed, kinnickinnick, peavine and American vetch. Their red-listed status is primarily because many of their known breeding areas are within timber supply areas and are slated for logging. Given the occurrence of similar habitats within the study area, black-throated green warblers are expected to occur.

Broad-winged Hawk (blue-listed)

Although broad-winged hawk records have historically been restricted to a small area in the vicinity of Boundary Lake and Fort St. John, in recent years they have been reported in increasing numbers from other areas of the province (C. Siddle, pers. comm., 1996; Campbell *et al.* 1990). Nests have been found in the Peace River lowlands and one or two pairs has been frequenting the Prince George area. Given this apparent range expansion, it is possible that broad-winged hawks may nest in the Pine River corridor (C. Siddle, pers. comm., 1996). Two large stick nests located in a mature aspen stand in the Pine River floodplain may be of broad-winged hawks although other species such as northern goshawk and great horned owls are also likely. The current species use and status of these nests should be confirmed in a spring survey during the active breeding period. According to Salt and Salt (1976) and Ehrlich *et al.* (1988), typical nesting habitats include dense deciduous and open, mixed forest habitats often near water. These habitats are prevalent in floodplain and low elevation habitats of the study area.

Canada Warbler (blue-listed)

Canada warblers are at the extreme western edge of their breeding range in North America. Most records are from riparian areas along the Peace and Fort Nelson Rivers. Although Canada warblers have not been reported along the Pine River, preferred breeding habitats are available. According to Ehrlich *et al.* (1988) typical breeding habitats are deciduous woodlands and riparian thickets. Salt and Salt (1976) indicate that preferred breeding territories are in thick willow and alder along streams, or in dense growth of shrubs and bushes at the forest edge of swamps. Enns and Siddle (1996) found that 84% of site records in the Peace River lowlands were in either white spruce/trembling aspen forest or riparian white spruce/balsam poplar. The occurrence of birch was a constant at all sites. Canada warblers appeared to prefer sites on steep slopes with an abundance of messy undergrowth most often dominated by soopalallie and rose. Other common shrub species included red-osier dogwood, saskatoon, chokecherry and gooseberry. These habitats are prevalent in creek ravines (i.e., Far East and Willow Creek) and along lower elevation slopes above the Pine River floodplain. Occurrence of Canada warblers on the study project have not been confirmed.

Cape May Warbler (blue-listed)

Cape May Warblers are also at the extreme western end of their range in the Peace and Fort Nelson lowlands. Although this warbler has not been recorded in the Pine River, it may be due to lack of effort. Typical breeding habitat includes open coniferous forest and coniferous forest edge habitats (Ehrlich *et al.* 1988). Salt and Salt (1976) indicated that dense stands of mature spruce in coniferous or mixed-wood forests are more typical breeding areas. Ten individuals were recorded by Enns and Siddle (1996) in a recent survey of warblers in northeastern British Columbia. Habitat preferences were variable and included fairly dense, tall stands of white spruce with the presence of openings due to either surface bedrock or small logging operations. Although apparently suitable habitat is available in lowland and upland portions of the study area, it is not clear whether Cape May warblers occur.

Connecticut Warbler (red-listed)

Connecticut warblers have been recorded throughout the Peace River lowlands including the northern tributaries of the Peace River such as the Murray River and Zonnebeke Creek (CDC 1996). Preferred breeding habitats according to Salt and Salt (1976) are deciduous forests or deciduous areas of mixed-wood forests. Nesting territories are often chosen in aspen-poplar woodlands where undergrowth is neither too dense nor too high. All Connecticut warblers reported by Enns and Siddle (1996) were located in trembling aspen dominated stands with large aspen in a widely spaced configuration. Understorey herb and shrub vegetation was well developed but generally less than three metres height. Because habitats preferred by Connecticut warblers are widespread in lowland forests of the study area, this species may occur.

Philadelphia Vireo (blue-listed)

Philadelphia vireos appear to be restricted to the Peace River lowlands where they inhabit dense, rapidly growing aspen stands, approximately 20 years of age, in a stage prior to self-pruning (Enns and Siddle 1996). Similar habitats occur infrequently within the study area. Salt and Salt (1976) indicate that Philadelphia vireos frequent open deciduous woods such as new-growth aspen and poplar or birch-poplar woods

Trumpeter Swan (blue-listed)

Although trumpeter swans are known to breed in the Peace River lowlands (Campbell *et al.* 1990), they are not expected to nest in floodplain habitats of the study area. However, trumpeter swans may occur occasionally during migration along the Pine River and in associated wetland habitats.

Yellow-bellied Flycatcher (blue-listed)

Yellow-bellied flycatcher is likely to occur in certain spruce communities along the Pine River. This species is known to be a scarce summer resident along the Peace River near Hudson's Hope and at one or two sites around Prince George. Pine Pass is a likely geographical route for this species to enter central B.C. (C. Siddle, pers. comm., 1996). Coniferous forest edge along the Pine River wetlands, and forest edge along upland willow wetlands may be suitable breeding habitat for this species.

4.12.3.2 Mammals

The terrestrial mammalian fauna of the Willow Creek subject property is diverse. Sign of ungulates and bears was particularly evident during the field survey. Table 4.12-2 lists all mammal species recorded during the field survey. Appendix 4.12-1 lists all mammal species known or expected to occur within the study area; this also provides the scientific names and apparent status of each mammal species. Each species or species group is described in more detail below.

TABLE 4.12-2

Relative abundance of mammal species observed on a proposed coal mine at Willow

Creek, west of Chetwynd during a late September field survey.

Mammal Species	**Relative Abundance During Field Survey**
Beaver	Common - tracks, paths and lodge in floodplain areas of Pine River

Black Bear	Common - scats, tracks, and individuals seen on many occasions
Coyote	Uncommon - tracks observed along roads on several occasions
Deer	Common - tracks, pellet groups and trails observed throughout site
Elk	Common - tracks and pellet groups observed throughout site
Red Fox	Rare - one set of tracks observed
Grizzly Bear	Uncommon - diggings and scat observed in northern portions of site
Lynx	Rare - one scat observed on rocky ridge at north end of study area
Marten	Rare - one possible individual calling in Pine River floodplain
Moose	Abundant - feeding sign, pellets and tracks throughout site
Muskrat	Rare - single set of tracks along Willow Creek forestry road
Porcupine	Uncommon - foraging sign, den site and scats recorded
Red Squirrel	Abundant - middens, individuals, feeding sign throughout
Snowshoe Hare	Common - individuals and pellets throughout
White-tailed Deer	Uncommon - doe and fawn observed in Pine River floodplain
Wolf	Uncommon - tracks observed along road and rocky ridge
Woodchuck	Rare - several burrows observed
Total Number of Species	**17**

Shrews

Six species of shrews are expected to occur within the study area (see Appendix 4.12-1) (Nagorsen 1996). All habitats of the subject property are likely utilized by one or more of the shrew species. The water shrew is associated with creeks, wetlands and riparian areas. Shrew species captured by Hatler (1994) on the subject property included dusky shrew and vagrant shrew.

Bats

Very little is known of the bat fauna of northeastern British Columbia. Nagorsen and Brigham (1993) indicate that four species may occur: big brown bat, little brown, silver-haired bat and northern long-eared bat, a red-listed species. General habitat preferences of bats include open areas such as wetlands, clearcuts and exposed ridges for feeding and adjacent mature timber for roosting. These habitats are particularly prevalent in floodplain areas of the Pine River.

Snowshoe Hare

Snowshoe hares occur throughout the subject property. Their abundance in any given year is dependent on what stage of an eight to ten year cycle they are in. Populations currently appear to be nearing the peak of the cycle. Hares are an important food source for lynx.

Rodents

A number of rodent species are known or expected to occur on the subject property. Muskrat and beaver occur apparently in high numbers, especially in floodplain areas of the Pine River and are an important species taken by the local trapper Mr. Roofthooft (pers. comm., 1996). Red squirrels, which are abundant on the subject property, are also trapped. Porcupines appear to be relatively common on the property. A well used den site and foraging sign was observed during the recent field survey. Hatler (1994) reported porcupine foraging sign, particularly on lodgepole pine. Of small mammal species expected to occur, five species were taken by Hatler (1994) during a survey of small mammal populations on the site. The five species include deer mouse, least chipmunk, long-tailed vole, southern red-backed vole and western jumping mouse. Rodents are expected to occur in all habitats, both disturbed and undisturbed, of the subject property.

Canids

Coyote, red fox and wolf are all present on the subject property. Coyotes often penetrate new areas by roads and seismic lines. Several track sets were observed during the recent field survey and by Hatler (1994). Both coyote and red fox are trapped in moderate numbers on and in the vicinity of the subject property.

Wolf wander throughout the area. Mr. Roofthooft, the local trapper, regularly captures wolves in trap sets around moose killed by trains. A single wolf was observed by mining exploration personnel (Wildlife Log Book 1996) and scats were noted by Hatler (1994).

Ursids

Both grizzly bear and black bear occur on the subject property, although black bears are far more abundant. Grizzly bears are most often sighted in the spring when they are seen foraging along roads and in clearcuts (Wildlife Log Book 1996). A significant amount of foraging sign in the form of diggings for *Hedysarum* was noted on exposed, grassy ridges along the northern edge of the property. MOE (1995) describe grizzly bears food preferences as including a wide range of herbaceous vegetation such as skunk cabbage, sweet vetch (*Hedysarum* spp.), roots, sedges, horsetails, grasses, and berries as well as insects and grubs, small and large mammals, carrion and fish. This wide range of food preferences suggest that grizzly bears can utilize a wide variety of habitats within the study area. Areas with concentrated food supplies include floodplain and riparian areas, clearcuts and upland meadows.

Black bears occur throughout the subject property and were commonly seen along roads and in clearcut areas where clover is abundant in spring and berries are prevalent in the fall (Wildlife Log Book 1996). An abundance of sign including scats and tracks were noted during the recent field survey and by Hatler (1994). One sow with three cubs was observed during the field visit. Based on the experience of the Bullmoose mine, grizzly bears may be expected to utilize revegetated areas as well.

Mustelids

Members of the mustelid family are some of the most sought after species by the local trapper. Mustelid species known to occur on the project area include marten, mink, wolverine, weasel, fisher and river otter (A. Roofthooft, pers. comm., 1996).

Marten is the most abundant species with generally more than 100 individuals taken within the entire trap line area, which occupies both sides of the Pine River between Lemoray Creek and Hasler Creek to the heights of land. Weasels are also taken although it is not known which species, least weasel or ermine, are most common. One possible marten was heard in floodplain forests during the field survey.

Fisher are less abundant than marten but are expected to occur throughout suitable habitats of the subject property. Mr. Roofthooft estimates that 30-40 fisher likely occur in his entire trapline area. Reported home range sizes were 4-44 km2 for females and 19 to 83 km2 for males (Banci 1989). Fisher inhabit forested habitats, particularly those with mixed habitat and structural stages, edges and riparian habitats (Banci 1989). Fisher like to hunt in open areas such as open ridges and the edge of clearcuts but require adjacent areas of mature forest. Winter resting sites are associated with large coarse woody debris and large spruce with spruce broom rust. Maternal den sites in British Columbia are almost entirely found in large, decadent cottonwood. Most habitat use is associated with structural stage 6 (mature) and 7 (old forest). Hatler (1994) reported one scat thought to be that of fisher. Habitats described above are particularly prevalent on the subject property in the Pine River floodplain and in upland areas with mature forest.

Mink and river otter occur in relatively low numbers in the Pine River floodplain. One River otter was observed by mining personnel at a wetland near the railway crossing of Willow Creek (Wildlife Log Book 1996). River otters are also regularly taken in low numbers by Mr. Roofthooft.

Wolverines occur in low numbers on the subject property. Mr. Roofthooft, the local trapper, estimates that there may only be 4-5 individuals over his entire trapline. The B.C. Ministry of Environment has given them a blue-listed rating to reflect their overall low population abundance in the province and their high sensitivity to habitat and human disturbance.

Felids

Lynx are expected to occur throughout the subject property. Lynx sign was observed during the September 1996 field survey and by Hatler (1994). Population levels are closely tied to snowshoe hare populations. Rocky ridges are used as vantage points and as travel corridors by lynx. Cougars were historically not known from the Peace River area. However, several recent sightings reported by A. Roofthooft and other residents suggests that some individuals now occur in the area. Cougars may likely attracted to the concentrated deer herds in winter. Cougar sightings are expected to increase in the Pine River corridor in the future.

Ungulates

Elk, moose, and mule and white-tailed deer are common inhabitants of the subject property. Although caribou have not been observed on the subject property, they are known to occur only a few kilometres to the east of the subject property. The previous trapper in the area had once seen a small band of caribou at the upper end of the Willow Creek property along a large seismic line.

An abundance of elk sign was observed on the subject property, particularly in the Pine River floodplain, the Far East Creek valley and northeastern portions of the subject property. Elk appear to be attracted to the rich herbaceous cover in these areas. A band of three elk was observed by mining exploration staff in the northern most clearcut and one cow was observed feeding on the pipeline right-of-way near the Pine River in 1996 (Wildlife Log Book 1996). Hatler (1994) observed two cows and two small bulls on 07 June 1994 in the Pine River floodplain near the railway tracks and noted tracks and pellet groups throughout the project area.

Moose sign was abundant throughout the subject property. Most red-osier dogwood and willow shrubs had some indications of browsing damage. Many aspen, especially in lower elevation areas, were partially barked by moose. Pellet groups were found in abundance throughout the site, although particular concentrations were noted along ridge crests and in the Pine River floodplain. Mining exploration staff reported one cow with three calves on the Willow Creek Forestry Road near the Pine River bridge. Several other moose observations were also noted (Wildlife Log Book 1996). Upland willow wetlands and floodplain areas of the Pine River appear to be particularly important wintering areas for moose. A number of shed antlers were found in the upland willow wetlands.

Mule deer were observed on several occasions by mining exploration personnel (Wildlife Log Book 1996) and Hatler (1994). Deer sign such as tracks and pellet groups noted during the recent field survey and by Hatler (1994) was either that of mule or white-tailed deer. White-tailed deer were also seen on several occasions by mining exploration personnel (Wildlife Log Book 1996), Hatler (1994) and on the recent field survey.

4.12.3.3 Amphibians

Due to the timing of the field survey, no amphibian species were observed. However, amphibian species which are known or are likely occur, include long-toed salamander (see Appendix 4.12-1 for scientific names), western toad, northern chorus frog, spotted frog and wood frog (Green and Campbell 1984; Corkran and Thoms 1996). Western toads were reported in the Wildlife Log Book (1996) and by Hatler (1994). A wood frog was also reported by Hatler (1994).

4.12.3.4 Reptiles

No reptile species were observed during the field survey. None were reported by Hatler (1994) or were noted in the Wildlife Log Book (1996). The reptilian fauna is restricted in northern British Columbia and common garter snake and western terrestrial garter snake are the only two species that may occur (Gregory and Campbell 1984).

4.12.3.5 Wildlife Capability Ratings

Wildlife capability and suitability ratings for all ecosystem units and structural stages located on the subject property for select species are summarized in Appendix 4.12-2. Species were selected if they are highlighted in the proposed Forest Practices Codes manual on ?Identified Wildlife' and/or are red or blue-listed by the B.C. Ministry of Environment (MOELP 1996). Comments on habitat capability for each of the species or species groups of concern is provided below.

Bay-breasted Warbler

Suitable habitat for bay-breasted warblers appears to be mature spruce forests at lower elevations. Therefore only structural stage 6 and 7 forests in the mid-elevation SBSwk2 zone and structural stages 5,6 and 7 in the BWBSmw1 were considered to be suitable for this species. Extremely dry sites are likely not utilized. Site series rated as being potentially suitable for bay-breasted warblers included: SBSwk2 (SO; SC; SD; SH); and BWBSmw1 (AM; SW; SO; SC; SH).

Black-throated Green Warbler

Mature spruce forest with open canopy and well developed shrub understorey appear to be the preferred habitats for black-throated green warblers. Structural stage 6 and 7 forests of all site series moister and more productive than mesic sites (i.e., 01) in all three biogeoclimatic zones were considered to be potentially suitable for this species. Site series rated as being potentially suitable for black-throated green warblers included: ESSFmv2 (FR; FO; FH); SBSwk2 (SO; SC; SD; SH); and BWBSmw1 (AM; SO; SC; SH).

Broad-winged Hawk

Mature, deciduous stands of aspen and cottonwood are preferred nesting habitats for broad-winged hawk. Deciduous stands in the BWBSmw1 were rated as being of either low or moderate suitability for this species. Most of these habitats are found on the Pine River floodplain. Site series rated as being potentially suitable for broad-winged hawk in the BWBSmw1 included: AM:ap-seral; SW; SW:as-seral; SO; SC; SC:ab-seral; SH; and SH:ac-seral.

Canada Warbler

Canada warblers are known to breed in mixed forest stands with a well developed understorey in the BWBS biogeoclimatic zone. These habitats are prevalent along the lower reaches of Willow and Far East Creeks and in the Pine River valley. Site series rated as being potentially suitable for Canada warbler in the BWBSmw1 included: AM; AM:ap-seral; SW; SW:as-seral; SO; SC; SC:ab-seral; SH; SH:ac-seral; and AS.

Cape May Warbler

Suitable habitat for Cape May warblers appears to be mature coniferous forests and coniferous forest edge habitats at mid to low elevations. Therefore, only structural stage 6 and 7 forests in the SBSwk2 and BWBSmw1 were considered to be potentially suitable for this species. Extremely dry sites are likely not utilized. Site series rated as being potentially suitable for Cape May warblers included: SBSwk2 (SO; SC; SD; SH); and BWBSmw1 (AM; SO; SC; SH).

Connecticut Warbler

Preferred breeding habitats appear to be aspen-poplar woodlands where undergrowth is neither too tall nor too dense. These habitats are reasonably widespread throughout low gradient areas of the BWBSmw1 biogeoclimatic zone on the site. Structural stage 5 and 6 forests in most site series were considered suitable. In seral stage site series, structural stage 7 was also considered to be suitable. Site series rated as being potentially suitable for Connecticut warbler in the BWBSmw1 included: AM; AM:ap-seral; SW; SW:as-seral; SO; SC; SC:ab-seral; SH; and SH:ac-seral.

Elk

During the growing season, elk concentrate in areas with an abundance of forage species. These conditions are generally found in early structural stage habitats (e.g., 2 and 3a) and under the canopy of mature, old-growth forests in rich, productive sites. None of the habitats within the site were considered to be of optimum value (i.e., 1 rating) to elk. Habitats that were rated as being of moderately high value to elk (i.e., 2) included (structural stage in brackets): ESSFmv2 [FO(2); Forb-Grass Meadow/00(2)]; SBSwk2 [SH(2)]; and BWBSmw1 [SH(2); SH:ac-seral stage(2); WH(2)]. Many ratings were in the moderate (i.e., 3) category.

Fisher

Fisher are generally found in mature and old-growth forests (i.e., structural stage 6 and 7) in rich and moist sites where trees are large, the shrub understorey is well established and coarse woody debris is abundant. Although mature forests are required for denning, fishers may be found in a wide range of other early structural stage and edge habitats while foraging. Most structural stages from 3a to 7 received a low suitability rating because of some foraging opportunities. Structural stages 6 and 7 of only a few habitats received a moderate or high rating. Habitats with these ratings include (structural stages in brackets): ESSFmv2 [FH(7)]; SBSwk2 [SH(6,7)]; and BWBSmw1 [SO(6,7); SH(6,7)].

Grizzly Bear

Foraging is concentrated in areas where herb production (spring and summer) and berry-producing shrubs (fall) is high. Early seral stage habitats (e.g., clearcuts, wetlands) and mature forests with well developed shrub understories are preferred foraging habitats. None of the habitats on the site were considered to be of optimum suitability (i.e., 1 rating) for grizzly bears. However a number of habitats in all biogeoclimatic zones were rated as being of moderately high (i.e., 2 rating) value. These include (structural stages in brackets): ESSFmv2 [FO(2); FH(2,3a,3b,6,7); Forb-Grass Meadow (2); SE(2)]; SBSwk2 [SD(3a,3b); SH(2,3a,3b); and BWBSmw1 [SO(2,3a,3b); SH(2); SH:ac-seral(2); and WH(2)].

Marten

Marten are generally found in mature and old-growth forests (i.e., structural stage 6 and 7) in rich and moist sites where trees are large, the shrub understorey is well established and coarse woody debris is abundant. Structural stage 7 habitats of the following site series were considered to be of high value to marten: ESSFmv2 (FH); SBSwk2 (SH); and BWBSmw1 (SC; SH). The two site series in the BWBSmw1 both currently occur on the site.

Moose

Moose sign was evident throughout the subject property. Shrub species such as red-osier dogwood and willow which grow in moist, rich sites are key browse species of moose. Aspen showed evidence of browsing but were considered of lower value to moose than abundant shrub cover. Habitats in the Pine River floodplain, in upland wetlands, and in open mature stands on rich sites were preferred feeding areas. None of the habitats on the site were considered to be of optimum (i.e., 1 rating) suitability for moose. However, a number of habitats were rated as being of moderately high (i.e., 2 rating) suitability. These habitat types included (structural stage in brackets): ESSFmv2 [FR(3b); FH(3a,3b); WS(3a,3b)]; SBSwk2 [SO(3b); SD(3a,3b); SH(3a,3b); WS(3a,3b)]; and BWBSmw1 [SO(3a,3b); SC(3a,3b); SC:ab-seral(3a,3b); SH/(3a,3b); SH:ac/-seral(3a,3b); SE(2); WH(2,3a,3b)].

Mule Deer

During the growing season, mule deer concentrate in areas with a abundance of forage species. These conditions are generally found in early structural stage habitats (e.g., 2 and 3a) and under the canopy of mature, old-growth forests in rich, productive sites. None of the habitats within the site were considered to be of optimum value (i.e., 1 rating) to mule deer. Habitats that were rated as being of moderately high value to mule deer (i.e., 2) included (structural stage in brackets): ESSFmv2 [FO(2); Forb-Grass Meadow(2)]; SBSwk2 [SH(2)]; and BWBSmw1 [SH(2); SH:ac-seral stage(2); WH(2)]. Many ratings were in the moderate (i.e., 3) category.

Northern Goshawk

Northern goshawks are known to breed in productive and moist, mature and old growth (i.e., structural stage 6 and 7) forests. Foraging is typically in forested habitats but may occur over structural stages ranging from 3a to older stages depending on prey availability. Most forested habitats on the site have some suitability for northern goshawk. The only habitats rated as being of high suitability for northern goshawk were SBSwk2 (SH) and BWBSmw1 (SC; SH). Only the later two habitats of the BWBSmw1 are currently present on the site.

Philadelphia Vireo

Philadelphia vireos appear to be restricted to dense, rapidly growing aspen stands in mid to low elevation areas (i.e., SBSwk2 and BWBSmw1). Some of these habitats are present in the Pine River floodplain. Preferred structural stage appears to be 4 and 5, although for site series in the BWBSmw1, structural stage 6 was also considered to be suitable. Site series rated as being potentially suitable for Philadelphia vireo include: SBSwk2 (SO; SC; SD); and BWBSmw1 (AM; AM:ap-seral; SW; SW:as-seral; SO; SC; SC:ab-seral; SH; SH:ac-seral; and AS).

Trumpeter Swan

Trumpeter swans are expected to make some use of wetland habitats in the Pine River valley (BWBSmw1), particularly during migration. Of vegetated sites, only the Sedge Wetland (SE) and Willow-Sedge-Horsetail Riparian Wetland (WH) are expected to be suitable for trumpeter swans.

White-tailed Deer

During the growing season, white-tailed deer concentrate in areas with a abundance of forage species. These conditions are generally found in early structural stage habitats (e.g., 2 and 3a) and under the canopy of mature, old-growth forests in rich, productive sites. None of the habitats within the site were considered to be of optimum value (i.e., 1 rating) to white-tailed deer. Habitats that were rated as being of moderately high value to white-tailed deer (i.e., 2) included (structural stage in brackets): ESSFmv2 [FO(2); Forb-Grass Meadow(2)]; SBSwk2 [SH(2)]; and BWBSmw1 [SH(2); SH:ac-seral stage(2); WH(2)]. Many ratings were in the moderate (i.e., 3) category. White-tailed deer are likely found in higher concentrations in the BWBSmw1 zone where shrub cover is dense.

Woodland Caribou

Woodland caribou forage on herbaceous plants during the growing season as do elk and deer. However, because food availability in winter (i.e., lichens) is limiting, mature and old growth forests on most site series were considered of some suitability to woodland caribou. None of the habitats were considered to be of moderately high or high value. Habitats that were rated as being of moderate (i.e., 3 rating) value to caribou included (structural stage in brackets): ESSFmv2 [FO(2,6,7); FH(2); Forb-Grass Meadow (2); SE(2)]; SBSwk2 [SH(7); WS(2)]; and BWBSmw1 [AM(2); AM:ap-seral(2); SO(2,7); SC(2,7); SH(2,5,6,7); SH:ac-seral(2); SE(2)].

Yellow-bellied Flycatcher

Preferred breeding habitats of yellow-bellied flycatchers appear to be mature, coniferous forests growing in moist, rich sites with adjacent open wetland habitat. Preferred structural stages for breeding range from structural stages 5 to 7. Some foraging may occur in open wetlands with structural stage 3a and 3b. Site series rated as being potentially suitable for yellow-bellied flycatchers included: ESSFmv2 (FH; WS); SBSwk2 (SD; SH; WS); and BWBSmw1 (SO; SC; SH; WH).

4.12.3.6 Valued Ecosystem Components

Wildlife Trees

Wildlife trees include large veteran cottonwood and aspen in lowland areas and several coniferous tree species, particularly white spruce, in upland areas. Wildlife trees provide: a) foraging opportunities for woodpeckers such as three-toed woodpecker; b) nesting sites for cavity nesters including small owls such as northern pygmy-owl, boreal owl and northern saw-whet owl, woodpeckers including pileated, hairy, downy, three-toed, and black-backed woodpecker, northern flicker and yellow-bellied and red-breasted sapsucker, and chickadees, nuthatches and brown creeper; and c) roost sites for a some bat species, especially where the tree is adjacent to potential foraging areas such as wetlands.

Wildlife Movement Corridors

Ridge crests and creek valleys are used by wildlife species to move or migrate between habitats and between wintering and summering areas. Abundant winter moose sign and ungulate paths were observed on several of the ridge crests on the property. Abundant elk sign was observed along the upper reaches of Far East Creek. Elk may utilize the ridge east of Far East Creek to move between upper elevation summering areas and lower elevation wintering areas. Sign of other wildlife species such as lynx, wolf, black bear and deer were also observed in these natural movement corridors.

4.12.3.7 Environmentally Sensitive Areas

Old and/or Mature Forests

Old and/or mature forests (i.e., Age Class 6 and 7) are sparsely distributed on the TEM study area. Several distinct patches occur just south of the upper clearcut and along the upper reaches of Far East Creek. Several areas of old cottonwood and aspen forest area are present in or immediately adjacent to the Pine River floodplain. Mature coniferous forests contain many snags and decadent trees which provide cavity nesting opportunities for a large variety of species (see Wildlife Trees above). Numerous three-toed woodpecker feeding sign was observed in old-growth spruce forest on the subject property. Old cottonwood and aspen forests are also important for cavity nesters. These forests are also preferred nesting areas for raptors such as northern goshawk, red-tailed hawk, great horned owl and possible other species including great gray owl and broad-winged hawk. Large cottonwood, especially along wetland edges, also provide roosting and perching habitat for raptors such as bald eagle, osprey and red-tailed hawk which forage in open grassland and wetland habitats. Large cottonwood and decadent aspen are potentially of high value to bats, which forage over wetland and open areas but require loose bark or cavities for day time roosts.

High Elevation Grasslands

High elevation grassland areas were only present along the northern edge of the TEM study area along a south facing exposed ridge outside the proposed area of disturbance for the mine. These habitats are of particular importance to grizzly bears, which forage on *Hedysarum* roots in spring and summer. White-tailed and mule deer and elk also forage on grasses and herbs in the spring. These exposed grassland areas are particularly important as spring forage sites because of early snowmelt and green-up compared to other, less exposed areas.

Ridge Crests

Because of their dry and exposed characteristics and west to east orientation (i.e., upper to lower elevation), rocky outcrops provide important movement corridors for wildlife such as moose, deer and elk. In some areas, important raptor perch sites are located along ridge crests. Lynx and wolf also utilize ridge crests as movement corridors and as vantage points for hunting. The most prevalent rocky bluffs are located along the northern end of the subject property above Far East Creek.

Creeks and Associated Riparian Areas

The subject property is intersected by several small creeks and tributaries. The largest creeks such as Willow Creek, some of its tributaries and Far East Creek flow year round. Well developed riparian strips are prevalent along some stretches of these creeks. Creeks and associated riparian habitats are not only important wildlife movement corridors, but also provide high structural heterogeneity and plant species diversity compared to the relatively uniform adjacent coniferous forests. As a result, these riparian areas are attractive to numerous bird, mammal and amphibian species. Moose browse on shrub plants occurring in these areas, especially in winter when herbaceous vegetation is unavailable. Creek and pool habitats are utilized as drinking and preening areas for wildlife, and possibly as breeding areas for salamanders.

Open Wetlands

Wetlands are most prevalent within the Pine River floodplain, although several small, willow dominated, wetlands occur at the upper reaches of Willow Creek.

Pine River Floodplain

Small ponds, marshes and backwater channels are present in the Pine River floodplain. These habitats are home to mammals such as muskrat, beaver, mink and river otter. Mallard, Canada goose and other waterfowl species breed. Many other waterfowl species, including bufflehead, goldeneye, teal and northern pintail are expected to occur during migration. These wetland habitats also provide important breeding areas for amphibians such as wood frog, spotted frog and western toad.

Upland Wetlands

Several small willow dominated wetlands are important to moose in winter. Willows, scrub birch, red-osier dogwood and other shrub species provide ample browsing opportunities. Several shed moose antlers were found in these wetlands during the field survey suggesting that moose densities are high during winter. One small wetland on the ridge above Far East Creek outside the proposed disturbance area had a well developed band of sedge. Sedges are utilized by bears and ungulates in the spring when fresh shoots are emerging. Other wildlife species such as olive-sided flycatcher and western wood-pewee, which nest in wetland edge habitats, are expected to occur. Forest dwelling amphibians (e.g., wood frog) likely use some of the wetlands for breeding.

Wetland Forest and Shrublands

Upland Wetland Forest

Several large patches of wetland forest were present in poorly drained sites in upland habitats and adjacent to open wetlands and creeks. These highly productive forests with their diverse and abundant shrub and herb layer are important foraging areas for ungulates and bears. Moose are particularly attracted to concentrations of willow and red-osier dogwood. Bears are attracted to areas with an extensive herbaceous layer consisting of species such as ferns and horsetail or an abundance of berry-producing shrubs (e.g., highbush cranberry). Well spaced, large spruce provide some cavity nesting opportunities as well as numerous foraging opportunities for birds such as three-toed woodpecker. High utilization of wetland forested areas at the collection area for the headwaters of Far East Creek were noted during the site visit.

Pine River Floodplain

Wetland forest is also extremely common in the Pine River floodplain where a variety of forested stands occurs. The extremely high productivity of these forest along with the diversity of shrub and herb species attracts numerous wildlife species. Some of the species which may occur are blue and red-listed by the B.C. Ministry of Environment (MOELP 1996). Blue-listed species such as broad-winged hawk, Philadelphia vireo and Connecticut warbler may nest in dense aspen or cottonwood stands. In shrubbier areas, species such as mourning warbler and black-and-white warbler, which are unique to northeastern British Columbia may nest. Most mammal species known or expected to occur on the subject property are expected to make some use of lowland forests. Blue-listed species such as fisher are expected to occur in these habitats. Grizzly bears are expected to occur, especially in the spring when an abundance of herbaceous species such as ferns, skunk cabbage, sedges and grasses are available. These lowland forests are also of critical importance as wintering areas for moose which forage extensively on willow, red-osier dogwood and other shrub species.

4.13 ARCHAEOLOGY/HERITAGE/TRADITIONAL USE

A critical area traditional use study will be conducted in consultation and with the assistance of Project Area First Nations personnel during the summer of 1997. A cooperative study could not be arranged in 1996. Previous work by Carlson (reported in Beak 1981) indicated no artifacts or significant resources were found in the area. Confirmation awaits the 1997 survey. A copy of the proposed study terms of reference is attached in Appendix 4.13-1. Both the work program and consultant have been agreed to by the West Moberly and Saulteau Bands.

The proposed consultation program will update the archaeologicl overview assessment referenced above and identify and assess potential impacts on traditional land use areas and heritage resource sites. The program will involve close cooperation with First Nations, joint site inspections and meetings and workshops to gather oral history from elders, information on herbal/medicinal plant use and other traditional land use issues.

First Nations issues are further discussed in Sections 11 and 17.

4.14 LAND USE

The following are the contacts made and the information each supplied regarding land interests in the Willow Creek project area:

· Jan Carlson, BC Assessment, Peace River Area

tax roll numbers of each district lot

· Sara Hui, BC Assessment, Vancouver Area

property legal descriptions and assessments

· Debbie Kunz, Peace River Regional District

Chetwyn Rural Area Official Community Plan, property sizes

· Jannene Disher, District of Chetwynd

Chetwyn Rural Area Official Community Plan

· Ron Poole, District of Chetwynd

Chetwyn Rural Area Official Community Plan

· Craig Hartell, Ministry of Forests, Dawson Creek

description of forestry activities, right of ways, and Crown land holdings

· Laurie Fast, Crown Lands, Fort St. John

description of Crown land holdings

· Jerry Gleason, Ministry of Forests, Dawson Creek

agricultural activity

· Peg FitzGerald, Petroleum Titles, Victoria

details of drilling and petroleum and natural gas titles

· Gillian, Petroleum Titles, Victoria

details of drilling and petroleum and natural gas titles

4.14.1 Agriculture

The project site is not used for agricultural purposes. The area is classified 6 and 7 for agricultural capability (non-arable, but capable of producing native and/or uncultivated perennial forage crops or having no capability for arable culture), i.e. the land is suitable as wildlife habitat.

4.14.2 Forestry

A number of timber licences and forestry tenures are held around the project area. Figure 4.14-1 shows the licences and the legend codes the type of tenures and permits.

Forestry related activity in the general Willow Creek area is high. CanFor has a land based tenure south of the Pine River known as Timber Forest License (TFL) 48, Block 4. The timber sale areas north of the Pine River are harvesting areas up for sale under the Small Business Enterprise Program. The entire Willow Creek area falls under Pulp Agreement 13; Louisianna Pacific Deciduous holds the tenure to harvest deciduous trees (mainly aspen) here. The three timber sale areas to the south of the Pine River are active; Louisianna Pacific Deciduous has applied to harvest in these areas. One of these areas is located along the south side of the rail line between Willow Creek and Middle Creek, another is located along the east side of Willow Creek to the south of the rail line, and the other is to the east of lot 383. The Ministry of Forests (MoF) have established two administrative areas to the east of Fred Nelson Creek as lands set aside for timber management. The timber within these areas has been verified to be Crown owned. The MoF areas with special use permits are locations of MoF rock quarries or logging camps.

4.14-3 Non-Renewable Resources

Both oil and gas leases and mining claims are held in and adjacent to the Project area. Figure 4.14-2 shows holdings.

Pine Valley Coal holds coal licences concentrated along Willow Creek and Falling Creek to the south of the Pine River, and several more on the north side of the river around Crassier and Fisher creeks. The coal tenure numbers and their locations are illustrated in Figure 4.14-3.

There are petroleum and natural gas leases over some of the same land which Pine Valley Coal holds coal tenures on. The current leases and their holders are listed in Table 4.14-1. The leases are held under provisions of the Petroleum and Natural Gas Act. The lease holder has the rights to the petroleum and/or natural gas within the area defined under their lease. The eight leases indicated on Table 4.14-1 were issued subject to the rights of previously issued coal licenses within the same location. Talisman Energy Inc. has a drilling license located in two blocks, one over the upper Willow Creek watershed, and the other southeast of the Willow Creek headwaters. Under this title, Talisman Energy Inc. holds the rights to drill and place wells in the land covered by their license. If they do install a well (or wells) they can choose to hold a petroleum and natural gas lease on their site. They must hold a lease if they want to put the well on production. If they do not install a well by the end of their lease on October 18, 2000, they may extend it for one more year. If they have not drilled on the land by the end of this term, the license cannot be renewed. This license is subject to prior rights of existing coal tenures.

Table 4.14-1: Pine Valley Coal, Willow Creek Area Land Interests

Property/Permit Owner	Property/Permit Type	Property Location
BC Rail	utilities	DL 364
BC Rail	utilities	DL 365
BC Rail	utilities	DL 366
Dennis and Marjorie Ward	residential	DL 367
Insley Contracting Ltd	residential	DL 367
Frank and Joanne Harmacek	residential	DL 367
Robert Olson	residential	DL 367
BC Rail	utilities	DL 368, BLK C
BC Rail	utilities	DL 369, BLK A
Provincial Crown Land	business/other	DL 370
BC Rail	utilities	DL 371, BLK A
BC Rail	utilities	DL 372, BLK B

Kenneth Sheen	residential	DL 373, BLK A
Westcoast Transmission Co Ltd.	utilities	DL 373
Westcoast Energy Inc	utilities	DL 373, BLKS A,C
Westcoast Energy Inc.	residential	DL 373
Westcoast Transmission Co Ltd.	residential	DL 373
Federated Pipe Lines (Western) Ltd.	utilities	DL 373, BLK A
Westcoast Transmission Co Ltd.	residential	DL 373
Andre Roofthooft	residential	DL 373, SW portion
BC Rail	utilities	DL 375, BLK A
Provincial Crown Land		DL 376
BC Rail	utilities	DL 377, BLK A
Provincial Crown Land		DL 378
BC Rail	utilities	DL 379, BLK A
BC Rail	utilities	DL 380, BLK A
BC Rail	utilities	DL 381, BLK C
Marvin Harrison	residential, farm	DL 381
BC Rail	utilities	DL 382, BLK C
Marvin Harrison	residential, farm	DL 382
BC Rail	utilities	DL 383, BLK C
Marvin Harrison	residential, farm	DL 383
BC Rail	utilities	DL 384, BLK C
Marvin Harrison	residential, farm	DL 384

Robert Olson	residential	DL 1138
Daniel Ball	residential, farm	DL 1138
BC Rail	utilities	DL 1138
Provincial Crown Land	residential	DL 1142, BLK A
John Proulx	residential	DL 1142, BLK B
Roderick and Annette Gordon	residential	DL 1142, BLK B
Provincial Crown Land	residential	DL 1142, BLK C
BC Rail	utilities	DL 1142, BLK C
Donald Smith, Kevin Ashworth, William Scoble	residential	DL 1147, BLK A
Provincial Crown Land	residential	DL 1147, BLK E
BC Rail	utilities	DL 1147, BLKS F,G,H
Janice and Stuart Chantree	residential, farm	DL 1149, BLK A
Provincial Crown Land	land tenures	throughout Willow Flats, usually along roads
Provincial Crown Land	reserves	throughout Willow Flats along Hwy 97
Provincial Crown Land	wood lot	north of Pine River, east of Fred Nelson Creek
CanFor	timber forest license	south of the Pine River
CanFor	timber cutting permit	around Middle and Far East creeks, and east of Beaudette Creek
West Fraser	timber cutting permit	around the lower end of Crassier Creek
Louisianna Pacific Deciduous	harvesting tenure	entire area
various small business logging companies	timber sales areas	five areas in Willow Flats
Ministry of Forests	administrative areas	two areas north of Pine River, east of Fred Nelson Creek

Ministry of Forests	special use permits	throughout Willow Flats along Hwy 97
Pine Valley Coal	coal licences	several licences from the Pine River southeast around and including Willow Creek
Pine Valley Coal	coal licences	three licences to the north of the Pine River around Crassier Creek
Pine Valley Coal	coal licences	several licences southeast of the Pine River around and including Falling Creek
Pine Valley Coal	coal licences	three licences north of the Pine River and west of Fisher Creek
Tailsman Energy Inc.	drilling license	*DL 46045
Home Oil Company Ltd.	petroleum and natural gas lease	PNG 2952
Home Oil Company Ltd. - 50%	petroleum and natural gas lease	PNG 4833
Suncor Inc. - 50%		
Husky Oil Operations Ltd. - 50%	petroleum and natural gas lease	PNG 5043
Suncor Inc. - 50%		
Husky Oil Operations Ltd.	petroleum and natural gas lease	PNG 5044
Husky Oil Operations Ltd. - 75%	petroleum and natural gas lease	PNG 13604
Suncor Inc. - 25%		
Tailsman Energy Inc.	petroleum and natural gas lease	PNG 13766
Tailsman Energy Inc.	petroleum and natural gas lease	PNG 13767
Amoco Canada Resources Ltd. - 37.5%	petroleum and natural gas lease	*PNG 14763
Gulf Canada Properties Ltd. - 50%		
Tailsman Energy Inc. - 12.5		
Amoco Canada Resources Ltd. - 37.5%	petroleum and natural gas lease	*PNG 14764

Gulf Canada Properties Ltd. - 50%		
Tailsman Energy Inc. - 12.5		
Shell Canada Ltd.	petroleum and natural gas lease	*PNG 40056
Home Oil Company Ltd. - 25%	petroleum and natural gas lease	*PNG 40057
Husky Oil Operations Ltd. - 50%		
Suncor Inc. - 25%		
Sekani Resources Ltd.	petroleum and natural gas lease	*PNG 40058
Shell Canada Ltd.	petroleum and natural gas lease	*PNG 40059
Shell Canada Ltd.	petroleum and natural gas lease	*PNG 40291
Enermark Inc. - 40%	petroleum and natural gas lease	*PNG 40351
Tailsman Energy Inc. - 60%		
Enermark Inc. - 40%	petroleum and natural gas lease	*PNG 40352
Tailsman Energy Inc. - 60%		
W. J. Quinn Consulting Services	petroleum and natural gas lease	PNG 41498
W. J. Quinn Consulting Services	petroleum and natural gas lease	PNG 41499
Shell Canada Ltd.	petroleum and natural gas lease	PNG 43039
Tailsman Energy Inc.	petroleum and natural gas lease	PNG 43328

* lease subject to previously issued coal licenses

There are rights of ways for the pipelines, transmission lines, railway, highway, and logging roads (Figure 4.14-4). The John Hart-Peace River Highway (Hwy 97) follows the Pine River along the north bank, and the BC Rail line follows the river along the south bank. Westcoast Energy's natural gas pipeline runs with Federated Pipeline's oil pipeline in an east-west direction north of the highway. One natural gas pipeline runs north-south along the east side of Fred Nelson Creek, and another runs through some of the district lots on the south side of the river. The two parallel sets of transmission lines on the north side of the highway and up Crassier Creek are carrying power from BC Hydro's Peace Canyon Dam. Logging roads are located near Willow Creek, and MoF right of ways for logging road locations exist within the timber cutting area around Crassier Creek, and up to the timber cutting area to the west of Beaudette Creek.

4.14.4 Private Land Holdings

There are five residences nearby to the site. Figure 4.14-4 shows private holdings.

The lands surrounding the proposed Willow Creek Project are held under various tenures. There are privately and publicly owned properties, as well as other land interests. The interests include various forestry designated areas, provincially designated areas and reserves, right of ways, licenses and tenures. Under Bylaw 1086-1977, an area surrounding the mine site has been incorporated into the District of Chetwyd. Within this boundary, the industrial sites fall under the jurisdiction of the municipality of Chetwynd. This is known as the Chetwynd Rural Area Official Community Plan.

Most of the owned property is along Highway 97 (Figure 4.14-4). Various individuals and partnerships own property in the valley as residential class. A few of these properties are also used for farming. BC Rail has a rail line along the south bank of the Pine River, and owns much of the surrounding land as a utilities property class. Westcoast Energy Inc. and Westcoast Transmission Co Ltd. (under Westcoast Energy Inc.) hold property as utilities and residential property classes in District Lot 373 (Figure 4.14-4). This is the location of a compressor station and a transmission station for the natural gas pipeline that follows the highway on the north side. At the station another gas pipeline running north-south and following the east side of Fred Nelson Creek meets the east-west line. Federated Pipelines (Western) Ltd. houses an oil pump station for their east-west running oil pipeline.

Provincial Crown Land has land holdings within some of the District Lots as well as the unsurveyed land in the area. The Crown has placed reserves over some land, and house gravel quarries or wells in some locations referred to as Crown land tenures. The land tenures are located mainly along roads (Figure 4.14-1). D. Hall and Associates have applied for a license of occupation for a quarry in the tenure located on the north side of the river, to the west of Lot 383, and Westcoast Energy Inc. has a similar license application for the tenure east of Lot 379. The Ministry of Transportation and Highways have five tenures for gravel sources along the highway. These are located west of lot 384, and within lots 378, 370, 367, and 1138. BC Rail has rights to quarry gravel within the area from 900m south to 800m north of their railway. The Ministry of Transportation and Highways also holds tenures on both sides of the highway in lot 1142 for a rest area. On the east side of the logging road following Willow Creek there is a gas well. A BC Parks recreation reserve is located near the mouth of Fisher Creek.

4.14.5 Guiding/Hunting

Guiding and hunting information is not released by MOELP and therefore there is no information on use of the area. The project area has been extensively disturbed and is therefore not a prime area for guiding activities. The use of the site by local hunters (i.e. those not requiring guides) is not known.

4.14.6 Trapping

Information on trapping is not released by MOELP. From our studies, we are aware of one trapper in the area (Mr. Roofthooft). As well as licensed trappers, First Nations may utilize the area for trapping. First Nations issues are discussed in Chapter 11.

4.14.7 Water Licences and Wells

Information on wells in the Chetwynd area (Fort St. John District) is incomplete as wells do not require registry. No wells are known to be used on the south side of the Pine River in the proximity of the project site.

The British Columbia Water Resources data base shows two water licences on the Pine River held by Westcoast Energy, each for withdrawal of 10,000 gallons per day (45,000 L per day) for industrial purposes. Other water licenses listed in the general area of the project are on tributaries not affected by mine development (Tricker Spring and Beverly Brook).

4.15 ACID ROCK DRAINAGE STUDIES

4.15.1 Introduction

The nine coal seams at Willow Creek are hosted by calcareous siltstones and shales of the Gething Formation. The seams were formed in a freshwater environment, hence sulphur concentrations were probably low in the paleoenvironment and are lower in the coal seams than coals formed in a brackish or saltwater environment. Limited acid-base accounting (ABA's) reported in 1982 indicated that sulphur concentrations were low. In any coal deposit, the highest sulphur contents and greatest potential for acid rock drainage (ARD exists adjacent to the seams in the typically shaley roof and floor.

No natural evidence of ARD was noted during a field visit in 1994. None of the rocks examined contained visible pyrite but calcite was abundant.

4.15.2 Sampling and Analysis

Samples for ABA were taken from drill cuttings and core obtained during the coal reserve delineation program. During drilling, a geophysical log was obtained which was used to correlate with rock types determined from examination of cuttings. To a degree, the cutting samples obtained are composites, but monitoring of the geophysical log and cuttings as they are produced allowed for thin, interbedded (non-economic) coal layers and shaley beds potentially containing higher concentrations of sulphur to be sampled separately. Ten drill hole locations for ARD sampling were selected based on current knowledge of the stratigraphy. At each location, cutting or core samples were collected in the interburden. Each time a major change in lithology was encountered (based on the geophysical log and observations of cuttings), a new sample was collected. The minimum sampling length was 5 m to allow for practical management during mining, should this prove necessary.

Samples were submitted for standard ABA analysis. This includes determinations of: paste pH, total sulphur, sulphate sulphur, acid potential(AP), neutralization potential (NP) and metals by ICP scan.

4.15.3 Description of Results

4.15.3.1 Form of Sulphur

Non-detectable (<0.02%) levels of sulphate-sulphur in the samples are coupled with generally low concentrations (<0.3%) of total sulphur. Previous sulphur speciation testing of drill samples representing product coal and in-seam waste material determined that almost all of the sulphur present was organic in nature and not present as sulphides (Table 4.15-1). Total sulphur is therefore assumed to be in the form of organic sulphur.

TABLE 4.15-1

SULPHUR SPECIATION BY SEAM

WILLOW CREEK COAL

Seam	Sulphur Content by Species (%)				Percent Distribution		
	Total	Sulphate	Pyritic	Organic	Sulphate	Pyritic	Organic
1	0.55	0.01	0.08	0.46	1.82	14.55	83.64
1	0.55	0.01	0.09	0.45	1.82	16.36	81.82
3-0	0.48	0.01	0.05	0.42	2.08	10.42	87.50
4-1	0.68	0.01	0.02	0.66	1.47	2.94	97.06
4-1	0.56	0.01	0.02	0.54	1.79	3.57	96.43
5	0.80	0.01	0.20	0.59	1.25	25.00	73.75
6	0.65	0.01	0.07	0.57	1.54	10.77	87.69
7	0.55	0.01	0.14	0.40	1.82	25.45	72.73
7-2	0.86	0.03	0.22	0.60	3.49	25.58	69.77

Analyses performed on the -15mm fraction

4.15.3.2 ABA Characteristics by Rock type

The samples were characterised into 5 rock types, based on the most prevalent lithology within each sample interval. Lithologic classifications were done using down-hole gamma-ray logs. The classifications (number of samples in parentheses) are: sandstone (21), coal-bearing units (17), shale (8), siltstone (7) and Moosebar shale (2). Any sample interval which reported the presence of coal was classified as coal-bearing. Because of this, there are minor discrepancies between sample intervals classed as coal-bearing and minable coal seams defined by the mine plan. This classification will tend to overestimate the presence of coal as a proportion of the number of samples. Moosebar shales were separated from other (Gething) shale units due to their marine origin and resultant potential for higher sulphide content than the terrestrial sediments. Geological data and corresponding ABA data for each sample are listed in Table 4.15-2

TABLE 4.15-2

DRILL HOLE, GEOLOGY AND ABA DATA

SAMPLE #	Hole No.		From	To	Rock Types	Grouped Rock Type	Paste pH	S (tot) %	S (SO4) (%)	AP*	NP	NNP	NP/AP
96036+96035	96-	65	10	30	sandstone	sandstone	8.79	0.08	<0.02	2.5	205.6	203.1	82.3
96030	96-	65	40	50	shale/sandstone	shale	8.71	0.12	<0.02	3.8	217.5	213.8	58.0
96031+96032	96-	65	50	70	shale/sandstone	shale	8.55	0.20	<0.02	6.3	78.1	71.9	12.5
96033+96034	96-	65	70	90	shale/coal	coal-bearing	8.64	0.12	<0.02	3.8	136.3	132.5	36.3
96011+96001	96-	72	1	2	mudstone	siltstone	8.51	0.09	<0.02	2.8	155.0	152.2	55.1
96002+96006	96-	72	3	4	mudstone	siltstone	8.57	0.06	<0.02	1.9	207.5	205.6	110.7
96015	96-	72	5	6	siltstone	siltstone	8.83	0.15	<0.02	4.7	198.1	193.4	42.3
96007-9+96004	96-	72	7	8	mudstone/coal tr.	coal-bearing	8.50	0.25	<0.02	7.8	156.3	148.4	20.0
96003+96019-21	96-	72	9	10	mudstone/coal tr.	coal-bearing	8.79	0.24	<0.02	7.5	170.0	162.5	22.7
96016+96018	96-	72	11	12	mudstone/coal tr.	coal-bearing	8.76	0.15	<0.02	4.7	205.0	200.3	43.7
96017+96012	96-	72	13	14	mudstone/coal tr.	coal-bearing	9.03	0.09	<0.02	2.8	177.5	174.7	63.1
96010	96-	72	15	16	siltstone	siltstone	8.67	0.11	<0.02	3.4	129.4	125.9	37.6
96014+96005	96-	72	17	18	siltstone	siltstone	8.76	0.08	<0.02	2.5	235.6	233.1	94.3

96013	96-	72	19	19	sandstone	sandstone	8.71	0.39	<0.02	12.2	233.1	220.9	19.1
96100+96105	96-	78	0	10	shale	shale	8.65	0.06	<0.02	1.9	173.8	171.9	92.7
96100+96105	96-	78	0	10	shale	shale	8.65	0.06	<0.02	1.9	175.0	173.1	93.3
96101+96107	96-	78	10	20	carb. shale	shale	8.66	0.15	<0.02	4.7	125.0	122.2	27.1
96103+96104	96-	78	20	30	sandstone	sandstone	8.91	0.09	<0.02	2.8	281.9	279.1	100.2
96102+96106	96-	78	30	40	sandstone	sandstone	8.41	0.12	<0.02	3.8	298.8	295.0	79.7
96108	96-	78	40	43	sandstone	sandstone	8.70	0.18	<0.02	5.6	237.5	231.9	42.2
96110+96111	96-	126	35	45	sandstone	sandstone	8.72	0.11	<0.02	3.4	218.1	214.7	63.5
96112	96-	126	45	50	sandstone/siltstone	sandstone	8.69	0.16	<0.02	5.0	160.0	155.0	32.0
96082+96085	96-	154	50	70	shale/sandstone	shale	8.97	0.13	<0.02	4.1	278.8	274.7	68.6
96083+96084	96-	154	70	90	shale/sandstone	shale	8.97	0.12	<0.02	3.8	223.1	219.4	59.5
96080+96081	96-	154	90	110	shale/coal	coal-bearing	8.95	0.21	<0.02	6.6	123.8	117.2	18.9
96091+96087	96-	154	110	130	shale/coal	coal-bearing	8.78	0.11	<0.02	3.4	146.9	143.4	42.7
96086+96093	96-	154	130	150	sandstone/shale	sandstone	8.92	0.14	<0.02	4.4	210.6	206.3	48.1
96088+96098	96-	154	150	170	sandstone	sandstone	8.80	0.19	<0.02	5.9	152.5	146.6	25.7
96090+96089	96-	154	170	190	sandstone/shale	sandstone	8.80	0.20	<0.02	6.3	110.0	103.8	17.6
96095+96094	96-	154	190	210	sandstone	sandstone	8.89	0.11	<0.02	3.4	86.9	83.4	25.3

96096+96092	96-	154	210	230	sandstone/coal	coal-bearing	8.90	0.19	<0.02	5.9	165.6	159.7	27.9
96096+96092	96-	154	210	230	sandstone/coal	coal-bearing	8.90	0.19	<0.02	5.9	160.6	154.7	27.1
96097	96-	154	230	245	sandstone/coal	coal-bearing	8.88	0.26	<0.02	8.1	66.3	58.1	8.2
96065+96054	96-	158	25	40	silty shale	Mooseb. shale	8.67	0.50	<0.02	15.6	202.5	186.9	13.0
96055+96046	96-	158	40	60	silty shale	Mooseb. shale	8.95	0.59	<0.02	18.4	117.5	99.1	6.4
96047+96043	96-	158	60	80	sandstone/siltstone	sandstone	8.58	0.77	<0.02	24.1	98.1	74.1	4.1
96058+96051	96-	158	80	100	carb. shale/ coal	coal-bearing	8.69	0.50	<0.02	15.6	113.8	98.1	7.3
96059+96060	96-	158	100	120	sandstone	sandstone	8.90	0.19	<0.02	5.9	175.0	169.1	29.5
96073+96057	96-	158	120	140	sandstone	sandstone	8.83	0.19	<0.02	5.9	222.5	216.6	37.5
96075+96070	96-	158	140	160	sandstone/siltstone	sandstone	8.93	0.36	<0.02	11.3	157.0	146.9	14.1
96053+96052	96-	158	160	180	shale/coal tr.	coal-bearing	9.19	0.18	<0.02	5.6	145.6	140.0	25.9
96048+96074	96-	158	180	200	shale/sandstone	shale	9.31	0.10	<0.02	3.1	270.0	266.9	86.4
96042+96056	96-	158	200	220	sandstone/shale	sandstone	9.16	0.16	<0.02	5.0	172.5	167.5	34.5
96041+96050	96-	158	220	250	coal/siltstone	coal-bearing	8.69	0.40	<0.02	12.5	26.9	14.4	2.2
96071+96062	96-	158	240	260	siltstone	siltstone	8.72	0.12	<0.02	3.8	114.4	110.6	30.5
96063+96076	96-	158	260	280	siltstone/shale	siltstone	8.67	0.29	<0.02	9.1	97.5	88.4	10.8

96067+96044	96-	158	280	300	coal/sandstone	coal-bearing	8.46	0.17	<0.02	5.3	64.3	58.9	12.1
96067+96044	96-	158	280	300	coal/sandstone	coal-bearing	8.46	0.17	<0.02	5.3	63.9	58.6	12.0
96049+96040	96-	158	300	320	sandstone/siltstone	sandstone	8.81	0.14	<0.02	4.4	57.5	53.1	13.1
96068+96061	96-	158	320	340	sandstone/siltstone	sandstone	8.90	0.22	<0.02	6.9	175.0	168.1	25.5
96064+96066	96-	158	340	360	sandstone/siltstone	sandstone	9.29	0.12	<0.02	3.8	269.4	265.6	71.8
96045+96077	96-	158	360	380	sandstone/siltstone	sandstone	9.32	0.16	<0.02	5.0	201.3	196.3	40.3
96072	96-	158	380	385	sandstone/siltstone	sandstone	9.13	0.25	<0.02	7.8	57.5	49.7	7.4

Table 4.15-3 summarizes the means, 10th and 90th percentiles, minimum and maximum values and the standard deviations for the main ABA parameters of the five lithologic groups. Figures 4.15-1 to 4.15-5 summarize the ABA characteristics of the lithologies. Paste pH values for the rock types are highly similar, ranging from 8.68 (siltstone) to 8.87 (sandstone). Critical lithologies, such as the coal-bearing and Moosebar shale units report pH values of 8.77 and 8.81, respectively. Moosebar shales contain the highest total sulphur contents (0.55%); however, the remaining lithologies do not exceed the 0.3% sulphide-S screening criteria. No sample reported sulphate-sulphur concentrations above detection limit. It is assumed that the sulphur present is in sulphide form. Mean acid potential (AP) values of 3.7 to 17 are countered by high neutralization potential values averaging from 162 to 192 for the five rock types The elevated NP values are likely the product of high carbonate concentrations in the lithologies and/or the presence of visible calcite. The high NP values result in NP/AP ratios which range from a low of 6.4 (Moosebar shale) to 110 (Shale). No sample shows a NP/AP value less than the conservative value of 4 used to for the BC ARD screening criteria. Net neutralization potential (NNP) values range from 14.4 to 295 and indicate that all lithologies will be net acid consuming.

TABLE 4.15-3

SUMMARY STATISTICS FOR ACID BASE ACCOUNTING

BY ROCK TYPE

		pH					
Rock Type	N	Mean	P10	P90	Min	Max	SD
Sandstone	21	8.87	8.69	9.16	8.41	9.32	0.22
Coal-bearing	17	8.77	8.48	9.00	8.46	9.19	0.21
Shale	8	8.81	8.62	9.07	8.55	9.31	0.25
Siltstone	7	8.68	8.55	8.79	8.51	8.83	0.11
Moosebar shale	2	8.81	8.70	8.92	8.67	8.95	0.20

		Total Sulphur (%)						Sulphate Sulphur (%)					
Rock Type	N	Mean	P10	P90	Min	Max	SD	Mean	P10	P90	Min	Max	SD
Sandstone	21	0.21	0.11	0.36	0.08	0.77	0.15	<0.02	<0.02	<0.02	<0.02	<0.02	0
Coal-bearing	17	0.22	0.11	0.34	0.09	0.50	0.11	<0.02	<0.02	<0.02	<0.02	<0.02	0
Shale	8	0.12	0.06	0.17	0.06	0.20	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	0
Siltstone	7	0.13	0.07	0.21	0.06	0.29	0.08	<0.02	<0.02	<0.02	<0.02	<0.02	0
Moosebar shale	2	0.55	0.51	0.58	0.50	0.59	0.06	<0.02	<0.02	<0.02	<0.02	<0.02	0

		AP						NP					
Rock Type	N	Mean	P10	P90	Min	Max	SD	Mean	P10	P90	Min	Max	SD
Sandstone	21	6.4	3.4	11.3	2.5	24.1	4.7	180.0	86.9	269.4	57.5	298.8	69.3
Coal-bearing	17	6.7	3.6	10.8	2.8	15.6	3.4	128.2	64.0	174.5	26.9	205.0	51.1

Shale	8	3.7	1.9	5.2	1.9	6.3	1.4	192.7	110.9	272.6	78.1	278.8	69.0
Siltstone	7	4.0	2.3	6.4	1.9	9.1	2.4	162.5	107.6	218.8	97.5	235.6	52.2
Moosebar shale	2	17.0	15.9	18.2	16.6	18.4	2.0	160.0	126.0	194.0	117.5	202.5	62.1
		NNP						NP/AP					
Rock Type	N	Mean	P10	P90	Min	Max	SD	Mean	P10	P90	Min	Max	SD
Sandstone	21	173.6	74.1	265.6	49.7	295.0	70.9	38.7	13.1	79.7	4.1	100.2	26.6
Coal-bearing	17	121.4	58.3	169.8	14.4	200.3	52.7	24.7	7.6	43.3	2.2	63.1	16.4
Shale	8	189.2	107.1	269.2	71.9	274.7	69.4	62.3	22.7	92.9	12.5	93.3	29.9
Siltstone	7	158.5	101.8	216.6	88.4	233.1	53.7	54.5	22.6	100.8	10.8	110.7	35.7
Moosebar shale	2	143.0	107.8	178.1	99.1	186.9	62.1	9.7	7.0	12.3	6.4	13.0	4.7

4.15.3.3 Seam Interburden

Table 4.15-4 lists summary statistics for ABA data on the samples grouped into producing coal seams and interburden waste material. These statistics have been subdivided by stratigraphic location and drill hole. Figures 4.15-6 to 4.15-8 summarize the ABA characteristics of these two groups. Paste pH values are all highly similar ranging from 8.41 to 9.31. Mean total sulphide concentration of the interburden is 0.20% with a maximum of 0.77% found in hole 96-158. Only 5 of the 36 interburden samples exceed the 0.3% screening criteria for sulphide-sulphur. No interburden sample reported sulphate-sulphur above the 0.02% detection limit. Sulphur speciation of a suite of coal and in-seam waste material by Pine Valley Coal determined that the majority of the sulphur was present as organic sulphur and not in the sulphide form. This suggests the sulphur present is organic in form. Acid Potential (AP) values of 1.88 to 24.06 kg/t are counteracted by high neutralization potential (NP) values of 58.94 to 295 kg/t. These high NP values produce high NP/AP values from 4.08 to 110.67 with a mean value of 41.82. No sample shows a value less than the conservative value of 4.0 used for the British Columbia ARD screening criteria. Net neutralization potentials range from 58.94 to 295 and indicate that the interburden will be net acid consuming.

TABLE 4.15-4

INTERBURDEN ABA STATISTICS

WILLOW CREEK COAL

	n=36	Paste	S%	S%				
		pH	(tot)	(SO4)	AP	NP	NNP	NP/AP
A-1 to A-0		8.71	0.12	<0.02	3.8	217.5	213.8	58.0
Below A-0		8.64	0.12	<0.02	3.8	136.3	132.5	36.3
Above 2 Seam		8.72	0.12	<0.02	3.8	114.4	110.6	30.5
96065+96054	96-	8.67	0.50	<0.02	15.6	202.5	186.9	13.0
96055+96046	96-	8.95	0.59	<0.02	18.4	117.5	99.1	6.4
96047+96043	96-	8.58	0.77	<0.02	24.1	98.1	74.1	4.1
96058+96051	96-	8.69	0.50	<0.02	15.6	113.8	98.1	7.3
96059+96060	96-	8.90	0.19	<0.02	5.9	175.0	169.1	29.5
96073+96057	96-	8.83	0.19	<0.02	5.9	222.5	216.6	37.5
96075+96070	96-	8.93	0.36	<0.02	11.3	157.0	146.9	14.1
96053+96052	96-	9.19	0.18	<0.02	5.6	145.6	140.0	25.9
96048+96074	96-	9.31	0.10	<0.02	3.1	270.0	266.9	86.4
96042+96056	96-	9.16	0.16	<0.02	5.0	172.5	167.5	34.5
96100+96105	96-	8.65	0.06	<0.02	1.9	173.8	171.9	92.7
96101+96107	96-	8.66	0.15	<0.02	4.7	125.0	122.2	27.1
96103+96104	96-	8.91	0.09	<0.02	2.8	281.9	279.1	100.2

96102+96106	96-	8.41	0.12	<0.02	3.8	298.8	295.0	79.7
96108	96-	8.70	0.18	<0.02	5.6	237.5	231.9	42.2
96110+96111	96-	8.72	0.11	<0.02	3.4	218.1	214.7	63.5
96112	96-	8.69	0.16	<0.02	5.0	160.0	155.0	32.0
Above 3 Seam		8.46	0.17	<0.02	5.3	64.3	58.9	12.1
96011+96001	96-	8.51	0.09	<0.02	2.8	155.0	152.2	55.1
96002+96006	96-	8.57	0.06	<0.02	1.9	207.5	205.6	110.7
96015	96-	8.83	0.15	<0.02	4.7	198.1	193.4	42.3
96007-9+96004	96-	8.50	0.25	<0.02	7.8	156.3	148.4	20.0
96003+96019-21	96-	8.79	0.24	<0.02	7.5	170.0	162.5	22.7
96016+96018	96-	8.76	0.15	<0.02	4.7	205.0	200.3	43.7
96082+96085	96-	8.97	0.13	<0.02	4.1	278.8	274.7	68.6
96083+96084	96-	8.97	0.12	<0.02	3.8	223.1	219.4	59.5
96080+96081	96-	8.95	0.21	<0.02	6.6	123.8	117.2	18.9
96091+96087	96-	8.78	0.11	<0.02	3.4	146.9	143.4	42.7
96086+96093	96-	8.92	0.14	<0.02	4.4	210.6	206.3	48.1
96088+96098	96-	8.80	0.19	<0.02	5.9	152.5	146.6	25.7
96090+96089	96-	8.80	0.20	<0.02	6.3	110.0	103.8	17.6
96068+96061	96-	8.90	0.22	<0.02	6.9	175.0	168.1	25.5

96064+96066	96-	9.29	0.12	<0.02	3.8	269.4	265.6	71.8
	Arithmetic Mean	8.80	0.20	<0.02	6.35	180.10	173.83	41.82
	Geometric Mean	8.80	0.17	<0.02	5.26	170.87	163.28	32.48
	10th Percentile	8.54	0.10	<0.02	2.97	114.06	101.41	12.53
	90th Percentile	9.07	0.43	<0.02	13.44	269.69	266.25	83.03
	Standard Dev	0.22	0.15	0.00	4.83	57.17	59.30	27.69
	Maximum	9.31	0.77	<0.02	24.06	298.75	295.00	110.67
	Minimum	8.41	0.06	<0.02	1.88	64.25	58.94	4.08

4.15.3.4 Coal

Table 4.15-5 lists summary statistics for ABA data on the samples grouped into producing coal seams and interburden waste material. These statistics have been subdivided by stratigraphic location and drill hole. Figures 4.15-6 to 4.15-8 summarize the ABA characteristics of these two groups. Production coal samples have a mean paste pH value of 8.85 with a minimum of 8.55 and a maximum of 9.32. Total sulphur concentrations range from 0.08% to 0.40% and report a mean concentration of 0.20%. Sulphate-sulphur concentrations were all below the detection limit of 0.02%. Acid Potential (AP) values have a narrower range than those found for the interburden, with a mean of 6.13 kg/t and a minimum and maximum of 2.50 kg/t and 12.50 kg/t respectively. Neutralization potentials (NP) for the coal are comparable to the interburden, with a mean of 131.96 kg/t, a minimum of 26.88 kg/t and a maximum of 235.63 kg/t. Resulting NP/AP ratios for the coal samples have a relatively high mean value of 31.39 and range from 2.15 to 94.25. Only two of the samples has an NP/AP ratio lower than the BC ARD screening criteria of 4.0. As noted, sulphur speciation carried out on other core samples from minable coal seams at the deposit indicated that in most cases the sulphur in the coal is organic in nature and does not occur in the form of pyrite.

TABLE 4.15-5

COAL SEAM ABA STATISTICS

WILLOW CREEK COAL

	n=15	Paste	S%	S%				
		pH	**(tot)**	**(SO4)**	**AP**	**NP**	**NNP**	**NP/AP**
96-065								
A-1 zone		8.79	0.08	<0.02	2.5	205.6	203.1	82.3
A-0 zone		8.55	0.20	<0.02	6.3	78.1	71.9	12.5
96017+96012	96-	9.03	0.09	<0.02	2.8	177.5	174.7	63.1
96010	96-	8.67	0.11	<0.02	3.4	129.4	125.9	37.6
96014+96005	96-	8.76	0.08	<0.02	2.5	235.6	233.1	94.3
96013	96-	8.71	0.39	<0.02	12.2	233.1	220.9	19.1
96095+96094	96-	8.89	0.11	<0.02	3.4	86.9	83.4	25.3
96096+96092	96-	8.90	0.19	<0.02	5.9	165.6	159.7	27.9
96096+96092	96-	8.90	0.19	<0.02	5.9	160.6	154.7	27.1
96097	96-	8.88	0.26	<0.02	8.1	66.3	58.1	8.2
1 Seam		8.69	0.40	<0.02	12.5	26.9	14.4	2.2
2 Seam		8.67	0.29	<0.02	9.1	97.5	88.4	10.8
3 Seam		8.81	0.14	<0.02	4.4	57.5	53.1	13.1
96045+96077	96-	9.32	0.16	<0.02	5.0	201.3	196.3	40.3
96072	96-	9.13	0.25	<0.02	7.8	57.5	49.7	7.4
	Arithmetic Mean	8.85	0.20	0.02	6.13	131.96	125.83	31.39

Geometric Mean	8.84	0.17	0.02	5.36	111.91	101.79	20.86
10th Percentile	8.67	0.08	0.02	2.63	57.50	51.06	7.68
90th Percentile	9.09	0.35	0.02	10.94	222.13	213.81	74.59
Standard Dev	0.20	0.10	0.00	3.26	69.60	70.74	27.99
Maximum	9.32	0.40	0.02	12.50	235.63	233.13	94.25
Minimum	8.55	0.08	0.02	2.50	26.88	14.38	2.15

4.15.3.5 Coarse Plant Rejects

Summary data for coarse plant rejects are shown in Table 4.15-6. Paste pH values range from a low of 7.36 to a high of 8.75 with a mean value of 8.23. Mean total sulphur concentration of the coal was 0.32% with a maximum of 1.41% and a low of 0.09%. Sulphate-sulphur determinations were not available for these samples, however, sulphur speciation carried out on other core samples from minable coal seams at the deposit indicated that in most cases the sulphur in the coal is organic in nature and not sulphidic. Only 6 of the 18 samples reported sulphur contents above the 0.3% British Columbia ARD screening criteria. Acid Potential (AP) values varied from 2.81 kg/t to 44.06 kg/t giving a mean potential of 9.97 kg/t. These were offset by neutralization potential (NP) values of 2.88 to 31.75 kg/t with a mean level of 15.67 kg/t. Neutralization potential ratios (NP/AP) have a mean value of 2.75 and a range of 0.11 to 9.69. Nine of the 18 samples reported NP/AP ratios below 2 while 15 samples reported values below the conservative value of 4.0 used in the BC ARD screening criteria. Net neutralization potential (NNP) values range from -25 kg/t to 27.38 kg/t with a mean of 5.70 kg/t.

TABLE 4.15-6

COARSE PLANT REJECT ABA STATISTICS

WILLOW CREEK COAL

	PASTE	S(T)	AP	NP	NNP	NP/AP
	pH	%				

96100+96102 No.A Seam Rock	8.29	0.12	3.8	16.6	12.9	4.4
96100+96102 No.A Seam	8.20	0.21	6.6	18.1	11.6	2.8
96075+96076 No.1 Seam Rock	8.31	0.17	5.3	9.4	4.1	1.8
96075+96076 No.1 Seam	7.57	1.41	44.1	27.0	-17.1	0.6
96145+96200 No.1 Seam	N/A**	0.12	3.8	13.9	10.1	3.7
96201 No.2 Seam (97554,55,57,58)	8.05	0.20	6.3	11.8	5.5	1.9
96209 No.3 Seam	8.32	0.18	5.6	8.9	3.3	1.6
96072+96073 No.4 Seam Rock	8.40	0.43	13.4	14.0	0.6	1.0
96072+96073 No.4 Seam	8.64	0.14	4.4	31.8	27.4	7.3
96118+96119+96142 No.4 Seam	8.74	0.09	2.8	7.3	4.4	2.6
96107 No.4 Seam B	8.52	0.15	4.7	15.9	11.2	3.4
96211 No.5 Seam	8.75	0.09	2.8	27.3	24.4	9.7
96109+96110 No.6 Seam Rock	7.63	0.19	5.9	2.9	-3.1	0.5
96109+96110 No.6 Seam	8.45	0.11	3.4	11.0	7.6	3.2
96108+96206 No.7 Seam	7.36	0.48	15.0	21.9	6.9	1.5
96111 No.8 Seam	8.73	0.36	11.3	31.3	20.0	2.8
96215 No.8 Seam	7.58	0.90	28.1	3.1	-25.0	0.1
96109+96110 No.6 Seam	8.45	0.39	12.2	10.1	-2.1	0.8
Arithmetic Mean	8.23	0.32	9.97	15.67	5.70	2.75

Geometric Mean	8.22	0.23	7.07	12.95	N/A	1.83
10th Percentile	7.58	0.10	3.25	6.01	-7.26	0.57
90th Percentile	8.73	0.61	18.94	28.45	21.33	5.28
Standard Dev	0.45	0.34	10.57	8.95	12.83	2.44
Maximum	8.75	1.41	44.06	31.75	27.38	9.69
Minimum	7.36	0.09	2.81	2.88	-25.00	0.11

4.15.4 Interpretation of ARD Potential

Low total sulphur contents and high neutralization potentials due to the presence of carbonate (ie. visible calcite) in the rocks have resulted in high NP/AP ratios which suggest that the Willow Creek mining operation will be acid consuming and not produce acidity. The results for the Moosebar shale samples also indicated that this marine unit will be net acid consuming and also not produce acidity when exposed during mining. Coarse reject samples of coal and in-seam waste report NP/AP ratios which are generally low and often have values less than 2.0. Evidence suggests that most of the sulphur occurs in the coal seams and in-seam waste as organic sulphur and not as pyrite. This implies that little acid will be generated from the oxidation of this material when exposed during mining activities.

Apart from low NP/AP ratios in coarse reject samples the evidence suggests that the risk of ARD is very low for this project. Coal mines in the northeast coal mining area have not released ARD in the past.

4.15.5 Conclusions

- High neutralization potentials in the host rock and mineable coal coupled with low acid potential suggest that mining of the Willow Creek deposit will not result in the production of acid rock drainage.
- The marine Moosebar shale unit will be net acid consuming and not produce acidity when exposed during mining.
- Interburden samples are classed as non-acid generating due to their high NP values (64 to 298 kg/t) and corresponding low AP values (2 to 24 kg/t) which result in high NP/AP ratios of 4 to 110.
- Coal samples are classed as non-acid generating due to their NP values (27 to 235 kg/t) and corresponding low AP values (3 to 13 kg/t) which result in generally high NP/AP ratios of 2 to 94. Low concentrations of pyritic sulphur and the presence of visible calcite in the coal seams supports their classification as non-acid generating.
- Coarse reject samples show lower NP/AP ratios (0.1 to 9.7) than the interburden or coal seam samples. This raises the possibility of acid production from this material. However, evidence of low sulphide contents in

these materials suggests that the potential for acid generation during weathering is low.

(1) The high concentration in the range is suspected to be an analytical error as nitrate concentration for the sample was not proportionally high.

(2) Streams without tributaries.

(3)Continuous height records when streams were frozen were considered unreliable, as wide

fluctuations in recorded stream heights were indicated, whereas stream heights and flows should have been nearly constant and low. The difficulties encounterd with stream height recorders were not atypical of problems encounterd in measurements of stream heights under ice.

(4)But see the previous footnote.

(5) The TEM study area is larger than the Project area, which only includes the blocks to be mined and the plant site (see, e.g. outlined area on Figure 1.2-2). The TEM study area encompasses the east flank of Far East Creek in addition to the Project area.

(6) Results are all presented at 1:7,500

5.0 SOCIO-ECONOMIC BASELINE

5.1 INTRODUCTION

Terms of reference were not developed by MOELP in 1994 for socio-economic studies. Rather a program was developed by NDM and agreed to by EAO in early 1997 (See Section 1.6). The TOR developed essentially meet the requirements of the *British Columbia Environmetnal Assessment Act*.

This section includes information on: present population, available housing, current employment levels, the economic base, description of major communities, community facilities/services and land use planning for both the Chetwynd and Dawson Creek areas. Because of its proximity to the Willow Creek project the potential to be more directly affected than Dawson Creek, information and analysis related to Chetwynd is discussed in more detail.

For ease of reference, this section is divided into two parts:

Part A:

Chetwynd and Area

History

Location

Economic Base and Development

Population and Labour Force

Community Services

Part B:

Dawson Creek Area Profile:

History

Location

Economic Base and development

Population and Labour Force

Community Services

5.2 PART A - CHETWYND PROFILE

5.2.1 History

Chetwynd was originally called "Little Prairie" by First Nations Aboriginal Peoples who hunted in the Sukunka Valley. The first non-Natives in the area were fur traders, who came

to Chetwynd around 1778. In 1861, gold was struck in the Peace area, which brought many people to the Chetwynd area. In 1885, Saulteau First Nations, who were fleeing from troops during the Louis Riel Rebellion, found a home at Moberly Lake.

In 1919, a log cabin opened as a small trading post and was built on the site just north of the B.C. Rail yards. This attracted a number of First Nations peoples, who built around it. The original cabin was later destroyed by fire. Many descendants of the original First Nations peoples presently reside within the District area.

Between 1946 to 1963, Little Prairie grew with construction of the Hart Highway, the Pacific Great Eastern Railway (PGE), the Westcoast pipeline, installation of a telephone system and a forest industries plant. Upon arrival of the railroad, the town was renamed Chetwynd after Mr. Ralph Chetwynd, one of the directors of the P.G.E. Railway. Chetwynd was originally incorporated as a village in September 1962 and in 1983 Chetwynd was re-incorporated as a District.

Because the District is fairly new, it has incorporated modern principles into the community design, complete with well-planned residential areas, commercial and industrial districts and park/recreational areas and facilities.

5.2.2 Location

Chetwynd is situated in the Northeast corner of B.C., 100 kilometres west of Dawson Creek and 310 kilometres north of Prince George. It is located at the junction of Highway 97 (John Hart Highway), which runs south to Prince George and east to Dawson Creek and Highway 29, which runs north to Hudson's Hope and south to Tumbler Ridge (Figure 5.2-1). A number of small communities are located between the Project area and Chetwynd, which are variously referenced throughout this report. Figure 5.2-2 shows location of these communities.

The District of Chetwynd is located on a terrace above an ancient floodplain. The northern edge of town is in the proximity of "Old Baldy", a hill rising 210 metres above the town centre. A valley of considerable size stretches north from Chetwynd, along Windrem Creek.

The Chetwynd area, as referred to in this report, covers the rural communities of Jackfish and Moberly Lake (north), the area to East Pine Bridge (east of the Chetwynd), to Mount Lemoray (west) including the small communities of Willow Flats and Hasler Flats and the community of Lone Prairie (south).

5.2.3 Area Communities

The community of **Moberly Lake** has the total population of 650: 200 living on the Saulteau Band reserve, West Moberly First Nations having 60, with the non reserve residents totalling 390.(1)

Moberly Lake has a volunteer fire department, fire hall, golf course and a few retail businesses. Tourism plays a part in the economy, although most residents commute to Chetwynd for employment.

The **Jackfish Lake** Road community is located north of Chetwynd with an estimated population of 480.(2) The community is predominantly agricultural, however it also includes Chetwynd Forest Industries and several oil rigs are also located in more remote areas of the community. Community Services include a fire hall and community hall.

Lone Prairie is situated off the Sukunka Road to Tumbler Ridge. The community is agriculturally based with a residential population of 160.

Hasler Flats, located 24 kilometres west of Chetwynd, is a small community of approximately 78 people(3). This area, including Willow Flats, does not have its own representational body or organization. However, it has in the past gathered as a group on several prior issues surrounding the community and its development.

Industry surrounding Hasler Flats is Westcoast Energy's Pine River Gas Plant (located above the Hasler Flats plain on a mountain) and Petrosul, a sulphur pelletizing plant.

Willow Flats, located between Mt. Lemoray and Hasler Flats on Highway 29, is comprised of Consolidated Pipelines (formerly known as Westcoast) employees that reside in the company residential compound. The area has an estimated population of 90 people(4). With exception to agricultural development and the Consolidated Pipeline facility, no other industry currently exists. As well, five families live along Highway 97 near the Project area.

Mount Lemoray, located 70 kilometres from Chetwynd on Highway 29, forms the beginning of the Pine Pass. There are eight residents: employees of Peace Country Maintenance, the highway maintenance contractor for the area(5).

Local government representation for the rural communities surrounding Chetwynd, (listed above) consists of the Peace River Regional District E committee: a group of Peace River community mayors/representatives and an elected Director for the area. Below listed are those currently sitting on this committee for Regional District E:

Municipal Representatives

Mayor Joe Judge - Pouce Coupe	Mayor Fred Jarvis - Taylor
Mayor Paul Kealy - Tumbler Ridge	Mayor Blair Lekstrom - Dawson Creek
Mayor Steve Thorlakson - Fort St. John	Mayor Joe Judge - Pouce Coupe
Mayor Lenore Harwood - Hudson's Hope	Councillor Bob Nicholson - Chetwynd

Director: Tim Caton

The two native reserves are self governing with an elected council:

Saulteau First Nations Band: As of May 1997, council included Chief Bud Napoleon, Councillors Stuart Cameron, Barb Loberg, Geraldine Gauthier and Vern Lalonde. Disolution of this council was ordered (May 20, 1997 ruling) by the Supreme Court of Canada effective June 3, 1997 and thus election of a new council will proceed after this date.

West Moberly First Nations Band: Chief George Desjarlais, Councillors Norlene Brown, Edward Cryingman, John Dokkie and Elder Councillor Max Desjarlais.

5.2.4 Population and Labour Force

The population of Chetwynd has seen a steady increase since 1966 when the population was 1,368 (6). During the past six years, Chetwynd has seen a steady increase of about five per cent per year. According to Statistics Canada Census information gathered between 1986 and 1991, the mean population expansion was 2.5 per cent per year. The greater population increase between 1991 and 1995 was mainly due to increased gas/ oil activity in the area. In 1996 the population increased to 2,890(7) with an estimated population of 1,680 in the outlying rural areas surrounding the municipality(8).

Population Trends for Chetwynd				
Population	1981	1986	1991	1996
	2553	2774	2843	2890

Age and Gender Characteristics

Chetwynd has a relatively young population:

15 years or less	28%
20 to 39	41%
40 to 49	10%
50 to 64	9.5%

65 and older	2.5%
Males	52%
Under 40	76%

Labour Force

Gender Labour Force Profile

Traditional occupational roles dominate the labour force of Chetwynd: 60% of the male labour force is in construction, machining, processing and primary occupations. The female workforce is highly represented in the services and clerical occupations (66%).

Labour Force Characteristics

According to the 1991 Statistics Canada Census, total working age population for Chetwynd was 1,685; however, actual participants in the labour force number 1,540 with an overall participation rate of 76% of the total population.

The labour force grew 20 percent from 1981 to 1991, with industry sector attachment increase in primary occupations, construction and transportation. Labour market participation in 1981 stood at 70% at the time: female participation rate at that time was only 52.8% while male participation rate was 87.1%. Rates of males had not changed, however, female participation increased 10% over this period of time.

As of February 2, 1997, the unemployment rate given for the Chetwynd area, according to an estimate given by HRDC Dawson Creek, is 14.99%. This figure signifies the unemployed on Employment Insurance and Income Support (welfare) and those looking for work. Excluded from this figure, are those who have given up in their search for employment.

Numbers of Employment Insurance Recipients by Length of Time(9)

	1-9 weeks	10 - 19 weeks	20 - 29 weeks	30 - 39 weeks	40 - 49 weeks	50 weeks +	Total
Males	37	30	15	4	2	4	119
Females	46	28	17	9	5	0	123
Total	83	58	32	13	7	4	242

Employment Insurance (EI) Claimants by Skill Level (Chetwynd)(10):

Labourers (number of EI claimants by Industry Sector)

primary industry	processing	trades	public works	mining/ oil/gas	logging/ forestry	primary production	process/ manuf/ utilities
2	3	33	2	2	15	2	3

The total number of labourers on Employment Insurance categorized in the labourer grouping for all industry sectors total 62.

(Equipment Operators Claiming Employment Insurance)

heavy equipment operators	19
truck drivers (heavy duty)	21

(Trades People Claiming Employment Insurance)

	electricians	welders	millwrights	h\duty equipment mechanics
Chetwynd	3	2	3	1
Dawson Creek	13	10	2	3
Fort St. John	12	6	1	5
Fort Nelson	2	1	1	0

Local labour force availability of trades person occupations is limited in Chetwynd.

Income Support Recipients (welfare):

Although there is no system in place for the occupational categorization within the Ministry of Human Resources, this group represents a significant portion of the available local labour force in Chetwynd.

Number of People on Income Assistance by Duration(11):

Duration:	1996	1995	1994
less than 12 months	293	247	188
12 - 23 months	61	35	49
24 months +	86	75	72
TOTAL	440	357	309

5.2.5Economic Base and Development

The main economic drivers in the Chetwynd area are forestry and wood manufacturing, oil/ gas industry (steadily increasing in importance) and the service sector.

Chetwynd Employment by Sector	
Wood Manufacturing	400
Oil & Gas	about 90
Business and Service Sectors	650

Wood manufacturing/Forestry provides direct employment for more than a quarter of Chetwynd residents and sustains Chetwynd’s economy in the business and retail sectors. Three major employers dominate this industry: Canfor, Chetwynd Forest Industries (West Fraser) and Louisiana-Pacific Canada.

Canfor (Canadian Forest Products)

Canfor purchased their existing mill in 1963 and upgrade of the plant was completed in 1965. During the mid 1980's, the mill underwent a technological upgrade with the loss of 15 jobs. Canfor's major sales are in the US. Thus the market for lumber (primarily in housing construction) and the trading value of the Canadian dollar and stumpage fees have considerable impact on the company.

Louisiana-Pacific (LP)

Louisiana Pacific, a US based company, began construction of the pulp mill in 1989 approximately 30 kilometres east of Chetwynd, with operations starting in 1991. The Chetwynd Plant is a Bleached Chemi-Thermo Mechanical (BCTMP) mill, creating pulp with a zero discharge policy using aspen, a previously unused and abundant wood species in the region.

According to Terry Mills, Industrial Adjustment Officer of the Ministry of Education, Skills and Labour, Louisiana Pacific Chetwynd pulp mill is presently negotiating with a Korean group of investors to build and operate a kraft paper plant at the present LP pulp mill site. If negotiations are successful, this $1.5 billion dollar project will create 350 direct jobs for operations in addition to 1,200 indirect jobs in the construction and logging sector.

Chetwynd Forest Industries (CFI)

Chetwynd Forest Industries, owned by West Fraser Mills, was built in 1980 and is located just outside of Chetwynd on Jackfish Lake Road. Production of dimensional wood increased to a current level of 186.5 million board feet per year, with a large portion of sales to the United States. CFI states that there are no plans for expansion in the foreseeable future.

Forestry/Logging/Transport Industry

Combined, these industries provide a major source of employment and revenue in the community. Seasonal in nature, the average duration of logging in the area is an estimated nine to ten months with a break usually the third week in March and lasting for up to two months. Climate limits the logging season: extreme cold winter weather, early spring weather in February/March and heavy rains between May and July have undesirable effects on logging (road bans commence with conditions of the logging roads). The new environmental regulations (BC Forestry Practices) are also cited to impact the logging industry.

Oil/gas Industry

Oil and gas exploration in the area have increased in activity in the past several years. Exploration by Shell, AMOCO, Texaco and others have impacted Chetwynd in terms of economic spin offs in the service sector. Two major companies involved in the processing and refinement are Westcoast Energy and Talisman Energy (formerly British Petroleum).

Westcoast Energy

Westcoast Energy's Pine River Gas Plant, located in the Hasler Flats area, is a gas processing/transmission facility which currently makes up 28 per cent of B.C.'s gas refining production. During 1993 and 1994, the plant underwent a major expansion. Construction resulted in an estimated 350 jobs, and with the influx of workers and job seekers into Chetwynd, housing availability declined to a low level of 2 per cent. Economic spin offs in the hospitality and retail trade were great: many small businesses were created during this period of time - existing businesses (mainly the retail and accommodation industries) experienced a substantial increase of activity during these years.

Westcoast Energy had plans for further expansion (Phase II); however, after making application to the National Energy Board in the fall of 1995, they put plans on hold, citing poor market conditions for this delay.

Nova Gas

Nova Gas of Calgary, Alberta, hopes to see a higher level of activity in the oil/gas exploration industry over the next two years. When enough reserves have been found the company hopes to build a gas plant between Chetwynd and Tumbler Ridge. Like Westcoast Energy, Nova Gas approached the National Energy Board in 1995 with an application to build a gas plant. These plans are presently on hold for an indefinite period of time due to poor market conditions for their product(12).

Business and Service Sectors

Accommodation and the retail sector of the service industry are major components of the local economy, relying heavily on the natural resource sector for their economic existence. Major employers in the service sector include: Chetwynd IGA, Shop Easy Foods, People’s Drug Mart and the various restaurants that employ over 100 people.

The retail sector has experienced the greatest growth over the past six years, specifically during the 1995 - 96 year when growth was 20 percent. There was speculation at that time of increased economic activity due to Westcoast Energy’s Phase II plans as well as increased oil/gas exploration in the area. Outside interest in Chetwynd has increased with major business chains such as SAAN (clothing store), A&W, KFC, 7-11 Convenient Store and Subway (fast food chains) commencing operation here. Since that time, the Pine Cone Restaurant closed as well as the Chinook Convenient Store - both citing over saturation of their specific markets as a major factor in their failure. Business start ups for the first three months of 1997 declined by an estimated 15 percent as well.(13)

5.2.6Community Services

As previously discussed, Chetwynd has a rather diverse economic base for the size of the town. As a result, it has experienced a steady growth pattern since its incorporation.

Transportation

Chetwynd is located at the junction of two highways, Highway 97 (Hart Highway) and Highway 29 and so it has excellent highway connections to the rest of BC. It is served by BC Rail, which provides indirect rail connection to Prince Rupert and direct connection to Vancouver. Chetwynd's airport is located one mile from the downtown core. The airstrip is paved, 1,360 metres (4,462 feet) in length and is serviced by lighting and non-directional beacon, suitable for most weather and night operation. Greyhound Bus Lines provides daily bus service to and from Dawson Creek, Fort St. John, Grande Prairie, Edmonton and Prince George. Local transportation is served by Little Prairie Cabs and private vehicles.

Communication

In December of 1996, Chetwynd received the approval from the CRTC to broadcast its local station CHET Radio, at 94.5 FM. Chetwynd also has access to three other radio stations, CJDC broadcasting from Dawson Creek, CBC North from Prince George and CFMI from Vancouver. The District has one weekly newspaper called The Chetwynd Echo/Pioneer. Chetwynd's telephone exchange is served by the British Columbia Telephone Company (BC Tel), with WesTel as a long distance competitor. Currently, about 15 per cent of long distance billing is handled through WesTel, with the other 85 per cent handled by BC Tel. Since cellular phone service as well as local Internet provider were introduced to Chetwynd, its residents have been provided with a broader variety of communication options.

Government Services

Local Government Services

Local government consists of a mayor and six councillors.

Provincial Services

Chetwynd has the following provincial services available in the community: Ministry of the Attorney General (Court), Ministry of the Environment (Conservation Officer Services), Ministry of Human Resources, Children and Families, Provincial Government Agent and the Ministry of Health (Peace River Health Unit).

Federal Services

Excluding the RCMP (see below), the District does not have any federal departments located in it.

Housing

As of January 1997, the vacancy rate for available housing averaged 10 to 12 per cent: up about 8 per cent from the 1995/96 year(14). Some of Chetwynd's work force is transient, depending on the availability of pipeline/oil/gas work. Therefore the vacancy rate for available housing can vary from year to year.

There are currently approximately 30 homes (including mobiles) for sale in the District of Chetwynd. The following is a breakdown of average housing costs:(15)

3 bedroom, non basement . . . . $50,000 to $90,000

3 bedroom, basement . . . . $115,000 to $140,000

Executive homes . . . . $150,000 to $200,000

Duplexes (both sides) . . . . $85,000 to $130,000

New homes currently cost about $100 per square foot. Accordingly, a 1,000 sq. ft., 3 bedroom home with a basement within District limits, would cost approximately $110,000 to build (excluding the cost of lot).

Residential Lots

Within District limits, the average lot size varies from 60' x 120' to 70' x 140'. The average lot costs between $10,000 to $35,000. There are currently 40 available lots, including mobile home lots, suitable for residential building purposes. In some cases, the building lots themselves have no services, however, services can be hooked up for an additional $3,000.

In the rural areas, east and west of Chetwynd, cost of lots/acreages can vary from $10,000 for a one acre parcel to $35,000 for an unserviced, 5 acre parcel. Prices also vary depending on location.(16)

Mobile Home Parks

Chetwynd has three mobile home parks, two located within District limits and one located 5 miles west of town. The two located within the District are both considered housing developments, due to the fact the mobile home owners are required to purchase the land the mobiles are situated on. In these two parks, the cost a mobile home can vary from $30,000 to $85,000, depending on age, location in the park and condition of the mobile. Serviceable lots in these parks sell for approximately $9,000 to $15,000.

Trailer Parks located in the Chetwynd area are as follows:

The Legion Sub/Division

-located in town limits

Pinewood Trailer Park

-located on Highway 29 North towards Hudson's Hope

Aspen Estates Mobile Home Park

-the only park providing rental pads in area - located 5 km. west of Chetwynd on Highway 97

The average cost per rental pad at "Aspen Mobile Home Estates" is $200 per month and the average cost of a mobile home is between $20,000 and $45,000.

Rental Accommodation

Average rental rates are as follows:

Homes

3 bedroom, non basement $600 per month

3 bedroom, basement $650 - 850 per month

Townhouses

2 bedroom $500 - 600 per month

3 bedroom $600 - 750 per month

Apartments

1 Bedroom $400 - 425 per month

2 Bedroom $426 - 495 per month

3 Bedroom $496 - 550 per month

There are 18 apartment complexes and two (2) townhouse complexes in Chetwynd, with a total of 412 apartments. The breakdown is as follows:

Bachelor suites 16 units

1 bedroom suites 72 units

2 bedroom suites 290 units

3 bedroom suites 24 units

There is currently a vacancy rate of 10 - 12 per cent equating to a total of 45 vacant suites.

Hotel/Motel Accommodation

Chetwynd has one hotel and five motels with a total of 218 rooms:

High Country Inn Hotel - 32 units

Pine Cone Motor Inn - 54 units

Chetwynd Court Motel - 14 units, with 10 kitchenettes

Windrem Motel - 12 units, with 8 kitchenettes

Country Squire Inn - 51 units, with 20 kitchenettes

Stagecoach Inn - 55 units, with 6 kitchenettes

Peak periods for accommodation are typically May to September, early autumn (hunters), Thanksgiving weekend and Christmas Week. Daily rates run from $35-$70 in the winter to $50-$80 in the summer season. Weekly and monthly rates can be negotiated at these facilities.

Health and Protective Services

There are two medical clinics in Chetwynd: Mountainview Medical Clinic with one doctor and Chetwynd Centre Medical Clinic with two doctors. Attempts are being made to encourage other doctors to the area at this time as the community is critically short of physicians. Out of the three doctors in town, only two have hospital admission privileges.

Chetwynd General Hospital is an acute care facility, with an 18 bed capacity. Because there are no surgeons in Chetwynd, patients with critical medical problems must be sent to Dawson Creek, Vancouver or Edmonton.

Fire

Chetwynd's Volunteer Fire Hall is located on North Access Road, adjacent to the District Office. Fire Chief Mr. Leo Sabulsky advised that Chetwynd has 34 volunteer fire fighters and in 1996, they attended 72 fires and 14 rescue operations. Their current range for fire protection is as follows: Class A - within District Boundaries, Class B - rural areas to an 8 km radius, Class C - forest areas within a 10 kilometre range. The rescue truck covers the same boundaries as the RCMP. Average time to an in-town fire call is about five to seven minutes.

Ambulance

The Provincial Ambulance Service, has a complement of 28 part-time paid employees. Their range is east to Groundbirch (halfway to Dawson Creek), south to Gwillim Lake (halfway to Tumbler Ridge) west to the Pine Pass area and north to Cameron Lake (halfway to Hudson's Hope), servicing 8,000 area residents. In 1996 call outs totalled 500(17).

RCMP

The local RCMP detachment supports a total of eight General Duty Members, two Highway Patrol Members and one Aboriginal Liaison Member for a total of eleven members. They cover the following areas: the District of Chetwynd, east to the East Pine Bridge, south to Gwillim Lake, west to Snowgate (Powder King) and north to Cameron Lake. After hours calls are re-routed to Dawson Creek and sometimes to Fort St. John(18).

Education

Chetwynd is home to four elementary schools, a high school, one alternative school (located in the high school for students requiring additional educational support), Northern Lights College (upgrading, vocational and university transfer courses) and the Anne Teslyk Enhancement Centre. The Centre provides an alternative form of providing adults with an opportunity to obtain a high school diploma with long hours to accommodate those working during the day.

The following is a current list of capacity versus enrolment levels for each school in the area(19):

Chetwynd schools: Capacity-K/ Enrolled Capacity-1-7/Enrolled Capacity 8-12/Enrolled

Windrem Elementary 50/20 210/153 -

Little Prairie Elementary NA/39 325/311 -

Don Titus Elementary 50/20 210/175 -

Chet. Senior Secondary - - 443/412

Area Schools:

Dokie Elementary 50/20 150/126 -

Moberly Lake Elementary K-5 NA/1 60/40 -

Water and Sewage.

The District's water facilities have just been upgraded to a sand filtration plant with the capacity of 4 million litres of water per day, meeting the needs of up to 4,000 people. The plant is located close to Pine River, at the end of the local air strip. The local sewage facility is a six-stage lagoon facility, built in 1991. Once sewage has been processed, it is discharged into the Pine River, just below the water facility. This facility has the capacity level of up to 4,000 people.(20)

Recreation

The District of Chetwynd has a variety of recreational facilities that include: a leisure pool, ice/hockey rink, curling rink, eight baseball diamonds, tennis courts, outdoor volleyball court,

hiking and cross country skiing trails and rodeo grounds.

There are four provincial campsite grounds in the surrounding area, 24 to 80 kilometers from Chetwynd as well as a ski hill located approximately 110 kilometers away. There are many cultural and sporting clubs in the area offering activities for both the adult and youth population such as hockey, figure and speedskating, baseball, snowmobile club, Rod and Gun club, threatre, arts council, Air Cadets, Boy Scouts/Girl Guides, swimming and soccer clubs.

Financial Services

Chetwynd presently has three chartered banks and one Credit Union, all providing banking machines for after-hours service.

5.3 PART B: DAWSON CREEK AREA PROFILE

5.3.1 History

Dawson Creek was named after George Dawson, a Canadian National Railway surveyor who explored the area in 1879 when seeking a feasible western route for the railroad. With the emergence of the railway in northern Alberta, settlers came to farm in this area. Population increased with the gold rush of 1898, Dawson Creek becoming a stopping point for transients making their way to the Yukon. Many discouraged gold seekers came back to settle in the area what was quickly becoming a farming community.

After the first world war, population increased again: with the construction of the Alaska Highway (1941) the town increased to a population of 3,589 with many highway workers staying in the area after construction.

Dawson Creek experienced its next major population increase between 1948 and 1961 as the north opened up for transportation - the town becoming the central point for trucking to the north, east and south. The railway came to Dawson Creek in 1958 along with increased oil and gas exploration. The area of Taylor, (which is 48 kilometres north of Dawson Creek), became increasingly important with the development with the construction of a gas refinery, scrubbing plant and sulphur recovery plant.

In 1961, the 700 million dollar construction of the W.A.C. Bennett Dam began in Hudson's Hope. Dawson Creek enjoyed the economic growth - acting as the distribution centre for supplies and workers. Total population at this time was 11,000, relatively close to Dawson Creek's population today.

5.3.2 Location

The City of Dawson Creek is located in the northeastern corner of British Columbia, at the junction of the Hart Highway (from Prince George), the Alaska Highway (to Fort St John, Fort Nelson and Whitehorse) and Highway 2 (to Grande Prairie, Edmonton and Southern Alberta) and Highway 49 (to Peace River, Northern Alberta and North West Territories. The distance from Chetwynd is 100 kilometres, Fort St. John - 75 kilometres and Tumbler Ridge- 120 kilometres away.

Dawson Creek is located in the Peace River region. Incorporated in this area is the land east of the Pine River Bridge of highway 29, south of the Peace River and the land east of the City to the BC - Alberta border. The municipality of Tumbler Ridge forms the southern boundary of this area, but is not part of the area described.

Outlying communities such as Farmington, Arras, Sunset Prairie, Tomslake, Tupper, Rolla and Pouce Coupe encompass the Dawson Creek area. Total population in the rural outskirts is 7,350.

5.3.3 Economic Base and Development

Agriculture

Historically, Dawson Creek's primary economic giant has been in agriculture, generating spin offs in the transport, business and retail sectors. Roughly half of all farms in the area raise livestock, the other half growing crops, primarily grain (85% of BC's grain is supplied by the area's farmers). Crops include wheat, barley and canola. Farmers have experienced hardship over the past several years, due to poor market conditions for grains and oilseeds; however, diversification into speciality foliage crops aided in alleviating some of the economic downturn in this sector.

Dairy industry in the region is small and works in an environment that is highly regulated. All producers are presently part of a producer-owned cooperative that processes, markets and promotes their product.

Forestry/Wood Manufacturing and Related Transport

Although agriculture has been dominant, it has been declining in significance during the past decade. Forestry/wood manufacturing and related transport has, since then, taken a larger role in the economy. Lousianna Pacific's wafer board plant in Dawson Creek commenced operation in 1987, employing 150 residents in the plant itself and another 200 in the logging/transport industry. Approximately 61 Dawson Creek residents work at LP's pulp mill (workforce of 154), roughly 60 kilometres between the City and Chetwynd.

Korean investors are currently negotiating with LP to construct and operate a kraft paper mill between Dawson Creek and Chetwynd in close proximity to the LP pulp mill plant. If negotiations are successful, 350 direct jobs will be created for operational requirements of the plant in addition to an estimated 1,200 direct jobs in construction and the logging industry.(21)

The BC government has announced that Forestry Renewal BC has committed more than $400 million plus for reforestation in the Dawson Creek forest district. This commitment will significantly impact the employment opportunities in this sector in the near future.

Oil and Gas

Oil and Gas exploration in the B.C./Alberta Peace River Region is quickly gaining importance: over 12,000 wells were drilled in 1996 in the northern BC and northern Alberta alone. Although the immediate area of Dawson Creek is not affected with this activity by means of employment, the economic spins offs in business and retail trade are significant.

Business/Retail

Business, retail and hospitality are major economic sectors as Dawson Creek provides many of the services to the smaller communities in the area. With the exception of government, these sectors are largely dependent on the health of primary industry sectors in the Peace River area - agriculture, forestry, oil/gas and mining for their economic stability. Presently, the City is working hard at diversifying the economic base by marketing tourism in the area.(22)

5.3.4 Population and Labour Force

Population

The current population estimate for the City of Dawson Creek is 11,100(23), which is relatively close to the 1981 figure of 11,375. During the periods of 1981 to 1986, the number of residents declined by nine percent, but increased 9 percent between the years 1986 and 1991. Since then, it is estimated that the number of people in the City increased slightly less than one percent. According to future estimations, the average expected growth for Dawson Creek is .9% per year.

Currently, Dawson Creek has a relatively young population: 24% of residents are not of labour force age (under 15 years), 15% between the ages of 15 and 24 years, 20% in the 25 to 34 years, 14% in the 35 to 44 year category, 18% being between 45 and 64 and only 9% being 65 years or older.

Of that growth, the age groups expected for growth are those under the age of 25 and over 35 years. Decline is expected at an estimated 1% per year in the age group 25 to 43 year olds.(24)

Labour Force

According to the 1991 Statistics Canada Census, the City's total labour force stands at 5,985. Although official statistics for the northern part of BC indicate an unemployment rate of 7%, specific information provided by the local Human Resources Development Canada office estimates Dawson Creek's current unemployment rate at 8%.(25)

Labour Profile by Industry Sector

The following table summarizes employment in Dawson Creek by industry sector:

Agriculture	400
Forestry	50
Manufacturing	about 412
Construction	500
Government Services	230
Health Services	400
Education	570
Retail Trades	1200

Although the agriculture sector is an economic driver for the community, it is not labour intensive. According to Human Resources Development Canada, reduction of work hours in a season/year along with economic hardships in grains and oilseeds have attributed to a decline in the number of workers since 1986.(26)

The workforce in forestry is relatively small. Many farmers in the area, sell and harvest aspen for Louisianna Pacific's pulp and wafer board plant. Although current employment figures for the transport of aspen are not available, it is assumed that a majority of jobs in transport sector equate to this activity. Employment in the areas of forestry and log transport are seasonal: generally from May/June to March.

The manufacturing sector grew 70 percent between 1986 and 1991 with the emergence of Lousianna Pacific Wafer board plant. Another major company in manufacturing is Northland Machinery, providing agricultural machinery and equipment to the area.

The major employer in the construction industry is Borek Construction. This company has on the average 150 employees, building roads, paving and seismic/pipeline construction. Other employers include industrial and residential construction.

Government, Education and Health Services account for a quarter of the total labour force in Dawson Creek as it is a service centre for the surrounding communities.

Organizations in health services include South Peace Community Resources Society, senior citizen intermediate and long term care facilities and the Dawson Creek and District Hospital.

Dawson Creek is an administrative centre for School District 59 - Dawson Creek and area, Tumbler Ridge and Chetwynd public schools. Northern Lights College is also the larger of the seven outlying community satellite colleges and acts as the administrative centre for all campuses.

The retail trades industry includes business/service and retail sectors and is the largest industry in Dawson Creek. Retail/store outlets employ over 400 people with the larger employers being Kmart, Zellers and the Co-Op. Hospitality (accommodation, food service, etc) has a workforce of approximately 170 with the George Dawson Inn being the largest employer in this sector. Seasonal trends are experienced in business/service and retail sectors - summer (tourism) and November/December (retail).

Community Services

Dawson Creek is the primary service and transportation centre for the surrounding rural areas, as well as the communities of Tumbler Ridge and Chetwynd.

Transportation

Transportation services available in Dawson Creek includes air service provided by Air BC (daily services to Edmonton, Prince George and Vancouver), BC Rail transport and bus services through Greyhound Bus Lines (daily service to and from Fort St. John, Grande Prairie, Chetwynd, Edmonton and Prince George. The City is a central point for trucking services because of the central location in the Peace River region.

Communication

Local radio and television stations provide local news coverage. CJDC (a radio and TV station) also cover the areas of Chetwynd, Tumbler Ridge and Fort St. John. Dawson Creek has two newspapers available: The Peace River Block News (Monday through Friday news) and The Mirror, a weekly newspaper.

BC Tel is the major provider, with WesTel also offering long distance carrier services. Cellular phones and a local Internet service provider (Peace River Internet Services) are also available.

Government Services

Local

City council consists of the a mayor and six councillors.

Provincial Services

Dawson Creek is presently the administrative centre for provincial services for the Peace River area services. Currently the following agencies have offices in the City: Ministry of Education, Skills and Training, Ministry of Human Resources, Children and Families, Ministry of Labour (Employment Standards Branch), Ministry of Agriculture, Ministry of Forests, Ministry of Finance and Corporate Affairs (Government Agent's office), Ministry of Environment, Motor Vehicle Branch and Ministry of Health.

Federal Services

With the reduction of staff and offices within the federal government, Dawson Creek presently has the following in federal offices: RCMP, Transport Canada, Human Resources Development Canada, Agriculture Canada and Farm Credit Corp Canada.

Housing

Residential Lots

Currently, there are between 175 and 200 homes for sale in the City, with the average three bedroom older home with a full basement selling for $70,000 to $120,000. The cost of a new home would average between $140,000 and $200,000 as building costs in the area are currently $100 per square foot. Dawson Creek hasn't seen a large number of sales compared to the outlying area in and around Fort St John and this could be attributed to the poor harvest in farming over the past year. Older homes have a strong market in the Dawson Creek area.(27)

Mobile Home Parks

There are four mobile home parks in the City with the average cost of rental pad at $165.00 per month. The vacancy rates for pad lots in Dawson Creek are currently not available.

Rental Accommodation

Dawson Creek has 1,765 dwellings (apartments, townhouses and homes) that are considered rental housing, with an average rental cost of $492.00 per month. Homes rent for $600 - $850 per month, townhouses go for $500 - $650/month and apartments from $400 to $575. The vacancy rate for rental accommodation are currently between three and four percent as the City exhibits a more stable population than that of Chetwynd due to less transient work population.(28)

Hotel/Motel Accommodation

There are over 500 units/rooms for rent within the twelve hotels/motels in Dawson Creek. The larger facilities are the George Dawson Inn (80 units), Peace Villa (46) and Sizzler Inn (49).

Health, Social and Protective Services

Dawson Creek has a total of eighteen doctors, five of which are specialists, nine dentists, three chiropractors and two veterinarians. The district hospital is a 57 bed facility, performing surgery for the smaller communities in the area such as Tumbler Ridge and Chetwynd. There is one long term care facility and two senior citizen housing facilities in the immediate area.

The City has a variety of health related organizations - Mental Health, Peace River Health Unit, South Peace Community Resources, Ministry of Families and Children as well as the Drug and Alcohol Program.

Protective Services for the City include the local RCMP detachment currently with 27 members. The detachment is responsible for receiving emergency calls for Tumbler Ridge and Chetwynd during office hours as well as acting as back up for these areas if required.

The local fire department currently employs 14 people and has a volunteer membership of 12 people. Coverage for fire protection is within the municipal boundaries. Ambulance services have 4 fulltime attendants and 24 part time employees serving over 25,000 people. Geographically, they cover half way to Spirit River, to East Pine, Blueberry mountain, Bear Canyon, Clayhurst to the Alberta border.

Education

The City currently has seven public and three private elementary schools, one junior secondary school and one senior secondary school that services the outlying rural areas of Dawson Creek. Capacity levels for elementary schools are between 63% to 86%, the junior high school at 93% capacity and the high school at 88% capacity rate.(29)

Dawson Creek has one post secondary educational facility: Northern Lights College. The College offers pre-employment classes such as upgrading, some vocational and university transfer courses. This campus is the administrative body for six other campuses in outlying communities.

Recreation

Dawson Creek has one golf course, with another in the immediate area of Farmington, a curling rink, two ice rinks, a speed skating oval rink, a rodeo and fairgrounds facility, indoor swimming pool, man-made lake at Rotary Park, tennis and racquetball courts, numerous softball diamonds and a local ski hill. There is variety of sports and cultural groups in the area as well as a Performing Arts Council.

Financial Services

Presently, there are five chartered banks in the City, a credit union and one loan company. Personal financial specialists are also available.

(1)West Moberly and Saulteau Band statistics. Jeannette Dutton, local resident provided an estimate for off reserve figures.

(2) Figures obtained by local resident, June LaCarte.

(3) Estimated population of Hasler Flats provided by Judy Winland - local resident.

(4) Willow Flats estimated figures provided by Stu Chantree, resident of the community.

(5) Peace Country Maintenance - Chetwynd

(6) Tim Caton, Peace River Regional District

(7) 1995 BC Stats figures

(8) Tim Caton, Representative of the Peace River Regional District - E Area

(9) Human Resources Development Canada (HRDC) - Dawson Creek: December 1996

(10) HRDC statistics for the Chetwynd labour force - January 1997. Occupational groupings are given according to anticipated operational labour requirements.

(11) HRDC - Dawson Creek: December 1996.

(12) NovaGas - Bernie Patterson

(13) Chuck Lenfesty - District of Chetwynd

(14) CHMC Housing Statistics 1996

(15) Figures for available housing is limited to those homes within town boundaries. The average costs for a home will vary 10% +/-, depending on the season.

(16) Norma Tower, Realtor - Cascade Realty, Chetwynd

(17)xfs According to Rick Treby, Chief - Chetwynd Ambulance

(18) Cpl. Turner - Chetwynd RCMP Detachment

(19) School District 59 Administration - Dawson Creek

(20) Clark Hazelhurst - District of Chetwynd

(21) According to Terry Mills, Industrial Adjustment Officer, Ministry of Education, Skills and Training - Prince George.

(22)Human Resources Development Update

(23) Current 1995 figure - Statistics Canada - CHMC Housing

(24) Population estimates - BC Stats

(25) Dawson Creek is included in the overall regional area that is from the Prince George region north, and west to the Coast - local statistics are based using figures obtained from Employment Insurance and Social Assistance Recipients.

(26) HRDC Dawson Creek Update - October 1996

(27) HRDC - Dawson Creek

(28) CMHC Housing - Prince George

(29) School District 59 statistics

6.0 DIRECT AND INDIRECT ENVIRONMENTAL

IMPACTS ASSESSMENT

6.1 INTRODUCTION

This section discusses potential environmental impacts from construction, operation and closure of the Willow Creek mine. The following topics are discussed:

- air quality;
- noise;
- visual quality;
- surface water quality;
- groundwater;
- fish;
- terrestrial habitats/vegetation; and
- wildlife.

The most likely development scenarios are discussed in this section; section 9 deals with alternatives considered. Section 7 discusses management plans to reduce environmental impacts to the greatest extent practical, measures that will be taken to protect valued ecosystem components and mitigation of unavoidable environmental impacts.

6.2 AIR QUALITY

6.2.1 Emission Sources

Air emissions from coal mining and processing will be predominantly dust; emissions from mobile equipment will also be dust and, additionally, those associated with diesel internal combustion engines (NO_x, CO, CO_2, VOCs).

6.2.1.1 Mining

All mining operations will be outdoors; dust sources listed are fugitive (not from a single point source, such as a stationary exhaust stack).

- timber clearing and hauling (minor air emissions);
- water management structures - ditches and sedimentation ponds (minor air emissions);
- road construction;
- soil salvage and stockpiling;
- drilling and blasting of rock;
- rock excavation and truck haulage to dumps/backfill;
- coal excavation and truck haulage to plant site handling facilities;
- road, bench, and dump maintenance (included in rock dumping);
- equipment dispatch and transport (pit-to-pit, pit-to-shops, etc.) (no air emissions);
- reclamation - dump levelling/resloping, soiling and revegetation; and
- supervisory and service vehicle traffic (minor air emissions).

6.2.1.2 Coal Handling

Most coal washing operations will be inside a building where dust can be readily controlled.

Location of handling operations will be as follows:

Operation	**Location**
raw coal handling - truck dump	outside
feeder-breaker	enclosed
conveying	partly enclosed
stacking	outside

front-end loader reclaim to hopper-feeder	outside
conveying to plant	partly enclosed
coal processing (washing, sizing, drying)	enclosed
product coal handling (conveying, stockpiling)	outside
rail car loading (reclaim from stockpile, conveying, car loading)	outside (conveyors partly enclosed)
tailings disposal	tailings pond (wet; no dust)
coarse reject disposal	truck haulage to dump
supervisory and service vehicle traffic	outside

6.2.1.3 Shops and Administration

- personnel, supervisory and service vehicles;
- mine equipment traffic - maintenance and ready line;
- roads and yard maintenance; and
- offsite traffic - personnel, truck deliveries, visitors.

6.2.2 Dust

Dust will be generated during mine construction and operation from a number of sources. Visible coarse dust will only travel beyond the property boundaries during heavy winds in dry weather.

6.2.2.1 Construction

Dust sources during construction will include the following:

- stripping of the pit overburden (depending on the overburden moisture content at the time of stripping);
- mine road construction;
- rail spur construction;
- vehicular traffic on roads;

- mine and plant site clearing (depending on soil moisture content at the time of clearing);
- stockpiling of overburden and rock(1).

All sources will be non-point source and entirely wind propelled. Dust from construction activities will be limited to near-source areas, except for very high wind conditions. As well, any moisture or precipitation encountered during construction will mitigate dust generation; roads and bare soil will be watered as required to suppress dust to the extent practicable.

6.2.2.2 Operations

Dust sources during operation will include the following:

- topsoil salvage and stockpiling;
- haul road construction;
- coal loading at the pit;
- coal and rock haulage;
- coal handling at the plant;
- rail car loading;
- vehicular traffic on roads;
- blasting of rock (very minor; short time periods); and
- reclamation

Topsoil Salvage and Stockpiling

Topsoil salvage and stockpiling will occur both during construction and operations phases. The amount of dust generated will be dependent on moisture content of the soil. Assuming moisture content is low, the amount of dust will be similar to that generated by rock or coal, discussed below.

Haul Road Construction

Haul road construction will occur both during construction and operations phases. Dust generation will be short-term during construction and will be controlled with watering if problematic.

Loading Coal and Rock In-Pit

Loading of coal and rock in pits will generate dust in dry weather. Dust generation will be fugitive, or non-point source. Most dust will be coarse and will remain within the pit boundary. Some fine dust will be blown beyond pit boundaries during windy conditions. An emission factor is not available for this operation but an emission factor is given by USEPA for truck dumping (1 g/t) which is likely close to the emission factor for loading trucks. Either coal or waste will be loaded at any one time in any pit. Productivity of the backhoe and loader which will be used for these operations is 500 t/h. A single source then will generate a maximum of 500 g/hr dust which is equivalent to 0.14 g/s or 4.3 t/a (assuming 24 h/d, 365 d/a operation). Depending on the phase of mining one to a few such sources could be generating dust, each at a different location. Dust will remain within the pits for the most part and may be controlled with water spray if an occupational health issue.

Rock Dumping/Overburden Soil Stockpiling

Emission factors have been published by the USEPA (Joyner 1992) that can be used to estimate fugitive dust from rock disposal. Assuming overburden stripping and dumping have the same potential to create dust provides the following for overburden stripping, stockpiling and waste rock dumping:

Dust emission from this source can be estimated by:

E = 0.33

PE2

100

WhereE = emission factor, kg/t

PE = Thornthwaite's precipitation evaporation index (55 used)

Materials handling estimates (tonnes/day) (average over mine life):

overburden/rock stripping 10,000

overburden stockpiling/rock dumping10,000

Using this figure and the above emission factor produces an estimated 109 kg/d (4.5 kg/hr) dust each at stripping and dumping sites. All dust should remain within property boundaries and dust generation from this source beyond property boundaries is not expected to be significant.

Coal Stockpiles

The probable location of coal stockpiles is shown in Figure 2.3-1. Coal stockpiles will be watered as required during times when temperatures are above freezing. During winter months sprinkling of coal piles will not be feasible and dust generation could occur during periods of high winds, depending on the moisture content of the coal. To the extent practical, coal piles will be shielded by trees or buildings from prevailing winter winds(2).

The commodity property (particle size, etc.), moisture level and weather conditions are the most important factors that relate to air emissions from coal stockpiles. Experience at coal terminals suggests that below about 6% moisture, coal dust can be generated by winds, depending on the particle size of the coal.

Reference to Figure 2.3-1 indicates there will be four stockpiles at the plant site with a maximum total surface area of approximately 6060 m2 (0.6 ha). The USEPA exposure area emission factor is 0.4 u lbs/acre-hour (448 u g/ha-hour) where u = wind speed in m/s. Using an average wind velocity of 6.6 km/hr results in a calculated 0.49 g/s (15 tonnes per annum) dust from the coal piles, assuming no dust suppression. With dust suppression assumed for six months, this figure would be half or 7.5 tpa. There is a potential for some of this dust to reach residents immediately adjacent to the plant site on Highway 97 during winter when winds are high and coal stockpiles are not snow covered. The amount of dust reaching Highway 97 will likely be highly variable and depend on strength and direction of winds and amount of time between snow fall events.

A number of scenarios were run to determine the effects of coal pile dust emissions on ambient air. The USEPA model SCREEN3 was used in its area configuration to derive predictions of ambient air concentrations of particulates at various distances from coal piles. The SCREEN3 model uses conservative estimates of atmospheric conditions and under most circumstances tends to overestimate ambient concentrations. The emission factor and coal pile surface area listed above were used. Figure 6.2-1 shows the effects of coal stockpile height on predicted ambient particulates at 20 kph wind velocity, as well as predictions for particulate concentrations at various wind speeds for 15 m high coal stockpiles. Appendix 6.2-1 contains a listing of all model results.

Figure 6.2-1 shows that ground level particulate matter concentrations are significantly higher for relatively low coal stockpiles near to the stockpile (this result would be expected), but that beyond about 2500 m, particulate matter at ground level is very similar irrespective of coal stockpile height. The figure also shows that higher winds not only increase particulate matter near the coal stockpiles, but that concentrations stay somewhat elevated some distance from the stockpiles.

However, model results must be interpreted with the following factors in mind:

- the emission factor used was for unwatered coal piles;
- the model assumes a flat surfaced receiving environment with not rough areas to reduce wind speeds and modify patters;
- the model assumes no screening from trees;
- the model assumes constant wind velocities at the speeds listed, rather than gusting wind conditions and variable speeds; and
- the model assumes very fine particulate matter than will readily remain in suspension and not be subject to dry or wet fallout.

Results suggest that at moderate wind speeds (20 kph), particulate matter will be measurable at Highway 97 in areas where tree screening is not effective and blocking dust emissions from the stockpiles.

Results from modelling at coal terminals using more sophisticated models and actual emisisons and meteorological data suggest that moderate winds which are high enough to create dust but not high enough for effective dispersion actually result in the creation of most particulate matter in the respirable range (less than 10 microns) (Levelton Assoc., *pers. comm.*).

Coal Handling

Coal trucks will dump coal into a hopper-breaker feeding a coal stacker at the plant and conveyed onto the raw coal stockpile. Coal will then be reclaimed and conveyed from the raw coal stockpile into the plant as required. Dust can be generated by each of these operations. Coal piles will be sprinkled during dry weather when temperatures are above freezing. At other times, dust may be generated during windy, dry conditions.

Using emission factors for truck dumping provided by the United States Environmental Protection Agency (USEPA) of 1 g/t, and a dumping rate of 103 t/hr (900,000 tpa), produces an estimate of 0.03 g/s dust from this operation. The previously discussed USEPA emission factor of 448 ug/ha-hour can be used. As dumping is not a continuous but a periodic activity, a conservative estimate is to double this average for short durations (days or less). Most of the dust will be coarse and have a short travel distance.

The effective area of the truck dump chute into the stacker is 100 m2 (0.01 ha), thus the emission rate from truck dumping is 0.030 g/s assuming a mean annual wind speed of 6.6 km/hr(3). The estimate should be doubled for short durations as above. Most of the dust will be coarse.

The above two estimates are identical within the precision allowed by the methodology. Truck dumping is not likely to be a significant source of dust.

Rail Car Loading

Rail cars will be loaded north of the plant at the rail spur shown in Figure 2.3-1. Rail car loading dust will be controlled by minimizing the falling distance of coal from the loading chutes into rail cars. If dust generation becomes problematic, artificial screens will be installed to screen the loading operations from prevailing winds. Loading will take place in 8 to 10 hours. At the 900,000 tonne-per-year level a unit train would be loaded every three to four days.

For transport, binders will be sprayed on the coal in rail cars to prevent dust generation. This is a standard procedure used successfully throughout B.C. for rail transport of coal.

Vehicular Traffic on Mine Roads

Sprinkling of roads will be used to limit dust during dry weather when temperatures are above freezing. Snow cover during winter will limit dust generation. Some dust will likely be generated during periods of dry, cold, sunny weather when snow has ablated (evaporated) from road surfaces. This has been an occupational health concern at other northeast coal mining operations and solutions are actively being sought. Road salt could be considered if winter road dust becomes an issue at Willow Creek in areas where impacts from runoff to surface water bodies cannot occur.

Dust emission as a result of haul road traffic can be estimated by:

E = 0.17 (0.81s)S 350-W

18.6 350

(US EPA)

where

E = emission factor (kg/vehicle-km)

s = silt content of road (assumed to be 10%)

S = vehicle speed in kph, assumed to be 20 kphd

W = mean annual number of winter days with sunshine (196)

= 0.31 kg/vehicle-km.

At a projected raw coal production rate of 2465 tpd; with up to 100 t trucks, an average 25 trips per day will be required an average distance of 3 km, or 75 km. Rock disposal will require an average of 100 trips per day an average distance of less than 1 km for an additional approximately 100 km.

Total calculated dust emissions from trucks with this scenario is therefore 54 kg per day, assuming no dust control. Most dust will be generated at locations well within the mine property and will be coarse in nature. Impacts beyond the mine property are from haulage are therefore not expected to be significant.

Blasting

Blasting at the Willow Creek operations will only be required for removal of rock. Blasting, to be effective in breaking rock, must have the majority of its force directed into the rock and not into the air which would result in dust generation. Blasting operations at existing coal mines in British Columbia has not resulted in any dust generation problems, based on a survey of a number of major operations (*Fording Coal, Greenhills, Quintette, Bullmoose Mine, pers. comm. 1997*). Dust from blasting operations at Willow Creek are therefore is not expected to be significant.

Coal Handling Inside the Plant

Dust from coal handling inside the plant can be generated by conveyor transfer points, surge bins, coal crushing. Dust will be controlled as required to prevent significant emissions from the plant building and to meet Ministry of Employment and Investment *Mine Health and Safety Code* occupational health requirements for workplace indoor air.

Thermal Drying of Coal

Although not in the present plan, thermal drying of coal as an option for the Willow Creek operations; drying may be required in the future to meet specifications of certain products. Typical emission factors for drying coal are 10 kg of particulates per tonne of coal processed without controls (Joyner 1985); this figure drops about in half where air cyclones are used to recover coal fines and hollow flight type thermal dryers have no emissions. Particulates from coal drying operations are predominantly large diameter particles which dry or wet deposit relatively quickly.

6.2.3 Other Emissions

Mine vehicles will produce emissions of NOx, CO and hydrocarbons. Emission levels will be relatively low and not significant, considering the low traffic volume. Estimates from Finning are as follows:

Vehicle	**NOx (g/m3a)**	**CO (g/m3)**	**Hydrocarbon (g/m3)**
5110 Excavator	2.246	0.223	0.019
992 Loader	2.568	0.130	0.047
777 Haul Truck	4.088	0.109	0.123

a grams per normal cubic meter corrected to 5% oxygen.

Estimates were not attempted for service and supervisory light vehicles, as use will be highly variable and emissions small compared to equipment used to move coal and rock. At the Willow Creek Mine site, emissions from mine equipment listed in this section will be a small fraction of total emissions in the area when vehicular traffic on Highway 97 is considered and are therefore unlikley to be significant.

6.2.4 Distances to Nearest Residence from Mine Facilities

The nearest residence on Highway 97, District Lot 1149, is the following approximate distances from proposed mine facilities(4):

- plant 2.5 km
- Phase 1 and 2 dumps1.5 km;
- north end of the north pit2.0 km;
- south end of the north pit3.5 km;
- north end of the central pit4.0 km;
- south end of the central pit6.0 km.

Facilities not in the Pine River floodplain (first two listed) will have limited effects on dust levels at the residence.

6.3 NOISE

6.3.1 Introduction

The industrial activities associated with the open pit mine at Willow Creek will lead to generation of noise at the site which will be an increment to the present noise in the area. Presently noise sources on and near Highway 97 adjacent to the Project site include:

- road traffic;
- twice-daily train traffic;
- local noise from miscellaneous sources generated at individual properties.

The community of Willow Flats, 4.5 km east of the proposed Willow Creek plant also has an additional noise source - that of the gas pumping station. Noise from the Willow Creek mining operation will not significantly affect the gas pumping station area because of the distance and local noise sources. Individual residences in the Willow Flats area, who may be affected by coal mining-related noise, are shown on Figure 6.3-1.

6.3.2 Mine Construction

Additional noise that will occur from mine construction will include:

- highway truck delivery of materials and supplies;
- noise associated with construction of the plant;
- machinery and blasting noise associated with north pit development (Summer 1998 [clearing--February 1998]).

The noise from mine construction will occur over an approximately 6-month period and will be incremental to highway noise adjacent to the site. Highway truck traffic noise is discussed in the next section. An estimated 2000 truckloads of materials and supplies over a 6-month period, will arrive at the site during the construction period. This will be a temporary addition to noise in the area which will cease once the mine construction is completed. Estimates are not available for plant construction noise. The plant site is partly shielded from the road by a wall of trees. The most penetrating noise will be backup horns from mobile equipment working at the site.

Noise from pit development will be similar to that encountered during mine operation and is discussed in the next section.

6.3.3 Mine Operation

Noise levels from mine operations will be greater during the time when the north pit is being mined as the pit is closest to Highway 97. This is projected to occur between mid 1998 and 2008.

Additional noise that will occur once the mine is in operation will include:

- noise from the excavator at the pit (principally from the back up horn) which will occur frequently throughout the day;
- noise from blasting, which will occur on average once per day and be of very short duration;
- noise from operation of haul trucks, especially back up horns in the pit area and transmission brakes on the down grade haul road from the pit to the plant which will occur periodically throughout the day;
- noise from the front end loaders (principally back up horns) at the pit and plant sites;
- increase in private automobile traffic from mine employees;
- increase in road truck traffic from trucks delivering goods and materials;
- low level noise from the plant site from the breaker, conveyors and exhaust fans;
- train operation from loading and movement of one to two unit trains per week based on 900,000 tonnes per year;

In the following subsections, these sources are quantified and impacts assessed.

6.3.3.1 Excavators and Front End Loaders

Equipment to be used will be a CAT 5110 excavator(5) (or equivalent) and CAT 992 loaders. Noise levels will be approximately equivalent to the backhoe listed above. One excavator and one loader will be used in the pit and one loader will be used at the plant site. The excavator will be used primarily for handling rock immediately adjacent to the seams and coal, and the front end loader primarily for rock. The excavator will only infrequently back up, whereas the front end loader will back up routinely in truck loading operations. Engine noise from the loader or excavator at Highway 97 will not be significant compared to highway traffic. Backup horns, especially from the north pit area, may be audible above normal highway traffic. The following information was supplied by Wajax Industries:

Hitachi EX-1800 Backhoe (=Cat 5110): (7 m from cab):91 dB;

at 30 m: 81 dB

Finning supplied the following:

Cat 5110 Backhoe:at 15 m:82 dB

Cat 992 Loader:at 15 m:81 dB

Cat D10R Dozerat 15 m:81 dB

Cat 16H Graderat 15 m:81 dB

6.3.3.2 Blasting

Blasting will only be carried out for removal of overburden and then only once per day on average. Blasting is usually carried out near mid afternoon. The noise level at Highway 97 will be similar to that produced by slamming a door in one's house.

The potentially most obvious effect from blasting is not the noise but the air blast causing a sharp vibration in structures, such as houses. In open pit mining, blasting methods are used to reduce this effect as much as possible. The blast vibration is dampened by delays so that blasts reduce rather than re-enforce each other. If problematic, monitoring equipment is available to measure ground vibration and air blast and assist with reduction of any problem.

6.3.3.3 Haul Trucks

Up to four CAT 777 (or equivalent) trucks will haul rock to rock dumps and raw coal to the plant during mine operation. Trucks are powered by 1000 hp diesel engines and have a load capacity of 90 to 100 tonnes. Noise from the trucks will derive from three sources: engine noise, transmission brake noise (downhill grades), and backup horns. Backup horns will be used in the pit and at the plant. The most penetrating noise will be the backup horns which are a Workers Compensation Board requirement. The following noise level estimates were provided by Wajax Industries:

Euclid R90 Haul Truck (= Cat 777D) (outside truck): 90.1 dB;at 30 m: 80 dB

Finning provided the following for a Cat 777 haul truck:

Cat 777: at 15 m: 82 to 85 dB

Haul trucks will operate 24-hours per day. Engine noise will be masked by Highway 97 road traffic at locations on and adjacent to the highway.

6.3.3.4 Private Automobiles

The mine will employ 100 to 120 people on three shifts. The day shift will account for the largest proportion, due to more day time activities and due to administrative staff being added to mine workers. The average number of occupants per vehicle will be somewhat greater than one (car pooling, busing services), so that 100 private cars will not be travelling to and from the mine site. Noise from automobiles will occur at shift changes. Automobile noise has not been quantified but will be incremental to existing road traffic on Highway 97, which is the major road link north in British Columbia between Prince George and the Peace River area including Dawson Creek, Fort St. John and Fort Nelson. Information provided by Ministry of Transportation and Highways in Prince George in January 1997 indicated the mean summer average daily traffic (24h, both directions) at the Westcoast Energy pump station at Willow Flats was 1151 vehicles in 1994, up from

1099 in 1993 and down from 1360 in 1991. Additional private automobile traffic from mine operation will then be less than 10% of the total traffic on Highway 97 at the project site, and is therefore not a significant source of increased noise.

6.3.3.5 Highway Truck Traffic

An estimated 1000+ trucks per year will deliver materials and supplies to the mine. This number represents a small percentage of the total truck traffic on Highway 97 and is therefore not a significant contributor to noise in the area.

6.3.3.6 Internal Plant Noise

Internal plant noise will be shielded by the plant walls. As well the trees north of the plant will further absorb plant noise. Thus plant noise at Highway 97 should not be audible under normal circumstances.

6.3.3.7 Train Noise

Figure 2.3-1 shows the proposed location of the rail spur for loading unit trains. The coal loading operation will consist of the following:

- front-end loader reclaiming from stockpiles to hopper-conveyor;
- conveying of coal from the stockpile to the loading hopper;
- loading of cars by conveyor;
- movement of the train slowly through the loadout to fill coal cars; and
- arrival and departure of the unit train at the site.

Noise from train loading will come from the front-end loader, conveying and loading coal into cars and train movement. The average noise level from the car loading operation will be continuous but will be very low, based on information from similar coal loading operations supplied by BC Rail.

6.4 VISUAL QUALITY

The viewscape of the Project area from Highway 97 will be modified by mine construction and operation. During construction and during operation certain facilities will be visible from the highway level. Locations of facilities discussed in the following paragraphs can be found on Figure 2.1-1.

6.4.1 Construction

The North Pit area will be cleared of trees preparatory to mining in the early winter of 1998 (conceptually February). The Peninsula Pit dump will also be cleared at that time. The 4N and AN pits will be cleared of trees; the 6N and 8N pits are not scheduled for mining until later in the mine life and will likely not be cleared at the same time as the other North Pit areas. Higher elevations of north-facing slope of the North Pit will be visible from Highway 97. The visible area will be approximately 40 to 50 ha. No other pits will be visible from Highway 97 level. The north end of the Central Pit will be visible at a distance.

Higher parts of the wash plant will also be visible from the road. Plant construction will commence during the summer of 1998.

6.4.2 Operation

The North Pit will be mined for the first seven years of operation. During early years of operation two external dumps will be used to store rock, the Phase 1 and 2 dumps. The tops of these dumps, once sufficiently high will be visible from Highway 97 level. Pits and dumps will be progressively reclaimed when no longer active, as discussed in Section 7.

In the plant area, the tops of coal stockpiles may also be visible during operation. Heights of the stockpiles will vary depending on the plant production schedule.

6.5 SURFACE WATER QUALITY

6.5.1 Introduction

The activities associated with the open pit mine at Willow Creek have the potential to impact water quality primarily during the construction and operations phases through release of sediments and through release of nitrogen from explosives. The following sections discuss potential water quality changes during the construction, operations and closure phases of the mine.

6.5.2 Construction Phase

Suspended solids in streams draining the mine site could increase temporarily as a result of pit development such as overburden removal, pit dewatering, haul road construction and other mining or construction activities. However, suspended solids will be controlled by the construction of various water management facilities to ensure acceptable levels of suspended solids in receiving waters. These facilities will include ditches and sedimentation ponds as described in Section 7.3. The performance of these facilities should be similar to that of facilities at existing mines in the northeast coal block.

6.5.3 Operations Phase

6.5.3.1 Suspended Sediments

During operation, the rock dumps will be sources of suspended sediments. Suspended solids will be controlled by ditches and sedimentation ponds as described in Section 7.3. The performance of these facilities should be similar to that of facilities at existing mines in the northeast coal block. Data supplied by Quintette for stabilized dumps indicates the following:

PERIOD	LOADING	
	AVERAGE	MAXIMUM

(grams/day/m2)		
March to April	0.280	1.668
July to August	0.032	0.178
Rest of the Year	0.006	0.018
(grams/day/bank cubic meter)		
March to April	0.024	0.141
July to August	0.0027	0.015
Rest of the Year	0.0005	0.0015

Table 6.5-1 provides estimates of sediment loadings from Willow Creek Project external dumps using the above loading factors and volumes of rock based on projected volumes of rock reporting to external dumps (locations of dumps can be referenced on Figure 2.1-1).

TABLE 6.5-1

Sediment Loading Estimates for External Dumps, Willow Creek Project

YEAR	**UNITS**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
NORTH EXTERNAL DUMPS	**BCM**	825,676	3,008,338	2,781,261	1,872,078									
	KG/DAY	7	27	25	17									

CUMULATIVE TOTAL	**BCM**	825,676	3,834,014	6,615,275	8,487,353								
	KG/DAY	7	35	60	76								
CENTRAL EXTERNAL DUMP	**BCM**					639,938	963,268	2,320,086	2,475,086	722,500	912,792	1,496,245	3,870,085
	KG/DAY					6	9	21	22	7	8	13	35
CUMULATIVE TOTAL	**BCM**					639,938	1,603,206	3,923,292	6,398,378	7,120,878	8,033,670	9,529,915	13,400,000
	KG/DAY					6	14	35	58	64	72	86	121

BCM - Bank Cubic Metres

Based on a weighted annual average of maximum seasonal unit sediment loading data from Quintette (.009 g/d/bcm) (see Table in Section 6.5.3-1)

These data indicate expected loadings are low for rock similar to that found at Quintette.

Initial operation of dumps may result in higher sediment loads, although information from Quintette(6) suggests that coarse rock at the base of rock dumps effectively filters sediment. Quintette studies indicate that during the dumping process, fines remain in the upper 10% of a dump zone, natural segregation of dumps precludes downward migration of fines from upper to lower portions of dumps, and, based on a five-year sampling record, negligible suspended sediment loads are generated by dumps (see figures above).

Quintette operated the North Alternate Dump without sediment control downstream of the dump from 1992 through 1994 under permit from MOELP. An active coarse rejects dump was utilized from 1994 to the present with no apparent significant effect on sediment loads downstream of the North Alternate Dump. The performance of rock dumps at the Willow Creek Project is expected to be similar to those at Quintette.

6.5.3.2 Nitrogen Compounds

Three nitrogen compounds, nitrate (NO_3), nitrite (NO_2) and ammonia (NH_3), can occur in elevated concentrations due to losses during blasting. Ammonia and nitrate are constituents of the explosives, while nitrite is an intermediate product of the oxidation of ammonia to nitrate. The impact assessment for these nitrogen compounds is based on modelling nitrogen loss from explosives and then determining the resulting concentrations of nitrogen compounds in Willow Creek, a fish-bearing stream. Concentrations of nitrogen compounds in Middle Creek have not been determined because this stream is not fish-bearing and because Middle Creek will discharge to a wetland where oxidation of nitrite and removal of ammonia and nitrate are expected to occur. Reference to Figure 2.1-1 shows that all water draining the north pit and part of the central pit reports to the Middle Creek basin, i.e. the wetland back channel of the Pine River.

Annual nitrogen losses from explosives to surface waters were predicted using the equations of Ferguson and Leask (1988). The total annual nitrogen loss varies with the types and proportions of explosives used. Ferguson and Leask (1988) provide the following formulas for estimating nitrogen losses:

1) Explosive loss (as N) = 0.2% (projected ANFO use as N), for mines that will use up to 1% slurry explosive;

2) Explosive loss (as N) = 0.1% (projected ANFO use as N) + 8.5% (projected slurry use as N), for mines that will use more than 1% but less than 20% slurry explosive; and

3) Explosive loss (as N) = 0.94% (projected ANFO use as N) + 5.1% (projected slurry use as N), for mines that will use more than 20% slurry explosive.

The explosives used in coal mining have changed considerably since Ferguson and Leask developed their formulas. Mines in the northeastern British Columbia now use an emulsion in place of slurry for blasting under wet conditions. In drier conditions, ANFO and/or other combinations of ammonium nitrate and emulsion may be used. For determining and applying the appropriate nitrogen loss model, all ammonia nitrate formulations were considered equivalent to ANFO, while emulsion was considered equivalent to slurry. This approach is appropriate because the major factor contributing to differences in the leaching rates of slurry and ANFO was the wetness or dryness of the conditions under which they were used.

Explosives use for the Willow Creek Project is expected to be 50% ANFO, 40% other ammonia nitrate formulations and 10% slurry. Thus, Equation 2 was used to calculate nitrogen loss during each year of operation.

The amounts of explosives used were expressed in kilograms of nitrogen, based on information supplied by the manufacturer. A weighted percent nitrogen content of 30.2% was calculated for "ANFO" based on the projected proportions of ANFO and "Super ANFO". The percent nitrogen content of the emulsion is 24.8% based on manufacturer's data.

For simplicity, the Ferguson and Leask nitrogen loss model assumes that all nitrogen released from explosives in a given year leaches from the waste rock spoil during that year. However, monitoring at Fording River Coal Operation in southeastern British Columbia has shown that this is not the case. Nitrogen release actually occurs over several years. Thus, the model tends to overestimate the nitrogen loss during the years of peak explosives use and underestimate the nitrogen loss in years when explosives use is significantly lower than during the previous year(s).

The expected annual nitrogen loadings calculated from the nitrogen loss model were used to predict monthly average and 7-day low flow concentrations of nitrogen species in Willow Creek. Initially, the total nitrogen loading to receiving water was calculated. This loading was later partitioned into nitrogen species. Predictions of nitrogen concentrations in receiving waters involved the following steps:

1. To determine daily nitrogen loadings to the streams, the annual nitrogen losses were partitioned into monthly losses and then divided by the number of days in the month. The monthly proportions of nitrogen loss were determined by calculating the nitrogen load (concentration times flow) represented by each sample collected from the S-4 settling pond at the Qunitette Coal operation from 1987 to 1996 (Table 6.5-2). These values were used to calculate the average nitrogen load for each month and the percentage of the average total annual load represented by each monthly average load.
2. The daily nitrogen loads (losses) were divided by the mean monthly and 7-day low stream flows (expressed as m3/day) to obtain total nitrogen concentrations. The 200-year low flow was used for the “worst case” predictions, although the 10-year, 7-day low flow is normally used in impact assessments. As discussed in Section 4, the 200-year low flow may be over-estimated; thus, it is appropriate to use this value in place of the 10-year, 7-day low flow. For the model, the 7-day low flows were assumed to occur in January.
3. The total nitrogen concentrations were partitioned into concentrations of nitrate, nitrite and ammonia. The proportions of the total nitrogen load represented by

nitrate, nitrite and ammonia were the average percentages of these compounds in the S-4 settling pond at Quintette Coal based on the 1987 to 1996 permit monitoring data. The percentages were derived by calculating the proportions of the three nitrogen compounds in each sample and then calculating the average percentage of each compound over the entire monitoring period. The average proportions obtained were nitrate - 91.4%, nitrite - 1.8% and ammonia - 6.8%.

TABLE 6.5-2

PERCENT OF TOTAL ANNUAL NITROGEN LOAD LEACHING FROM WASTE EACH MONTH

MONTH		PERCENT OF ANNUAL LOAD
	January	3.9%
	February	2.5%
	March	14.2%
	April	6.8%
	May	9.6%
	June	18.2%
	July	8.4%
	August	6.9%
	September	6.6%
	October	12.7%
	November	5.6%
	December	4.5%

Nitrogen Loadings

Table 6.5-3 summarizes the modelled total annual nitrogen losses from the Pine Valley Coal Operation from 1998 through 2013. Table 6.5-4 shows the nitrogen loads to Willow and Middle Creeks, respectively. These values were derived by prorating the total load according the percent of the total waste destined for the dumps in each drainage basin.

TABLE 6.5-3

PROJECTED ANNUAL NITROGEN LOSS FROM THE PINE VALLEY COAL PROJECT

YEAR	VOLUME TO BLAST	TOTAL EXPLOSIVES REQUIRED	POWDER FACTOR (Kg/BCM)	% ANFO	% EMUL.	NITROGEN CONTENT OF ANFO	NITROGEN CONTENT OF EMUL.	TOTAL NITROGEN CONTENT OF EXPLOSIVES USED	TOTAL NITROGEN LOSS
	(BCM X 1000)	(X 1000 Kg)				(X 1000 Kg)	(X 1000 Kg)	(X 1000 Kg)	(X 1000 Kg)
1998	875	455	0.52	90.0%	10.0%	124	11	135	1.08
1999	3687	1917	0.52	90.0%	10.0%	521	48	568	4.56
2000	4332	2253	0.52	90.0%	10.0%	612	56	668	5.36
2001	4381	2278	0.52	90.0%	10.0%	619	57	675	5.42
2002	4649	2417	0.52	90.0%	10.0%	657	60	717	5.75
2003	4800	2496	0.52	90.0%	10.0%	678	62	740	5.94
2004	4257	2214	0.52	90.0%	10.0%	601	55	656	5.27

2005	4617	2401	0.52	90.0%	10.0%	652	60	712	5.71
2006	4693	2440	0.52	90.0%	10.0%	663	61	723	5.81
2007	4558	2370	0.52	90.0%	10.0%	644	59	703	5.64
2008	4769	2480	0.52	90.0%	10.0%	674	62	735	5.90
2009	4944	2571	0.52	90.0%	10.0%	698	64	762	6.12
2010	4958	2578	0.52	90.0%	10.0%	700	64	764	6.13
2011	5005	2602	0.52	90.0%	10.0%	707	65	771	6.19
2012	4102	2133	0.52	90.0%	10.0%	579	53	632	5.08
2013	705	367	0.52	90.0%	10.0%	100	9	109	0.87

EMUL. - Emulsion (used for wet blasting conditions)

TABLE 6.5-4

PROJECTED ANNUAL NITROGEN LOADINGS TO WILLOW AND MIDDLE CREEKS FROM THE PINE VALLEY COAL PROJECT

YEAR	WASTE TO WILLOW CREEK	WASTE TO MIDDLE CREEK	TOTAL N TO WILLOW CREEK	TOTAL N TO MIDDLE CREEK
	(%)	(%)	(Kg)	(Kg)
1998	0.0%	100.0%	-	1,083
1999	9.5%	90.5%	433	4,129

2000	28.2%	71.8%	1,513	3,848
2001	18.5%	81.5%	1,003	4,418
2002	18.9%	81.1%	1,085	4,667
2003	8.8%	91.2%	522	5,417
2004	9.9%	90.1%	519	4,748
2005	0.0%	100.0%	-	5,713
2006	0.0%	100.0%	-	5,807
2007	0.0%	100.0%	-	5,640
2008	0.0%	100.0%	-	5,901
2009	0.0%	100.0%	-	6,117
2010	0.0%	100.0%	-	6,134
2011	0.0%	100.0%	-	6,193
2012	0.0%	100.0%	-	5,076
2013	91.1%	8.9%	795	78

Predicted Nitrogen Concentrations

The model predicts mean monthly and 7-day low flow concentrations (in milligrams per litre) of nitrogen in Willow Creek. To assess the impacts of nitrogen loadings on Willow Creek, the mean monthly concentrations are compared with the British Columbia Ministry of Environment, Lands and Parks (MOELP) receiving water criterion for 30-day average nitrate, nitrite and ammonia concentrations. The 7-day low flow values are compared with the MOELP maximum acceptable criterion.

Tables 6.5-5 to 6.5-7 summarize the predicted nitrate, nitrite and ammonia concentrations in Willow Creek for the years 1999, 2000, 2005, 2011, and 2013. These years were selected to represent conditions near the beginning (1999 and 2000) and end (2013) of the life of the mine, the "worst case" year (2011) when the greatest amounts of material will be placed in dumps draining to Willow Creek, and one intermediate year (2005).

Predicted incremental concentrations of all three nitrogen species are far below the MOELP 30-day and maximum acceptable receiving water criteria. The maximum predicted monthly (average) nitrate concentration is 0.423 mg N/L, and the maximum concentration predicted during a 200-year 7-day low flow is 0.960 mg N/L (Table 6.5-5). These maximum values are far below both the 40 mg N/L MOELP criterion for protection of aquatic life and the more restrictive 10 mg N/L criterion for drinking water. The maximum predicted monthly and 7-day low flow nitrite concentrations are 0.008 mg N/L and 0.019 mg N/L, respectively (Table 6.5-6). Both values are below the 0.02 mg N/L 30-day average criterion and the 0.06 mg N/L maximum criterion for nitrite. The maximum predicted monthly and 7-day low flow ammonia concentrations are 0.031 mg N/L and 0.071 mg N/L, respectively (Table 6.5-7). Criteria for ammonia vary with water temperature and pH. At the maximum pH measured in Willow Creek (8.5) the 30-day average ammonia criterion ranges from 0.405 to 0.261 mg N/L over a temperature range of 0·C to 20·C. Thus the average ammonia criteria are over three times the 200-year, 7-day low flow concentration and approximately an order of magnitude higher than the incremental maximum monthly average concentration predicted by the Willow Creek nitrogen model.

TABLE 6.5-5

PREDICTED INCREMENTAL NITRATE CONCENTRATIONS IN WILLOW CREEK DURING OPERATION OF THE PINE VALLEY COAL MINE

		PREDICTED CONCENTRATIONS (mg N/L)				
MONTH	**STREAM FLOWS (X 1,000 m3/d)**	**1999**	**2000**	**2004**	**2010**	**2013**
January	32	0.016	0.055	0.019	0.000	0.029
February	10	0.036	0.124	0.043	0.000	0.065
March	62	0.029	0.102	0.035	0.000	0.054
April	153	0.006	0.021	0.007	0.000	0.011
May	235	0.005	0.018	0.006	0.000	0.010
June	129	0.019	0.065	0.022	0.000	0.034

July	139	0.008	0.027	0.009	0.000	0.014
August	44	0.020	0.070	0.024	0.000	0.037
September	26	0.033	0.117	0.040	0.000	0.061
October	35	0.046	0.162	0.056	0.000	0.085
November	21	0.035	0.123	0.042	0.000	0.065
December	22	0.026	0.091	0.031	0.000	0.048
Mean Ann. 7-day Low	9.4	0.053	0.185	0.064	0.000	0.097
200-year 7-day Low	4.8	0.105	0.367	0.126	0.000	0.193

TABLE 6.5-6

PREDICTED INCREMENTAL A36 NITRITE CONCENTRATIONS IN WILLOW CREEK DURING OPERATION OF THE PINE VALLEY COAL MINE

		PREDICTED CONCENTRATIONS (mg N/L)				
MONTH	**STREAM FLOWS (X 1,000 m3/d)**	**1999**	**2000**	**2004**	**2010**	**2013**
January	32	0.000	0.001	0.000	0.000	0.001
February	10	0.001	0.002	0.001	0.000	0.001
March	62	0.001	0.002	0.001	0.000	0.001
April	153	0.000	0.000	0.000	0.000	0.000

May	235	0.000	0.000	0.000	0.000	0.000
June	129	0.000	0.001	0.000	0.000	0.001
July	139	0.000	0.001	0.000	0.000	0.000
August	44	0.000	0.001	0.000	0.000	0.001
September	26	0.001	0.002	0.001	0.000	0.001
October	35	0.001	0.003	0.001	0.000	0.002
November	21	0.001	0.002	0.001	0.000	0.001
December	22	0.001	0.002	0.001	0.000	0.001
Mean Ann. 7-day Low	9.4	0.001	0.004	0.001	0.000	0.002
200-year 7-day Low	4.8	0.002	0.007	0.002	0.000	0.004

TABLE 6.5-7

PREDICTED INCREMENTAL AMMONIA CONCENTRATIONS IN WILLOW CREEK DURING OPERATION OF THE PINE VALLEY COAL MINE

		PREDICTED CONCENTRATIONS (mg N/L)				
MONTH	**STREAM FLOWS (X 1,000 m3/d)**	**1999**	**2000**	**2004**	**2010**	**2013**
January	32	0.001	0.004	0.001	0.000	0.002

February	10	0.003	0.009	0.003	0.000	0.005
March	62	0.002	0.008	0.003	0.000	0.004
April	153	0.000	0.002	0.001	0.000	0.001
May	235	0.000	0.001	0.000	0.000	0.001
June	129	0.001	0.005	0.002	0.000	0.003
July	139	0.001	0.002	0.001	0.000	0.001
August	44	0.001	0.005	0.002	0.000	0.003
September	26	0.002	0.009	0.003	0.000	0.005
October	35	0.003	0.012	0.004	0.000	0.006
November	21	0.003	0.009	0.003	0.000	0.005
December	22	0.002	0.007	0.002	0.000	0.004
Mean Ann. 7-day Low	9.4	0.004	0.014	0.005	0.000	0.007
200-year 7-day Low	4.8	0.008	0.027	0.009	0.000	0.014

		PREDICTED NITRITE CONCENTRATIONS (mg/L) - VARIABLE % NO2 ASSUMPTION				
MONTH	**STREAM FLOWS (X 1,000 m3/d)**	**1999**	**2000**	**2004**	**2010**	**2013**
January	32	0.002	0.006	0.002	0.000	0.003
February	10	0.004	0.001	0.005	0.000	0.007

March	62	0.003	0.001	0.004	0.000	0.006
April	153	0.001	0.002	0.001	0.000	0.001
May	235	0.001	0.002	0.001	0.000	0.001
June	129	0.002	0.007	0.002	0.000	0.004
July	139	0.001	0.003	0.001	0.000	0.002
August	44	0.002	0.007	0.003	0.000	0.004
September	26	0.004	0.001	0.004	0.000	0.007
October	35	0.005	0.001	0.006	0.000	0.009
November	21	0.004	0.001	0.005	0.000	0.007
December	22	0.003	0.010	0.003	0.000	0.005
Mean Ann. 7-day Low	9.4	0.006	0.001	0.007	0.000	0.001
200-year 7-day Low	4.8	0.001	0.002	0.001	0.000	0.001

When the predicted incremental nitrogen concentrations are added to background nitrogen concentrations, the predicted concentrations of all three nitrogen compounds still meet receiving water criteria. Adding the on the average spring or summer background concentrations of nitrate, nitrite and ammonia (Section 4) to the predicted incremental concentrations, the maximum predicted concentrations are 1.17 mg N/L nitrate, 0.019 mg N/L nitrite and 0.161 mg N/L ammonia. These levels meet both the 30-day average and maximum receiving water criteria for nitrate, nitrite and ammonia. Thus, nitrogen lost from the mine operation will have no significant impact on the water quality of Willow Creek.

6.5.4 Reclamation and Closure Phase

No impacts to water quality are expected during the reclamation and closure phase of the mine. During the first few years after the cessation of mining, nitrogen levels in Willow and Middle creeks may be slightly elevated over background (pre-mining) conditions due to extended leaching of explosives residues as discussed in Section 6.5.2. However, the concentrations of nitrate, nitrite and ammonia will be lower than those predicted during the operations phase. Therefore, they will not have any negative impacts on water quality.

There is some potential for sediment loadings due to earth-moving operations (contouring) during reclamation and some potential for erosion until vegetation is established on disturbed areas.

6.6 GROUNDWATER

Shallow groundwater is evident on the property from both artesian drill holes (3 flowing in 1996; 5 found by IEC Beak in 1982) and from the spring origin of Far East Creek (which is off the eastern boundary of the proposed development zone). Groundwater movement in the Project area is in overburden and bedrock with bedrock and topography ultimately controlling flow direction.

IEC Beak (1882) estimated average hydraulic conductivity of coal formations to be 10-7m/s. Coal seams are mostly within the zone of saturation. Pits will act as a sink to groundwater flow, however, the area of coal seams is small compared to the total area of the hanging and footwall, i.e. the area where conductivity is increased. Therefore the footwall and hanging walls will control the amount of groundwater flow into the pits. The amount of groundwater inflow will be dependent upon the vertical hydraulic conductivity of the surrounding rock, perpendicular to the plane of bedding which IEC Beak calculated to be approximately 10-8 m/s. Beak calculated the flow into the ultimate underground mine (roughly equivalent to the north pit) to be 1.5 x 10-2 m3/s (195 igpm). A somewhat greater amount could result from open pit development, depending on the ratio of exposed coal seam area to total hanging and footwall areas at a given time. Since the floor of the pit will have variable hydraulic conductivities, depending on the stage of mining, recharge will also be variable and a conservative assumption is that no groundwater will recharge. The volume of water generated from groundwater surfacing in the pits will be easily handled by proposed sedimentation ponds. Further, since groundwater is controlled by bedrock and topography, the ultimate discharge areas, i.e. Pine River floodplain and Willow Creek will not be affected, since approximately the same volume of water will report to these receiving bodies, albeit via surface discharge and sediment control structures rather than groundwater discharge.

Upon closure, pits will be backfilled and thus the mine will continue to act as a sink to groundwater bedrock flow. Discharge flows from pits upon closure and reclamation will be low in sediment, based on the experience of other northeast coal mines where sediment levels from closed dumps are low and near background.

6.7 FISH

6.7.1 Project Design

Environmental impact avoidance and ecological protection measures will be initiated with project planning, particularly in relation to interactions between project facilities and environmental values (e.g. road crossings of creeks, waste impoundment dykes and sediment control plans). These measures are discussed in Section 7.3.

6.7.2 Project Construction

The primary concerns related to construction activities and potential impacts on aquatic resources include:

- sedimentation of streams from surface runoff from disturbed areas; and
- direct disturbance to fish-bearing habitat from road building, mine development and/or changes in hydraulic conditions due to upstream changes that result in bedload movement and substrate deposition and potential fish migration barriers.

6.7.3 Mine Operation

During project operations, the primary potential impacts to fish populations will include:

- potential water quality changes downstream, particularly in Middle Creek (which is not fish-bearing, except for in the Pine River floodplain area);
- continued limitations to fish production from past disturbances in the area, including bedload transport and deposition, improperly placed culverts and/or lack of cover for fish (e.g. cut-banks, LWD, deep pools); and/or
- possible ongoing sport fishing pressures from project personnel and families (likely limited to the Pine River).

6.7.4 Abandonment and Closure

The main effects of decommissioning and abandoning the project will be to restore and/or rehabilitate the disturbed areas related to fish production, including stream channels (habitat availability, complexity and productive capacity) and riparian zones (the latter principally by creation of habitat in central pit pond).

6.7.5 Residual Impacts

The only adverse impact to fisheries resources expected from mine development will be some increase in nitrogen levels in backwater areas of the Pine River south of the BC Rail tracks. As discussed in Section 4.6, this area is of limited value as fish habitat, although fish do occur in this area. The adverse impacts to fishery resources that cannot be entirely avoided by design, or mitigation measures, will be offset by compensation measures, such as fish habitat creation or enhancement, such that overall fish production in the region will be sustained. The potential residual aquatic impacts associated with the proposed development include:

- occasional, short term water quality changes depending on precipitation and runoff conditions;
- displacement of the upper reaches of Middle Creek, and the middle drainage basin of Tributary 1 by the mine footprint (these drainages are devoid of fish);
- potential dewatering of some of the creeks that drain the project area due to displacement of portions of drainage basins in some cases (again, these drainages are devoid of fish);
- loss of small amounts of riparian habitat at road crossings of creeks (offset to some extent by bridge, or (passable) culvert crossing structure that could provide cover); and
- fishing pressures on local fish stocks from project personnel (which, if problematic, can be controlled through area-specific fishing regulations set by both Pine Valley Coal and BC Environment).

6.8 ECOSYSTEM UNITS

6.8.1 Construction and Operational Phases

6.8.1.1 Loss of Ecosystem Units

Willow Creek Project activities that will result in loss or alteration (i.e. clearing of trees, grading, excavation or similar activities) of terrestrial ecosystem units during construction and operational phases include the development of pits, rock dumps, sedimentation ponds, topsoil storage, roads and the plant site. The existing Willow

Creek forestry road has not been included in calculations.

Areas of impacted ecosystem units were calculated by overlaying mapped terrestrial ecosystem units with proposed mine site facilities. Two slightly different operational layouts have been proposed for the Pine Valley Project. Alternative B includes all the mine facilities as shown in Figure 2.1-1, while Alternative A does not include the haul road that bisects the north slope of the Pine Valley and the proposed 8C - North Pit.

Based on the two development options presented, approximately 400 ha of the land base will be used for Alternative A while 460 ha will be used for Alternative B. Project facilities will occur in the three biogeoclimatic units (BEC units) found in the project area; total area of all ecosystem units disturbed for the two alternatives is as follows:

Biogeoclimatic Unit	Alternative A (ha)	Alternative B (ha)	Willow Creek Project Area (ha)
BWBSmw1	111.31 (28.1%)	121.74 (26.6%)	628.82 (26.6%)
SBSwk2	129.86 (32.8%)	142.41 (31.2%)	541.04 (22.9 %)
ESSFmv2	154.86 (39.1%)	192.98 (42.2%)	1197.74 (50.6 %)
Total	**396.03**	**457.13**	**2367.6**

The greatest area of proposed mine facilities is located in the ESSFmv2 (39.1% and 42.2% of Alternatives A and B, respectively), with lesser amounts in the SBSwk2 and BWBSmw1. Tables 6.8-1 and 6.8-2 provide summaries of the area (ha) of ecosystem units to be disturbed by proposed mine facilities for both alternatives. The majority of ecosystem units disturbed (about 83.41% and 84.39% under Alternatives A and B, respectively) are covered by ecosystem units in the mature stage (80-250 years for the SBSwk2 and ESSFmv2; >140 years for the BWBSmw1). Other structural stages that will be impacted include herb, shrub/herb and young forest. Table 6.8-3 summarizes area to be disturbed by site series. A discussion of impacts by biogeoclimatic unit (BEC unit) and site series is provided below.

Areas to be Developed by Pine Valley coal Operations

by Ecosystem Unit Alternative A

TABLE 6.8-1 AREAS (ha) TO BE DEVELOPED BY PINE VALLEY COAL OPERATIONS BY ECOSYSTEM UNIT ALTERNATIVE A Biogeoclimatic	Site Series &	Structural Stage						Area (ha)	Percent
Unit	Modiifer	2	3	4	5	6	7		
BWBSmw1	AMcn					1.29		1.29	0.33
BWBSmw1	AMkm					3.78		3.78	0.95
BWBSmw1	AMmn					2.82		2.82	0.71
BWBSmw1	AMm					2.19		2.19	0.55
BWBSmw1	AMcn:ap		2.08			23.87		25.95	6.55
BWBSmw1	AMm:ap					31.92		31.92	8.06
BWBSmw1	ASvw				2.53			2.53	0.64
BWBSmw1	SWkm					1.05		1.05	0.27
BWBSmw1	SWkv					0.45		0.45	0.11
BWBSmw1	SWm:as					8.80		8.80	2.22
BWBSmw1	SWkm:as					10.96		10.96	2.77
BWBSmw1	SWsw:as				4.68			4.68	1.18

BWBSmw1	SOkm			2.54	2.54	0.64
BWBSmw1	SOm			4.27	4.27	1.08
BWBSmw1	SCm	0.63	0.32		0.95	0.24
BWBSmw1	SCm:ab			4.62	4.62	1.17
BWBSmw1	SHmn:ac			1.88	1.88	0.47
BWBSmw1	SH:ac	0.63			0.63	0.16
SBSwk2	SO			12.09	12.09	3.05
SBSwk2	SOk			27.56	27.56	6.96
SBSwk2	LHrs			0.61	0.61	0.15
SBSwk2	SCk			2.35	2.35	0.59
SBSwk2	SCks	2.25		19.39	21.64	5.46
SBSwk2	SCw			0.60	0.60	0.15
SBSwk2	SCsw	0.97		20.95	21.92	5.53
SBSwk2	SCvw			2.98	2.98	0.75
SBSwk2	SCm			4.89	4.89	1.23
SBSwk2	SCkm			2.55	2.55	0.64
SBSwk2	SCmw			4.14	4.14	1.05

SBSwk2	SD					11.57		11.57	2.92
SBSwk2	SDw					2.37		2.37	0.60
SBSwk2	SDk					1.51		1.51	0.38
SBSwk2	SH					5.04		5.04	1.27
SBSwk2	SHm					8.04		8.04	2.03
ESSFmv2	FR	36.39	3.51		3.46	24.76		68.12	17.20
ESSFmv2	FRs		2.04			18.66		20.70	5.23
ESSFmv2	FRk					7.00		7.00	1.77
ESSFmv2	FRks					28.90		28.90	7.30
ESSFmv2	FRw					4.57		4.57	1.15
ESSFmv2	FRsw					6.85		6.85	1.73
ESSFmv2	FLs					7.52		7.52	1.90
ESSFmv2	FO	4.97				5.01		9.98	2.52
ESSFmv2	FH	1.23						1.23	0.31
Total		**42.59**	**12.11**	**0.00**	**10.99**	**330.35**	**0.00**	**396.04**	**100.00**
Percent		**10.75**	**3.06**	**0.00**	**2.77**	**83.41**	**0.00**		

TABLE 6.8-2

AREAS (ha) TO BE DEVELOPED BY PINE VALLEY COAL OPERATIONS BY ECOSYSTEM UNIT

ALTERNATIVE B

Biogeoclimatic	Site Series &	Structural Stage						Area (ha)	Percent
Unit	Modifiers	2	3	4	5	6	7		
BWBSmw1	AMcn					1.29		1.29	0.28
BWBSmw1	AMkm					4.19		4.19	0.92
BWBSmw1	AMmn					2.82		2.82	0.62
BWBSmw1	AMm					2.19		2.19	0.48
BWBSmw1	AMcn:ap		2.08			23.89		25.97	5.69
BWBSmw1	AMm:ap					33.36		33.36	7.31
BWBSmw1	ASvw				2.53			2.53	0.55
BWBSmw1	SWkm					4.54		4.54	1.00
BWBSmw1	SWkv					1.82		1.82	0.40
BWBSmw1	SWm:as					8.80		8.80	1.93
BWBSmw1	SWkm:as					10.96		10.96	2.40
BWBSmw1	SWsw:as				4.68			4.68	1.03
BWBSmw1	SOkm					2.81		2.81	0.62

BWBSmw1	SOm			4.27	4.27	0.94
BWBSmw1	SCm	1.67	0.84		2.51	0.55
BWBSmw1	SCm:ab			5.48	5.48	1.20
BWBSmw1	SHmn6:ac			1.88	1.88	0.41
BWBSmw1	SH3:ac	1.67			1.67	0.37
SBSwk2	SO			12.09	12.09	2.65
SBSwk2	SOk			28.58	28.58	6.26
SBSwk2	LHrs			0.61	0.61	0.13
SBSwk2	SCs			2.37	2.37	0.52
SBSwk2	SCk			4.92	4.92	1.08
SBSwk2	SCks	2.39		21.19	23.58	5.17
SBSwk2	SCw			0.60	0.60	0.13
SBSwk2	SCsw	1.57		20.95	22.52	4.94
SBSwk2	SCvw			2.98	2.98	0.65
SBSwk2	SCm			7.73	7.73	1.69
SBSwk2	SCkm			3.77	3.77	0.83
SBSwk2	SCmw			4.14	4.14	0.91

SBSwk2	SD					11.57		11.57	2.54
SBSwk2	SDw					2.37		2.37	0.52
SBSwk2	SDk					1.51		1.51	0.33
SBSwk2	SH					5.04		5.04	1.10
SBSwk2	SHm					8.04		8.04	1.76
ESSFmv2	FR	36.39	4.83		3.46	24.96		69.64	15.27
ESSFmv2	FRs		2.92			28.41		31.33	6.87
ESSFmv2	FRk					14.00		14.00	3.07
ESSFmv2	FRks					42.70		42.70	9.36
ESSFmv2	FRw					7.27		7.27	1.59
ESSFmv2	FRsw					6.85		6.85	1.50
ESSFmv2	FLs					9.01		9.01	1.98
ESSFmv2	FO	4.97				5.01		9.98	2.19
ESSFmv2	FH	1.23						1.23	0.27
Total		**42.59**	**17.13**	**0.00**	**11.51**	**384.97**	**0.00**	**456.20**	**100.00**
Percent		**9.34**	**3.75**	**0.00**	**2.52**	**84.39**	**0.00**		

Table 6.8-3: Areas (ha) of Site Series to be Developed by Pine Valley Coal Operations

			Alternative A		Alternative B	
Biogeoclimatic Zone and Site Series No.	**Site Series Symbol**	**Site Series**	**Area (ha)**	**Percent**	**Area(ha)**	**Percent**
BWBSmw1/01	AM	SwAt - Step moss	67.95	17.2	69.80	15.3
BWBSmw1/03	SW	Sw - Wildrye - Peavine	25.94	6.6	30.79	6.7
BWBSmw1/05	SO	Sw - Currant - Oak fern	6.81	1.7	7.08	1.5
BWBSmw1/06	SC	Sw - Currant - Bluebells	5.57	1.4	7.99	1.7
BWBSmw1/07	SH	Sw - Currant - Horsetail	2.51	0.6	3.55	0.8
BWBSmw1/00	AS	SwAt - Soopolallie	2.53	0.6	2.53	0.6
BWBSmw1/00	SE	Sedge Fen	0.00	0.0	0.00	0.0
BWBSmw1/00	WH	Willow - Horsetail -Sedge Riparian Wetland	0.00	0.0	0.00	0.0
SBSwk2/01	SO	Sxw - Oak fern	39.65	10.0	40.67	8.9
SBSwk2/02	LH	Pl - Huckleberry - Cladina	0.61	0.2	0.61	0.1
SBSwk2/03	SC	Sxw - Huckleberry - Highbush-cranberry	61.07	15.4	72.60	15.9
SBSwk2/05	SD	Sxw - Devil's club	15.45	3.9	15.45	3.4
SBSwk2/06	SH	Sxw - Horsetail	13.08	3.3	13.08	2.9
SBSwk2/00	WS	Willow - Sedge Fen	0.00	0.0	0.00	0.0
ESSFmv2/01	FR	Bl - Rhododendron - Feathermoss	136.14	34.4	171.78	37.6

ESSFmv2/02	FL	Bl - Lingonberry	7.52	1.9	10.00	2.2
ESSFmv2/03	BT	BlSb - Labrador tea	0.00	0.0	0.00	0.0
ESSFmv2/04	FO	Bl - Oak fern - Knight's plume	9.97	2.5	9.97	2.2
ESSFmv2/06	FH	Bl - Alder - Horsetail	1.23	0.3	1.23	0.3
ESSFmv2/00	SE	Sedge Fen	0.00	0.0	0.00	0.0
ESSFmv2/00	WS	Willow - Sedge Fen	0.00	0.0	0.00	0.0
ESSFmv2/00	UNC	Unclassified forb meadow	0.00	0.0	0.00	0.0
Totals			396.03	100	457.13	100

BWBSmw1

The majority of the project area to be disturbed for both project alternatives in the BWBSmw1 currently supports mixed wood or deciduous forest stands in the mature structural stage (i.e. 80-140 years in age). Mature seral units are especially common. White spruce-Trembling aspen - Step moss (AM) is the site series which will be most impacted in the BWBSmw1 under both project alternatives. About 17.2 and 15.3 percent of the total mine area developed under Alternatives A and B, respectively will be the AM site series (Table 6.8-3). This is the zonal site series and is very common throughout the biogeoclimatic unit (DeLong et. al., 1990). Five other site series will be disturbed. These include, in order of greatest to least disturbance under Alternative A: White spruce - Wildrye - Peavine (SW), White spruce - Currant - Oak fern (SO), White spruce - Currant - Bluebells (SC), White spruce - Currant - Horsetail (SH), and Trembling aspen - White spruce - Soopolallie (AS). Under Alternative B, the impact to site series is similar, except that the order of SC and SO are reversed. SC is a common site series, while SW, SO, and SH are described as uncommon in the MOF field guide (DeLong et. al., 1990). Although listed as uncommon, these site series are not listed as rare elements (CDC, 1996). No old growth forests, non-forested wetlands or rare plant communities will be disturbed in this BEC unit (such areas are of most interest from a botanical perspective).

SBSwk2

Five site series will be impacted by mine related developments within this BEC unit. They are, in order of greatest to least disturbance for both Alternatives: Hybrid white spruce - Huckleberry - Highbush-cranberry (SC), Hybrid white spruce - Oak fern (SO), Hybrid white spruce - Devil’s club (SD), Hybrid white spruce - Horsetail (SH), and Lodgepole pine - Huckleberry - Cladina (LH). About 15.4% and 15.9% of the total mine area to be disturbed under Alternatives A and B, respectively, is covered by SC ecosystem units (Table 6.8-3). All of these site series, with the exception of LH are described as common in the MOF field guide (MacKinnnon et. al., 1990). Although described as uncommon, the LH site series is not listed as a rare element (CDC, 1996). The majority of the project area to be developed in this BEC unit currently supports coniferous forest in the mature structural stage (i.e. 80 - 140 years in age). Other structural stages that will be disturbed include young forest and shrub/herb. No old growth forest, non-forested wetland or rare plant community will be disturbed in this BEC unit.

ESSFmv2

Four site series will be impacted by mine related developments within this unit. In order from greatest to least disturbance under Alternatives A these are: Subalpine-fir - Rhododendron - Feathermoss (FR), Subalpine-fir - Oak fern - Knight's plume (FO), Subalpine-fir - Lingonberry (FL), and Subalpine-fir - Alder - Horsetail (FH). A slightly larger area of FL ecosystems than FO ecosystems would be impacted by Alternative B (Tabel 6.8-3). A significant amount of the total disturbed area will occur on ecosystem units in the FR site series (about 34.4% and 37.6% under Alternatives A and B, respectively). This is the zonal site series and is described as very common in the MOF field guide. The FL site series is described as uncommon in the MOF Field Guide, but is not listed as a rare element by the Conservation Data Centre (DeLong et. al., 1994, CDC 1996). About 2.2% of the total mine site area (Alternative B) is covered by FL forests. No old growth forest, non-wetland or rare plant communities will be disturbed in this BEC unit. The majority of the project area to be developed in this BEC unit currently supports coniferous in the mature structural stage (80 -250 years in age).

Comparison to Total Project Area Ecosystem Map Area

Terrestrial ecosystem mapping was completed for an area of approximately 2367 ha in the vicinity of proposed mine facilities. Table 6.8-4 provides a comparison of site series that will be disturbed by the two project alternatives to the total areas mapped within the entire Willow Creek project area. Approximately 16.7 and 19.3 percent of the total area mapped will be disturbed by Alternatives A and B, respectively. The most common site series in the map area are the Bl - Rhododendron (FR) of the ESSFmv2 (39.38%); Sxw - Huckleberry - Highbush cranberry (SC) of the SBSwk2 (13.75%) and the Sw - Wildrye - Peavine (SW) of the BWBSmw1 (10.13%). The SW site series is described as uncommon, but is not listed as a rare element.

Table 6.8-4: Comparsion of Pine Valley Coal Development Alternatives to Total Ecosystem Map Area

			Pine Valley Map Area		Alternative A		Alternative B	
Biogeoclimatic Unit & Site Series	Site Series Symbol	Site Series Name	Total Map Area (ha)	Percent of Total Map Area	Area to be Disturbed (ha)	Percent of Ecosystem Unit Area	Area to be Disturbed (ha)	Percent of Ecosystem Unit Area
BWBSmw1/01	AM	SwAt - Step moss	151.73	6.41	67.95	44.78	69.80	46.00
BWBSmw1/03	SW	Sw - Wildrye - Peavine	239.91	10.13	25.94	10.81	30.79	12.83
BWBSmw1/05	SO	Sw - Currant - Oak fern	10.58	0.45	6.81	64.37	7.08	66.92

BWBSmw1/06	SC	Sw - Currant - Bluebells	87.29	3.69	5.57	6.38	7.99	9.15
BWBSmw1/07	SH	Sw - Currant - Horsetail	73.89	3.12	2.51	3.40	3.55	4.80
BWBSmw1/00	AS	SwAt - Soopolallie	27.74	1.17	2.53	9.12	2.53	9.12
BWBSmw1/00	SE	Sedge Fen	5.89	0.25	0.00	0.00	0.00	0.00
BWBSmw1/00	WH	Willow - Horsetail - Sedge Riparian Wetland	27.87	1.18	0.00	0.00	0.00	0.00
N/A	OW	Open water	3.92	0.17	0.00	0.00	0.00	0.00
SBSwk2/01	SO	Sxw - Oak fern	134.37	5.68	39.65	29.51	40.67	30.27
SBSwk2/02	LH	Pl - Huckleberry - Cladina	4.00	0.17	0.61	15.25	0.61	15.25
SBSwk2/03	SC	Sxw - Huckleberry - Highbush-cranberry	325.57	13.75	61.07	18.76	72.60	22.30
SBSwk2/05	SD	Sxw - Devil's club	22.24	0.94	15.45	69.47	15.45	69.47
SBSwk2/06	SH	Sxw - Horsetail	48.95	2.07	13.08	26.72	13.08	26.72
SBSwk2/00	WS	Willow - Sedge Fen	5.91	0.25	0.00	0.00	0.00	0.00
ESSFmv2/01	FR	Bl - Rhododendron - Feathermoss	932.27	39.38	136.14	14.60	171.78	18.43
ESSFmv2/02	FL	Bl - Lingonberry	77.31	3.27	7.52	9.73	10.00	12.93
ESSFmv2/03	BT	BlSb - Labrador tea	16.53	0.70	0.00	0.00	0.00	0.00

ESSFmv2/04	FO	Bl - Oak fern - Knight's plume	120.14	5.07	9.97	8.30	9.97	8.30
ESSFmv2/06	FH	Bl - Alder - Horsetail	34.71	1.47	1.23	3.54	1.23	3.54
ESSFmv2/00	SE	Sedge Fen	2.01	0.08	0.00	0.00	0.00	0.00
ESSFmv2/00	WS	Willow - Sedge Fen	2.68	0.11	0.00	0.00	0.00	0.00
ESSFmv2/00	UNC	Unclassified forb meadow	12.09	0.51	0.00	0.00	0.00	0.00
Totals			2367.60	100.00	396.03		457.13	

The least common forested site series mapped in the Willow Creek project area are: the Pl - Huckleberry - Cladina (LH) (0.17%) of the SBSwk2; the Sw - Currant Oak fern (SO) (0.45%) of the BWBSmw1; the BlSb - Labrador tea (BT)(0.70%) of the ESSFmv2; and the Sxw - Devil’s club (SD) (0.94%) of the SBSwk2. About 69.5 %, 66.9% and 15.3% of the total area of the SD, SO and LH site series, respectively, will be disturbed under Alternative B (largest disturbed area). Although described as uncommon in the MOF field guides, these site series are not listed as rare elements ((DeLong et. al., 1990; MacKinnnon et. al., 1990; CDC, 1996). None of the BT site series, the only mapped blue-listed plant community, will be lost under either project alternative. Non-forested ecosystem units are also relatively uncommon in the project area. None of the Sedge Wetland (SE), Willow - Sedge wetlands (WS), Willow - Horsetail - Sedge Riparian Wetlands (WH) or the unclassified forb meadow (UNC) will be disturbed by the either project alternative.

In conclusion, direct loss of ecosystem units found in the Willow Creek project area is not considered significant, given that no rare elements (plant communities), old growth forest, or less common non-forested ecosystems will be disturbed by the project. A discussion of the significance of ecosystem unit losses to wildlife species is contained in Section 6.9.

6.8.2 Reclamation and Closure Phase

Reclamation objectives and plans are detailed in Section 7.1. The short term objectives are generally to cover the reclaimed ground with grasses and forbs in order to provide erosion control, stabilize material, restore drainage, restart soil building processes and provide cover for aesthetic reasons. Long-term reclamation objectives are to maintain or improve wildlife habitat; maintain or improve the value of the forest for logging; and create an aesthetically pleasing environment.

Reclamation can proceed in certain mine areas (i.e. rock dumps) as early as the year 2002 while in other areas (i.e. sedimentation ponds, roads and the plant site), reclamation will not proceed until closure. Herb plant communities (dominated by grasses) are generally established first on reclaimed areas. Shrubs and trees are planted after the areas have been stabilized and the short term objectives realized.

Selection of plant species for reclamation will depend on goals established by BC Environment for wildlife habitat enhancement, results of field trials, and availability of plant material. Herb and shrub/herb structural stages can likely be expected on reclaimed areas for a minimum of twenty years. Mature forest will not be created until 80 years after trees are established and free growing. Therefore, ecosystem units similar to those presently found on the site will not be expected until 80 to 100 years after closure. The diversity of ecosystems present will depend on several factors including physical and chemical characteristics of subsoil and topsoil, drainage, slope, aspect, plant species selection and natural selection.

6.9 WILDLIFE

The section below discusses impacts of mine development on key wildlife utilizing the study area. The impact assessment is based on the maximum potential area disturbed by mine development activities (i.e., Alternative B - see Section 6.8). Options for mitigating impacts are provided in Section 7.

6.9.1 Habitat Alteration

Surface disturbance related to mine development will result in alienation of habitat within the immediate development area, as described in Section 6.8. While the total mine life is 15 years, total area of disturbance will be minimized through progressive reclamation. Reclamation can be initiated as early as the year 2002 in some mine areas such as rock dumps. Herbaceous and shrub communities established on reclaimed areas will provide foraging habitats for ungulates and bears in the short-term until forests develop.

Habitat suitability ratings have been developed for key wildlife species occurring within the mine development area. Habitats considered of value (i.e., suitable) for these species will be directly removed as a result of mine development; Table 6.9-1 lists the approximate area of key habitats that will be disturbed for each species of concern. Species are listed in order of management concern on the subject property.

TABLE 6.9-1:

TOTAL AREA OF IMPORTANT HABITATS FOR KEY SPECIES

DISTURBED BY THE MINE DEVELOPMENT PROJECT

(see Appendix 4.12-2 for suitability ratings tables;

Appendix 4.12-2a for ratings definitions).

Wildlife Species	Habitat suitability rating levels used to determine disturbance	Total disturbed area (ha) (% of total area disturbed)
Grizzly Bear	2 and 3 ratings	55.82 (13.0)
Elk	2 and 3 ratings	13.06 (3.1)

Moose	2 and 3 ratings	132.63 (31.0)
Mule Deer	2 and 3 ratings	13.06 (3.1)
White-tailed Deer	2 and 3 ratings	13.06 (3.1)
Marten	M and H ratings	100.24 (23.4)
Fisher	M and H ratings	17.35 (4.1)
Northern Goshawk	M and H ratings	40.72 (9.5)
Broad-winged Hawk	L and M ratings	89.90 (21.0)
Black-t. Green Warbler	U ratings	263.21 (61.5)
Connecticut Warbler	U ratings	102.85 (24.0)
Bay-breasted Warbler	U ratings	143.69 (33.6)
Cape May Warbler	U ratings	139.07 (32.5)
Canada Warbler	U ratings	103.96 (24.3)
Philadelphia Vireo	U ratings	119.41 (27.9)
Yellow-b. Flycatcher	U ratings	36.09 (8.4)
Woodland Caribou	3 ratings	9.79 (2.3)
Trumpeter Swan	L ratings	0.00 (0.0)

Some habitats are suitable for a number of key wildlife species, making them of particular importance. Within the BWBSmw1, these habitats include mature forests (i.e., structural stage 6) of site series SO (05; White spruce - Currant - Oak Fern) and mature, seral stage forests of site series SC:ab (06; White spruce - Currant - Bluebells) and SH:ac (07; White spruce - Currant - Horsetail). Total number of key wildlife species for which these habitats are important are 11, seven and 10, respectively. Within the SBSwk2, the most important habitats are mature forests (i.e., structural stage 6) of site series SD (05; White spruce hybrid - Devil's club) and SH (06; White spruce hybrid - Horsetail). These habitats are important for a total of nine of the key wildlife species. Within the ESSFmv2, the most important habitats are mature forests (i.e., structural stage 6) of site series FO (04; Balsam - Oak fern - Knight's plume) and structural stage 2 habitats of site series FH (06; Balsam - Alder - Horsetail). These habitats are important for a total of eight and six key wildlife species. All habitats described above are moist, productive forests where tree growth is rapid and understorey vegetation is prolific.

Specific impacts of mine development on each of wildlife species of management concern are discussed below.

6.9.1.1 Grizzly Bear

Grizzly bears appear to be most common on the property in the spring, when an abundance of forage is available along roads and in clearcuts. Lowland areas along the Pine River valley are also utilized during the spring. During the summer, most grizzly bears likely move to nearby subalpine and alpine habitats. Utilization of the site likely increases again in the fall when berries have ripened. An assessment of the impacts of mine development on important grizzly bear habitats (habitats rated as 2 [moderately high] or 3 [moderate] suitability), indicates that 55.82 ha (13.0% of total disturbed area) of important habitats will be disturbed. Of these key habitats, 15.61 ha are within the BWBS mw1 (14.3% of total BWBSmw1 disturbed area), 30.42 ha in the SBSwk2 (22.4%), and 9.79 ha in the ESSFmv2 (5.3%). Key habitat types disturbed by development activity include mature forests on rich, moist sites in the SBSwk2 zone (28.53 ha) and early seral stage (i.e., structural stages 2 and 3) habitats (8.24 ha). These habitats typically have well developed herb and shrub understories which provide foraging opportunities both in spring and the fall. On a regional level, overall direct impacts to grizzly bear habitats are expected to be relatively low.

6.9.1.2 Elk

Elk are common in many areas of the subject property during the summer growing season. In winter, elk move to south-facing, steep slopes along the Pine River, downstream of the project area. The primary importance of habitats on the project site is for foraging. Only 13.06 ha of key habitats (habitats rated as 2 [moderately high] or 3 [moderate] suitability) for elk are estimated to be disturbed by the proposed mine development (3.1% of the total disturbed area). Of these key habitats, 3.27 ha are within the BWBS mw1 (3.0% of total BWBSmw1 disturbed area) and 9.79 ha in the ESSFmv2 (5.3%). A total of 4.96 ha of the ESSFmk2 habitats is structural stage 2 and 3 (i.e., upland clearcuts). Most of the prime foraging areas for elk are located along upper reaches of Far East Creek and in the Pine River lowlands and will not be directly disturbed by mine development. On a regional level, overall direct disturbance to key elk habitats is expected to be very low.

6.9.1.3 Moose

Moose are common throughout the project area. Utilization of habitats appears to occur in all seasons, although a movement to lower elevations (i.e., Pine River floodplain) is evident during the winter. An assessment of the impacts of mine development on important moose habitats (habitats rated as 2 [moderately high] or 3 [moderate] suitability), indicates that 132.63 ha (31.0% of the total disturbed area) of important habitats will be disturbed. Of these key habitats, 17.69 ha are within the BWBS mw1 (16.3% of total BWBSmw1 disturbed area), 71.88 ha in the SBSwk2 (52.9%), and 43.06 ha in the ESSFmv2 (23.5%). Clearcut areas and early seral stage habitats in all biogeoclimatic zones (49.77 ha), and mature forests in the SBSwk2 zone (68.64 ha) which have a wide diversity and abundance of browse species for moose, are particularly important. Many key wintering habitats for moose, located on the Pine River floodplain, will not directly be impacted by mine development.

6.9.1.4 Mule Deer and White-tailed Deer

Because mule deer and white-tailed deer have similar foraging requirements as elk, habitat suitability ratings were the same. Only 13.06 ha of key habitats (habitats rated as 2 [moderately high] or 3 [moderate] suitability) for deer are estimated to be disturbed by the proposed mine development (3.1% of the total disturbed area). Of these key habitats, 3.27 ha are within the BWBS mw1 (3.0% of total BWBSmw1 disturbed area) and 9.79 ha in the ESSFmv2 (5.3%). A total of 4.96 ha of the ESSFmk2 habitats is structural stage 2 and 3 (i.e., upland clearcuts). Due to high winter snowfalls, deer are generally forced to lower elevations earlier than elk. Many habitats within the Pine River floodplain are important to deer, providing foraging areas, and thermal and security cover. The majority of the Pine River floodplain will not be directly impacted by the proposed development. On a regional level, overall direct disturbance to key deer habitats is expected to be very low.

6.9.1.5 Marten

Based on trap records, marten are the most common mustelid species within the project area. Marten densities are generally highest in mature and old growth forest habitats with an abundance of large snags and coarse woody debris at all elevations (i.e., BWBSmw1, SBSwk2 and ESSFmv2). A large portion of the proposed disturbance area may be moderately suitable for marten (100.24 ha or 23.4% of total disturbed habitats). No high suitability habitats (i.e., generally structural stage 7) are located within the disturbance area. Of these suitable habitats, 4.27 ha are within the BWBS mw1 (3.9% of total BWBSmw1 disturbed area), 28.53 ha are within the SBSwk2 (21.0%), and 67.44 ha in the ESSFmv2 (36.8%). Excellent marten habitat occurs outside the proposed disturbance area in the Pine River floodplain. Overall direct impacts to marten habitats, on a regional level, are considered to be moderately low.

6.9.1.6 Fisher

Based on local knowledge, fisher populations within the project area are at relatively low densities. Prime habitats are old growth forests in riparian areas with an abundance of snags, coarse woody debris, structural forest diversity and edges. This habitat is generally uncommon on the subject property, except for small areas of the Pine River floodplain. Only 17.35 ha (4.1%) of habitats considered to be of moderate suitability for fisher was located within the proposed disturbance area. Of these moderately suitable habitats, 4.27 ha are within the BWBS mw1 (3.9% of total BWBSmw1 disturbed area) and 13.08 ha are within the SBSwk2 (7.1%). No high suitability habitats were located within the proposed disturbance area. Overall direct impacts to fisher habitat are considered to be very low.

6.9.1.7 Northern Goshawk

Little is known of population densities and distribution of northern goshawks in the study area. However, northern goshawks are known to nest in mature, productive forests (i.e., structural stage 6 and 7) and to forage over a wider range of habitat types. Of the total area expected to be disturbed by mine development, 40.72 ha (9.5%) is considered to be of moderate suitability for goshawks. Of these moderately suitable habitats, 7.36 ha are within the BWBS mw1 (6.8% of total BWBSmw1 disturbed area), 28.53 ha in the SBSwk2 (21.0%), and 4.83 ha in the ESSFmv2 (2.6%). None of the disturbed area was assessed to be of high suitability. However, two raptor nests found in the northwest corner of the study area (i.e., between the proposed tailings pond and a coarse rejects stockpile) may be of this species. Mine site development would likely result in the destruction of these nest sites. Overall impact to habitats considered of moderate suitability for northern goshawks is low. Impacts to specific nest locations may be high.

6.9.1.8 Broad-winged Hawk

Broad-winged hawks have been found nesting in several locations in the Prince George area and in the Peace River lowlands. Because suitable habitats are available on the study site, it is possible that this species occurs. An assessment of impacts of mine development on potentially suitable broad-winged habitats (habitats rated as L [low]or M [moderate] suitability), indicates that as much as 89.90 ha (21.0% of the total disturbed area) of these habitats will be disturbed by development activity. All 89.90 ha are within the BWBSmw1 biogeoclimatic zone and represent 82.6% of BWBSmw1 habitats expected to be disturbed by mine development.. Only 1.88

ha of this area is rated as being of moderate suitability for broad-winged hawks. Moderate suitability habitats are located in the vicinity of the proposed tailings pond and tailings dump site at the northwest end of the study area. Two raptor nests located in this area, which may be utilized by broad-winged hawks, will likely be destroyed by mine development activities.

6.9.1.9 Black-throated Green Warbler

Although black-throated green warblers have not been surveyed in the proposed development area, they likely occur in suitable habitats of mature and old growth, well spaced spruce stands in all three biogeoclimatic zones. As little is known of this species' distribution, densities and specific habitat utilization in British Columbia, only a presence/absence rating system was used to determine habitat suitability. An assessment of the impacts of mine development on potential black-throated green warbler habitats indicates that 263.21 ha (61.5% of the total disturbed area) of these habitats will be disturbed. Of potentially suitable habitats, 6.86 ha are within the BWBSmw1 (6.3% of total BWBSmw1 disturbed area), 132.21 ha in the SBSwk2 (97.3%), and 124.14 ha in the ESSFmv2 (67.8%). Overall impacts to black-throated green warbler populations are difficult to determine because of lack of site-specific information, but are relatively small.

6.9.1.10 Connecticut Warbler

Site-specific information on Connecticut warbler populations is not available. Preferred breeding habitats appear to be trembling aspen dominated stands with widely spaced large aspen, and a well developed but short shrub understorey. These habitats are located within the BWBSmw1 zone in the Pine River floodplain and on the slopes immediately above the floodplain. As little is known of this species' distribution, densities and specific habitat utilization in B.C., only a presence/absence rating system was used to determine habitat suitability. As a result, a large range of deciduous forest habitats was considered to be potentially suitable. Breeding bird surveys would be necessary to determine occurrence and specific habitat utilization of this species in the study area. An assessment of the impacts of mine development on potential Connecticut warbler habitats indicates that 102.85 ha (24.0% of the total disturbed area) of these habitats will be disturbed. The 102.85 ha comprises 94.5% of total BWBSmw1 habitats disturbed by mine development. Overall impacts to Connecticut warbler populations are difficult to predict because of lack of site-specific information, but are relatively small.

6.9.1.11 Bay-breasted Warbler

It is not known if this species occurs on the subject property. However, in the absence of site-specific information, this species is assumed to potentially occur in suitable habitats throughout the BWBSmw1 and SBSwk2 zones of the subject property. Presence/absence ratings for habitat suitability result in a broad range of potentially suitable habitats. An assessment of the impacts of mine development on potential bay-breasted warbler habitats indicates that 143.69 ha (33.6% of the total disturbed area) of these habitats will be disturbed. Of potentially suitable habitats, 11.48 ha are within the BWBS mw1 (10.5% of total BWBSmw1 disturbed area) and 132.21 ha are in the SBSwk2 (97.3%). Overall impacts to bay-breasted warbler populations are difficult to determine because of lack of site-specific information but are relatively small.

6.9.1.12 Cape May Warbler

Typical breeding habitats of Cape May warbler include mature coniferous forest and coniferous forest edge habitats in the BWBSmw1 and SBSwk2 biogeoclimatic zones. These habitats are widespread throughout the study area. Lack of detailed information on Cape May warbler distribution, abundance and habitat utilization does not permit a detailed assessment of suitable habitats. An assessment of impacts of mine development on potential Cape May warbler habitats, indicates that 139.07 ha (32.5% of the total disturbed area) of these habitats will be disturbed. Of potentially suitable habitats, 6.86 ha are within the BWBS mw1 (6.3% of total BWBSmw1 disturbed area) and 132.21 ha are in the SBSwk2 (97.3%). Overall impacts to Cape May warbler populations are difficult to predict because of lack of site-specific information, but are relatively small.

6.9.1.13 Canada Warbler

It is not clear whether Canada warblers occur on the subject property. However, suitable breeding habitats such as deciduous woodlands and riparian thickets exist in the BWBSmw1 zone of the study area. A more specific assessment of habitat suitability was not possible for this species because of lack of site-specific information. An assessment of impacts of mine development on potential Canada warbler habitats indicates that 103.96 ha (24.3% of the total disturbed area) of these habitats will be disturbed. The 103.96 ha comprises 95.5% of total BWBSmw1 habitats disturbed by mine development. Overall impacts to Canada warbler populations are difficult to determine because of lack of site-specific information, but are relatively small.

6.9.1.14 Philadelphia Vireo

Although suitable breeding habitat exists for Philadelphia vireo on the subject property, no surveys for occurrence have been conducted. Typical breeding habitat is dense, rapidly growing stands of aspen and cottonwood in the BWBSmw1 and SBSwk2 biogeoclimatic zones. Due to an absence of site-specific information on this species, most structural stage 4, 5 and 6 forests on the site were rated as being potentially suitable. An assessment of impacts of mine development on potential Philadelphia vireo habitats indicates that 119.41 ha (27.9% of the total disturbed area) of these habitats will be disturbed. Of potentially suitable habitats, 103.96 ha are within the BWBS mw1 (95.5% of total BWBSmw1 disturbed area) and 15.45 ha are in the SBSwk2 (11.4%). Overall impacts to Philadelphia vireo populations are difficult to determine because of lack of site-specific information, but are relatively small.

6.9.1.15 Yellow-bellied Flycatcher

The yellow-bellied flycatcher is another rare species for which very little site-specific information on distribution, abundance and habitat utilization exists. However, known habitat requirements appear to be restricted to mature spruce communities along rivers, lakes and other open wetlands. Habitat of this nature is relatively restricted on the subject property. An assessment of impacts of mine development on potential yellow-bellied flycatcher habitats indicates that 36.09 ha (8.4% of the total disturbed area) will be disturbed. Of potentially suitable habitats, 7.56 ha are within the BWBS mw1 (6.9% of total BWBSmw1 disturbed area) and 28.53 ha are in the SBSwk2 (21.0%). Overall impact to yellow-bellied flycatcher habitat is expected to be very low although it is not confirmed whether the study site is within this species' distribution.

6.9.1.16 Woodland Caribou

Although no records of woodland caribou occurrence on the study site were located, suitability ratings were determined for each of the habitats on the site. Generally, poor suitability habitats for caribou exist on most areas of the property (partially explains absence of caribou). An assessment of the impacts of mine development on key caribou habitats (habitats rated as 3 [moderate] suitability), indicates that 9.79 ha (2.3% of the total disturbed area) of these habitats will be disturbed. All 9.79 ha of these disturbed habitats are within the ESSFmv2 zone at the south end of the site and represent 5.3% of total ESSFmv2 habitats which will likely be disturbed. On a regional level, no impacts to woodland caribou are expected.

6.9.1.17 Trumpeter Swans

Trumpeter swans are expected to occasionally utilize open wetland habitats of the study area. The current mine plan will be unlikely to result in any significant physical disturbance of open water areas that may be utilized by the swans.

6.9.2 Reduced Habitat Effectiveness

Short-term and long-term sensory disturbance associated with development of the Willow Creek Mine can result in displacement of wildlife away from areas of disturbance. Although displacement can be significant for larger species such as moose, elk and grizzly bear, effects of sensory disturbance are not well understood for smaller wildlife species such as songbirds. Studies of moose along the Quintette Conveyor RoW found that moose avoided intensive construction activity by as much as 500 m (Sopuck and Ferguson 1983). Generally, grizzly bears are displaced further from intensive development activities than species such as black bear, elk and deer. Decreased use of habitats adjacent to heavily utilized roads by grizzly bear has been documented by McLellan and Shackelton (1988), Aune and Stivers (1987) and Kasworm and Manley (1990). Declines in elk use of habitat adjacent to heavily travelled roads has also been well documented (Lyon 1984), although the mine area road traffic will not compare to that found on a provincial highway. Expected habitat effectiveness impacts related to specific features of the proposed mine site are discussed below.

New Pine River Floodplain Access Roads

Construction, maintenance and heavy use of proposed new access roads on the south side of the Pine River Floodplain will result in sensory disturbance to wildlife species utilizing adjacent riparian and floodplain habitats. Raptors utilizing known nests between the proposed road and tailings pond will likely abandon nests. Abandonment of chicks may occur depending on timing of road construction. As the proposed road runs centrally through lowland habitats located between the railway line and the base of the slope to the south, the value of these habitats to wildlife will be greatly reduced. Continued construction noise, moving trucks and other vehicles will reduce effectiveness of these habitats and songbirds which potentially utilize these habitats could be negatively impacted.

New access roads and the edge of the lower rock dump site on the southern edge of the wetland created by construction of the BC Rail rail bed will reduce utilization of the wetland by wildlife. The wetland is likely utilized by waterfowl during migration and species such as mallard may nest. Other wildlife species, such as beaver, which have a large lodge along the wetland edge, may also be affected. Overall value of the wetland to wildlife will be reduced during the proposed activities.

Increased Utilization of Willow Creek Road

Increased frequency of heavy traffic on the Willow Creek Road will reduce the value of habitats along sections of Willow Creek. Habitats along the first section of the road are within the BWBSmw1 biogeoclimatic zone and may be utilized by a number of wildlife species of concern, particularly red and blue-listed songbirds. Larger wildlife such as moose, elk, deer and grizzly bear also likely utilize the Willow Creek corridor to move between upland and lowland sites. Wildlife may be less likely to utilize this corridor with increased noise and activity on the mine road above.

Plant Site

Some indirect disturbance of adjacent habitats on the Willow Creek fan and Pine River floodplain will likely occur. Red-listed songbird species such as Connecticut and Canada warblers, potentially breeding in adjacent deciduous dominated stands, may be disrupted.

Pine River Floodplain Tailings and Sedimentation Ponds

Activity related to excavation and maintenance of the proposed tailings and sedimentation ponds at the northwest end of the study area will likely result in disruption to wildlife utilizing adjacent habitats. Nesting success of raptors utilizing nests identified to the east of the pond will likely be impacted.

Upland Pits and Adjoining Dumps

Displacement of wildlife because of sensory disturbance may occur adjacent to the upland seam pits, their adjoining rock dump sites, and sedimentation ponds. The greatest impacts will be to wildlife utilizing the dry ridge east of Far East Creek and the Far East Creek valley. The Far East Creek valley appears to be an important corridor for wildlife moving between upland and lowland habitats. Wildlife species such as elk likely move up and down this corridor throughout the summer, however, the corridor is likely most important in spring and autumn when elk, deer and moose move between wintering grounds. Coal extraction activities being conducted above Far East Creek will limit use of this corridor for wildlife.

6.9.3 Blockage of Wildlife Movement

Mine development will result in a disruption of wildlife movement across the site. However, the most important movement period and direction for wildlife, especially for the larger mammals such as elk, deer, moose and grizzly bear is in a north-south direction. As the pits and other mine activities are oriented in a north-south manner, disruption of wildlife movement corridors is not as significant as if the mine were oriented in an east-west direction. Based on field observations and an understanding of wildlife movement, the primary routes for wildlife movement on the property are the Willow Creek valley, the Far East Creek valley and the dry ridge on the east side of Willow Creek. These natural movement corridors will, for the most part, not be greatly disrupted by mine development. Some blockage of wildlife movement will likely occur along the west bank of the lower reaches of Far East Creek, where the proposed mine development goes close to the top of bank.

6.9.4 Habitat Fragmentation

Some habitat fragmentation is inevitable, however, given the sequence of mining and reclamation, most habitat fragmentation issues have been reduced. One exception is construction of a new west access road which would greatly fragment the large area of existing continuous forest. Development of new access roads in the Pine River floodplain and proposed rock dump site will result in some habitat fragmentation until the dump and road are reclaimed. Construction of this east-west ?barrier’ will separate undisturbed upland habitats from lowland habitats of the Pine River floodplain.

6.9.5 Project Related Wildlife Mortalities

Increased Road Traffic

Increased vehicular traffic on existing and new access roads will result in an increased potential for road kills of wildlife, ranging from songbirds and small mammals to larger mammals. As traffic will generally be travelling at low speeds, road kills of larger mammals such as deer, elk and bear are expected to be minimal. The most critical time of year for road kills is in winter when plowed roads create artificial movement corridors for wildlife such as moose.

Increased Hunter Presence

An increase in hunting pressure is not likely, given the proximity of the project area to local residences, roads, highway, railway, and Chetwynd. The area already has ready access. During construction and operation, there will be a no firearms policy in place for worker and public safety; the mine area will be designated a “*Closed*

Area" under Wildlife Act Regulation.

Destruction of Problem Animals

Scavenging animals such as grizzly bear, black bear and wolverine may be attracted to improperly handled human foods and wastes on the project area. This can be a particular problem with bears, which can become habituated to the presence of humans. Management measures will be in place to minimize this potential impact.

(1)Stripping and dumping will occur both at construction and during operation; both are discussed in Section 6.2.2.2.

(2)Strong winter winds periodically blow down valley from Pine River tributaries, including Willow Creek and these winds will likely be the most problematic.

(3)Based on data provided by Westcoast Energy for the Hasler gas plant for 1996; IEC Beak (1982) estimated an average annual velocity of 6.4 km/hr, or nearly the same velocity.

(4)To be Confirmed

(5)Use of trade names is for illustrative purposes and does not imply endorsement of a particular manufacturer's products, nor that those products will necessarily be used; equipment purchase or lease will be on a competitive bid process.

(6)Bitman, K.K. 1990. The Economics of Environmental Control: A Mining Perspective. Proc. 14th Ann. BC Mine Reclam. Symp.

7.0 MITIGATION AND ENVIRONMENTAL MANAGEMENT

7.1 CONCEPTUAL RECLAMATION PLAN

7.1.1 Introduction

The Pine Valley conceptual reclamation plan has the objective of minimizing the environmental impact of the mining operations and maintaining or improving the present productivity of the site. The reclamation plan presented here is conceptual in scope. It involves describing the landscape units, the site preparation activities, revegetation of the sites and the monitoring and research details needed to successfully complete the reclamation program. A time frame for each of these activities is suggested. All reclamation activities will be supervised by a qualified reclamation technician conversant with requirements for coal mine reclamation in the Northeast coal block.

7.1.2 Land and Resource Use

The present land use of the area is logging and wildlife habitat (described in Chapter 4). The resource use of the area is forestry, mining and with some very limited trapping.

7.1.3 Reclamation Objectives

The short-term reclamation objectives are to:

- progressively reclaim disturbed areas as soon as they are no longer actively used;
- prevent water erosion and sediment transport into waterways;
- stabilize slopes;
- restore drainage;
- cover ground to prevent soil drifting/dust;
- start to rejuvenate the soil and start soil-building processes; and
- create a green cover for aesthetic reasons.

Long-term objectives are to:

- maintain or improve wildlife habitat;
- maintain or improve the value of the forest for logging; and
- create an aesthetically pleasing environment.

7.1.4 Post-Mining Landscape Units

Figure 7.1-1 shows the conceptual final reclamation land units. They may change depending on the final mine plan, however the intent to stabilize the land and return it quickly to productive use will not change. Table 7.1-1 provides approximate dates when landscape units will become available for reclamation treatments. Soil stockpiles are not listed as these facilities will be reseeded as soon as stockpiling ceases. Dates must be viewed as conceptual and will depend on a number of factors including exact location of internal dumps, actual versus project mining schedules etc.

TABLE 7.1-1

CONCEPTUAL TIME SCHEDULE FOR DEACTIVATION OF MINE FACILITIES

Facility	Deactivation Year
North External Dumps	2002

Middle Dump	2011
7C Dump	2001
Pits 1 to 4 North(1),(2)	2006
Pit A North	2005
Peninsula Central Pit	2005
Pits 1 to 4 Central	2010
Pits 5 to 7 Central	2014
Pit 8 Central	2014
Plant Infrastructure and Site(3)	2014
Mine Access Roads	After no longer required
Pine River Floodplain Sedimentation Ponds	After 2014(4)
Pit 7 Central Pond	Not reclaimed; fish habitat enhancement project
Tailings Pond	2014
Clean water ditches	When diversion no longer required to protect water resources
Willow Creek Forestry Road	Depends on Ministry of Forests post mining requirements

(1) Pit deactivation includes internal (and in some cases external access) roads.

(2) Exact timing for various parts of pits will depend on internal dumping scheduling and may vary from that shown.

(3) Closure time depends on water quality meeting MOELP/DFO criteria.

(4) Some buildings may be required through the mine closure phase (typically 5 years) until final abandonment.

7.1.4.1 External Rock Dumps

There will be external rock dumps created in two areas of the mine from pit excavation activities. The major rock dumps are located at the north end of the mine site above the Pine River floodplain (Phase 1 and 2 dumps); the centre of the mine, in the “middle dump”; and the “7C external dump”.

The north dump site will be developed first, in Phases 1 and 2. After Phase 1 (about 2 years), no more material will be added to the north west and most northerly part of dump site. After Phase 2, or in an additional approximately 3 to 5 years, the north external dumps will be completed. The north dumps combined will be 35 ha in aerial extent when completed.

The center external dump sites will consist of a dump known as “middle dump” and a smaller dump west of Pit 7C. These sites are to be used in Phase 1 and 2 of the development of the center part of the site, from about 2005 to 2015. Some time after 2010, no more dumping into 7C dump will occur, and after about 2015, no more dumping into the middle dump will occur.

7.1.4.2 Pits

There are seven pits outlined in the mine plan. There are four pits in the north area, and three pits in the centre area of the mine site.

The pits will be backfilled with rock material to the extent possible. Where practical, reclaimed slopes will not exceed 27 degrees, except where highwalls are exposed.

The mine sequencing has been phased to exploit the opportunity for internal backfilling of pits and to minimize the area of disturbance for the project. Upon completion of an area of mining, the rock dumps will be resloped and the topsoil/subsoil will be spread on the reclaimed land.

North Area

The four pits in the north area are called:

- A seam (AN);
- 1-4 Pit (4N);
- North 5-6 seam pit (6N); and
- North 7-8 seam pit (8N).

Commencing after approximately 2002, parts of the North Pit could be available for backfilling. More area will be progressively available until about 2008 when mining in the North Pit will be completed. Backfill will be terraced to prevent long slopes which are more susceptible to runoff erosion (described in more detail below). Reference to Figure 7.1-1 indicates that over half of the North Pit will require resloping and all, except high walls (shown as closely spaced parallel lines on the figure) will be revegetated.

Water bodies shown in the North Pit area will be ephemeral and will only occur during storm events; at other times water will filter through the backfill to the floodplain. To the extent possible, natural drainage channels will be allowed to re-establish.

Central Area

The three pits in the centre area are called:

- Peninsula;
- Pit 1-4 Central (4C); and
- Pit 5-7 Central (7C).

In the Central Area, the Peninsula pit will be mined first and therefore available for backfilling prior to other parts of the Central Area. Parts of the central pit may be available for backfilling sometime after about 2005 and mining in the pit will likely be completed prior to 2010. No highwall areas will be left in the Peninsula Pit proper. As shown in Figure 7.1-1, approximately one-half the pit area will require resloping.

The Central Pit will be mined from approximately 2005 to 2019. Backfilling in this pit will be largely confined to the eastern part (Pit 4C) as the mine plan calls for creation of a pond in the west pit (Pit 7C). In the Central Pit, highwalls will be created on the southwest side of Pit 4C and on both east and west sides of Pit 7C. Nearly all of the 4C pit will be resloped and sedimentation ponds removed prior to abandonment.

A small pond will likely form on the south end of Pit 4C which may exfiltrate to Tributary 2, except under high rainfall. The north end of Pit 7C will be filled with rock to form a barrier to water flow at that end where the pit bottom would direct water northward without intervention. Rock fill will also be placed at the south end to create a shallow wetland area suitable for growth of emergent aquatic vegetation. The pit will be allowed to fill with water from the Tributary 1 catchment basin and the pond will discharge through the present Tributary 1 stream as shown in Figure 7.1-1. The pond is discussed further in Sections 7.3 and 7.4.

7.1.4.3 Sedimentation Ponds

Sedimentation ponds will be limited to the Central Pit and the Pine River floodplain with the possible requirement of one on the east shoulder of the ridge above Willow Creek (Figure 7.3-1). All ponds will need to be reclaimed after the mine is closed, except the large pond formed in the west central pit which can function both as a sedimentation pond until mine closure and a lake thereafter.

7.1.4.4 Roads

There are a number of roads presently existing on the site from forestry operation. Some of these will be improved and widened with the mine activity, e.g., the Willow Creek forestry road. In addition, more roads will be developed as shown on Figure 2.1-1. Roads will be progressively reclaimed as they are no longer required for pit access. The final reclaimed road configuration is shown conceptually on Figure 7.1-1, which indicates the Willow Creek Forestry Road left for fire access or forestry activities.

7.1.4.5 Plant Facilities

The area for the plant facilities is located at the north end of the mine, above the river plain. This is at the lowest elevation, at 630 to 675 m. The reclamation of the plant site will also be one of the last operations after the mine closes.

7.1.5 Site Preparation

7.1.5.1 Soil Stockpiling

There will be stockpiling of soil from all areas to be disturbed by the mine activities, except where stability would be adversely affected by soil removal and certain steep areas where soils are very thin or non-existent. Initially topsoil will be stockpiled at an exclusive site in each region, as shown on Figure 2.1-1. Upon completion of mining phases and concurrent with on-going reclamation, where possible soil will be directly placed to regraded areas to promote regeneration of native species and minimize top soil degradation. The amount of soil that is suitable for use as a topsoil is limited; details of the depth of topsoil were extrapolated from field investigation. The following general guidelines will be used:

- Use of both the organic and mineral layers will be considered. If too much organic material is present, the material may be more difficult to handle, but this is not expected as normally too little organic material is available for the soil to sustain a supply of nutrients to the vegetation, resulting in the need to re-fertilize. If the topsoil contains organic matter, applied nutrients may be recycled, and there is a ready pool of nutrients to be used in years after fertilizer has been applied.
- In some areas the subsoil will be stripped as well. The subsoil will enhance the topsoil, if the topsoil is very gravelly (>30%) and if the subsoil is sandy, silty and or loamy. If the subsoil is clayey, stripping of the subsoil will be done with caution as too much clay in soil makes the soil difficult to handle and clay will compact too easily when the topsoil is spread with heavy machinery. Experience at Quintette suggests that a subsoil-topsoil mix provides a better growth medium than topsoil alone (Quintette Coal staff, *pers. comm.*, 1997)

Approximate Depths Of Soil Salvage

The soil that can be salvaged varies from location to location and is also dependent on clay content (high clay content soil is difficult to handle). A target depth for stripping that has been set conceptually is 30 to 50 cm; actual depths will depend on site conditions encountered. Sufficient soil will be salvaged to meet reclamation objectives with depths varying from minimal in rocky areas to full depth where soil development is better. All soil in the north pit and dumps area will be salvaged for reclamation use. Initial storage of soil from the North Pit during the first two to three years of mine operation will be in the east end of the Phase 2 North Dump.

Table 2.2-4 provides an estimate of potential soil salvage in the mine area where soil stripping will be required. The total volume available, based on estimates of soil depths from the existing road cuts on the site, is 3.191 million cubic metres. Assuming a disturbance of 450 ha (4,500,000 m2) provides a potential soil depth over the entire disturbed area of 0.70 m. While all areas will not require or be amenable to covering with soil prior to reclamation, some areas will not have all top and subsoil removed because of impracticality of soil salvage (e.g. thin soils on outcrops) or exacerbation of erosion problems with soil removal (e.g. steep V gullies). Table 2.2-4 does, however, indicate that adequate soils are present on the site for reclamation purposes.

Maintaining Soil Stockpiles

The soil stockpiles will be subject to erosion. To minimize erosion slopes will be kept below the angle of repose and stockpiles will be covered with vegetation (over one season, winter ryegrass, over several, a reclamation mix).

When transporting soil from stockpiles for spreading, compaction will be avoided by spreading soil when dry wherever feasible and using a minimal amount of traffic when spreading. Surfaces will be scarified prior to seeding if compaction is a problem.

The conceptual plan is to initially use external stockpiles. Once pits have been developed sufficiently and space is available, soil will be directly stockpiled on backfilled areas where it will ultimately be used. The creation of stockpiles will allow for mixing of the soil material, as it is generally suggested to use soil from the organic horizon, the A horizon and the B horizon. Since soil will be necessary to reclaim the plant site, some topsoil stockpiles will be left for reclamation after mine closure.

7.1.5.2 Rock Dumps

The rock dumps are assumed to have a 37· slope prior to resloping (target final slopes are 27·). The reclamation plan for preparation of the rock dumps addresses three issues:

- Erosion control and slope stability;
- Sediment control; and
- Drainage.

Erosion Control And Slope Stability

The Pine Valley area has moderately high summer rainfall and winter snowfall, the latter especially at higher elevations. Water erosion could occur during the summer during major storm events especially if there is high antecedent moisture.

The following guidelines will be used wherever practical:

- Upon resloping, the toe of the dump will have a more gentle slope than that on top. This will retard soil movement, reduce sedimentation problems, and make a more stable configuration.
- To the extent practical, rock dumps will be configured so that there are terraces. The terraces will be constructed so that they slope in toward the hillside. This intercepts downward flowing water, and slows it down, redirects it or causes it to infiltrate. Benches prevent rill erosion from occurring unless water pools on upper benches then pours over the side.

Vegetation is the main means of controlling erosion and stabilizing slopes. Vegetation increases water infiltration, lessens raindrop impact and increases soil aggregate stability. It physically and chemically binds soil particles, making it very difficult for soil to wash away, and stabilizing the slope. Grasses and shrubs bind soil to 0.75 - 1.5 m. Trees can stabilize soil up to 3 m depth.

Vegetation requires at least 20% fines in order to establish. As well, grass seeds establish better on a rough, not smooth surface. Compaction will hinder the establishment of vegetation. Therefore, care will be taken to ensure the surface material applied to the rock dump is not overcompacted with excessive passes of machinery, or surfaces will be ripped prior to seeding where necessary.

- A grass cover will be established as soon as possible. This will be done in the first year after the rock dump has been completed or on a finished section of the rock dump. Grass will be given at least one growing season to establish, before planting trees and shrubs.
- The phase 1 and 2 rock dump lifts will be reclaimed as each lift becomes available.

7.1.5.3 Pit Preparation

The preparation of pits addresses five issues:

- backfill;
- erosion prevention;
- slope stability;
- vegetation establishment; and
- establishment of drainage.

Pit backfilling will be used to the extent practical as previously discussed. Erosion is a concern prior to establishment of vegetative cover. Terraces will be established on backfilled materials as for rock dumps. Vegetation will be established quickly once topsoil has been spread over the surface. The slopes will generally be stable. However, in order to ensure that the soil does not slide down the hill, or creep, the pit surfaces will be scarified if required before the topsoil is spread.

The successful establishment of vegetation requires a fertile growing medium, with organic matter mixed into the mineral soil. Therefore, dump surfaces and backfill will have as much topsoil as prescribed spread over the pit excavations and the compacted surfaces and will be scarified prior to application of seed.

Drainage will be established as for the rock dumps discussed in Section 7.3. It will be included in the early planning stages. The drainage trenches will be in place before establishment of vegetation to minimize disturbance to the site after seeding.

The general order of operations in preparing the backfill/dumps for reclamation is:

- Ensure over compaction of backfilled rock dump material on the final layer does not occur and rip after placement if necessary.
- Establish the drainage trenches on any benches that will be created.
- Scarify the surface, especially any compacted surface.
- Spread the topsoil, making sure the topsoil is mixed.

- Seed with the grass reclamation mix as soon as possible, but targeting spring and fall where possible to ensure better plant establishment, followed a year or two later with a herb, shrub and tree planting program.

7.1.5.4 Decommissioning of Roads, and Plant Site

This will be in the final phase of the reclamation program, except roads in pits which are no longer required. These latter will be reclaimed once no longer active. The general steps that will be followed are to:

- pull out the culverts;
- re-establish the surface drainage;
- scarify the surface and spread soil to prescribed depth on the surface;
- reslope if required using rock from pits as fill; and
- revegetate.

As well, slope stability issues will be addressed as required.

Reclamation of the plant site will involve tearing down and removing all the buildings, etc. The drainage of the site will be restored, if necessary. The ground surface will then be scarified. Soil will be spread on the compacted surface to prescribed depth. The soil surface will be prepared for seeding by harrowing, and then re-vegetation started by seeding the soil to reclamation grasses. This will be followed by planting trees and shrubs.

7.1.6 Re-vegetation

7.1.6.2Re-vegetation of Rock Dumps/Backfill

Topsoil will be spread on the backfill and dumps. The re-vegetation sequence in all areas will involve first establishing a grass cover, then after the grass has had a chance to establish, planting herbs, shrubs and trees. The vegetation mixture will, if practical, include native species. The availability of native species through nurseries will be investigated. The grass cover will be planted by broadcast seeding, either by hydroseeding, or by hand where necessary.

7.1.6.3 Selection of Vegetation

The selection of planting mixes depends on three factors:

- The goals of the site as set by the Ministry of Environment: which wildlife species are to be enhanced, etc.
- The natural successional mix, as determined by the field study, and what is suitable for that elevation and environmental conditions
- What species are available and how if it is possible to propagate them for replanting onto the site

To a degree, the need to establish an erosion-resistant cover rapidly militates against later establishment of trees and shrubs. Where practical use will be made of less competitive herbaceous vegetation to enhance later tree and shrub establishment.

There are less expensive commercial reclamation mixes that may be best to use in establishing a grass cover. The reclamation mix is best to include bunch grasses and fescues for the rock dumps.

At least two and possibly three different vegetation mixes are expected to be required. One will be for the north rock dump and pit backfill area, one will be for the central area (dumps and backfill), and one may be for the plant site area. In addition, an intermediate mix may be developed for the south end of the north site. The detailed reclamation plan (*Mines Act*, Section 10 requirement) will include lists of species to be grown on the various sites.

7.1.7 Monitoring and Research

A monitoring and research plan will be included in the detailed reclamation plan. Monitoring and research will have, as primary objectives the following:

- confirmation of methods and vegetation mixes to be used to ensure effective reclamation; and
- the need for and depth of soil required to establish and promote plant growth in reclaimed areas.

Answers learned in the first reclaimed site in each area will be used to more efficiency revegetate that area of the mine. Other areas that will be monitored will be the success of the drainage patterns, erosion and slope stability.

7.2 CONCEPTUAL WASTE MANAGEMENT PLAN

7.2.1 Construction Phase

Clearing limits for the overall project are shown on Figure 2.1-1. A minimal approach has been employed to reduce windfall after local and final reclamation. Clearing and grubbing will occur on an as required basis through the development schedule approach. Grubbed material will report with the topsoil, to promote volunteers, and synergistically provide organic material to improve top soil chemistry.

The plant site will be logged, stumps grubbed and soil during the plant site preparation phase of development. A total of approximately 20.8 ha (plus 3.8 ha for the tailings pond) will be cleared and salvaged. Salvaged soil will be used to construct a berm along the west side of the plant site as shown in Figure 2.3-1. The purpose of the berm will be flood control. The berm will be vegetated after placement of soil to retard erosion and control dust.

Control of sedimentation to surface water bodies arising from surface disturbance will be a key focus of waste management during the construction phase and throughout mine life when fresh disturbance occurs. Standard, accepted construction practices will be used whenever fresh disturbance occurs in previously vegetated areas upslope from surface water bodies. Measures such as silt fences and leave strips (where feasible) will be employed. Avoidance of construction work in soils upslope from surface water bodies during heavy rain storms will also be used wherever practical.

7.2.2 Operations Phase

7.2.2.1 Overburden and Rock

The total amount of overburden and rock projected for the two pit areas (north and central) is 58,810,000 bank cubic metres (bcm). In order to exploit coal reserves initially in the north pit, the Phase 1 external dump will be developed as shown in Figure 2.1-1. To initially develop the peninsula pit, an external dump west of pit 7C will be constructed as shown on Figure 2.1-1. As well, for development of the central pits, an external dump in the Middle Creek drainage will be initially required. As discussed in Section 2.2, development of pits has been phased to maximize the potential for internal backfilling of waste material.

The rationale for selection of external and internal dumps was discussed in Section 2.2. As discussed further in Section 7.1, once dumps are no longer active, they will be reclaimed so as to minimize erosion and soil loss. The amount of rock generated by mining phase is discussed further in Section 2 reference to Table 2.2-3 and Figure 2.1-1 provides information on the location and amount of rock and overburden dumped or stockpiled during each mining phase.

Table 7.2-1 provides a summary of rock to be dumped by year and location. The rock dumping schedule is conceptual at this time and subject to modification as mine planning is finalized and as mine development proceeds.

TABLE 7.2-1

VOLUMES OF ROCK BY YEAR AND DUMP LOCATION

	YEAR	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**TOTALS**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	
PIT 1-4	**PHASE 1 WASTE**	397,387	1,342,779	732,752														2,472,918

NORTH	**PHASE 2 WASTE**			446,023	1,187,500	1,023,086	717,228											3,373,837
	PHASE 3 WASTE					699,416	639,772	2,208,229	153,086									3,700,503
	TOTAL WASTE REMOVED	397,387	1,342,779	1,178,775	1,187,500	1,722,502	1,357,000	2,208,229	153,086									9,547,258
A PIT	**PHASE 1 WASTE**	428,289	1,665,559	1,602,486	1,318,101													5,014,435
NORTH	**PHASE 2 WASTE**				736,632	1,720,614	1,599,600	53,086										4,109,932
	TOTAL WASTE REMOVED	428,289	1,665,559	1,602,486	2,054,733	1,720,614	1,599,600	53,086										9,124,367
PIT 5-6	**TOTAL WASTE REMOVED**														1,165,963			1,165,963
NORTH																		
PIT 7-8	**TOTAL WASTE REMOVED**															884,896		884,896
NORTH																		
ALL NORTH	**TOTAL WASTE REMOVED**	825,675	3,008,338	2,781,261	3,242,233	3,443,116	2,956,600	2,261,315	153,086						1,165,963	884,896		20,722,483
PITS	**NORTH EXTERNAL DUMPS**	825,675	3,008,338	2,781,261	1,872,078													8,487,352
	NORTH INTERNAL DUMPS				1,370,155	3,443,116	2,956,600	2,261,315	153,086						1,165,963	884,896		12,235,131
PENINSULA	**8 SEAM WASTE**																582,053	582,053
CENTRAL	**7 SEAM WASTE**		267,552	1,066,496	654,437	721,086	265,792	265,791										3,241,154

	TOTAL WASTE REMOVED		267,552	1,066,496	654,437	721,086	265,792	265,791									582,053	3,823,207
PIT 1-4	**PHASE 1 & 2 WASTE**						639,938	963,268	2,320,086	2,475,086	2,593,086	459,272						9,450,736
CENTRAL	**PHASE 3 WASTE**											2,192,086	2,993,344	327,086				5,512,516
	TOTAL WASTE REMOVED						639,938	963,268	2,320,086	2,475,086	2,593,086	2,651,358	2,993,344	327,086				14,963,252
PIT 5-7	**UPPER BENCH WASTE**						453,086	312,086	1,689,505	1,763,870	1,511,141	751,086						6,480,774
CENTRAL	**LOWER PIT WASTE**											912,792	1,496,245	4,185,926	3,397,568	2,776,076	52,086	12,820,693
	TOTAL WASTE REMOVED						453,086	312,086	1,689,505	1,763,870	1,511,141	1,663,878	1,496,245	4,185,926	3,397,568	2,776,076	52,086	19,301,467
ALL CENTRAL	**TOTAL WASTE REMOVED**		267,552	1,066,496	654,437	721,086	1,358,816	1,541,145	4,009,591	4,238,956	4,104,227	4,315,236	4,489,589	4,513,012	3,397,568	2,776,076	634,139	38,087,926
PITS	**CENTRAL EXTERNAL DUMPS**		267,552	732,448			639,938	963,268	2,320,086	2,475,086	722,500	912,792	1,496,245	3,870,085				14,400,000
	CENTRAL INTERNAL DUMPS		0	334,048	654,437	721,086	718,878	577,877	1,689,505	1,763,870	3,381,727	3,402,444	2,993,344	642,927	3,397,568	2,776,076	634,139	23,687,926
TOTAL	**TOTAL WASTE REMOVED**	**825,675**	**3,275,890**	**3,847,757**	**3,896,670**	**4,164,202**	**4,315,416**	**3,802,460**	**4,162,677**	**4,238,956**	**4,104,227**	**4,315,236**	**4,489,589**	**4,513,012**	**4,563,531**	**3,660,972**	**634,139**	**58,810,409**
	TOTAL EXTERNAL DUMPS	**825,675**	**3,275,890**	**3,513,709**	**1,872,078**	**0**	**639,938**	**963,268**	**2,320,086**	**2,475,086**	**722,500**	**912,792**	**1,496,245**	**3,870,085**	**0**	**0**	**0**	**22,887,352**
	TOTAL INTERNAL DUMPS	**0**	**0**	**334,048**	**2,024,592**	**4,164,202**	**3,675,478**	**2,839,192**	**1,842,591**	**1,763,870**	**3,381,727**	**3,402,444**	**2,993,344**	**642,927**	**4,563,531**	**3,660,972**	**634,139**	**35,923,057**

Dumps have been designed from preliminary geotechnical investigations (Piteau 1996). Prior to construction of dumps, additional geotechnical investigations will be carried out to confirm dump configurations. Coarse rock will be placed at the toe of dumps where required to ensure adequate drainage (discussed further in Section 7.3).

As discussed in Section 4.15, rock will not be acid generating, and therefore no special handling will be required to address this issue. Runoff from dumps will be directed to sediment ponds as appropriate and discussed in Section 2.2 and 7.3. Water from sediment ponds will be monitored prior to release for contaminants of concern; sediment, nutrients are expected to be low as discussed in Section 6.4. Based on the experience of other northeast coal mines, metals should be near background concentrations.

7.2.2.2 Tailings

There will be no uncontrolled discharge of effluents from within the washery, every fluid will be contained, collected and treated as appropriate for recovery and re-use. Normal methods of capture/treatment will be utilized for the primary washery effluents, comprised of thickener tailings, wash-down fluids, materials produced during regular plant operations, and occasional spillage related plant clean-ups.

Slurry disposal will be to a tailings pond east of the plant (Figure 7.3-1). Tailings will be pumped via two lines. A third line will recycle recovered water from the tailings pond. Water will be recovered after the fine coal refuse material has settled out and recycled to the washery for re-use. Wash-down water will be taken from the washery clarified water circuit and distributed throughout the plant. Plant personnel will use the water via flexible hoses, to washdown the plant both at regular intervals and to clean-up unanticipated plant spillages.

The tailings pond will be designed to hold two years' storage of tailings at the 900,000 tpa production rate. The tailings pond will be built in two sections for tailings storage and a supernatant pond. The impoundment area will be approximately 3.8 ha and have a contained volume of 146,000 m3. The supernatant pond will hold 20,000 m3 of water. The pond design will be similar to the large sediment ponds discussed in Section 7.3.

Reference to Drawing 1942-SC-01 indicates feed rate of tailings from the plant to the pond will be 39 tonnes per hour of -1.0 mm sized material; moisture content will be approximately 50 %. Approximately 45 m3/hr water will be pumped back to the plant from the tailings pond. Tailings will be non-acid generating as the feedstock to the mill is non-acid generating.

The tailings embankments will be constructed from pit rock and till scraped from the floodplain area where the pond will be created. The embankments will be constructed of compacted till and will initially allow some seepage of water. Once tailings slimes plug the interstices in the embankments, permeabilities will drop and less water will exfiltrate. The water that exfiltrates will be essentially free of chemicals except possible small amounts of nitrogen compounds from blasting residuals which cannot be estimated prior to plant operation (see Section 6.5) and flocculant residues, if flocculants are used. Water will exfiltrate through floodplain vegetation and into the ground. Since the water table is very near the surface in the proposed tailings pond area, water will likely reach the wetland downslope in a relatively short time. Any nitrogen compound residuals in this exfiltrated water will be absorbed by organic sediment and plants in the wetland based on the well-known capacity of wetlands to absorb nitrogen compounds (Norecol Environmental Consultants 1992; Kadlec and Knight 1996).

Final tailings pond location will be dependent on detailed geotechnical investigations, including drilling or test pitting.

7.2.2.3 Coarse Plant Rejects

The coarse reject disposal site will be a dump or waste backfilling location which is within the catchment area of a sedimentation pond. The most likely refuse disposal site will be on the east side of the Phase 1 dump (Figure 2.3-1) so as to be contained within the area where runoff reports to the water treatment system in the floodplain. The current concept is to blend this coarse reject material with other rock. Coarse rejects will be trucked to site and spread with a dozer.

7.2.2.4 Domestic Sewage

The system was designed to meet the maximum expected sanitary and grey water volumes developed by the project. System design includes 3 septic tanks, associated piping, and a drain field for sanitary and grey water use for all facilities except the washbay. Washbay effluent will be stored in two 10K gallon tanks, and will require pumping and disposal, on an on-going basis. This option was chosen to prevent nitrates from the washbay soap and hydrocarbons from equipment and component washing, from entering the groundwater. It is recognized that the site is on the flood plain of the Pine River and this was a primary consideration in system design.

7.2.2.5 Refuse Management

All non-process refuse, e.g. lunchroom wastes, packing materials, non-hazardous waste containers, will be temporarily stored in dumpsters and removed from the site by a contractor.

Used, but serviceable materials and equipment will be stored in a designated area (as yet to be chosen) which is typically called a “bone yard”. This yard area will not be used for storage of hazardous materials or wastes (as defined under the *Transportation of Dangerous Goods Regulations* or the *Special Waste Regulation*). The yard will be kept orderly and all large materials with a possible reuse value will be stored in this one location.

7.2.3 Closure Phase

All rock dumps, pits and roads will be progressively reclaimed as they are no longer active. Subsoil will be placed on rock and top dressed with topsoil where possible as discussed under reclamation. External dumps will be monitored throughout their construction for stability and throughout the closure phase of mine. The tailings pond will be reclaimed by backfilling the pond, regrading berms (if necessary) and seeding all unvegetated surfaces as discussed in Section 7.1.

7.3 CONCEPTUAL WATER MANAGEMENT PLAN

The Water Management plan was developed by Piteau Associates in conjunction with Norwest Mine Services.

7.3.1 Site Description and Drainage

The terrain in the Project area consists of four deeply incised drainage channels which drain northwest into the Pine Valley. The westernmost and largest of the four drainages is Willow Creek. The other three drainages include, from west to east, a small unnamed creek, Middle Creek and for East Creek. The area to the southeast of these catchments is drained by two small tributaries to Willow Creek, which flow in a southwesterly direction (Figure 2.1-1).

Soils that underlie the area range from a veneer/blanket of silty sand colluvial and/or morainal soils on the slopes and upland areas, to silty sand fluvial sediments on the Pine River floodplain. Coarse channel deposits and bedrock outcrops are present along the creek bottoms and margins. Bedrock outcrops are expected on the ridge tops. Bedrock consists of interbedded sandstone, siltstone, claystone, shale, mudstone and coal.

Surface slopes in the proposed mine area range from less than 3% (<2º) on the Pine River floodplain, to 15 to 60% (8.5 to 30º) on the valley slopes. The average slope for the valley walls is about 25% (14º). Gradients along the small drainage courses range from about 10 to 30% (6 to 17º), and average about 15% (8.5º). Concentration times for storm runoff are expected to be very short for this steep terrain. Based on an empirical formula to estimate concentration times (Kirpich, 1940), the time of concentration for the lower half of the Middle Creek drainage basin is approximately one-half hour. Short duration, high intensity storms will therefore generate the highest runoff flows from this site.

7.3.2 Sediment and Water Control During Construction

Major construction activities will include:

- pre-stripping of the North Pit, Phase 1 Dump;
- clearing and overburden removal and stockpiling for floodplain sediment and tailings ponds;
- upgrading of the forestry road and construction of Phase 1 mine roads; and
- clearing of the plant site and construction of the plant.

The rail spur beside the plant area will also be constructed but little additional disturbance is expected as the spur will be within the existing rail right-of-way except at the plant site.

Major clearing is projected for early winter of 1998 (February-March) when the ground will be frozen, precipitation is in the form of snow and not rainfall, and small tributary streams are frozen. Standard clearing practices will be used. Clearing boundaries will be marked with high visibility ribbon or paint as appropriate. Where required to protect water bodies, clean water ditches, silt fences and temporary sedimentation ponds will be constructed. In-stream work will not be carried out in fish bearing streams without prior consultation with MOELP, Fish and Wildlife Branch and authorization to proceed.

Overburden and subsoil will be salvaged, stockpiled in designated areas and surfaces stabilized as quickly as practical. Interim control measures, such as polythene sheeting may be used if erosion is problematic prior to surface stabilization.

7.3.3 Sedimentation and Diversion Requirements

The mine is to be developed as a series of pits in the North and Central Areas of the deposit. These pits will be progressively mined in over the period between the start of mining and about the year 2015. A series of sedimentation ponds will be required to treat runoff waters from the different pit areas over the various stages of mine development. The conceptual water management plan has been based on six distinct drainage areas, as shown on Figure 7.3-1.

Two large sedimentation ponds and up to eight small ponds are proposed to service the mine at various stages of pit development. The plant site will be serviced by three small sedimentation/exfiltration ponds located within the plant site area. A single large pond located on the floodplain at the north end of the site will service the North Area. A second large pond constructed in the backfilled Phase 2 North Pit will service the Central Pit areas, in conjunction with up to five other small sedimentation ponds. The locations of the various sedimentation ponds included in the conceptual water management plan are shown on Figure 7.3-1.

A number of diversion ditches are required to divert natural drainage channels or large catchment areas around the active pit and dump areas. Most of these diversions will be quite small, such as those required on the southeast side of the North Area and Central Area pits (Figure 7.3-1). However, a major diversion will be required to divert flows in Middle Creek and an unnamed creek around the North Pits and North Pit dump areas. The proposed location for this diversion is shown on Figure 7.3-1.

7.3.4 Sedimentation Pond Phasing and Sizing

7.3.4.1 Conceptual Phasing and Design Criteria

The principal objective of the sedimentation facilities is to reduce, to an acceptable standard, the concentration of suspended solids contained in runoff from the plant site, open pits, waste dumps and undisturbed or reclaimed areas that are located within the sediment pond catchments. Runoff from natural areas above the main haulroad would be diverted into natural drainage courses above the road, and passed under the road in culverts, wherever possible. Runoff from the road surface, and runoff from those areas which could not be diverted above the haulroad, would be collected in a ditch constructed along the inside edge of the road, and conveyed under the road in culverts placed at regular intervals.

The initial phase of mine development would be serviced by the Upper and Lower Plant Site sedimentation/exfiltration ponds, the North Pit Area sedimentation pond and the Phase 1B pit area sedimentation ponds (Peninsula Pit Area). A small sedimentation pond may also be required for the external Phase 1B waste dump, which is included as an option to overland flow treatment of waste dump runoff (i.e. allowing runoff to flow over native ground below perimeter of waste dump). Flow into the sedimentation ponds will initially consist of six components:

i) Groundwater and surface water runoff from the open pits, in-pit dumps and haulroads located at the north end of the site, and in the Peninsula Pit area;

ii) Runoff from the initial rock dumps, to be located on the margins of the Pine River floodplain, and on high ground in the West Central Pit area;

iii) Runoff from undisturbed areas upstream of the open pits, which cannot be diverted around the pit or dump areas; and

iv) Runoff from the plant site area.

As the pit areas are reclaimed, surface runoff can be directed back into natural drainage courses, freeing up available sedimentation capacity for later phases of mining. For the purpose of this preliminary design, the mine development has been divided into five drainage phases, plus the plant site area that will require sedimentation for the life of the mine. The approximate extents of the drainage area included in each phase are shown on Figure 7.3-1, and a Gant chart showing the approximate schedule for each phase is presented as Figure 7.3-2.

The schedule presented on Figure 7.3-2 indicates that a second large sedimentation pond will be required when the first phase of the Central Area is developed (Phase 2 Drainage). The Phase 2 Drainage sedimentation pond will be sited in a backfilled portion of the North Pit, and should only involve the construction of conveyance channels to and from the pit. After this pond is constructed, all future phases of mining in the North and Central Areas could be serviced with existing sedimentation ponds. However, some additional small ponds are included in the conceptual water management plan, to service the south end of the 1 to 4 Seam Central Pit (Phase 3 Drainage) and the 8C Seam Pit (Phase 4B Drainage).

Storm flows will be pumped from pit sumps in the southern portion of the Central Area (Phase 3 and Phase 4 drainage areas; see Figure 7.3-1), but runoff flows in most other areas will be conveyed to sedimentation ponds by gravity. All conveyance channels to and from the sedimentation facilities, and all diversion channels, must therefore be designed to pass runoff from a 1:200 year storm. The flow of water through a sedimentation pond must be retained for a sufficient time to allow suspended sediments to settle and be retained in the pond. The quality of water which decants from the pond must meet discharge criteria which are set on the basis of the 1:10 year precipitation event of 24-hour duration. Based on Province of British Columbia Ministry of Environment, Lands and Parks regulations, the upper limit for suspended sediments in water discharged from the pond will likely be between 25 to 75 mg/L above background levels.

The method used to estimate the flow of water to the sedimentation pond, and to size the ponds, is presented below.

7.3.4.2 Preliminary Estimate of Pond Inflows

Inflows to the sedimentation pond were estimated using precipitation data extracted from the “Rainfall Frequency Atlas for Canada” (Hogg and Carr, 1985). Design storms included the one, six, twelve and twenty-four hour duration storms of 1:10 year frequency, and the 1:200 year one-hour storm. A one-hour intensity storm is expected to generate the peak flow condition, as the time of concentration for the small drainage basins is expected to be less than one hour. A spring storm or snow pack event was not considered, as it is expected to generate less peaky runoff than an intense rain storm.

Surface water runoff rates during the 1:10 year and 1:200 year storm events were estimated using the Rational Method. Each catchment area was divided into the five different types of ground surface with expected similar runoff characteristics. The five ground surface types and estimated runoff coefficients were as follows:

Pit slopes, pit bae and haul roads0.9

Waste dumps and coarse reject0.5

Reclaimed pit areas 0.5

Natural ground 0.65

Native alluvial areas (plant site)0.4

Runoff coefficients for each of the categories were estimated from a US Soil Conservation Service chart of watershed characteristics (Van der Leeden et al, 1990).

Pond inflows for 1:10 year ten-hour storms and 1:200 year one-hour storms were estimated for each of the drainage phases/areas shown on Figure 7.3-1. These calculations are summarized on Tables B-1 to B-16 in Appendix 7.3-1. An overall summary of the calculated flows is presented on Table 7.3-1. It should be noted that the flow estimates are considered preliminary only, and are intended to determine approximate area requirements for the sedimentation facilities. Information from the ongoing hydrological studies should be used to determine actual flows for final design.

TABLE 7.3-1

SUMMARY OF PRELIMINARY SEDIMENTATION

REQUIREMENTS AND DITCH CAPACITIES

	AREA	1:10 YEAR DESIGN FLOW1		PEAK FLOW1	DITCH	DITCH CROSS-SECTION		FLOW REPORTS TO	POND	SEDIMENTATION
		Avg. Flow During 12 Hour Storm	10 Hour Retention	1:200 Year, 1 Hour Duration	GRADE	INVERT WIDTH	HEIGHT		CAPACITY	PERIOD
	ha	m3/s	m3	m3/s	%	(m)	(m)		m3	
UPPER PLANT SITE	66	0.12	4,250	1.1	8.0	0.8	0.65	Upper Plant Site Ponds	4,500	LIFE OF MINE
LOWER PLANT SITE	10	0.05	2,000	0.5				Lower Plant Site Pond	2,000	LIFE OF MINE
PHASE 1A	148	1.1	39,800	10.5				Phase 1A Pond	45,000	1998 - 2015
PHASE 1B - PIT	24	0.2	6,700	1.8	N/A			Phase 1B In-Pit Pond	7,000	1998 - 2015
PHASE 1B - DUMP	13	0.07	2,600	0.7				Phase 1B Dump Pond	2,500	1998 - 2008
PHASE 2	103	0.75	27,500	7.3				Phase 2 Pond	40,000	2008 - 2013
PHASE 3	62	0.5	7800 2	4.9 3	N/A			Phase 3 (& Phase 2 Pond)	7,800	2010 - 2013

PHASE 4A	49	0.4	6200 2	3.9 3	N/A	Phase 2 Pond	40,000	2012 - 2016
PHASE 4B	6.4	0.06	2,300	0.6		Phase 4B In-Pit Pond	2,300	2012 - 2016
PHASE 5	27	0.26	9,630	2.6		Phase 2 Pond	40,000	2014 - 2016

NOTES: 1) Flows and quantities from tables in Appendix B.

2) Assumes flows accumulate in pit sump and are pumped to sedimentation pond.

3) Peak flows would report to pit sump, but would be pumped to sedimentation ponds at a much lower rate.

7.3.4.3 Pond Sizing

Sedimentation ponds should be sized to provide a sufficient detention time for a 15 micron particle to settle to the bottom of the pond, or beneath a 2 m depth. The time required for a 15 micron particle to settle a distance of 2 m can be calculated using Stoke's law of settling:

$V_s = g\ (SG-1)D2$

$18u$

Where: V_s= settling velocity (cm/s)

g = acceleration of gravity (981 cm/s2)

SG= specific gravity of particle (2.67)

D = diameter of particle (0.0015 cm)

u= kinematic viscosity of water at 0·C (1.8 x 102 cm2/s)

V_s = 0.0114 cm/s

The time required for a 15 micron particle to settle 2 m would be approximately:

Time = 2 m/0.0114 cm/s

= 4.9 hours

The pond must therefore provide a minimum five hours average retention time to allow 15 micron particles to settle out of the storm flow prior to discharge. A ten-hour retention time, twice the calculated minimum, is generally used as the basis for sizing a sedimentation pond, to provide a factor of safety and to allow for non-uniform flow paths, and various mechanisms that could affect settling time (e.g. wave action, varying mineralogy of fines, etc.).

Clay particles would take much longer than ten hours to settle from storm runoff. In practice, clay is sedimented by adding flocculants on an as-required basis, as building adequate retention for clay sedimentation is not practical.

Flow through the lower 1 m of a 2 m deep sedimentation pond does occur, but is not as rapid as flow through the top 1 m. Pond sizing is therefore based on the assumption that flow only occurs in the top 1 m; hence, there is an additional factor of safety built into the retention time calculation if the pond is at least 2 m deep and is properly maintained (i.e. a portion of the 1 m sediment storage zone is generally available for hydraulic flow).

Based on the estimated storm inflows, the Upper Plant Site, Phase 1A (North Pit) and Phase 2 sedimentation ponds must provide 4,500 m3, 40,000 m3 and 40,500 m3 of water storage, respectively. An optimum length to width ratio of 5:1 (square ponds will result in significant stagnant areas and possible “short circuiting” across the centre) was assumed when laying out the ponds shown on Figs. 7.3-1, 7.3-3 and 7.3-4.

The quantity of sediment that will accumulate during a 1:10 year storm is estimated to be equivalent to a sediment load of about 5 gm/L in the influent flow. Based on an average suspended sediment concentration of 5 gm/L, the quantities of sediment that are expected to accumulate in the Upper Plant Site, Phase 1A (North Pit) and Phase 2 ponds during a 24-hour, 1:10 year event are on the order of 22 tonnes, 200 tonnes and 200 tonnes, respectively.

7.3.5 Sedimentation Pond and Ditch Design

As noted above, the proposed locations for the required sedimentation pond facilities are shown on Figure 7.3-1. The proposed site for the Phase 1A pond will be investigated to determine foundation conditions, and the suitability of native sediments for construction of earth embankments. It may be possible to construct the embankments from selected mine wastes, if they are properly placed and compacted. A preliminary design section for the Phase 1A sedimentation pond, which assumes construction with mine waste rock, is presented in Figure 7.3-5.

The Lower and Upper Plant Site sedimentation/exfiltration ponds would be excavated in alluvial soils, and would be designed to promote exfiltration. A decant would be provided for extreme events. Exfiltration capacity would be preserved by periodic cleaning and scarification of the base. The Phase 1B Waste Dump Sedimentation Pond and Phase 3 Sedimentation Ponds (if required) would be small cut and fill structures. Designs for these structures would be developed following site investigations, but it is anticipated that they would be constructed from native materials, with 2H:1V slopes. In-pit sedimentation ponds in the Peninsula Pit would be created by berming off low areas within the pit (Figure 7.3-3), and constructing sumps on an as-required basis to relay flows to these ponds.

The Phase 1A in-pit sedimentation pond would be created by the waste backfilled into the Phase 2 North Pit (Figure 7.3-4). This facility would likely drain through the waste rock most of the time, with complete filling and surface decant occurring only during very intense storm events. As part of detailed design, the effect of a high phreatic surface on the stability of the waste dump would have to be addressed. A rip rap buttress created with select waste placed at the toe of the dump may be required to maintain stability of the waste dump, and to prevent seepage erosion at the toe.

Preliminary design flows for the haulroad culverts (assuming 50 m maximum culvert spacing) and the Middle Creek diversion were calculated using the procedure discussed in Section 7.3.4.2. These flows are provided on Figs. 7.3-1 and 7.3-6. Preliminary design flows for the conveyance ditches to the sedimentation ponds are summarized on Table IV. All ditches excavated in soil (either in cut or fill) would have 2:1 sideslopes and riprap armouring as necessary where slopes exceed 2%. Ditches cut into rock would not require any rip rap protection, and ditch slopes would be cut to the maximum stable angle. Ditches placed on fill would require lining to prevent leakage, and rip rap armouring to prevent erosion of the fill. The preliminary design for the main haulroad ditch is shown on Figure 7.3-6.

7.3.6 Wash Plant Water Balance

The wash plant water balance is listed on DWG 1942-SC-01, previously referenced in the project description section (Section 2.0). Wash water requirements (made up from tailings pond return and fresh water as detailed below) will be as follows:

Product	**Water Use**	**Product**	**Water Use**
Thermal coal	5.0 m3/hour	Coking coal	12.4 m3/hour
Thermal refuse	16.8 m3/hour	Coking refuse	34.2 m3/hour
Total required	21.8 m3/hour	Total required	46.6 m3/hour
From tailings pond	10.4 m3/hour	From tailings pond	10.4 m3/hour
Make up	11.4 m3/hour	Make up	36.2 m3/hour

The foregoing indicates that there will always be a water deficit for the tailings pond and that all the water available can be used for plant make up. Given these circumstances, water will not need to be discharged from the tailings pond, except under extreme storm conditions.

7.4 FISHERIES

7.4.1 Mitigation

General

The primary impact avoidance and mitigation measures to minimize adverse effects to the local aquatic environment include:

- conduct any initial instream work during the period of minimum risk to fish - mid-summer - to avoid impacts to sensitive egg and alevin stages of fish (both spring and fall spawners) in the system;
- use of proper stream crossing structures and associated fill areas to minimize sediment loads to streams. This will require the use of flume, dam-and-pump and/or stream diversions in order to divert sediment-laden water away from fish-bearing watercourses. All sediment laden water in the excavation, fill and construction areas would be pumped to a sump for exfiltration to groundwater and/or to well vegetated upland at least 100 m from any creek to allow for sediment loads to settle out in the terrestrial areas before the water reaches a stream;
- use of silt fencing between any disturbance areas and streams downslope of the disturbance areas. Silt fencing, erected on 2x2" stakes, will be used wherever sediment transport to watercourses is possible; and
- use of perimeter ditches between disturbance sites and natural watercourses to catch and contain runoff. The runoff will be directed to the sump system, pumped to vegetated upland, or sent to sedimentation ponds.

Operation Phase

The key measures to be implemented to avoid, or mitigate, these potential effects on fish habitat and stocks in the local creeks and Pine River include the following:

- establishment of an ongoing in situ water quality monitoring program that will detect on the quality of the water leaving the project area in each of the streams affected. Water quality monitoring is discussed further in Section 18;
- biological monitoring as required will be conducted on a schedule, to be developed in consultation with MOELP; and
- proper decommissioning, reclamation and abandonment of each affected/disturbed area as it is decommissioned. Grading and/or revegetation of abandoned roads, dump areas and, the backfilled pits, will be completed to restore the disturbed areas to productive upland.

Abandonment and Closure

Pine Valley Coal will complete the following tasks in the process of project decommissioning and abandonment of the Willow Creek Project:

- regrade and revegetate all disturbed areas not previously treated (see reclamation plan, Section 7.1), except any to be left by authority of the regulatory agencies (e.g. some roads); and
- allow Central Pit 7C to fill with water. Once the water quality is suitable for local fish species, a fish transfer from the Pine River system to the lake in the former pit would be conducted, if approved by the regulatory agencies. The pit may provide good fish habitat after mine abandonment, as it will be deep enough for overwintering.

7.4.2 Compensation

If required by DFO and/or MOELP, Pine Valley Coal would offset any potentially unavoidable and unmitigable adverse impacts of the proposed mining project with acceptable measures to create, or enhance, fish habitat in the general project area, such as the central pit pond discussed previously, increasing access for fish to upper areas of Willow Creek, or other suitable measures.

The final habitat compensation plan, if one is required, would meet the approvals of both DFO and MOELP, and be implemented under the direction of a fisheries biologist with experience in habitat creation and compensation.

7.5 WILDLIFE HABITAT PROTECTION PLAN

A wildlife management plan will be developed to ensure that environmentally sensitive habitats and key wildlife are adequately protected. The main elements that could be included are discussed in the following subsections.

7.5.1 Reduction Of Habitat Alteration

- only those areas specifically designated for mine development will be clearcut logged. Proposed undisturbed areas will be flagged to avoid unnecessary disturbance to these areas;
- soil will be stockpiled where practical for future reclamation activities;
- land clearing where feasible will not be undertaken during the critical nesting period between May 15 through July 31 to avoid possible contravention of the B.C. Wildlife Act; Section 35 of the Act protects all

birds and their nests during the breeding season.

7.5.2 Improve Habitat Effectiveness

New Pine River Floodplain Access Roads and Upgraded Willow Creek Forestry Road

· natural drainage patterns and water quality of wetlands will be retained. Adequately sized culverts, sedimentation control structures, and stabilization of road edges by planting shrub vegetation will be employed where required.

Plant Site

- open areas of plant site will be seeded where necessary. Trees and shrubs will be planted along new roads, berms and other structures to create vegetated buffers to adjacent natural habitats
- surface run-off will be controlled to avoid sedimentation of nearby Willow Creek

Pine River Floodplain Tailings Pond

· berms, pond edges will be planted with shrub species to create habitats and provide vegetated buffers to adjacent habitats

7.5.3 Minimize Blockage Of Wildlife Movement

· road width will be minimized wherever possible consistent with safety and economic considerations.

7.5.4 Decrease Habitat Fragmentation

· continuous bands of natural vegetation will be maintained when possible

7.5.5 Reduce Project Related Wildlife Mortalities

Road Traffic

· coal haul truck speeds will be a maximum of 50 km; mining and service vehicle speeds will be set at suitable speeds and monitored. Road speeds will be clearly posted.

Hunter Pressure

- possession of firearms, except for worker safety, will be prohibited on the property;
- the mine area will be established as a “no hunting/no shooting” zone by regulation under the *Wildlife Act*;
- use of the Willow Creek forestry road will eliminate access by the public into areas behind the mine; access will be limited to industrial use only.

Problem Animals

- To minimize attracting potential problem animals such as bears, food wastes will be stored in bear-proof containers and regularly hauled to a regional disposal facility; and
- Feeding of wildlife will be discouraged.

7.6 NOISE

An increase in ambient noise levels will result from operation of the mine and plant. Noise will be mitigated to the extent possible by project design. As much sound deadening vegetation as possible (e.g. trees) will be kept. The main haul route for coal trucks will be in the Willow Creek valley rather than on the exposed, north-facing ridge east of Willow Creek. Blasting will be kept (as far as practical) to one time of the day during daylight hours. Backup horns on mobile equipment, if problematic, may possibly be replaced by backup lights. Safety of crews will be the deciding factor as to use of backup horn substitutes.

7.7 DUST

Dust generation sources will be controlled to the greatest extent practical by watering, containment within structures or other means (such as surface agents for coal cars). Trees and other natural barriers will be used to deflect winds where practical and reduce the effect of strong winds blowing across facilities such as coal stockpiles.

7.8 VISUAL QUALITY

As discussed in Section 6.4, certain of the facilities will be visible from the road. Higher parts of the processing plant will be visible throughout the mine life and much of the North pit will be visible for the first years of mine life. Where safety is not an issue, large trees will be left to block visibility wherever possible. A program of revegetation at the earliest possible time for facilities visible from Highway 97 will be instituted. This will include the North Pit and Phase 1 and 2 dumps. When other pit areas become visible, the same approach to reclamation will be employed. Wherever possible, the first choice for mine road locations will be through areas that are not visible from Highway 97. Use of flood lights at night will be limited to those required for safety, or other reason, by provincial regulation.

8.0 DIRECT AND INDIRECT SOCIO-ECONOMIC IMPACTS

8.1 GENERAL

The potential for both positive and negative socio-economic impacts from the Willow Creek project is influenced by a number of important features:

- The project is relatively small in capital cost and total workforce. However, there is the potential for long term benefits, primarily to the regional communities. The operating workforce is estimated at 100 to 120 people.
- The mine will be located 45 km west of the District of Chetwynd, and there is good existing road and rail access. Chetwynd and the surrounding areas provide adequate and readily available infrastructure for the workforce.
- Chetwynd’s growth has been based upon industrial development of the forest, oil and gas and mining industries. A significant number of Chetwynd’s residents presently work in the mining industry, commuting to the Bullmoose and Quintette mines. Chetwynd is interested in diversification and growth of the District by development of the Willow Creek project.
- The Quintette and Bullmoose mines are expected to significantly reduce their 1996 level work forces (950 and 405 respectively) during 1997. The timing of this workforce reduction, with the planned startup of the Willow Creek project, should mitigate some of the loss of these existing mining jobs, and provide a trained workforce for the Willow Creek project.
- The Willow Creek project area is within Treaty #8, with Treaty rights ensuring traditional hunting, fish and trapping for Treaty 8 First Nations peoples. Consultation is on-going with the two First Nations in the immediate area to try to minimize impacts on traditional use, and cultural values, and to provide opportunities and economic benefits with mine development.
- There are several families at Willow Flats that would be impacted by project development. There are other residents located further north at the Westcoast Energy’s Compressor Station #2 who could also be affected with the development.

8.2 INDICATORS OF ECONOMIC BENEFITS

The mine life used in the feasibility analyses is 15 years, with the potential for extending the coal reserve and mine life indefinitely. Based upon the feasibility analyses, the following are key economic factors.

Secondary benefits will accrue to the community and surrounding areas with mine development. The jobs created in the area will increase the local purchasing power and the demand for goods and services. The mine area has been incorporated into the District of Chetwynd for tax purposes to further support the District of Chetwynd. Additional taxes will accrue to the Provincial and Federal governments.

A quantitative impact assessment on economic variables was conducted by the firm of KPMG using, as a base, the feasibility report prepared by Norwest Mine Services Ltd. and the BC Input-Output Model (BCIOM) of the BC Ministry of Finance and Corporate Relations.

8.2.1 Assessment of Impact on Economic Variables

Once the relevant variables had been calculated, the direct, indirect and induced impacts on the provincial economy were assessed using the BC Provincial Economic Multipliers (derived from the BCIOM by the Analysis and Evaluation Branch of the BC Ministry of Finance and Corporate Relations) for the coal mining industry.

KPMG used the discounted cash flow analysis for the 15 year mine life duration to calculate the taxation benefits accruing to both the federal and provincial governments for both personal and corporate income taxes and mineral taxes.

8.2.2 Summary of Economic Study Results

The results of the KPMG study of economic benefits (Appendix 8.2-1) from the Willow Creek Project to the BC economy and both provincial and federal tax revenues are summarized in Table 8.2-1. All values are measured in Canadian dollars with the exception of employment which is measured in person years.

TABLE 8.2-1

Willow Creek Project Summary of Economic Impacts

Economic Variable	Direct	Indirect	Induced	Total
Industry Output				
equipment purchases	$5,601,283	$2,296,526	N/A	$7,897,809
wages and benefits	$79,198,718	N/A	$59,399,039	$138,597,757
other goods & services	$122,440,358	$50,200,547	N/A	$172,640,905
operating surplus	$60,144,631	$24,659,299	N/A	$84,803,930
Gross Domestic Product				
wages	$38,015,385	$15,047,756	N/A	$53,063,141
operating surplus	$28,869,423	$11,427,480	N/A	$40,296,903
Employment				
person years	1542	960	N/A	2502
Federal Tax Revenues				
personal income	$20,591,667	N/A	N/A	$20,591,667
corporate income	$14,394,471	N/A	N/A	$14,394,471

Provincial Tax Revenues				
personal income	$10,707,667	N/A	N/A	$10,707,667
corporate income	$10,181,980	N/A	N/A	$10,181,980
BC mineral	$8,673,972	N/A	N/A	$8,673,972

8.2.3 Aggregate Economic Impacts

Relevant Economic Variables

The BCIOM can be used to assess the economic significance of specific changes in activity within the BC economy. Conceptually, the model is a simplified mathematical representation of relationships among industries and commodities within the economy. When activity in one industry changes, the model will estimate how that change impacts demand and supply for related industries. Although the relationships within the economy are simplified, the model itself is highly complex involving 216 industries and 627 commodities.

Since the level of detail provided by the BCIOM was not required for the Willow Creek Project, the assessment undertaken utilized the economic multipliers inherent to the model to estimate the aggregate impacts of the project on a few key economic variables.

Industry Output

Industry output is the economic measure of the value of an industry's total production or output. This value is calculated by summing the costs of all inputs to production (regardless of their source) and adding any operating surplus (or profit) earned on the sale of that output.

For the Willow Creek Project, the variables used to calculate the value of output are the following:

- equipment purchases;
- wages and benefits;
- other goods and services (required to carry out operations); and
- operating surplus.

Gross Domestic Product (GDP)

GDP is the measure of the value of all primary inputs to production. Primary inputs are those which are not directly linked to the production of commodities by other industries. For example, labour is a primary input because it is not a product of another production process. Heavy equipment, however, is produced by equipment manufacturers who in turn use the inputs of other industrial processes. GDP is also referred to as the measure of economic value-added and includes such factors as operating profits, indirect taxes and interest.

For the Willow Creek Project, the variables used to calculate GDP were the following:

- wages and benefits; and
- operating surpluses.

Employment

Employment can be measured in a number of different ways. For the Willow Creek Project, the employment effect was measured in terms of person-years of employment generated. Table 8.2-2 lists the value of economic variables used in this study. With the exception of employment, all variables are valued in Canadian dollars.

TABLE 8.2-2

Willow Creek Project Value of Economic Variables

(15 Year Totals)

Economic Variable		**Value**
Industry Output		
equipment purchases		$5,601,283
wages and benefits		$79,198,718
management and supervision	$22,040,708	
plant operating labour	$9,860,769	
mine operating labour	$47,297,250	
other goods and sevices		$122,440,358
operating surplus		$60,144,631
Gross Domestic Product (GDP)		
wages and benefits		$79,198,718
operating surplus		$60,144,631
Employment		
person years		1542

BC Provincial Economic Multipliers

The estimated direct, indirect and induced impacts of the Willow Creek Project on the BC economy were calculated using multipliers derived from the BCIOM. The specific multipliers used were the large aggregation industry multipliers for coal mining operations. Use of these multipliers for the purposes of estimating the economic impacts of this project was guided by the instruction manual provided by the Analysis and Evaluation Branch of the BC Ministry of Finance and Corporate Relations.

Estimates of Aggregate Economic Impacts

Table 8.2-3 summarizes the results of the aggregate economic impact analysis.

TABLE 8.2-3

Estimated Aggregate Economic Impacts (15 Year Totals)

Economic Variable	**Direct**	**Indirect**	**Induced**	**Total**
Industry Output				
equipment purchases	$5,601,283	$2,296,526	N/A	$7897,809
wages and benefits	$79,198,718	N/A	$59,399,039	$138,597,757
other goods & services	$122,440,358	$50,200,547	N/A	$172,640,905
operating surplus	$60,144,631	$24,659,299	N/A	$84,803,930
Gross Domestic Product				
wages and benefits	$38,015,,385	$15,047,756	N/A	$53,063,141
operating surplus	$28,869,423	$11,427,480	N/A	$40,296,903
Employment				
person-years	1542	960	N/A	2502

Impacts on Industry Output

The Project is expected to impact industry output in the BC economy over $400 million during its fifteen years duration. The direct and induced effects arising from expenditures on wages and benefits are expected to total approximately $140 million. Expected direct and indirect effects from other production inputs total over $180 million and those arising from operating surplus near $85 million.

Impacts on GDP

The Project is also expected to impact the GDP of BC's economy by over $90 million over the course of the operation. Direct and indirect effects expected from expenditures on wages and benefits total $53 million while those from operating surplus total $40 million.

Impacts on Employment

In terms of employment benefits, the direct and indirect impacts of jobs created by the project are expected to total approximately 2500 person years of employment over the course of its operation.

8.2.4 Government Revenues

Calculating Economic Impacts of Tax Revenues

Tax values are important economic effects of the mine project. Tax revenues were estimated using federal and BC tax rates, employee wages and benefits and discounted cash flow analysis prepared by Norwest for the fifteen year duration of the project.

The economic effects of tax revenues were estimated in terms of direct impacts only. The indirect and induced impacts on the BC economy of tax revenues are difficult to measure with confidence and have therefore been omitted from this analysis.

Personal Income Tax

Personal income taxes were estimated using average federal and provincial tax rates:

- **Federal tax** - estimated at 26% of total wages and benefits;
- **Provincial tax** - estimated at 52% of federal tax amount.

Corporate Income Tax

Corporate income taxes were estimated using the federal and provincial corporate tax rates for taxable earnings. Taxable earnings, or annual operating surplus, was estimated using the annual revenue, operating cost and capital expenditure estimates contained in the cash flow analysis while depreciating capital assets according to the class 41 (mine assets) CCA rate. The tax rates used were as follows:

- **Federal tax** - estimated at 29.12% of annual taxable earnings until all capital expenditures are recouped, then at 21.84%.
- **Provincial tax** - estimated at 16% of annual taxable earnings.
- **BC mineral tax** - estimated at 2% of annual taxable earnings.

Taxation Benefits Accruing to Federal and Provincial Governments

The results of the tax revenue analysis are summarized in Table 8.2-4. A detailed calculation of these estimated tax revenues is provided in Appendix 8.2-1.

TABLE 8.2-4 **Government Revenues (15 Year Totals)**			
	Direct Impacts		
	Federal	**Provincial**	**Totals**
personal income tax	$20,591,667	$10,707,667	$31,299,334

corporate income tax	$14,394,471	$10,181,980	$24,576,219
BC mineral tax	---	$8,673,972	$8,673,972
Totals	**$34,986,138**	**$29,563,619**	**$64,549,525**

Personal Taxes

The Project is expected to generate a total of over $31 million in personal tax revenues for the federal and provincial governments during its lifetime. Although the greatest tax benefits will be accrued to the federal government, the benefits to provincial revenues are also significant at over $10 million.

Corporate Taxes

In terms of corporate taxes, the Project is expected to generate a total of over $24 million in revenues for the federal and provincial governments. Benefits accrued to the province exceed $10 million while benefits to the federal government exceed $14 million.

BC Mineral Tax

The province will also accrue benefits through the BC mineral tax in excess of $8.6 million.

8.3 DISTRICT OF CHETWYND

The District of Chetwynd will be the community benefiting most from development of the Willow Creek project. It is expected that the majority of the mine workforce will reside in Chetwynd and surrounding areas because of the available infrastructure of housing, schools, health care, recreational and other available services.

The present unemployment level in Chetwynd is estimated to be 15% (Tables 8.3-1 and 8.3-2). In addition, there are an estimated 106 residents who commute to the Bullmoose and Quintette mines, which is a significantly longer commuting distance than to the Willow Creek project area. Many of the job skills required on the Willow Creek project already exist in the Chetwynd area and we believe that the majority of the jobs can be filled locally. The areas where skills are expected to be in short supply are in the trades area and the supervisory and management level.

TABLE 8.3-1

EMPLOYMENT INSURANCE CLAIMANTS

BY SKILL LEVEL (CHETWYND) *

Labourers (by industry sector):	
Primary Industry	2
Processing	3
Trades	33

Public Works, etc.	2
Mining/Oil/Gas	2
Logging/Forestry	15
Primary Production	2
Processing, Manufacturing and Utilities	3
Total Labourers: **Skilled Workers**	**62**
Heavy Equipment Operations:	19
Truck Drivers:	21
Mechanics (Heavy Duty):	6
Electricians:	1
* HRDC statistics for the Chetwynd Labour Force - January 1997. Occupational groupings are given according to anticipated operational labour requirements.	

TABLE 8.3-2

INCOME SUPPORT RECIPIENTS (WELFARE):

EMPLOYABLE CATEGORY *

Duration:	1996	1995	1994
less than 12 months	293	247	188
12 to 23 months	61	35	49
24 months +	86	75	72
TOTAL	440	357	309
* **HRDC - Dawson Creek: December 1996. Occupational or skill level groupings are not available for these figures.**			

The availability of skilled labour for the Willow Creek project will be affected by decisions made at the Bullmoose and Quintette mines on production levels as their coal contracts come up for renewal. A recent announcement made by Teck Corp to renew their coal contracts to the existing purchasers, would result in continuing mining operations, but at a lower rate unless additional contracts are signed. Information provided by the Ministry of Employment and Investment (Brian Parrott, pers. comm.) are that coal sales to the Japanese for both mines will be reduced from 6.35 mt/y to 4.6 mt/y. Based upon these production rates, the Quintette mine is expected to reduce their workforce over the next year from 870 to approximately 600 people; and the Bullmoose mine from 340 to approximately 290. This is expected to increase the skilled and unskilled labour force available for the Willow Creek project.

Based upon a Willow Creek mine workforce of approximately 100 people, and the analyses of the available local workforce, the majority of the jobs, 75, would be filled by the regional workforce. The workforce would come from the unemployed, people seasonally employed or employed but preferring more secure long term work, people preferring the shorter commute to the Willow Creek project, and some of the Bullmoose and Quintette mines workforce available from downsizing of these operations. Only about 25 of the 100 jobs, primarily in the skilled technical area, would need to be filled by people from outside the region. This is only an estimate, based upon the above assumptions, but we believe that this is conservative, as it assumes that 60% of these skilled jobs will be filled from outside the area. If the existing mines have a substantial workforce reduction, then fewer people would be hired from outside the region. The opposite would be true if the Bullmoose and Quintette workforce reductions occur significantly before the Willow Creek project is developed, because presumably fewer of the layed-off workforce would remain in the region and be available to move to the Willow Creek project.

KPMG made an assumption that of the estimated 75 jobs that would be filled in the region, that some would be filled by people living in Tumbler Ridge. While it is difficult to estimate the number of people in this group, KPMG estimates that this would be a maximum of 20% of the workforce or 15 jobs. Because of the commuting distance from Tumbler Ridge to the Willow Creek project, most of the people residing in Tumbler Ridge could be expected to eventually mover to the Chetwynd area.

Based upon the assumption of 25 jobs being filled from outside the region, and 15 jobs within the region by people living in Tumbler Ridge who will eventually move to Chetwynd, we estimate that the Willow Creek project will potentially bring into the Chetwynd area an estimated maximum 100 people. This estimate is based upon each job representing, on average, a family of 2.5 people (40 x 2.5). Of the new residents, some will wish to reside in areas outside of the District of Chetwynd, so the actual impact on Chetwynd can be expected to be less than 100 people.

Based upon the assumption of 100 new residents in the Chetwynd area, the following impacts can be expected.

A. Housing

There are currently approximately 30 homes (including mobiles) for sale in Chetwynd, and 40 available lots, including mobile home lots, suitable for residential building purposes. In addition, there is a vacancy rate of between 10 to 12 percent of the rental accommodation, for a total of approximately 45 vacant suites. There is an adequate supply of rental housing accommodation and lots available to accommodate the 20 maximum estimated new families moving to the Chetwynd area. The project will not significantly affect the housing supply although it will likely lead to some increase in home values.

B. Schools

Chetwynd is home to four elementary schools, a high school, one alternative school (located in the high school for students requiring additional educational support), Northern Lights College (upgrading, vocational and university transfer courses) and the Anne Teslyk Enhancement Centre. The number of new families settling in Chetwynd District as a result of the Willow Creek Project are not expected to result in a significant impact on the school capacity as capacity is currently underutilized.

C. Police and Other Community Services

The local RCMP detachment presently covers a relatively large territory in addition to Chetwynd and the additional population influx projected from opening of a mine at Willow Creek will not likely produce any requirements for additional policing services. The Chetwynd fire department is largely made up of volunteers and additional volunteers could be recruited upon opening of the Willow Creek mine if required. Medical services are presently limited by the shortage of physicians in Chetwynd, and the project will further support the need for another physician.

D. Water and Sewage

The water and sewage facilities have been recently upgraded and can now serve a population of 4000. Thus no impacts on these services are expected.

8.4 WILLOW FLATS AND COMMUNITY

There are approximately five families in the immediate Willow Flats area that are in relative proximity to the proposed north pit mining area. Blasting noise, dust and visual impacts are all of concern to these residents.

Discussions with the residents have been held on an on-going basis to keep them informed of the mine planning, the review process, schedule and to try to address their concerns about impacts with the mine development. It is planned to continue discussions once the Project Report has been submitted and, a final development decision made.

There are also approximately 18 homes (50 residents) located to the north at Westcoast Energy's Pump Station Number 2. The homes are rented to employees of Westcoast. Initial consultation started with these residents in April 1996 and detailed discussions with the residents are planned for September 1997 following submission of the Project Report.

8.5 PROCUREMENT AND HUMAN RESOURCE POLICIES

To the extent possible, and where prices and service are comparable, Pine Valley Coal will look to the use of local suppliers of goods and services.

The company policy is to hire as many people locally as possible. Selected areas will be targeted for First Nations employment, subject to the availability of adequately trained people. Local skilled and unskilled workers will be given opportunities for employment as the need arises and the skills required are available in the community.

Pine Valley Coal will not provide housing to employees. There is an adequate supply of suitable housing in Chetwynd and the surrounding areas.

Pine Valley Coal will not provide busing to the mine from Chetwynd. There would be opportunities for local contractors to supply this service.

9.0 PROJECT ALTERNATIVES

9.1 INTRODUCTION

A number of project alternatives were examined in mine planning. They are discussed in this section and further details are provided in Section 2.

9.2 PLANT LOCATION ALTERNATIVES

The mine plan calls for a wash plant to be located on the east bank of Willow Creek south of the BC Rail line. Alternatives considered included two locations further to the east on the Pine River floodplain and on the west bank of Willow Creek, opposite the presently proposed location. The two alternative sites both located east of the proposed site on the lower floodplain, would require extensive fill and pre-loading to be used for a plant.

The alternative site on the west bank of Willow Creek would require less clearing of trees, but has no other advantages over the presently proposed site. Moreover it would require a bridge to be built across Willow Creek. The proposed plant site is in an area planned to be logged-off by Louisiana Pacific and therefore tree removal may occur whether the site is used for a plant or not.

9.3 MAIN HAUL ROAD ALTERNATIVES

Two routes for the main haul road have been considered. The current mine plan calls for upgrading the Willow Creek forestry road to a mine haul road. The alternative is to construct a new road up the north slope and along the ridge to the east of the forestry road. While the forestry road route is slightly longer to the north central area, it is more desirable because:

- haul distance to the mill is shorter to the Peninsula Pit scheduled for initial mining in the Central area;
- haul truck engine noise will be less apparent at Highway 97 and Willow Flats because of location in the Willow Creek valley;
- less potentially higher value wildlife habitat is lost;
- the visual impact will be less;
- construction is easier;
- construction costs would be lower; and
- more efficient coal haulage will result.

The proposed alternate new access and haul road that traverses the ridge between Middle and Willow Creeks may result in impacts to wildlife inhabiting these habitats or wildlife utilizing them to move between upland and lowland sites. Moose are known to heavily browse the well established shrub understorey in this area and likely also utilize the ridge as a movement corridor. Endangered songbird species such as Connecticut warbler and Canada warbler (which may nest in these mixed forest habitats) may potentially be affected by development and utilization of the secondary access road.

If the new west access road up the ridge east of Willow Creek proceeds, natural drainage patterns will be retained. Adequately sized culverts, sedimentation control structures, and stabilization of road edges by planting shrub vegetation will be employed as necessary.

9.4 TAILINGS POND

An alternative to disposing of the thickener underflow tailings in a pond is to de-water this material. This can be accomplished by pumping the thickener underflow to a filter belt-press. The fine refuse material is then discharged in cake form onto the refuse conveyor, in conjunction with the coarse refuse from the jig. The combined refuse is hauled away for disposal. It is felt that this alternative is a more expensive one, and is more difficult to operate than a pond disposal system. The severe winters in the region may also make this option more complicated to operate than pond disposal.

9.5 REJECT DISPOSAL

Rejects disposal is proposed for integration into the active rock waste dumps in the current mine plan. It would be possible, however, if this proves unacceptable, to place rejects in a separate storage area adjacent to the tailings pond. This was considered less desirable than the chosen alternative because of the alienation of more floodplain land.

10.0 ASSESSMENT OF ALTERNATIVES EFFECTS

The impacts of alternative development scenarios are discussed where the alternatives are described. From an environmental perspective, mine design planning has favoured the lowest impact alternative wherever economically feasible.

11.0 POTENTIAL EFFECTS ON ABORIGINAL TRADITIONAL USE

As discussed in Section 4.14, a traditional use study involving West Moberly First Nations will be carried out in the Project area in the summer of 1997. The Willow Creek Project is within lands covered by Treaty #8, and treaty rights are defined for hunting, fishing, trapping and cultural use. Consultation is on going with the West Moberly and Saulteau First Nations about the Willow Creek project, and the potential for effects on Treaty #8. A traditional use and herbal plant study terms of reference have been discussed with First Nations to augment the previous archaeological survey (1981) to more clearly reflect present First Nations concerns. Input to the terms of reference has been provided by West Moberly First Nation. The study will be carried out during the summer of 1997, results discusssed with First Nations and a report prepared. The report will be released once satisfactory to the First Nations band members involved. Results will be submitted as an addendum to the Project Report.

The traditional use study will be used to assess and mitigate the potential effects on aboriginal traditional resource use in the Project Area. Operation of the mine will not prevent traditional use by First Nations in the same general area as that used prior to mining.

Consultations to date and future planned consultations are discussed in Section 17.

12.0 SAFETY AND CONTINGENCY RESPONSE

12.1 SCOPE AND PURPOSE

The information in this section provides an overview of the procedures and policies that will be developed for handling spills and emergencies at the Willow Creek Mine by Pine Valley Coal Ltd. It is not a Spill or Emergency Response Manual. This latter document will be developed to facilitate the rapid deployment of personnel and resources to spills, so that the environmental impact and risk are minimized. The Safety and Contingency Response Plan will be prepared in accordance with the *Spill Response Contingency Planning Guidelines* set by MOELP.

12.1 REGULATORY FRAMEWORK

Mine safety is regulated through the *Mines Act* and regulations are set out in the *Health, Safety and Reclamation Code for Mines in British Columbia*. Regulations in the Code are consistent with Workers' Compensation Board regulations with respect to occupational health and safety. Regulations under the *Workplace Hazardous Materials Information System* (WHMIS) with regard to workplace notification of hazardous substances will apply. Handling and use of explosives is specifically regulated under the Code.

Environmental legislation related to spills includes:

Regulation	**Responsible Ministry**
Spill Reporting Regulation	MOELP1
Waste Management Act	MOELP
Special Waste Regulation	MOELP
Fisheries Act	DFO2
Transportation of Dangerous Goods Act and Regulations	EC3

1 Ministry of Environment, Lands and Parks

2 Department of Fisheries and Oceans

3 Environment Canada

12.2 CHEMICAL STORAGE AND HANDLING

Initially no chemicals will be used for coal separation/refining, only water and mechanical separation. A heavy media circuit using magnetite may be installed if market demands call for it after start up. The following classes of chemicals will be used at the mine:

12.2.1 Chemicals List

Chemical	**Area Used**
flocculants	Possibly at sediment ponds
Lime	Wash plant
Diesel	Mine and wash plant
Gasoline	Mine (small trucks)

Propane	Wash plant, administration and shop
Lubricating oils	Shop, wash plant
Janitorial products	Administration and shop
Miscellaneous (small quantity) chemicals	Coal laboratory, shop

12.2.2 Flocculants

Flocculants may be required in sedimentation ponds if clay-sized particles become problematic. Only approved flocculants will be used and MOELP will be consulted prior to use if downstream effluents are released to the environment.

12.2.3 Lime

Lime will be stored in silos, or live bins and used where dust and other release to the environment can be controlled.

12.2.4 Petroleum Products

Petroleum products will be used for fuelling mobile equipment, for maintenance of mobile equipment, and for heating. Gasoline and diesel will be stored in approved double-lined tanks in a fuel farm area near the shop where tanks will be protected from accidental impact and where fire suppression equipment and spill kits (for small spills incidental to filling and use of tanks) will be available. Double-walled tank design will be used for any petroleum storage tank over 5000 L. Waste oil will also be stored in a double-walled tank of capacity less than 5000 L. In addition the tank will be equipped with a drip and spill proof delivery system. The waste oil tank will be emptied by a licensed waste oil contractor. Propane will be used for heating. All tanks and fuelling stations will meet *BC* and *National Fire Code* standards. Drains from fuelling stations will be equipped with approved oil-water separators. Water released from separators will be tested periodically to ensure MOELP criteria are met. Water will be pumped to either the tailings or sediment ponds. Sludge from oil-water separators will be periodically removed with waste oil.

Lubricants will be supplied and stored in totes (up to 1000 kg), barrels (205 L), pails (20 L) and cartridges. As per Fire Code requirements, lubricants will be stored on a concrete slab in an engineered structure with an approved sprinkler and fire alarm system. Used containers will be returned to suppliers in conformance with federal and provincial legislation. Spill kits will be available for small spills and clean up materials will be disposed of in an approved manner. Reportable spills will be reported to MOELP as required. Employees handling chemicals will be provided Workplace Hazardous Materials Information System (WHMIS) and *Transportation of Dangerous Goods Act* (TDGA) training as appropriate. Spill and emergency response procedures will be part of training and response action forms (examples appended in Appendix 12.2-1) will be provided and kept in a visible place (such as with Material Safety Data Sheet [MSDS] binders).

Waste oil from vehicle maintenance will be collected and stored in an approved, double-walled waste oil tank. Waste oil will be recycled through a petroleum products supplier. On-hand quantities will be kept below the *Special Waste Regulation* threshold value of 5000 L storage on site.

12.2.4 Other Chemicals

Other chemicals will be limited to miscellaneous (small quantity) supplies required for equipment routine repairs (such as gasket glue, penetrating oil, etc.), and small volume laboratory chemicals. Janitorial supplies will also be kept on hand at the warehouse: soap, cleansers, floor dry, dust bane, etc.). Approved methods of handling these materials will be followed and employees using these products will be made familiar with appropriate MSDS. Appropriate WHMIS training will be provided upon hiring.

12.3 SAFETY

In conformance with requirements under the health and safety code (previously cited), a joint management-worker occupational health and safety committee will be formed with duties and responsibilities as set out in the code. Management will cooperate fully with the committee. Accidents or dangerous occurrences will be reported to the district mines inspector.

Management will take all practical measures to ensure a safe and healthy work environment. Appropriate training will be provided to employees prior to job commencement. The workplace will be kept hazard-free to the extent possible; employees will be made aware of potential hazards and provided appropriate training and safety equipment where required. Hazardous materials and wastes will only be handled by employees following prescribed training for the materials in question.

12.4 EMERGENCY RESPONSE

An emergency response plan will be developed by mine management prior to operation of the mine, likely during construction phase. The emergency response plan will address all aspects of the mine and wash plant operations and provide instruction and direction for appropriate responses for all anticipated emergencies. The emergency response plan will meet the requirements of *Health, Safety and Reclamation Code for Mines in British Columbia* which includes the Workers' Compensation Board requirements for first aid facilities.

12.5 ORGANIZATION AND RESPONSIBILITIES

Spills of chemicals, fuels and other substances may occur as isolated events or as a result of other emergencies such as fire, explosion, natural causes or accidents. The key persons involved during a spill occurrence would be as follows:

1. The person discovering the spill, and their supervisor.

2. The mine general manager.
3. The mine superintendent (if the spill occurred in an area of their responsibility).
4. The wash plant superintendent (if the spill occurred in an area of their responsibility).
5. The safety and environment manager.
6. The on scene spill control coordinator.
7. The response team leader.
8. The clean up crews.

12.5.1 Responsibilities of the Person Discovering the Spill

The person discovering the spill will:

1. Assess the hazards to health and safety (many chemicals that vaporize readily can rapidly reach Immediately Dangerous to Life and Health [IDLH] levels; flammable liquids [such as gasoline] can rapidly reach concentrations where a spark or open flame will trigger an explosion [between lower and upper explosives limits - LEL to UEL]).
2. Notify their supervisor immediately. The supervisor will notify the security office. Security will in turn notify MOELP (**Spill Line: 1-800-663-3456**).
3. Arrange for appropriate operating equipment to be shut down, if applicable, to minimize the extent of the spill.
4. If warranted, notify on-site industrial first aid persons for first aid. Fire fighting response will be coordinated by the supervisor in attendance backed up by Mine Rescue personnel and any other available personnel.

The general manager and either the wash plant or mine superintendent must be contacted immediately by the supervisor or the person discovering the spill with the following information:

- name of person discovering the spill;
- the time of the spill;
- the location of the spill;
- the type of substance spilled;
- the quantity of substance spilled;
- the cause of the spill (if known);
- the weather conditions (if appropriate);
- perceived potential for hazard, and any impacts to water bodies, wildlife or people;
- actions already taken;
- whether a fire or explosion hazard is deemed to exist; and
- persons already notified.

The person discovering the spill will also ensure that every remedial action is taken, safely, to stop and minimize the extent of the spill. The supervisor will remain on site.

12.5.2 Responsibilities of the General Manager and Mine or Wash Plant Superintendent

The general manager and/or the mine or wash plant superintendent will immediately inform:

- the safety and environment manager;
- MOELP, Provincial Emergency Program (if Security has not done so);
- Fort St. John MOELP;
- Pine Valley Coal Ltd. Vice-President of Operations or President; and
- the Prince George Mines Inspector (250-565-6125).

They will plan for disposal of the recovered spill material and upon completion of the cleanup and restoration actions, prepare a spill report. As well, they will keep a complete log of events and activities during and after the spill, and photographs, if possible, for legal purposes and critical review of events at a later date.

12.5.3 Responsibilities of the On-Scene Work Crew

Upon receiving a report of a spill, the on-scene work crew will carry out the following:

1. If injury, serious health threats exist, or potential equipment hazards exist, call the Site Manager if the person reporting the spill has not already done so.
2. Consult the appropriate **Action Plan** (which will be developed as part of the mine Spill Prevention, Countermeasures and Control [SPCC] Plan) to review the properties of the spilled material and recommended response actions. If further information is required, contact one of the resource services listed in Section 12.7.
3. Assess the spill requirements for manpower, equipment, materials, tools and protective gear to contain the spill, in consideration of the resources available. Mobilize these resources and take responsibility for implementation of the response actions in the spill site.
4. If the spill is too large or complex to be handled entirely by the Company's resources, call an appropriate group or agency listed in Section 12.7.
5. Contact the Safety and Environment Manager to determine what, if any, sampling should be done and to discuss the spill and any environmental implications; and
6. Once the initial response action is underway, contact the General Manager and, either the Mine or Wash Plant Superintendent (depending on in whose area of responsibility the spill occurred) and review the situation and strategy.

12.5.4 Responsibilities of the Site Crew

The response crews and equipment operators will undertake the actual cleanup, maintain responsibility for the activities at the site of the spill, and maintain contact with and coordinate work with the Safety and Environment Manager.

12.5.5 Duties of the Safety and Environment Manager Not Related to the Spill Event

The duties of the Safety and Environment Manager not related to the spill event are:

- Update the Spill Prevention, Countermeasures, and Control Plan as required, for all potentially hazardous materials, accurate names of personnel and phone numbers.
- Plan and coordinate required skills.
- Be responsible for assessing new spill hazards as they develop and take preventative actions.
- Check and maintain the operating status of required response equipment which may be required at a spill.
- Train emergency response personnel with respect to their duties.

12.6 GOVERNMENT NOTIFICATION PROCEDURE

12.6.1 Minesite Spills

Although several government agencies at the district, provincial and federal levels may ultimately be involved, only one government contact is required to be made by the on-scene coordinator or his backup for the minesite spills:

Provincial Emergency Program (PEP)

1-800-663-3456

This is a 24 hour toll-free number. PEP will notify all concerned agencies, as appropriate.

12.6.2 Transport Spills

Goods will normally be purchased FOB the minesite and are therefore the responsibility of the transport company until delivered. However, all assistance that is feasible to render by minesite personnel should be given in the case of a transport-related accident. All dangerous occurrences (defined below) must be reported to:

- the local police;
- the employer;
- the transport truck owners;
- the owner or consignor of the dangerous goods.

A dangerous occurrence is considered to be:

- any loss of dangerous goods in excess of specified amounts or which represents a danger to health and safety or the environment;
- damage to any container of dangerous goods;
- a transportation accident in which radioactive goods are involved;
- an unintentional explosion or fire involving dangerous goods.

Additional information is contained in Section 9 of the *Transportation of Dangerous Goods Regulations*.

12.7 SUPPLIES AND RESOURCES

The SPCC plan which will be developed for mine operation will contain procedures sufficient in most instances to deal with the problems that may arise. In some instances, there may be a need to obtain further assistance. A number of private and government sources exist to assist with technical advise, provision of response personnel and equipment in the event of a spill.

12.7.1 Explosives Manufacturers and Suppliers

CIL (and likely other explosives manufacturers) provide technical advice and, if warranted, may dispatch a response team with specialized equipment to the site of a spill.

12.7.2 Canadian Transport Emergency Centre (CANUTEC)

CANUTEC provides information and communications assistance for transportation emergencies involving dangerous goods. CANUTEC has information on over 25,000 products and can be contacted for advice on what to do and what not to do in case of emergencies.

CANUTEC 24 Hour Emergency Number (613) 996-6666

12.7.3 Chemical Waste Disposal Contractors

A number of private companies provide response, cleanup and disposal services on a contract basis. A list of contractors able to respond to a spill emergency at the Willow Creek Mine will be developed as part of the SPCC Plan.

12.7.4 Suppliers and Dealers

A list of suppliers and dealers for all products purchased for mine and wash plant use will be compiled for the SPCC Plan.

12.7.5 Other

Poison Control Centre 492-4000

492-4060

Forest Fire Reports 1-800-663-5555

13.0 CUMULATIVE IMPACTS ASSESSMENT

13.1 DIRECT IMPACTS FROM THE PROJECT

Direct impacts identified in Section 6.0 include noise, dust, visual, water quality, temporary loss of wildlife habitat, discharge of treated water to waters potentially inhabited by fish, and positive: provision of employment, taxes, and exports for Canada. The closest industrial activity that may potentially negatively affect the environment is the gas pumping station at Willow Flats, approximately 2.5 km to the northeast. The plant mainly contributes air emissions and some local noise. The Project area has been the site of small scale logging in the past and several timber licenses are held in the area (see Section 4.14). Logged areas are mostly naturally revegetating and these areas appeared to have stabilized at the time of the 1996 baseline studies for this project. The main source of noise in the area is currently highway traffic on Highway 97 and train traffic on the BC Rail line (two trains per day).

The geographic scope of this cumulative impact assessment is limited to the Project area and immediate surroundings (2.5 km radius), since effects from the Project are not predicted to be significant beyond that radius. The time frame for this assessment is the project mine life and some period (5 to 10 years) after closure at which time the area will be revegetated enough to be stable and mine infrastructure will be removed or reclaimed.

The following sections discuss cumulative impacts which are considered to be significant, or could be measurable.

13.2 FISHERIES

The project area was previously logged and has past road, rail, transmission line and pipeline-construction activities and existing structures. Farming and concomitant leaching of fertilizers also occurs along the Pine River. Some of the potential cumulative impacts from these activities, based on limited field information and experience with Watershed Restoration work under the Forest Practice Code, include:

- changes to the flows in Middle and Far East Creeks in the floodplain due to the BC Rail line. The area downstream of the railway has a wide floodplain with no clearly defined channel such that it has little, or no, water and is of little, or no, use for fish;
- probable increase in accumulations of substrate material over background in the low-gradient lowermost reaches of Willow Creek. This often occurs after logging due to erosion and increased runoff velocities that carry larger loads of sediment material, including cobble-size gravels, to the lower gradient lowermost reaches of the creeks. Both clear-cutting and road-building would contribute to this process. The existing accumulations have created partial (seasonal) fish migration barriers and reduced the amount of viable habitat available to fish. The same phenomenon is likely occurring in the Pine River, where numerous large gravel bars with little cover material are present;
- limited channelization in lower Willow Creek for the road and rail bridge crossings. The bridges are not considered a significant adverse impact to fish production in the system;
- limited and short-term sedimentation from the construction phases of the roads, railway and the natural gas pipeline and transmission line. If pesticides were used to limit terrestrial vegetation on the transmission and pipe lines, some chemical residues may have reached the Pine River;
- relatively small quantities of domestic sewage from river-side residents, small communities and businesses has also likely reached the Pine River. The sewage from Chetwynd is treated before release under permit (Westcoast Energy 1993);
- an unknown amount of nutrient addition (nitrogen and phosphorus) to the Pine River from agricultural activities; and
- an unknown, but probable, loss of fish production from sport fishing pressures on the Pine/Sukunka River system. Verbal reports from long-time residents and helicopter pilots indicate that more and larger fish were generally caught with less effort than in recent years. This may be due to overfishing, or to habitat degradation, or, more likely, both.

13.3 ECOSYSTEM UNITS/VEGETATION

The Willow Creek project area is located within the Hasler Landscape Unit of the Dawson Creek Forest District. Terrestrial ecosystem mapping has not been completed for this landscape unit. Canadian Forest Products, Chetwynd Division, has scheduled ecosystem mapping of the Hasler Landscape Unit to begin in the summer of 1997. Therefore, data on abundance of ecosystem units in the landscape unit or region are presently not available. However, the Dawson Creek Forest District has estimated extent of the forested and non-forested land base by structural stage and biogeoclimatic zone (Table 13.3-1).

TABLE 13.1-1

Hasler Landscape Unit - Area of Forested, Forested Land Base by Biogeoclimatic Zone (ha)

Hasler Landscape Unit - Area of Forested, Forested Land Base by Biogeoclimatic Zone (ha)

BEC Zone	Admin Unit	NDT	Structural Stage	Excluded Area	Timber Harvest Land Base	Total Forested Land Base	Non-forested Land Base	Total Area														
ESSF	TFL	1	early	171.97	552.98	724.94	13.31	738.25														
			immature	801.82	3088.15	3889.97	74.32	3964.29														
			mature	883.79	1249.46	2133.25	30.07	2163.32														
			N/A	0	0	0	356.37	356.37														
			old	8.75	86.49	95.24	2.08	97.32														
			Subtotal	1866.33	4977.08	6843.4	476.15	7319.55														
ESSF	TFL & TSA Areas	2	early	944.27	2268.63	3212.89	56.06	3268.96	TSA	NDT -2	early	277.98	947.41	1225.39	23.12	1248.51	TFL	666.29	1321.22	1987.5	32.94	2020.45
			immature	2314.61	10886.86	13201.47	263.27	13464.73			immature	417.81	3732.48	4150.29	91.09	4241.37		1896.8	7154.38	9051.18	172.18	9223.36
			mature	3859.71	5711.38	9571.09	138.09	9709.17			mature	368.77	1867.12	2235.89	45.57	2281.46		3490.94	3844.26	7335.2	92.52	7427.71
			N/A	11.92	0	11.92	1914.67	1926.59			N/A	0	0	0	790.88	790.88		11.92	0	11.92	1123.79	1135.71
			old	1.8	56.99	58.79	1.37	60.16			old	0	0	0	0	0		1.8	56.99	58.79	1.37	60.16
			Subtotal	7132.31	18923.86	26056.16	2373.46	28429.61														
SBS	TFL & TSA Areas	2	early	222.78	1078.36	1301.13	27.51	1328.66	TSA	NDT -2	early	67.1	394.46	461.55	9.63	471.18	TFL	155.68	683.9	839.58	17.88	857.48
			immature	1060.53	3066.28	4126.81	74.32	4201.13			immature	643.43	1534.89	2178.32	37.46	2215.78		417.1	1531.39	1948.49	36.86	1985.35
			mature	3777.54	12309.42	16086.97	297.44	16384.41			mature	505.32	3561.23	4066.55	86.91	4153.46		3272.22	8748.19	12020.42	210.53	12230.95
			N/A	0	0	0	1990.75	1990.75			N/A	0	0	0	1246.99	1246.99		0	0	0	743.76	743.76
			old	12.36	19.98	32.34	0.48	32.82			old	0	0	0	0	0		12.36	19.98	32.34	0.48	32.82
			Subtotal	5073.21	16474.04	21547.25	2390.5	23937.77				1215.85	5490.58	6706.42								
BWBS	TFL & TSA Areas	3	early	261.98	1243.52	1505.5	33.43	1538.94	TSA	NDT-3	early	43.35	57.84	101.19	1.41	102.61	TFL	218.63	1185.68	1404.31	32.02	1436.33
			immature	3321.54	5433.12	8754.65	131.32	8885.97			immature	1516.1	1239.49	2755.58	30.25	2785.83		1805.44	4193.63	5999.07	101.07	6100.14
			mature	3002.36	9095.31	12097.67	219.22	12316.9			mature	268.9	998.6	1267.5	24.37	1291.87		2733.46	8096.71	10830.17	194.85	11025.03

			N/A	57.65	0	57.65	9038.68	9096.33	N/A	57.65	0	57.65	6749.92	6807.57	0	0	0	2288.76	2288.76
			old	501.84	3056.74	3558.58	73.82	3632.39	old	302.75	747.45	1050.2	18.24	1068.44	199.09	2309.29	2508.38	55.58	2563.95
			Subtotal	7145.37	18828.69	25974.05	9496.47	35470.53											
AT	TFL	5	N/A	3.28	0	3.28	140.35	143.63											
Totall Hasler				21220.5	59203.67	80424.14	14876.93	95301.09											
				21220.49	59203.67	80424.16	14876.91	95301.06											

NDT =	Natural Disturbance Type.
NDT1	ecosystems with rare stand-initiating events - mean return interval for disturbance is 350 years.
NDT2	ecosystems with infrequent stand-initiating events - mean return interval for disturbance is about 200 years.
NDT3	ecosystems with frequent stand-initiating events - mean return interval for disturbance is about 125 years.
Seral stages are totalled by biogeoclimatic zone and NDT as per the seral stage definitions contained	
in the Biodiversity Guidebook (Forest Practices Code, September, 1995)	

Zone		Seral Stage (years)			
		Early	Immature	Mature	Old
ESSF	NDT1, NDT2	<40	>40 <120	>120	>250

SBS	NDT2		<40	>40 <100	>100	>250
BWBS (c)	NDT3		<40	>40 <100	>100	>140
BWBS (d)	NDT3		<20	>20 <80	>80	>100
BWBS (c) - coniferous dominated ecosystem						
BWBS (d) - deciduous dominated ecosystem						
Terrestrial Ecosystem Mapping Age Criteria						
<20	Structural Stages 1 - 3 (non-vegetated through shrub stages)					
20 - 40	Structural stage 4 - pole sapling					
40 - 80	Young forest					
80 - 140	Mature forest in the BWBS					
80 - 250	Mature forest in the SBSwk2 and ESSF					
>140	Old forest in the BWBS					
>250	Old forest in the SBSwk2 and ESSF					

Hasler Landscape Unit - Forested Land Base by Biogeoclimatic Zone

BEC Zone	Admin	NDT	Structural Stage	Excluded Area	Timber Harvest Land Base	Total Forested Land Base	Non-forested Land Base	Total Area	Percent Excluded	Percent Timber Harvest Land Base
ESSF	TFL	1	early	171.97	552.98	724.94	13.31	738.25		
			immature	801.82	3088.15	3889.97	74.32	3964.29		
			mature	883.79	1249.46	2133.25	30.07	2163.32		
			N/A	0	0	0	356.37	356.37		
			old	8.75	86.49	95.24	2.08	97.32		

			1866.33	4977.08	6843.4	476.15	7319.55
ESSF	TFL	2 early	666.29	1321.22	1987.5	32.94	2020.45
		immature	1896.8	7154.38	9051.18	172.18	9223.36
		mature	3490.94	3844.26	7335.2	92.52	7427.71
		N/A	11.92	0	11.92	1123.79	1135.71
		old	1.8	56.99	58.79	1.37	60.16
			6067.75	12376.85	18444.59	1422.8	19867.39
ESSF	TSA	2 early	277.98	947.41	1225.39	23.12	1248.51
		immature	417.81	3732.48	4150.29	91.09	4241.37
		mature	368.77	1867.12	2235.89	45.57	2281.46
		N/A	0	0	0	790.88	790.88
		old	0	0	0	0	0
			1064.56	6547.01	7611.57	950.66	8562.22
SBS	TFL	2 early	155.68	683.9	839.58	17.88	857.48
		immature	417.1	1531.39	1948.49	36.86	1985.35
		mature	3272.22	8748.19	12020.42	210.53	12230.95
		N/A	0	0	0	743.76	743.76
		old	12.36	19.98	32.34	0.48	32.82
			3857.36	10983.46	14840.83	1009.51	15850.36
SBS	TSA	2 early	67.1	394.46	461.55	9.63	471.18
		immature	643.43	1534.89	2178.32	37.46	2215.78
		mature	505.32	3561.23	4066.55	86.91	4153.46
		N/A	0	0	0	1246.99	1246.99
		old	0	0	0	0	0
			1215.85	5490.58	6706.42	1380.99	8087.41
BWBS	TFL	3 early	218.63	1185.68	1404.31	32.02	1436.33
		immature	1805.44	4193.63	5999.07	101.07	6100.14
		mature	2733.46	8096.71	10830.17	194.85	11025.03

			N/A	0	0	0	2288.76	2288.76
			old	199.09	2309.29	2508.38	55.58	2563.95
				4956.62	15785.31	20741.93	2672.28	23414.21
BWBS	TSA	3	early	43.35	57.84	101.19	1.41	102.61
			immature	1516.1	1239.49	2755.58	30.25	2785.83
			mature	268.9	998.6	1267.5	24.37	1291.87
			N/A	57.65	0	57.65	6749.92	6807.57
			old	302.75	747.45	1050.2	18.24	1068.44
				2188.75	3043.38	5232.12	6824.19	12056.32
AT	TFL	5	N/A	3.28	0	3.28	140.35	143.63

Table 13.3-1: Area of Forested, Non-forested and Timber Harvest Land Base by Biogeoclimatic Zone and Structural Stage in the Hasler Landscape Unit (ha)

BEC Zone	Admin Unit	NDT	Structural Stage	Excluded Area (ha)	% of Zone	Timber Harvest Land Base (ha)	% of Zone	Total Forested Land Base (ha)	% of Zone	Non-forested Land Base (ha)	% of Zone	Total Area (ha)	% of Zone	% of Hasler Landscape Unit
ESSF	TFL	1	early	171.97	2.35	552.98	7.55	724.94	9.90	13.31	0.18	738.25	10.09	0.77
(wk2)			immature	801.82	10.95	3088.15	42.19	3889.97	53.14	74.32	1.02	3964.29	54.16	4.16
			mature	883.79	12.07	1249.46	17.07	2133.25	29.14	30.07	0.41	2163.32	29.56	2.27
			N/A	0	0.00	0	0.00	0	0.00	356.37	4.87	356.37	4.87	0.37
			old	8.75	0.12	86.49	1.18	95.24	1.30	2.08	0.03	97.32	1.33	0.10
			Subtotal	1866.33	25.50	4977.08	68.00	6843.4	93.49	476.15	6.51	7319.55	100.00	7.68
ESSF	TFL &	2	early	944.27	3.32	2268.63	7.98	3212.89	11.30	56.06	0.20	3268.96	11.50	3.43

TSA NDT -early 2 277.98 947.41 1225.39 23.12 1248.51 TFL 666.29 1321.22 1987.5 32.94 2020.45

(mv2)	TSA		immature	2314.61	8.14	10886.86	38.29	13201.47	46.44	263.27	0.93	13464.73	47.36	14.13		immature	417.81	3732.48	4150.29	91.09	4241.37		1896.8	7154.38	9051.18	172.18	9223.36
			mature	3859.71	13.58	5711.38	20.09	9571.09	33.67	138.09	0.49	9709.17	34.15	10.19		mature	368.77	1867.12	2235.89	45.57	2281.46		3490.94	3844.26	7335.2	92.52	7427.71
			N/A	11.92	0.04	0	0.00	11.92	0.04	1914.67	6.73	1926.59	6.78	2.02		N/A	0	0	0	790.88	790.88		11.92	0	11.92	1123.79	1135.71
			old	1.8	0.01	56.99	0.20	58.79	0.21	1.37	0.00	60.16	0.21	0.06		old	0	0	0	0	0		1.8	56.99	58.79	1.37	60.16
			Subtotal	7132.31	25.09	18923.86	66.56	26056.16	91.65	2373.46	8.35	28429.61	100.00	29.83													
SBS	TFL &	2	early	222.78	0.93	1078.36	4.50	1301.13	5.44	27.51	0.11	1328.66	5.55	1.39	TSA NDT -2	early	67.1	394.46	461.55	9.63	471.18	TFL	155.68	683.9	839.58	17.88	857.48
(wk2)	TSA		immature	1060.53	4.43	3066.28	12.81	4126.81	17.24	74.32	0.31	4201.13	17.55	4.41		immature	643.43	1534.89	2178.32	37.46	2215.78		417.1	1531.39	1948.49	36.86	1985.35
			mature	3777.54	15.78	12309.42	51.42	16086.97	67.20	297.44	1.24	16384.41	68.45	17.19		mature	505.32	3561.23	4066.55	86.91	4153.46		3272.22	8748.19	12020.42	210.53	12230.95
			N/A	0	0.00	0	0.00	0	0.00	1990.75	8.32	1990.75	8.32	2.09		N/A	0	0	0	1246.99	1246.99		0	0	0	743.76	743.76
			old	12.36	0.05	19.98	0.08	32.34	0.14	0.48	0.00	32.82	0.14	0.03		old	0	0	0	0	0		12.36	19.98	32.34	0.48	32.82
			Subtotal	5073.21	21.19	16474.04	68.82	21547.25	90.01	2390.5	9.99	23937.77	100.00	25.12			1215.85	5490.58	6706.42								
BWBS	TFL &	3	early	261.98	0.74	1243.52	3.51	1505.5	4.24	33.43	0.09	1538.94	4.34	1.61	TSA NDT- 3	early	43.35	57.84	101.19	1.41	102.61	TFL	218.63	1185.68	1404.31	32.02	1436.33
(mw1)	TSA		immature	3321.54	9.36	5433.12	15.32	8754.65	24.68	131.32	0.37	8885.97	25.05	9.32		immature	1516.1	1239.49	2755.58	30.25	2785.83		1805.44	4193.63	5999.07	101.07	6100.14
			mature	3002.36	8.46	9095.31	25.64	12097.67	34.11	219.22	0.62	12316.9	34.72	12.92		mature	268.9	998.6	1267.5	24.37	1291.87		2733.46	8096.71	10830.17	194.85	11025.03
			N/A	57.65	0.16	0	0.00	57.65	0.16	9038.68	25.48	9096.33	25.64	9.54		N/A	57.65	0	57.65	6749.92	6807.57		0	0	0	2288.76	2288.76
			old	501.84	1.41	3056.74	8.62	3558.58	10.03	73.82	0.21	3632.39	10.24	3.81		old	302.75	747.45	1050.2	18.24	1068.44		199.09	2309.29	2508.38	55.58	2563.95
			Subtotal	7145.37	20.14	18828.69	53.08	25974.05	73.23	9496.47	26.77	35470.53	100.00	37.22													
AT	TFL	5	N/A	3.28	2.28	0	0.00	3.28	2.28	140.35	97.72	143.63	100.00	0.15													
Total Hasler				21220.49		59203.67		80424.16		14876.91		95301.06															

Source: Ministry of Forests, Dawson Creek Forest District

Definitions:

Excluded Area = roads, highways, towns, agricultural land, seismic lines, federal parks and reserves

Total Forested Land Base = Excluded area + Timber Harvest Land Base

Non-forested Land Base = non-commercial and non-productive

Table 13.2-1 (definitions continued)

NDT =	Natural Disturbance Type.
NDT1	ecosystems with rare stand-initiating events - mean return interval for disturbance is 350 years.
NDT2	ecosystems with infrequent stand-initiating events - mean return interval for disturbance is about 200 years.
NDT3	ecosystems with frequent stand-initiating events - mean return interval for disturbance is about 125 years.

Seral stages are totalled by biogeoclimatic zone and NDT as per the seral stage definitions contained

in the Biodiversity Guidebook (Forest Practices Code, September, 1995)

Zone		Seral Stage (years)			
		Early	Immature	Mature	Old
ESSF	NDT1, NDT2	<40	>40 <120	>120	>250
SBS	NDT2	<40	>40 <100	>100	>250
BWBS (c)	NDT3	<40	>40 <100	>100	>140
BWBS (d)	NDT3	<20	>20 <80	>80	>100

BWBS (c) - coniferous dominated ecosystem

BWBS (d) - deciduous dominated ecosystem

Terrestrial Ecosystem Mapping Age Criteria

<20	Structural Stages 1 - 3 (non-vegetated through shrub stages)
20 - 40	Structural stage 4 - pole sapling

40 - 80	Young forest
80 - 140	Mature forest in the BWBS
80 - 250	Mature forest in the SBSwk2 and ESSF
>140	Old forest in the BWBS
>250	Old forest in the SBSwk2 and ESSF

Five biogeoclimatic zones are found in the Hasler Unit. The approximate extent of these zones is as follows: ESSFwk2 (7.68%), ESSFmv2 (29.83%), SBSwk2 (25.12%), BWBSmw1 (37.22%) and AT (0.15%) (Table 13.2-1). Three of these zones will be impacted by the Willow Creek project. Under Alternative B (project alternative with the larger disturbance area), approximately 121.74 ha (0.34%), 142.41 ha (0.59%) and 192.98 ha (0.68%) of the total area of the BWBSmw1, SBSwk2 and ESSFmv2 in the landscape unit, respectively, will be disturbed by mine activities. These areas represent losses of about 0.47, 0.66 and 0.74 percent of the total forested land base of the BWBSmw1, SBSwk2 and ESSFmv2 in the landscape unit, respectively.

The majority (80424.16 ha; 85.4%) of the total land base within the Hasler Landscape Unit is forested (Table 13.3-1). All of the land base to be disturbed by the Willow Creek project alternatives supports forests in various structural stages. Alternative B would remove about 457 ha (0.57%) from the forested land base (and wildlife habitat) during construction and operational phases. About 91.65 % of the ESSFmv2 is located within the total forested land base. The majority of this total land base is covered by immature (46.44 %) and mature (33.67 %) forests. Removal of ecosystems due to the Willow Creek project will be most significant in mature forest, which falls within the late immature and mature seral stages defined by MOF (Table 13.3-1). The herb and shrub/herb ecosystems that will be disturbed by the project have been created by past logging activities. None of the small area of old growth ESSFmv2 forest remaining in the Hasler Landscape Unit will be impacted by the Willow Creek project.

Impacts to the SBS are similar to those in the ESSF. Approximately 90% of the SBSwk2 found in the Hasler Landscape Unit is located within the total forested land base. The majority of this forested land base is covered by mature forest (67.20%), while immature is next most common (17.24 %) (Table 13.3-1). Removal of ecosystems due to the Willow Creek project will be most significant in mature forest, which falls within the late immature and mature seral stages defined by MOF (Table 13.3-1). Relatively small areas of shrub/herb ecosystems (created by logging activities) will be disturbed by mining activities. None of the small area of old growth SBSwks forest remaining in the Hasler Landscape Unit will be impacted by the Willow Creek project.

About 73.23% of the BWBSmw1 found in the Hasler Landscape Unit is classified within the total forested land base. A greater amount of the BWBS has been alienated because of the greater frequency of human activities in the low lying Pine Valley. The majority of land area within the BWBS is covered by immature (24.68 %) and mature forest (34.11%) (Table 13.3-1). Removal of ecosystems due to the Willow Creek project will be most significant in mature seral and climax forest, which falls within the mature seral stages defined by MOF (Table 13.3-1). Relatively small areas of shrub/herb ecosystems (created by logging activities) and young forest will be disturbed by mining activities. None of the of the old growth BWBSmw1 forest (10.03 %) remaining in the Hasler Landscape Unit will be impacted by the Willow Creek project.

In summary the Willow Creek project will not have significant impacts to the forested land base of the Hasler Landscape Unit. About one-half of one percent of the total forested land base and total land base in the each of BwBS, SBS and ESSF zones will be disturbed under Alternative B (larger of the two alternatives). Further, no old growth forests, non-forested ecosystems such as wetlands, or rare elements (red or blue-listed plant communities) will be physically disturbed.

13.4 WILDLIFE

13.4.1 Cumulative Effects

Direct disturbance of sensitive wildlife habitats is different for each of the key wildlife species identified for the site. Overall cumulative effects on wildlife will be low in the long-term, based on experience at other British Columbia coal mines, because of reclamation and habitat restoration activities proposed for the site. Cumulative effects are discussed separately for each of these species below.

13.4.3.1 Grizzly Bear

Of the 55.82 ha of important grizzly bear habitats to be disturbed by mine development activity, 15.61 ha are within the BWBS mw1, 30.42 ha are in the SBSwk2, and 9.79 ha are in the ESSFmv2. These areas represent losses of 0.06, 0.14 and 0.04 percent of the total forested land base of the BWBSmw1, SBSwk2 and ESSFmv2 in the Hasler Landscape Unit, respectively. Reclamation of the mine development area will result in an increased area of herb and shrub stage forests over the next approximately 40 years. These habitats are preferred spring and fall foraging areas for grizzly bears. Although, very small losses in important habitats will occur in the short-term, gains in foraging habitats will occur over the long-term. No long-term cumulative impacts related to habitat alteration are anticipated.

A cumulative impact of greater concern is the potential increase in access and hunter pressure resulting from mine development activities. However, restrictions during mining and deactivation of mine roads following the closure of the mine will minimize long-term impacts.

13.4.3.2 Elk

Of the 13.06 ha of key elk habitats estimated to be disturbed by the proposed mine development, 3.27 ha are within the BWBS mw1 and 9.79 ha in the ESSFmv2. These areas represent losses of only 0.01 and 0.04 percent of the total forested land base of the BWBSmw1 and ESSFmv2 in the Hasler Landscape Unit, respectively. Of the 13.06 ha to be disturbed, approximately 38% consists of upland clearcuts. Similar habitats will be created as part of the reclamation project and will likely remain as high quality elk foraging habitats for several decades. Although some short-term impacts will occur, cumulative impacts are not anticipated because of the creation of prime elk foraging areas.

13.4.3.3 Moose

A total of 132.63 ha of important moose habitats will be disturbed by mine development activity, of which 17.69 ha are within the BWBS mw1, 71.88 ha are in the SBSwk2 and 43.06 ha are in the ESSFmv2. These areas represent losses of 0.07, 0.33 and 0.17 percent of the total forested land base of the BWBSmw1, SBSwk2 and ESSFmv2 in the Hasler Landscape Unit, respectively. Clearcut areas and early seral stage habitats represent 49.77 ha or approximately 38% of key habitats. Early seral stage forests with high shrub densities and diversity will be established on the site as part of the reclamation program. These areas are expected to be of high value as browse for moose, especially in winter. Although short-term losses in habitat will occur, long-term increases in suitable habitat are expected. No cumulative effects are anticipated.

13.4.3.4 Mule Deer and White-tailed Deer

Of the 13.06 ha of key deer habitats estimated to be disturbed by the proposed mine development, 3.27 ha are within the BWBS mw1 and 9.79 ha in the ESSFmv2. These areas represent losses of only 0.01 and 0.04 percent of the total forested land base of the BWBSmw1 and ESSFmv2 in the Hasler Landscape Unit, respectively. Of the 13.06 ha to be disturbed, approximately 38% consists of upland clearcuts. Similar habitats will be created as part of the reclamation project and will likely remain as high quality deer foraging habitats for several decades. Although some short-term impacts will occur, cumulative impacts are not anticipated because of the creation of prime deer foraging areas.

13.4.3.5 Marten

Of the 100.24 ha of suitable marten habitat located within the disturbance area, 4.27 ha are within the BWBS mw1, 28.53 ha are within the SBSwk2, and 67.44 ha are in the ESSFmv2. These areas represent losses of 0.02, 0.13 and 0.26 percent of the total forested land base of the BWBSmw1, SBSwk2 and ESSFmv2 in the Hasler Landscape Unit, respectively. Because mature forests are preferred habitats of marten, an immediate short-term loss of habitats will occur. Reclamation of the mine development area is expected to result in the creation of suitable forested habitats in approximately 100 years. Habitat loss, as a proportion of the Hasler Landscape Unit, is low.

13.4.3.6 Fisher

Of the only 17.35 ha of fisher habitats to be disturbed by mine development activity 4.27 ha are within the BWBSmw1 and 13.08 ha are within the SBSwk2. These areas represent losses of 0.02 and 0.06 percent of the total forested land base of the BWBSmw1 and SBSwk2 in the Hasler Landscape Unit. Cumulative impacts are not significant. Reclamation will result in restoration of suitable habitats in the long-term (i.e., approximately > 100 years).

13.4.3.7 Northern Goshawk

Total area expected to be disturbed by mine development is 40.72 ha of which 7.36 ha are within the BWBS mw1, 28.53 ha are in the SBSwk2, and 4.83 ha are in the ESSFmv2. These areas represent losses of 0.03, 0.13 and 0.02 percent of the total forested land base of the BWBSmw1, SBSwk2 and ESSFmv2 in the Hasler Landscape Unit, respectively. Reclamation will result in restoration of suitable habitats in the long-term.

13.4.3.8 Broad-winged Hawk

A total of 89.9 ha of habitats, all within the BWBSmw1 biogeoclimatic zone, is expected to be disturbed by mine development activity. This area represents a loss of 0.35 percent of the total forested land base of the BWBSmw1 in the Hasler Landscape Unit. Of the 89.9 ha, only 1.88 ha (i.e., 0.01% of total forested land base) is considered to be of moderate suitability. Cumulative impacts are considered to be negligible, especially since many impacted areas will eventually be restored to near natural conditions.

13.4.3.9 Black-throated Green Warbler

Of the 263.21 ha of potential black-throated green warbler habitats disturbed by mine development activity, 6.86 ha are within the BWBS mw1, 132.21 ha are in the SBSwk2, and 124.14 ha are in the ESSFmv2. These areas represent losses of 0.03, 0.61 and 0.48 percent of the total forested land base of the BWBSmw1, SBSwk2 and ESSFmv2 in the Hasler Landscape Unit, respectively. Cumulative impacts to black-throated green warbler populations are difficult to determine because of lack of site-specific information on populations. However, reclamation activities should restore potentially suitable habitats in the long-term (i.e., > 100 years).

13.4.3.10 Connecticut Warbler

The 102.85 ha of potentially important Connecticut warbler habitats that will be disturbed by mine development represents 0.40 percent of the total forested land base of the BWBSmw1 in the Hasler Landscape Unit. Cumulative impacts to Connecticut warbler populations are difficult to predict because of lack of site-specific information on populations. However, reclamation should restore potentially suitable habitats in the long-term (i.e., > 50 years).

13.4.3.11 Bay-breasted Warbler

Of the 143.69 ha of potentially suitable bay-breasted warbler habitats to be disturbed by mine development, 11.48 ha are within the BWBS mw1 and 132.21 ha are in the SBSwk2. These areas represent losses of 0.04 and 0.61 percent of the total forested land base of the BWBSmw1 and SBSwk2 in the Hasler Landscape Unit, respectively. Cumulative impacts to bay-breasted warbler populations are difficult to determine because of lack of site-specific information on populations. However, reclamation should restore potentially suitable habitats in the long-term (i.e., > 80 years).

13.4.3.12 Cape May Warbler

A total of 139.07 ha of habitats potentially suitable for Cape May warbler will be disturbed by mine development activity. Of these, 6.86 ha are within the BWBS mw1 and 132.21 ha are in the SBSwk2, representing losses of 0.03 and 0.61 percent of the total forested land base of the BWBSmw1 and SBSwk2 in the Hasler Landscape Unit, respectively. Cumulative impacts to Cape May warbler populations are difficult to predict because of lack of site- specific information on populations. However, reclamation should restore potentially suitable habitats in the long-term (i.e., > 100 years).

13.4.3.13 Canada Warbler

All of the 103.96 ha of habitats potentially suitable for Canada warbler which will be disturbed by mine development activity is located within the BWBSmw1. The 103.96 ha comprises 0.40 percent of the total forested land base of the BWBSmw1 in the Hasler Landscape Unit. Cumulative impacts to Canada warbler populations are difficult to determine because of lack of site-specific information on populations. However, because of this species preference for mid-aged structural stage forests with a high incidence of deciduous vegetation, reclamation activities following mine development will likely restore suitable habitats within 50 to 70 years.

13.4.3.14 Philadelphia Vireo

Of the 119.41 ha of potentially suitable Philadelphia vireo habitats expected to be disturbed, 103.96 ha are within the BWBS mw1 and 15.45 ha are in the SBSwk2. These areas represent losses of 0.40 and 0.07 percent of the total forested land base of the BWBSmw1 and SBSwk2 in the Hasler Landscape Unit, respectively. Cumulative impacts to Philadelphia vireo populations are difficult to determine because of lack of site-specific information on populations. However, because of this species preference for young, rapidly growing deciduous stands, reclamation activities will likely provide suitable habitat within 30 to 50 years.

13.4.3.15 Yellow-bellied Flycatcher

A total of 36.09 ha of potentially suitable yellow-bellied flycatcher habitats will be disturbed. Of potentially suitable habitats, 7.56 ha are within the BWBS mw1 and 28.53 ha are in the SBSwk2, representing 0.03 and 0.13 percent of the total forested land base of the BWBSmw1 and SBSwk2 in the Hasler Landscape Unit, respectively. Cumulative impacts to yellow-bellied flycatcher habitat is expected to be very low although it is not confirmed whether the study site is within this species' distribution.

13.4.3.16 Woodland Caribou

Only 9.79 ha of suitable caribou habitats, all within the ESSFmv2, is expected to be disturbed by mine development. The 9.79 ha represents 0.04 percent of the total forested land base of the ESSFmv2 in the Hasler Landscape Unit. Because caribou are not known from the subject property and potential habitat to be disturbed is low, no cumulative effects are anticipated.

13.4.3.17 Trumpeter Swans

Because very limited disturbance to suitable trumpeter swan habitats will occur, no cumulative effects are anticipated.

13.5 WATER QUALITY

There is limited potential for cumulative impacts of the mine with residual impacts from previous and recent logging and construction of the Willow Creek Forestry road in the proposed mine area. Areas of erosion and sedimentation have been observed. During storms, high flows and/or floods sediments in these areas could be remobilized, contributing incrementally to the suspended sediments concentrations in the streams that resulted from mining activities.

13.6 AIR QUALITY

There are presently some very limited impacts to ambient air quality in the proposed mine area, principally from vehicle exhaust and dust from road traffic. Operation of the mine will likely bring increased dust levels to adjacent areas on Highway 97. Windy, dry conditions in winter when watering is not feasible are the most likely to be problematic in this regard. Increases in emission of exhaust gases will be nearly negligible in comparison to existing vehicular traffic on the highway.

13.7 VISUAL IMPACTS

Evidence of human improvements are presently limited to areas on or immediately adjacent to Highway 97. With development of the North Pit area, an area of forest on the south side of Highway 97 will be temporarily removed. The North Pit will be active to up to seven years, at which time it will be reclaimed. For a period of some years following reclamation, the Pit will continue to be visible from the highway. High areas of the processing plant and the tops of coal stockpiles will also be visible from Highway 97 throughout the life of the mine. However, logging has occurred and continues to occur in the area which can result in patches of trees being removed. As well, the area is not a wilderness in that much of the forest along Highway 97 has been cut and human modifications made to the landscape, such as farms, villages, other industrial activity, etc.

13.8 IMPROVEMENTS RESULTING FROM PROJECT DEVELOPMENT

On closure of the central pit area, a permanent pond and wetland area could be created from 7C Pit. Once sediment levels drop to background, the pond can be stocked with sportfish. Riparian vegetation at the south end of the pond which could be made shallow will add to upland wetland vegetation in the area which is limited at present.

Fish habitat enhancement opportunities may be exploited which could include increasing the length of Willow Creek accessible to fish and improving habitat in the Pine River floodplain.

Disturbed areas will be progressively reclaimed accelerating the natural greening up process.

Better access for forestry activities will be provided if resource agencies involved approve retention of certain roads construction on the site or improved for mining.

There will be short-term improvements to wildlife habitat in some areas, such as shrubs favourable for deer, which, through progressive reclamation will be available for decades.

Over 1500 person years of employement will be created by the Willow Creek mine and the project will contribute some $270 million to the provincial economy over the 15 year projected mine life.

13.9 POST CONSTRUCTION MONITORING OF CUMULATIVE IMPACTS

Construction and operational monitoring are discussed in Section 18.0. Noise, dust and (with some time) visual impacts will cease with mine closure. At the end of reclamation once all disturbances are stabilized, any impacts of water quality and aquatic habitat will also cease. Progressive reclamation of no longer used areas will ensure a minimum of area will require reclamation and stabilization at mine closure. With seral development, wildlife habitat will in time return to pre-mined conditions. The planting and encouragement of native species will help ensure this period is a short as possible.

14.0 POTENTIAL CROSS-BOUNDARY EFFECTS

The Pine River is a tributary of the Peace River which flows into the Slave River near Lake Athabasca. The Slave River empties into Great Bear Lake and the Great Bear River flows into the Mackenzie which empties into the Arctic Ocean in Canadian Waters. The Peace River flows into Alberta and this is the point where cross-boundary effects would first be found. Considering the size of the Peace River at the Alberta border and the large and varied number of influences on the river downstream of it confluence with the Pine River, it is not possible that coal mining activities on Willow Creek, a tributary of the Pine River which is in turn a tributary of the Peace River, could have any measurable effect. Likewise the site is too remote from the Yukon and Alberta borders for air contaminants that might be generated by mining operations to be measurable at these borders.

15.0 ENERGY EFFICIENCY AND CONSERVATION

The Willow Creek Project has been designed to minimize the requirements for energy use through optimizing mine design to minimize movement of materials and optimizing coal processing to minimize handling and re-handling of coal as far as economically possible. Water will be conserved through recycling. Other opportunities for recycling will be maximized to the extent practical. Unit trains will be used to transport coal which is the most efficient option available for transport of coal to marine ports from the Project area.

The wash plant, maintenance and administration buildings will be supplied power from the B.C. Hydro grid. The operation will require an estimated maximum power of 1500 kw. The maintenance and administration buildings will be combined for efficiency both in construction materials use and conservation of energy in use, particularly heating in winter. Buildings used for administration and shops for maintenance will be insulated to preserve heat and reduce the use of propane.

16.0 PUBLIC CONSULTATION

16.1 PUBLIC CONSULTATION TO DATE

1994

A public consultation process for Pine Valley Coal's Willow Creek Project was initiated in 1994. Contacts were made with various local land owners, community groups, and First Nations people. Communications were initiated between Pine Valley Coal and the District of Chetwynd and the Peace River Regional District regarding progress and schedule for the proposed development.

Meetings were also held with a representative of the Friends of Northern Rockies and the community of Willow Flats to discuss the feasibility report, design concepts, and scheduling; topics raised by the group included visual impact, water quality, dust, noise, and traffic.

1996

Meetings were held on April 1, 1996 with MEI (Prince George) to provide a general overview of the project and developments with respect to the joint venture; on April 2 with MOF (Dawson Creek) to provide the Ministry with a general overview of the project; on April 2 with Chetwynd Town Council to provide a project update; and on April 2 at Willow Flats to conduct an information meeting on the status of the Willow Creek Project (list of attendees attached in Appendix 16.1-1).

On June 26, a representative of Louisiana Pacific was met to discuss their logging plan for Willow Flats.

1997

In January 1997, a meeting was held with the Mayor and Council of Chetwynd to discuss environmental issues, socio-economic issues, employment opportunities, transportation, the mine's economic stability, and local Willow Flats issues.

Meetings were held with MEI and MOELP in January 1997 to discuss general project status, environmental studies, and the public and First Nations consultation programs. A subsequent meeting with the BC Environmental Assessment Office was held in January 1997 to discuss similar topics.

A meeting was held in Prince George in June 1997 with the Northeast Review Committee to update the Committee on project status.

Public consultation to date is documented in Appendix 16.1-1.

16.2 PLANNED ADDITIONAL PUBLIC CONSULTATION

More extensive public consultation is planned through 1997 with local and regional government, local residents (Willow Flats), First Nations people and local interest groups. The consultation program will be implemented once the Project Report has been submitted, and the decision has been made to develop the Willow Creek project.

The consultation program will focus on Willow Flats residents, the two First Nations groups who have traditionally used the area, the District of Chetwynd, the residents of Chetwynd and surrounding areas, local government officials and interested parties including the Chamber of Commerce and Chetwynd Conservation Society. The consultation will include a series of open houses as well as group meetings.

16.3 GOVERNMENT MEETINGS

Members of EAO, MOELP and MEI (Mines Branch) visited the project site in early July, 1996 in the company of PVC and NDM personnel. The purpose of the visit was to gain familiarity with the site and to discuss issues.

Meetings were held in Victoria with the EAO in June and July 1996, January and July 1997. Meetings were also held in Victoria with MEI (Mines Branch) in February 1997. The purpose of meetings was to update key agency personnel on project progress and to discuss issues and concerns.

A meeting was held in October, 1996 in Vancouver with EAO personnel to discuss progress on studies, public and First Nations consultations to that time.

17.0 FIRST NATIONS CONSULTATION PLAN

17.1 FIRST NATIONS CONSULTATIONS TO DATE

There has been on-going consultation with two First Nations groups of Treaty Number 8 that have traditionally used the Willow Creek Project area. These two groups include the West Moberly First Nations and the Saulteau First Nations. A draft Cooperation Agreement has been negotiated between West Moberly First Nations and Pine Valley Coal, subject to ratification by the Chief and Council of West Moberly, and the Board of Directors of Pine Valley Coal. This Cooperation Agreement covers areas of archaeology and traditional land use studies, environmental protection and consultation over the life of the mine, employment and training opportunities.

Discussions have been initiated with Saulteau First Nations, but have not progressed as fast as expected due, in part, to on-going political and legal issues with the Band. Elections of a new Chief and Council are expected to be completed in July. It is hoped that a similar agreement to that of West Moberly can be completed after the new Chief and Council are elected to office.

One recent discussion was also held with the McLeod Lake Band who are interested in future contracting opportunities.

A log of consultations to date is contained in Appendix 17.1-1.

17.2 PLANNED ADDITIONAL CONSULTATIONS

Consultation with West Moberly and Saulteau will continue with their involvement in the up-dated archaeological and cultural study (scheduled for late July 1997) and presentations (following Project Report submission) by Pine Valley Coal on project impacts. PVC will also try to complete the Cooperation Agreement with West Moberly and continue discussions with Saulteau following their elections of Chief and Council. Information meetings will also be held with the Kelly Lake Band and other First Nations in the vicinity of the project as appropriate.

18.0 OPERATIONAL MONITORING AND IMPACT EVALUATION PLAN

This section discusses a conceptual operational monitoring plan to provide an on-going assessment of impacts and management plans developed to mitigate any residual impacts. Elements of the plan include:

- on-going reclamation trials (discussed in Section 7.1);
- water quality monitoring;
- dust/suspended particulates monitoring; and
- biomonitoring.

18.1 WATER QUALITY MONITORING AND FINAL CONTROL POINT FOR LIQUID DISCHARGE

There are two principal sites where water leaves the project area, one where it enters and several sites where sedimentation could occur. Contaminants of concern associated with the coal mining operation are nutrients (principally nitrogen species) and sediments. A monitoring program to be carried out while the mine is operating is proposed that contains the following elements:

- monthly monitoring for pH (field), conductivity (field), turbidity (field), nitrate, nitrite, ammonia, total dissolved and total suspended sediments at the outlet to the wetland below Middle Creek (Figure 18.1-1). This site is proposed as the final control point where discharge must meet MOELP freshwater criteria, or be at background. If feasible, a continuous flow monitor will be installed at the site. Monitoring will commence at this site prior to construction to establish background concentrations of the above-referenced parameters;

- monthly monitoring for the same parameters at the mouth of Willow Creek (Figure 18.1-1);
- monthly monitoring for the same parameters at the present water quality station WC 2 (Upper Willow Creek);
- monthly monitoring for same parameters at the present water quality stations upstream and downstream of the site on the Pine River (PR1 and PR2);
- weekly monitoring of pH, turbidity and conductivity at Willow Creek tributaries 1 and 2 at the existing Forestry Road (present Trib 1 and Trib 2 water quality stations) during periods when water is flowing; monitoring to continue until agreement between the operator and MOELP that parameters of concern have stabilized;
- weekly monitoring of pH, turbidity and conductivity at Far East Creek above where the creek goes subgravel (approximately at the present FEC1 water quality site);
- weekly monitoring of pH, turbidity and conductivity in all sedimentation ponds and at the outlet from the ponds (Figure 18.1-1) until such time as the ponds are closed or three consecutive months' data indicate turbidity consistently remains at background levels as agreed by MOELP; and
- quarterly monitoring of groundwater piezometers placed downgradient of sedimentation ponds; parameters measured will be as for monthly monitoring of surface water;.

18.2 ATTACHED ALGAE (PERIPHYTON)

A periphyton survey will be conducted at the pre-operation monitoring sites one year after commencement of mining and at the same time of year to provide a comparison of pre- and operational periphyton communities. Data will be compared on the basis of taxonomy, biomass and chlorophyll *a*, i.e. the parameters measured prior to operation. If changes in periphyton are found that can be reasonably correlated with mining activities, an on-going monitoring program will be designed in consultation with MOELP.

18.3 DUST MONITORING

The present dust monitors will be maintained for one year after mine start up. Data will be evaluated at that time to determine whether any measurable effects attributable to mining activities are evident from the data. The utility of program will be evaluated at that time and discussed with MOELP.

18.4 NOISE

A noise survey will be conducted prior to construction start up (focussing on Highway 97 adjacent to the Project site). The survey will consist of noise meter measurements at discrete times of the day over a 24 hour period. The survey will be conducted over a three day period to establish average background noise levels. The noise survey will be repeated once operation has commenced and at a time mutually agreed upon by MOELP and PVC.

18.5 OTHER MONITORING

Stability of dumps, dams and berms will be monitored on an on-going basis as part of mine safety requirements.

If useful to the project, the automated meteorology station will be maintained while the dust fall program is carried out and beyond that point if of interest to MOELP or Environment Canada.

Depending on agreed upon compensation for wildlife and fisheries habitat, the success of compensation programs will be monitored at appropriate and agreed upon periods after initiation. Agreements will be struck with the responsible agency (ies) in each case.

Pine Valley Coal recognizes there may be a requirement for an environmental effects monitoring program at some future time.

19.0 PINE VALLEY COAL LTD. COMMITMENTS TO THE ENVIRONMENT

A number of environment- and socioeconomic-related commitments have been described in this report. They are repeated here for ease of reference. The context for the commitment can be found in the section referenced in Table 19-1.

TABLE 19-1

Environment and Economic Commitments

COMMITMENT	**SECTION**
Progressive Reclamation	7.1
Waste Management	7.2
Water Management	7.3

REFERENCES

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