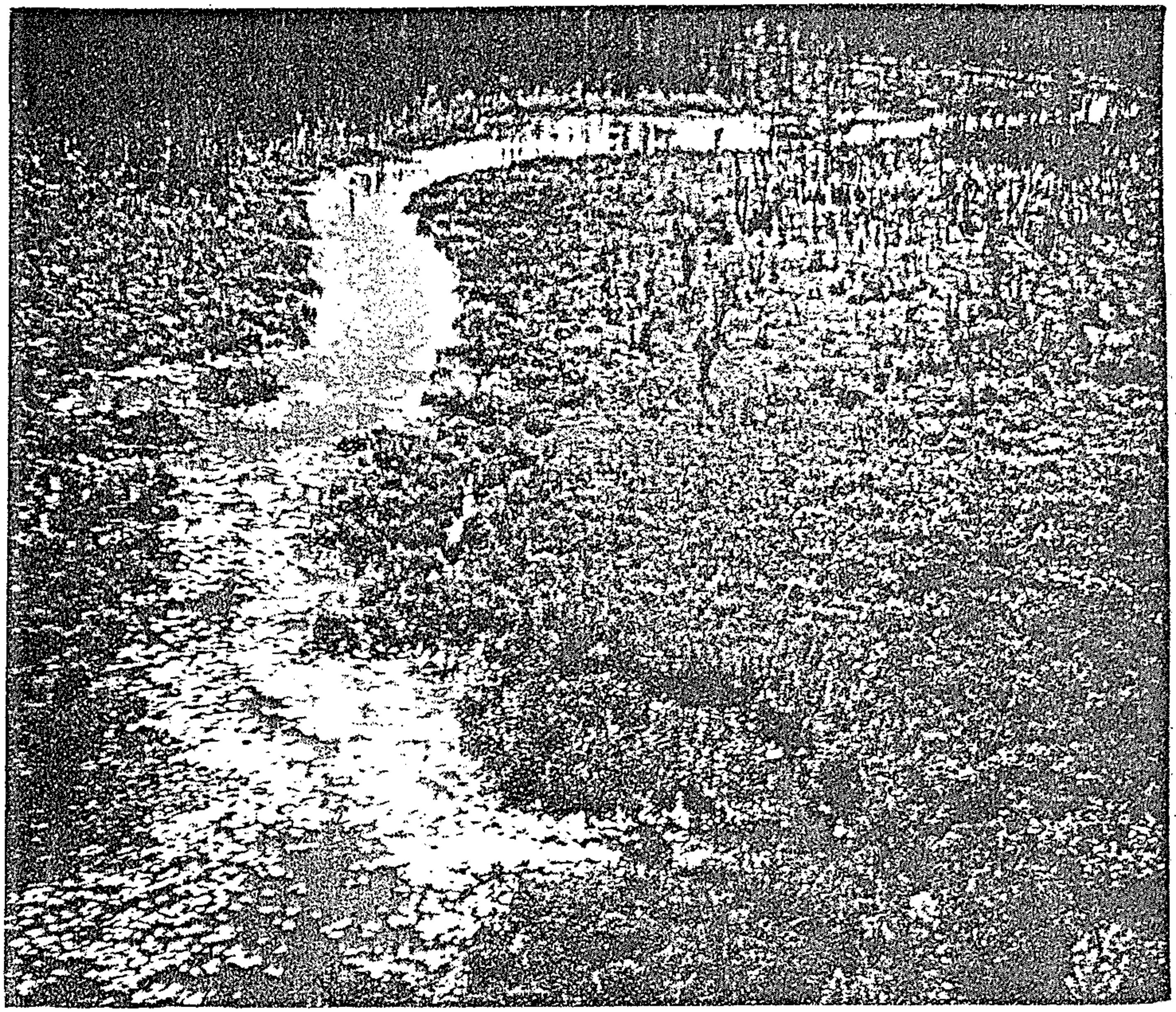
beak

PRELIMINARY ENVIRONMENTAL EVALUATION OF THE GREAT SLAVE REEF PROJECT, NWT

A REPORT PREPARED FOR

WESTERN MINES LIMITED
VANCOUVER, B.C.



Twin Creek

Beak Consultants Limited

File: K4466
Date: June 1980

INITIAL ENVIRONMENTAL EVALUATION FOR THE GREAT SLAVE REEF PROJECT

Prepared for:

WESTERN MINES LIMITED
Vancouver, B.C.

Prepared by:

BEAK CONSULTANTS LIMITED
Vancouver, B.C.

TABLE OF CONTENTS

Table of Contents Continued

Table of Contents Continued

PREFACE

The following report was prepared for Western Mines Limited of Vancouver, B.C. as the Initial Environmental Evaluation for their proposed Great Slave Reef mining project near Pine Point, B.C.

This report was prepared under the direction of Beak Consultants Limited, Vancouver, who also contributed the following team: Ian Robertson - Project Manager; Birds and Mammals; G.A. Nieminen, P. Eng. - Climate and Air Quality, Hydrology and Water Quality; J.A. Howell - Geology and Soils; D.A. Fernet -Aquatic Flora and Fauna; A.I. Moody - Vegetation. The Social and Economic section was undertaken by Mr. A.L.P. Horsman of A.L.P. Horsman and Associates. Western Mines contributed the sections on Project Rationale and Project Description.

The assistance of many people from both the Federal Government and the Government of the Northwest Territories in providing information used in this report is greatly appreciated. They are listed in Appendix B. The cooperation of Western Mines personnel has made our task much easier.

Further environmental information is being collected at the present time. In addition, further definition of project plans is anticipated. Therefore, when appropriate, further supplements to this report will be prepared.

Report Preparation Coordinated By:

Ian Robertson, M.Sc.
Project Manager

Approved by:

J.D. Ganshorn
Manager, Pacific and Yukon Divison

LIST OF TABLES

LIST OF FIGURES

1.0 OVERVIEW SUMMARY

1.1 Introduction

Western Mines Limited has been exploring the area between the Buffalo River and Hay River just south of Great Slave Lake since 1975. Two orebodies have been identified and are known as R190 and X25. While exploration is continuing, the company now plans to develop a mine at the R190 mineralization. This report has been prepared to provide the information available on the Great Slave Reef Project, in terms of an outline of the project as proposed to date, a review of existing environmental and socio-economic conditions, and a preliminary environmental and socio-economic evaluation of the effects of the proposed project development. As Western Mines Limited wishes to proceed with the project, it is anticipated that subsequent discussions with the government and other parties will define areas of concern and allow development of programs to meet those concerns and licencing requirements.

1.2 Project Rationale

Development of a mine at the Great Slave Reef Project would provide a further economic base to the Hay River and Pine Point region of the Northwest Territories by means of additional employment opportunities, benefits to local and regional commerce and government revenue.

1.3 Project Description

Present development plans are to exploit the reserves of lead-zinc ore at the R190 orebody. An underground mining operation presently appears the most cost effective. Ore extracted would be stockpiled and shipped to other mine-milling operations for processing. Since no processing of ore is planned on site, tailings disposal facilities will not be required. Except for a camp facility during mine construction, no permanent housing accommodation is planned at the mine. Employees would live in Pine Point or Hay River and commute daily to the mine site. Because the mineralization zone is located in a geological formation containing considerable groundwater, mine dewatering will be necessary, similar to operations at Pine Point Mines Limited at Pine Point. It is proposed to dispose of mine dewatering waters into lowland areas north of the mine where they can dissipate back into the ground without runoff into local creeks and rivers with identified or potential resource values.

1.4 Existing Environment and Resource Use

The study area is located within an extensive stand of mature and possibly over-mature boreal forest. Two main drainages, Buffalo River and Twin Creek, emptying into Great Slave Lake comprise the existing area of exploration. The former is important to fisheries, serving as an important fish migration route. There is a commercial fishery for the Buffalo River run of inconnu. A sports fishery has developed in Polar Lake stimulated by residents of Pine Point.

There is bird life typical of the boreal forest, and the south shore of Great Slave Lake appears to be an important concentration site for birds on migration. Woodland caribou and moose are the chief ungulates in the study area, but none of the large mammals are very common in the study area. Hunting and trapping are a minor concern in the study area.

The exploration area lies close to the road, and rail links between Hay River (pop. 3,500-4,000) and Pine Point (pop. 1,700-2,000) provide easy access to them and the services they provide. Native Indians are a significant component (approx. 20%) of the population with the Hay River Band being the most significant local Indian organization.

Both centres have experienced a recent population decline and thus tend to offer services which could accommodate a greater population.

1.5 Environmental Impacts

At present, development plans for the Great Slave Reef property are modest with no on-site processing contemplated. The primary impacts consist of: i) disturbance to the terrain and resulting habitat alteration, and ii) discharge of upwards of 30,000 gpm of groundwater during the continuous dewatering operations, and related impacts, should the drawdown cone extend through the overburden.

Specifically, site development will involve some disturbance to the terrain, but the possibility of significant erosion is small if careful mining procedures are followed. Vegetation will also be locally disturbed, and revegetation may be necessary if vegetative cover is removed from too extensive an area. Impacts on vegetation may occur in bog areas receiving pit dewatering discharges. More remote is the possibility that the drawdown cone will extend through the overburden leading to likely die off of the forest in the effected area. Pump tests are presently determining this possibility.

Impacts on terrestrial birds and mammals are considered to be slight and relate to habitat changes near the development site. However, such impacts could become significant if this modest disturbance is accompanied by harassment from the mine staff or the general public attracted to the site by improved access.

The fate of the pit dewatering discharge and the extent of the drawdown cone have a major impact potential to fish and aquatic birds and mammals. The prime concern is the Buffalo River drainage and the sports fishery at Polar Lake.

1.6 Mitigating Measures

The principal mitigation measures are efforts directed at providing better definition of possible impacts. The chief one concerns the areal extent of the drawdown cone, the results of which should be known this year, 1980. This will help determine impacts on wetlands and vegetation on the surface. Surface water investigations should be maintained on a seasonal basis and the addition of a few stations should be considered. Pit dewatering effluent should be discharged into bog rather than fen habitats.

To maintain the aesthetic qualities of Polar Lake environs, consideration should be given to moving the mine facilities closer to the R190 orebody.

Backfill for mined out areas will come from nearby lacustrine deposits. Although there is an abundance of raised beaches and till ridges in the area, extensive disturbance might require substrate rehabilitation in addition to some planting.

Exploration will expose wildlife populations to the potential of greater hunter pressure. As a response, hunting should be discouraged and guns prohibited at the camp except under the control of the mine manager, and used only to protect the site from nuisance animals such as bears. Means to discourage nuisance animals are discussed.

1.7 Residual Impacts

Residual impacts are not believed to be great. They include: i) habitat alteration near the mine affecting terrestrial flora and fauna, ii) habitat change in the boggy areas used for pit dewatering discharges.

2.0 PROJECT RATIONALE

2.1 Declaration

This preliminary environmental evaluation is restricted to consideration of the potential environmental and socio-economic effects resulting from the development of a lead-zinc mine and support facilities by Western Mines Limited at a site south of Great Slave Lake west of the Buffalo River in the Northwest Territories. Section 3.0 outlines the description of the proposed development.

The intent of this environmental evaluation is to review the environmental information available for the area with a view to assessing its adequacy; the need for further studies and to present a report for discussions with government and regulatory agencies. These discussions would identify areas of concern to the regulatory agencies; programs to be undertaken in parallel with pre-operation phases of the project and, programs aimed at evaluation and resolution of long-term potential concerns: e.g., effluent qualities and quantities, and ultimate site reclamation or abandonment plans.

This report has been prepared using existing guidelines for preparing preliminary or initial environmental evaluations for mining developments.

2.2 The Need

Western Mines Limited has been exploring the area of the proposed mine development for several years. ~~At this point~~ two significant ~~orebodies~~ of lead-zinc mineralization have been identified. ~~At this point~~ one orebody at site R190 appears to be of sufficient size and quantity to economically justify a mining operation in which the ore would be transported elsewhere for processing. At present, insufficient reserves have been identified to warrant an on-site ore processing plant. The development of a mine would provide a further economic base for the Hay River-Pine Point region and the Northwest Territories in general. In addition to providing additional direct employment opportunities to people of the area, the development would benefit local contractors, business owners and the general regional economy and government revenue.

There is a need as well to develop the underground mining technology for recovery of the types of orebodies that exist in the area being explored. Development of the R190 orebody will require mine dewatering similar to that utilized at Pine Point, however, mining would be underground rather than open pit.

2.3 Alternatives

The alternatives available to Western Mines Limited other than not proceeding with a mine development as described in Section 3.0 are as follows:

a) Delay development until a larger orebody is found to justify a mine-mill complex. The probability of significantly larger orebodies being found is possible but is considered low.

b) Develop a mine at both the R190 and X25 orebodies. The X25 orebody is smaller than the R190 mineralization and the economics of development are considered less attractive at this time. Development of the X25 orebody may be possible at some time in the future.

2.4 Associated Projects

At the present time, Western Mines Limited is continuing to explore in the AX Claim Group (Great Slave Reef Project) and in the WD and BES Claim Group (West Reef Project) for additional mineralizations. The environmental and socio-economic effects of further discoveries and developments resulting therefrom cannot be identified at this time.

If a proposal by others is initiated to increase output of the Talston River power project for the purposes of supplying more power to Pine Point, as well as introducing hydro power to Hay River, a powerline corridor through the area of the Great Slave Reef Project may result. Environmental aspects of this possibility are not examined in this report.

DRAFT

3.0 PROJECT DESCRIPTION

This summary describes the most likely mining concept as viewed by ~~the mine manager~~ at this time. Economic feasibility of this concept is under investigation and results should be known in 1980.

3.1 Development Concept

The Great Slave Reef structure has been shown to be a continuation of the ore bearing structure at Pine Point Mines Limited. Historically this structure has contained many scattered, relatively small lenticular lead zinc deposits. Several mineralized deposits at Western's Great Slave Reef property ranging from 90,000 metric tons to 900,000 metric tons have been located to date.

The deposits are overlain by dolomite, shale and overburden with an average depth of 130 metres. The dolomites which host the lead-zinc mineralization are very permeable and would require extensive dewatering prior to mining.

The R190 orebody would be mined first as a pilot situation in order to verify technical and economic feasibility of deep mining in this area. Favourable results coupled with delineation of further reserves by diamond drilling could lead to subsequent larger scale production.

Development of the R190 orebody would require the drilling of approximately 15 to 20 wells. Required groundwater discharge is at present estimated to be a minimum of 1.9 cubic metres per second (30,000 US gallons per minute). Estimated pumping time is five years - two years for initial dewatering and mine development and three years for the actual mining of the orebody. Water would be discharged into an appropriate swampy area.

Access to the mine would be attained by sinking a vertical shaft to the 200 metre horizon. In addition, a vertical ventilation shaft would be bored.

Facilities constructed on-site during the preproduction period would include the shaft headframe, hoistroom, 5 MW diesel power plant, compressor room, change house, backfill plant, mechanical and electrical shops, offices, warehouse and storage area.

Construction crews and mine staff would be housed in either Pine Point or Hay River and bused to the work site. There are preliminary indications that Pine Point Mines Limited has spare bunkhouse capacity which could be rented or purchased.

3.2 Orebody

The R190 deposit contains some one million tons of rock containing 18 percent combined lead and zinc. Seventy-five percent of this should be recoverable by normal mining methods.

3.3 Mining

The R190 orebody would be mined underground by a mechanized cut and fill mining method. Drilling would be done by jumbo mounted drills and broken ore transferred by rubber tired diesel equipment. Run of mine ore would be hoisted to surface via the main service-production shaft. Approximately 20,000 metric tons of ore per month would be mined. Mined out areas would be backfilled with a sand-cement mixture. Sand would be obtained from a gravelly ridge near the mine site.

Ore would be stockpiled on surface pending a decision to go to larger scale production or to truck and sell it to a custom mill.

The workforce requirements are estimated to be 115 to 120 people including surface diamond drilling.

3.4 Processing and Tailing Disposal

No mineral processing is envisioned on-site during mining of the R190 orebody. There would therefore be no tailings disposal problem.

3.5 Mine Products

The mine would produce run of mine ore.

3.6 Miscellaneous Waste

Estimated waste rock at the R190 site from preproduction development would be 15,300 cubic metres. Very little waste rock would be mined after the initial preproduction period.

The other source of waste material is groundwater discharged by dewatering operations. Groundwater would be ditched to discharge areas. This process represents a potential water quality problem and is discussed at length in Section 4.3.

3.7 Supporting Industrial Services and Associated Projects

The heaviest use of supporting industrial services would be during the construction stage when local contracting firms would be invited to bid on specific projects. It is anticipated that supplies would be shipped via rail to Hay River or trucked from the distributor directly to the mine site. Possibly a local trucking firm would be contracted to haul ore to a custom mill.

Housing would have to be provided in one of the adjacent communities. The details of this have yet to be worked out but serviced lots are available in Pine Point and Hay River. Western would provide some form of financing for home construction. Bunkhouse accommodation for construction crews would be utilized during the production stage for single men.

In the event of a later decision to expand to larger scale production, including a concentrator, it would be desirable to obtain electric power from a public utility and use the company power plant for emergency standby power only. This source of power is not available at present.

3.8 Hazardous Material Control

Since in the present concept, no mineral processing is envisioned on-site, there will be no requirement for process circuit reagents. Fuel storage, explosives and other materials would be stored as required according to government guidelines and regulations.

3.9 Construction Details

All buildings would be constructed at the R190 site and would be of metal construction. Waste rock from the preproduction period would be used for fill in the plant area and if suitable for road construction. There is additional sand and gravel available on-site. Wherever possible, buildings would be under one roof to conserve heat.

3.10 Abandonment

All legal requirements concerning abandonment would be fulfilled. All entrances to the underground mine would be sealed off. There would be minimal disturbance through waste piles due to the small volume of waste rock.

3.11 Energy Conservation

The mine and facilities would be designed with cost effective energy conservation measures in mind to reduce fuel requirements. Waste heat from the power plant would be utilized for heating.

3.12 Study Area

The primary study area is bounded by the Buffalo River to the east, Twin Creek to the west, Great Slave Lake to the north and Highway No. 5 to the south as shown in Figure 3.1.1.

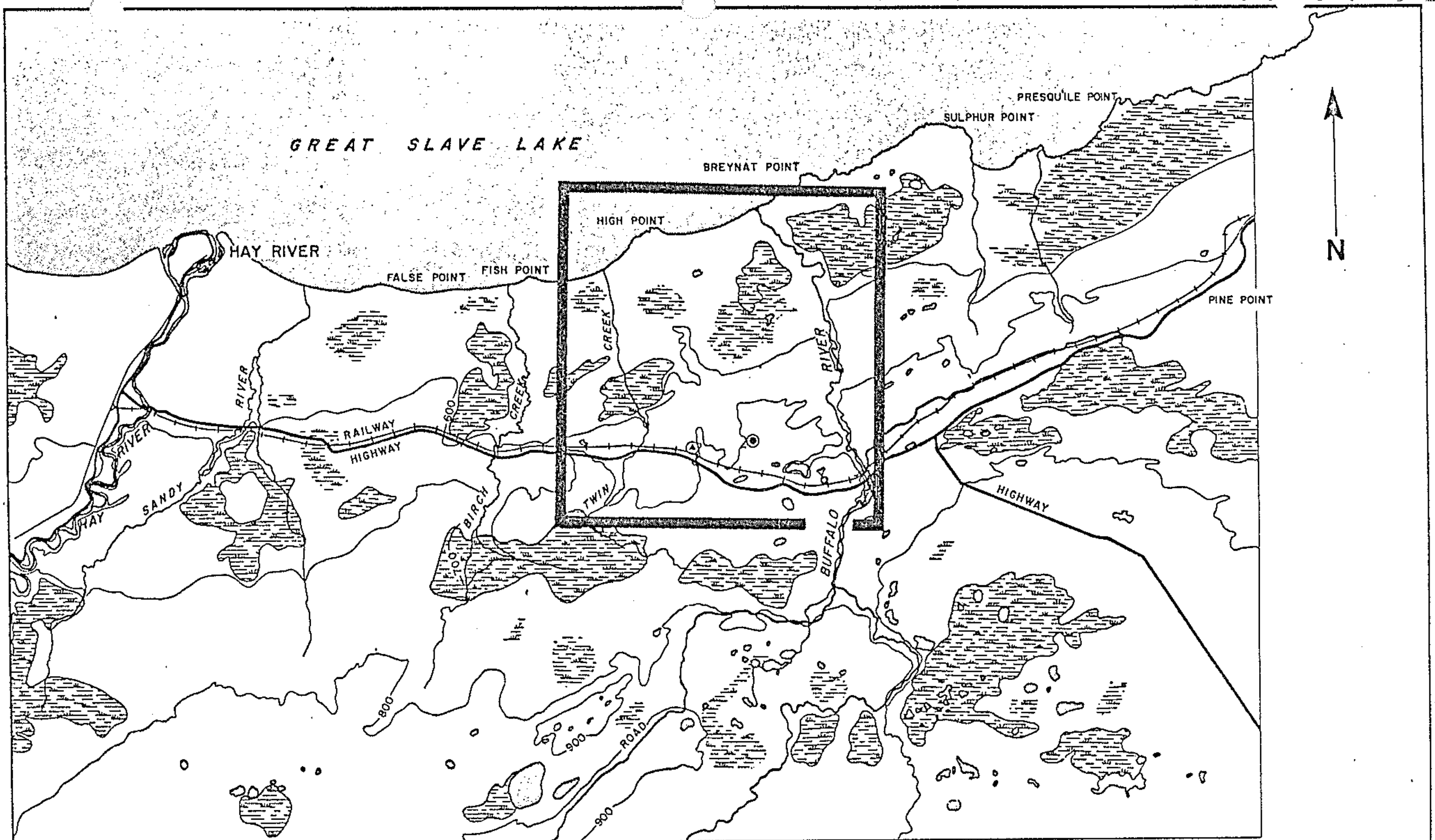


FIGURE 3.1-1: Primary Study Area

◎ X25 OREBODY

▲ R190 OREBODY

SCALE

0 5 10km

CONTOUR INTERVAL = 100 FEET

beak

DATE	March 80 HV
PROJECT	K4466
DWG NO	

VANCAL-4363

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT AND RESOURCE USE

4.1 Climate and Air Quality

4.1.1 Precipitation And Evaporation

Data on the main forms of precipitation (rain and snow) in the proposed mine site area from Atmospheric Environment Service (AES) for Hay River and Pine Point averaged to represent conditions at the site are shown in Table 4.1-1. A day with measurable rain is one where 1/100 of an inch or more has fallen, and a measurable snowfall day is one where 1/10 of an inch or more of snow has fallen. A day with measurable precipitation is one where 1/100 of an inch of water equivalent is recorded.

The area annual lake evaporation and evapotranspiration is about 40 cm/yr and 25 cm/yr respectively (Hydrological Atlas of Canada).

Table 4.1-1

Precipitation and Evaporation Summary

Mean Precipitation (Total Annual)	cm	34.2
Mean Precipitation (Mean Monthly)	cm	2.8
Mean Rainfall (total annual)	cm	18.6
Mean Snowfall (total annual)	cm	161.0
Days with measurable precipitation (total annual)	cm	99.0
Days with measurable precipitation (mean monthly)	cm	8.3
Annual Evapotranspiration	cm	25.0

These data indicate that the proposed site can expect measurable precipitation approximately 27 percent of the time on an annual basis.

The month of August contributes the highest monthly rainfall with November having the highest monthly snowfall and overall precipitation throughout the year.

4.1.2 Temperature and Frost

The following temperature and frost conditions for the proposed mine site are averages of compiled data from Hay River and Pine Point. (AES 1941-1970)

Table 4.1-2

Temperature and Frost Summary

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Daily Temp°C	-28.2	-20.8	-14.2	-6.1	5.9	12.4	16.0	14.6	7.2	1.2	-9.1	-18.5	-3.3
Days of * Frost	31	28	31	28	18	2	0	0	8	22	30	31	229

* Frost occurs when the minimum recorded temperature is 0.4°C or less, i.e. when the minimum temperature, rounded off, is 0°C or less.

4.1.3 Fog

A day with fog is one where visibility was reduced to less than one kilometre at any time during the 24 hour period. Table 4.1-3 shows mean monthly and annual number of days with fog and ice fog. The values are taken from approximately 25 years of data compilation and because no data is available for the exact proposed mine location, they are an average of recorded data from Hay River and Fort Resolution. (Hemmerik, 1971)

Table 4.1-3

Fog Occurrence

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Monthly Days With Fog	2.1	1.1	0.9	0.9	1.4	1.3	1.0	1.3	1.4	2.2	2.1	1.6	17.2

The actual amount of fog occurrence at the mine site would be somewhat less than this as the data represent locations near the Great Slave Lake where fog formation would more readily occur.

4.1.4 Rain Intensity

Rainfall intensity for the area under consideration is best approximated by the data provided by the Atmosphere Environment Service for Hay River. Rainfall intensity is a measure of the probability of a specific amount of rain per unit of time. For example, from Figure 4.1-1, the once in 10 year - 24 hour rainfall intensity is indicated to be 2.3 mm/hr. This type of storm is frequently used to size mine surface drainage sediment control facilities.

4.1.5 Surface Winds

Extensive wind data detailing speed, directions, and frequency has been recorded for Hay River and Fort Resolution between 1955 and 1972. Wind roses in Figure 4.1-2 were generated using the average value of the two sources for wind direction and frequency but only Hay River data was used to illustrate wind speeds. The average annual wind speed (all directions) for the proposed mine site is approximated to be 11.5 km/hr. The strongest surface winds occur from the west-northwest to the north-northwest sector at about 15 - 16 km/hr (annual average). The predominant winds in the area occur from the east to east-northeast and from the northwest.

4.1.6 Meteorology

Mixing Heights and Inversions

The "mixing height" concept is founded on the principle that heat transferred to the atmosphere at the earth's surface results in convection, vigorous vertical mixing, and in the absence of moisture, the establishment of a dry-adiabatic lapse rate. During precipitation the afternoon mixing heights are lower than under non-precipitation conditions. Precipitation conditions were not considered in this report.

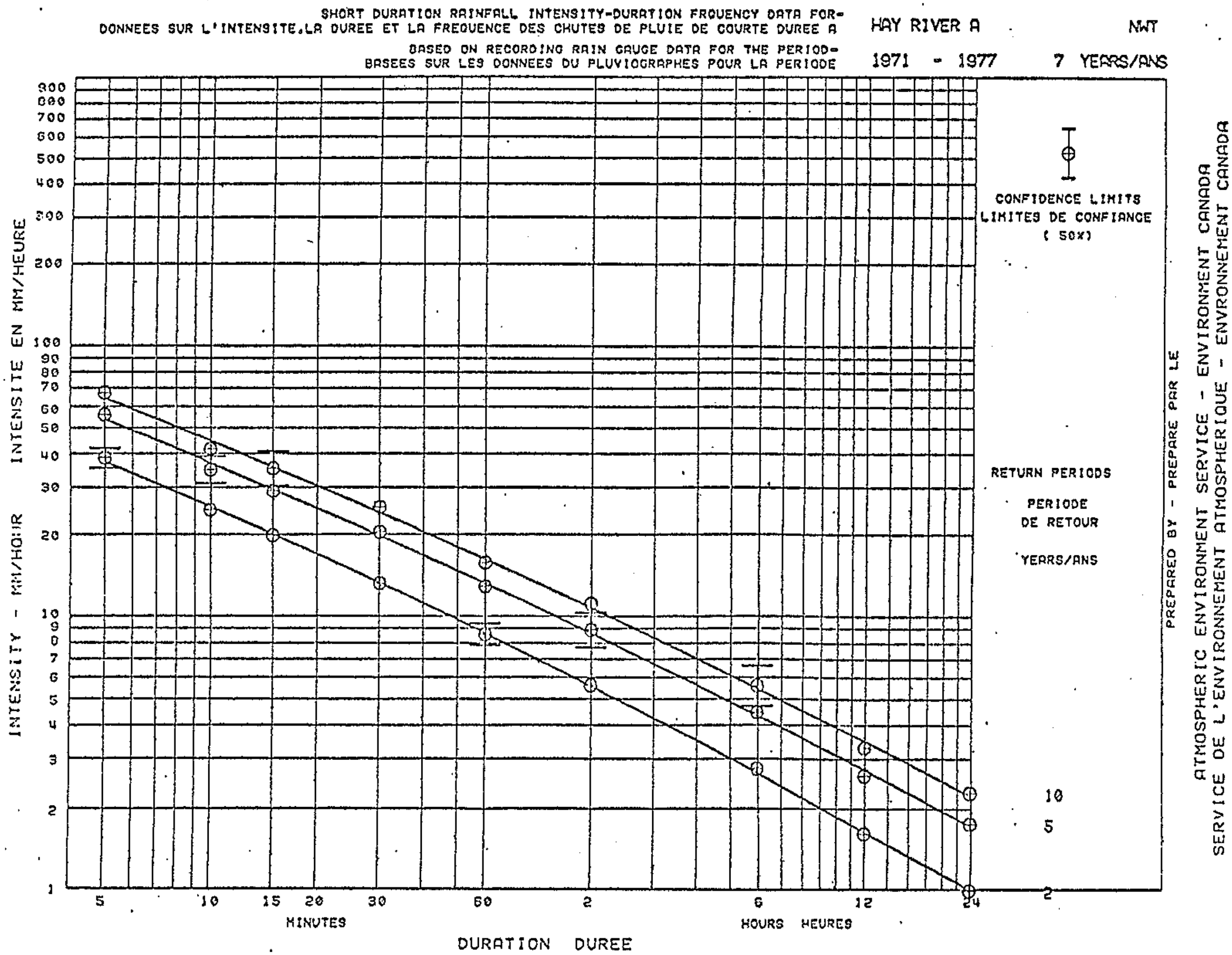
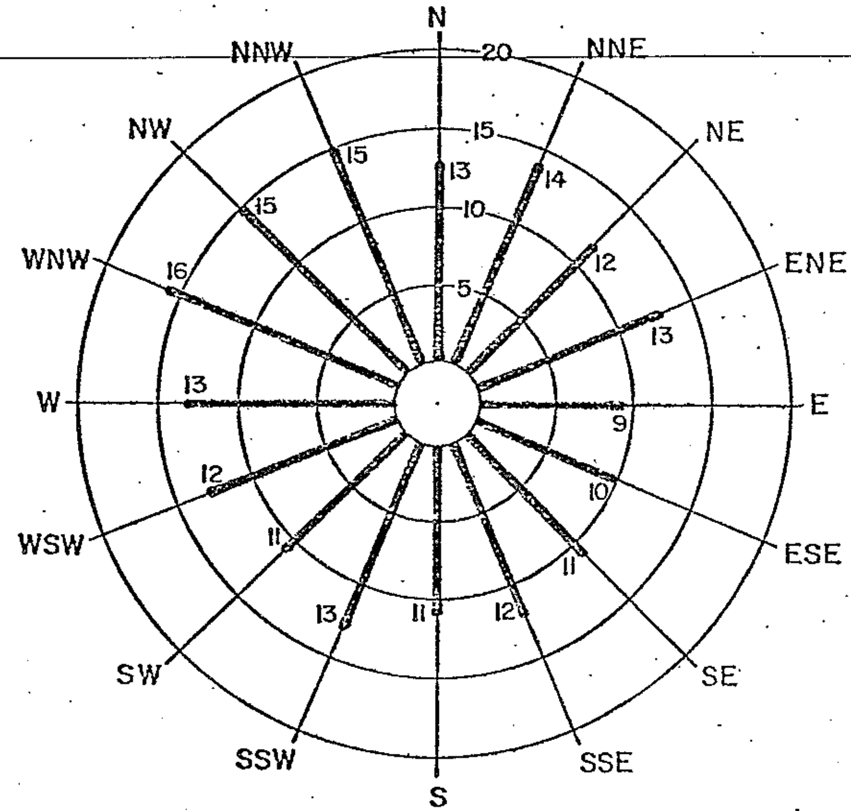


FIGURE 4.1-1: Rainfall Intensity - Hay River

DATE	DEC.79
PROJECT	K4466

A. Annual Average Surface Wind Speed (km/hour)

beak



B. Annual Surface Wind Direction Frequencies (%)

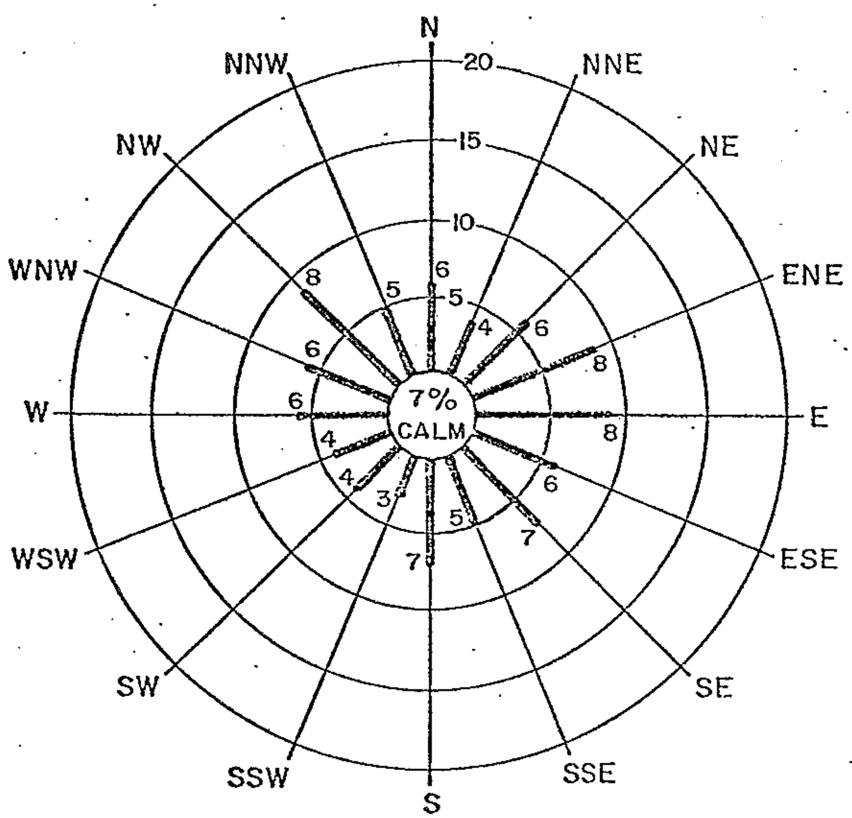


FIGURE 4.1-2: Projected Windroses

DATE	DEC. 79	H.V.
PROJECT	K 4466	
DWG. NO.		

When considering air pollution episodes, it is important to know the extent of vertical mixing during the daytime when mixing is normally maximized. Night-time mixing layers in the open-rural areas, such as those under investigation, are usually close to zero, being replaced by ground based temperature inversions. The closest source (to the site) of mixing height and mixing wind speed data is Fort Smith. Using information from stations across Canada of similar latitudes and longitudes, Portelli (1977) plotted isotherms representing seasonal mixing heights, mixing layer wind speeds, and mixing layer ventilation coefficients. Table 4.1-4 shows the seasonal variations and annual averages of these.

Table 4.1-4

Seasonal Mixing Heights, Mixing Wind Speeds, and Mixing Layer Ventilation Coefficients*

	Mixing Heights (m)	Mixing Layer Wind Speeds (m/s)	Ventilation Coefficients (m^2/s)
Spring	1000	5	5400
Summer	1500	5.5	7700
Autumn	580	5	3200
Winter	230	3.5	1000
Annual	880	4.5	4600

* Average afternoon maximums

Mixing Layer Winds

The mean mixing layer wind is calculated by averaging the wind speeds observed at a number of levels through the mixed layer. For the proposed site, annual value is about 4.7 m/sec based on interpolation of the data available for the region.

Mixing Layer Ventilation Coefficient

The product of the mixing height and the mean wind speed in the mixed layer is referred to as the "ventilation coefficient". It can be interpreted as a ventilation or dilution factor so that the greater the ventilation co-efficient, the more able the atmosphere is to disperse pollutants.

4.1.7 Air Quality

Guidelines and Regulations

Currently, the Northwest Territories does not have regulations governing the release of pollutants into the atmosphere from stationary or non-stationary sources. They also do not have regulations covering the ambient air quality of the Territories overall. They have adopted the Department of the Environment - Arctic Mining Industry Emission Guidelines and the National Air Quality Objectives but to date they remain only guidelines and objectives. The appropriate values from these documents are listed in Tables 4.1-5 and 4.1-6.

Existing Air Quality

No information on ambient air quality in the proposed mine site area is available at the present time. The nearest ambient air surveillance station, for which data is available, is located at Yellowknife. Because of the degree of industrialization in that area, it is felt that the data would not be reflective of the air quality characteristics of the area near Western Mines operations.

4.2 Geology and Soils

The geology and soils portion of this report is based on a review of the literature and examination of aerial photographs of the study area. Because this is an initial environmental evaluation of the area, detailed mapping of the surficial deposits and soils has not been included. Instead, descriptions and conclusions are based primarily on existing information.

Table 4.1-5

Arctic Mining Industry
Source Emission Guidelines

Contaminant	Emmission Rate	
Particulate Matter	0.040 gm/m^3	(0.017 grains/ft^3)
Sulphur Dioxide	1.1 gm/1000 Kcal	(0.61 lb/million BTU)
Opacity	20 %	

Table 4.1-6

Federal Ambient Air Quality Objectives

Contaminant	Concentrations ($\mu g/m^3$)	Range of Quality
Sulphur Dioxide	0-30 (annual arithmetic mean) 0-150 (average 24 hour conc.) 0-450 (average 1 hr. conc.)	Desirable
Sulphur Dioxide	30-60 (annual arithmetic mean) 150-300 (average 24 hr. conc.) 450-900 (average 1 hr. conc.)	Acceptable
Suspended Particulate	0-60 (annual geometric mean)	Desirable
Suspended Particulate	60-70 (annual geometric mean) 0-120 (average 24 hr. conc.)	Acceptable
Nitrogen Dioxide	0-60 (annual arithmetic mean)	Desirable
Nitrogen Dioxide	0-100 (annual arithmetic mean) 0-200 (average 24 hr. conc.) 0-400 (average 1 hr. conc.)	Acceptable

4.2.1 Bedrock Geology

The bedrock geology of the Great Slave Reef Project area has been discussed in detail by Randall (1977). The following summary is from his report.

The area is underlain by slightly deformed Ordovician through Devonian marine sedimentary rocks which strike N 65^{o}E and dip very gently to the southwest. Figures 4.2-1 and 4.2-2 are cross-sections of the study area, showing the bedrock units and overlying unconsolidated sediments. The location of the cross-sections are shown in Figure 4.2-3.

The Keg River Formation consists of marine sands with shale beds. Overlying this formation is the Pine Point Group which is a sequence of marine shales, limestones and dolomites and evaporites. The Presquile Dolomite is a member of this group. The Watt Mountain Formation, a light-coloured micrite (microcrystalline calcite) with pockets of shale and clay overlies the Pine Point Group. Above the Watt Mountain is the Slave Point Formation. This unit consists of marine limestone and dolomites with a shale bed, the Amco Shale, at the bottom. Overlying the Slave Point Formation is the Hay River Formation, composed of shales and limestones. This unit is overlain by unconsolidated sediments, discussed below.

The bedrock has been faulted parallel to the strike, creating three fault zones of highly fractured rock. Collapse structures are present in the Pine Point Group, representing karst development which began during the erosional period following the lithification of this group and continued after overlying sediments had been deposited.

Minerals present in the deposits include galena, sphalerite, marcasite and pyrite in a gangue of dolomite and calcite. Traces of bitumen and swamp gas are also present in the area.

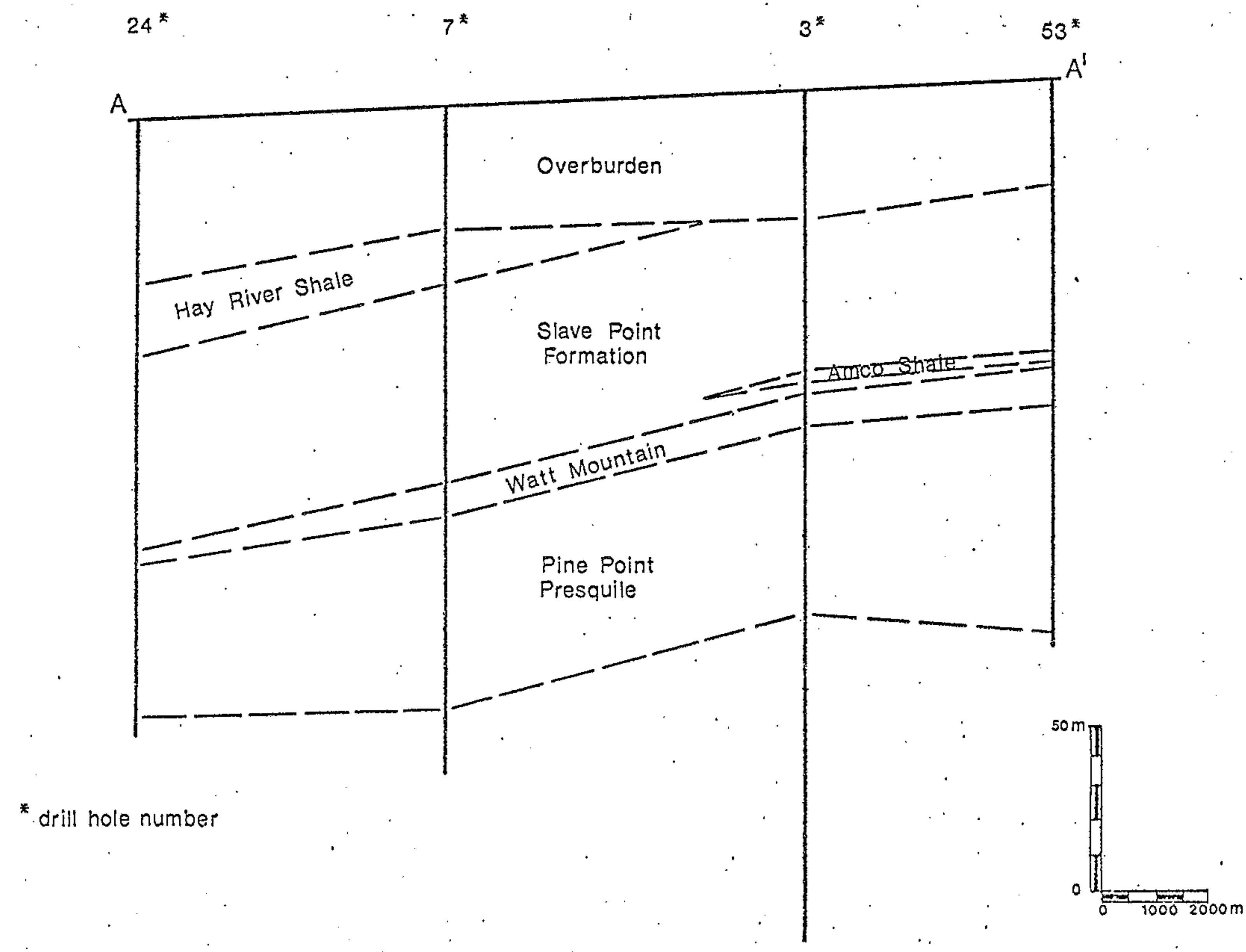


FIGURE 4.2-1 : Great Slave Reef Project Area geologic cross section A-A'.

DATE	March 80
PROJECT	K4466
DWG. NO	

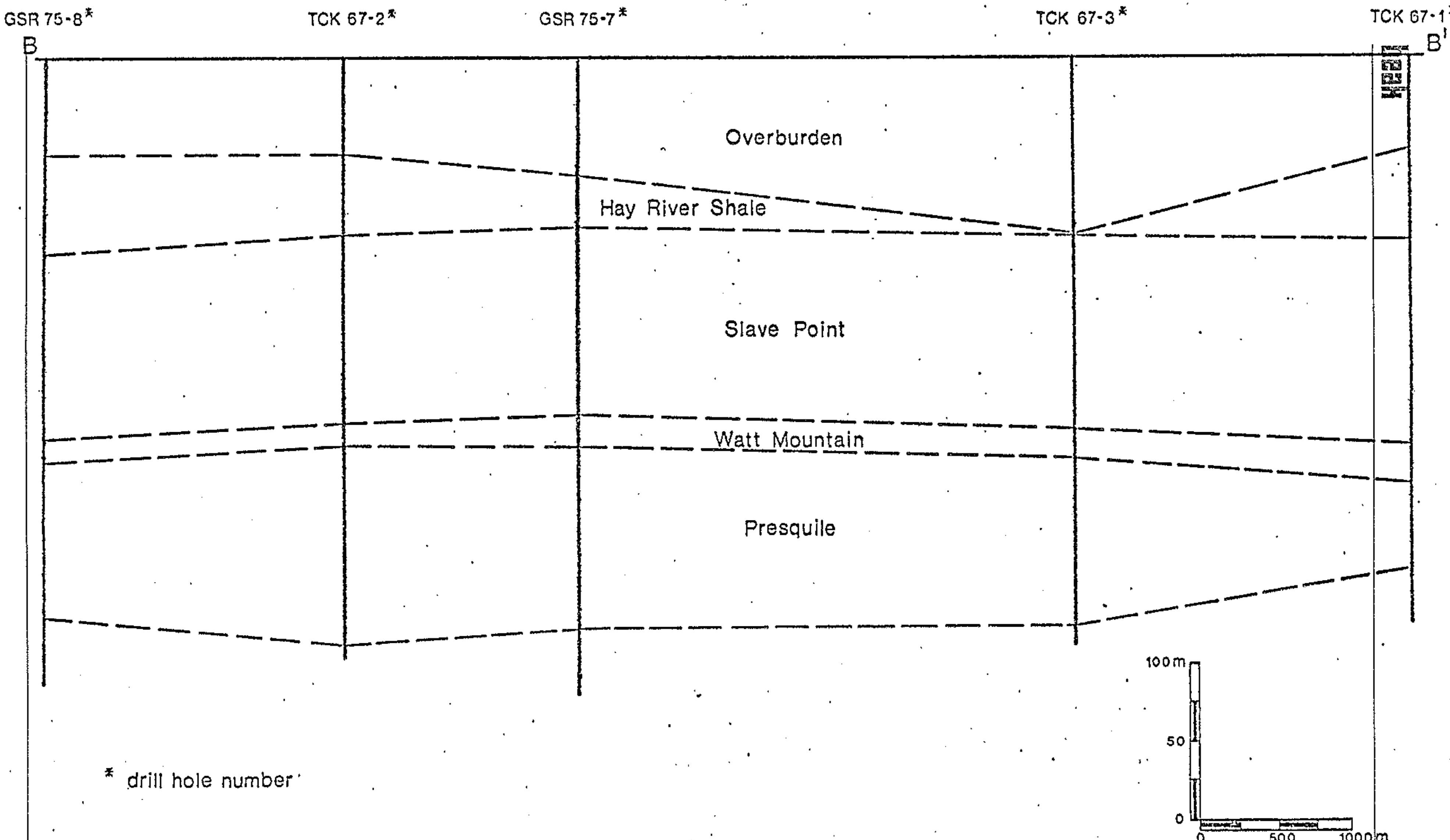


FIGURE 4.2-2 : Great Slave Reef Project Area geologic cross-section B - B'.

DATE	March 80 HV
PROJECT	K 4466
DWG. NO	

ANCAL - 4364

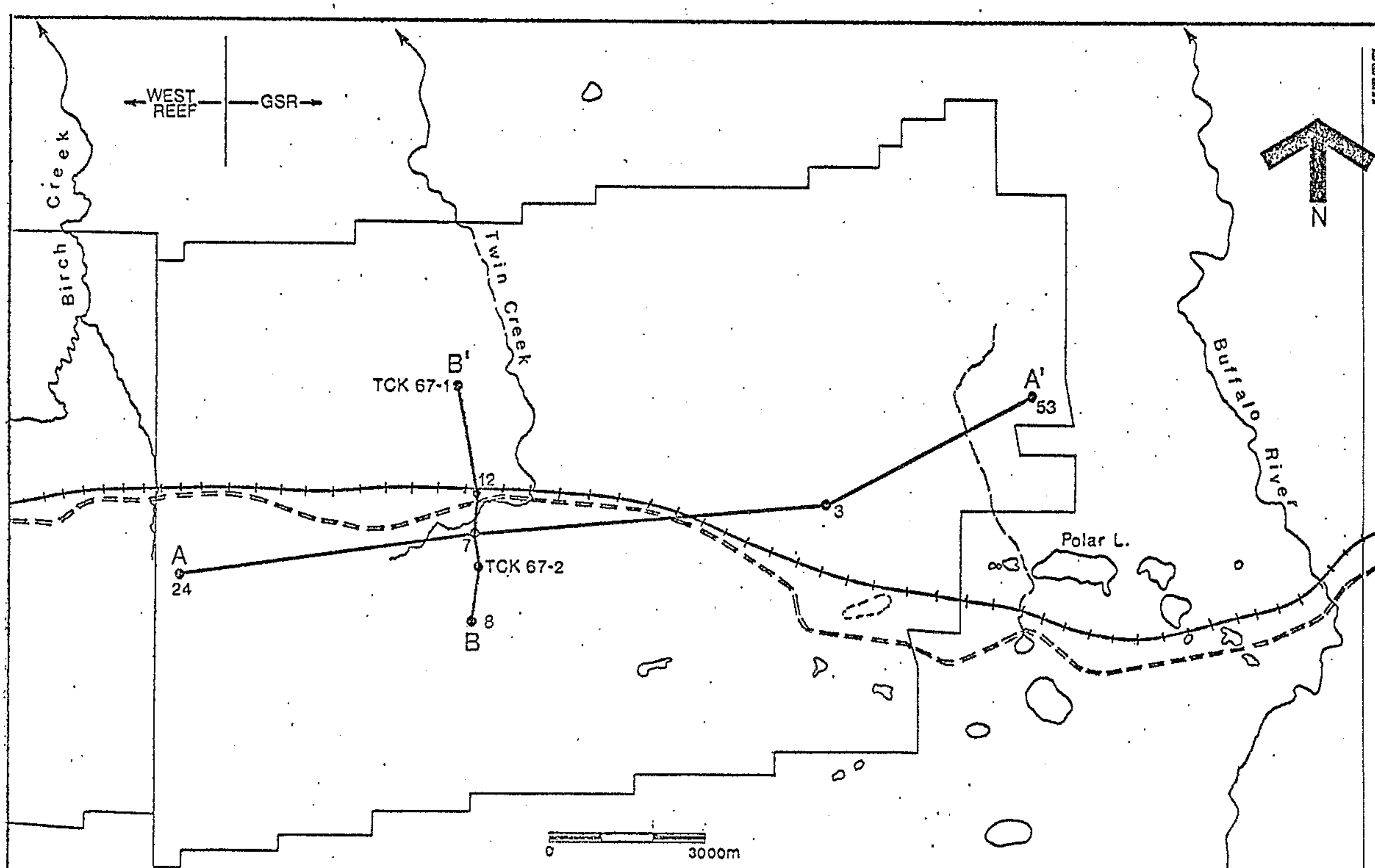


FIGURE 4.2-3: Great Slave Reef Project Area showing the location of cross-sections A-A' & B-B'.

DATE	March 80
PROJECT	K4466
DWG. NO.	

4.2.2 Geomorphology

The Great Slave Reef study area is in the Great Slave Plain Division of the Interior Plains Physiographic Region (Geol. Surv. Can. 1970). Bostock (1970) describes this division as an area of low relief with low scarps of resistant strata and small shallow lakes.

Elevations in the study area range from 175 m above sea level in the northwest to 232 m in the southeast, giving a maximum relief of 57 m. The topography for the most part, can be regarded as level to gently sloping.

The area has been extensively glaciated during the Pleistocene Epoch, and the present landforms reflect the influence of the last glaciation. Till, deposited by the glacier, and lacustrine deposits from the glacial stages of Great Slave Lake are present throughout the area, and are overlain in places by post-glacial fluvial and organic deposits. The area is in the zone of Discontinuous Permafrost (Brown 1978) where frozen ground is widespread. Investigations by BEAK personnel revealed the presence of permafrost in some of the organic landforms at the site. Total thickness of unconsolidated materials is as great as 90 m, although the thickest sections are associated with collapse features in the underlying bedrock (Randall 1977).

The following description of the landforms in the Great Slave Reef Project area is taken from B.C. Research's (1977) description of the adjacent Pine Point area.

Till is unsorted, unstratified material deposited directly by a glacier. In the Slave Lake area, much of the till has been reworked by wave action from Glacial Slave Lake. This has resulted in a removal of finer materials and the deposits often resemble coarse fluvial materials. However, this phenomenon is restricted to the uppermost portions of the till and finer textured beach deposits are found capping the till in most places. The beach deposits range from 2 to 80 cm in thickness. The topographic expression of the till is level to irregular, very gently sloping, for the most part, suggesting that the resultant landform is ground moraine. Till ridges are also present.

Lacustrine deposits in the study area were deposited in Slave Lake during the retreat of the last glacier when lake levels were higher. The materials are finer grained than the till, having greater than 50 percent clay and silty clay to clay textures. In most cases, the lacustrine deposits occur at lower elevations than the till. Landforms associated with these deposits are lacustrine plains, lacustrine complexes and beach ridges. The plains are relatively flat to gently sloping areas of lake sediments. Lacustrine complexes are found along the base of till ridges, on portions of the lacustrine plains and in depressions. These landforms consist of lake sediments overlain by coarser grained beach deposits that may be over 1 m thick. Beach ridges, consisting of stratified sands and fine gravel, are common in the northeastern portion of the study area where several of them occur sub-parallel to one another. These ridges mark former shorelines of Great Slave Lake.

Fluvial deposits, in the form of coase grained outwash terraces, are present overlying the till, in places.

Extensive areas of organic terrain are present in the study area. The organic deposits occur in depressions and former lagoons, generally overlying lacustrine matrials. Both fens (meadow-like areas nourished by mineral waters) and bogs (treed and non-treed areas nourished principally by rainwater) are present. Permafrost is present in some of the organic deposits. Organic material thicknesses range up to 3 m (Randall, 1977).

4.2.3 Soils

The study area falls within the region of Dominantly Brunisolic Soils on the Soils of Canada map (Clayton et al., 1977). The dominant soil subgroup (covering >40 percent of the map unit) is Orthic Eutric Brunisol while subdominant groups (>20 percent) are Orthic Gleysol and Cryic Fibrisol. The Soils of Canada map was published prior to the new Canadian System of Soil Classification (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978), in which the Cryosolic Order was introduced. Cryic Fibrisols are now classified as Fibric Organic Cryosols.

Soil climate, according to Clayton et al. (1977), is Subarctic, very cold (mean annual soil temperature -7 to <2°C) to cryoboreal, cold (mean annual soil temperature 2 to < 8°C) with organic soils containing permafrost being classified as the former. The moist unsaturated regime is subhumid (soil dry in some parts when soil temperature ≥5°C in some years) to humid (soil not dry in any part for as long as 90 consecutive days in most years). The aquic regime is subaquic (soil saturated for short periods).

Although the soils of the Great Slave Reef Project area have not been studied in detail, B.C. Research (1977) has mapped the soils immediately to the east as part of the environmental impact study of Pine Point for Cominco Ltd. The soils of the Great Slave Reef Project area are expected to be similar to those at the Pine Point site. The Pine Point soils were mapped as soil associations and classified at the subgroup level according to the 1974 System of Soil Classification for Canada (Canada Dept. Agriculture 1974). A total of sixteen associations were described and mapped on four types of surficial material. These are shown in Table 4.2-1 which has been adapted from B.C. Research and updated to incorporate the latest edition of the Canadian System of Soil Classification (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978). The associations are described below.

Associations Developed on Till

Till that has been minimally modified by wave action and has a stony gravelly sand to sandy clay loam texture supports rapidly drained Orthic Eutric Brunisols and Brunisolic Gray Luvisols.

In areas where the till is capped by shallow beach deposits, the material has a gravelly sand to sandy loam texture. Rapidly drained sites occur along ridgetops and are characterized by Orthic Eutric Brunisols and Eluviated Eutric Brunisols. At imperfectly drained sites along the margins and in the depressions on the ridges, Gleyed Eutric Brunisols are present.

Low-relief ridges with a high water table are imperfectly to poorly drained. The dominant soil is a Gleyed Eutric Brunisol while Rego Gleysols, which in some cases have up to 60 cm of peat at the surface, are subdominant.

Table 4.2-1

Relationship Between Surficial Material, Landform, Drainage and Soil Associations in the Pine Point Area

(adapted from B.C. Research 1977)

SURFICIAL MATERIAL	LANDFORM	TEXTURE	DRAINAGE	DOMINANT SOIL	SUBDOMINANT SOIL
Till	Till complex	Stony gravelly sand to sandy clay loam	Rapidly drained	Orthic Eutric Brunisol	Brunisolic Gray Luvisol
		Gravelly loam	Rapidly drained	Brunisolic Gray Luvisol	Orthic Eutric Brunisol
	Shallow beach sands over till	Gravelly sand to sandy loam	Rapidly drained	Orthic Eutric Brunisol Eluviated Eutric Brunisol	Gleyed Eutric Brunisol
			Imperfectly to poorly drained	Gleyed Eutric Brunisol	Rego Gleysol
Lacustrine	Lacustrine plain	Clay	Moderately well to imperfectly drained	Brunisolic Gray Luvisol	Rego Gleysol
		Clay	Imperfectly to poorly drained	Rego Gleysol	Gleyed Eluviated Eutric Brunisol
		Silty clay to clay	Imperfectly to poorly drained	Gleyed Gray Luvisol	Rego Gleysol
			Poorly drained	Rego Humic Gleysol	Rego Gleysol

Table 4.2-1 continued

SURFICIAL MATERIAL	LANDFORM	TEXTURE	DRAINAGE	DOMINANT SOIL	SUBDOMINANT SOIL
	Lacustrine	Loam	Moderately well to imperfectly drained	Gleyed Eluviated Eutric Brunisol	Rego Gleysol
		Loam to silt loam	Imperfectly drained	Rego Humic Gleysol	Rego Gleysol
		Sandy Loam to silty clay	Poorly to very poorly drained	Humic Gleysol	-
	Beach ridge	Sand Loamy sand to loam	Rapidly drained Imperfectly drained	Eluviated Eutric Brunisol Gleyed Eutric Brunisol	Gleyed Eutric Brunisol Rego Gleysol
Fluvial	Outwash complex	Stony gravelly sand to sandy loam	Rapidly drained	Brunisolic Gray Luvisol	Eluviated Eutric Brunisol
Organic	Fen over lacustrine	Fibric	Very poorly drained	Typic Fibrisol	Rego Gleysol
	Sphagnum bog over beach sands	Fibric	Very poorly drained	Typic Fibrisol	Rego Gleysol

Associations Developed on Lacustrine Deposits

Lacustrine plains have clay or silty clay textures with low permeability and, consequently, moderately well to poorly drained soils. In the better drained areas with clay textures, Brunisolic Gray Luvisols dominate. The imperfectly to poorly drained sites support Rego Gleysols and Rego Humic Gleysols. On drier ridges and hummocks, Gleyed Eluviated Eutric Brunisols are present. Silty clay lacustrine deposits that are imperfectly to poorly drained support Gleyed Gray Luvisols.

Landforms classified as Lacustrine Complex consist of a few centimetres to a metre of beach deposits over the lacustrine deposits. This results in sandy loam to silty clay textured moderately well to very poorly drained soils. In the better drained areas, Gleyed Eluviated Eutric Brunisols are present. At the base of beach ridges in areas of low relief, imperfectly drained Rego Humic Gleysols have developed, while depressions and old beach lagoons host poorly to very poorly drained Humic Gleysols with carbonated phases. Beach ridges, consisting of stratified sands and fine gravels, support rapidly drained Eluviated Eutric Brunisols with Rego Gleysols in the depressional, poorly drained areas.

Associations Developed on Fluvial Deposits

Coarse-grained fluvial outwash terraces are rapidly drained and support Brunisolic Gray Luvisols and Eluviated Eutric Brunisols.

Associations Developed on Organic Deposits

Organic terrain occurs mainly in depressions and in remnant beach lagoons. It is characterized by a high water table and the dominant soil is a Typic Fibrisol. The mineral terrain surrounding the organic deposits supports very poorly drained Rego Gleysols.

4.3 Hydrology and Water Quality

4.3.1 Groundwater Hydrology

The flow pattern and the chemistry of groundwater in the area south of Great Slave Lake, between the Slave River on the east and the Hay River on the west, has been studied by Weyer et al. (1978,1979,1977/78). They have established, with a reasonable degree of certainty, that in the area, there are large regional groundwater flow systems. These systems show that the groundwater tends to flow from the Caribou Mountains, north to Great Slave Lake. Some of the groundwater is discharged to the surface at points between the Caribou Mountains and Great Slave Lake and some is discharged under Great Slave Lake. In the study area, groundwater discharges occur at the shoreline of Great Slave Lake, between Fish Point and Presqu'ile Point and along the lower reaches of the Buffalo River downstream of the highway bridge. The part of the Buffalo River which is close to the McDonald fault, where the river turns north, was also found to be a groundwater discharge area. Runoff measurements by Weyer et al. (1978,1977/78)) showed an inflow of about 5.7 m^3/sec at this point.

Information obtained from the exploration program in the region of the ore deposits X25 and R190 indicate the surface water table is near the top of muskeg layers overlying the overburden layer except in gravel ridges where this water table may be 1.5 to 9.4 m below the surface. The overburden layer consists of 30 - 37 m of dense impervious till and clay. The groundwater table observed in bore holes is generally about 22 metres below the surface, usually in the overburden layer. It is projected that this level probably reflects the piezometric head of underlying confined bedrock aquifers in the Slave Point and Pine Point horizons. The Slave Point formation below the overburden consists of 30 - 37 m of limited permeability - low porosity dense limestone and dolomite including an impermeable Amoco Shale layer. The Pine Point horizon is overlain by a shallow horizon of waxy, green shale and clay 6 - 9 m thick known as the Watt Mountain horizon. The Pine Point horizon is composed of a 37- 46 m sequence of facies varying from marine shales, evaporates and dolomite and limestone. The dolomites contain the bulk of the lead zinc mineralization and are highly porous and permeable at a depth of 60 to 90 metres below the surface. The Keg River formation of an unknown depth of granular dolomite and limestone lies below the Pine Point formation.

A pump test was conducted in the X25 orebody area by Western Mines in August 1978 in a bore hole penetrating all horizons to the Keg River unit and cased through overburden indicated a combined permeability of about 2.5 x 10^{-2} cm/sec (Golder, 1979). Hydrogeologically, the Presquille Dolomite unit is considered to be the likely main water bearing unit, although the permeability of the individual units of dolomite and overburden have not been established. A pump test planned for Spring 1980 at the R190 orebody area is attempting to establish permeability of the various horizons. This information will allow more refined estimates of mine dewatering requirements as well as allow projections of any drawdown in overburden and shallow water table levels from such operations.

4.3.2 Surface Hydrology

The general region is flat to gently sloping and a considerable area is covered by poorly drained muskeg ranging up to 3 metres deep. The area also contains several generally east-west low ridges which are considered to have been formed by old lake level beaches. Several small lakes and numerous potholes exist. The primary area of consideration in this report is bounded on the east by the Buffalo River which flows north into Great Slave Lake, on the north by Great Slave Lake and on the west by a small creek system known as Twin Creek. Highway No. 5 and the CN Railway to Pine Point run just south of the main exploration area being investigated by Western Mines. In general, the topography slopes north towards Great Slave Lake.

The lower Buffalo River flows northeasterly out of Buffalo Lake located approximately 56 km south of Great Slave Lake. The total drainage area of the Buffalo River is about 18,130 km^2 of which 17,844 km^2 lies upstream of the Water Survey of Canada Gauging Station at the No. 5 Highway Bridge (Station 07PA001). The Buffalo River is moderately incised into the surrounding terrain at the Highway bridge and drops approximately 55 metres in about 19 km of travel to Great Slave Lake.

Based on discharge records 1969 to 1978, the mean annual flow is 55 m^3/sec, mean maximum daily is 182 m^3/sec which usually occurs in May or June, however, peak flows have also been recorded in September (Water Survey of Canada).

Minimum discharge occurs in the winter when for several months, sometimes as early as January, flow can drop near zero until mid April when spring runoff begins. Ice conditions at the gauging station normally start between early October to early November with ice conditions ending in late April to late May. Small open water patches have been observed by others (Weyer) in the lower Buffalo River in late November and were attributed to groundwater discharges entering the river at these points. The mean annual surface runoff in the Buffalo River watershed above the gauging station is 17 x 10^4 hectare-metres per year or an equivalent of about 9.6 cm/year. This represents approximately 28 percent of the average annual area precipitation.

Twin Creek is a small creek system with an estimated drainage area of about 260 km^2 originating in the region about 16 - 25 km south of Highway No. 5. The upper drainage is not confined to well-developed creek bed until reaching the area near to and for about 2.7 km north of the Highway. At this point it essentially disappears into a large, open, almost treeless, swampy area for about 3.2 km before emerging as a defined creek channel again eventually reaching Great Slave Lake. Discharge records do not exist for Twin Creek nor for any other similar small system in the area. Miscellaneous flow measurements have been made on the Sandy River and Birch Creek located about 20 and 6.4 km west of Twin Creek by the Water Resources Division, DIAND (Jasper, 1979). These data have not been examined as DIAND indicated a reliable stage-discharge relationship has not yet been established on their program of determining peak annual flows. Western Mines personnel indicate significant discharge has been observed in Twin Creek at the Highway crossing during spring runoff. Discharge was, however, undetermined. During the fall visit on September 11, 1979 BEAK observed zero discharge at the Highway crossing, at water quality sampling Station A about 2.7 km north of the Highway and no noticeable discharge in the pooled channel near the mouth of Twin Creek Station B. Approximate drainage area boundaries are shown on Figure 4.3-1 based on NTS maps (1:250,000).

Because of the nature of the terrain north of the Highway between Twin Creek and the Buffalo River, it was not possible to firmly establish surface drainage patterns from available NTS maps (1:250,000 largest scale available) airphoto inspection or aerial reconnaissance. Recently produced contour maps of the area between Twin Creek and Buffalo River to about 5.6 to 7.2 km north of the Highway indicate the surface

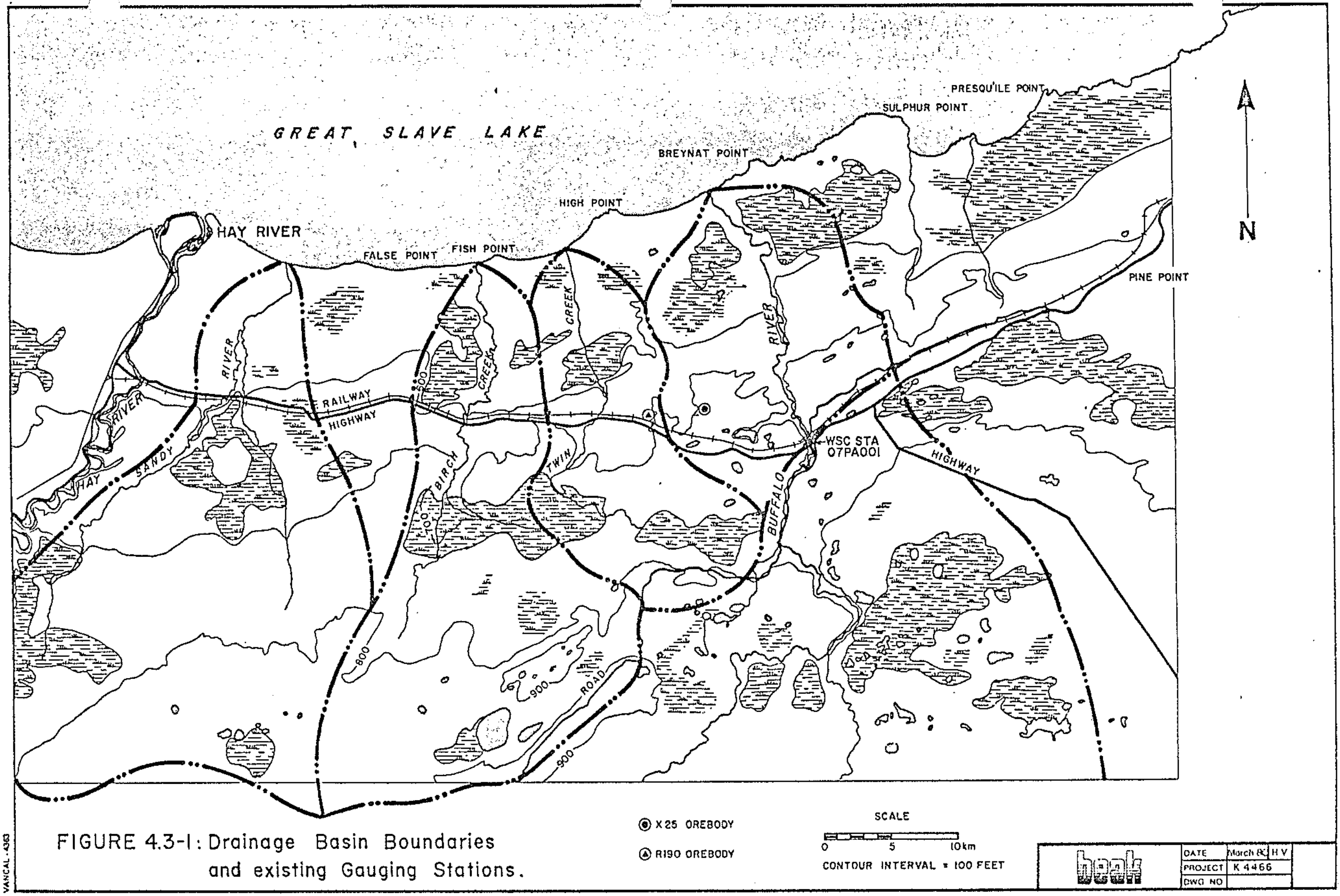


FIGURE 4.3-1: Drainage Basin Boundaries and existing Gauging Stations.

topography and thus allow prediction of the probable surface drainage patterns as shown in Figure 4.3-2. In the R190 area a ridge of higher ground exists. Surface drainage east of the ridge heads northwesterly towards Twin Creek. Drainage east of the ridge heads northeasterly and then northerly out into the central lowland between Twin Creek and the Buffalo River.

Great Slave Lake on the northern boundary of the primary area of interest is the final receptor of drainages from Twin Creek and the Buffalo River systems. Data available on lake levels at the Water Survey of Canada recording station at Hay River (Station No. 070B002) indicates the mean lake level is 156.7 metres with normal seasonal variation between 156.59 and 156.93 and extreme variation recorded of 157.28 and 156.22. Highest water levels occur in mid-summer (Environment Canada, 1978).

Polar Lake in the southeast sector of the area of interest is a shallow lake with no significant surface feed streams or outlet drainages. There is some speculation that the lake is fed by groundwater sources. It is considered a rather sensitive water body in that it is the only small lake in the immediate area with existing recreational potential. Polar Lake is approximately 1.6 km long, 0.6 km wide, and has a surface area of about 0.73 km^2. The lake is located 0.8 km north of Highway No. 5, about 3.2 km southeast of orebody X25 and about 6.4 km east of orebody R190. Western Mines personnel observed Polar Lake level in the spring of 1979 to be at its highest level in about 5 years, approximately 0.6 m above its normal level. The elevation at the time of the contour mapping was 214.6 metres (Summer, 1979).

4.3.3 Water Quality

Water samples have been taken in the region of the study area, to evaluate water quality, by at least five parties:

1. Weyer and Horwood (1979)
2. Environment Canada
3. B.C. Research (1977)
4. Beak Consultants Limited
5. Western Mines
6. Department of Indian Affairs and Northern Development

FIGURE 4.3-2: Surface Drainage Patterns

✱ X25 OREBODY
✪ R190 OREBODY

CONTOUR INTERVAL = 2 m

SCALE

0 200 400 600 800 1000 metres

N

North West Survey Corporation International Ltd.

beak			
	DATE	March 80	HV
	PROJECT	K4466	
	DWG. NO.		

The water sampling sites are described in Table A1, Appendix A and illustrated on a map in Figure 4.3-3. The data of Weyer and Horwood (1979) are summarized in Table A2, Appendix A. These data provide information on both groundwater quality and surface water quality, at numerous points in the study area. Data from Environment Canada on one sampling station on the Hay River and another on the Buffalo River, both at Highway #5, are summarized in Table A3, Appendix A. Data for four river samples and one lake sample, obtained by B.C. Research (1977) are summarized in Table A4, Appendix A. The results of the analysis of six surface water samples taken by BEAK on a field visit on 11 September, 1979, are summarized in Table 4.3-1.

A pump test was conducted for Western Mines in August, 1978, at the X25 orebody near Polar Lake. The analyses of groundwater samples taken during this pump test are summarized in Table 4.3-2.

Weyer et al. (1977/78, 1978) have identified three different types of groundwater:

- Sulphur water. A sulphate/bicarbonate water with Ca^{++} as the main cation. This water is probably derived from the Devonian gypsum layers. Conductivities are usually between 1000 and 2000 µmhos/cm. This type of groundwater is apparent in discharges at the following sites in Figure 4.3-3: 41, 42, 43, 44, 45, 46, and 47; these sites are along the lower reaches of the Buffalo River.

- Salty water, carrying sodium chloride and showing conductivities between 3000 and >80,000 µmhos/cm. These brines are derived by contact of groundwater with Devonian evaporitic layers. This type of groundwater is apparent in discharges at sites 10, 11, 12, 13, 14, 18, 48, 49, 50, 51, and 52. These sites are along the south shore of Great Slave Lake and along the lower reaches of the Buffalo River.

- A calcium bicarbonate water, found locally in glacial drifts. Conductivities are less than 1000 µmho/cm. This type of groundwater is apparent at sites 18, and 33, both along the Buffalo River.

The chemistry of some groundwater samples indicates a mixing of these three basic types of water. Some samples show high concentrations of magnesium sulphate.

Table 4.3-1 : Results of Surface Water Samples taken by BEAK on Field Visit, September 11, 1979.

Major Chemical Constituents
mg/l unless noted

BEAK Station #	A	B	C	D	E	F
Site # in Figure 4.3-3						
Location	Twin Creek	Twin Creek	Swampwater	Polar Lake	Buffalo River	Buffalo River
Phenolphthalein Alkalinity	<0.5	<0.5	< 0.5	4.9	<0.5	< 0.5
Total Alkalinity	215.0	145.0	280.0	132.0	67.4	67.3
Dissolved Chloride	1.4	11.0	1.1	0.4	2.3	6.4
True Colour (units)	50.0	40.0	40.0	20.0	60.0	60.0
Conductivity (μ mhos/cm)	407.0	346.0	541.0	325.0	182.0	206.0
Dissolved Fluoride	0.192	0.139	0.185	0.175	0.120	0.125
Dissolved Hardness (by calculation)	415.0	308.0	547.0	328.0	148.0	156.0
Nitrate Nitrogen	< 0.05	< 0.05	0.07	< 0.05	< 0.05	< 0.05
pH (units)	8.1	7.9	7.9	8.5	8.0	8.0
Dissolved Total Phosphate Phosphorus	< 0.003	0.009	< 0.003	< 0.003	0.018	0.028
Filtrable Residue	320.0	246.0	384.0	259.0	154.0	168.0
Nonfiltrable Residue	< 1.0	3.0	< 1.0	5.0	64.0	42.0
Total Residue	320.0	252.0	384.0	264.0	218.0	210.0
Dissolved Sulphate	11.0	20.0	23.0	32.0	20.0	23.0
Dissolved Inorganic Carbon	45.0	32.0	66.0	28.0	14.0	13.0
Dissolved Organic Carbon	42.0	21.0	23.0	23.0	22.0	23.0
Dissolved Arsenic	0.013	0.007	0.008	0.006	0.012	0.011
Dissolved Boron	< 0.1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dissolved Cadmium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Dissolved Calcium	110.0	84.0	150.0	87.0	38.0	41.0
Dissolved Chromium	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dissolved Copper	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Dissolved Iron	0.03	0.08	0.15	0.02	0.08	0.09
Dissolved Lead	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dissolved Magnesium	34.0	24.0	42.0	27.0	13.0	13.0
Dissolved Mercury	0.0013	0.0010	0.00065	0.0016	0.00090	0.0010
Dissolved Molybdenum	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved Potassium	0.36	0.80	0.30	0.91	1.18	1.12
Dissolved Sodium	4.6	10.0	5.2	1.6	5.5	7.9
Dissolved Zinc	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table 4.3-2: Analyses of Groundwater Samples in a Pump Test Conducted for Western Mines in 1978. (X-25 Deposit Near Polar Lake) (Department of Indian Affairs and Northern Development, unpublished data)

Parameter	
pH	7.1 - 8.1
Conductivity (µmho/cm)	3049 - 3122
Turbidity (JTU)	25 - 39
Colour (colour units)	40 - 70
Suspended Solids (mg/l)	160 - 3120
Calcium (mg/l)	407 - 457
Magnesium (mg/l)	167 - 177
Total Hardness (mg/l as $CaCO_3$)	1705 - 1784
Total Alkalinity (mg/l as $CaCO_3$)	366 - 420
Sodium (mg/l)	106 - 122
Potassium (mg/l)	<0.1
Cl^- (mg/l)	93.5 - 108
$SO_4^=$(mg/l)	145 - 204
Ammonia Nitrogen (mg/l as N)	0.1 - 0.7
Nitrate Nitrogen (mg/l as N)	< 0.01
Total Phosphorus (mg/l as P)	<0.005
Total Arsenic (mg/l)	< 0.01
Total Cadmium (mg/l)	0.01
Total Copper (mg/l)	0.01 - 0.03
Total Iron (mg/l)	0.48 - 1.59
Total Lead (mg/l)	0.06 - 0.17
Total Mercury (mg/l)	0.01
Total Nickel (mg/l)	0.04 - 0.11
Total Zinc (mg/l)	0.02 - 0.16

Note: Range of data is based on 6 samples taken on August 5, August 7, August 9, August 12, August 13, and August 14, 1978.

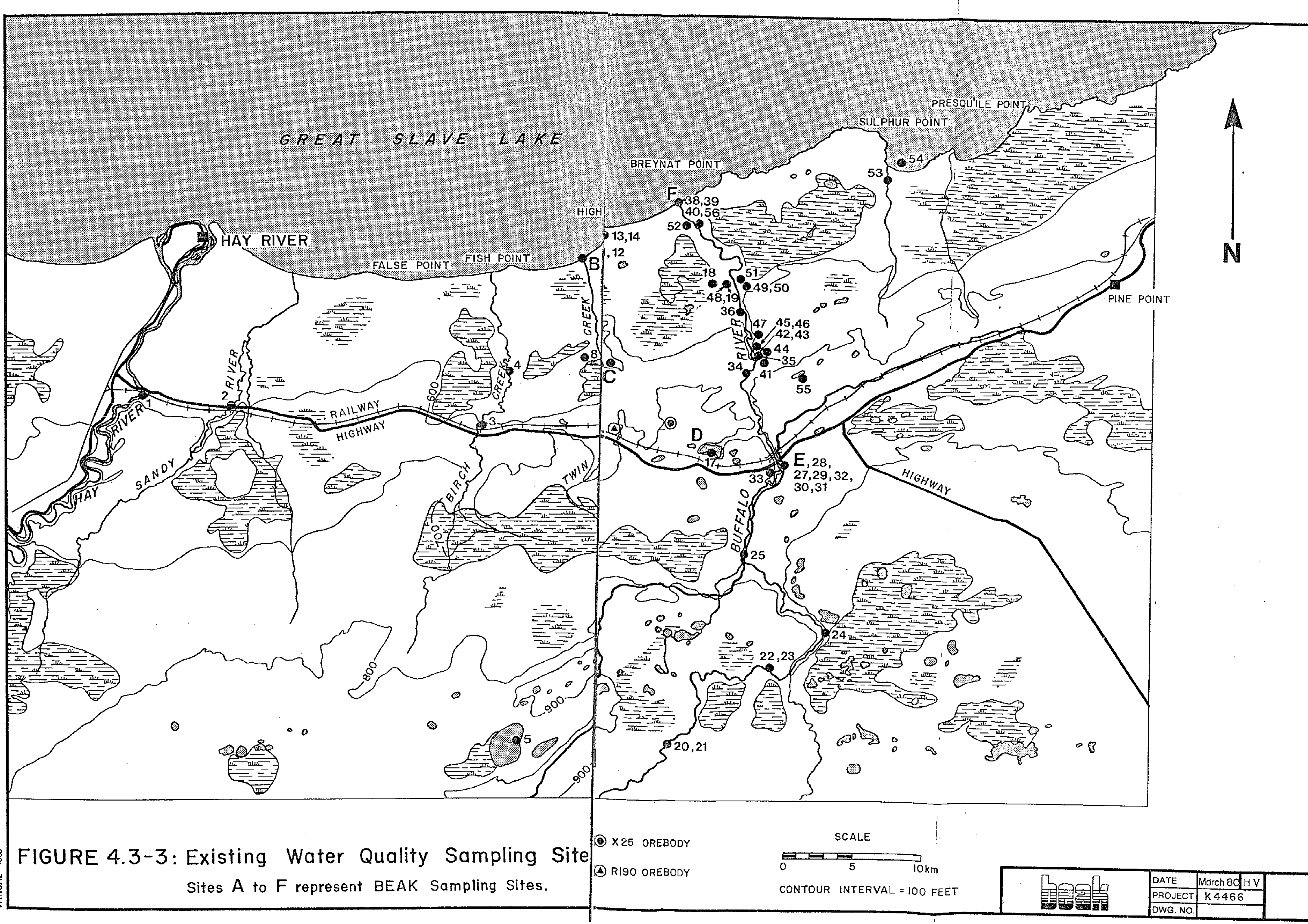


FIGURE 4.3-3: Existing Water Quality Sampling Site

Sites A to F represent BEAK Sampling Sites.

The bedrock groundwater samples obtained in the Western Mines pump test at X25 orebody near Polar Lake (Table 4.3-2), appears to be indicative of a mixture of sulphur water and salty water. The concentrations of heavy metals in these samples were low, except for iron, which has moderately high concentrations, between 0.5 and 1.6 mg/l. No data is currently available on quality of shallow groundwater in the overburden unit.

Major surface waters in the area tend to be moderately hard with low concentrations of heavy metals. This generalization applies to Birch Creek, Twin Creek, Buffalo River, and small lakes such as Polar Lake.

The groundwater discharge, north of Highway #5, appears to have a significant effect on the water quality in the Buffalo River. Weyer et al. (1978) indicate that during the summer, the conductivity of the Buffalo River water increases from a typical value of about 250 µmho/cm at Highway #5 to about 700 µmho/cm at the mouth. The conductivity, dissolved sulphate and the hardness of the Buffalo River water at a given point may vary by a factor of two or more during the ice-free period, the highest levels probably coinciding with spring runoff and periods of heavy flow (B.C. Research, 1977). The suspended solids concentration in the Buffalo River ranges from about 10 to 150 mg/l; in general, it is a turbid river.

4.4 Biological Characteristics

4.4.1 Aquatic Flora and Fauna

The study area is characterized by areas of low relief and poor drainage. The only defined watercourses in the study area are Buffalo River and Twin Creek. A large number of small shallow lakes are scattered throughout this region, particularly between the proposed mine site and Great Slave Lake, lakes which do not have any visible drainage. The results of a reconnaissance of this region, as well as a literature search and personal communication with fisheries personnel who are familiar with the study area, indicated the only lakes which support fish populations in this study area are Great Slave Lake and Polar Lake (Figure 3.1-1).

Great Slave Lake

The shoreline of Great Slave Lake between the mouths of Twin Creek and Buffalo River was surveyed from helicopter on September 11, 1979. The shore was observed to be regular in shape, and essentially devoid of terrestrial vegetation. The beach consisted entirely of small, sand-sized particles. Localized beds of aquatic macrophytes, judged to be Potamogeton sp., were growing along the shoreline approximately 10 m from the lake's edge. The lake waters were murky, likely due to suspended sediment from wave action, which precluded observation of nearshore substrate types. The open nature of the shoreline, combined with the observation of sandy beaches, the presence of aquatic macrophytes and the presence of suspended sediments in the water column, indicates the lake substrate type in the study area is likely composed of sand and silt-sized particles.

At least 27 species of fish are known to occur in Great Slave Lake, the common and scientific names of which are presented in Table 4.4-1 (Rawson, 1951; Scott and Crossman, 1973; G. Low, Fishery Biologist, Hay River, pers. comm.). The area of the lake adjacent to the study area, in particular the region at the mouth of Buffalo River, is fished from break-up through to the end of July, during which time a 45,000 kg quota of inconnu is taken in the commercial fishery (G. Low, pers. comm.). In addition to inconnu, some lake whitefish and the odd lake trout are also taken in this fishery. Although winter fishing has been conducted at this locale in the past, no such activities take place in this region of Great Slave Lake at the present time. It is not known if any spawning activity by lake whitefish or lake trout occurs in this area; however, the habitat appears suitable for spawning usage by lake whitefish. Inconnu spawning occurs in Buffalo lake and not in this area of Great Slave Lake (G. Low, pers. comm.).

Polar Lake

Polar Lake has been stocked to provide a recreational fishery by a group of sportsmen from the town of Pine Point. The lake was stocked with brook trout (Salvelinus fontinalis) in 1971, and rainbow trout (Salmo gairdneri) in 1972, 1977 and 1978 (M. Falk, Freshwater Institute, Winnipeg, pers. comm.). The lake was scheduled for stocking in 1979; however, suitable hatchery stock was not available in 1979. The lake is used during the summer and winter by sports fishermen (M. Falk, pers. comm.).

Table 4.4-1

The Fish Fauna of Great Slave Lake

COMMON NAME	SCIENTIFIC NAME
Arctic lamprey	Lampetra japonica (Martens)
goldeye	Hiodon alosoides (Rafinesque)
cisco (lake herring)	Coregonus artedii (Lesueur)
shortjaw cisco	Coregonus zenithicus (Jordan and Evermann)
lake whitefish	Coregonus clupeaformis (Mitchill)
chum salmon	Oncorhynchus keta (Walbaum)
round whitefish	Prosopium cylindraceum (Pallas)
inconnu	Stenodus leucichthys (Guldenstadt)
lake trout	Salvelinus namaycush (Walbaum)
Arctic grayling	Thymallus arcticus (Pallas)
northern pike	Esox lucius (Linnaeus)
lake chub	Couesius plumbeus (Agassiz)
flathead chub	Hybopsis gracilis (Richardson)
emerald shiner	Notropis atherinoides (Rafinesque)
spottail shiner	Notropis hudsonius (Clinton)
longnose dace	Rhinichthys cataractai (Valenciennes)
longnose sucker	Catostomus catostomus (Forster)
white sucker	Catostomus commersoni (Lacepede)
trout- perch	Percopsis omiscomaycus (Walbaum)
burbot	Lota lota (Linnaeus)
brook stickleback	Culaea inconstans (Kirtland)
ninespine stickleback	Pungitius pungitius (Linnaeus)
yellow perch	Perca flavescens (Mitchill)
walleye	Stizostedion vitreum vitreum (Mitchill)
slimy sculpin	Cottus cognatus (Richardson)
spoonhead sculpin	Cottus ricei (Nelson)
fourhorn sculpin	Myoxocephalus quadricornis (Linnaeus)

Sources: Rawson 1951, Scott and Grossman 1973, G. Low, pers. comm.

The Freshwater Institute has been monitoring the fish and selected limnological characteristics in Polar Lake since 1977, and a data report documenting the results of these investigations will be produced in early summer, 1980 (M. Falk, pers. comm.). Preliminary analyses of this data, as provided by M. Falk, indicates that the initial stocking of 40,000 brook trout in 1971 was too great for Polar Lake. These fish have disappeared from the lake, and the occasional capture of a brook trout is interpreted as the inadvertent contamination of fish stocks transplanted subsequent to 1971. The reason for the loss of the brook trout initially planted in Polar Lake is unknown. Polar Lake is recharged from muskeg drainage and underground springs (M. Falk, pers. comm.). Dissolved oxygen determinations in the late winter have resulted in values as low as 3.0 mg/l being recorded (March 1979), which is approaching the minimum requirement for successful overwintering of fish. A possible explanation for the disappearance of brook trout from Polar Lake may be an oxygen deficiency in the lake during the critical late-winter period (M. Falk, pers. comm.). There have been no fish kills in Polar Lake since the inception of the monitoring program by the Freshwater Institute.

Polar Lake is virtually unique in Northwest Territories, as it is a stocked lake. There are presently no Federal regulations which control development in the area of stocked waterbodies in Northwest Territories, although such regulations are expected to be in place in the very near future (M. Falk, pers. comm.).

Buffalo River

The Buffalo River has its origin in the northern extremity of the Province of Alberta, and flows in a northwesterly direction to Buffalo Lake, and from the outlet of Buffalo Lake, it flows approximately 80 km to its mouth in Great Slave Lake. Buffalo River constitutes the eastern boundary of the study area under consideration here.

The Buffalo River, from Highway No. 5 to its mouth, was approximately 100 m wide, shallow and fast moving on September 10 and 11, 1979. The river was turbid, and the substrate was covered with a heavy layer of silt and filamentous algae when examined. The river substrate was composed of pebble to cobble-sized particles along its length, with the exception of the river mouth area where the substrate along the shorelines was composed of fines.

The Buffalo River is used by inconnu to attain spawning areas in Buffalo Lake (G. Low, pers. comm.). The inconnu which use the river are presently under investigation under the direction of Bob Moshenyko of the Freshwater Institute. This migration route is one of very few known migration routes used by this species. The inconnu upstream migration is not a well-defined, mass movement of fish, and takes place during the summer months (B. Moshenyko, pers. comm.) The inconnu are evident in Buffalo Lake at the beginning of September, and spawn during late September and early October. Residents of Hay River report a rapid downstream migration, following spawning, in mid-October. This has not been confirmed, but is judged likely (B. Moshenyko, pers. comm.). Buffalo Lake supports a domestic fishery for inconnu and lake whitefish.

Other fishes taken from Buffalo River include lake whitefish, northern pike, goldeye and walleye. The possibility does exist that lake whitefish spawn in the lower reaches of Buffalo River in the fall (G. Low, pers. comm.). No spring spawning activity is anticipated in this region of the river, although walleye may migrate up the river and spawn in tributaries of Buffalo Lake (G. Low, pers. comm.). Department of Fisheries and Oceans regulations prohibited commercial harvesting of fishes in Buffalo River. However, the mouth of the river in Great Slave Lake supports a commercial fishery, primarily for inconnu. Three abandoned fish camps were observed at the mouth of the Buffalo River on September 11, 1979.

The Buffalo River is an extremely important river due to the inconnu spawning migration. The potential for overwintering in the river by fishes is likely very limited, due to very low water levels at this time of year, but the possibility does exist that overwintering may take place in isolated pools (B. Moshenyko, pers. comm.).

Twin Creek

The 1:250,000 National Topographic System map series indicates Twin Creek arises in a bog area immediately south of Highway No. 5, and drains areas of bog along its length to the creek mouth in Great Slave Lake.

Twin Creek was examined at Highway No. 5 on Setember 10, 1979, and was not discharging at this location although isolated pools were in evidence. The creek was surveyed from helicopter on September 11, 1979, at which time the watercourse was found to be poorly defined and meandering through the bog areas. The creek was dammed by beaver in at least four locations between Highway No. 5 and Great Slave Lake, and other than the creek mouth, these were the only areas where any significant amount of water was in evidence in the creek. The beaver dams supported heavy growths of aquatic vegetation including Potamogeton sp., Typha latifolis, Equisetaceae sp., Nymphaea sp., and extensive areas of sedges (likely Carex sp.).

The first beaver dam on the creek was located approximately 1,500 m upstream of the creek mouth. This 1,500 m stretch of the stream was 10 to 15 m in width. No current was apparent at the creek mouth on September 11, 1979. The creek mouth supported a heavy growth of aquatic macrophytes. The habitat was judged to be suitable for spawning by northern pike and suckers. The beaver dam located just upstream of the creek mouth would preclude the movement of fish further upstream. The habitat above this blockage was judged to be unsuitable for use by fish.

4.4.2 Terrestrial Flora and Fauna

4.4.2.1 Vegetation

The boreal forest region encompasses most of the forested land in Canada; it reaches almost coast to coast in a continuous belt. The Western Mines study area is situated in the upper Mackenzie section of the Boreal forest (Rowe, 1972). The topographic features of this area govern the distribution of vegetation. Alluvial flats bordering rivers are dominated by white spruce and balsam poplar; the benchlands and terraces bordering the alluvial flats are dominated by jack pine and aspen on sandy soils or by black spruce and tamarack on moist to wet areas.

Although the vegetation of the western subarctic has not been investigated in great detail, there are several botanical surveys which have been conducted along the Yellowhead Highway and adjacent areas which provide species lists and general botanical descriptions. Useful descriptions are available in Moss (1953a and 1953b), Porsild (1951), Raup (1946), Thieret (1964) and references therein. More recent research has been undertaken to investigate the effects of pipeline development on northern environments. As a result, the ecological relationships operating in these northern areas are now much more clearly understood. Vegetation and fire interactions in the north were investigated by Rowe et al., (1975), Johnson and Rowe (1975) and Wein and Weber (1974). From the opposite position, successional patterns in unburned areas were discussed by Strang (1973). However, the report most applicable to the Western Mines study area is the Environmental Survey and Assessment for Pine Point, produced by B.C. Research in 1977. In this study, the vegetational communities in the vicinity of Pine Point, east of the Western Mines study area have been thoroughly described.

The objectives of the vegetation section were to describe and map the vegetation of the Western Mines study area, primarily relying on aerial photographs but also aided by a brief field visit, and the literature referenced above.

The mapping of plant communities was carried out using black and white aerial photogaphs taken in June 1979. Interpretation was facilitated by the use of a mirror stereoscope, equipped with 8x lenses for detailed examination. Plant communities were identified as jack pine, aspen, mixed jack pine/black spruce, white spruce, black spruce, shrub, fen, muskeg and burn, for a total of nine distinct types. More thorough descriptions based on understory characteristics would necessitate extensive ground truthing (field investigations). The vegetation of the study area has been mapped in simplified form (Figure 4.4-1).

Plant Community Description and Status

Jack pine is characteristically found on well drained soils. In the Pine Point area jack pine occurred on Degraded Eutric and Ortho Eutric Brunisols (B.C. Research 1977). Jack pine is a "fire adapted" species and tends to predominate after forest fires. In the Western Mines study area, a variety of tree ages were found. The oldest jack pine measured as 202 years old and 38 cm in diameter. Detailed studies in the Pine Point area (B.C. Research 1977) separated jack pine stands into two types. The pine/ryegrass type was characterized by an understory dominated by ryegrass and shrubs such as prickly rose (Rosa acicularis), soapberry (Shepherdia canadensis), bearberry (Arctostaphylos uva-ursi) and twinflower (Linnaea borealis). Although mosses and lichens were sparse, herbs such as bunchberry (Cornus canadensis), arctic aster (Aster sibiricus) and strawberry (Fragaria virginiana) were common. The Pine/bearberry/lichen type was considered a more mature community. It differed from the above type primarily by the absence of ryegrass and the abundance of lichens.

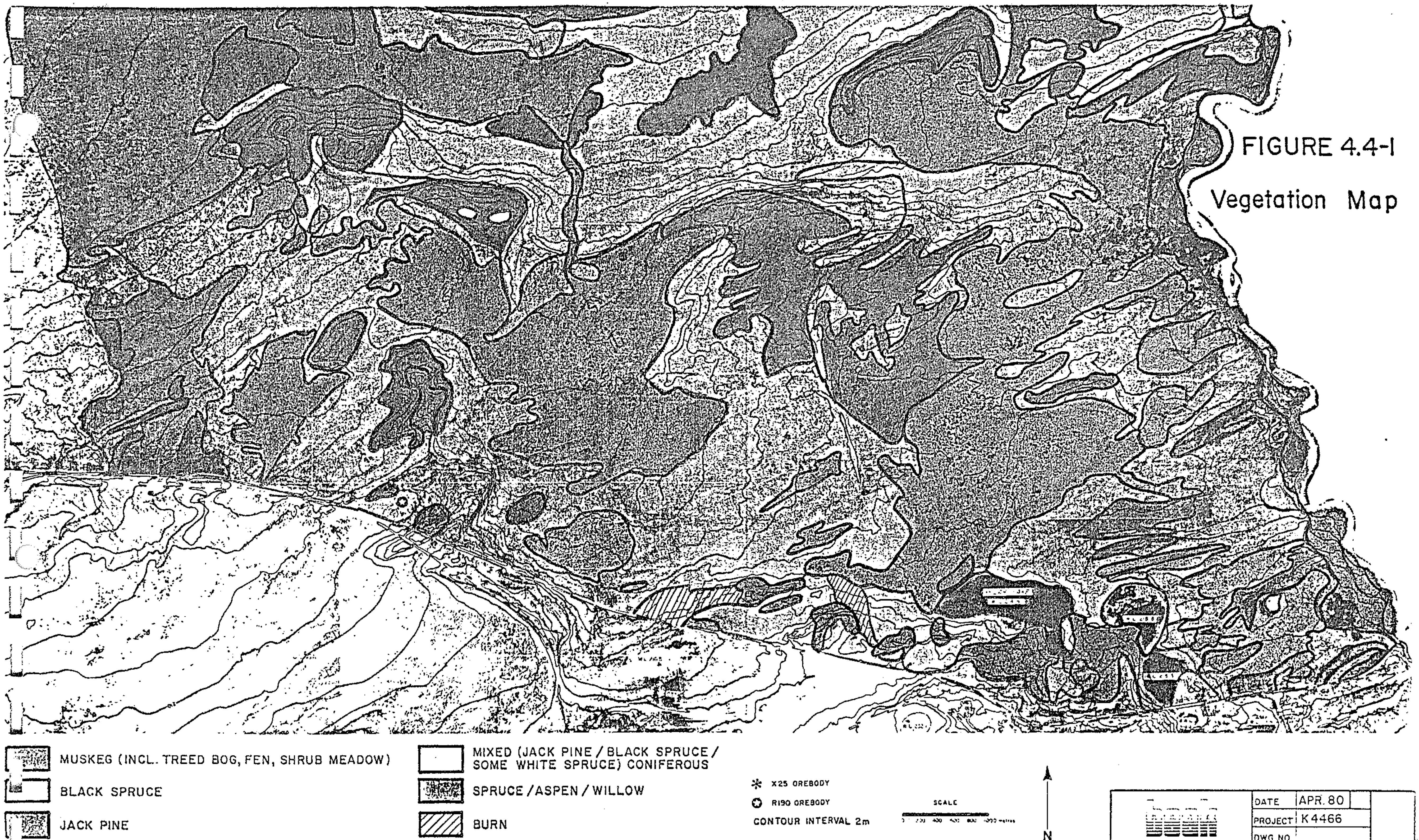


FIGURE 4.4-1

Vegetation Map

Only one burned area was identified within the Western Mines study area. This was an area west of the camp, adjacent to the road. Fires are a common and natural feature in the boreal forest. Indeed it is unusual to have an area unburned for over 200 years as is the case in the Western Mines study area. Burn cycles in the boreal forest are in the order of 60 years (Rowe et al., 1975). Two major questions arise from the length of time this area has been unburned. One is that since the likelihood of fire is high in this area, what would be the effects of fire on wildlife habitat? The second question which is addressed first, concerns the vigour of such old stands of trees.

There has been considerable discussion in the Pine Point literature regarding whether pit dewatering or overmaturity has been responsible for the decline of trees in the area. The studies undertaken by B.C. Research (1977) and supported by other literature sources indicate that jack pine stands undergo a decline at between 60 and 100 years depending upon the site. There appears to be little supporting evidence to show that pit dewatering is a major problem in the area, although it cannot be ruled out as a factor.

The tree ages measured are in agreement with the hypothesis that forests in the Western Mines - Pine Point area are over-mature and are therefore probably subject to decline in the future, if there are no fires in the area. *

A critical question in northern areas has always been: what is the effect of fire on wildlife habitat. Initial investigations by Scotter, 1964 in northern Saskatchewan indicated that fire eliminated lichens, which took approximately 100 years to regain their previous abundance. However, Rowe, et al., 1975 concluded that not all fires destroyed lichens, in fact, fires often destroyed sphagnum (peat moss) hummocks, favouring the eventual growth of lichens. Lichens were also determined to have a relatively low flammability and fires often expired partially through lichen plateaus. A further study in the Northwest Territories (Kershaw and Rouse, 1975) concluded that caribou preferred habitats which had been burned 75 to 150 years previously. These areas were dominated by the lichen Stereocaulon paschale. The differences in these findings may be attributable in part to the different areas studied. However, most authors agree that fire is a widespread natural phenomenon and an essential part of the northern landscape.

The study area has a considerable extent of mature timber which has not been burned for at least 200 years. Lichens were abundant in many of these stands. The presence of caribou in the study area at present would indicate a preference for the area, likely due to lichen abundance. From both Kershaw and Rouse, and Scotter it appears that it would take at least 75 years after a fire for an area to become desirable as caribou habitat again. However, light crown fires might serve to rejuvinate the forest and still permit the lichen to survive (as discussed in Rowe et al, 1975). However, should fire occur, early successional stages would represent an improvement in moose habitat as discussed below.

4.4.2.2 Birds

The Great Slave Reef project area is composed of a number of terrestrial and aquatic communities which provide habitat for a variety of birds. Terrestrial habitats dominate the areas presently under exploration by Western Mines. Aquatic habitat includes the Twin Creek system, the Buffalo River, south shore of Great Slave Lake and wetlands to the north of the immediate study area.

Specific information on the birds of the study area is lacking, but this is largely compensated for by two pertinent publications. The first is Erskine's comprehensive account of Canada's birds of the boreal forest (Erskine, 1977) which provides a quantitative description of the avifaunas of the major boreal forest zones. This includes the southern N.W.T. Second, the birds of the Pine Point area is the subject of a recent report prepared by B.C. Research (1978). The background for these recent studies includes a rather extensive literature cited by Erskine, some of which deal with birds of the Great Slave Lake area (e.g. Fairbairn, 1931; Soper, 1957; and Stewart, 1966). This literature provides the principal sources of this report.

The objectives of this section are to utilize existing information to:

i) describe the species composition and abundance of the avian community.
ii) identify the distribution of the principal species with reference to the plant communities existing on site.
iii) identify rare and endangered species.
iv) describe man's traditional and current use of the avian community.

The bird species of the study area are well-known, based on the work of B.C. Research (1978), Godfrey (1966) and Erskine (1977). From these sources a hypothetical checklist has been drawn up (Table 4.4-2). While this list includes a large number of aquatic

Table 4.4-2

HYPOTHETICAL CHECKLIST OF BIRD SPECIES
REPORTED FROM THE HAY RIVER - PINE POINT AREA[1, 2]

COMMON NAME	SCIENTIFIC NAME
Common Loon	Gavia immer
Yellow-billed Loon	Gavia adamsii
Arctic Loon	Gavia arctica
Red-throated Loon	Gavia stellata
Red-necked Grebe	Podiceps grisegana
Horned Grebe	Podiceps auritus
Pied-billed Grebe	Podilymbus podiceps
American Bittern	Botaurus lentiginosus
Whistling Swan	Olor columbianus
Canada Goose	Branta canadensis
White-fronted Goose	Anser albifrons
Snow Goose (incl, Blue)	Chen caerulescens
Mallard	Anas platyrhynchos
Pintail	Anas acuta
Green-winged Teal	Anas crecca
Blue-winged Teal	Anas discors
American Wigeon	Anas americana
Northern Shoveler	Anas clypeata
Redhead	Aythya americana
Canvasback	Aythya valisineria
Ring-necked Duck	Aythya collaris
Greater Scaup	Aythya marila
Lesser Scaup	Aythya affinis
Common Goldeneye	Bucephala clangula
Bufflehead	Bucephala albeola

1 Nomenclature from American Ornithologist's Union (1957), as revised by Eisenman et al. (1973, 1976).

2 Based on Godfrey (1966), B.C. Research (1978), and Erskine (1977).

TABLE 4.4-2 (Continued)

COMMON NAME	SCIENTIFIC NAME
Oldsquaw	Clangula hyemalis
White-winged Scoter	Melanitta deglandi
Surf Scoter	Melanitta perspicillata
Ruddy Duck	Oxyura jamaicensis
Common Merganser	Mergus merganser
Red-breasted Merganser	Mergus serrator
Goshawk	Accipiter gentilis
Sharp-shinned Hawk	Accipiter striatus
Red-tailed Hawk	Buteo jamaicensis
Rough-legged Hawk	Buteo lagopus
Golden Eagle	Aquila chrysaetos
Bald Eagle	Haliautus leucocephalus
Marsh Hawk	Circus cyaneus
Osprey	Pandion haliaetus
Gyrfalcon	Falco rusticolus
Peregrine Falcon	Falco peregrinus
Merlin	Falco columbarius
Spruce Grouse	Canachites canadensis
Ruffed Grouse	Bonasa umbellus
Sharp-tailed Grouse	Pedioecetes phasianellus
Willow Ptarmigan	Lagopus lagopus
Rock Ptarmigan	Lagopus mutus
Whooping Crane	Gras americana
Sandhill Crane	Gras canadensis
Virginia Rail	Rallus limicola
Sora	Porzana carolina
Yellow Rail	Coturnicops noveboracensis
American Coot	Fulica americana
American Golden Plover	Pluvialis dominica
Black-bellied Plover	Pluvialis squatorola

TABLE 4.4-2 (Continued)

COMMON NAME	SCIENTIFIC NAME
Semipalmated Plover	Charadrius semipalmatus
Killdeer	Charadrius vociferus
Ruddy Turnstone	Arenaria interpres
Common Snipe	Capella gallinago
American Avocet	Recurvirostra americana
Whimbrel	Numenius phaeopus
Eskimo Curlew	Numenius borealis
Hudsonian Godwit	Limosa haemastica
(Red) Knot	Calidris canutus
Upland Sandpiper	Bartramia longicauda
Buff-breasted Sandpiper	Tryngites subruficollis
Solitary Sandpiper	Tringa solitaria
Spotted Sandpiper	Actitis macularia
Greater Yellowlegs	Tringa melanoleucus
Lesser Yellowlegs	Tringa flavipes
Stilt Sandpiper	Micropalama himantopus
Pectoral Sandpiper	Calidris melanotus
White-rumped Sandpiper	Calidris fuscicollis
Baird's Sandpiper	Calidris bairdii
Least Sandpiper	Calidris minutilla
Dunlin	Calidris alpina
Semipalmated Sandpiper	Calidris pusilla
Short-billed Dowitcher	Limnodromus griseus
Long-billed Dowitcher	Limnodromus scolopaceus
Sanderling	Calidris alba
Wilson's Phalarope	Steganopus tricolor
Northern Phalarope	Lobipes lobatus
Pomarine Jaeger	Stercorarius pomarinus
Parasitic Jaeger	Stercorarius parasiticus
Long-tailed Jaeger	Stercorarius longicaudus

COMMON NAME	SCIENTIFIC NAME
Herring Gull	Larus argentatus
California Gull	Larus californicus
Ring-billed Gull	Larus delawarensis
Mew Gull	Larus canus
Bonaparte's Gull	Larus philadelphia
Little Gull	Larus minutus
Sabine's Gull	Xema sabini
Franklin's Gull	Larus pipixcan
Common Tern	Sterna hirundo
Arctic Tern	Sterna paradisaea
Caspian Tern	Hydroprogne caspia
Black Tern	Chlidonias niger
Rock Dove	Columbia livia
Mourning Dove	Zenaidura macroura
Snowy Owl	Nyctea scandiaca
Great Horned Owl	Bubo virginianus
Hawk Owl	Surnia ulula
Great Grey Owl	Strix nebulosa
Short-eared Owl	Asio flammeus
Long-eared Owl	Asio otus
Boreal Owl	Aegolius funereus
Common Nighthawk	Chordeiles minor
Belted Kingfisher	Megaceryle alcyon
Ruby-throated Hummingbird	Archilohus colubris
Common (Yellow-shafted) Flicker	Colaptes auratus
Pileated Woodpecker	Dryocopus pileatus
Yellow-bellied Sapsucker	Sphyrapicus varius
Hairy Woodpecker	Dendrocopos villosus
Downy Woodpecker	Dendrocopos pubescens
Black-backed Three-toed Woodpecker	Picoides arcticus

TABLE 4.4-2 (Continued)

COMMON NAME	SCIENTIFIC NAME
Northern Three-toed Woodpecker	Picoides tridactylus
Eastern Kingbird	Tyrannus tyrannus
Eastern Phoebe	Sayornis phoebe
Say's Phoebe	Sayornis saya
Western Word Pewee	Contopus sordidulus
Yellowbellied Flycatcher	Empidonax flaviventris
Alder Flycatcher (Traill's)	Empidonax traillii
Least Flycatcher	Empidonax minimus
Olive-sided Flycatcher	Nuttallornis borealis
Horned Lark	Eremophila alpestris
Tree Swallow	Iridoprocne bicolor
Bank Swallow	Riparia riparia
Barn Swallow	Hirundo rustica
Cliff Swallow	Petrochelidon pyrrhonota
Gray Jay	Perisoreus canadensis
Black-billed Magpie	Pica pica
Common Raven	Corvus corax
Common Crow	Corvus brachyrhynchos
Black-capped Chickadee	Parus atricapillus
Boreal Chickadee	Parus hudsonicus
Red-breasted Nuthatch	Sitta canadensis
American Dipper	Cinclus mexicanus
House Wren	Troglodytes aedon
Winter Wren	Troglodytes troglodytes
Long-billed Marsh Wren	Telmatodytes palustris
American Robin	Turdus migratorius
Hermit Thrush	Hylocichla guttata
Swainson's Thrush	Hylocichla ustulata
Gray-cheeked Thrush	Catharus minimus
Mountain Bluebird	Sialia currucoides

TABLE 4.4-2 (Continued)

COMMON NAME	SCIENTIFIC NAME
Golden-crowned Kinglet	Regulus satrapa
Ruby-crowned Kinglet	Regulus calendula
Water Pipit	Anthus spinoletta
Bohemian Waxwing	Bombycilla garrulus
Northern Shrike	Lanius excubitor
Common Starling	Sturnus vulgaris
Solitary Vireo	Vireo solitarius
Red-eyed Vireo	Vireo olivaceus
Philadelphia Vireo	Vireo philadelphicus
Warbling Vireo	Vireo gilvus
Black and White Warbler	Mniotilta varia
Tennessee Warbler	Vermivora peregrina
Orange-crowned Warbler	Vermivora celata
Yellow Warbler	Dendroica petechia
Magnolia Warbler	Dendroica magnolia
Cape May Warbler	Dendroica tigrina
Yellow-rumped (Myrtle) Warbler	Dendroica coronata
Bay-breasted Warbler	Dendroica castanea
Blackpoll Warbler	Dendroica striata
Palm Warbler	Dendroica palmarum
Ovenbird	Speurus aurocapillus
Northern Waterthrush	Seiurus noveboracensis
Mourning Warbler	Oporornis philadelphia
Common Yellowthroat	Geothlypis trichas
Black-throated Green Warbler	Dendroica virens
Wilson's Warbler	Wilsonia pusilla
American Redstart	Setophaga ruticilla
House Sparrow	Passer domesticus
Western Meadowlark	Sturnella neglecta
Yellow-headed Blackbird	Xanthocephalus xanthocephalus

TABLE 4.4-2 (Continued)

COMMON NAME	SCIENTIFIC NAME
Redwinged Blackbird	Agelaius phoeniceus
Rusty Blackbird	Euphagus carolinus
Brewer's Blackbird	Euphagus cyanocephalus
Common Grackle	Quiscalus quiscula
Brown-headed Cowbird	Molothrus ater
Western Tanager	Piranga ludoviciana
Rosebreasted Grosbeak	Pheucticus ludovicianus
Pine Grosbeak	Pinicola enucleator
Evening Grosbeak	Hesperiphona vespertina
Hoary Redpoll	Carduelis hornemanni
Common Redpoll	Carduelis flammea
Pine Siskin	Spinus pinus
White-winged Crossbill	Loxia leucoptera
Red Crossbill	Loxia curvirostra
Savannah Sparrow	Passerculus sandwichensis
Le Conte's Sparrow	Passerherbulus caudacutus
Sharp-tailed Sparrow	Ammospiza caudacuta
Vesper Sparrow	Pooecetes gramineus
Dark-eyed (Slate-coloured) Junco	Junco hyemalis
Tree Sparrow	Spizella arborea
Chipping Sparrow	Spizella passerina
Clay-coloured Sparrow	Spizella pallida
Harris's Sparrow	Zonotrichia querula
White-crowned Sparrow	Zonotrichia leucophrys
White-throated Sparrow	Zonotrichia albicollis
Fox Sparrow	Passerella iliaca
Lincoln's Sparrow	Melospiza lincolnii
Swamp Sparrow	Melospiza georgiana
Song Sparrow	Melospiza melodia
Lapland Longspur	Calcarius lapponicus
Smith's Longspur	Calcarius pictus
Snow Bunting	Plectrophenax nivalis

species, present exploration is primarily in terrestrial habitats, and these habitats predominate the study area.

In the previous section nine separate vegetation zones were identified. Outside of wetlands and burns, black spruce and jack pine are the predominant climax forest species. Bird densities in such forests in S. MacKenzie - N.E. B.C. have been estimated at 316 (range 106 - 575) pairs per km^2 in spruce stands, and 186 (range 80 - 292) pairs per km^2 in jack pine stands (Erskine, 1977). The most numerous and typical species in black spruce stands are reported by Erskine to be Boreal Chickadee, Swainson's Thrush, Ruby-crowned Kinglet, Tennessee Warbler, Yellow-rumped Warbler, Northern Junco and Chipping Sparrow.

In jack pine forests the principal breeding species are very similar, i.e. American Robin, Swainson's Thrush, Tennessee Warbler, Yellow-rumped Warbler, Northern Junco and Chipping Sparrow (Erskine, 1977). B.C. Research (1978), during their roadside surveys, confirmed most of these species as occurring at Pine Point but did not observe Boreal Chickadees and Golden-crowned Kinglets. Considering the short (5 day) survey period, such omissions may not be significant.

Among the raptorial birds, bald eagles appear to be the most conspicuous, based on the BEAK reconnaissance and observations by B.C. Research (1978). One Goshawk and one Rough-legged Hawk were tentatively identified during the BEAK reconnaissance, in addition to sharp-shinned hawk, red-tailed hawk, and marsh hawk identified by B.C. Research.

The chief breeding grounds of the rare and endangered Whooping Crane lie within Wood Buffalo National Park (Novakowski, 1966), whose northern boundary lies approximately 20 km south of the study area. There are no recent records of this species occurring in the study area, but it probably did in the past.

In the study area, the aquatic birds concentrated along the south shore of Great Slave Lake, but Polar lake and other wetlands closer to the exploration sites undoubtedly have breeding potential for limited numbers of loons, grebes, waterfowl, shorebirds, kingfishers, rails, coots and bitterns. The south shore of Great Slave Lake west of the Buffalo River has considerable potential as wetland habitat, although probably more in terms of staging than for breeding. During the September 10 - 11 reconnaissance an estimated total of 845 aquatic birds were observed between the mouths of the Buffalo River and Twin Creek. Concentrations were recorded at the mouth of Twin Creek (including 38 swans, believed to be Whistling Swans), and within 1 kilometre east of High Point.

Information on hunting for birds in the study area was determined from officers of the Territorial Wildlife Service in Hay River; government data where available applies to a much wider area. The principal hunting areas for residents of Hay River and Pine Point are to the west and east of these centres, respectively (Mr. Jim Beaulieu, N.W.T. Wildlife Service, pers. comm.), with little apparent hunting pressure for birds exerted along the south shore of Great Slave Lake adjacent to the study area.

4.4.2.3 Mammals

The study area lies within the lowland portions of the northern boreal forest. Rowe (1972) refers to it as the Upper MacKenzie Forest Section and it is a relatively narrow zone which borders the Northwestern Transition Section east of the Slave River and the Hay River Section to the south. The latter makes up much of Wood Buffalo National Park. The boundaries of the various forest sections near the study area have important implications on its mammalian fauna, particularly ungulates.

Information collected on mammals during the September 10 - 11 reconnaissance were limited and consisted of sightings of least chipmunk, red squirrel, beaver lodges and tracks of caribou. Instead, the chief sources of information for this section are the recent studies in the adjacent property of Pine Point (B.C. Research, 1977), wildlife habitat potential in the Land Use Information Series map of Hay River (Canada, Fisheries and Environment, 1978), discussions with biologists and conservation officers of the N.W.T. Wildlife Service in Hay River and Yellowknife, and with staff of Western Mines at Polar Lake.

General distribution data in Banfield (1974) and adjacent site information from Pine Point (B.C. Research, 1977) was used to develop a hypothetical species list (Table 4.4-3). Special comment is required for Barren-ground caribou, and White-tailed deer. Barren-ground caribou (Beverly herd) winter southeast of Great Slave Lake extending as far

Table 4.4-3

HYPOTHETICAL CHECK LIST OF MAMMALS OCCURRING IN THE GREAT SLAVE REEF AREA[1]

Common Name	Latin Name
ORDER INSECTIVORA (Shrews)	
Masked shrew	Sorex cinereus cinereus
Vagrant shrew (Dusky)	Sorex vagrans obscurus
American water shrew	Sorex palustris palustris
Arctic shrew	Sorex arcticus arcticus
Pigmy shrew	Microsorex hoyi hoyi
ORDER CHIROPTERA (Bats)	
Little brown bat	Myotis lucifugus lucifugus
Hoary bat	Lasiurus cinereus
ORDER LAGOMORPHA	
Snowshoe hare	Lepus americanus macfarlani
ORDER RODENTIA (Rodents)	
Least chipmunk	Eutamias minimus borealis
Woodchuck	Marmota monax canadensis
American red squirrel	Tamiasciurus hudsonicus preblei
Northern flying squirrel	Glaucomys sabrinus sabrinus
American beaver	Castor canadensis canadensis
Deer mouse	Peromyscus maniculatus borealis
Gapper's red-backed vole	Clethrionomys gapperi athabascae
Northern bog lemming	Synaptomys borealis borealis
Heather vole	Phenacomys intermedius mackenzii
Muskrate	Ondatra zibethicus spatulatus
Meadow vole	Microtus pennsylvanicus drummondii
Chestnut-cheeked vole	Microtus xanthognathus
Meadow jumping mouse	Zapus hudsonicus hudsonius
American porcupine	Erethizon dorsatum myops
ORDER CARNIVORA (Carnivores)	
Coyote	Canis latrans incolatus
Wolf	Canis lupus occidentalis

Continued ...

Common Name	Latin Name
ORDER CARIVORA (cont'd)	
Arctic fox	Alopex lagopus innuitus
Red fox	Vulpes vulpes abietorum
American black bear	Ursus americanus americanus
American marten	Martes americana actuosa
Fisher	Martes pennanti
Ermine	Mustela erminea richardsonii
Least weasel	Mustela nivalis rixosa
American mink	Mustela vison lacustris
Wolverine	Gulo gulo luscus
Striped skunk	Mephitis mephitis hudsonica
River otter	Lutra canadensis preblei
Lynx	Lynx lynx canadensis
ORDER ARTIODACTYLA (Cloven Hoofed Mammals)	
Woodland caribou	Rangifer tarandus caribou
Barren-ground caribou[2]	Rangifer tarandus groenlandicus
Mule deer	Odocoileus hemionus hemionus
White-tailed deer[2]	Odocoileus virginianus dacotensis
Moose	Alces alces andersoni
Wood bison	Bison bison athabascae
Plains bison	Bison bison bison
Plains-Wood bison cross	Bison bison bison x Bison bison athabascae (cross)

DRAFT

1 Sources: Banfield, A.W.F. 1974. The Mammals of Canada. University of Toronto Press. Toronto. 438 p.

B.C. Research, 1977. Environmental Survey and Assessment, Pine Point, N.W.T. Report to Cominco Ltd., May 1977. 99 pp and appendices.

2 See text.

south as Lake Athabasca. According to a report cited by B.C. Research (1977) Barren-ground caribou were last observed at Fort Resolution in 1960. This is 75 km east of the study area. However, caribou migrations can be unpredictable and recently the Beverly herd extended 500 kilometres further south in Saskatchewan than previously recorded (L.R. Quaife, Beak Consultants, pers. comm.). Their normal migratory route is sufficiently close to the study area to warrant inclusion here. White-tailed deer have been reported from the Ft. Smith area (Kuyt, 1966), but their normal range is much further south. This appears to be an isolated sighting, rather than a range extention. Excluding these two species, the mammalian fauna comprises 40 species, which includes 41 subspecies. In the brief discussion of this fauna presented below, emphasis is placed mainly on ungulates, because of their traditional importance to man.

The principal ungulates of the study area are moose and woodland caribou (Mr. Jim Beaulieu, N.W.T. Wildlife Service, pers. comm., Mr. Alf Randall, Western Mines, pers. comm.). Neither species are believed to be very abundant. B.C. Research (1977) concluded that densities were low in the Pine Point area on the basis of winter surveys between Buffalo and Little Buffalo Rivers and browse and pellet group surveys in summer. It is significant to this report that no moose or their tracks were observed within 10 kilometres of the Great Slave Lake Reef study area in these winter surveys. Moose prefer early seral stages of forest succession rather than climax boreal forest and their low numbers might be attributed to climax status of the forests in the Pine Point area. In this report, Beak Consultants Limited has confirmed that most forests in the Great Slave Reef project area are climax forests indicating the likelihood of low moose numbers here. Recent (1979) forests fires near Pine Point are likely to lead to improved moose habitat within 11 to 30 years (Kelsall <u>et al</u>., 1977). This indicates that moose numbers are not likely to increase in the study area for some time.

Woodland caribou have been sighted more frequently than moose by Western Mines staff even though the frequency of sightings of all ungulates is low. N.W.T. Wildlife Service staff confirmed that Woodland caribou occur in the Buffalo River area. In contrast to moose, woodland caribou prefer mature coniferous forests principally because of the development of lichens, which serve as a prime winter food. B.C. Research (1977) cites a report by Stardoum (1975) which found that wintering woodland caribou alternately utilize both black spruce and jack pine forests for foraging depending on the snow thickness and hardness. The inference of this study is that optimum woodland caribou wintering habitat involves a mix of these two forest types, similar to that occurring in the study area. Even with apparently favorable habitat, Woodland caribou densities are believed to be low throughout much of their range and until further studies are conducted there is no reason to believe that densities in the study area are exceptional.

Other than woodland caribou and moose only mule deer and bison might occur in the study area. According to Banfield (1974) mule deer range extends northward to the southern shores of Great Slave Lake. No evidence of their presence is reported by B.C. Research (1977) on the adjacent Pine Point property. Bison, both subspecies plus the hybrid occur in Wood Buffalo National Park some 20 km south of the study area. Though they occur in the southeast quadrant of the Pine Point study area, there is no evidence that they occur in the Western Mines study area.

Carnivores in the study area include black bear and canids such as coyote, wolf and red fox. Black bear have been reported to be common in the Pine Point area (B.C. Research, 1977), but canids are secretive and the relative abundance of these species is not known. Arctic fox are considered rare.

Lynx and the mustelids (marten, fisher, ermine, least weasel, mink, wolverine and river otter) occur and represent a potential commercial resource to the trapping industry. The more aquatic furbearers, muskrat and beaver are reported to be common in the area (B.C. Research, 1977). Active beaver dams were spotted in the study area along the tributary streams of the Buffalo River, and along much of the length of Twin Creek from Great Slave Lake south to the highway. Trapping does not presently take place in the study area, but a nearby trapline (Birch Creek) caught beaver (c. 10), marten (c.5), and mink (2), during the 1979-80 winter (Mr. Jim Beaulieu, pers. comm.).

4.5 Social and Economic Characteristics

4.5.1 Introduction

The primary social and economic concerns expressed by government, particular interests and private citizens, regarding proposed projects in lesser developed regions, revolve around the impact of the population generated by the project on the existing communities and populations. There are cases where such concerns have a very real basis in fact, where the attracted population overwhelms that of the host region and by sheer numbers creates many problems for various levels of government, who must create or expand services to accommodate the newcomers. This is not the case here.

The proposed mine would bring about a population increase in the order of 10 percent for the Hay River - Pine Point sub-region, and would scarcely bring the sub-regional population back up to recent highs, which resulted from anticipations of pipeline activity. The new population would be more locally significant if concentrated in one or the other of the two potential settlement bases. In the case of Pine Point, the additional 500 or so people would represent an increase of slightly over 28 percent, a substantial and significant increase, but not beyond the capacity of Pine Point to absorb. For Hay River, a like number would represent an increase of 15 percent approximately. Such an increase would create even less stress for Hay River than for Pine Point, due to the larger size and more complex infrastructure existing in Hay River.

It should be noted that Hay River experienced a recent high population of over 4,000 while Pine Point once was home to over 2,000. The aggregate decline from these levels amounts to about 700 persons, which is less than the projected population increase attributable to the proposed project.

This is not to say that growth, particularly concentrated growth, cannot create problems, and this could be the case in the study area. It is likely that, in the absence of advanced planning, housing could be a problem. Additionally, any tendency on the part of entrepreneurs to take advantage of the growth, could touch off a round of local price inflation, beginning with the construction phase and continuing on into the initial years of production.

Problems could also arise if the proposed project proceeded during a period of economic downturn, and so attracted a number of voluntary job-seekers. The resulting influx of transient would-be workers could create difficulties in the temporary housing market, make problems for government agencies responsible for indigent citizens, and conflict with local residents in various social and economic ways.

Most of these issues are beyond reach of this preliminary assessment of the proposed project but are noted here in case it is otherwise asssumed that the Proponent has not taken them into consideration in commissioning this report. As the project planning proceeds, more detailed attention will be given to these and other issues.

4.5.2 Study Objectives

The objectives of this study were:

a. To provide a preliminary description of the social and economic resources of the region likely to be influenced by the proposed Great Slave Reef project. The description was to include recreational, cultural, and archaeological resources within the area of possible influence.

b. To identify those components of the local region most sensitive to the likely influences of the project, and to recommend measures of mitigation and enhancement relative to them, appropriate to this initial level of study (Sections 5.5 and 6.5)

c. To evaluate the data base available for more detailed studies, and to identify major data gaps.

d. To produce a report satisfying the governmental requirements regarding resource development in the Northern Territories, at this preliminary level.

4.5.3 Methods of Study

The study program, carried out over a period of approximately 20 working days in late 1979, involved the review of government and other reports, a field trip to the study area and Yellowknife, during which discussions were held with government and private interests, and the application of basic methodologies bearing on population and income effects in developing regions. In addition, project descriptions were provided by Western Mines.

The basic descriptions of the study area and the two communities likely to be affected by the proposed project were obtained from published reports, briefs and community plans, obtained from local authorities. Additional information was obtained through interviews with municipal authorities, government employees, and private citizens, including business people. The documents and other materials used are listed in the bibliography, together with a record of the personal communications.

The theoretical bases of the population/income multipliers are simplified applications of basic theory. The population expansions were derived from assumptions made in the Hay River General Plan 1975, the Hay River Industrial Development Study (1975), and from those used in the population estimation and projection studies carried out in 1978 by the Statistics Section of the Government of the Northwest Territories. These are listed with full titles, in the bibliography.

Population estimations and projections are difficult to produce, particularly in regions characterized by quite different population components, since the number of variables multiply when natural increases, fertility rates, and birth rates vary internally and are complicated by the role of largely unpredictable, exogenously determined factors of in/out migration.

The generation of a population by the creation of a labour force is subject to similar uncertainties. The mode of analysis known as basic/non-basic is deceptively simple in general outline. It merely describes the fact that once a job has been created in a community, the needs of the worker filling that job create additional employment. However, in practice the tracing of that relationship is a complex exercise. In this study, the multiplier ratio used has been taken from the Hay River Industrial Development Study, since it has the virtue of having been based on a recent historical record reflective of the study area. Similarly, the population multiplier, which is based on family size, has been taken from the General Plan 1975 since it also is based on recent local conditions. However, the conceptual and practical problems associated with this theoretical approach remain effective, and it cannot be assumed that the multiplier ratios used in this report are definitive. For a review of the concept and its problems, the reader is referred to the appropriate items in the bibliography.

Similar problems are associated with efforts to trace the effect of investment and/or wage bills. Indeed, the wage bill question is closely related to employment/population equations, and the basic/non-basic multiplier ratio is largely a function of income flowing into the economy from basic employment. In this study, data on wage bills have not been available. The figures used are presented for illustrative purposes, and in order to convey an "order of magnitude" to the reader.

Any wage bill is partially expended outside of the region of employment, a phenomenon generally referred to as "leakage". The amount or proportion of income leaked is a function of the propensity to consume modified by the level/type of goods and services available in the earning region. Leakage is also structured by such factors as saving patterns and the direct export of earnings for saving, investment, or private consumption outside of the region. It is also subject to various taxes. The propensity to save can be high in resource regions, since many workers seek employment in such occupations in order to save, usually with some specific sum in mind. Such workers are referred to as "target" workers.

It is not possible at this level of analysis to quantify the causes and magnitudes of leakages that prevail in the study region. However, it is certain that significant leakage will prevail. Consequently, the illustrative dollar values cited here must be treated with caution when being translated into a measure of local benefit.

In general, and at the risk of weakening these preliminary findings, it is believed that the analysis here presented tends to over-state the population increases to be expected and under-states the size of the wage bill, although perhaps not the effective wage bill.

Finally, it should be noted that, due to the preliminary state of the mine plan, no data has been available regarding capital and operating costs. Consequently, this report does not deal directly with such issues as local expenditures for suppliers, taxation and royalties, or the general distribution of costs and benefits pertinent to the proposed project.

4.5.4 Government Regulation and Requirements

The government of the Northwest Territories and the federal government have various regulations governing resource developments. The social and economic requirements of government are not laid down in guideline detail but are evolving within government departments, as policy is interpreted in terms of particular departmental concerns. The policy which has evolved, which is presented in Policy On Single Resource Community

(Government of the N.W.T., January 1979), focuses on several broad concerns rather than on particular requirements bearing on methods and areas of study. The Policy notes that the government of the N.W.T. supports the orderly exploration and development of resources but expects that such activity will take place within the following constraints:

A. The Policy will be effective in cases where new communities are contemplated as part of proposed development, but will also govern cases where existing communities are brought in to the development matrix.

B. The overall emphasis of the Policy is concern for ......"improvement of the general welfare of northern people".

C. This concern of the Policy will be best met by ...... "providing long-term employment for northern residents".

D. Following the line of that concern, would-be developers are expected to utilize ..... "the resources and business facilities of existing communities in the proximity of the development", and to explore the potential for otherwise maximizing local employment by training programs and by the introduction of ..... "job rotation schemes to facilitate employment of northern residents".

Where proposed developments are satisfactory in these terms, the government in turn may negotiate with the development company a Special Services Agreement, through which the government may contribute capital and other investments to the provision of various municipal, educational, medical and social services and other facilities, to support the infrastructural and operational needs of the development.

Formal hearings are not specified as part of the development application process but hearings may be required. (pers. comm. L. Matthews, Head, Regional Planning, Department Planning and Program Evaluation, Yellowknife. Sept. 1979).

4.5.5 Regional Setting

The Hay River sub-region is part of the Fort Smith District of the N.W.T. The District contains about 57 percent of the N.W.T. total population and includes within its boundaries most of the major settlements, including Yellowknife. The Fort Smith District is the only one of the four in the N.W.T. in which the non-Indian/Inuit population is the majority of residents.

Demographically, the Hay River sub-region, comprising the towns and settlements of Hay River, Pine Point, Fort Providence, Fort Resolution, Enterprise, and some scattered minor settlements, contains about 7,000 persons, with some half of these residing in Hay River, which, together with Pine Point, dominates the population with some 75 percent of the total. Hay River and Pine Point together contain over 90 percent of the non-Indian/Inuit population of the sub-region. Indians (there are no Inuit permanently residing in the sub-area) number 1,251 in five communities named above, which represents 20 percent of the total population in those centres (See Tables 4.5-1 and 4.5-2).

The southern part of the Fort Smith District is primarily based on development transportation and administrative considerations. Historically, this southern area has been an access corridor between the south and the interior of the N.W.T., with connections north and west into the Mackenzie Valley, the central lakes area, and Yukon. The transportation network is shown in Figure 4.5-1.

Since the late 1800's, the focus and orientation of the transport/administration role has been comparatively stable, although the technology and settlement pattern associated with those functions have undergone considerable change.

Economically, the Hay River region is dominated by the transportation and administration functions, which provide the bulk of the permanent employment in the area. Mining is significant as a result of the Cominco operation at Pine Point, and mining exploration creates a significant number of temporary jobs, adding to the locally exerted demand for goods and services. The Proponent's field exploration, for example, has extended over a four year period, employing 30 men in winter and 15 in summer, and has undoubtedly contributed to the local economy.

Fishing and forestry are also significant employers in the area. Fishing has historically been a major employer and, while the total catch has been in decline for several decades, there are hopes that additional processing of previously ignored species will contribute a

Table 4.5-1

Population of Study Area

	1971	1976	1977	1978 (est)	1979 (est)
Enterprise	56	83	40	40	75
Fort Providence	587	602	566	556	527
Fort Resolution	623	501	519	521	612
Hay River	2,527	3,329	3,531	3,398	3,500
Pine Point	1,217	1,915	1,878	1,763	1,970

Table 4.5-2

Ethnic Composition of Study Area
December 1978

	Indian	(%)	Inuit (%)	Other	(%)	Total
Enterprise	NA	-	NA	NA	-	40
Fort Providence	425	(76.4)	Nil	131	(23.6)	556
Fort Resolution	171	(32.8)	Nil	350	(67.2)	521
Hay River	368	(10.8)	Nil	3,030	(89.2)	3,398
Pine Point	287	(16.3)	Nil	1,476	(83.7)	1,763
Totals	1,251	(20.0)		4,987	(80.0)	6,238

Table 4.5-3

Estimated Age Distribution (1978)

	Age 0-4	5-19	20-39	40-64	65+	Total
Fort Providence	55	227	166	88	20	556
Fort Resolution	50	199	131	107	34	521
Hay River	329	993	1,337	653	86	3,398
Pine Point	258	571	717	204	13	1,763

Source: Population Estimates, Statistical Cross Tabulations, Statistics Section, Department of Planning and Program Evaluation, Government of the Northwest Territories, December 1978.

1979 estimate from J. Lamoureux, Area Economic Development Officer, Hay River

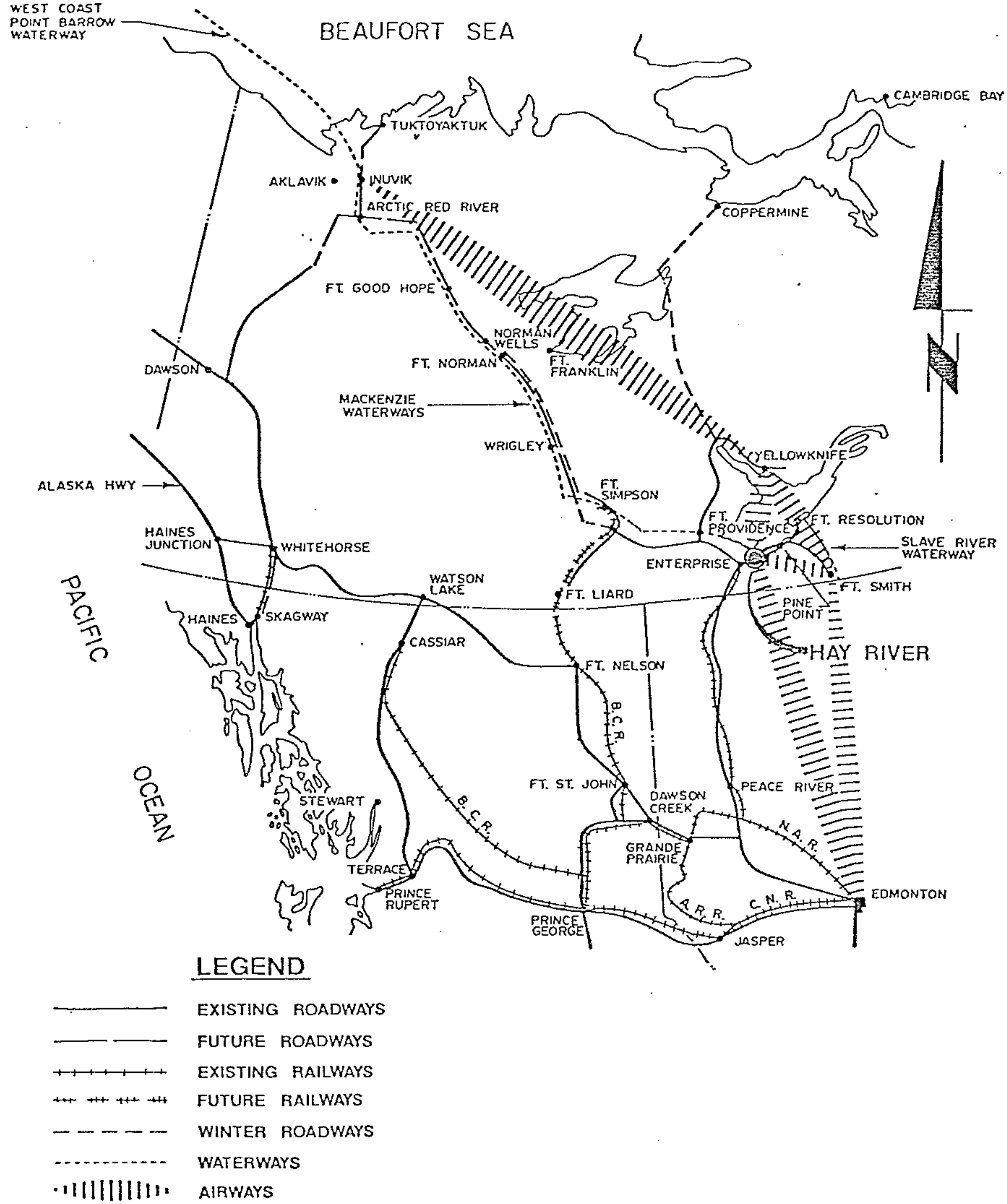


FIGURE 4.5-1: Transportation Routes

beak	DATE	March 80 HV
	PROJECT	K4466
	DWG. NO.	

significant and stable payroll to the area in the near future. Forestry is a more modest activity, although it, too, has a potential for expansion. Trapping is significant for the Indian population but is not a major producer of income or wage employment.

In terms of concentration of population and economic activity, Hay River and Pine Point dominate the area, and are of most concern to this study. The two communities are described below.

4.5.6 Hay River

Hay River is the largest community in the sub-area, with a population variously given as 4,179 (Travel Arctic, 1979, p. 14), 3,398 (estimated, 1978, Statistics Section, Department of Planning and Program Evaluation, Yellowknife 1978) and 3,500 (pers. comm. J. Lamoureux, Area Economic Development Officer, Hay River, September 1979).

The layout of the town is given in Figure 4.5-2. As can be seen, it lies concentrated between the Hay River to the east and the Hay River Highway and rail line to the west, with an extension along the west side of the transportation corridor.

The major area on the north of the settlement is Vale Island, which once was the site of Hay River proper. Flood problems led to the re-establishment of the town in its present location and Vale Island is now largely devoted to the rail/water interchange function, although some residential settlement remains as a vestige of the old town.

Data bearing on Hay River is both limited in scope and dated. The most recent studies of any comprehensive scale were prepared some five years ago, when the Mackenzie pipeline was expected. This expectation coloured the studies done, and the projections and plans contained in the two main documents have found the recent reality falling short of the levels and types of growth anticipated. The popultion projection, for example, appearing in the General Plan 1975 (p.15) predicts a 1979 population of 5,890, which over-estimated the event by some 1,000 persons.

Nonetheless, the 1975 General Plan is still the official planning document for Hay River, and it has been used here, with qualifications based on personal communications and data gathered in the field. It might be noted that one "benefit" conferred by the relative

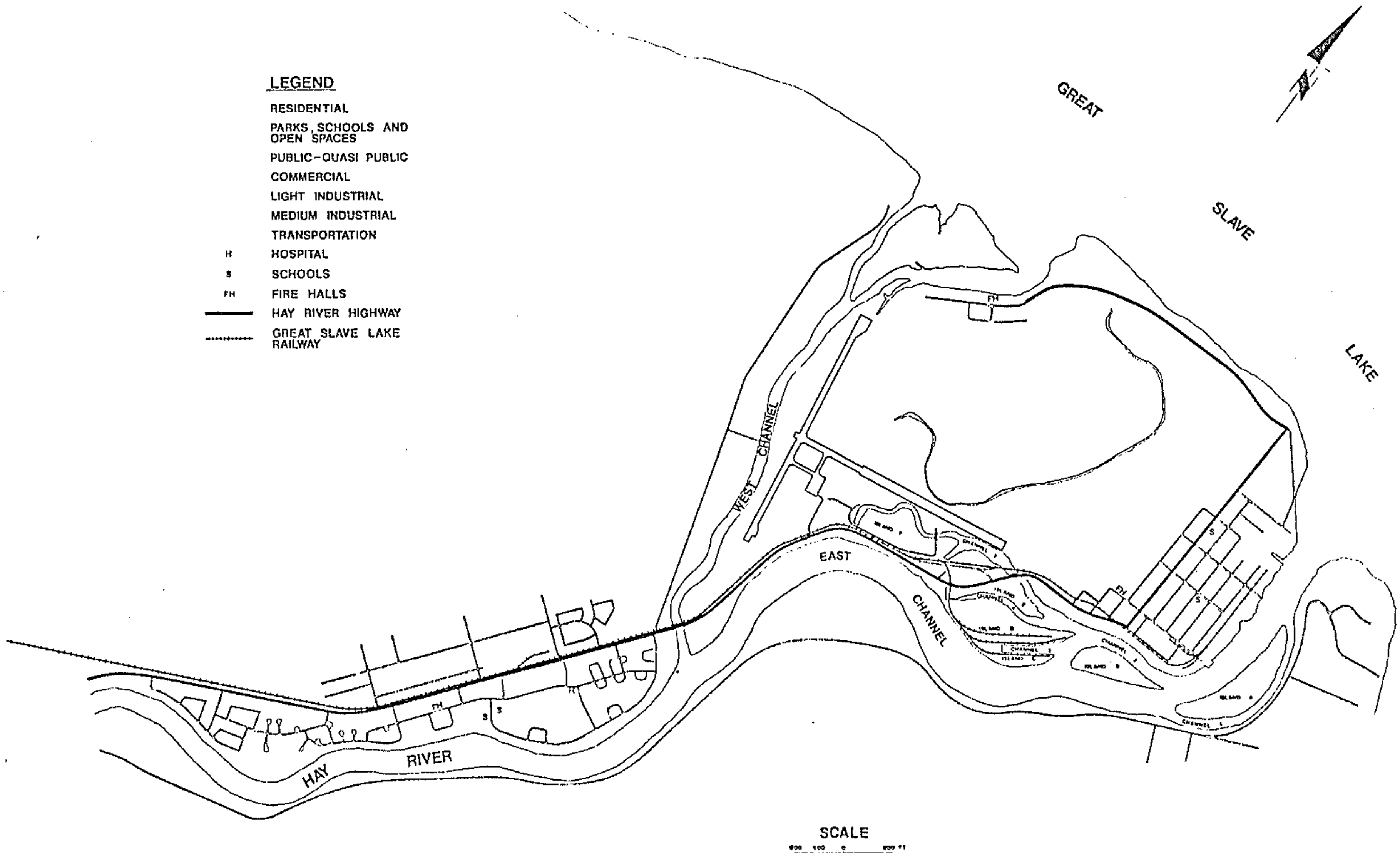


FIGURE 4.5-2: Hay River Townsite

DATE	March 80	HV
PROJECT	K4466	
DWG NO		

downturn in Hay River growth is that current proposed projects in the region can be expected to fit neatly under the levels of growth provided for in the General Plan, and so (marginally) take up the slack in the plans prepared on the expectation of pipeline related growth.

Given the hiatus in growth over the 1975-9 period, it is reasonable to assume that the structural components of the descriptions offered in the General Plan still hold, in broad outline, for such factors as housing, retail-commercial activity, and employment patterns. The difference between the 1975 and (estimated) 1979 population is, for example, less than 200 persons.

The governmental-administrative component of the Hay River economy is pronounced. The federal government maintains offices and staff in Hay River, with at least ten departments represented there, plus a police detachment. Similarly, the Territorial government maintains five or more departments in the town, and administers the adjacent regions from Hay River. Hay River is the major medical services centre in the southern region and is the headquarters for the N.W.T. Public Library Service.

No data is available regarding the employment represented by these government services, to which can be added that of the town administration itself, but it clearly is substantial. The primary economy of Hay River (in 1969, assuming here that structurally it has not greatly altered) supports a work force described in the General Plan as follows:

Fishing	35%
Transportation	35%
Communications	15%
Personal Services	10%
Trapping	5%
	100%

It is probable that the personal service sector is relatively larger today than it was when this distribution was calculated, and likely that construction, which was in decline ten years ago, has revived and would be represented in current data.

Annual population growth in Hay River has in recent years been more a function of in-migration than of natural increases, although natural increase in the early 70's was at the relatively high level of 3 percent, dropping to around 2.3 percent in more recent years. In-migration up to the mid-1970's was some 8.6 percent but it is expected to have been lowered since 1975 to around 2.5 percent. Since in-migration is basically a function of government expansion and general resource development, it is only partially accessible to reliable analysis.

Tourism is widely regarded as a significant factor in the N.W.T. generally and in the Great Slave Lake area in particular. Hay River attracts a significant tourist flow and is the base for several tourist-oriented fishing and hunting lodges and camps in the southern N.W.T. However, as the General Plan notes:

> "There are no reliable quantitative data available to indicate the strength of tourism as an employment generator or as an income producer in the Hay River economy."

Housing

The housing stock in Hay River is dominated by single family dwellings, which make up some 60-70 percent of the housing units. Apartments represent some 10-12 percent of the stock, while mobile homes make up the balance. There are, in addition, some 80 units available in hotels-motels in the community (Explorers' Guide 1979, modified).

The housing stock is primarily owned by private companies and different levels of government, necessitated by the need to provide housing as an incentive to employees. The two senior government levels in 1975 owned 28 percent of the housing stock, while private companies owned an additional 17 percent; only some 33 percent was then privately owned, and owner occupied. Virtually no rental units were available in Hay River, other than commercial accommodation, until quite recently. While this 1975 pattern of housing has shifted somewhat toward more private housing and the promise of more rental units, housing remains a constraint on growth in Hay River.

The town has moved considerably toward easing the situation, however, and in 1979 there were 80 serviced lots available for purchase, and an additional 120 lots were on the planning board. With an occupancy level of three persons per unit, these 200 lots represent a surplus in terms of the projected needs of the proposed project (pers. comm. J. Hamilton, Hay River Municipal Hall, September 1979).

The current availability of these existing and planned lots is quite significant, since due to drainage and permafrost problems, a lead time of two years is required to prepare land for construction in Hay River.

In addition, there is a two storey apartment block, containing 57 units, in Hay River. This complex, which was built in 1974-75, is under basic maintenance but is not open for occupancy. Presumably, if the demand was present, it would be made available for tenants.

Commercial and Retail Services

Hay River in the context of present demand is well serviced by commercial and retail entrepreneurs. In the transportation sector, numerous charter air services are based in Hay River or maintain service through the ground and water-based facilities. Ground transportation is available on regular schedule and charter basis for freight and passengers, and scheduled air service is maintained by Pacific Western Airlines and by Ptarmigan Air Service, which connects with Yellowknife.

Other commercial services such as heavy-equipment maintenance and warehouse/supply are tailored to existing levels of activity but could expand to meet new demand if it arose.

On the retail service side, Hay River is less of a regional centre. While residents of other communities, such as Pine Point, do make use of Hay River as a higher order retail centre, recent estimates indicate that only 10 percent or so of the retail business done in Hay River can be attributed to outside demand. The range of services offered is relatively comprehensive, including supermarket and department store levels of service, and the retail mix is appropriate to the size and composition of the population it is designed to serve. For both retail and commercial services, ample land exists for any future expansion, and the groundwork done by the General Plan 1975 assures that any increase in demand would be promptly met by the implementation of existing plans for development. There are active plans to add 26,000 ft^2 of office-retail space to Hay River in 1980 (pers. comm. M. Currie, Ferguson Real Estate, Pine Point, September 1979).

Schools and Town Recreation

Hay River has elementary and high school capacity, with accompanying open space, at a quality level equivalent to any schools in the south, and superior to most. The schools have shop and gymnasium facilities, which are also used for community education and recreation, and the Arena Complex in Hay River, built in 1969, has hockey and curling ice, and various other facilities/rooms for other activities.

Hay River also has a licensed day-care centre. The high school currently (1979) has about 270 students, with the capacity to accommodate 450, giving a surplus capacity for 180 additional students. The capacity of the lower grades, however, from Grade 9 down to and including kindergarten, is about fully occupied by existing enrolment, and any increase in the number of pupils would require expansion of these grade level facilities. There is, however, an intermediate school scheduled for construction in 1981-2, which would alter the overall school capacity situation. In addition, the Hay River schools have generous land allowances and portable classrooms could be set up on the school grounds, without seriously reducing the open areas available (pers. comm. J. Maher, Dept. of Education, Hay River, September 1979). Such an improvisation could only be a temporary measure, since mobiles are not the ideal teaching-learning environment.

In addition to the school grounds and facilities and the town arena, there are several developed parks in Hay River, and a major camp ground, with beach access, on Vale Island.

Municipal and Personal Services

The municipal services, including water, sewage, waste disposal, electric power and telephone (not all municipally run services) have been constructed to superior levels. Although the new water system required modifications in 1979, once fully operable it will also be a superior system.

It is estimated by the Hay River municipal staff that the existing services could support a population of 10,000 people without major expansions, other than those associated with servicing land areas newly brought under use (pers. comm. J. Hamilton, Hay River, September 1979). The Mayor believes existing facilities would support 17,000 people. (pers. comm. September 1979).

Fire and ambulance service is provided by a volunteer system, which has been found to be a satisfactory and efficient method for communities up to the 10,000 population range (General Plan 1975).

The Hay River hospital services the regional population as well as the town proper, and is the base from which medical personnel serve other communities on a visiting basis. In addition, the hospital provides advanced medical facilities, and has the organized capacity to transfer cases to Edmonton expeditiously, and to participate in telex consultation with specialists outside the N.W.T.

The hospital has six doctors, of whom two are surgeons, and a complete nursing staff, including operating room nursing support. Hay River also has two resident dentists, who visit other communities.

Weakness in the medical services are concentrated in the areas of psychiatric care, as related to emotional problems and to alcoholism. In this, Hay River shares a weakness in common with many other larger areas, including some metropolitan regions.

Hay River housed a childrens Receiving Home, with a staff of 11, able to accommodate 36 children, until March 1980. The home was closed in March and the service shifted to Ft. Smith. However, there are plans for a Crisis Centre in Hay River, which would provide a wide range of social services for children, and older age groups, in an integrated fashion.

The town is policed by an RCMP detachment, which is also responsible for an extensive area outside of the town, as far east as Buffalo River, which includes the proposed mine site.

The RCMP detachment in Hay River is made up of 14 officers, including one responsible for court duties, and two civilian office workers. One officer is responsible for highway patrol, and one other officer fills a specialist role in the Identification Section of the detachment. New detachment premises are currently (April 1980) under construction, and the resulting facilities will be adequate to service a population in the 8-10,000 range (pers. comm. Constable J.E. Carnegie, Hay River, April 1980).

The detachment is accustomed to dealing with a fluctuating population level, and an increase in the population of up to 600 - 700 persons would not constitute a critical situation for the detachment. The major concern so far as policing is concerned, relative to the proposed project, is that of increased traffic on the highway out of Hay River. This could be a problem, particularly during the construction phase of the proposed project.

The population increase attributable to the project could warrant one or possibly two additional officers, depending on the final distribution of the new population. The construction phase might require two additional officers on highway patrol.

Transportation

Hay River, the transportation hub of road, rail and Mackenzie River system, is well served in terms of access into and within the N.W.T. The town has daily bus and air service from points to the south, and regular service to other N.W.T. points is routed through Hay River.

Air charter services and boat rentals are available locally, and major lake-river freight shipping companies are based on Vale Island. On the local level, car-truck rental agencies are located in Hay River, and taxi service is available.

The rail system, which is freight only, has its effective railhead in Hay River, although a branch connects Pine Point with the system. The annual capacity of the rail system was estimated in 1975 as being 36,000,000 tonnes at 100 percent capacity, which is unlikely to be called upon in the foreseeable future (Hay River Industrial Development Study, 1975).

Indian Reserve

The only Indian reserve in the N.W.T. is adjacent to Hay River. The reserve has a considerable potential for development, under the authority of the Band Council, although no plans for development are active at this time, so far as is known.

The Hay River Indian Band has an interest in the strip of land between the Great Slave Lake and the Hay River Highway, extending as far as the Buffalo River just west of Pine Point. This area of interest contains the mineral resources under exploration by Western Mines. The Hay River Indian Band has in the recent past made an effort to have this area placed under an educational reserve, for use by the Band. Since the area in question contains fish migration-spawning streams, it is likely that historically the Band made extensive use of it. Current use is apparently at a low level, and is limited to some trapping activity.

Given the historical connection, it is possible that some sites along the lake shore east of Hay River might be of archaeological significance. This possibility was not investigated as part of this study.

Labour Availability

Hay River, like most other communities in the sub-area, does not contain a significant surplus of labour. There are target groups within its population, such as native Indians, who are under-employed, but the number of experienced, active workers available for employment is limited to the frictional unemployment component. In late 1979, there were some 60 persons registered with Manpower. In general, however, the unemployed are relatively unskilled or have skills developed in sectors other than mining (pers. com. G. Halliday, Canada Manpower, Hay River, September 1979).

It is possible that, given a vigorous program of recruitment and training, some labour might be attracted from non-traditional sources (women); and it is also possible that Indians might be interested in a wide range of employment, including sub-contracting roles, if suitable arrangements can be made to accommodate indigenous life-styles.

4.5.7 Pine Point

The town of Pine Point, a fully incorporated municipality, services the Cominco mine operation, east of Hay River, on the shore of Great Slave Lake. The town has a population in the 1700-2000 range, supported by the approximately 450-500 jobs with

Cominco, and by the service sector created by the resultant demand. The figure of 400 was provided by the Union. Other, earlier sources indicate that Cominco employed 500-525 hourly workers, plus staff, for a total of 650 - 700 in 1977.

Pine Point has the full range of municipal services, water, sewage, paved roads, and various other services appropriate to a town of its size. It has a four-man RCMP detachment (Cominco also has security staff), a volunteer fire department, and a medical centre staffed by professional nurses, supported by visiting doctors from Hay River.

The Town Manager believes that Pine Point could support an additional population of 700 -800 without requiring any major extension of or improvement to existing services (pers. comm. D. Lagore, Town Manager, Pine Point, September 1979).

The retail-service sector of the town is concentrated in a mall area, which houses a hotel, a department store, a movie house (recently closed), supermarket level food outlets, and various other retail stores (Figure 4.5-3).

The economy, directly dependent on the level of employment at Cominco and on the level of local spending, fluctuates, and has little potential for growth beyond the potential for expansion of the mining and processing activity. This limitation is accentuated by the tendency on the part of many Pine Point residents to make use of Hay River as a higher order service centre, with a corresponding loss of retail dollars for Pine Point.

Schools

Pine Point has a play school for children 3 - 4 years of age , operating four days a week. The Galena Heights School, with eight teachers and three tutorial assistants, plus support staff, provides kindergarten to Grade 3; Matonabbee School, with 22 teachers and 12 tutorial assistants, provides grades 3 - 12 for over 400 students. The Senior school has a gymnasium and shop facilities. The Pine Point schools follow the Alberta curriculum.

GUIDE KEY

1. CURLING RINK
2. ARENA
3. THEATRE
4. LEGION
5. WATER RESERVOIR
6. REVERSE OSMOSIS WATER TREATMENT PLANT
7. SHELL SERVICE STATION
8. PINE POINT MALL
   - i TOWN OFFICE
   - i TOWN OFFICES
   - ii R.C.M.P.
   - iii POST OFFICE
   - iv OGILVIE'S IMPORTS
   - v I.G.A. STORES
   - vi LIQUOR OUTLET
   - vii UNION OFFICES
   - viii C.N. TELECOMMUNICATIONS
9. PINE POINT HOTEL AND RESTAURANT
10. PINE POINT DRUGS BUILDING
    - i MEDICAL CLINIC
    - ii CLOTHING STORE
    - iii DRUGSTORE
11. BANK OF MONTREAL
12. SIMPSON'S-SEARS
13. RECREATION HALL
14. ELEMENTARY AND SECONDARY SCHOOL
15. PENTECOSTAL CHURCH AND MANSE
16. CATHOLIC CHURCH AND MANSE
17. CHURCH OF THE NAZARENE
18. GULF SERVICE STATION
19. CBC-TV
20. BALL PARK
21. GOLF COURSE AND ORIGINAL TOWNSITE AREA
22. DENTAL CLINIC AND PUBLIC HEALTH SERVICES

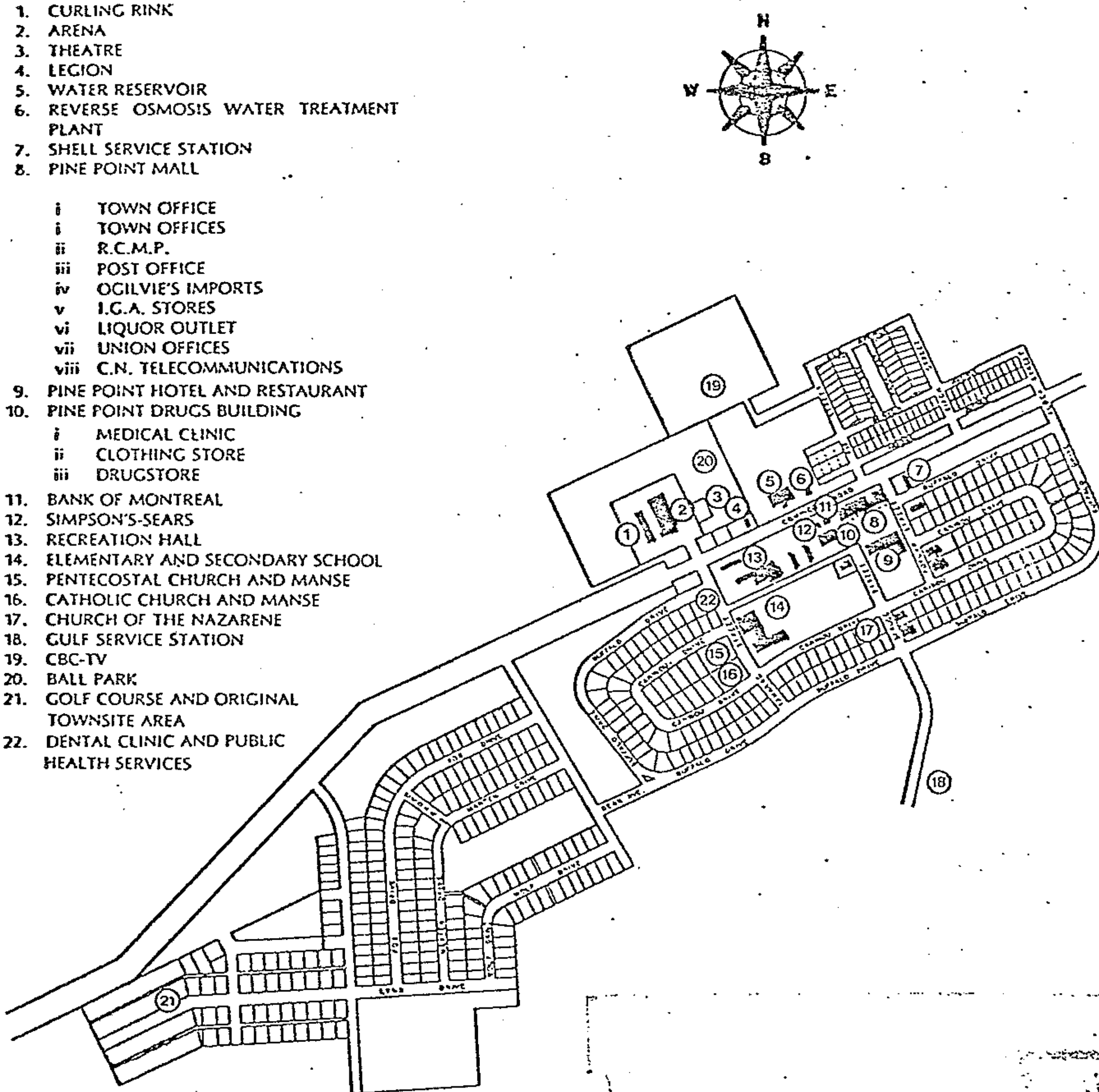


FIGURE 4.5-3: Pine Point Townsite

DATE	March 80	HV
PROJECT	K4466	
DWG. NO.		

VANCAL - 3786

Recreation

Pine Point has a covered arena with curling and hockey ice. The arena has lounge facilities as well as the usual changing rooms and spectator space (for 500 people), in addition to other room space suitable for meetings of small groups or classes. The high school gym is also available for community use. The town also has an indoor gun range, a 9-hole golf course, open space park areas, and a swimming pool. There are plans in hand for an indoor swimming pool.

The resident population is active on a volunteer basis in the provision of recreation and a nearby lake has been developed for recreational use. General outdoor recreation is popular with Pine Point residents and there is widespread use made of the bush resources for hunting, fishing, snowmobiling, cross country skiing, etc.

The town receives two TV signals and a second cable is planned.

Housing and Land

Housing is available in Pine Point largely through Cominco employment. Rents and services for employees are governed by the collective agreement in force between Cominco and the United Steelworkers, Local 804 (pers. comm. J. Ferguson, Pres. USWA, Pine Point, September 1979).

Not all employees of Cominco look upon Pine Point as a permanent home, and it appears that this has tended to weaken the private housing market. In addition, a number of single male workers are housed in a camp, which is being phased out. In late 1979, according to the manager and staff of Ferguson Real Estate, there were about six trailers and no houses on the market in Pine Point.

In 1977-78 a major subdivision was planned for an area in the southwest part of town. The plan calls for 400 single family lots, with a school and park facilities, as well as a commercial-retail complex. The subdivision is planned to a level able to accommodate some 1,600 people.

Pine Point also has a site of 9.2 acres, zoned for commercial-multiple family residential, which is currently available should the market justify the construction of apartments. Industrial land is also available.

Transportation

The town has no scheduled flights connecting outside of the N.W.T. although an up-to-date airport is present and recently supported such a service. There is a limited but scheduled flight connection with Yellowknife and charter air services are available. There is a daily bus service, which provides connection through Hay River and points east. Freight service by road is available five days a week. Taxi service is available in town, and Cominco provides a free commuting service for employees.

Other Communities

Other communities in the sub-area, Enterprise, Fort Providence, and Fort Resolution, are small in population sizes (40/556/521, respectively) and in municipal and other services. None of these communities is likely to be directly affected by the proposed development but some employment opportunities may be indirectly created that could benefit one or more of them.

5.0 ENVIRONMENTAL SENSITIVITIES

5.1 Climate and Air Quality

we're not talking about this!

The typical contaminants from a mining and crushing-concentrating operation are particulates, sulphur dioxide, and nitrogren oxides. Table 5.1-1 shows the typical emission source and the contaminants expected from each.

Table 5.1-1
Typical Base Metal Mine Emission Sources

	Particulate	Sulphur Dioxide	Nitrogen Oxides
Excavation, hauling and dumping crushing and conveying	X		
Diesel Generators	X	X	X
Concentrate Driers	X	X	possible

With modern control measures on particulate source emissions and considering the relatively small magnitude of gaseous emissions from the possible future processing operations, there would appear to be little potential for any significant impact on the local or regional air quality and meteorology.

5.2 Geology and Soils

Development of the Great Slave Reef property by Western Mines Limited has the potential to adversely affect the terrain (geology and soils) in the following ways:

1. Activity may result in the disturbance to the permafrost present in the organic terrain and the subsequent development of thermokarst. This can lead to the formation of thermokarst ponds.

2. Permafrost-free organic terrain is also prone to disturbance by surface activity. Vehicles travelling across organic terrain can initiate the formation of long-lasting ruts.

3. Fine-grained lacustrine deposits and the soils they support are more susceptible to erosion, if disturbed, than are coarser-grained deposits and their associated soils. The removal of vegetation from the lacustrine deposits and the movement of vehicles and equipment across them has the potential for erosion in the form of rilling by water and mass wasting if slopes of fine-grained material are disturbed.

4. Western Mines Limited plans to use sand from a gravel ridge near the minesite to backfill the mined out areas. This will result in the destruction of the gravel ridge. However, the abundance of raised beaches and till ridges in the area minimizes any adverse terrain effects associated with the removal of this landform.

5. Western Mines Limited estimates that there will be 15,300 cubic metres of waste rock from preproduction development of the mine. This rock is to be used for road construction and as fill for the mine plant area. If the waste rock is left exposed during the time between extraction and used as fill, it will be prone to erosion by water and wind. This may lead to sedimentation in nearby streams.

The above-mentioned potential impacts are of a general nature only. More specific ones can be identified only when detailed site plans have been formulated. The low value of the soils for agricultural use and the lack of unique geologic and pedologic features suggest that if careful mining procedures are followed, the environmental impacts to the terrain will be minimal.

5.3 Hydrology and Water Quality

5.3.1 Hydrology

Based on the description of the project as outlined in Section 3, development of a mine at the R190 orebody, the major environmental concerns from a groundwater standpoint are the effects of extraction and discharge of upwards of 30,000 gpm of groundwater during the continuous dewatering operations. Available information on substrata characteristics and local hydrogeology indicate the magnitude of drawdown of the surface water table would likely be minor due primarily to the existence of the thick, relatively impermeable overburden unit. Information obtained from the pump test at the X25 orebody site was incomplete in that permeability data was not determined on the individual substrata including the overburden. This information will be obtained in the pump test at R190 and should allow more refined projections to be made on extent and magnitude of any drawdown effects from a full-scale mine dewatering operation at that site.

Discharge of the mine dewatering water onto the lowland area north of the mine via ditches constructed to convey and distribute the water could cause some localized flooding. Experience at Pine Point from similar procedures of discharging a considerably greater quantity of dewatering waters indicates initial increases in surface water with no significant alteration of the characteristics of the landform once the new equilibrium is reached and the water dissipates into the lowland muskeg area (B.C. Research, 1977). Although serious impacts from a surface hydrology viewpoint appear unlikely, more detailed assessments should be made in the detail mine planning stages of the most suitable area for discharge of mine dewatering waters. The area selected should avoid flooding, extensive ponding and allow good dissipation of the water without formation of runoff channels that might connect to existing small creeks leading directly to the Twin Creek or Buffalo River systems. It appears that the area northeast of R190 draining out into the central lowland between Twin Creek and the Buffalo River would likely meet these requirements.

5.3.2 Water Quality

The main concerns of the development of a mine as described in Section 3 - Project Proposal from a water quality prespective would be mine domestic sewage disposal, and mine dewatering water disposal. Since there would be no ore processing mill associated with the mining at the R190 site, there will be no requirement for a tailings disposal facility. Domestic sewage treatment requirements would be resticted to handling the small amount from the mine operations since no permanent on-site housing is planned and therefore should pose no significant disposal problems.

Based on the available information on the quality of water to be expected from mine dewatering operations (Table 4.3-2, Section 4.3-3), as determined in the X25 orebody pump test, in comparison with the typical discharge quality requirements to be applied by the regulatory agency, present indications are that the water quality would not exceed the maximum permissible concentrations. This comparison is shown in Table 5.3-1.

Table 5.3-1

Comparison of Probable Water Quality Requirements with X-25 Orebody Water Quality

Water Quality Parameter	Probable Maximum * Permissible Concentration (mg/l)	X-25 Pump Test Water Quality (mg/l)
Total Arsenic	0.05	<0.01
Total Cadmium	0.01	0.01
Total Copper	0.10	<0.01 - 0.03
Total Lead	0.20	0.06 - 0.17
Total Mercury	0.002	< 0.01
Total Nickel	0.40	0.04 - 0.11
Total Zinc	0.40	0.02 - 0.16
pH (units)	6.0 - 9.0	7.1 - 8.1

* Based on Requirements of Pine Point Mines Limited's Water License issued by Northwest Territories Water Board in 1979.

The concentrations of the parameters listed in Table 5.3-1 for the mine water are somewhat higher than the existing water quality in the single characterization of the swamp water north of the R190 orebody as shown in Table 4.3-1. This indicates some potential for moderate changes in water quality in areas which would receive the mine water discharges.

Additional water quality data of the bedrock groundwater in the R190 orebody area will be collected during the proposed 1980 pump test at that site. This information will allow further assessment of the probable character of waters to be disposed of from mine dewatering operations and potential for any significant water quality effects.

5.4 Biological Characteristics

5.4.1 Aquatic Systems

The areas of aquatic concern in relation to development of a Pb-Zn mine on the south shore of Great Slave Lake may be considered under three major categories:

1. The budget of heavy metals in mine waters and effluents produced during the construction and operation of the mine, and the effects of these metals on the aquatic environment;
2. The effects of groundwater removal on the hydrological regime of the area; and
3. The specific effects of the construction, operation and abandonment of the mine on commercial, domestic and sport fisheries of the area.

Heavy Metals and the Aquatic Environment

The effects of heavy metals on various aspects of the aquatic environment have been the subject of innumerable studies and publications. Hynes (1971) suggests, however, that a disproportionate amount of research has been expended on toxicological research of very narrow scope, and that not enough effort has been expended on an understanding of the pollutants on the aquatic ecosystem as a whole. This author cites the varying sensitivities of aquatic organisms, both invertebrate and vertebrate, to the same pollutants as an example. There is no question, however, that heavy metals are capable of killing fish directly, or creating stress from sub-lethal metal pollution (Stein and Miller 1972).

In considering the potential effects of heavy metal contamination on the aquatic ecosystem, the following components of aquatic systems should be addressed:

i) water quality
ii) sediment
iii) aquatic vegetation
iv) benthic organisms
v) fish

The major area of concern in relation to a Pb-Zn mine and the possibility of heavy metal pollution is that of tailings disposal, and the potential for contamination of surrounding waterbodies with by products such as heavy metals or fine particulate matter. This is not a concern at the Great Slave Reef Project as it is presently conceived, in that no processing of ore is planned at the site, thus eliminating any concerns about mine tailings.

The major area of concern in relation to heavy metal contamination will involve the ultimate disposition of effluent, which includes both the groundwater removed from the mine and surficial drainage from the area of the mine site, and the chemical characteristics of this effluent. These concerns are addressed in Section 5.3.2 on Water Quality and Section 5.3.1 on Hydrology in this report.

An examination of the topography between the proposed mine site and the surrounding waterbodies with fisheries potential (Buffalo River, Great Slave Lake, Polar Lake, and to a very limited extent, Twin Creek) indicates the bog-shallow lake complex would act as a buffer between significant aquatic systems and the effluent. Further definition of the chemical characteristics of the effluent, and surficial and groundwater movements in the area are required before any firm conclusions may be reached. The results of these determinations will dictate the necessity and scope of any special mitigation measures. A pre-development data collection program should be conducted at the potential points of entry of these waters to a sensitive aquatic habitat. This pre-development data collection should result in the documentation of ambient heavy metal concentrations in waters, sediment samples, fish, benthic invertebrates and aquatic vegetation. Such a sampling program should be standardized and conducted at regular intervals.

Groundwater Removal and Aquatic Systems

The subject of groundwater removal and the effects on the hydrological regime is discussed in Section 5.3.1 of this report. The concern raised here involves the potential effect groundwater may have on nearby Polar Lake. If the aquifer which is recharging Polar Lake is in the drawdown cone, lake water levels may be depressed such that the lake is no longer suitable for habitation by fish. A fish kill may result from high water temperatures and low dissolved oxygen concentrations during the summer if the volume of the lake is significantly reduced, and more importantly a reduction in lake volume, as a result of interrupting the aquifer feeding Polar Lake, could cause a winterkill situation due to depressed dissolved oxygen levels in late winter. This would be particularly serious if the aquifer feeding Polar Lake does play a role in the dissolved oxygen balance for the lake during the winter season, as suggested by M. Falk (pers. comm.). Further assessment is therefore necessary of the extent of drawdown which would result from mine dewatering at the R190 orebody about 6.4 km west of Polar Lake.

The potential effects of groundwater removal on Buffalo River must also be defined, as Buffalo River exhibits very little discharge during the winter (G. Low, pers. comm.). Any reduction in water discharge has the potential of adversely affecting overwintering areas in this watercourse. It is not known if fish do overwinter in Buffalo River, but if mine dewatering is determined to have an affect on this watercourse, the use of this river by fishes during the winter will have to be determined, and appropriate mitigation measures developed to protect overwintering fish fauna if present.

Fish Harvesting Activities

The development of the Great Slave Reef Project is not likely to affect either domestic or commercial fishing activities in Great Slave Lake. The proposed mine will not likely affect sport fishing activities in the region, with the significant exception of the sport fishery at Polar Lake.

The existing exploration camp is located less than 1 km from Polar Lake. The access road to the Polar Lake sport fishery presently skirts the exploration camp. The existing camp detracts from the attractiveness of this recreational area. Any further develop ment of the camp site at its present location would probably be detrimental to the attractiveness of this sport fishery, both from an aesthetic point of view and in light of other factors associated with any such development such as noise levels.

5.4.2 Terrestrial Flora And Fauna

5.4.2.1 Vegetation

The main impacts include:

- The modification of communities in pit dewatering discharge areas;
- The possibility of increased fire frequency;
- The effects of dewatering on the forest communities.

The vegetation in the vicinity of the Western Mines property has already been somewhat disturbed for exploration lines and drilling sites. It is expected that natural succession will occur in these areas once the disturbance factors are eliminated. However, for recolonization to take place, it is important that substrates be disturbed as little as possible. This is particularly important in sandy areas where wind erosion may become a problem when the vegetational cover is removed.

The presence of areas into which pit dewatering discharge is expelled will result in increased water levels in some plant communities, particularly lowland communities, and the possible introduction of foreign substances into plant root environments. The water levels for lowland communities may create problems for fen communities which require flowing nutrient rich water. Fens are normally used extensively by wildlife.

Depending on the extent of the elevated water tables, some shifts from upland types to more wetland like communities, may occur. The extent of such changes is not easy to predict as a number of factors such as soil porosity and water holding capacity will be involved. It is not possible at this time to predict the effects of possible contaminants of the pit dewatering discharge until a further assessment of its composition can be made. The effects of dewatering on forest communities has already been discussed with reference to Pine Point and is probably not an issue in the area.

As fires are a natural and repetitive occurrence in the boreal forest, and as the area in the vicinity of the Western Mines site has not been burned for over 200 years, it is likely that with greater activity in the area the probability of fires will increase. The probability of fires has implications for the future wildlife value of the area.

5.4.2.2 Birds

Impacts on birds from the development of the Great Slave Reef project may result from several processes inherent in a mining development.

There will be habitat losses and disturbances associated with the construction and operation of the mine, and certain species are sensitive to these changes. Other species can utilize human habitiations for breeding and foraging and might colonize the facilities to a limited extent.

A more subtle impact is the effect that the use of water by mining activities might have on water bodies. The most apparent impacts would be on fish, but any lowering of water in the May - July period could inhibit breeding, and at other times reduce the overall capacity of wetlands to support waterfowl.

5.4.2.3 Mammals

The main impacts include:

- habitat loss during exploration and operation
- disturbance or harassment of animals
- increased hunting pressure
- greater likelihood of forest fire owing to higher human population
- attraction of nuisance animals to camp facilities

The animal populations of the study area have been exposed to recent exploration in the adjacent Pine Point property and via the road and rail lines which traverse its southern flank. The present development by Western Mines can be viewed as part of the gradual economic expansion of this area, and in terms of mammals this frequently brings about a gradual retreat away from the areas of high human activity. This section, particularly the discussion of disturbance, is based on BEAK (1980), Geist (1975) and MacKenzie (1976).

The initial effect of disturbance is withdrawal of animals from the immediate project area, which can be recolonized once the activity has ceased. Ungulates can habituate to disturbance, and this can limit the effective habitat loss. The degree of habituation and the area of habitat lost depend on the intensity of the disturbance and whether it is accompanied by hunting and other harassments by people.

At the Great Slave Reef site, the impact of disturbance on mammals is likely to be small because of their apparent low densities. If the operation of a mine is accompanied by greater recreational use of the study area by people for hunting and other pursuits, the impacts on ungulates particularly would be more significant.

The proposed mine is located in an area of mature, if not actually decadent forest. As this report has pointed out the susceptibility to fire is great, and this is underlined by the major fire which recently (1979) threatened neighbouring Pine Point. Increased human activity in these forests could increase the risk of fire which would drastically alter the habitat for all terrestrial animals. In the case of woodland caribou it would eliminate the affected habitat until a mature forest was restored (Kelsall et al., 1977). For moose, it would initiate a process of succession which would improve the habitat over the long term. Forest fires are now considered a natural feature of the maintenance of boreal forests, but certain mitigation measures outlined in Section 6 might reduce the risk of a major fire threatening the proposed mine and terrestrial habitats of the study area.

Black bears are reported to be common in the study area, and improper garbage disposal can encourage scavenging by bears as well as foxes. Such animals can become a threat as well as a nuisance. Garbage disposal guidelines identify the problem and in Section 6 recommended procedures are reviewed.

5.5 Social and Economic Impacts

5.5.1 Employment and Income Effects

The figures used in this section are preliminary only, and are derived for the work force from "Typical" Manning Schedules, in a context of local demographics based on recent estimations and government projections. In such a circumstance, the precision of the analysis must be qualified by the recognition that differences that would be obtained by varying one or more of the many operational assumptions are far outweighed by the differences that could be brought about by changes in the eventual manning schedules. Similarly, any program of Proponent - Government co-operation in local hiring and training could easily create major departures from the findings of this preliminary analysis, particularly if women were employed in any appreciable numbers.

A more detailed analysis would need to consider a number of questions not dealt with here. These include a more investigative approach to the entire question of the basic/non-basic multiplier ratio effective in the region and under the impact of a new mine, and a closer inquiry into the question of net employment creation relative to the existing labour force, employed and unemployed. Similarly, more would need to be known regarding the capacity/utilization ratios of the existing socio-economic infrastructure before an analysis of employment and population could be carried to a firm conclusion. However, as tentative projections of the probable impact of the proposed project on employment and earnings in the local region, the findings of this section should provide illustrative "orders of magnitude" which can be modified by later study, should the proposed project proceed onto more definitive levels of analysis.

Construction Phase

The construction phase, may extend over a period of three years and employ a construction crew of possibly 150-200 people, with a peak of 250 workers.

The construction/development phase may overlap the beginning of production, and so contribute to a compressed period in which the new employment effective in the study area might be in excess of the crew sizes discussed in this report. This would be a temporary situation only.

The construction program would probably be a matter of contract, with specialized construction firms being responsible for the project. Similarly, the work force would be dominated by skilled and experienced workers, who regularly earn their livings in heavy construction. Given the unknowns, it is not possible to conduct an assured analysis of the construction phase. However, for illustrative purposes the following exercise was carried out, with conservative assumptions regarding the size of the work force and the level of income that would be earned.

The assumptions of the analysis were as follows:

a. The construction work force (CWF) would average 150 persons, working 220 days per year. The peak is assumed to be around 250, but this has no role in the analysis.

b. The (low) average of $100 per day is assumed as the level of construction wages, producing an annual wage bill of $33 million dollars.

c. The CWF will have 15 percent hired locally.

d. The CWF will have 10 percent who bring their families into the study area; the balance of 75 percent (i.e. less locals plus family in-migration) will in effect be single workers.

e. The 25 percent of the CWF will have the impact on the local economy equivalent to the same number of basic jobs, so this share of the wage bill will enter the economy subject only to leakages.

f. The 75 percent "single" workers will have a much reduced impact, and this share of the wage bill, effected by target working and export of income, will amount to only 5 percent of the 75 percent share of the wage bill.

g. The wage bill share flowing into the study area per construction year, will be:

Locally hired 15% CWF	=	$ 500,000
In-migrants 10% CWF	=	330,000
"Single" 5% of 75% of wage bill	=	124,000
Total Wage Bill	=	3,300,000
Total share in region	=	954,000

h. The CWF will be housed in a camp, with locals and in-migrants commuting to the site.

i. The locally hired CWF will continue to occupy present homes.

j. The 10 percent of CWF who in-migrate will require 15 family units. These may be single family homes, apartments, or mobile homes, depending on availability.

k. Some residential units will be required by administrative/supervisory staff, and by periodic site visits by senior construction personnel. These may be commercial accommodation (hotel/motel) or may be rental units.

l. The in-migrating family population is not expected to contain a significant school age population.

? Why

Construction Phase, Indirect Employment

The ratio between construction employment and indirectly created employment is not known. It clearly must vary greatly between cases, depending on the scale and structure of the host economy and settlement pattern, and on the stability of employment levels during the construction phase.

Construction activity is characterized by peaks and troughs representing the crew size on-site over time, and is subject to seasonal constraints which influence the timing of the project and hence the crew size and composition on-site. The influence of a construction crew on a host environment is similarly structured by a number of variables, difficult to anticipate and perhaps impossible to predict. Among these are:

1. The proportion of the crew which brings its family into the region (assumed here as 10 percent of the CWF).

2. The proportion of the crew married/single, which greatly influences the propensity to spend locally.

3. The location of the crew relative to the host town or towns, and the sophistication of recreational facilities and personal services available in camp, all of which influence the amount of visitation between crew and host communities.

4. The average age of the construction crew, which is effective since it has been found that older men tend to spend less than younger men, while on the job.

Given the relative transiency of the construction phase, and the likelihood that for the majority of the crew expenditures made locally would be concentrated in recreational, entertainment, and personal services, rather than in a domestic basket of goods, it is not likely that the employment generated would come close to the 1:1 ratio postulated for the production phase. However, there would undoubtedly be <u>some</u> additional employment created by construction crews spending in the region, which requires a qualitative judgement to establish. The following assumptions have been made:

1. Indirect employment will be in the recreational, entertainment, and personal services (retail etc.) sectors of the economy, and will be only marginally represented in the more professional levels of the economy.

2. The wage level in these indirect categories will be below the average calculated for the corresponding production phase.

The assumption is that the ratio between direct construction jobs and indirectly created employment will be 1:0.25 for the in-migrant workers and 1:1 for the locally hired construction workers. The two classes of construction workers are taken here to be 125 in-migrants and 25 locally hired. Thus, the employment created amounts to approximately 56 jobs, lasting over the life of the construction phase. The distinction between in-migration and "single" workers has been ignored here.

Assuming an indirect income level below that of the construction phase, relative to the primary level, the assumption here is that jobs indirectly created by the construction wage bill will amount to 56 in number, and will receive a wage level equal to 50 percent of that earned in construction, or approximately $50 per working day, or $12,000 p.a.

Summary - Construction Work Phase

The direct and indirect wage bill of the construction work phase effective in the study area will total about $1,626,000 per year of construction.

Direct and Indirect Production Work Force

The project is expected to employ some 116 workers. This work force will economically generate an indirect work force, which is estimated to be roughly equivalent in number to the direct work force but which will have a lower level of income.

The analysis, and the assumptions applied, are as follows:

a. Of the 116 work force, some 20 percent will be hired locally, representing 23 workers.

b. The balance of 93 workers will generate an equal number of indirect jobs (i.e. the ratio is taken as 1:1. This is the ratio used in the Hay River Industrial Development Study 1975, it was calculated for Hay River from 1961-69 averaged employment data). Thus, this component of the work force will aggregate to 186 new jobs.

c. The locally hired workers, being already established in the area, will not have the same indirect impact. However, assuming some net increase in wage levels for this group, it is assumed that some indirect impact will be effective. The assumption here is that this will amount to 50 percent of the in-migrant impact, (i.e. the ratio will be 1:0.5). Thus, this component will amount to 11 new jobs.

d. The total direct and indirect employment will amount to 197 new jobs.

e. It is assumed that 65 percent of the workers (direct and indirect) will be married.

f. It is assumed that the average family size will be 3.63 (per General Plan 1975).

g. Calculating through, the new work force will represent a total population increase of 520 persons.

It should be noted here that this figure is probably on the high side, since the immigrant group will likely be younger than the local population average from which the family size was calculated. Moreover, the question of local hiring as dealt with here is not subjected to any analysis regarding changes in jobs by locals to take up mine employment, which could involve a second round of in-migration to fill the resulting vacancies. However, for the purposes of this preliminary assessment, it is assumed that the proposed project will bring an increase of population amounting to 520 persons.

Production Phase, Income

With a direct employment level of 116 workers and an average annual income of $24,000, the annual wage bill would amount to $2,784,000. The $24,000 p.a. figure is based on estimates of income in the mining industry, and is perhaps lower than many averages. However, the proposed mine is not expected to go into continuous 24 hour seven day week production, with attendant shift differentials and potential for overtime, which elsewhere in the mining industry has produced relatively high incomes.

Assuming that 30 percent of the PWF are target workers, only 70 percent of the wage bill will flow to the local region, subject only to the leakages prevailing in the economy.

This wage flow would total $1,950,000 per year. The balance of the wage bill, $834,000, would go to target workers, who would have a much lower propensity to consume locally. Assuming that this propensity is but 50 percent of that of the "permanent" work force, the target workers would contribute $417,000 to the local economy, also subject to the usual leakages. Thus, the total effective direct wage bill in the sub-area would amount to $2,367,000 per year, ex-leakages.

Production Phase, Indirect Income

Under the assumptions specified in the employment section above, indirect employment would amount to 81 positions. It is difficult to assess the income effects of the indirect wage bill, since so much depends on the categories of employment created. Income levels vary significantly between categories in the infrastructure. Similarly, the propensities to consume, as already noted, vary between permanent, temporary and target workers, and it cannot be predicted how these categories of worker will be distributed in the indirect labour force. However, given the lower wage level, discretionary income will be a smaller portion of the wage bill, and so reduce to some extent the effect of leakage on the regionally effective income.

For the purposes of this preliminary assessment it is assumed that the following conditions are effective:

a. The employment analysis in the direct/indirect section above is correct.

b. The indirect labour is distributed proportionately through the infrastructure and is not concentrated in either high or low income levels.

c. The indirect employment opportunities are filled by in-migrants, from outside or from other regions of the N.W.T. and not by existing residents of the sub-area. This assumption implies that if cross-occupation does take place, the vacated positions will in turn be filled by in-migrants, with the result that no net qualitative shift is effective in the case under study.

d. The income level prevailing in the indirect category is below that of the direct sector. This involves a qualitative judgement, since data are not available to support any precise measure. The assumption applied here is that indirect income levels will average 60 percent of the level prevailing in the direct sector.

Based on these assumptions, indirect employment will total 81 positions, averaging $15,000 per year in income. The total indirect wage bill will amount to $1,215,000. The amount of this total which will be subject to leakage cannot sensibly be assessed.

Summary - Production Phase

Subject to the validity of the assumptions used, the total direct and indirect wage bill that can be expected to be effective in the study area amounts to $3,582,000 per year of production.

5.5.2 Other Potential Developments in the Region

The proposed project in its own context promises little difficulty for the host region. However, should the proposed development proceed within a time frame which included other new projects, then the resulting combination of demands for local resources could impede the smooth response to requirements for labour, housing, and various other goods and services.

It is not possible to provide quantified assessments of the possible joint activities that could occur over the next few years in the study region. However, the following potentials have been identified:

1. There is a possibility that the Northern Canada Power Committee might be prevailed upon to move some of its office staff into Hay River. This could involve some 90 - 100 positions, with a possible total population increase of around 400 - 500 persons. Such a development would represent a competition for housing and services in Hay River.

2. There is a mine prospect on the shore of Great Slave Lake which is considering making Hay River its townsite, with an air commuting service to the mine site. This would also create a competition for housing and services. The mine could employ some 50 - 60 people, involving 40 families, for a total population addition of about 300 persons.

3. Hay River and Area Economic Development Committee is actively exploring development potentials in the region. These include a prefabricated housing plant, a fish meal operation, various transportation-related projects and, over the longer term, the establishment of a custom ore milling plant. Any or all of these would involve new implyoyment, increased population, and a consequent expansion of the socio-economic infrastructure. The prefabrication plant could initially employ 12 - 20 workers, rising to 20 - 40 jobs. Such a level of employment could support a population increase of up to 200 persons, assuming that the positions are not filled by local residents.

4. There has recently been a revival of a scaled-down version of the Mackenzie pipeline. This would involve a period of concentrated construction activity and some degree of permanent employment in Hay River and Region.

The relative feasibility and timing of these potentials is not known. But taken together they represent, together with the Proponent's project, a major change in the Hay River region. Without detailed planning, the demands of such projects could conflict and create problems.

The kinds of effects different combinations of development could have on the project under study depend primarily on the time inter-face between the proposed mine development and the development of other projects. In any combination or sequence, different potential projects would find themselves either: the prime generator of support development, the "spoiler" coming in at a time when the support facilities are incapable of immediate response due to full-utilization, or the beneficiary of support development raised to a level of sufficient surplus capacity to meet more demands with the minimum of new expansion.

It is not possible to judge at this time where the proposed project fits into these alternate scenarios.

5.5.3 Settlement Needs

Construction

The construction phase will require a single-man camp for the in-migrant portion of the CWF. This may be located in Pine Point rather than on the mine site, since the Cominco camp is being phased out of use and so could be available for lease or purchase.

Local labour will maintain existing residences, although camp facilities will be available for use if preferred by individual workers. Some construction workers may in-migrate with their families and so go to the market for housing. This study has assumed that 10 percent of the CWF will fall into this category, requiring between 10 and 20 housing units, depending on the eventual size of the total work force. The preference as to type of housing cannot be anticipated but it is most probable that in-migrants will seek out whatever the market offers, and that few if any will seek permanent long-term housing. These workers will be in competition for housing with the in-migrant component of the employment indirectly created by the construction phase. Unless the local housing market responds early in the development, by adding to the presently very low number of rental units, this competition will spill over into the commercial accommodation market (hotel/motel) and could contribute to pressures for increases in the rent levels prevailing in the study area.

It is possible that some in-migrants will bring in house trailers - mobile homes, and so seek pad space, or occupy space in recreational park areas. This could create problems but their scale cannot be assessed at this time.

Production

The production crew will enter the local social economy as a permanent component, limited only by the life of the mine. Western Mines will probably inaugurate a housing assistance program, to help employees settle in the area, but primarily the private market will be looked to for the necessary housing. Only if the private sector demonstrates an inability to meet the demand would Western Mines likely consider a more direct role.

Locally employed workers will maintain their existing residences. The construction camp may be extended to serve single workers but the expectation is that the rental market will eventually fill this need and the camp will then be phased out.

The married in-migrants with families will be free, as will all the work force, to make their own settlement decision. Whether the choice is Hay River or Pine Point will be up to the individual worker, with the choice being heavily limited by the availability of housing. The Proponent's housing policy will not favour one location over another.

The proposed project is expected to create demand for housing amounting to 123 family residential units, exclusive of single men. The housing mix cannot be anticipated but if it follows the present pattern in Hay River it will be made up of 70 percent single family detached dwellings, 11 percent apartment-type units, and 20 percent as mobile homes - trailers. In unit terms, this demand involves approximately 86 SFD, 13 apartments, and 25 trailers.

5.5.4 Service Needs

The proposed project is expected to add some 520 persons to the existing population in the study area. The effect of this increase will vary in accordance with the distribution of the new population. In aggregate, such a population, with the age distribution postulated, would require one or two extra police officers, and a maximum of 10 teaching professionals with support staff. The need for teachers would be determined by the actual age distribution of the incoming children, since the Hay River High School has a substantial surplus capacity in the upper grades. The teaching need would also be affected by the location decisions of the workers.

Currently, there are six doctors and two dentists, supported by nursing staff, serving the area population of about 7,000 people. The same ratio is to be maintained after a population increase in the order of 500 persons, one doctor and perhaps four nurses would be needed.

It is not expected that an additional 500 persons would require other personnel increases in other social services.

6.0 MAJOR SENSITIVITIES AND MITIGATING MEASURES

6.1 Climate and Air Quality

Climate and air quality impacts should be minimal provided adequate particulate emission control systems are installed where required. After identifying a specific mine development, it is recommended that Western Mines consider installation of a standard meteorological station and dustfall monitoring stations. These should be functional prior to mine start-up to provide pre-operational data. Indications are that the regulatory agencies would probably require these measures.

6.2 Geology and Soils

Terrain impacts associated with the mining development of Great Slave Reef will minimal if careful construction and operation practices are followed. Organic terrain containing permafrost should be avoided, if possible, as should fine-grained surficial deposits. If fine-grained materials are disturbed, care should be taken to remove as little vegetation as is possible, as the plants act as an erosion protection measure for the soil. Areas that are exposed should be seeded or covered immediately in order to prevent erosion. This applies to exposed waste materials as well.

Prior to construction, more detailed studies should be conducted for the development in order to determine microenvironmental changes and to identify site-specific problems.

6.3 Hydrology and Water Quality

Available information indicates that the degree of drawdown of the surface water table as a result of mine dewatering will be minor. Further assessments are necessary after completion of additional pump tests planned for the spring of 1980. In order to provide information on the natural and seasonal variation in groundwater tables, piezometers should be installed in the vicinity of the R190 orebody that can be monitored routinely. This information will be required in support of the water license application for the mine. These stations for long-term monitoring should be selected after review of the results of the pump test. These stations should then be monitored in the interim period to mine start-up and into mine operation to provide baseline data and post-operational data to detect any significant impending impacts. In addition to the further water quality data on bedrock groundwater that will be collected during the planned pump test at R190, samples should also be collected of the more shallow groundwater in the overburden near the orebody to more fully characterize existing groundwater quality conditions.

Serious impacts on area surface hydrology appear unlikely. Discharge of mine dewatering waters could cause some flooding and there is the potential for increased small drainage chanelling if good distribution onto the lowland disposal area is not implemented. Surface hydrology monitoring should commence in terms of discharge measurements of Twin Creek, water level monitoring of Polar lake and a more detailed assessment of surface drainage in areas being considered for discharge of mine dewatering waters.

The major concern identified with the project in terms of water quality is associated with the discharge of mine dewatering waters. Based on available data, the mine water would not exceed the maximum permissible concentrations likely to be applied to a discharge of this nature. Direct runoff from probable discharge areas to Twin Creek or the Buffalo River appears remote, thus the water quality of these systems should not be altered.

Surface water quality monitoring at all the stations selected and sampled by BEAK in September 1979 should be continued as a minimum on a seasonal basis to fully document the baseline conditions. It is recommended that two to three additional stations be considered to provide an improved definition of existing conditions. One of the additional stations should be located on Twin Creek at Highway No. 5 crossing to provide a station upstream of any possible mine influence. The one or two other additional stations should be located in the area of mine dewatering water disposal, to better define existing conditions and to monitor future mine operations.

6.4 Biological Characteristics

6.4.1 Aquatic Flora and Fauna

The definition of major impacts on aquatic systems which could result from the proposed development can not be determined at this stage of project design. In order to assess potential impacts resulting from heavy metal contamination, further information on the quality of effluents and their ultimate disposition is required. Likewise, further definition of the drawdown cone is required before such factors as potential effects on Twin Creek, Polar Lake, or the potential effects of lowered water levels in Buffalo River are addressed.

The effect of developing the above-ground facilities at the existing exploration camp would, however, have a significant impact on the Polar Lake sport fishery. This impact may be mitigated by relocation of mine facilities to a point nearer the orebody at R190. Further, design measures should be developed such that noise and dust production from the facility are not detectable at Polar Lake. Any above-ground facilities should not be visible from Polar Lake, to maintain the aesthetic qualities of this recreational area.

how to hide a head-frame

6.4.2 Terrestrial Flora And Fauna

6.4.2.1 Vegetation

The effects of physical disruption of plant communities during development are expected to be remedied by natural succession; however, in areas where the substrates have been heavily disturbed, it may be desirable to undertake revegetation procedures to ensure a rapid recovery. These would include substrate rehabilitation in addition to some planting.

The problems associated with elevated water tables in the pit dewatering discharge areas may be minimized by restricting such discharge to presently occurring bog communities. The possibility of foreign substances in the dewatering discharge requires monitoring to determine probable effects on the vegetation of the area.

Since the probability of fire in the area will in all likelihood be increased, some form of fire control measures may be desirable to eliminate the possibility of severe forest fires in the general area. Selective logging of decadent stands may help control the amount of fuel for fire. In addition, Western Mines should consult with local forestry officials to discuss the long-term fire hazard and consequently the suitability of creating fire guards in locations appropriate to protecting the mine facilities.

6.4.2.2 Birds

There will be site-specific habitat alteration around the mine site, adjacent buildings and service roads. Such impacts are not considered serious and no specific protection measures are required other than adhered to land use regulations.

Upland game birds and some waterfowl occur on suitable habitat near the exploration sites. BEAK recommends that hunting be discouraged near the mine development and that no shotguns be allowed at the mine or exploration sites.

6.4.2.3 Mammals

Two types of mitigation are conceived. One concerns the habitat alteration at the development sites and the disturbance associated with it. This primarily applies to ungulates. The other concerns the attractiveness of the development to nuisance animals.

In the case of the former, precedures recommended above under soils (6.2) and vegetation (6.4.2.1) have application to mammals, particularly ungulates, as it relates to soil disturbance, erosion, and the possible requirement for revegetation. Although the size of home ranges of moose and woodland cariboo are not known for this area, the possible areas of disturbance would appear to be extremely small in comparison.

Further habitat alteration may occur in the pit dewatering discharge areas, but as noted above, the impact can be mitigated by utilizing bog rather than fen areas.

Nuisance animals could become a problem and the following regulations, extracted from garbage disposal regulations under the Territorial Lands Act, were designed for its mitigation:

i) daily disposal of garbage
ii) garbage to be incinerated in a fuel-fixed, forced air incinerator;
iii) dumps to be isolated from camp and fenced with chain link fencing;
iv) all sewage to be treated.

Feeding of animals at camp should be prohibited.

6.5 Socio And Economic Aspects

The effects of the proposed project will arise primarily from the population increase it will generate. This is expected to be about 520 persons.

The study area, and both of the main communities, Hay River and Pine Point, are at levels of population and development which could accommodate such a population increase, even if the increase were geographically concentrated in one or the other of the two centers. The employment needs of the project could not find sufficient surplus labour in the sub-area to fill the manning schedule. In addition, the specialized nature of much of the required work force would limit the opportunities for local hiring. However, given a well organized training program, local labour could be used, initially and increasingly, in the project.

The housing situation in the study area could become a bottleneck if sufficient lead time is not allowed for developers to respond to the enlarged market. However, both Hay River and Pine Point have existing plans for increased residential development at scales well in excess of that projected to arise from the project.

There are several areas of potential social concern, particularly in the case of Indian rights and claims, which could influence and be influenced by the project. These, however, are diffused throughout the prevailing socio-political environment, and are difficult to connect directly with the proposed project without the intervention of senior levels of government.

In summary, the proposed project, in the context of the host area, would seem to represent a potential benefit and should be enhanced by judicious co-operation between local interests. Government and Western Mines.

The following recommendations address the salient issues identified in the body of this report.

1. Employment

a. Western Mines should make every effort to meet employment needs locally. To this end, Western Mines should enter into discussions with the appropriate government agencies, with a view to maximizing this potential through a pre-employment and post-hiring training program. It is expected that government support will be provided sufficient to cover any difference in project efficiency that arises from introducing new practices of manning and production organization into the project.

b. Western Mines should allow for on-job training and skill advancement during the life of the project, and, where feasible, promote and advance from within the existing work force.

2. Use of Local Industrial and Commercial Resources

a. Western Mines should, to the extent feasible given corporate needs for privacy, inform the local business community and interested government departments of the development and operational needs of the project. This should be done as early as possible to allow for investment decisions to be made by local entrepreneurs wishing to enter the resulting market. All else being equal, Western Mines should favour local providers of goods and services.

3. Municipal, Retail and Personal Services

a. As the project is finalized in design, information regarding the manning schedule should be provided to allow for careful and informed planning in response to various needs. Of particular concern will be the demographic implications of the project.

b. During the construction phase, Western Mines should co-operate with local authorities and interests in reducing the potential impact of the construction crew on the local communities. This can be best done by regulating the provision of transportation to town and by establishing a high level of recreational amenity in the camp.

c. It is recommended that Western Mines enter into discussions with local authorities and citizen groups interested in recreation to explore the ways in which the Proponent might make a contribution to the recreational facilities of the region.

4. Housing

a. Western Mines should enter into the housing market to the extent made necessary by the limitations of the private sector.

b. Western Mines' involvement in the housing market should be designed to facilitate a smooth disengagement as soon as the situation allows for private interests to take over. Ideally, this transition should involve the privatisation of housing by employee purchase.

5. Transportation

a. Although the basic transportation systems in the area contain adequate surplus capacity to accommodate any foreseeable increase in demand, Western Mines should make early decisions regarding the need for on-site rail/hopper loading sidings and facilities, and should define other transportation needs, including bus commuting requirements, early enough for local entrepreneurs to respond with bids to meet these needs.

b. The scheduled air service into Hay River may require special notice to accommodate the construction phase. This should be given to avoid congestion and inconvenience to other users of the service.

6. Schools

a. The effect on in-coming school-age children cannot be assessed until the location decision has been made (Hay River vs. Pine Point) and the age distribution is known. Western Mines should, in recruiting and hiring, pay particular attention to these facets of the operation, and feed definitive information to the school authorities as it becomes known.

b. Western Mines should co-operate with the appropriate government authorities in investigating the educational training needs that will arise from the project. This may involve use of school facilities, the provision of some facilities on-site for on-job training, and the seconding of professional staff from the project to participate in the educational programs put in place.

7. Native Indians

a. Western Mines should take special steps, in co-operation with the government of the N.W.T., to encourage and facilitate the employment of Indians on the project. At the Band level, Western Mines should make the opportunity for Band companies to bid on sub-contracts related to the project.

b. Western Mines should seek the advice and guidance of the government in assessing his responsibilities toward the question of the Hay River Band's interest in the land area proximate to the mine site, and toward the question of Native Land Claims in general, as they bear on the environment of the project.

8. General

Western Mines should consider creating a staff position with the responsibility and authority to deal with the local community authorities and other interests on all matters pertaining to the project-community interface.

7.0 RESIDUAL IMPACTS

7.1 Climate and Air Quality

Residual impacts on climate and air quality should be minimal. A very localized effect on ambient particulates would be expected associated mainly with fugitive dust generation caused by surface activities in the mining operations.

7.2 Geology and Soils

Assuming careful construction and mining practices, the residual terrain impacts associated with the mine will be minimal. The major changes will be the destruction of the landform used as fill. The possibility of subsidence over the underground workings does exist, but this will be minimized by the backfilling of the mine.

7.3 Hydrology and Water Quality

The extent and nature of groundwater table drawdown is not fully determinable at this stage and further assessment will be necessary after the additional pump test is conducted. Surface hydrology impacts appear to be minor. Some water quality changes can be expected in the lowland area which will receive mine water discharges, however, impacts should be acceptable since significant and major water resources containing potential or known aquatic resources or recreational values are unlikely to be affected.

7.4 Biological Characteristics

7.4.1 Aquatic Flora and Fauna

The identification of residual impacts on aquatic systems is not possible at this stage of the project design.

7.4.2 Terrestrial Flora and Fauna

7.4.2.1 Vegetation

Residual impacts on vegetation would include a small loss of forested area at the mine and campsite location. Insufficient information is available at this time to assess whether vegetation will be affected by mine dewatering activities.

7.4.2.2 Birds

There will be a small amount of habitat loss in the development area, which may be partially compensated for by certain habitat creation for species which breed around human habitation.

Assuming that the pit dewatering effluent does not involve serious deterioration of water quality and that the drawdown cone does not reduce water levels in surrounding wetlands, there should be no impact on waterfowl.

7.4.2.3 Mammals

Habitat alteration and human activity about the development area will no doubt mean some minor habitat loss. For big game mammals, this is not viewed as a significant impact, based on the size of development presently contemplated.

The concerns about any link between reduced water quality and waterfowl mentioned above, also apply to aquatic furbearers, such as beaver and muskrat and their use of wetlands in the Twin Creek and Buffalo River drainages. Since pit dewatering effluent of Pine Point is within existing standards, no major impact on wetlands is anticipated at this time.

7.5 Social and Economic Aspects

Residual impacts include a projected increase in area population by about 520 persons together with an increase in services to accommodate this change. In general these changes would be beneficial to the area although some stress would occur in the area of housing depending upon the development schedule. The development would add to local employment and entreprenurial opportunities.

8.0 REFERENCES

8.1 Climate and Air Quality

Fisheries and Environment Canada. Hydrological Atlas of Canada. 1978.

Hemmerick, G.M. and Kendall, G.R. 1972. Frost data 1941-1970, Environment Canada, Atmospheric Environment.

Hemmerick, G.M. 1971. Mean monthly and annual days with fog, 1941-1970. Atmospheric Environment Service.

Portelli, R.V. 1977. Mixing heights, wind speeds and ventilation coefficients for Canada, Climatological series number 31, Fisheries and Environment Canada, Atmospheric Environment.

8.2 Geology and Soils

B.C. Research. 1977. Environmental survey and assessment, Pine Point, N.W.T. Prepared for Cominco Ltd., Pine Point, N.W.T.

Bostock, H.S. 1970. Physiographic subdivisions of Canada. pp. 11-30 in R.J.W. Douglas (ed.). Geology and Economic Minerals of Canada. Geol. Surv. Canada, Economic Geology Rept. 1.

Brown, R.J.E. 1978. Permafrost. in Hydrological atlas of Canada. Fisheries and Environment Canada. Printing and Publishing, Supply and Services Canada, Ottawa.

Canada Department of Agriculture. 1974. The System of Soil Classification for Canada. Canada, Dept. Agriculture Publ. 1455. 255 pp.

Canada Soil Survey Committee, Subcommittee in Soil Classification. 1978. The Canadian System of Soil Classification. Canada, Dept. Agriculture. Publ. 1646. 164 pp.

Clayton, J.S., W.A. Ehrlich, D.B. Cann, J.H. Day and I.B. Marshall. 1977. Soils of Canada. Canada, Dept. Agriculture. Publ. 1544. 2 vols.

Geological Survey of Canada. 1970. Physiographic Regions of Canada. Map 1254A.

Randall, A.W. 197. Summary report on exploration of the Great Slave Reef and West Reef projects Pine Point area - N.W.T. Unpubl. Rept. - Western Mines Limited. 3 vols.

8.3 Hydrology and Water Quality

B.C. Research, "Environmental Survey and Assessment, Pine Point, N.W.T.", Project Report, Project 1-06-757, May 1977.

Environment Canada, "Naquadat Detailed Report, Water Quality Data", Inland Waters Directorate, Calgary, Alberta.

Environment Canada. Historical Water Levels Summary to 1976 Yukon and Northwest Territories. Inland Waters Directorate Water Resources Branch, Water Survey of Canada, Ottawa, Canada, 1978.

Fisheries and Environment Canada. Hydrological Atlas of Canada. 1978.

Golder Associates. Draft Report to Western Mines Ltd. on Pump Test of X25 Orebody. April 1979.

Jasper, J.N. Letter to Beak Consultants Limited from Water Resources Division, Indian and Northern Affairs, Yellowknife, N.W.T. August 1979.

Water Survey of Canada. Surface Water Data, Yukon and Northwest Territories.

Weyer, K.U., "Investigation of Groundwater Flow in the Pine Point Region", Report for the Fiscal Year, 1977/78.

Weyer, K.U. and Horwood, W.C., "Tabulation and Semi-Logarithmic Diagrams of Major Chemical Constituents in 330 Water Samples Taken South and West of Great Slave Lake in 1976, 1977, and 1978," Environment Canada, Hydrology Research Division, Calgary, Alberta. April 1979.

Weyer, K.U., Krouse, H.R., and Horwood, W.C., "Investigation of Regional Geohydrology South of Great Slave Lake, Canada, Utilizing Natural Sulphur and Hydrogen Isotope Variations", Isotope Hydrology 1978, Volume I, page 251.

8.4 Biological Characteristics

Aquatic Flora and Fauna

Hynes, H.B.N. 1971. The biology of polluted waters. University of Toronto Press. 202 pp.

Rawson, D.S. 1951. Studies of the fish of Great Slave Lake. J. Fish. Res. Board Can. 8:207-240.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. 966 pp.

Stein, J.N. and M.D. Miller. 1972. An investigation into the effects of a lead-zinc mine on the aquatic environment of Great Slave Lake. Resource Development Branch, Fisheries Service, Department of the Environment, Winnipeg. 56 pp.

Terrestrial Flora and Fauna

Banfield, A.W.F. 1974. The Mammals of Canada. University of Toronto Press. Toronto. 438 pp.

B.C. Research. 1978. Environmental Survey, Phase II- Bird Census Study. Pine Point, N.W.T. Report prepared for Cominco Ltd., Pine Point, N.W.T. 32 pp plus appendices.

B.C. Research. 1977. Environmental survey and assessment, Pine Point, N.W.T. prepared for Cominco Ltd. Pine Point, N.W.T. 99 pp and appendices.

Erskine, A.J. 1977. Birds in boreal Canada: communities, densities and adaptations. Can. Wildl. Serv. Rept. Ser. No. 41. Ottawa. 62 pp plus appendices.

Fairbairn, H.W. 1931. Notes on mammals and birds from Great Slave Lake. Can. Field-Nat. 45:158-162.

Godfrey, W.E. 1966. The Birds of Canada. National Museum of Canada. Bull. No. 203, Biol. Ser. No. 73. Queen's Printer, Ottawa. 428 pp.

Johnson, E. and J.S. Rowe. 1977. Fire and vegetation change in the western sub-arctic. ALUR Program, Report No. 75-76-61.

Kelsall, John P., E.S. Telfer and T.D. Wright. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian north: a review and selected bibliography. Can. Wildl. Service, Occ. Pap. No. 32. Ottawa. 56 pp.

Kershaw, K.A. and W.R. Rouse. 1975. The impact of fire on forest and tundra ecosystems. Final report ALUR 1975-76-63 DINA, Ottawa. 54 pp.

Kuyt, E. 1966. White-tailed deer near Ft. Smith, N.W.T. Blue Jay 24: 194.

Moss, E.H. 1953a. Forest communities in northwestern Alberta. Can. J. Bot. 32:212-252.

Moss, E.H. 1953b. Marsh and bog vegetation in northwestern Alberta. Can. J. Bot. 31:448-470.

Novakowski, N. 1966. Whopping crane population dynamics on the nesting grounds, Wood Buffalo National Park, Northwest Territories, Canada. Can. Wildl. Serv. Rept. Ser. No. 1. Ottawa. 20 pp.

Porsild, A.E. 1951. Botany of southeastern Yukon adjacent to the Canol Road. Nat. Museum Canada Bull 121.

Raup, H.M. 1946. Phytogeographic studies in the Athabaska - Great Slave Lake Region, II Jour. Arn. Arb. 27: 1-85.

Rowe, J.S., D. Spittlehouse, E. Johnson, and M. Jasianiuk. 1975. Fire studies in the upper Mackenzie Valley and adjacent Precambrian uplands. ALUR Program 74-75-61.

Rowe, J.S. 1972. Forest regions of Canada. Dept. of Environment CFS publication No. 1300.

Scotter, G.W. 1964. Effects of forest fires on the winter range of Barren Ground Caribou in northern Saskatchewan, C.W.S. Bull. 1(18).

Soper, J.D. 1957. Notes on the wildfowl of Slave River and vicinity, Northwest Territories. Can. Field-Nat. 71:74-81.

Stardown, R.R.P. 1975. Woodland caribou and snow conditions in southeastern Manitoba. pp 324-334, In: Proceedings of the First International Reindeer and Caribou Symposium. Biol. Pap. Univ. Alaska. Special Report. (reference seen in B.C. Research, 1977).

Stewart, R.E. 1966. Notes on birds and other animals in the Slave River - Little Buffalo River area, N.W.T. Blue Jay 24: 22-32.

Strang, R.M. 1973. Studies of vegetation, landform and permafrost in the Mackenzie Valley: some case histories of disturbance. Env-Soc Comm., Northern Pipelines, Task Force on Northern Oil Development. Report 73-14. 49 p.

Thieret, J.W. 1964. Botanical survey along the Yellowknife Highway, N.W.T. Canada II Vegetation SIDA 1(4): 187-239.

Wein, R.W. and M.G. Weber. 1974. Recovery of vegetation in arctic regions after burning and nutrient budget changes following fire in arctic plant communities. Env-Soc Comm., Northern Pipelines, Taskforce on Northern Oil Development. Report No. 74-6. 63 p.

APPENDIX A

WATER QUALITY SAMPLING SITE DESCRIPTION AND DATA

Table A1: Description of Water Sampling Sites

Site Number in Figure 4.3-3	Description of Sample Site	Sample Type	Data Source
1.	Hay River at Highway #5	River	(00NW070B0001) Env. Canada (1979)
2.	Sandy River at Highway #5	River	(#174) Weyer and Horwood (1979)
3.	Birch Creek at Highway #5	River	(#21) Weyer and Horwood (1979)
4.	Flowing borehole to east of Birch Creek, north of Hwy #5	Groundwater	(#175) Weyer and Horwood (1979)
5.	Small lake south of Hwy. #5, west of Buffalo River	Lake	(#29) Weyer and Horwood (1979)
6.	Twin Creek, at Highway #5	River	(#22) Weyer and Horwood (1979)
A.	Twin Creek, north of Highway #5	River	BEAK
8.	Flowing borehole west of Twin Creek, north of Hwy. #5	Groundwater	(#176) Weyer and Horwood (1979)
B.	Twin Creek, at mouth	River	BEAK
10.	Spring or flowing borehole near lakeshore close to High Point	Groundwater	(#177) Weyer and Horwood (1979)
11.	Spring or flowing borehole near lakeshore close to High Point	Groundwater	(#178) Weyer and Horwood (1979)
12.	Spring or flowing borehole near lakeshore close to High Point	Groundwater	(#234) Weyer and Horwood (1979))
13.	Spring or flowing borehole near lakeshore close to High Point	Groundwater	(#179) Weyer and Horwood (1979)
14.	Spring or flowing borehole near lakeshore close to High Point	Groundwater	(#235) Weyer and Horwood (1979)
C.	Swampy area north of Highway #5	Swampwater	BEAK
D.	Polar Lake	Lake	BEAK
17.	Polar Lake	Lake	(#23) Weyer and Horwood (1979)
18.	Spring or flowing borehole west of Buffalo River	Groundwater	(#181) Weyer and Horwood (1979)
19.	Spring to west of Buffalo River	Groundwater	(#182) Weyer and Horwood (1979)
20.	Buffalo River, south of Highway #5	River	(#164) Weyer and Horwood (1979)
21.	Buffalo River, south of Highway #5	River	(#165) Weyer and Horwood (1979)
22.	Buffalo River, south of Highway #5	River	(#166) Weyer and Horwood (1979)
23.	Buffalo River, south of Highway #5	River	(#167) Weyer and Horwood (1979)
24.	Buffalo River, south of Highway #5	River	(#168) Weyer and Horwood (1979)
25.	Buffalo River, south of Highway #5	River	(#169) Weyer and Horwood (1979)

Table A1 Continued

Site Number in Figure 4.3-3	Description of Sample Site	Sample Type	Data Source
E.	Buffalo River, at Highway #5	River	BEAK
27.	Buffalo River, at Highway #5	River	(#37) Weyer and Horwood (1979)
28.	Buffalo River, at Highway #5	River	(#69) Weyer and Horwood (1979)
29.	Buffalo River, at Highway #5	River	(#114) Weyer and Horwood (1979)
30.	Buffalo River, at Highway #5	River	(#170) Weyer and Horwood (1979)
31.	Buffalo River, at Highway #5	River	(00NW07PA0002) Env. Canada (1979)
32.	Buffalo River, at Highway #5	River	(S10) B.C. Research
33.	Seep near Buffalo River bridge (west bank)	River	(#294) Weyer and Horwood (1979)
34.	Buffalo River, at Mellor Rapids	River	(#173) Weyer and Horwood (1979)
35.	Buffalo River, below Mellor Rapids	River	(#194) Weyer and Horwood (1979)
36.	Buffalo River	River	(S/9) B.C. Research (1979)
F.	Buffalo River, at mouth	River	BEAK
38.	Buffalo River, at mouth	River	(#28) Weyer and Horwood (1979)
39.	Buffalo River, at mouth	River	(#172) Weyer and Horwood (1979)
40.	Buffalo River, at mouth	River	(#224) Weyer and Horwood (1979)
41.	Spring or flowing borehole to east of Buffalo River	Groundwater	(#76) Weyer and Horwood (1979)
42.	Spring to east of Buffalo River	Groundwater	(#77) Weyer and Horwood (1979)
43.	Spring to east of Buffalo River	Groundwater	(#78) Weyer and Horwood (1979)
44.	Flowing borehole to east of Buffalo River	Groundwater	(#79) Weyer and Horwood (1979)
45.	Spring, east bank of Buffalo River	Groundwater	(#80) Weyer and Horwood (1979)
46.	Spring, east of Buffalo River	Groundwater	(#171) Weyer and Horwood (1979)
47.	Flowing borehole on east bank of Buffalo River	Groundwater	(#193) Weyer and Horwood (1979)
48.	Spring, west bank of Buffalo River	Groundwater	(#222) Weyer and Horwood (1979)
49.	Flowing borehole to east of Buffalo River	Groundwater	(#360) Weyer and Horwood (1979)
50.	Flowing borehole to east of Buffalo River	Groundwater	(#361) Weyer and Horwood (1979)
51.	Spring to east of Buffalo River	Groundwater	(#195) Weyer and Horwood (1979)
52.	Spring to west of Buffalo River, near mouth	Groundwater	(#180) Weyer and Horwood (1979)
53.	Creek to east of Buffalo River	River	(S7) B.C. Research (1977)
54.	Great Slave Lake, near Sulphur Point (water chemistry affected by groundwater discharge)	Lake	(#27) Weyer and Horwood (1979)
55.	Small lake, north of Hwy.#5, east of Buffalo River	Lake	(L1) B.C. Research (1977)
56.	Buffalo River, at mouth	River	(S8) B.C. Research (1977)

Table A2: Surface and Groundwater Quality Data of Weyer and Horwood (1979)

Site Number in Figure 4.3-3	Weyer & Horwood #	Date Sampled	Major Chemical Constituents mg/l *						
			Ca	Mg	Na	K	Cl	SO_4	HCO_3
2. Sandy River	174	Sept. 30, 1977	72	20	12	1	5	17	288
3. Birch Creek	21	Sept. 24, 1976	80	15	8	1.5	1.5	6	273
4.	175	Sept. 30, 1977	470	200	146	7	192	1620	528
5.	29	Sept. 25, 1976	44	11	4	1.5	-0-	5	164
6. Twin Creek	22	Sept. 24, 1976	83	16	8	1	1.3	39	256
8.	176	Oct. 1, 1977	509	210	98	7	75	1785	520
10.	177	Oct. 1, 1977	860	265	1680	13	2970	2050	555
11.	178	Oct. 1, 1977	990	280	2000	15	3260	2270	527
12.	234	Aug. 9, 1978	1030	280	2220	10	3840	2370	452
13.	179	Oct. 1, 1977	1050	290	2600	17	4280	2300	532
14.	235	Aug. 9, 1978	1140	310	2850	11	5160	2380	456
17. Polar Lake	23	Sept. 24, 1976	59	13	3	1	0.1	37	181
18.	181	Oct. 1, 1977	1140	315	8800	22	13600	2880	381
19.	182	Oct. 1, 1977	34	8	17	1	7	20	99
20.	164	Sept. 25, 1977	46	12	7	1	5	-0-	193
21. Buffalo River	165	Sept. 25, 1977	29	8	7	1	6	2	95
22. Buffalo River	166	Sept. 25, 1977	28	7	7	1	5	13	95
23. Buffalo River	167	Sept. 26, 1977	44	13	8	1	4	21	155
24. Buffalo River	168	Sept. 26, 1977	28	7	7	1	5	18	99
25. Buffalo River	169	Sept. 26, 1977	28	8	7	1	5	14	99
27. Buffalo River	37	Sept. 26, 1977	34	8	6	1	0.8	32	88
28. Buffalo River	69	Aug. 5, 1977	30	10	6	1	2	41	79
29. Buffalo River	114	Aug. 25, 1977	20	10	10	1	6	-0-	83
30. Buffalo River	170	Sept. 27, 1977	28	7	7	1	6	3	95
33.	294	Oct. 4, 1978	70	20	11	2	15	124	145
34. Buffalo River	173	Sept. 30, 1977	34	9	7	1	5	21	100

Table A2 Continued

Site Number in Figure 4.3-3	Weyer & Horwood #	Date Sampled	Major Chemical Constituents mg/l * Ca	Mg	Na	K	Cl	SO_4	HCO_3
35. Buffalo River	194	Oct. 7, 1977	40	10	7	1	10	44	87
38. Buffalo River	28	Sept. 25, 1976	41	9	8.5	1.5	1.5	40	101
39. Buffalo River	172	Sept. 27, 1977	29	8	8	1	5	13	99
40. Buffalo River	224	July 27, 1978	20	6	9	1	15	10	66
41.	76	Aug. 21, 1977	460	175	35	4	28	1580	440
42.	77	Aug. 21, 1977	520	174	44	4	28	1736	419
43.	78	Aug. 21, 1977	510	175	45	4	32	1753	422
44.	79	Aug. 21, 1977	540	160	42	4	32	1761	408
45.	80	Aug. 21, 1977	310	115	23	3	10	946	431
46.	171	Sept. 27, 1977	508	170	59	5	19	1620	431
47.	193	Oct. 7, 1977	500	160	39	4	20	1547	442
48.	222	July 27, 1978	600	210	1410	7	2430	1600	222
49.	360	Oct. 17, 1978	510	210	760	6	1200	1880	327
50.	361	Oct. 17, 1978	450	230	850	8	1200	1900	351
51.	195	Oct. 8, 1977	520	160	460	6	655	1636	295
52.	180	Oct. 1, 1977	1340	290	7900	21	12900	2730	284
54. Great Slave Lake		Sept. 225, 1976	45	9	9	1.5	1.4	54	110

*Not stated by authors whether "total" or "dissolved" concentrations.

Table A3 Continued

Parameter	STA. 00NW07SB0006 Hay River Site #1 in Figure 4.3-3	STA. 00NW07PA0002 Buffalo River Site #31 in Figure 4.3-3
Extractable Vanadium (mg/l as V)	< 0.05 (18)	<0.05 (10)
Extractable Chromium (mg/l as Cr)	< 0.01 (18)	<0.01 (11)
Extractable Manganese (mg/l as Mn)	0.01 - 0.4 (19)	0.01 - 0.1 (11)
Dissolved Iron (mg/l as Fe)	0.1 - 0.9 (10)	0.02 - 0.12 (11)
Extractable Iron (mg/l as Fe)	1 - 10 (19)	0.3 - 5.2 (12)
Extractable Cobalt (mg/l as Co)	< 0.001 - 0.008 (18)	< 0.001 - 0.007 (12)
Dissolved Copper (mg/l as Cu)	0.006 - 0.014 (8)	< 0.001 - 0.02 (10)
Extractable Copper (mg/l as Cu)	< 0.001 - 0.020 (19)	< 0.001 - 0.007 (12)
Extractable Nickel (mg/l as Ni)	0.005 - 0.025 (19)	0.003 - 0.012 (1
Dissolved Zinc (mg/l as Zn)	.001 - .008 (9)	< 0.001 - 0.005 (10)
Extractable Zinc (mg/l as Zn)	<0.001 - 0.05 (18)	< 0.001 - 0.02 (11)
Extractable Strontium (mg/l as Sr)	.1 - .3 (19)	< 0.02 - 0.13 (12)
Extractable Molybdenum (mg/l as Mo)	< 0.05 (18)	< 0.05 (11)
Lead Dissolved (mg/l as Pb)	<0.001 - 0.005 (8)	<0.001 - 0.004 (9)
Extractable Lead (mg/l as Pb)	< 0.001 - 0.008 (21)	<0.001 (12)
Extractable Cadmium (mg/l as Cd)	< 0.001 (19)	<0.001 (11)
Dissolved Thallium (mg/l as Tl)	< 0.005 (1)	< 0.005 (1)
Extractable Mercury (g/l as Hg)	<0.05 - 0.11 (6)	< 0.05 - 0.15 (2)
Dissolved Arsenic (mg/l as As)	< 0.0005 - 0.01 (12)	< 0.0005 - 0.01 (9)

Notes:

1. Numbers given represent typical ranges in measured data.
2. Number in brackets after each data range indicates number of samples.
3. Samples taken over the period of 1968 to 1974, inclusive.

Table A3: Surface Water Quality Data of Environment Canada

Parameter	STA. 00NW07SB0006 Hay River Site #1 in Figure 4.3-3	STA. 00NW07PA0002 Buffalo River Site #31 in Figure 4.3-3
Apparent Colour (Relative Units)	60 - 600 (32)	30 - 200 (25)
Specific Conductivity (μSIE/cm)	150 - 820 (40)	150 - 800 (25)
Temperature (^{o}C)	0 - 22 (32)	0 - 20 (21)
Turbidity (JTU)	5 - 225 (21)	8 - 80 (14)
pH	6.9 - 8.7 (44)	7.7 - 8.3 (29)
Nonfiltrable Residue (mg/l)	2 - 1270 (18)	10 - 150 (18)
Fixed Nonfiltrable Residue (mg/l)	< 1 - 1170 (15)	5 - 110 (15)
Total Alkalinity (mg/l as $CaCO_3$)	50 - 260 (34)	50 - 130 (24)
Phenolphthalein Alkalinity (mg/l as $CaCO_3$)	0 - 11 (33)	0 (24)
Total Hardness (mg/l as $CaCO_3$)	100 - 400 (34)	75 - 400 (23)
Dissolved Calcium (mg/l as Ca)	30 - 208 (34)	15 - 130 (24)
Dissolved Sodium (mg/l as Na)	5 - 36 (32)	3 - 15 (25)
Dissolved Potassium (mg/l as K)	1 - 4 (32)	1 - 2.5 (25)
Dissolved Chloride (mg/l as Cl)	1.5 - 15 (33)	2 - 15 (25)
Dissolved Sulphate (mg/l as SO_4)	50 - 175 (34)	15 - 300 (25)
Reactive Silica (mg/l as SiO_2)	3 - 8 (34)	2 - 5 (25)
Dissolved Fluoride (mg/l as Fl)	0.1 - 0.3 (34)	0.1 - 0.3 (19)
Oxygen Demand (mg/l)	20 - 30 (2)	----
Total Organic Carbon (mg/l as C)	24 - 39 (25)	15 - 30 (22)
Total Inorganic Carbon (mg/l as C)	10 - 40 (25)	10 - 30 (22)
Dissolved Boron (mg/l as B)	0.1 - 0.2 (18)	0.1 - 0.2 (11)
Total Kjeldahl Nitrogen (mg/l as N)	0.7 - 2.2 (16)	0.8 - 1.3 (10)
Dissolved Nitrogen, NO_3 and NO_2 (mg/l as N)	0.02 - 0.60 (24)	.005 - 0.2 (16)
Dissolved Phosphorus, Ortho PO_4 (mg/l as P)	0.002 - 0.05 (25)	<0.002 - 0.007 (20)
Total Phosphorus, Inorganic PO_4 (mg/l as P)	0.03 - 0.15 (19)	0.01 - 0.17 (12)
Dissolved Phosphorus, Inorganic PO_4 (mg/l as P)	0.005 - 0.045 (24)	< 0.001 - 0.01 (15)
Total Phosphorous (mg/l as P)	0.03 - 0.6 (20)	.02 - 0.23 (13)
Extractable Lithium (mg/l as Li)	0.01 - 0.03 (18)	<0.005 - 0.015 (11)

Table A4: Results of Surface Water Quality Samples Taken by B.C. Research (1977)

Parameter	Buffalo River #32 (S10)	Buffalo River #36 (S9)	Creek #53 (S7)	Small Lake #55 (L1)	Buffalo River #56 (S8)
	Site Number in Figure 4.3-3				
pH	8.0	8.0	8.1	8.4	7.9
Suspended Solids (mg/l)	114.0	150.0	1.0	8.0	63.0
Conductivity (mhos/cm)	172.0	175.0	1160.0	289.0	169.0
Alkalinity (mg/l as $CaCO_3$)	68.0	71.0	285.0	159.0	63.0
$SO_4^{=}$ (mg/l)	20.0	20.0	436.0	13.0	23.0
Cl^- (mg/l)	3.0	2.8	25.0	0.6	54.0
H_2S (mg/l)	<0.3	<0.3	<0.3	---	< 0.3
Sodium (mg/l)	6.0	5.6	30.0	3.0	7.2
Potassium (mg/l)	0.75	0.70	1.3	0.6	0.65
Magnesium (mg/l)	7.1	7.5	75.0	18.1	6.5
Calcium (mg/l)	25.0	25.0	175.0	49.5	23.5
Aluminum (mg/l)	81.0	81.0	9.0	---	74.0
Arsenic (μg/l)	<1.0	---	<1.0	---	<1.0
Cadmium (μg/l)	<1.0	<1.0	<1.0	<1.0	<1.0
Copper (μg/l)	1.0	1.0	<1.0	<1.0	1.0
Iron (μg/l)	300.0	300.0	9.0	<1.0	320.0
Lead (μg/l)	<5.0	<5.0	<5.0	<5.0	<5.0
Tin (μg/l)	<5.0	<5.0	<5.0	---	<5.0
Zinc (μg/l)	10.0	19.0	17.0	3.0	17.0