Wolverine Project Description Report

prepared for:
Expatriate Resources Ltd.

prepared by:
Gartner Lee Limited

in association with:
EnTox Services

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November 1, 2004

Mr. Bill Dunn
Department of Energy Mines and Resources
Mineral Management Branch
Suite 400 - 211 Main St.
Whitehorse YT
V1A 2B2

Dear Mr. Dunn:

Subject: Wolverine Project

This letter accompanies the Project Description Report for our Wolverine Project, located in the Finlayson District of south-east Yukon. Expatriate Resources Ltd. intends to develop this project as a 1250 tonne per day underground mining operation. As part of our development plans, Expatriate is seeking a Quartz Production Licence under the Yukon Quartz Mining Act and necessary amendments to our Mining Land Use Approvals.
With the submission of the Wolverine Project Description Report to your office, Expatriate seeks to formally enter the process to acquire these licences and approvals. We have also submitted a copy of this report to the Yukon Water Board in anticipation of our need for a Type A Water Licence under the Yukon Waters Act. We hope that you will find the contents of this report acceptable and we look forward to working with you through the permitting process.

Yours truly,
Expatriate Resources Ltd.

Harlan Meade

Dr. Harlan Meade
President and C.E.O.

jh

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November 1, 2004

Ms. Judi White
Yukon Water Board
Suite 106 – 419 Range Road
Whitehorse, Y.T.
Y1A 3V1

Dear Ms. White:

Subject: Wolverine Project

This letter accompanies the Project Description Report for our Wolverine Project, located in the Finlayson District, south-east Yukon. Expatriate Resources Ltd. intends to develop this project as a 1250 tonne per day underground mining operation. As part of our development plans, Expatriate is seeking a Type A Water Licence under the Yukon Waters Act.

With the submission of the Wolverine Project Description Report to your office, Expatriate seeks to formally enter the process to acquire this licence. We have also submitted a copy of this report to the Mineral Management Branch of the Department of Energy, Mines and Resources in anticipation of our need for a Quartz Production Licence under the Yukon Quartz Mining Act. We hope that you will find the contents of this report acceptable and we look forward to working with you through the permitting process.

Attached to this letter is a table summarizing our estimated 1st year water use, a cheque for $114.58 to cover the first years water use, and a $30 cheque for the application fee. Please feel free to contact me should you have any questions or concerns.

Yours truly,
Expatriate Resources Ltd.

Harlan Meade

Dr. Harlan Meade
President and C.EO.

jh

EXPATRIATE RESOURCES
WOLVERINE PROJECT

PROJECT DESCRIPTION REPORT

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EXECUTIVE SUMMARY

The Project

The Wolverine Project is located in the south east Yukon Territory. The project is roughly midway between the communities of Ross River and Watson Lake immediately west of the Robert Campbell Highway. The project is situated in a geological zone known as the Finlayson District. This district hosts several known deposits of polymetallic volcanic hosted massive sulphide (VHMS) and has been the subject of extensive exploration activity since the mid 90's.

The Wolverine Project was advanced as a joint venture between Westmin Resources Ltd. (60%) and Atna Resources Ltd. (40%) during 1995-97. Expatriate Resources Ltd. acquired Boliden Westmin (Canada) Ltd.'s 60% interest in the Wolverine Project in March of 1999. During 1999-2001, Expatriate acquired further interests in the Finlayson District by optioning claims held by Cominco, including the Kudz Ze Kayah Project. Kudz Ze Kayah was subject to a complete feasibility study in 1998 by Cominco Ltd.(now Teck Cominco Limited), who initially discovered and delineated the deposit. The project was permitted under the Canadian Environmental Assessment Act (Screening Level Assessment) and received its Class A Water Licence while under Cominco's ownership.

In 2000, Expatriate combined its assets in the Finlayson District and initiated a prefeasibility study on the Finlayson Project which included an open pit and milling operation at Kudz Ze Kayah and an underground mining operation at Wolverine. Prefeasibility results were positive and Expatriate entered the environmental permitting process in September of 2000. A downturn in global metal markets resulted in project financing difficulties. In June of 2001, Expatriate relinquished its option on the Cominco properties in the Finlayson District. The environmental permitting process for the Finalyson Project was suspended.

In May 2004, Expatriate entered into a purchase agreement to buy all of Atna Resources Ltd's 39.4% participating interest in the Wolverine Joint Venture. Upon completion of the purchase agreement, Expatriate will own 100% of Wolverine and Atna will retain a royalty interest in the Wolverine Deposit.

Expatriate commenced the advancement of Wolverine as a stand-alone mine-mill complex in June of 2004. The Wolverine operations will include an underground mine, processing facilities and supporting infrastructure. Site facilities will include:

- a mill facility;
- tailings storage facility;
- mine access including a road connection to the Robert Campbell Highway and an airstrip;
- temporary waste rock storage facility;
- a truckshop and warehouse;
- an assay lab;
- cemented rockfill (backfill) plant;

- a water treatment plant and incinerator;
- accomodation complex; and
- fuel storage facilities.

A gravel borrow area will be developed near the underground mine to supply backfill materials for the operations.

The solid wastes associated with the Wolverine Project have been identified to include, waste rock, tailings, water treatment plant precipitates, sewage, domestic wastes, and miscellaneous special wastes. Waste management plans have been developed for the project and are presented in Section 2 of the Project Description Report. The effluent streams identified for the Wolverine Project include water treatment plant discharges. Water management plans have been developed for the project and are described in detail in Section 2 of the Project Description Report.

The capital cost of developing the project is estimated to be roughly $100 to $120 million (CDN$). The current development schedule considers a 12 to 14 month window for permitting and feasibility studies and an additional 16 to 18 months for construction. The mining and mill operations will provide approximately 121 full time positions. This does not consider the general and administrative staff and numerous contracting opportunities.

The Regulatory Framework

The Wolverine Project is subject to the Yukon Environmental Assessment Act (EAA). EAA is very close in its substance to the Canadian Environmental Assessment Act (CEAA), and is now in place given the transfer of administration and control of land and resources from the Federal government to the Yukon Government in 2003. For base metal mining projects, such as the Wolverine Project, operations that meet or exceed 3000 tonnes per day of ore throughput are required to undergo a Comprehensive Study under the EAA. The Wolverine Project, however, will be designed to have a daily throughput of 1250 tonnes per day and as such will not require a Comprehensive Study, but instead be subject to a screening under EAA. The administration of the EAA will be conducted by the Yukon Government's Executive Council Office through its Environment Directorate.

The permits and approvals required for the Wolverine Project fall under three major sets of acts and regulations. Firstly, the project will require a Type A Water Licence under the Yukon Waters Act. The Yukon Water Board issues this licence which requires approval by the Territorial Minister of the Executive Council Office. The Water Resources Section of the Yukon Department of Environment provides an inspection function to ensure compliance by the proponent. Secondly, the project will require a Quartz Mining Licence under the Yukon Quartz Mining Act. The issuance of this licence is administered by the Mining Land Use Branch of the Yukon Government's Department of Energy, Mines and Resources and requires approval by the Territorial Minister responsible. Thirdly, the project will require additional Surface Leases under the Territorial Lands Act (TLA) that is administered by Lands Branch in the same Department. It is anticipated that a security will be required as part of the obligations for restoration of the site.

Valuable Cultural Components of the Project Area

The Wolverine Project falls within the traditional territory of the Kaska Nation. The Kaska Nation is comprised of three principle groups, the umbrella Kaska Dena Council representing all Kaska communities in B.C. and the Yukon, the Liard First Nation located near Watson Lake in Southern Yukon, and the Ross River Dena Council based in Ross River. The traditional territory of the Kaska Nation is considered to be shared equally by all groups; however the communities recognize the traditional use of portions of the territory by a particular group. The Wolverine Project area falls within the area recognized as the traditional territory of the Ross River Kaska.

Since the mid 90's, there have been several projects in the Finlayson District that have carried out consultation with the Kaska Nation and Ross River communities to determine important cultural and heritage aspects of the area:

- 1995-97 Wolverine Project (Westmin/Atna Joint Venture);
- 1994-98 Kudz Ze Kayah Project (Cominco);
- 1999-2001 Finlayson Project (Expatriate Resources Ltd.); and
- 2003-04 Wolverine Project (Expatriate/Atna).

The important cultural and heritage issues identified by these projects include:

- Traditional fishing and hunting areas;
- First Nations grave sites;
- Caribou fence sites;
- Ross River group trapline;
- Ross River community issues (jobs, training); and
- Cross cultural understanding of mine employees.

Valuable Ecological Components of the Project Area

Wildlife in the project area includes the Finlayson Caribou herd, moose, bears, and various small furbearers. The Tintina Trench, a major land feature of the region, is a migration route for several bird species, including the Sandhill crane, Trumpeter swan and Whitefronted goose. Golden eagles, Bald eagles and Gyrfalcons have also been observed in the Kudz Ze Kayah – Wolverine Lake area although no nesting sites are known to occur near the proposed development areas. Regional streams and lakes support populations of Arctic grayling, Lake trout, Dolly Varden char (Bull trout), and Longnose suckers.

The environmental issues of importance identified during consultation for previous projects in the Finlayson Region include:

- Air quality;
- Water quality;
- Fisheries resources;
- Wildlife resources;
- Moose populations;

- Finlayson Caribou herd;
- Wilderness setting; and
- Recreational fishing and hunting.

This list of VECC's is assumed to be appropriate and comprehensive for the Wolverine Project.

The Environmental Assessment

In the environmental effects analysis, the definition of the environment will be extended beyond biological and physical aspects of the project area. The definition of project environment will include consideration of the biological and physical environment, socioeconomic effects, effects on regional and aboriginal land use, effects on archaeological and heritage resources, and effects on human health.

The environmental assessment will be considered through all development phases including construction, operations, reclamation and decommissioning, and final closure.

The environmental effects analysis of the Wolverine Project will consider this project environment through the following components:

- Analysis of alternative means of carrying out the project and the potential environmental effects of those alternatives;
- Identification of project-environment interactions;
- Potential effects of project-environment interactions;
- Measures taken to mitigate these effects;
- Determination of significance of effects;
- Analysis of cumulative effects resulting from project development in combination with other regional activities; and
- Identification of potential accidents and malfunctions associated with the project and analysis of their environmental effects.

Expatriate intends to carry out a thorough consultation program throughout the regulatory and review process. The Company will hold open houses in Whitehorse, Ross River and Watson Lake at regular intervals as the project develops. The open houses will be well publicized and open to all members of the public. Expatriate Resources will endeavour to identify potentially effected groups and address concerns raised by the public and stakeholders.

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

PROJECT DESCRIPTION REPORT

1 INTRODUCTION

This introduction provides a brief summary of the Wolverine Project. The Wolverine Project is the development portion of the Yukon Silver-Zinc Project that includes the exploration of all of the Company's claims in the Finlayson District. This introduction includes a broad discussion of project components and site conditions, an introduction to the proponent and a summary of the regulations and laws governing the development of the Wolverine Project. The introduction also includes a proposed assessment scope to be used in development of the Environmental Assessment Report.

1.1 Purpose of the Project Description Report

The Project Description Report is intended to give the reader a comprehensive review of the Wolverine Project and the general conditions of the project area. This report includes a discussion of the project history, the principle components of the project, the rationale for developing the project, and possible alternatives to the project.

1.1.1 Project Outline

1.1.1.1 Site Conditions

The Wolverine Project is located in the south east Yukon Territory. The project is roughly midway between the communities of Ross River and Watson Lake immediately west of the Robert Campbell Highway. The climate of the area is cold and dry. Annual average precipitation is approximately 479 mm equally divided between rain and snow. Maximum site temperatures have been measured between 30°C and –33°C.

The topography and landscape of the area are typical of montane glacially effected areas with rounded peaks and U-shaped valleys. Higher elevation areas are generally mantled with morainic deposits, colluvium and bedrock with vegetation which includes dwarf birch and willow, alpine fir and grasses, sedges and lichens. Valley bottom areas contain thick glaciofluvial, glaciolacustrine and alluvial deposits with wetlands and mixed spruce boreal forests. The area around the Wolverine Project has discontinuous permafrost with poorly drained depressional areas containing peat plateaus, patterned fen and bog complexes. Scree covered slopes are most prominent along steep upper mountain slopes. Deep colluvium occurs on steeper mid to lower slopes.

Wildlife values around the Wolverine Project include the Finlayson Caribou herd, moose, bears, and various small furbearers. The Tintina Trench, a major physiographic feature of the region, is a migration route for several bird species, including the sandhill crane, trumpeter swan and Whitefronted goose. Golden eagles, bald eagles and gyrfalcons have also been observed in the Kudz Ze Kayah – Wolverine Lake area although no nesting sites are known to occur near the proposed development areas. Regional streams and lakes support populations of arctic grayling, lake trout, dolly varden char and bull trout, longnose suckers, and slimey sculpin.

1.1.1.2 Project History

The Finlayson District is a newly discovered volcanogenic massive sulphide (VMS) district. The area was discovered as a potentially mineral rich area in the mid-1990's which resulted in a staking rush and extensive exploration activity. During this period of exploration, two important deposits were identified to contain high zinc, copper, lead, silver and gold contents. The Kudz Ze Kayah and Wolverine Projects were taken to an advanced exploration level.

Kudz Ze Kayah was subject to a complete feasibility study by Cominco Ltd., who initially discovered and delineated the deposit. The feasibility study outlined the project as an open pit operation producing 2,950 tonnes per day or ore. The project was approved under the Canadian Environmental Assessment Act (Screening Level Assessment) and received its Class A Water Licence.

The Wolverine Project was advanced as a joint venture between Westmin Resources Limited. (60%) and Atna Resources Ltd. (40%). During the period 1995-97, the Wolverine mineral deposit was partially delineated. In 1997, it was discovered that the Wolverine deposit contained high levels of selenium and that the zinc concentrate would likely not be acceptable to smelters in large amounts. Interest in the project rapidly declined. A short time later, Westmin Resources was subject to a takeover by Boliden Limited and all work on the Wolverine Project stopped.

Expatriate Resources Ltd., a junior mining company with large, strategic land position in the Finlayson District, acquired Boliden Westmin (Canada) Ltd.'s 60% interest in the Wolverine Project in March of 1999. During 1999-2001, Expatriate acquired further interests in the Finlayson District by optioning claims held by Cominco, including the Kudz Ze Kayah Project.

Expatriate commenced evaluation of its combined assets in the Finlayson District and initiated a prefeasibility study on the Finlayson Project that included an open pit and milling operation at Kudz Ze Kayah and an underground mining operation at Wolverine. Prefeasibility results were positive and Expatriate entered the environmental permitting process in November of 2000. A downturn in global metal markets resulted in project financing difficulties. In June of 2001, Expatriate relinquished its option on the Cominco properties in the Finlayson District. The environmental permitting process for the Finalyson Project was suspended.

Expatriate Resources has continued its interest and exploration in the district. Recent studies on the Wolverine Project suggest that the project is feasible on a stand-alone basis. World markets for selenium have drastically improved since the mid 90's and it now represents a potential significant value for the project. Since July of 2003, selenium prices have increased from US $4/lb to US $33/lb. Selenium is used as decolorant in glass, as a solar heat insulator in architectural glass, a fertilizer supplement, and in the steel industry. Expatriate is moving forward with a bankable feasibility study, First Nations Socioeconomic Participation Agreement and environmental permitting for the project.

1.1.1.3 The Wolverine Project

The Wolverine operations will include an underground mine, processing facilities and supporting infrastructure. Site facilities will include:

- a mill facility,
- tailings storage facility,
- mine access including a road connection to the Robert Campbell Highway and an airstrip
- temporary waste rock storage facility,
- a truckshop and warehouse,
- an assay lab,
- cemented rockfill (backfill) plants,
- a water treatment plant and incinerator,
- accomodation complex; and
- fuel storage facilities.

The capital cost of developing the project is estimated to be roughly $100 to 120 million (CDN$). The current development schedule considers a 12 to 14 month window for permitting and feasibility studies and an additional 16 to 18 months for construction. Concentrates would be produced and marketed by late 2007.

1.1.2 Need for and Purpose of the Project

At present, the world demand for zinc is exceeding the available supply. North America is not been self sufficient in it's zinc production. China has become the world's largest consumer of zinc, constituting 25% of the world's consumption. The demand for zinc in China grew by 19% in 2003 and interim numbers in 2004 suggest strong continued growth in zinc consumption.

The long-term picture for zinc production shows no relief in sight for the current market trend. The increasing demand for zinc will continue to outpace the forecasted modest increases in production. There are no major world zinc projects scheduled for development over the next three years that could make up the market shortfall. The timing for the development of a low cost zinc producer is excellent. The market for zinc concentrates is strong, bringing favourable purchase terms and providing long-term security to project economics.

Expatriate Resources intends to take advantage of this excellent market opportunity and the exceptional ore resource of the Wolverine Project to create profits for its shareholders.

The Wolverine Project will also provide a much-needed boost to the Yukon economy that has experienced a serious downturn in recent years, particularly in the mining sector. The project will provide many employment opportunities, a solid tax base, support for infrastructure development, and workforce development opportunities for local communities.

1.1.3 Project Alternatives

For a Screening Study under CEAA, the project may be required to consider alternatives to the project and alternative means of carrying out the project. The assessment of alternatives means of carrying out the project will be completed in detail as part of the Environmental Assessment Report. It will consider the various alternatives considered for each of the project components and the potential environmental effects of these alternatives.

In consideration of the business objectives of the Company, Expatriate Resources sees no feasible alternative to Wolverine Project. Although there are other mineral deposits in the District, Expatriate does not own any interest in them and therefore cannot effect the evaluation of the possible co-development of Wolverine with one or more other deposits. Similarly, it is not possible to consider the potential addition of other deposits that may be discovered through exploration. The Wolverine Project is a principle asset of the Company. Given the current and future global market for zinc the project is exceptional and the best available project to achieve the business goals of the Company.

1.2 Project Proponent

Expatriate Resources Ltd. was founded in 1994. The company is publicly traded on the Toronto Venture Exchange (TSX.V - EXR) and is based in Vancouver, B.C. Direct contact information is presented below.

#701 – 475 Howe Street
Vancouver, British Columbia
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The company's mineral assets are located primarily in Canada, mainly in the Yukon Territory (Figure 1.1). The core asset of the company is its large land position in the Finlayson District (YT) and specifically the properties that make up the Wolverine Project.

The Company also has additional mineral exploration properties in Yukon, Nunavut, Ontario, and California, some of which have partly defined mineral resources. Through it's wholly owned subsidiary,Latina Resources Ltd., the company holds a 100% interests in several exploration properties in Chile (Figure 1.1). Expatriate also owns Nitrosyl Technologies Corporation. This metallurgical process technology company holds a majority interest in two research companies and has patented four process technologies.

Expatriate has recently announced its intention to reorganize the Company. In the reorganization the non-Finlayson District properties, excluding the Logan property in south central Yukon, will be transferred to its wholly owned subsidiary Pacifica Resources Ltd., which will then be taken public as a new base-precious metals exploration company. Expatriate will become a single purpose exploration and development company focused on exploration in the Finlayson District and development of the Wolverine deposit. To reflect the new focus, Expatriate will change its name to Yukon Zinc Corporation.

1.2.1 Management and Policy

1.2.1.1 Management Team

The company has a strong management team with a broad base of experience and expertise. Management team members are very experienced in the exploration, development, and permitting of major mining projects. All team members have previous experience with large mining companies and all phases of mine development, from grass roots exploration to closure and reclamation.

Dr. Harlan Meade, B.Sc.(Geol), Ph.D. (Geol), MBA
President and C.E.O.

Dr. Meade has over 20 years of experience in the mining industry. Dr. Meade has experience with underground and open pit mining operations, permitting and environmental issues, financing, and management.

As the Vice-President of Exploration and Environment for Westmin Resources Limited, Dr. Meade was directly involved in the initial discovery and advancement of the Wolverine Project. This high-grade zinc-lead-copper-silver-gold deposit is a major component of the Finlayson Project. During the exploration and advancement of Wolverine, Dr. Meade maintained a successful and beneficial relationship with the Ross River Kaska Dena including the negotiation of a socioeconomic agreement between the Westmin/Atna joint venture partnership and the Ross River Dena Council. This agreement was unfortunately never formalized.

Dr. Meade was responsible for management of environmental issues for Westmin Resources Limited. His management of environmental issues included the successfully implementation of the company's environmental audit system. During his time as VP of Exploration and Environment, the company enjoyed an excellent record on environmental compliance and permitting issues. Dr. Meade also co-chaired the Aquamin Review on behalf of the Mining Association of Canada. This review was a national, multi-disciplinary, review program of the impacts of metal mining on the aquatic environment.

Mr. Robert McKnight
Chief Financial Officer, Vice President Corporate Development

Mr. McKnight joined Expatriate in January 2004. Mr. McKnight is a geological engineer with broad experience in the mining industry having held senior roles with Wright Engineers, Cassiar Mining, Getty Resources, Endeavor Financial and most recently Pincock Allen & Holt Ltd. and AMEC. His experience includes: feasibility studies; financial evaluations of mining, oil and gas and coal projects; technical and financial due diligence; project finance, and mergers and acquisitions. He is a graduate of the University of British Columbia and Simon Fraser University with degrees in Geological Engineering and Business Administration.

Mr. Jason Dunning
Vice President Exploration

Mr. Dunning joined the company in April 2003. Prior to joining Expatriate, Mr. Dunning was a Project Geologist for Hudson Bay Exploration and Development Co. Ltd. based in Flin Flon, Manitoba where he conducted both grassroots and advanced exploration in Northern Saskatchewan and Manitoba. Mr. Dunning is a graduate of Carleton (Hon. BSc. Geology 1994) and Laurentian (MSc. Geology 1998) universities with a strong background in volcanogenic massive sulphide and other types of deposits.

The Board of Directors for Expatriate also has a broad range of mine development, operation, closure and financing experience.

1.2.1.2 Management Approach to the Permitting Process

The approach of the company to the permitting process for the Wolverine Project is based on four principles:

1. Dedicated Management – the Company is taking a proactive role in the permitting of the Finlayson Project. The management team will ensure that environmental and permitting issues are considered in all management decisions.

2. Experience and Expertise – Expatriate has selected a team of consultants who have previous experience in the Finlayson District and have the expertise to assist the company in permitting and developing the project. This team includes:

   Gartner Lee Ltd., Steve Morison and Don McCallum – Gartner Lee is the lead consultant on permitting issues for the Finlayson Project Description Report (2000). Kirk Cameron and Sally Howson have extensive experience with permitting in the Yukon.

   Access Mining Consultants, Rob McIntyre and Dan Cornett – Access Mining Consultants developed and implemented the Wolverine Project environmental baseline studies during 1995-97.

   EnTox Environmental Services, Justin Himmelright – Mr. Himmelright was the Manager of Environment for Expatriate Resources in 2000-01. He was involved in previous permit applications for the Wolverine Advanced Exploration Project and the Finlayson Project. Prior to working for Expatriate, Mr. Himmelright was a Senior Environmental Coordinator with Hallam Knight Piesold Ltd. and Knight Piesold Ltd. In this capacity, Mr. Himmelright was been involved environmental studies and permit application work for mining projects in Canada (BC, Yukon, Ontario) and Central and South America (Panama, Honduras, Peru, and Chile) since 1995.

3. Existing Documentation – there is an extensive library of studies and other documentation related to the Wolverine Project. The exploration properties that comprise the project have been subject to prefeasibility level engineering studies, and extensive environmental baseline studies. Projects in the Finlayson District have published a wealth of information on regional issues and environmental aspects. The company intends to utilize this documentation and information to the maximum extent possible when developing report submissions for the regulatory agencies.

4. Joint Work Planning – using principles outlined in a recently developed administration protocol (the "Blue Book" protocol), Expatriate Resources will work

closely with regulatory agencies to develop joint work plans for approval and permitting processes. The Company and the review groups will work together in developing joint work plans which allow both groups to anticipate and allocate the resources required to meet the timelines associated with each step in the permitting process.

1.2.1.3 Expatriate's Environmental Policy

Although Expatriate is not a member of the Mining Association of Canada, the company has chosen to adopt environmental policies of this organization. As a junior mining company with no operating mines, only certain components of the Mining Association of Canada's environmental policies apply to Expatriate Resources. These components include the following:

1. Integrated Management - Integrate environmental policies, programs, and practices into all activities of the organization.
2. Environmental Management - Monitor the performance of environmental programs and management systems to ensure compliance with company and legislative requirements.
3. Continual Improvement - Establish and ongoing program of review and improvement of environmental performance.
4. Risk Management - Identify, assess, and manage environmental risks.
5. Incident Management - Develop, maintain, and test emergency preparedness plans to ensure protection of the environment, workers, and the public.
6. Public Policy - Work with government and the public to develop effective, efficient, and equitable measures to protect the environment based on sound science.
7. Contractors and Suppliers - Require contractors to comply with company environmental policies and work co-operatively to improve environmental performance.
8. Communications - Encourage dialogue on environmental issues with employees and public and be responsive to concerns.
9. Employees - Ensure that all employees understand and are able to fulfill their environmental responsibilities.
10. Closure - Reclaim sites in accordance with site-specific criteria in a planned and timely manner.

1.2.1.4 Mineral Assets

Expatriate's mineral rights in the Finlayson District are based on three groups of claims (Figure 1.2). The Expatriate claim group is comprised of claims originally staked by Expatriate Resources Ltd. in the mid-1990's. The company retains a 100% interest in these claims. Expatriate's interest in the second claim group (the Wolverine Joint Venture) was acquired from Westmin in 1999. Expatriate is now the 100% owner of the Wolverine Joint Venture lands.

1.3 Regulatory Context

1.3.1 The Project and the Yukon Environmental Assessment Act and Federal Interests

1.3.1.1 Applicability of the Yukon Environmental Assessment Act

The Wolverine Project is subject to the Yukon Environmental Assessment Act (EAA). EAA is very close in its substance to the Canadian Environmental Assessment Act (CEAA), and is now in place given the transfer of administration and control of land and resources from the federal government to the Yukon Government in 2003.

The applicability of EAA to any proposed project is dependent on three component questions:

1. Does it meet the definition of a "project" under EAA?

   The EAA definition of a project includes undertakings in relation to physical work as well as some activities not related to physical work. EAA contains "Inclusion List Regulations" which outline the types of activities that would require Environmental Assessment. The Wolverine Project does meet the definition of a project under EAA.
2. Does the project include a territorial "trigger"?

   Activities which constitute a "territorial trigger" include the involvement of the Yukon government as a proponent of the project, as a provider of funds in support of a project, as seller or lessor of lands enabling the project, or as a regulator and administrator of territorial acts which govern the project (i.e. provider of permits and approvals). The Wolverine Project requires permits and approvals from the territorial government and as such the project includes a territorial "trigger".
3. Is the project excluded by the Exclusion List Regulations?

   The EAA Exclusion List Regulations make provisions for certain types of activities to be excluded from territorial environmental assessment process. These activities include emergency actions and repairs to existing physical works. The Wolverine Project does not fall under the Exclusion List Regulations.

1.3.1.2 Level of Environmental Assessment

EAA prescribes five levels of environmental assessment; screening, class screening, comprehensive study, mediation, and panel review. The applicable level of environmental assessment for a project can be determined by consulting the Comprehensive Study List of EAA. This list outlines which projects will be subject to a Comprehensive Study or lesser assessment.

For base metal mining projects, such as the Wolverine Project, operations that meet or exceed 3,000 tonnes per day of ore throughput are required to undergo a Comprehensive Study under the EAA. The Wolverine Project, however, will be designed to have a daily throughput of 1,250 tonnes per day and as such will not require a Comprehensive Study, but instead be subject to a screening under EAA. The administration of the EAA will be conducted by the Yukon Government's Executive Council Office through its Environment Directorate.

1.3.1.3 The Law List and Territorial Triggers

The permits and approvals required for the Wolverine Project fall under three major sets of acts and regulations. Firstly, the project will require a Type A Water Licence under the Yukon Waters Act. The Yukon Water Board issues this licence which requires approval by the territorial Minister of the Executive Council Office. The Water Resources Section of the Yukon Department of Environment provides an inspection function to ensure compliance by the proponent. Secondly, the project will require a Quartz Mining Licence under the Yukon Quartz Mining Act. The issuance of this licence is administered by the Mining Land Use Branch of the Yukon Government's Department of Energy, Mines and Resources and requires approval by the territorial Minister responsible. Thirdly, the project will require additional Surface Leases under the Territorial Lands Act (TLA) that is administered by Lands Branch in the same Department. It is anticipated that a security will be required as part of the obligations for restoration of the site.

Additional acts and regulations that will need to be considered for the project, and which require separate formal approvals from federal Responsible Authorities include:

- CEAA – A harmonized process will be established. Yukon Government will be the lead, but federal interests in respect to matters like fish habitat, navigation, explosives will require federal departments to complete CEAA screenings in harmonization with the EAA assessment.
- The Navigable Waters Protection Act (Canadian Coast Guard) – Expatriate Resources is reviewing several options for development of an access road to the Wolverine operation. Depending on the route selected, large stream crossings involving bridgework may be required. Such works would require approval under the Navigable Waters Protection Act.
- The Fisheries Act (Fisheries and Oceans, Canada) – The underground operations at Wolverine are not anticipated to have any effect on fisheries or fish habitat. Although the tailings storage facility will effect the upper Go Creek Watershed, no fish have been detected in or above this reach of the stream during baseline studies. Treated mine water will be released to Go Creek during the Wolverine operations and closure. Some stream crossings, depending on the selected road alignment may require examination for impact on fish habitat. These crossings may have a minor effect on local fish habitat, depending on the attributes of the crossing location and design. With certain engineering it may be possible to avoid fish habitat alteration, disruption or destruction (HADD).
- The Explosives Act (Natural Resources Canada) – It is unlikely that there will be explosives manufacturing at the Wolverine Project and a permit under the Explosives Act is likely not required.

1.3.1.4 Potentially Applicable Federal and Territorial Policies and Strategies

The federal and territorial governments have several strategies and policies related to environmental issues that may influence the project design and mitigation and will need to be reported in any Environmental Assessment Report. A summary of those policies and strategies is presented below.

Canadian Biodiversity Strategy

The Canadian Biodiversity Strategy was developed as a guide for the implementation of the United Nation's Biodiversity Convention, signed by Canada and 160 other countries at Rio de Janeiro in 1992.

The objectives of the Convention are to conserve the ecosystem, species and genetic diversity; ensure the wise use of the earth's resources; and ensure that the economic benefits from these resources are shared fairly and equitably. The Canadian Biodiversity Strategy is generally based on these three objectives. There are five goals that provide the framework for the Canadian Biodiversity Strategy:

1. Conserve biological diversity and sustainable use of biological resources.
2. Improve our understanding of ecosystems and increase our resource management capacity.
3. Promote an understanding of the need to conserve biodiversity and the sustainable use of biological resources.
4. Maintain or develop incentives and legislation that support biodiversity conservation and sustainable use.
5. Co-operation at an international level to conserve biodiversity, the sustainable use of biological resources and share equitably the benefits of genetic resources.

Kyoto Protocol

The purpose of the Kyoto Protocol is to achieve quantified limitations and reductions in the emission of greenhouse gases and other pollutants to promote the objectives of sustainable development. The key objectives of the Kyoto Protocol are:

- enhancement of energy efficiency in relevant sectors of the national economy;
- protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, accounting for international environmental agreements and promotion of sustainable forest management practices;
- promotion of sustainable forms of agriculture in light of climate change considerations;
- research on, promotion, development and increased use of new and renewable forms of energy, of carbon dioxide sequestering technologies and innovative environmentally sound technologies;
- progressive reduction of market imperfections, subsidies and other financial incentives in all greenhouse gas emitting sectors that run counter to the objectives of the Convention;
- encouragement of appropriate reforms in sectors aimed at promotion of policies limiting or reducing emissions of greenhouse gases not controlled by the Montreal Protocol;
- limits and /or reductions in emissions in the transport sector that are not controlled by the Montreal Protocol; and

- limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy.

Montreal Protocol

Canada was a participant in the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987, and has continued to be involved in initiating programs and initiatives in reducing air pollutants. Entering into agreements with the United States, it has made specific commitments on the reductions of nitrogen oxides and sulphur dioxides, in an effort to curb transboundary air pollution.

In addition to the interest in ozone, from an environmental assessment perspective, the EA will determine if there is a potential for a project to emit greenhouse gases, make suggestions regarding the use of best available technology for emissions control and energy efficiency and address the potential for cumulative effects and implications for climate change. Proponents should be encouraged to develop action plans and follow-up programs aimed at identifying sources and reduction options for greenhouse gas emissions

Pollution Prevention – Federal Strategies for Action

The federal government defines Pollution Prevention as, "…the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, and reduce overall risk to human health or the environment". This strategy provides a framework to achieve a proactive approach to pollution in all sectors of society.

The federal strategy for action on Pollution Prevention is supported by four key goals.

1. Institutionalizing pollution prevention across all government activities.
2. Working with the private sector to achieve a climate in which pollution prevention becomes a major consideration.
3. Providing access to all Canadians to the information and tools required to implement pollution prevention practices.
4. Participating in international pollution prevention initiatives.

This policy instrument was developed to ensure that processes or products that avoid or minimize the creation of pollution and waste are developed and implemented. In the context of this policy, the EA will consider air, land and water pollution issues, as it relates to the project. The focus of such comments should be on opportunities for the project to incorporate pollution prevention programs, energy recovery programs and remediation efforts. Programs that would improve the environmental performance of projects should be encouraged and detailed within an environmental assessment.

Migratory Bird Convention Act and Regulations

The Migratory Bird Convention allows for co-operation between Canada and the U.S. in the protection and management of migratory birds. The 1995 protocol to amend the Convention emphasizes the need to provide for and protect necessary habitat for the conservation of migratory birds. This is consistent with other approaches, such as the establishment of Migratory Bird Sanctuaries, under the *Migratory Birds Convention Act* and the National Wildlife Areas under the *Canada Wildlife Act*.

Yukon Government's Commitment to Sustainable Development

The Yukon *Environment Act*

This act sets a legislative context for the principles of sustainable development and integrated resource management in the Yukon.

The Preamble to the act outlines these commitments:

- Recognizing that the way of life of the people of the Yukon is founded on an economic, cultural, aesthetic and spiritual relationship with the environment and that this relationship is dependent on respect for and protection of the resources of the Yukon;
- Recognizing that the resources of the Yukon are the common heritage of the people of the Yukon including generations to come;
- Recognizing that long-term economic prosperity is dependent on wise management of the environment; and
- Recognizing that comprehensive, integrated and open decision-making processes are essential to the efficient and fair discharge of the environmental responsibilities of the Government of Yukon.

The Yukon MINE Plan

This Plan outlines the government's commitment to the mining industry, and again restates the commitments to sustainable development and wise management of resources in a manner respectful of the environment. Its objectives outline these commitments:

- To restore the Yukon mining industry so it can once again provide an important contribution to the Yukon economy;
- To ensure the minerals industry conducts its activities in an Environmentally and socially responsible manner;
- To ensure environmental management and protection measures consider economic impacts
- To ensure access to and wise use of mineral resources in a manner that optimizes the long-term social, environmental and economic Benefits and opportunities for Yukoners;
- To improve understanding of inter-relationships among geology, mineral resources, the industry, the environment and the economy.

1.3.2 Agreements Relevant to Decision-making – Kaska Bi-lateral Agreement

This Agreement sets out commitments made by the Government of Yukon on the shared role of the Kaska in determining the direction of development in the Kaska traditional territories which includes the mine and access areas under review here. This agreement sets out a number of likely applicable requirements:

- "3.3 Yukon shall not agree to any significant or major dispositions of interests in lands or resources or significant or major authorizations for exploration work and resource development in the Kaska Traditional Territory without consulting and obtaining the consent of the Kaska. Consultation and consent shall be required in particular in the following:
  a) Hard rock mines with a Type A Water License, coal mines, major hydro developments, major construction and linear projects such as highways and pipelines;
  b) Any other project subject to a Level II screening process under the Yukon Environmental Assessment Act;
  c) Major land use designations; and
  d) Such other matters which the working group established under 3.4 may recommend and to which the parties agree."
- "3.9 In order to facilitate resource development, Yukon and Kaska shall, on a government to government basis, develop a process of resource planning that takes into account an integrated strategy for all social and economic values within the Kaska Traditional Territory."
- "5.1 The parties agree… to implement and build upon the economic partnership described in paragraph 2(f) of this Agreement. As part of this partnership, the parties shall discuss:
  a) Requirements for Impact and Benefits Agreements between proponents and the Kaska in the various resource sectors and the appropriate triggers and thresholds for requiring such agreements;
  d) Kaska preferential access to other economic opportunities in the Kaska Traditional Territory…"

1.3.3 Land Use Designations Affecting Project Development

The Finlayson District is not part of any special land use planning process. Land use stakeholders in this area include guide outfitters and local First Nations. Ken Reeder of Teslin Outfitters Ltd. holds the commercial guiding rights for the project area. Warren and Anita LaFave operate a tourist facility called Inconnu Lodge on McEvoy Lake, north of Finlayson Lake. Neither of these operations includes special designations or land use rights which effect the project.

The major Aboriginal group affected by the Wolverine Project is the Kaska Nation whose traditional territories cross in to B.C. The Kaska Nation is comprised of three principle groups, the umbrella Kaska Dena Council representing all Kaska communities in B.C. and the Yukon, the Liard First Nation located near Watson Lake in Southern Yukon, and the Ross River Dena Council based in Ross River. The traditional territory of the Kaska Nation is considered to be shared equally by all groups; however, the communities recognize the traditional use of portions of the territory by a particular group. The Wolverine Project area falls within the area recognized as the traditional territory of the Ross River Kaska.

The Ross River Dena Council holds the group trapping rights for the project area. No one person owns a trapline, but trapping takes place on Group Traplines. The Ross River Dena Council has management responsibility for the Group Traplines. The

Wolverine Socioeconomic Participation Agreement (SEPA) currently under negotiation is considering provisions for compensation for interruption of trapping land use.

As part of the land claims negotiation process between the governments of Canada and the Kaska Nation, land selections designated as “R-Blocks” have been set aside for future consideration in the land claims process. There are four such R-Blocks (LFNR – 142A, RRDC R –15A, RRDC R 16A, RRDC R 17B) in the Finlayson District (Figure 1.2). These lands are withdrawn from any future land use plans until such time as they are selected or released by the First Nation during the land claims negotiation process. Although these blocks are in close proximity to the project operation areas and access corridors, they will not directly affect the development of the project.

1.3.4 Project Description Report Circulation

Copies of this report and application for licence cover letter will be distributed by Energy Mines and Resources Minerals Management with the assistance of the Yukon Government’s Executive Council Office (Environmental Assessment Unit) to the following groups:

- Government of the Yukon:
  - Department of Environment (Environment Affairs Section, Water Resources);
  - Energy, Mines and Resources – Minerals Management Branch;
  - Tourism and Culture;
  - Yukon Water Board;
  - Highways and Public Works;
  - Health and Social Services; and
  - Workers Compensation.
- Government of Canada (the Canadian Environmental Assessment Agency will coordinate distribution to all or some of the following as they assess to be necessary:
  - Department of Fisheries and Oceans;
  - Natural Resources Canada;
  - Transport Canada; and
  - Environment Canada.
- Other Interested Bodies:
  - Ross River Dena Council;
  - Liard First Nation; AND
  - Yukon Conservation Society.

1.4 Project and Assessment Scope

1.4.1 Project Scope

The scope of the project to be assessed includes the following components:

- The mine and processing operations and supporting infrastructure and facilities at Wolverine; and
- The mine access road connecting to the Robert Campbell Highway.

1.4.2 Assessment Scope

The assessment will consider the following issues:

- The purpose of the project;
- Alternative means of carrying out the project and the environmental effects of those alternatives;
- Technically and economically feasible measures that would mitigate any significant adverse environmental effects resulting from the project;
- The residual environmental effects of the project including the effects of potential accidents and malfunctions that may occur in connection with the project. This will include an assessment of effects on:
  - The physical and biological environment;
  - Archaeological and heritage resources in the project area;
  - Effects on aboriginal land use;
  - Socioeconomic effects in local communities; and
  - Effects on human health.
- The cumulative environmental effects that may result from development of this project in combination with other projects that have been carried out or are proposed;
- The significance of these effects; and
- The need for and requirements of a follow-up program.

Throughout the assessment, the definitions of “environment” and “environmental effect” will be defined as per the Canadian Environmental Assessment Act. This is as follows:

- environment - the components of the earth and includes land, air and water and all layers of the atmosphere, all organic and inorganic matter and living organisms, and the interacting natural systems including the previously mentioned components; and
- environmental effect – any change that the project may cause in the environment including including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the *Species at Risk Act,* any effect of any such change on health and socioeconomic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes by aboriginal persons, or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance; any change to the project that may be caused by the environment.

The scope established by these definitions does not consider socioeconomic effects which do not result from changes in the environment. It is historically established that major projects in remote areas can result in socioeconomic effects to original inhabitants as a result of rapid immigration of outsiders seeking work. Major projects also bring many positive socioeconomic benefits through employment and tax revenues. In this case, the social and economic effects do not result from changes to the environment (as defined by the Canadian Environmental Assessment Act) but from changes to the local social and economic conditions. For the purposes of this environmental assessment, the Company intends to include the social and economic conditions of the area in the definition of the project “environment”.

The capacity of renewable resources, that are likely to be significantly affected, to meet present and future needs should not be considered by the Environmental Assessment. While the present and future needs for the metal products produced by the operation can be assessed, the global availability of these resources cannot be determined. There are certainly other mineral deposits in the world which have not been discovered, and for those that have been discovered, their development is predicated on many unpredictable circumstances including political and economic conditions in the jurisdiction in which they occur.

As discussed in previous sections, Expatriate Resources does not have any feasible alternatives to the project that would achieve its business objectives. As such, it is proposed that the EA Report not consider “alternatives to the project”. It is acknowledged that a determination on this issue is ultimately for the Responsible Authority to make.

It is proposed that the approximate spatial boundaries for assessment be selected based on the potential geographic extent of effect. The spatial boundaries proposed for assessment of biological environment, physical environment, aboriginal land use, and archaeological and heritage resources is shown in Figure 1.3. The boundary shown in Figure 1.3 is intended to encompass all mine infrastructure including the access road and waterways in the downstream flowpath from the mine. The assessment of economic effects would be presented in a regional context, including the Yukon Territory as a whole.

The temporal boundaries of the assessment are proposed to include the construction, operations, reclamation and decommissioning, closure, and post closure phases of the project.

2 PROJECT DESCRIPTION

The Wolverine Project will be an underground mine producing 1,250 tonnes per day (tpd) of ore. Ore will be processed on site in a flotation mill, producing zinc, copper, and lead concentrates. Concentrates will be likely trucked to Skagway and transported to customer smelters via ocean shipping. Other transport alternatives will be considered during feasibility studies.

The mine facilities will include an airstrip, mine access road, underground mine, tailings storage facility, temporary waste rock storage, process mill, and ancilliary buildings and equipment. The operations will be powered by a diesel plant located on site.

The mine and mill operations will employ approximately 121 people. Crews will work on a two week in, one week out rotation. Chartered flights from Whitehorse, Watson Lake and Ross River will be used to bring workers to the airstrip near the mine site. Crew buses will transport the crews from the airstrip to the mine site.

Based on known reserves, the mine is expected to operate for about 9 years. The extent of the ore body is not fully known and an extended mine life is probable as additional work brings current resources into mineable reserves. Additional employment benefits to the Yukon during this time including contracting and service opportunities, is estimated to be about 970 jobs.

The general arrangement of site infrastructure is shown in Figures 2.1 and 2.2. Additional assessment will be completed as part of a project feasibility study to finalize the project layout. Final locations will be selected based on minimizing environmental effects and risk, utilization of natural features (i.e. topography and drainage patterns) to enhance operational efficiency, and minimizing capital and operating costs. The final location of infrastructure required for the Wolverine operation is relatively flexible due to its small footprint.

2.1 Wolverine Project Mineral Resource

2.1.1 Exploration and Data Collection

The resource inventory published by Westmin Resources Limited in February 1998 was based on drill hole data acquired during the 1995-1997 exploration drilling programs. All core was halved, with half assayed at Chemex Labs in Vancouver for Zn, Cu, Pb, Au, and Ag, using standard assay and analytical methods. The assay program included duplicate samples and standards for assuring assay quality. Individual density measurements were made at the same time and are available for most of the samples in the database. All assay intervals in each drill hole with the same geological code were averaged into a single composite, using sample length and density as the weighting factors. The Westmin database used in the modelling included all assay, density and coded geological information.

2.1.2 Ore Outline and Block Model Development

The Wolverine Deposit is a volcanogenic polymetallic massive sulphide body with a defined strike length of 700 m and a down dip length of at least 400 m. The main zone strikes northwest-southeast and has a dip that ranges from near flat locally, to 30° to 40° to the north east. The favourable mineralized horizon is open in the down dip direction. Within the proposed mining area there are two distinct areas where the mineralization thickens to between 8 m to 15 m. These zones are known as the Wolverine and the Lynx, and they occur as lozenge shaped pods that extend over a minimum of 100 square metres at their thicker centres. At the distal edges of the lozenges the thickness is generally 4 m or less. The average thickness of the Wolverine Zone is 5.1 m, whereas the average thickness of the Lynx Zone is 6.7 m. Overlying the Lynx Zone is the Upper Lynx Zone. The Upper Lynx Zone has limited aerial extent with a thickness sufficient for underground mining.

The Wolverine assay database was loaded into a MEDSYSTEM® format. The assay data was composited for the length of the mineralized zone intercept. A preliminary Gridded Seam Model was developed for all the mineralized horizons that include the Upper Lynx Zone, the Wolverine-Lynx Zones and the Footwall Zones.

The Lower Lynx and Wolverine Zone hanging wall and footwall surfaces were modelled by gridding the drill hole intercept data. These top and bottom surfaces were used to calculate the gridded seam thickness. The copper, zinc, lead, silver and gold grades for blocks in the ore model were interpolated by the inverse distance cubed method.

2.1.3 Resource and Reserve Summary and Classification

For the purposes of developing preliminary production schedules the mine design parameters, operating costs, economics, etc. have been applied in deriving the following reserve estimates (Nilsson 2000):

Table 2.1. Wolverine Indicated Resource Estimate

	Indicated	Inferred	Total
Millions dmt	4.941	0.498	5.439
Zn,%	13.0	13.61	13.06
Pb,%	1.58	1.70	1.59
Cu,%	1.43	1.36	1.43
Ag,g/t	379.4	365.3	378.1
Au,g/t	1.76	1.51	1.74

2.2 Mining Production and Operations

A preliminary geotechnical assessment of the property, entitled ***"Preliminary Geotechnical Assessment of the Wolverine Project"***, dated April 9, 1997, was completed by Golder Associates (Golder). An updated geotechnical assessment of the property was provided by BGC Engineering, entitled ***"Wolverine Deposit – Geomechanics Assessment"***, September 28, 2000. The preliminary mine plan is based on the geotechnical recommendations as outlined and provided in the BGC report.

2.2.1 Ore Reserves and Underground Design

Ore extraction from the Wolverine deposit has been scheduled on the basis of stoping and ground control recommendations set out by BGC Engineering Inc.'s report "Wolverine Deposit - Geomechanics Assessment". In their report, BGC recommend an overhand cut-and-fill technique in which slices and slots of ground are extracted in longitudinal panels. A key element of the mining method is the need to restrict exposure of the very weak hanging wall, while attempting to take advantage of the relatively stronger ground within the ore limits. The probable reserve, based on this mine plan, is shown in Table 2.2.

Table 2.2. Wolverine Probable Reserves (Nilsson 2000)

	Total Probable Reserves
Millions dmt	3.469
Zn, %	12.43
Pb, %	1.44
Cu, %	1.37
Ag, g/t	336.6
Au, g/t	1.59

2.2.2 Geotechnical

2.2.2.1 Ground Conditions

The intact strength of the various rock types was estimated by using standard ISRM procedures and by using a point-load tester. A summary of the rock strengths as defined by BGC is shown in Table 2.3.

Table 2.3. Rock Strength – Field Test Runs

Surface	Strength	Comments
Hanging Wall	R1 to R3 (1 Mpa to 50 MPa)	Very weak to medium rock. Generally weak.
Iron Formation	R3 – R4 (50 Mpa to 100 MPa)	Medium to Very Strong. Generally Strong.
Ore	R3 to R5 (50 Mpa to 250 MPa)	Medium to Very Strong rock.
Footwall	R1 to R3 (1 Mpa to 50 MPa)	Very Weak to Medium rock. Generally Weak.

The rock mass rating for the hanging wall and footwall are poor and in the ore zone it is considered fair to good. Due to the strongly foliated and friable nature of the rock, excavation spans and must be maintained as narrow as possible for a short a time as possible to avoid costly ground support. The *"stand up or exposure time"* of the argillite and rhyolite in the hanging wall is estimated to be in the order of hours for spans greater than 3 m. In the ore zone, the *"stand up or exposure time"* for spans in the range of 3 m to 9 m is in the order of years in areas where the back is comprised of sulphides.

2.2.2.2 Ground Support

Design recommendations have been made that limit the allowable exposed hanging wall span to 4 m measured along the dip. Installation of temporary support is estimated to be adequate for supporting the span over approximately 1 month. When the hanging wall is exposed in the back, support will consist of 1.8 m long resin grouted #6 rebar on one meter staggered spacing. Weld mesh will also be installed in the back. Spot bolting with 1.8 m long mechanical anchored rock bolts will be carried out in the harder rock in the walls as required. In very poor ground it may be necessary to apply a 25 mm thick layer of shotcrete on the hanging wall, covering bolts and screens.

The size of permanent openings will be limited to 4.5 m by 5.0 m arch with 75 mm of fibre reinforced shotcrete in the back and 25 mm in the walls. Rock bolts will be installed on 1 m centres in the back and 2 m centres on the walls. In both permanent and temporary openings, ground support will be installed immediately after a round is mucked out.

2.2.3 Underground Mine Access

The deposit is located near surface and access will be by means of a decline ramp. This decline will be collared in a valley southeast of the deposit as shown in Figure 2.3. The decline will be driven using trackless equipment at a grade of –15%. It will measure 4.5 m by 5.0 m in cross-section. The decline will intersect the footwall of the Wolverine Zone at approximately 1,750 m elevation, where it will follow the footwall down-dip. Access to both the Wolverine and Lynx Zones can be achieved at any elevation from this main ramp.

Access will be provided within the Lynx Zone and Wolverine Zone from the main access ramp by means of 4.5 m x 4.5 m development ramps as shown in Figure 2.3. These development ramps will provide multiple working faces and ventilation.

2.2.4 Production Plan

2.2.4.1 Mining Method

The mine plan has been developed using a retreating cut-and-fill mining method. The access plan and proposed mining areas are shown in Figure 2.3. A combination of drift-and-fill and overhand cut-and-fill methods will be required to extract the resource. Drift-and-fill methods will be employed in those sections of the deposit where the true thickness is between 2 m and 6.0 m. The drift sizes are also summarized in Table 2.4.

Initial drifts will be driven along the deposit footwall contact. Once the ore has been removed, the mined stope will be tight filled with a suitable backfill material. It is proposed to divide the deposit into distinct sections and mine each section from the bottom up, advancing up-dip. The mining areas have been scheduled so that at least two mining blocks are available simultaneously.

Broken muck from active headings will be transported back to the main access ramp where it will be stored in muck bays. The material will then be reloaded into haul trucks using a dedicated hauling crew for transport to the surface.

Table 2.4. Stope Sizes at Various Vertical Thicknesses for the Wolverine Operation

Vertical Thickness	Stope Size
4.0 m	1 @ 3.5 m wide x (3.5 – 5.8 m) high
6.0 m	1 @ 3.5 m wide x (3.5 – 6.0 m) high
8.0 m	1 @ 6.0 m wide x 5.0 m high 1 @ 3.0 m wide x (2.2 – 4.2 m) high 1 @ 3.0 m wide x (4.2 – 6.4 m) high
10.0 m	1 @ 6.0 m wide x 5.0 m high 1 @ 3.0 m wide x (2.6 – 4.8 m) high 1 @ 3.0 m wide x (4.8 – 6.9 m) high
12.0 m	1 @ 9.0 m wide x 5.0 m high 1 @ 3.0 m wide x (2.6 – 4.6 m) high 1 @ 3.0 m wide x (4.6 – 6.8 m) high
14.0 m	1 @ 5.0 m wide x 5.0 m high 1 @ 9.0 m wide x 5.0 m high 1 @ 3.0 m wide x (2.6 – 4.6 m) high 1 @ 3.0 m wide x (4.6 – 6.8 m) high

A downcast ventilation system is proposed for the Mine. Air will enter the Mine through the main access ramp. Ventilation raises will be driven at both east and west extremities of the deposit as shown in Figure 2.3. These raises will be driven in ore and they will break through to surface. Access to the raises will be possible at the elevation of each drift that is driven along the strike of the orebody. Air down cast through the main access ramp will pass through the ore drifts left open at selected elevations as required to balance airflow and pressure in the mine. The ventilation air will discharge to surface via the ventilation raises. The ventilation raises will also serve as a means of emergency exit from the Mine.

2.2.4.2 Mine Production Development Plan

The primary access to the Mine is developed as part of the pre-production phase. Mining Area A and B will be required for ore production in Year 1 of the Mine Plan (Figure 2.3). Access development to both of these areas will be carried out in the pre-production phase. In general, for the balance of the mine life, the development of the mining areas takes place in the year prior to scheduled ore production. Mine development is completed by Year 5 of the 8-year mine plan. As more resources are converted to mining reserve during the planned test mining and definition drilling program, the mine plan may be extended.

2.2.5 Backfill

The poor quality of the hanging wall rock will require that all mined openings be backfilled. The most suitable method for mining the Wolverine deposit is a combination of mechanized, overhand cut-and-fill and drift-and-fill. In shallower dipping sections of the deposit, this technique will closely resemble drift-and-fill stoping. A preliminary concept has been developed for backfill delivery. This concept consists of use of cemented rockfill (CRF). CRF prepared on surface will be trucked underground and filled into the void stopes using rammer jammer. Future work should define most appropriate fill type and optimize fill delivery.

The backfill will require gravel. A gravel borrow area is proposed near the Wolverine operations. Sufficient gravel deposits exist near the proposed Wolverine operations.

2.2.6 Description of Operation

2.2.6.1 General

The Mine will operate on a 10-hour shift basis, two shifts per day, seven days per week. Since the site is in a remote location, it is planned that the Mine will operate 365 days per year with crews working a rotation of two weeks in and one week out.

2.2.6.2 Equipment

The mining method will be trackless cut-and-fill. The key elements of the fleet included jumbo production drills, mechanical bolters and supporting scissors lift vehicles, shotcrete delivery vehicle, as well as 4 m^3 load haul dump units and 36 t haulage trucks. The haulage trucks will carry muck to the surface where it will be stockpiled and re-handled into transport vehicles that will carry the material to the process facility.

2.3 Process

2.3.1 Introduction

The following section provides an overview of milling and flotation process that will be used to develop concentrates from the Wolverine Ore.

AMTEL carried out flotation testwork on Wolverine ore in 1997 and International Metallurgical and Environmental Inc. published preliminary metallurgical testwork results in 1999. Early in 2000, Expatriate Resources commissioned Process Research Associates to conduct further metallurgical testwork on the Wolverine ore under the direction of Dr. Morris Beattie. The 2000 laboratory metallurgical program consisted of batch and locked cycle flotation tests. The testwork utilized drill core samples from the Lynx and Wolverine zones obtained in 1996 and 1997. These samples represent ore that is anticipated to be mined during the first four years of production.

The following information sources were used in this report.

- Process Research Associates Ltd., “Filtration and Settling Studies on Products from Flotation of Wolverine Samples”, September 5, 2000;
- Beattie Consulting Ltd., “Metallurgy of the Wolverine Deposit”, June 2000;
- Process Research Associates Ltd., “Flotation Study on Samples from the Wolverine Deposit”, June 14, 2000; nd
- AMTEL, “Copper, Lead and Zinc Flotation from a Wolverine Project Composite Sample”, April 29, 1997.

2.3.2 Ore Characterization

Ore characterization for Wolverine is taken from the Process Research Associates report, "Flotation Study on Samples from Wolverine Deposit", June 2000. The Wolverine deposit, consisting of both the Lynx and Wolverine zones is a volcanogenic massive sulphide deposit. The mineralized zones contain an abundance of pyrite with the average feed containing in the order of 35% sulphide sulphur. In addition to pyrite, the major sulphide minerals in the Wolverine ore are sphalerite, galena and chalcopyrite. Pyrrhotite, arsenopyrite, marcasite and sulphosalts (tetrahedrite, meneghinite, boulangerite) are present in lesser amounts but will account for arsenic and antimony impurities in the concentrates. The tetrahedrite also carries most of the silver in the ore, containing about 19% (w/w) silver. The sphalerite is iron-bearing, with iron content up to 7.95% by weight and also contains about 0.45% cadmium. A noteworthy feature of the Wolverine deposit is the elevated content of selenium in the sulphide minerals resulting from the substitution of this element for sulphur in the mineral lattice.

The Wolverine deposit is highly pyritic massive sulphides containing copper, lead and zinc. The predominant minerals are chalcopyrite, galena and sphalerite. The galena contains elevated concentration of selenium while the sphalerite contains significant iron and cadmium. The mineralogy of the deposit is such that the flotation concentrates will contain impurity elements, some of which will incur smelter penalties.

2.3.3 Process Testwork

Laboratory batch and locked cycle tests have been conducted on the Wolverine ore. The flowsheet consisted of primary grind to a P_{80} of 58 microns and sequential flotation of copper, lead and zinc. In each case, the cleaner circuit included a regrind mill to optimize concentrate grade and recovery. Concentrate settling and vacuum filtration tests have also been carried out to estimate equipment requirements.

A primary grind of 80% passing 58 microns is estimated to be required to maximize copper recovery. Sodium metabisulphite addition will be necessary to enhance the selectivity of sulphides in the sequential flotation. For optimum concentrate recovery and grade, the copper and lead rougher concentrates will be reground prior to cleaning, and the zinc scavenger concentrate will be reground prior to cleaning.

The estimated metallurgical balance for the ore, based on the locked cycle test (PRA Test No. F13) has been tabulated in Table 2.5. The head grade has been based on Life of Mine data in the conceptual mine plan developed by Nilsson Mine Services Ltd. in November 2000.

Table 2.5. Metallurgical Balance for Wolverine Ore

Product	Weight	Grade, g/t, %					Recovery, %				
	%	Au	Ag	Cu	Pb	Zn	Au	Ag	Cu	Pb	Zn
Head	100.0	1.6	336.6	1.37	1.44	12.43	100	100	100	100	100
Cu conc.	4.9	11	4500	22	2.2	3.7	32	58	78	7.5	1.2
Pb conc.	2.9	13.5	1625	2.0	22	12.4	22	12	4.2	44	2.3
Zn conc.	19.7	0.74	151	0.4	1.0	55	10	10	6.5	16	87
Tail	72.5	0.5	71	0.1	0.5	1.0	36	20	10	33	9.5

The grades and recoveries of the concentrates are expected to vary slightly as the head grade varies over the life of the mine.

A continuous pilot plant operation should be conducted during the feasibility stage of development to establish variations in grade and recovery that can be expected in the production facility.

2.3.4 Flowsheet Development

The flowsheet design has been based on testwork completed by PRA and AMTEL. The following design philosophy and assumptions have been made in developing the flowsheet for the mill.

- Single stage crushing followed by SAG (semi-autogenous grinding) and ball milling is preferred over multi-stage crushing followed by ball milling. The crushing circuit will be simpler and have less dust containment requirements.
- A two-stage grinding circuit has been selected over a three-stage circuit because the improvements in grinding efficiency and total power requirements of the three-stage do not justify the increased equipment requirements and capital costs.
- The SAG mill circuit will not include a recycle crusher because the ore is relatively soft. As a result, the SAG mill has been sized based on the Bond ball mill work index.

- The flotation circuits have been based on locked cycle flowsheets with open-circuit cleaners to avoid potential buildup of middlings. Conventional cells will be used in all stages.
- Sulphur dioxide, instead of sodium cyanide, will be used to depress pyrite and upgrade the lead concentrate. Both reagents showed similar effectiveness in the testwork but sulphur dioxide has the advantages that it does not affect zinc flotation and that excess water does not need to be treated prior to discharge. This will require testwork confirmation in the work during the feasibility study.
- Concentrate dewatering will be accomplished with conventional thickeners followed by membrane filter presses to obtain minimum cake moisture given the fine particle size.
- The mill tailings will be impounded.
- Underground mine water and excess process water will be treated to remove heavy metals prior to discharge to the environment.

2.3.5 Process Description

2.3.5.1 General

Detailed flowsheets and general arrangement drawings of the process facilities are presented in the Figures 2.4a - j. The Wolverine plant has been designed to process 456,250 tonnes per annum ore containing copper, lead, zinc, gold, and silver. The plant will include facilities to produce separate copper, lead, and zinc flotation concentrates. The plant will comprise the following unit operations:

- Ore storage;
- Crushing;
- Two-stage grinding;
- Differential flotation;
- Rougher concentrate regrinding;
- Concentrate thickening;
- Concentrate filtration;
- Concentrate storage;
- Tailings and process water reclaim; and
- Underground mine water treatment. A portion of the treated water will be recycled as plant fresh water.

The plant will operate 24 hours per day, 365 days per year with scheduled downtime for maintenance of equipment and will process an average of 1,250 tonnes of ore per calendar day.

The tailing solids from the plant will be pumped to a tailings containment facility. Water from the tailing impoundment will be reclaimed, conditioned and recycled to the process.

Selected process streams will be sampled and analyzed in an on-stream analytical system for operations monitoring and control purposes.

2.3.5.2 Crushing and Reclaim

Underground ore from the Wolverine deposit will be hauled to the surface primary crusher station. The crusher station will be designed for direct dump of the ore from underground.

The crusher station will consist of:

- Fixed grizzly;
- Rock breaker;
- Dump pocket;
- Apron feeder;
- Jaw crusher; and
- Collection conveyor.

The fixed grizzly will be installed above the dump pocket. A rock breaker will be installed above the fixed grizzly. The ore will be reclaimed from the dump pocket using an apron feeder.

Fine ore will drop through the apron feeder to the collection conveyor. Oversize ore will be fed to the jaw crusher. Ore will be conveyed to a covered 1,250 tonne live capacity coarse ore stockpile.

One apron feeder will be installed to reclaim ore from the stockpile to feed the grinding circuit. An emergency hopper has been included to feed ore directly onto the SAG mill feed conveyor. In the event of a freeze up within the stockpile, a front-end-loader will load the hopper.

2.3.5.3 Grinding

The ore will be withdrawn from the stockpile via an apron feeder and conveyed to the grinding circuit. It will be ground in a two-stage circuit. The circuit will be designed with primary semi-autogenous grinding mill (SAG) and a secondary ball mill circuit. The SAG mill will operate in closed circuit with a trommel screen. The screen oversize will be collected in a tote and removed from the circuit. The screen undersize will discharge to the common SAG and ball mill sump.

The secondary grinding unit will operate in closed circuit with a two cyclones. The combined product from the SAG mill screen undersize and ball mill discharge will be pumped to the cyclones. The cyclone underflow will be recycled to the ball mill and the overflow will be directed to the copper flotation circuit.

2.3.5.4 Flotation and Regrind

Cyclone overflow from the grinding circuit will be piped to the copper flotation conditioning tank where the slurry will be conditioned with sodium metabisulphite and M2030 to enhance copper flotation. From the copper conditioner slurry will be piped to the copper rougher flotation circuit. Rougher concentrate will be pumped to the copper regrind circuit while the copper rougher tails will be pumped to the lead flotation circuit.

The copper cleaner flotation circuit will consist of a vertical regrind mill operated in closed circuit with cyclones and three stages of cleaning. Each stage of cleaner flotation tails will be recycled to the preceding stage, except the first cleaner scavenger tails, which will be directed to the lead flotation circuit.

Copper rougher-scavenger flotation tails and first cleaner scavenger tails will be combined and pumped to the lead flotation conditioner. Primary lead flotation reagents will include lime and collectors (A3477 and SIPX). The lead flotation circuit will comprise rougher flotation and two stages of cleaner flotation with a regrind circuit. The rougher concentrate will be reground in a vertical regrind mill operated in closed circuit with cyclones then upgraded in the cleaner flotation circuit. Sulphur dioxide will be added to the cleaner circuit to depress pyrite and improve concentrate upgrading. The second cleaner tails will be recycled to the first cleaner stage, while the first cleaner scavenger tails will be directed to the zinc flotation circuit.

Lead rougher tailings and first cleaner scavenger tails will be pumped to the zinc flotation conditioning tank. Here the slurry will be conditioned with copper sulphate, lime and collector (SIPX) to promote zinc mineral flotation.

The zinc flotation circuit will consist of rougher-scavenger flotation followed by three stages of cleaner flotation to achieve marketable concentrate grades.

A vertical regrind mill, with closed circuit cyclones, will be installed on the scavenger concentrate stream. Cleaner scavenger tails will be combined with the zinc scavenger flotation tails for disposal in the tailings pond.

2.3.5.5 Dewatering

Flotation concentrates will be dewatered in respective circuits, each consisting of a concentrate thickener followed by a concentrate storage stock tank and a pressure filter. One 12-chamber filter press each will be installed for the copper and lead concentrate, while a 40-chamber filter press will be used for the zinc concentrate.

2.3.5.6 Tailings and Reclaim Water

Zinc scavenger flotation tails and first cleaner scavenger tails will be pumped to the tailings pond.

Water will be reclaimed from the tailings pond and pumped to the process water distribution system. Excess pond water will be treated together with the underground mine water prior to discharge to the environment. Separate copper, lead and zinc process water tanks will be installed for water recycle within each circuit to minimize potential cross effects of reagents.

2.4 Infrastructure

A summary of the infrastructure to support the Wolverine mine and mill is given below and shown in Figure 2.2. The Wolverine plant site consists of:

- Main Complex including: grinding, flotation, dewatering, concentrate loadout and water treatment facilities;
- Power generating plant;
- Assay laboratory;
- Accommodation Complex;
- Truckshop and Warehouse including:
    - Engineering office;

  - Administrative office; and
  - Mine Dry.
- Fuel Supply and Storage;
- Cemented rockfill plant;
- Sewage and Waste Disposal;
- Tailings Disposal and Water Reclaim;
- Fresh Water Distribution and Fire Protection;
- Communications;
- Mine access Road and site roads;
- Airstrip; and
- Security.

2.4.1 Description of Main Complex

The mill facilities will be housed within an 84 m long by 36 m wide building. It is proposed to have three main operating levels as shown in Figures 2.5a - d.

2.4.2 Power Generating House

The power plant will be located in a separate building, connected to the mill complex, and will consist of five diesel gensets, laydown space and provision for future expansion. The power station would be designed to be PLC controlled and completely automatic, with operators not required. Each genset would have its own control PLC and would be capable of operating independently in manual mode, but would normally be controlled by a supervisory plant PLC, which would automatically start and stop sets to match load requirements. Security of supply and reliability would be paramount design objectives.

In consideration of the long heating season and high fuel costs, it has been determined economic to include full heat recovery including jacket water plate and frame heat exchangers and exhaust gas heat recovery units. The waste heat will be used to heat the process building, assay lab and camp. Backup heating would be provided by fuel oil or propane fired hot water boilers and/or furnaces.

Fuel would be automatically pumped from the bulk storage facility to day tanks located at the power plant.

2.4.3 Truckshop and Warehouse

The truckshop and warehouse arrangement is shown in Figure 2.5e. The maintenance shop will consist of one washbay, two heavy vehicle maintenance bays, a welding and machine shop bay, light vehicle maintenance bay and small enclosed shops for electrical, instrumentation and hydraulic repairs. The heavy vehicle bays will be large enough to accommodate 90 t trucks or 9 m^3 front end loaders. These bays will be serviced with a 15 t overhead crane. The usual services will be provided including welding, lubrication, pressure washer, compressed air and power for small tools.

The warehouse will be located on the ground floor for normal receiving, dispatch and storage of spares with a partial mezzanine for the storage of small and fragile spare parts. Large pieces such as mill liners and truck tires can be stored in a fenced area outside the warehouse. An adjacent unheated cold storage building will be used for storing bulk supplies, which do not require heated storage. A single wicket for dispensing parts has been provided for use of all departments.

The mine dry will be located on the ground floor with lockers provided for street clothes and baskets for working clothes. Showers, washbasins and toilet facilities will also be provided. A small ladies changing room is included. The first aid room, ambulance and emergency vehicle garage are also located nearby.

Offices for the mine personnel will be located on the upper level above the mine dry area.

2.4.4 Assay Laboratory

The assay labroratory general arrangement is shown in Figure 2.5f. The assay laboratory will have the ability to carry out both conventional wet assaying and fire assaying. An area has also been provided as an environmental laboratory. Samples from the mine will be brought to the sample preparation area..

2.4.5 Accommodation Complex

The accomodation complex general arrangement is shown in Figure 2.5g. An accommodation complex will be provided which will be connected to the main complex. Each employee will be provided with a single room with a toilet and shower shared with the adjacent room. There will be a communal cafeteria style cookhouse together with limited indoor recreational facilities such as TV, reading, games and weight room.

2.4.6 Fuel Supply and Storage

An adequate supply of diesel fuel is available in Whitehorse, which will allow the storage onsite to be kept at a minimum of about 2 weeks. Diesel will be trucked in with a 450,000 litre capacity road tanker. One 8 m diameter x 9 m high tank will provide 450 m^3 of diesel fuel storage. The storage tank will be constructed to meet safety and environmental requirements complete with liner and berm.

Fuel will be pumped to a small daytank in the power plant as well as to a dispensing station for fuelling trucks and loaders. Some heavy equipment will be fuelled at the worksite by a fuel truck.

It is the intention to minimize the use of gasoline powered equipment at the site. A small gasoline storage facility will be provided for fuelling pickups and other small gas engines.

2.5 Wolverine Site Power Requirements

The power generation plant consists of five, 1.45 MW diesel fuelled units. The engines will be 1,200 rpm, four stroke, turbo charged, direct injection diesels with electronic fuel injection. The generators would be rated 3 phase, 60 Hz, 4,160 volts.

The forecast demand loads are 3600 kW and 4500 kW peak. The total annual power consumption is estimated at 30,676,000 kWh. Estimated annual fuel consumption for the power generation is about 7.5 million litres. The estimated power load is tabulated in Table 2.6.

Table 2.6. Power Forecast Summary

Area	Installed kW	Demand kW	Operating hours/yr	Annual kWh Consumption	Diesel (litres) Consumption
Mine					
Crushing	196	157	4,380	688,186	168,970
Grinding	1,011	809	8,760	7,085,088	1,739,604
Copper Float	328	262	8,760	2,298,624	564,382
Lead Flot	215	172	8,760	1,509,523	370,634
Zinc Flot	629	503	8,760	4,405,930	1,081,790
Dewatering & Tailings	200	160	8,760	1,401,600	344,135
Underground					
Ventilation	475	380	8,059	3,062,420	751,917
Pumping	25	20	8,059	161,180	39,575
Backfill	275	220	8,059	1,772,980	435,320
Surface Facilities					
Water Supply	150	120	8,760	1,051,200	258,102
Reagents	72	58	8,760	504,576	123,889
Water Treatment	121	97	8,760	847,968	208,202
Site Utilities	90	72	8,760	630,720	154,861
Laboratory	100	80	8,760	700,800	172,068
Warehouse	150	120	8,760	1,051,200	258,102
Lighting	100	80	8,760	700,800	172,068
Camp	400	320	8,760	2,803,200	688,271
TOTAL	**4,538**	**3,630**	**142,437**	**30,675,994**	**7,531,889**

2.6 Workforce Requirements

The mining and milling operations at Wolverine are anticipated to employ 121 people in either salaried or direct labour jobs. General and administrative staff are not included in this estimate. Additional opportunities are also available in contracted support for the mine operations such as:

- trucking and shipping;
- fuels and lubricant supplier;
- reagents supplier;
- gravel and borrow material contracts;
- catering;
- explosives;
- road maintenance; and
- communications and office equipment and supplies.

The estimated total workforce requirement of the mine is 121 persons, not including contracting opportunities estimated to be about 850 jobs.

2.6.1 Mine Workforce

The salaried and hourly employees required to operate the Mine are listed in Table 2.7. The total staff involved in mine operations is 81. This includes 13 salaried employees, 36 labour workers in the mine and additional 32 direct labour workers supporting the operation.

Table 2.7. Wolverine Mine Workforce

Description	Number of Employees
Salaried Employees	
Mine Superintendent	1
Shift Foreman	2
Maintenance Foreman	1
Chief Engineer	1
Senior Engineer	1
Geologist	2
Surveyor	1
Surveyor Helper	1
Technician	1
Sampler	2
Sub-Total	**13**
Direct Labour	
Jumbo Operator	8
LHD Operator	8
Rockbolter	4
Ground Support	2
Shotcrete	2
Truck Driver	4
Truck Loader Operator	0
Blasting Crew	8
Sub-Total	**36**
Indirect Labour	
Utility Crew	8
Mechanics	16
Electrician	2
Backfill Underground Crew	6
Sub-Total	**32**

2.6.1 Mill Workforce

Milling operations are anticipated to employ 40 people; nine in general operations, 26 operators, and five in the assay lab. The employees required to operate the mill are outlined in Table 2.8.

Table 2.8. Wolverine Mill Workforce

	No. of Personnel
A. Staff	
Mill Superintendent	1
General Foreman	1
Supervisors	3
Metallurgist	1
Mill Technicians	1
Environmental Technician	1
Clerk	1
Sub-Total	9
B. Operations	
Crusher Operator	4
Grinding Operator	4
Flotation Operator	4
Dewatering Operator	4
Reagent and Water Treatment Operator	4
Concentrate/Tailing Load-out	4
Labourer	2
Sub-Total	26
C. Assay Laboratory	
Assayer	3
Sample Bucker	2
Sub-Total	5

2.7 Mine Access

Access to the site for personnel will generally be by aircraft. The major airport for the Yukon is located in Whitehorse and is serviced by regular jet service from Vancouver. Regional airports are located in Watson Lake, Ross River and Faro and are mainly served by small, twin engine turboprop aircraft from Whitehorse. The current airstrip servicing the property is being expanded to a length of 1,200 m in order to service the project. This airstrip will typically handle twin engine turbo prop commuter planes. The airstrip will be equipped with a heated trailer for traffic control and a waiting room. This will necessitate the installation of a small diesel generating set to supply power for the trailer and landing lights. A locator beacon and wind sock will be the only navigational aids provided at the airstrip.

It is proposed to fly employees by chartered aircraft from Whitehorse, Ross River and Watson Lake to this airstrip. Vehicles will be operated between the airstrip and the mine, a distance of 7 km.

After there has been a positive production decision resulting in the construction of the mine and its infrastructure, a permanent road will be established between the mine and the Robert Campbell Highway. This road will be 6 m wide and have a 20 m right of way. Currently there are two routes being examined for possible use in supporting the mine and its infrastructure (Figure 2.6).

Alternative 1 – Ridge Route

The Ridge Route is approximately 25 km long. It travels east along the southern aspect of the Go Creek watershed. The route turns north in the upper watershed of Pup Creek, a first order tributary to Go Creek. The route crosses a watershed divide and follows a first order tributary to an unnamed creek (designated Creek 1 for the purposes of this report). The route then travels north, parallel to Creek 1. The road maintains a northerly heading, moving upstream to the upper watershed of Creek 1 and crossing the watershed divide into the Light Creek watershed. The road crosses Light Creek and then parrallels it for a short distance before turning east to cross the creek again and join the Robert Campbell Highway.

An aerial reconnaissance of the proposed routes, accompanied by ground-truthing and sampling some sites, was carried out by Gartner Lee Ltd. staff in October 2004, to confirm base mapping, assess the quality of the fish habitat at the proposed crossings, determine autumn fish presence .

Based on field observations, the proppoosed Ridge Route crosses eleven streams, four of which were surveyed on the ground. Nine of these streams are first order drainages, with an approximate channel width of 1-2 m, while one is a second order creek which is 1.5 m wide and the last is a third order creek, 2.4 m wide.

Habitat studied at four locations is marginal wherein cover is provided primarily by overstream vegetation and instream refuge for fish is limited. Culverts would likely be sufficient for all creek crossings, except the third order creek, where a bridge would be more suitable due to creek size, proposed road grade and site constraints.

Alternative 2 – Money Creek Route

The Money Creek Route is approximately 35 km long. It also travels east along the southern aspect of Go Creek, crossing a number of first order tributaries before turning north into the Money Creek valley. The route continues north following the Money Creek drainage along the west side of the valley. It crosses a number of small first order tributaries before reaching Creek 1. At this point, the Money Creek route and Ridge Route alternatives merge. The field survey along the common route from the junction to the Robert Cambell highway identified only one first order and one third order creek that would have to be crossed along this segment of the access road.

The October 2004 field observations both from the ground and from the air confirm that the Money Creek route crosses two third order streams (2.4 m wide and 3.4 m wide), two second order streams (2-3 m wide) and eight first order streams (1-2 m wide), while channels at six of the crossings illustrated on the base map were not discernable from the air.

Recent beaver activity was observed in the areas surrounding the north junction of the proposed routes. This activity has altered the hydrology of the area. Further biophysical and engineering studies will be required before a preferred route can be identified.

2.8 Waste Management

The waste streams associated with the Wolverine operations have been identified to include:

- Waste rock;
- Tailings;
- Water treatment plant discharge;
- Water treatment plant precipitates;
- Sewage;
- Domestic wastes; and
- Miscellaneous special wastes.

2.8.1 Waste Rock

Waste rock production from the Wolverine underground mine during the production phase will be very limited. Most of the underground workings will be developed in ore grade materials and therefore almost all of the rock produced from the Wolverine Mine will be processed in the mill. Any waste rock that is segregated from the ore material will remain underground and be placed with backfill in mined out areas. During the early stages of development, approximately 7,900 tonnes of waste rock will be generated during development of the access ramp and declines. This material will be stored on surface in a temporary facility (described below). At the earliest possible date, the material will be added to the crushed rock backfill and redeposited underground as part of the backfill material.

2.8.1.1 Geochemical Considerations

Waste rock from mining operations has the potential to generate acid. When stockpiled waste rock comes in contact with water (direct precipitation, runoff, or groundwater infiltration), acid drainage from the stockpiles can occur. Acid generation occurs as the result of the oxidation of sulphide minerals when they are exposed to air (oxygen) and water. Chemical oxidation of the primary sulphide minerals is generally very slow but the process is often accelerated by bacterial assisted oxidation. Bacteria, known as *Thiobacillus ferrooxidans*, live off the iron sulphide minerals and release acidity and soluble metals. This process is referred to as Acid Generation, which is a natural phenomena which is enhanced by breaking up the rock and exposing new sulphide surfaces. If the acid is not naturally consumed by alkaline material, Acid Rock Drainage (ARD) may be produced.

Preliminary geochemistry work was initiated by Westmin Resources Ltd. in late 1996. Following is a summary of that program.

Sampling included 49 discrete samples from five drillholes, and covered lithologies in the hanging wall, footwall and massive sulphide mineralization. Analyses included acid-base accounting (EPA 600/2-78-054) and 30 element ICP metal scans on the sample solids. ABA analyses were conducted by Process Research Associates Ltd. (PRA) in Vancouver, and ICP metal scans by International Plasma Laboratory Ltd. (IPL) also of Vancouver. Summaries of the ABA results are presented in Tables 2.9 through 2.12.

Splits of six of the samples were sent to BC Research (BCR) for external QA/QC on the ABA analyses. The results are included in Appendix 2A.

Several of the 49 discrete samples, along with grab samples from other lithologic units, were combined to represent composite samples of the hanging and foot wall portions of the individual drillholes. The composites included 4 of the hanging wall, 5 of the footwall, and one of a zone located between two massive sulphide ore zones, called a hanging/footwall zone. These samples were also submitted for ABA analyses and ICP metal scans. An additional three composites representing the massive sulphide zones (locations unspecified) were submitted for ICP metal scans only.

Two of the hanging wall composite samples and two of the footwall composites samples were submitted for kinetic tests. These tests were conducted by PRA, and results are provided in Appendix 2A.

The Westmin sampling program has been reviewed for applicability to lithologies associated with the current Expatriate mine plan. The existing data provides:

- A good range of discrete samples which characterize the hangingwall rhyolite and argillite through which most of the development work will occur;
- Single samples of the iron formation, the overlying argillaceous rhyolite, and underlying exhalite layers; and
- A good range of discrete samples which characterize the footwall rhyolite and argillite, which will form the base of the active stopes.

There appears to be a potential shortage of data on the iron formation and the units immediately above and below the iron formation. Also, a lack of extraction test data, which would address the potential for short term release of soluble products.

Results

The Westmin geochemistry data is currently in the process of being verified and assessed with respect to the proposed Wolverine project plans. Based on the presented ABA data (Tables 2.9 through 2.12), the hangingwall and footwall materials demonstrate a wide range of acid and neutralizing potential. The overall mean NP/mean AP value for the hanging wall samples of 1.27 (Table 2.9) indicates a probable potential for acid generation. The three samples representing the layer of potential waste between the two massive sulphides zones in drilhole WV96-72 have a mean NP/mean AP of 0.44 (Table 2.9) indicating a stronger potential for acid generation. As expected, the massive sulphide ore zone (Table 2.11) has a strong potential for acid generation, with an overall mean NP/mean AP of 0.07. The mean NP/mean AP value for the footwall samples of 1.52 (Table 2.10) indicates a somewhat lower overall potential for acid generation than the hanging wall, but would be considered a probable acid generator on the basis of generic criteria.

The results for the composite samples, composited by drill hole, indicates that the both the foot wall and hanging wall may have portions that are potentially acid consuming. For example, the hanging wall composite from drill hole WV96-63 gave an NP/AP ratio of 3.29, and foot wall composites in drill holes WV96-72 and 39 gave NP/AP ratios of 5.76 and 3.29 respectively.

Thus, the preliminary results indicate that the majority of development waste rock must be handled in a manner that anticipates the production of potentially acidic drainage with elevated metal levels.

2.8.1.2 Storage Facility

The Wolverine underground operations will generate approximately 7,900 tonnes of waste rock during the development of the access and development declines. Portions of this material are expected to be mildly to strongly acid generating. This waste material will be temporarily stored on surface and returned to the mine as backfill as soon as possible.

The temporary containment facility will be constructed to store all of the material generated from the underground access development as shown on Figures 2.7 and 2.8. The purpose of the facility will be to contain ARD in the short-term. The facility is designed to drain to a seepage collection sump at its northwest corner. In the event that testing indicates poor water quality, the drainage will be treated to meet discharge standards.

Management of drainage from this temporary stockpile is discussed below in Section 2.9, Water Management.

2.8.2 Tailings

Tailings will be stored in a Tailings Facility, shown in Figure 2.9. At the end of the mine life, the Tailings Dam will be approximately 27.5 m high and will have a tailings and water storage capacity of up to 4.5 million cubic metres. The preliminary design of the tailing facility is based on field investigations of foundation conditions and considerations for tailings geochemistry, capacity requirements, water balance, dam failure consequence rating, and earthquake and flood potential. The following sections summarize these design considerations. Detailed information can be found in Appendix 2B.

Initial water balance modelling indicates that the facility will operate with a net water surplus. Treatment and discharge of tailings supernatant will be required during the operational phase of the mine. At closure, the facility will be allowed to flood and a water cover will be maintained over the tailings mass through direct runoff to the facility.

The proposed tailings impoundment facility includes a Seepage Recovery Dam (see Figure 2.9) downstream of the Tailings Dam to intercept seepage from the tailings pond in the event that the seepage water quality is not suitable for release to downstream receiving waters. In this case, the tailings pond seepage, and the precipitation and runoff collected in the Seepage Recovery Pond would be recycled to the Tailings Pond.

The mean annual water balance analysis indicated that there would be a substantial water surplus in the Tailings Pond and, therefore, diversion ditches are required to minimize runoff into the pond. These ditches would be constructed on both sides of the Tailings Pond and the Seepage Recovery Pond (Figure 2.10).

On the southwest side, the ditch would intercept runoff from the area uphill of the Tailings and Seepage Recovery Ponds and would discharge into a natural gully downstream of the ponds. The second diversion ditch on the southwest side would intercept runoff and direct it towards Little Wolverine Lake.

On the northeast side, the ditch would divert the upper catchment of Go Creek past the Tailings and Seepage Recovery Ponds. Additional ditches would discharge into a natural gully, which would carry the diverted flow back into Go Creek downstream of the Seepage Recovery Pond. The ditch on the northeast side of the Tailings Pond would divert water towards Little Wolverine

Lake. The proposed diversion structures for will consist of earth berms constructed across the stream channel. The berms would be provided with gated culverts to allow release of water into the Tailings Pond if and when required.

2.8.2.1 Geochemical Considerations

The tailings from the Wolverine mill are anticipated to be susceptible to acid generation due to their high sulphide content. In order to limit acid development potential from the tailings mass, permanent underwater (saturated) disposal of tailings has been selected as the project basis. The minimum water cover depth required is a function of the site water balance considering direct precipitation, run-in to the pond, lake evaporation and seepage losses. A minimum water depth able to prevent de-saturation of the tailings during a 1 in 100 year dry year has been selected as the design criterion. For this site, this could be expected to be approximately 0.5 m. Since the submerged beach will slope towards the centre of the impoundment, there could be on the order of 2 m of water cover at the low point.

On closure, the impoundment is intended to form a permanent pond by maintaining a constant net positive water balance at this location and by building a stable structure requiring minimal maintenance. A spillway will be developed in the dam to allow the natural passage of runoff and precipitation inflows to the downstream environment.

Expatriate has committed to ensuring that the discharge water quality does not exceed Metal Mining Effluent Regulations MMER (MFO 2002) discharge limits. A water treatment plant will be used during construction, operations and closure phases of the mine to ensure compliance with these limits.

2.8.2.2 Field investigations

Two site investigation programs were carried out in 2004 as part the tailings facility site investigations (Appendix 2B):

- a site reconnaissance and subsoil investigation by Klohn Crippen; and
- a multi-electrode resistivity survey by Frontier GeoSciences Inc.

The test holes/pits were located along the proposed tailings dam and plant site area. The details of these investigations are outlined in Appendix 2B.

Results from the test pits showed that the subsoil conditions at shallow depths along the two alignments are similar. Along the downstream dam alignment, a 2 m thick peat layer was encountered in the swamp area on the valley floor. Outside the swamp area, glacio-fluvial silt-sand-gravel-cobble material is encountered on the valley floor. Along existing and abandoned creek channels, cleaner sand-gravel-cobble material is present. Up the northeast valley slope, glacial morainal silt-sand-gravel-cobble material is found above the water table. In general, morainal deposits are denser than the glacio-fluvial deposits. The overburden thickness appears to be thinner at upper valley slopes. Bedrock outcrop appears to be present in the general area and along the upstream dam alignment.

2.8.2.3 Design and Capacity Requirements

As outlined above, sub-aqueous disposal of tailings was selected as the design basis for the storage facility owing to the acid generating potential of the tailings. Thus, the tailings dam is to be designed as a water-retention structure, and a net water balance is to be maintained in the impoundment. Other design parameters for the tailings impoundment include:

- a nominal storage capacity of 4.5 million m^3 of tailings;
- in situ density of stored tailings estimated at 1.85 tonnes/m^3, thus the maximum amount of tailings that could be stored is estimated at 9.25 million tonnes;
- tailings are produced at an average rate of 983 tonnes/day or 0.35 million tonnes per year; and
- total tailings in the order of 2.8 million tonnes corresponding to the current ore resources.

2.8.2.4 Water Balance

A mean annual water balance analysis was completed for the tailings impoundment. Inflows to the tailings pond during mine operation include:

- Direct precipitation on the Tailings Pond;
- Surface water runoff from the Tailings Pond catchment; and
- Tailings transport water from the Mill.

Outflows from the Tailings Pond include:

- Evaporation from the pond;
- Reclaim recycled water to the Mill;
- Water lost to tailing voids;
- Water conveyed to the Water Treatment Plant; and
- Seepage losses from the Tailings Pond.

The mean annual water balances, shows a surplus of water even with the construction of diversion ditches, albeit the surplus will be much smaller than without the ditches. With Diversion ditches in place, the annual water surplus ranges from 4.7 m^3/hr to 23.2 m^3/hr. In the absence of diversion ditches, the annual water surplus ranges from 329.5 m^3/hr to 348 m^3/hr.

For the water balance analysis, it has been assumed that the seepage from the Tailings Pond is relatively small and that it is of suitable quality for release to downstream receiving waters, i.e., Tailings Pond seepage is not required to be intercepted in the Seepage Recovery Pond and recycled to the Tailings Pond.

Should it be necessary to intercept and recycle Tailings Pond seepage back to the pond, the recycled water would include not just the seepage water but precipitation and runoff intercepted by the Seepage Recovery Pond as well. In this case, there would be an additional surplus of 10.0 m^3/hr and 13.7 m^3/hr for the schemes with and without the diversion ditches, respectively.

2.8.2.5 Dam Failure Consequence Classification

The consequence classification of the Wolverine Tailings Impoundment facility has been assessed to guide the selection of criteria for the flood and seismic design. This assessment was based on a preliminary screening-level review with consideration of the potential incremental life safety, socioeconomic, financial and environmental consequences of failure, and the associated hazard ratings as provided for in the Canadian Dam Safety Guidelines (CDA 1999).

The tailings impoundment is located in a remote area of Yukon and, except for a campsite on Frances Lake, there are no major population centres or commercial and industrial activities downstream of the impoundment. In the event of an incident at the tailings impoundment, the discharge from the facility would enter Go Creek and then Money Creek. Money Creek discharges into Frances Lake, which is located east of the mine about 40 km downstream of the tailings impoundment. In the event of a breach at the Tailings Dam, no fatalities are anticipated, and moderate socio-economic, financial and environmental damages could be expected. Therefore, the tailings impoundment is classified as a “Low” consequence facility.

2.8.2.6 Design Earthquake

The design earthquake selected for the tailings dam was based on the Canadian Dam Safety Guidelines (CDA 1999) and the Mine Reclamation Guide for the Northwest Territories and Yukon (INAC 1992). Although the tailings impoundment is classified as a “Low” consequence facility in Section 3.3, the annual probability of exceedance of horizontal peak ground acceleration is chosen as 0.001, corresponding to a return period of 1,000 years. Thus, the site horizontal peak ground acceleration value is selected as 0.1 g. This value will be used to assess foundation liquefaction potential, when appropriate subsoil information is acquired.

2.8.2.7 Design Floods

The design flood criteria selected for the various components of the water management facilities associated with the tailings impoundment are summarized in Table 2.13 below. The selection of the design floods was based on the Canadian Dam Safety Guidelines (CDA 1999) and the Mine Reclamation Guide for the Northwest Territories and Yukon (INAC 1992). The expected operating life of the mine was also taken into account in the selection of the design floods for temporary facilities, such as the surface runoff diversion ditches, the Starter Dam Spillway and the Seepage Recovery Pond. The mine is expected to be active for a period of about nine years. During this time all facilities related to the tailings impoundment would be closely and frequently monitored, and personnel, equipment and materials are expected to be readily available in the event that remedial measures are required to be taken under routine and/or emergency maintenance. Therefore, a lower design criteria for temporary facilities is justifiable.

Table 2.13 Selected Flood Design Criteria for Water Management Facilities

Facility	Minimum Design Flood Return Period (years)	Comments
Surface Water Diversion Ditches	50	-
Starter Dam Spillway	200	Assume that surface water diversion ditches are functioning.
Tailings Dam Closure Spillway	1,000	Assume that surface water diversion ditches have been decommissioned.
Seepage Recovery Pond Spillway	50	Assume that surface water diversion ditches are functioning.

2.8.2.8 Dam Construction

The preliminary estimates for dam-related construction quantities are summarized in Table 2.14.

Table 2.14 Estimated Quantities for Tailings Dam

Excavation or Fill Items	Description of Materials or Extent	Quantities (m^3)	
		Starter Dam	Ultimate Dam
Dam Fill above Original Ground Surface	Select Pit-run Silt-Sand-Gravel	280,000	560,000
Filter/Drainage Blanket	Screened Sand and Gravel Creek Deposits	5,000	26,000
Foundation Topsoil Stripping	0.5 m depth within dam footprint area	17,000	27,000
Foundation Swamp Deposits Stripping	2 m depth within swamp area	38,000	52,000
Foundation Backfill	Select Pit-run Silt-Sand-Gravel	55,000	79,000

Dam volumes for incremental raises of the Starter Dam are shown in Table 2.15.

Table 2.15 Estimated Yearly Dam-Raise Quantities Above Starter Dam

Dam Crest El. (m)	Dam Crest Raise (m)	Dam Volume (m^3)	Incremental Dam Volume (m^3)
1323.00	Starter Dam	284,000	-
1324.00	1.00	319,000	35,000
1324.84	0.85	351,000	32,000
1325.61	0.77	381,000	30,000
1326.41	0.79	415,000	34,000
1327.26	0.86	452,000	37,000
1327.99	0.73	485,000	33,000
1328.68	0.69	518,000	33,000
1329.34	0.66	551,000	33,000
1330.00	0.66	586,000	35,000

2.8.3 Water Treatment Plant Precipitates

Precipitates from the water treatment will be pumped to the tailings pump box for disposal in the tailings pond.

2.8.4 Sewage

A primary and secondary sewage treatment facility will be designed in accordance with applicable legislation, including Public Health Ordinance and an Environmental Health permit. Liquid waste from the sewage treatment plant will be discharged to the tailings facility. Digested sludge from the facility will be disposed bi-monthly or as required, in sediment containment pits located adjacent to the tailings area.

2.8.5 Domestic Waste

Domestic wastes include camp waste, putrescibles, waste paper and burnable packaging material. This material will be collected and incinerated on site, in an oil-fired, dual chamber incinerator. Waste oil from routine equipment and vehicle servicing would be used as a fuel source for the incinerator. The incinerator will be operated in accordance with Federal Operations and Emissions Guidelines for Municipal Solid Waste Incinerators[1], and in accordance with the Yukon Environment Act, *Air Emissions Regulations*. The incinerator will be installed in a building site located away from the immediate camp area.

2.8.6 Miscellaneous Special Wastes

Special wastes from the project include waste oil, ethylene glycol, and miscellaneous lubricants and solvents. Milling operations will also involve the use of a number of reagents and other chemicals, which will be covered by the solid waste management plan during operations. The updating of this plan upon commencement of mining operations will include the preparation of a detailed listing of all chemicals at the site, their storage locations and conditions, recycling and/or disposal regimen, and will refer to the Spill Contingency Plan for actions to be taken upon any accidental spill or release of these chemicals to the environment.

2.8.6.1 Waste Oil

The major sources of waste oil will be from the mobile equipment and power plant generators. This oil will be collected in waste oil tanks located in the mobile equipment maintenance area and in the generator room. The oil will be centrifuged to remove particulate matter and then used as fuel in the incinerator and possibly the generators. The oil cleaning will be done in a contained area. The solid residue from the oil cleaning will be stored in a drum and periodically removed from the site by an authorized waste management contractor.

Waste oil management measures during operation will include the following:

- Outside storage area for waste oil will be covered to protect containers from the weather;
- All containers will be closed at all times;
- Secondary containment will be provided to prevent any leaks and spills from entering the surrounding soil or water;
- Records will be maintained including waste type, volume, origin and storage location; and
- Containers will be labelled stating the identity of the waste inside.

2.8.6.2 Ethylene Glycol

Used ethylene glycol from mobile equipment coolant systems (antifreeze) and from the generator cooling/heat recovery system will be cleaned and re-used. A small packaged glycol recycling plant utilizing distillation and filtration will be installed to handle the anticipated volume. Glycol that cannot be cleaned and recycled will be placed in drums and removed from the site by an authorized waste management contractor.

2.8.6.3 Waste Solvents and Lubricants

Miscellaneous, small quantities of waste solvents and lubricants will be generated through routine maintenance and repair of equipment and vehicles used during mining operations. They

[1] Canadian Council of Ministers of the Environment (CCME) 1989.

will be collected on site, and, depending on the type, these wastes will either be burned in the incinerator, if burning can be done safely and efficiently, or collected in drums for disposal by a registered hazardous waste management company.

2.8.7 Miscellaneous Non-Hazardous Solid Waste

These wastes are defined as non-burnable materials (cans, bottles, etc), used rubber products, scrap metal, and wood. This waste will be deposited in a landfill site. Hauling solid waste to municipal landfill sites in Ross River, Watson Lake, or Faro is not considered feasible since these sites are not designed to accept large volumes of industrial waste. No special wastes will be deposited at this location.

During operations, scrap metal will be kept near the mill, in an identified 'boneyard', so that they are readily available for use for maintenance or repair of equipment and/or structures at the mine. Once mining operations cease and the decommissioning and reclamation plan is being implemented, the scrap metal will be sold as scrap/salvage, or deposited in the landfill. The first option upon closure for all unused, partially used, and damaged material is to segregate the material that can be sold for salvage/scrap value, and that which is not recyclable. That determination is chiefly an economic decision based upon local needs, availability of scrap dealers, trucking costs, etc., and cannot therefore be made at this time.

2.8.8 Waste Management Procedures

In waste management operations, all applicable requirements of the Environment Act, *Solid Waste Regulations, Special Waste Regulations*, *Air Emissions Regulations* and the *Public Health and Safety Act* will be compliant with.

2.8.9 Landfill Development and Use

The landfill will be developed and operated according to “Operating Standards for Dumps” set out in the *Solid Waste Regulations*. The landfill will be located to maximize its distance from ephemeral streams. A compacted pad of overburden material will be used for any initial placement of waste materials. This pad will have a minimum thickness of 1.5 m to ensure adequate separation of waste from the groundwater table.

The small sized waste materials will be delivered to the site in covered vehicles or containers to minimize uncontrolled litter on the route to or at the landfill site. Loads of small waste will be covered immediately with to prevent the spread of litter around the landfill area. Materials will be deposited and compacted in lifts not more than 0.5 m thick, separated by compacted layers greater than 0.1 m thick. It is recognized that larger size materials cannot be compacted to this thickness and some lifts may exceed 0.5 in some locations. Landfill cover material will be contoured to encourage precipitation runoff and discourage ponding and infiltration.

It is very unlikely that animals will be attracted to the landfill site since no putrescibles or kitchen waste will be delivered and the area will be in close proximity to active work. The landfill will be supervised on a regular basis and any visitation by animals actively discouraged. Prevention measures such as electric fencing or noise deterrents may be employed if necessary.

2.8.10 Incinerator Operations

A diesel/waste oil fuel-fired, dual chamber incinerator is proposed as part of the solid waste management strategy. This facility will be operated in accordance with the *Special Waste Regulations* and the *Air Emissions Regulations* of the Yukon Environment Act. Upon notification of construction, project operators will apply to have the proposed incinerator facility permitted as an authorized special waste management facility.

The incinerator will be designated to burn waste oil, diesel, appropriate special wastes (i.e. solvents), non-compostable food waste, non-recyclable packaging materials, and any other appropriate waste materials. Incineration will be conducted in accordance with the *Air Emissions Regulations*, the *Forest Protection Act*, and the *Yukon Forest Protection Regulations (Canada),* as appropriate.

The incinerator compound will be continuously supervised during active burning and regularly patrolled during down times. The area will be securely fenced to prevent unauthorized entry and/or animal visitation. A burn schedule will be implemented to limit stockpiling of waste. Wastes temporarily stored in the compound will be segregated according to waste type (i.e., non-compostable kitchen waste, waste oil and solvents, packaging materials, etc.). Appropriate storage will be available for each waste type. Kitchen wastes will be temporarily stored in locking dumpsters to prevent scavenging by animals. Special wastes (oil, diesel, solvents etc.) will be stored in a concrete, bermed facility with a collection sump and sized in accordance with the *Special Waste Regulations* for fuel storage. A spill contingency plan will be posted near the facility and spill kits will be immediately available. Packaging and/or non-recyclable paper products will be appropriately stored to keep them dry and in a burn-ready condition.

The incinerator itself will be constructed on a concrete pad to allow for easy clean-up and housekeeping of the facility. Incinerator ash will be delivered to the landfill site for disposal periodically as needed. An electrified fence will be installed around the incinerator to prevent access by wildlife (particularly bears).

2.8.11 Record Keeping

A record keeping system will be developed and maintained for all waste disposal and recycling activities. The weight or volume of each load of waste reporting to the landfill will be recorded. Before any layer of waste in the landfill is covered over, its dimensions, location (elevation and UTM), and general description of contents will be recorded. Volumes and general nature of recycled materials will also be recorded. Volumes and general nature of incinerated materials will be recorded with each load of waste that is incinerated. Records of wildlife visitation to the landfill, incinerator site, or composting facilities will be recorded as environmental monitoring staff observes them. Measures taken to discourage wildlife visitation will also be recorded.

Waste generation records and minimization program information will be included in the annual report presented to the Yukon Territory Water Board.

2.9 Water Management

The water management flow sheet for the Wolverine operations is shown is Figure 2.11.

Surface runoff in the vicinity of the tailings impoundment, temporary waste rock storage facility, and mine buildings will be collected in perimeter ditches and directed away from the mine facilities toward natural drainage channels. Local diversion ditches will be used around the portal and vent raises to prevent surface runoff from entering to underground mine. Surface facilities at Wolverine are largely indoors and as such will not require protection from surface runoff.

The runoff diversion system is designed to capture runoff before it reaches mine facilities and divert these flows around the mine facilities. This approach minimizes the effects on stream flows and downstream water quality.

Diversion berms on Go Creek will be installed with gated culverts to allow Go Creek runoff to be diverted to the tailings facility should additional water be needed for the milling process or to cover tailings beach areas.

In the underground operations, mine water collected from the underground working will be used for all mine related operations (not potable water). Excess water will be pumped from the underground to a series of two settling ponds located at the surface near the portal entrance. Some of the water from these ponds will be redirected to the underground mine for use in operations. Overflow from the second pond will be directed by grouted ditch or pipeline to a water treatment plant at the Wolverine complex.

It is expected that the temporary waste rock stockpile at Wolverine will be acid generating. The temporary stockpile will be surrounded by a berm to prevent run-on. Direct precipitation within the bermed area will be collected in a lined sump and directed to the water treatment plant.

Excess water in the tailings facility will be reclaimed for the mill process and/or sent to the water treatment plant. The Water Treatment Plant at Wolverine will be conventional high-density sludge lime treatment plant. The inflows to the water treatment plant include mine water from dewatering of the underground operations, seepage and runoff from the temporary waste rock storage facility, and excess water from the tailings facility. Clarifier overflow from the water treatment plant will be directed to the mill process. Water from the clarifier overflow that is in excess of process needs will be discharged to Go Creek downstream of the Seepage Collection Dam. Precipitates from the water treatment will be pumped to the tailings pump box for disposal in the tailings pond.

Mill process water will be made up of water treatment plant clarifier overflow and reclaim of tailings supernatant. Process water from these sources will be pumped into a 670 m^3 tank adjacent to the mill. If needed, freshwater makeup may be added from the groundwater wells or surface intakes in Go Creek above the diversion berms.

Fresh water will be drawn from wells and pumped into a 750 m^3 storage tank located adjacent to the accommodation complex (10 m diameter x 10 m high). This tank will store fresh water for potable water with the majority being available for fire protection. Fresh water will be distributed in a pressurized loop within the main service complex.

A fire water distribution system will be installed around the plant site and camp area with wall hydrants at strategic locations. In order to achieve the desired insurance coverage, all the enclosed areas of the buildings and the conveyor galleries will be equipped with sprinkler systems. Electrical rooms will also be protected with dry chemical systems.

The potable water supply will be chlorinated prior to distribution to the various locations in the main building complex and accommodation complex.

2.10 Reclamation and Closure Plans

This section provides a conceptual plan for the decommissioning and closure of all facilities and infrastructure associated with the Wolverine Project. The restoration of land and habitat and the provision of access control to prevent excessive pressure on wildlife populations are key objectives of the plan. In view of the potential ARD properties of the deposits, permanent water quality protection is considered a primary goal. In this regard, there is a vital link between the development and operating plans for the project and its final closure. Planning for the Wolverine Project has adopted a “Design for closure” philosophy.

The best available technology for ARD prevention and management has been included in the project to protect water quality and minimize liabilities on closure. This has been combined with established practices for site restoration.

The detailed closure plan will be developed in phases, with the plan becoming more detailed as closure approaches. This would provide a comprehensive scope definition for all closure measures not subject to research or operating experience. It would also define study programs and additional operating monitoring needed to support final closure. The second phase and final plan would be submitted at about two years prior to closure. It would serve to address areas of technical uncertainty based on operating and field trials, where appropriate.

2.10.1 Mine Site Decommissioning and Restoration

Reclamation of sites no longer required for exploration, construction or operation will be carried out as soon as possible. Reclamation of drill sites, borrow sources and road embankments has already commenced. The reclamation of drill pads, drill roads and borrow pits typically involves re-grading, scarifying if necessary and re-vegetation. These sites will serve as test sites to develop strategies for closure re-vegetation. The information that is developed on these sites can be used to develop the final closure plan. In addition to borrow pits and exploration sites, this policy will also be applied in other areas as opportunities arise.

Immediately after operation has permanently ceased, a program will be undertaken to restore the operations areas to pre-production conditions as much as possible or practical. All valuable equipment will be removed from the site and sold. One exception will be the water treatment plant that will be needed for the closure process. After clean-up, buildings will be dismantled and/or demolished with materials being salvaged where feasible. Residual fuels, chemicals and any hazardous waste materials will either be returned to suppliers in accordance with standard purchase agreements or removed from the site and disposed of in accordance with federal and territorial regulations. Concrete foundations will be broken down to below ground level and covered.

Closure of the tailings facility will include treatment and release of remaining supernatant followed by reestablishment of natural drainage patterns, directing surface runoff into the tailings facility. The tailings mass will be flooded with fresh water to the design capacity of the dam. A spillway designed to handle a 1 in 1,000 year flood will built from the southwestern end of the tailings facility (Figure 2.10). Storm and flood events will be directed through this spillway to natural drainage channels downstream of the facility.

Monitoring of tailings water and seepage quality will be carried out during the closure phase. The water treatment plant will continue to operate until such time as water in the tailings facility and seepage collection facility are suitable for direct release to the environment.

Closure of underground operations at Wolverine will include plugging the main access adit and vent raises. The main portal will be blasted shut and the mine working will be left to flood as the phreatic surface returns to pre-mining levels.

The final restoration measures on all areas of surface disturbance including building sites, roads and the landfill will include regrading and sloping. Revegetation techniques will be investigated in the course of preparing the detailed closure plan. The species mix to be used will be based on a combination of on-site trials and reclamation experience in the Yukon. It may be necessary to use some overburden as a cover to ensure the long term viability of vegetation without a high level of maintenance.

2.10.2 Mine Access Road Closure

This will be the final decommissioning and closure program carried out for the project as the road will be maintained until all necessary work has been completed at the mine site. This program will include measures necessary to ensure permanent water quality protection. Road access to the site will be maintained as long as reclamation activities continue and until permanent water quality protection is assured. During this period, security provisions at the intersection with the Robert Campbell Highway will be maintained.

A primary objective of road closure will be to restrict vehicle access in order to control hunting pressures. The overall approach will entail removing the road using the remaining mining equipment as it is withdrawn from the site. This will be followed by a one-time campaign of seeding by helicopter after all structures have been removed and the construction of access control measures completed. The work on the road to be conducted during the withdrawal will include:

- Removal of all bridge spans but not abutments if they are clear of the high water marks;
- Removal of culverts on stream courses and the restoration of natural drainage paths;
- Construction of additional ditch/berm combinations on road sections with deeper fill; and
- Transplanting “rafts” of young spruce or fir (~10 m x 10m) to the road surface at about two locations each kilometre.

In addition to the above, road surface scarification would be done in preparation for a late fall or early spring seeding campaign.

Inspection after decommissioning of the access roads will be undertaken on an annual basis as part of the reclamation program. The effectiveness of measures taken to prevent vehicular access will be evaluated and appropriate adjustments made. It is anticipated that deterrents to vehicular access placed as part of road decommissioning will be effective.

2.11 Project Opportunities

The following section outlines alternatives for project development currently being considered by Expatriate. These alternatives represent potential improvements to the “base case” project presented above. These alternatives are being studied as they may significantly reduce environmental liability associated with the project and improve project economics. These alternatives may or may not be considered in the final project design presented in the Wolverine Project Environmental Assessment Report.

2.11.1 Mine Planning

The mine plan proposed for Wolverine may be subject to additional refinement, based on underground test mining planned for the feasibility study. The deposit is open down dip and the final plan presented in the Environmental Assessment Report may consider a larger resource than estimated in this report. Mining methods and specific design parameters may be improved based on geotechnical conditions encountered during the test mining phase.

Other exploration targets exist in the Finlayson District. Continuing exploration of these targets may result in the inclusion of other identified mineral resources to add to the Wolverine Project development plan.

2.12 Project Schedule

2.12.1 Summary

The anticipated schedule is presented as Figure 2.12. Project activities over the coming months include test mining and additional exploration work. Environmental Impact Studies and Feasibility Studies will be completed by the end 2005. Detailed engineering and site preparation will be completed by mid-2006 with site construction completing in late summer of 2007. Production of concentrate from the Wolverine Project is anticipated in late 2007.

This schedule is subject to timely progress of permitting and financing activities.

2.12.2 Project Construction Schedule

2.12.2.1 Wolverine Mine

Access to the Wolverine orebody will be developed in two phases. Phase I will consist of developing the main ramp access from surface to a depth that will permit development of the top portion of both the Lynx Zone and the Wolverine Zone. During Phase I, test mining of the upper portion of the Wolverine Zone will be carried out to more accurately access ground conditions in and around the ore zone so that the optimum stope dimensions, expected mining dilution and ground control requirements can be confirmed. Phase 2 will commence in 2006 and will start with access development to ore zones scheduled for production in the first year of operation.

Phase 1, including test mining has been assumed to commence in early 2005. The costs for this phase have been included with the pre-production costs and have been excluded from the Project capital cost estimate.

2.12.2.2 Surface Facilities

During the summer months of 2006, site preparation will commence. This will include construction, roads building and infrastructure. It will be critical to get the process building enclosed so that construction can continue into the winter months. The mill will be completed in late summer of 2007 to coincide with ore production from the mine.

3 ENVIRONMENTAL SETTING AND SOCIOECONOMIC CONDITIONS

Environmental conditions in and around the Wolverine Project are well understood as a result of extensive baseline studies that were conducted for the project in 1995-97 and 2000-01. Regional data is also available from the Kudz Ze Kayah Project Initial Environmental Evaluation (Cominco 1996) and Water Licence Application (Cominco Ltd. 1997). Baseline studies conducted for the Wolverine Project in 1996-97 have been previously presented in the Finlayson Project Description Report (Expatriate Resources Ltd. 2000). Additional studies conducted in 2000-01 have been compiled with previously collected data and the combined results are summarized in this section.

The Wolverine Project is located in the northern foothills of the Pelly Mountains on the Yukon Plateau, and on the east side of the divide between the Pelly River and Liard River drainage basins. The Wolverine Project area is located at an elevation of 1,123 masl in the Finlayson Creek/River drainage, which forms part of the Liard basin. The development area is located on the watershed divide between the Wolverine Lake and Go Creek drainages, both of which form part of the Liard basin (Figure 3.1).

The following sections provide a summary of the studies that have been completed for the Wolverine Project and relevant regional information available from public sources.

3.1 Physical Environment

3.1.1 Climate

The Wolverine Project is in an area has a typical northern Cordilleran interior climate with over 50% of precipitation falling as snow. The snow-pack generally peaks in early April at most snow course stations although snow may continue to accumulate later in the year at higher elevations. Precipitation is higher on the windward side of mountain ranges, and there is a general trend toward higher precipitation in the direction of the Selwyn and Logan Mountains, to the north-east of the site. Snow-melt and ice break-up in area streams generally occurs between late April and early May. Summer rainstorms can result in significant flood peaks throughout the months of May to September, although such events are most likely to occur in June or July.

The Wolverine Project is at the junction of three ecoregions that are part of the Boreal Cordillera ecozone; the Liard Basin, the Yukon North Plateau and the Pelly Mountains (Figure 3.2). An ecoregion is defined as a subdivision of an ecozone, characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water, and fauna. The distinctive characteristics of each ecoregion are as follows:

Liard Basin

The Liard Basin ecoregion spans the British Columbia–Yukon boundary to incorporate the Liard Plain, a broad, rolling, low-lying area mantled with glacial drift and outwash deposits in which the Liard River is entrenched. The mean annual temperature for the area is approximately -3°C with a summer mean of 11°C and a winter mean of -18.5°C. Annual precipitation is 350–450 mm.

Pelly Mountains

This ecoregion encompasses the Pelly and northern Cassiar Mountains spanning the British Columbia–Yukon border. The mean annual temperature for the area is approximately -3°C with a summer mean of 10.5°C and a winter mean of -17.5°C. Mean annual precipitation is 500–1,000 mm, varying with elevation.

Yukon Plateau - North

This ecoregion lies within the Stewart, MacMillan, and Pelly plateaus and the southern foothills of the Selwyn Mountains. The terrain includes rolling uplands, small mountain groups, and nearly level tablelands dissected by deeply cut, generally broad, U-shaped valleys. The Tintina Trench, a straight, steep-sided valley 5 to 22 km wide, traverses the ecoregion from southeast to northwest. The mean annual temperature for the area is approximately -4°C with a summer mean of 10.5°C and a winter mean of -20°C. Mean annual precipitation ranges from 300 mm in the major valleys up to 600 mm in the mountains to the northeast.

3.1.1.1 Project Site Weather Data

A manual weather station was in operation at Wolverine during the summers of 1996 and 1997. This station monitored maximum and minimum temperatures, precipitation, and relative humidity. An automated station was installed in October of 1997 but the project was shut down shortly after and the station abandoned. This station was refurbished in June of 2000 and collected data until July of 2001.

Data collected from these stations is summarized below.

Precipitation

Precipitation data from 1996-97 are summarized in Table 3.1. The precipitation gauge on the automated station was not functioning properly in 2000 and 2001 and therefore no records are available for this time. Precipitation records at Wolverine indicate that the spring months are generally drier than summer months. Minimum monthly total precipitation at Wolverine was 5.8 mm during June of 1996. Maximum monthly precipitation occurred during July of 1997 (96.2 mm). The 1997 season was wetter than 1996. Maximum daily precipitation was 20.8 mm, occurring on August 8th of 1996.

Evaporation

An evaporation pan was established at the Kudz Ze Kayah Project, 35 km north east of Wolverine at an elevation of approximately 1,300 m. The IEE for Kudz Ze Kayah (Cominco Ltd., 1996) indicates that pan evaporation daily averages at Kudz Ze Kayah varied between 2.1 and 5.3 mm in 1995 the period of record. The highest average occurred in late May, and the lowest in early August. A maximum daily value of 6 mm was recorded in late May and mid-August. The weather station database indicates that the evaporation pan was malfunctioning for most of the 1996 field season and that the data collected during this period is not reliable.

No evaporation data has been collected at Wolverine.

Snow Course

Snow course measurements were conducted at two locations on March 18th, 1997. Snow depth at the higher elevation station (airstrip, elev. 1,340 m) were 71 cm with a water equivalent of 128 mm. At the lower elevation station (camp, elev. 1,145 m) snow depths were 46 cm with a water equivalent of 70 mm.

Temperature

Temperature data from the Wolverine Project area are summarized in Table 3.2 and shown in Figure 3.3. The average annual temperature is estimated at –2.0°C. Average monthly temperatures range from 12.3°C in July to –15.4°C in December. The warmest temperature recorded at the site was 30 °C on July 29, 1996. The coldest temperature recorded at the site was –33°C on March 20, 2001.

Humidity

Humidity data from the Wolverine Project area are summarized in Table 3.3 and shown in Figure 3.4. The average annual humidity is estimated at 74%. Average monthly humidity ranges 58% in April and June to 86% in November. Humidity can reach 100% in almost any month of the year. The lowest humidity recorded is 12%, measured on June 18, 2001.

Wind Speed/Direction

Wind speed and direction data are summarized in Table 3.4 and Figure 3.5. Winds at Wolverine are predominately out of the north-west. Average monthly wind speeds range from 0.2 km/h in January to 1.2 km/h in August. The highest recorded windspeed at the project site is 33 km/h, measured on July 29, 2000.

3.1.1.2 Analysis of Regional Stations

Precipitation data collected in the region over the past 55 years was analyzed to determine long-term average and extreme precipitation conditions for the Wolverine site. Using stream flow data from the Kudz Ze Kayah and Wolverine baseline studies, a hydrologic analysis was completed for the Wolverine Project area (Appendix 3A, Gartner Lee Letter Report, February 2001). Streams flow characteristics from stations in the Liard Basin Ecoregion were found to most closely resemble those in the Wolverine area. Therefore, the regional climate analysis also relied on regional data from climatic stations within the Liard Basin Ecoregion.

Three Environment Canada AES (Atmospheric and Environmental Services) climate stations within the Liard Basin Ecoregion were selected to determine the estimated mean annual precipitation and the estimated extreme annual precipitation values. These stations are: Watson Lake Airport (2101200), Hour Lake (2100 FCG) and Tuchitua (2101135).

The mean annual precipitation is estimated to be 478.7 mm/year (Table 3.5). Mean monthy precipitation is shown in Figure 3.6.

An annual precipitation frequency analysis was carried out based on annual precipitation totals for the selected regional stations. Given that the length of record for many of the stations is short, a theoretical distribution must be used to predict the annual frequency analysis. The British Columbia Ministry of Lands, Environment and Parks (MELP) Flood Frequency Analysis Program called Ffame (Version 1.1) was used for this purpose. This program uses four different theoretical distributions: Log-Normal, Gumbel, Pearson Type III, and Log-Pearson Type III. The Log-Normal Distribution was found to provide the best fit to the data as it had the lowest Klomogorov-Smirnov statistic. Since the Hour Lake station had less than the required 10 years of data required for frequency analysis, it was dropped from further analysis, and the Watson Lake and Tuchitua stations used to determine the extreme events. The results of the frequency analysis are shown in Table 3.6.

This analysis yielded 100-year return period high and low annual precipitation estimates of 695 mm and 244 mm, respectively. Corresponding 10-year return period estimates were 601 mm and 354 mm, respectively.

3.1.2 Geology

3.1.2.1 Regional Geology

The Wolverine Project is situated within the Finlayson Lake District of the southeastern Yukon, an elongate composite geological terrane bounded on the southwest by the Tintina Fault Zone and on the northeast by the Finlayson Lake Fault Zone (Figure 3.7). The Tintina Fault Zone is a major transcurrent structure along which approximately 450 kilometers of right lateral offset occurred in Late Cretaceous and/or early Tertiary time (Tempelman-Kluit *et al.* 1976). The Finlayson Lake Fault Zone is described by Mortensen (1996, personal communication) as a complex structure which may in part represent a transgressive dextral fault juxtaposing different geological terranes.

Rocks grouped within the Yukon Tanana Terrane (YTT) by Mortensen and Jilson (1985), underlie much of the Finlayson Lake District. The YTT underlies a large area of western to southeastern Yukon and east central Alaska. Mortensen (1992) has divided the YTT in the Yukon into three main structural assemblages:

1) The Nisling assemblage, a lower quartzite and marble package of possible Proterozoic and/or Cambrian age;
2) The middle Nasina assemblage, a package of Late Devonian to mid Mississippian carbonaceous metasedimentary and mafic to felsic metavolcanic rocks; and
3) An upper package of mid-Permian felsic metavolcanics (Klondike Schist) and metaplutonic rocks.

Recent interpretations conclude that the YTT represents a mid-Paleozoic volcanic-plutonic arc assemblage built on continental crust (Nokleberg and Aleinikoff 1985; Mortensen and Jilson 1985; Foster *et al.* 1987; and Mortensen 1992). Although one would expect there to be voluminous andesitic volcanic rocks in a continental margin volcanic arc setting, they are seemingly not present in the Finlayson Lake District. Mortensen (1996, personal communication) suggests that large K-feldspar megacrystic granitoids which form part of the core of the belt are intermediate in composition and therefore, together with the volcanic rocks, represent a differentiated igneous suite.

Regional metamorphism throughout the YTT ranges from very low grade to amphibolite facies. Radiometric dating suggests that metamorphic events may have occurred at different times in different subterranes. Mortensen and Jilson (1985) have subdivided the YTT in the Finlayson Lake District into six major lithologic packages:

1) A sequence of layered metasediments and metamorphic rocks,
2) Paleozoic metaplutonic rocks,
3) Middle to late Paleozoic mafic and ultramafic igneous rocks and chert,
4) Early Mesozoic clastic rocks,
5) Mesozoic plutonic rocks, and
6) Late Cretaceous and/or early Tertiary volcanic rocks.

See Figure 3.8 for distribution of rock lithologies.

3.1.2.2 Wolverine Geology

The Wolverine Deposit and its host stratigraphy belong to the middle unit of the Layered Metamorphic Package (LMP); which is composed of (1) a lower Devonian and older quartz-mica±garnet schist and quartzite package with an upper marble/calcareous schist unit, (2) a middle dark siliceous to carbonaceous phyllite unit interlayered with mafic to felsic volcanic rocks of Devonian to mid-Missippian-age, and (3) an upper white carbonate/quartzite package of early Pennsylvanian to Permian-age. The host stratigraphy can be traced along the northeastern side of Wolverine Lake to the southeast for more than 20 kilometres. It comprises an upright east-facing volcano-sedimentary sequence locally intruded by feldspar porphyritic subvolcanic intrusions.

In the vicinity of Wolverine Lake, the middle unit is comprised of a complex sequence of carbonaceous and tuffaceous sedimentary rocks, rhyolitic, volcanic and volcaniclastic rocks, hypabyssal intrusive rocks and several facies of banded iron formation (oxide and calcareous). Andesitic to basaltic rocks structurally overlying the felsic-sedimentary rock package is of uncertain affinity. On a more regional scale monzonitic orthogneiss outcrops to the south, and Carboniferous-Permian serpentinized (magnetite-bearing) ultramafic rocks are exposed to the north.

The Wolverine ore sequence comprises the volcano-sedimentary sequence above the footwall phyllite and below the overlying andesite. The ore sequence is a complex interval made up of carbonaceous sedimentary units, felsic volcaniclastics, argillaceous volcaniclastics, rhyolite volcanic and volcaniclastic rocks, and feldspar-quartz phyric rhyolite volcanic rocks, and subvolcanic intrusions. The massive sulphide horizon lies in the lower portion of the ore sequence. Situated above the massive sulphides are both calcite-pyrite exhalites and two or more intervals of banded magnetite iron formation (Figure 3.9).

The Wolverine Deposit consists of two stratabound lenses of massive sulphide mineralization, the Wolverine and the Lynx Zones, having a combined strike length of 800 metres and a dip length of up to 500 metres (Figure 3.10). The main massive sulphide lens in the Wolverine and Lynx zones are thought to form a contiguous tabular body referred to as the Main Lens. The Main Lens in each of the zones has a thicker core flanked by thinner massive sulphide material. In approximately 14 drill holes there is an upper lens referred to as the Upper West Lens. The Main and Upper lenses have an average true thickness of 5.1 metres, with a maximum thickness of 12.98 metres.

The deposit dips moderately to the northeast at a dip of 25 to 45 degrees. Trenching in the early 1980's in this location identified chlorite-sericite schists with narrow veinlets of copper and zinc mineralization.

The massive sulphide mineralization is composed mainly of pyrite, sphalerite, chalcopyrite, galena, pyrrhotite and tetrahedrite with minor amounts of other sulphosalt minerals and minor free gold. The massive sulphide mineralization may contain up to 75% sulphide minerals with quartz and carbonate gangue; although sulphide minerals are generally about 50% in massive sulphides.

The detailed stratigraphic succession of the Wolverine Zone is very similar throughout the deposit to both the east and west.

3.1.3 Physiography

3.1.3.1 Geomorphology

The topography around the Wolverine Project is typical of historically glaciated areas. Mountains are rounded and valleys are broad and U-shaped. Elevations in the project area range from 1,100 m to 1,780 m.

Glacial, periglacial and fluvial processes are the main process that have been involved in the creation of landforms, and are the origin of surficial deposits. The Yukon has been glaciated four times over the last two million years, which has significantly modified the landscapes of southern and central Yukon. The Wolverine Lake area lies within the limits of the McConnell glaciation and most of the geomorphic features are related to the McConnell glaciation. McConnell glacial ice covered this area between 14,000 and 35,000 years ago.

As the McDonnell ice retreated and down-wasted, a complex network of ice tongues developed in valley bottoms. Morainal deposits are found at lower to mid-elevation areas and larger valley floors may contain more complex assemblage of glaciofluvial, glaciolacustrine and fluvial sediments. In this area, the upper steep slopes are covered by rock, often weathered and frost shattered, colluvial veneers with morainal blankets and colluviated moraine and rock covering the mid to lower slopes. Depressions and small valleys are often covered with morainal deposits with a narrow belt of fluvial deposits.

Permafrost is present almost everywhere. At high elevations, it is expressed by mud and stone circles (frost boils), stripes and pushed up stones. On many slopes, solifluction and soil creep are slowly modifying the surface. In the valley floors and depressions, poor drainage and thick organics are often present. Peat palsas up to three meters thick are present just east of Wolverine Lake.

3.1.3.2 Terrain Hazards

Slope failures in steep bedrock represent the highest risk hazard in the area. Failures in unconsolidated deposits are also a concern, due to the presence of permafrost. These failures can be rapid and involve large volumes of material, or they can occur slowly on small surfaces.

Landslides have occurred in a variety of surficial geological units in the Finlayson Lake area (Jackson 1994). Large rock avalanches (rock falls) are still taking place, as indicated by the large number of talus cones and aprons throughout the mountainous portions of the map. Snow avalanches are common and evidence indicates that they often entrain large volumes of boulders and debris.

Dry permafrost (frozen ground with very little to no moisture) is often present in colluvial and morainal blankets at high elevations and is often detected by the presence of thick organic mats in poorly drained sites, solifluction lobes and stripes and sorted stone polygons. Thermokarst collapse and thaw slides are possible hazards in fine-grained, glaciolacustrine and fluvial sediments.

Floods related to ice-jams, snowmelt and summer rainstorms are possible hazards in lower reaches of most streams in the area. The steep portion of alluvial fans in the area are subject to flooding and mud and debris flows during storm events.

3.1.4 Soils and Surficial Geology

A surficial geology study for the Wolverine area and potential access corridors was completed in 1996 (Mougeot Geoanalysis). It is comprised of the following components:

- The soil survey was performed in conjunction with the surficial geology survey since the surficial geology units are strongly related to the soil parent material.
- Air photos at 1:40,000 scale, were used to construct a preliminary map of surface geology and terrain hazards, such as frequently flooded areas, avalanche chutes, landslide scars, areas prone to permafrost and permafrost-related processes, as well as areas sensitive to surface disturbance, such as sand dunes, etc. This map was used as a base and checked in the field along the areas of main interest, including the campsite, exploration targets, and potential access road corridor.
- Ground truthing was completed in the summer of 1996 to provide both a description and a distribution map of soil subgroups, including organic soil, using the Canadian Soil Classification System. Data collected in the field included descriptions of major pedological horizons, pH, textural and structural classification, moisture holding capacity and drainage and topographical classes.
- Information on grain-size distribution, basic lithology, variability, and stratigraphy of Quaternary geology units was collected.
- Presence of permafrost and depth to permafrost were indicated whenever possible, particularly along the potential road corridor.
- A soil and surficial geology map was developed indicating potential aggregate source locations and possible terrain hazards. Boundaries were transferred from airphotos to the basemap and were digitally stored allowing the interaction with maps generated from other study components of the Baseline Biophysical Survey.

In the Wolverine area surficial geology units include morainal blankets, slopes of mixed colluvium and morainic sediments and fluvial deposits. The units are shown on the surficial geology map, Figure 3.11, produced as a result of a terrain analysis. The geologic units are based on deposit genesis, general texture (grain size), landform description, expected soil types, as well as possible terrain hazards, and/or active modifying processes.

Terrain Hazards - Wolverine Lake Area

The most severe hazards in the area are related to exfoliation of steep rock faces (shown on Figure 3.11, map symbol R), as is the case for the north and east facing walls of the cirque located directly east of the airstrip. The base of this cirque-like gully is well vegetated and appears stable, although poorly drained to wet. Several other steep rocky walls have bouldery colluvial fans at their base. Avalanches are probably a hazard at these sites as well. The areas where the possibly of both rock fall and avalanche hazards were observed include the northeastern shoreline of Wolverine Lake and south and east of the present exploration camp. These areas are denoted by the slide scarp (AR) symbol on Figure 3.11.

Most other slopes have either slow soil creep or solifluction processes (S on Figure 3.11), or frost shattered rock colluvium. These slopes do not present a hazard to human life, as the processes are slow and involve a low volume of material. However, the cost of road and facility maintenance can rise considerably if these surfaces are not considered during road design.

High water table or very poor drainage conditions (W on Figure 3.11) are usually associated with low relief, low elevations with organic (O on Figure 3.11) and ice-rich deposits (X or Z on Figure 3.11). The water table is usually higher in mid summer to late summer, as the permafrost melts.

3.1.5 Water Resources

3.1.5.1 Surface Hydrology

Monitoring of stream flows in the project area has been ongoing since 1996. Figure 3.12 shows the locations of hydrology monitoring network developed for the Wolverine baseline studies. Baseline data has been compared with regional information to develop estimates of long-term average runoff and extreme events. The following section presents the results of the baseline monitoring program and the findings of the regional analysis.

Wolverine Site Hydrology Monitoring Program

Figure 3.12 shows the locations of hydrology monitoring network developed for the Wolverine baseline studies in 1996. The 24 sites monitored during the baseline studies period can be put into three categories:

- 3 stations - Automatic stations (i.e., sites equipped with a datalogger and pressure transducer, and also a staff gauge);
- 3 stations - Manual stations (i.e., sites equipped with a staff gauge only); and
- 18 stations - Direct measurement stations (i.e., sites with no water level measuring).

Automatic Stations

The automatic stations were established in late May 1996 on Go Creek above Pup Creek (Station W-12) and on Nougha Creek above the Robert Campbell Highway (Station W-21). A third station was established at Wolverine Creek (W9) on May 29, 1997. The equipment installed at each station comprised a datalogger (Lakewood Chartpac with 32K memory), a PS-9000 pressure transducer, communication cables, battery power set up, and a staff gauge. Sturdy steel shelters were constructed to house each datalogger from the elements. Data was recorded at 15 minute to one hour intervals throughout the day. Measurements were averaged to calculate daily mean flow.

W12 - Go Creek

Station W12 on Go Creek and monitors a drainage area of 36.4 km^2 at an elevation of 1,430 masl. It was monitoring continuously during May to November 1996, March to September 1997, June to September 2000, and from January to August 2001. During that time, 15 stage discharge measurements were taken, eight in 1996, four in 1997, and three in 2001 (Table 3.7). The rating curve developed from these measurements was used to estimate streamflows over the period of record (Figure 3.13). The information presented in this figure has been processed and several anomalous measurements were removed. All of these measurements occurred near the end of the season and were presumed to be the result of ice formation in the stream. Ice has two effects on automated instrumentation. Firstly it changes the dimensions of the stream cross-section which disrupts the established stage-discharge relationship. Secondly, if ice develops directly over the automated sensor, the pressure registered by the sensor will increase. Since the instrumentation relies on pressure as a surrogate measurement for stage, the recorded stage will be incorrect.

Flows in 1996, 1997, and 2000 were similar. Peaks occurred during the freshet in late May and early June. Intermittent peaks occurred between June and early September, likely due to rainfall events. Freshet started late in 2001 (mid June) and the snow melt occurred rapidly, resulting in high maximum flows and a rapid fall in the hydrograph. Flow patterns observed are typical of a small drainage with low attenuation capacity; characterized by sharp peaks in the hydrograph indicating rapid changes in flow volume in response to precipitation events. Flows declined steadily throughout September and into later months.

The highest flow measured occurred on June 6, 2001 (2.63 m^3/s). Winter low flow measurements were conducted at this site in on January 13th of 2001 (see Appendix 3A) using salt slug injection technique (Kite, Geoff, 1993). Low flows were estimated at 0.107 m^3/s. This estimate is higher than the estimates provided by the flow-calibrated rating curve (0.01 m^3/s). The difference indicates a poor reliability of the rating curve at the extreme ends of the curve.

W21 - Nougha Creek

The Nougha Creek station monitors an area of 287 km^2 at an elevation of 1,360 m. Valid data was collected from Station W21 between May and October 1996, May and September 1997, June to October 2000, and January to June 2001. Although the station was monitored outside these times, the data collected was discarded. Ice formation in the stream resulted in anomalous measurements.

Seven stage-discharge calibrations were collected over this time (Table 3.8), four in 1996, two in 1997 and one in 2001. The stage-discharge was used to convert the collected stage data into a continuous record of streamflow (Figure 3.14). The more frequent (15 minute to one hour) recordings were converted to estimates of daily average flow.

Stream discharge at W21 varied between approximately 16 and 0.4 m^3/s. Flows in 1996, 1997, and 2000 were similar. Peaks occurred during the freshet in late May and early June and then declined. Intermittent peaks occurred between June and early

September. Freshet started late in 2001 (early June) and the snow melt occurred rapidly, resulting in high maximum flows and a rapid fall in the hydrograph. Flows declined steadily throughout September and into later months.

W9 – Little Wolverine Creek

Data was collected from W9 from May to September 1997, July to August 2000, November to December 2002, and January to September 2003. This station included V-notch weir of known dimension and which was used to calculate the stage-discharge relationship. As with the other stations, the more frequent daily measurements (every 15 minutes to ½ hour) were used to estimate daily average flows.

The daily estimates are presented in Figure 3.15. Peak flows (approximately 0.08 m^3/s) at this station occurred in mid-July, much later than other monitored streams. Minimum flow was estimated at 0.003 m^3/s.

Manual Stations

Manual stations were installed at Campbell Creek near the mouth (Station W-8), Money Creek below Go Creek (Station W-14), and Hawkowl Creek near the mouth (Station W-15). The datum of each staff gauge was surveyed relative to the elevation of a local benchmark. This was done as a precautionary measure so that correction factors could be readily computed in the event that the staff gauges either shift under the weight of winter ice or are washed away during an extreme flood.

Figure 3.16 contains the stage-discharge calibrations that were collected at these three stations during 1996 and 1997. This figure also shows the rating curves developed from these measurements. Stage measurements were not collected from these stations on a regular basis, consequently no hydrograph can be developed for these sites. Based on the brief record of data, the seasonal distribution of flows at these stations is similar to that seen at the automated stations. Flows peak in late May and early June and then decline streadily throughout the year.

Direct Measurement Stations

Stream flow data was also collected at various stations throughout the Wolverine Project area during water quality and fisheries study campaigns. This data is summarized in Table 3.9. This information will assist in examining how streamflow characteristics vary amongst the various streams in the immediate vicinity of the Wolverine Lake deposit. This will be of particular importance in assessing the low-flow characteristics of these streams, which can not be accurately predicted without the availability of at least some site-specific flow measurements. In combination with water quality data, this flow information will assist in analyzing how the chemical quality of the local streams varies as a function of discharge rate.

Regional Analysis

The Wolverine Project sits at the junction of three ecoregions; the Yukon Plateau North, the Pelly Mountains and the Liard Basin (Figure 3.2). Streamflow data obtained from the Kudz Ze Kayah site at Fault Creek (1995) and from the Wolverine site at Go Creek (1996-7) were compared using a linear regression and visual comparison of unit hydrographs to streamflow data from 14 Water Survey of Canada stations and three Department of Indian and Northern Affairs seasonal stations. Appendix 3A provides further detail about the selection process for the stations used in this report. From this analysis, it was determined that stations in the Liard Basin ecoregion had the best fit in both the linear regression and visual observation in comparison to the Wolverine Project stream data. The following Water Survey of Canada stations are used in all subsequent analysis:

- 10AB003: King Creek at km 20.9 Nahanni Range Road;
- 10AA005: Big Creek at km 1084.8 Alaska Highway;
- 10AA004: Rancheria near the Mouth;
- 10AB001: Frances River near Watson Lake; and
- 10AA001: Liard River at Upper Crossing.

Mean Annual Runoff Analysis

Using the mean monthly flows from the selected regional stations in the Liard Basin Ecoregion, mean annual runoff for the project area was determined to be 335 mm/yr (Table 3.10). Runoff distribution was also calculated as a percentage per month (Figure 3.17). The stations were divided into small basins (<1,000 km^2) and large basins (>1,000 km^2) in order to observe the difference in runoff. In the early part of the year from January to April the large basins experience approximately 0.5 percent more runoff than the smaller basins. In May the difference increases to over five percent, but from June until October the smaller basins experience about two percent more runoff than the larger basins. In November and December, the two basins experience about the same percentage of the yearly runoff.

Estimated Runoff From Mine Sub-Catchment Areas

Using the runoff distribution calculated in the mean annual runoff analysis, mean monthly and annual runoffs were calculated for each of the mine sub-catchment areas (Table 3.11).

Annual Runoff Frequency Analysis

An annual runoff frequency analysis was carried out based on annual runoff totals for the selected regional stations. Given that the length of record for many of the streams is short, a theoretical distribution must be used to predict the annual frequency analysis. The British Columbia Ministry of Lands, Environment and Parks (MELP) Flood Frequency Analysis Program called Ffame (Version 1.1) was used for this purpose. This program uses four different theoretical distributions: Log-Normal, Gumbel, Pearson Type III, and Log-Pearson Type III. The Log-Normal Distribution was found to provide the best fit to the data as it had the lowest Klomogorov-Smirnov statistic. Annual runoff values for return periods showing low flow and high flow events were extracted from Ffame (Table 3.12). The ratio of the frequency estimates to the mean annual flow was calculated and applied to the mean annual runoff to determine the frequency of mean annual runoff for the project area.

Low Flow Analysis

Annual 10-Year 7-Day Low Flows

A low flow frequency analysis was conducted based on the 7-day average annual low flows for the selected streams using the BC MELP Flood Frequency Analysis program low flow option. Again, the Log-Normal distribution was found to provide the best fit for the available data. The frequency estimates generated by this program are presented in Table 3.13. The frequency estimates were then plotted on a log-log scale (Figure 3.18) to allow for the interpretation of regional trendlines. Big Creek was eliminated from further low flow analysis due to the anomalous results generated by the frequency analysis for this station. The regional trendline equations allow for the estimation of low flow events at the mine sub-catchment areas (Table 3.14).

Monthly 10-Year 7-Day Low Flows

The low flow frequency analysis was repeated on a monthly basis to determine the 10-year 7-day monthly low flows. The frequency estimates are presented in Table 3.15. The frequency estimates were then plotted on a log-log scale (Figure 3.19) to interpolate 10-year monthly low flow trendlines. The regional trendline equations (Table 3.16) allow for the estimation of low flow events at the mine sub-catchment areas shown in Table 3.17.

Normal Variations in Monthly Flows

Flow data from the selected streams were analyzed to determine the average ratio between the minimum flow in a month and the mean monthly flow. Results are summarized in Figure 3.20.

Flood Frequency Analysis

A flood frequency analysis was carried out based on maximum values as well as instantaneous maximums for the selected regional stations. Given that the length of record for many of the streams is short, a theoretical distribution must be used to predict the annual frequency analysis. The BC MELP Flood Frequency Analysis Program (Ffame) was used for this purpose. This program uses four different theoretical distributions: Log-Normal, Gumbel, Pearson Type III, and Log-Pearson Type III. The Log-Normal Distribution was found to provide the best fit to the data and was used to obtain values for flood estimates from 2 to 1,000 year return periods. Maximum instantaneous flood estimates are presented in Table 3.18 and maximum daily flood estimates are shown in Table 3.19. The flood frequency estimates were then plotted on a log-log scale to interpolate regional trends. Figure 3.21 graphically presents the maximum instantaneous flood estimates and maximum daily flood estimates are shown in Figure 3.22. The trendline equations (Table 3.20) were then used to estimate mean, 10-year, 100-year and 1,000-year floods for the mine sub-catchment areas (Table 3.21).

3.1.5.2 Limnology

Bathymetric surveys of Little Wolverine and Wolverine Lakes were conducted in July of 1996. Lake profiles were also collected at Little Wolverine and Wolverine Lakes during this period. These profiles included measurements of temperature, dissolved oxygen, specific conductance and total dissolved solids (calculated from specific conductance) at regular depth intervals in several different locations at each lake.

Wolverine Lake

Wolverine and Little Wolverine Lakes have a combined area of 8.4 km^2. The shoreline perimeter is 30.4 km. The maximum depth recorded during bathymetric surveys was 77.9 m in Wolverine Lake. The water quality in Wolverine Lake is soft and low in dissolved solids. The water is very clear (turbidity less than 0.4 NTU) and neutral in pH. Ammonia is occasionally detectable at the surface and nitrate is occasionally detectable at depth. Phosphates are detectable throughout the water column and appear higher near the lake bottom.

Between July 19^{th} and 20^{th} of 1996, four lake profiles were done at separate locations in Wolverine Lake, roughly following the center axis of the lake. Depths ranged between 20 m and roughly 73 m. These profiles indicate that the limnological conditions of Wolverine Lake are different for the main part of the lake than they are for the northern end. The northern portion of the lake is shallower and almost separated from the main body of the lake by an island.

Surface temperatures at the time of the survey were roughly 13°C at all locations in the lake. The temperature profile (Figure 3.23) shows the very clear development of the thermocline, starting at approximately 5 m depth. This is consistent at all locations measured. For the main body of the lake, temperatures fall below 4 °C at about 25 m depth and are consistent through the underlying hypolimnion. In the shallower northern end of the lake, temperatures drop more quickly with depth and are generally lower than the main body of the lake. This may suggest that this portion of the lake is not as well mixed as the main body. This theory is consistent with the more sheltered characteristics of the northern end.

The oxygen profile (Figure 3.24) shows consistent dissolved oxygen levels throughout the water column at all locations in the main body of the lake. Dissolved oxygen levels are roughly 9 ppm throughout this area. Oxygen levels start to decline at approximately 55 m depth, reaching 7 ppm in the deepest portions of the lake. It should be noted that this decline in oxygen levels is related to absolute depth. Locations less than 55 m in depth show consistent dissolved oxygen levels throughout the water column. This decline is likely the result of aerobic processes consuming oxygen during the natural decomposition of lake sediments.

The northern end of the lake shows a different pattern, with oxygen levels rapidly declining starting at approximately 10 m depth to about 6 ppm at the lake bottom (20 m). Again, this decline is likely the result of natural decomposition of lake sediments. From the bathymetric profiles of the lake, it is apparent that the northern end is separated from the main body of the lake by a height of land and that the main body is relatively consistent in its bottom profile. This suggests that sediment build-up (and subsequent decomposition and oxygen consumption) would occur primarily at the deepest locations in these two separated basins. The dissolved oxygen profiles support this theory. The decline in oxygen levels, in both cases, occurs in the water column roughly ten meters above the deepest portion of the basin.

Little Wolverine Lake

The maximum depth recorded during bathymetric surveys was 18 m in Little Wolverine Lake. Water in Little Wolverine Lake is soft and low in dissolved solids. Nutrients are detectable, particularly ammonia and phosphate species.

Little Wolverine Lake was profiled at one location on July 19, 1996. Surface temperatures were roughly 13°C at that time. The thermal profile (Figure 3.25) shows the development of the thermocline at about 4 m depth. This is slightly shallower than seen in Wolverine Lake. Water temperatures at the lake bottom were approximately 4.6°C and appeared to stabilize over the last meter of the water column.

The dissolved oxygen profile of Little Wolverine Lake is very erratic (Figure 3.26). The readings indicate a sharp decline in oxygen levels approximately one meter below the surface. Oxygen levels recover over the interval from 2 m to 4 m depth and then decline irregularly to the lake bottom. The trend in dissolved oxygen below the 4 m depth is generally consistent with the oxygen consumption related to sediment decomposition. However, several sharp increases of 1 or 2 ppm in this segment of the water column are indicated by the data. This irregularity may be a result of equipment malfunction although there are no notes to that effect.

3.1.5.3 Hydrogeology

No groundwater information has been collected for the Wolverine Operations Area. Terrain mapping provides some indication of hydrogeological conditions. The groundwater is likely a subdued replica of the topography. The phreatic level is closer to surface in the valley bottoms and is likely much deeper as slopes increase. This is supported by terrain conditions which show poorly drained areas on valley bottoms and little or no evidence of groundwater springs on the steeper slope in the area. Anecdotal information from exploration drilling in the Wolverine area indicates that very few holes upslope of the valley bottom produced water, indicating that groundwater aquifers are at significant depth as elevations increase.

3.1.5.4 Surface Water Quality

Sampling Program

Westmin Resources conducted a water quality sampling programs in 1995, 1996, and 1997 for the Wolverine Project. Expatriate Resources reinitiated water quality samping at the site in 2000 and 2001 for the then proposed Finlayson Project. The locations of the water quality sampling stations, along with the frequencies of visits, are provided on Table 3.22. Samples were collected from 39 sites, including 28 stream locations and 11 lake locations. The water quality monitoring stations are shown on Figure 3.27.

In 1995, one round of samples was collected during October 2-4. There were 22 sample stations identified during this initial sampling effort. In 1996 and 1997 the program was expanded and sampling stations were designated as "routine" stations or "comprehensive" stations. During both years, routine stations were sampled in late March and samples were collected on a monthly basis until June. Samples were collected on a roughly biweekly basis, starting with the June samples, for five (1997) or six (1996) consecutive sampling rounds. Comprehensive stations were sampled twice during the summer exploration program, during mid-July and late August or early September. During July 19-20, 1996 Westmin Resources conducted limnology studies for the lakes in the project area. Water quality samples were collected at various depths in Little Wolverine Lake, the inflow to Wolverine Lake, and at several locations in Wolverine Lake.

In-situ parameters of temperature, pH, specific conductance, and dissolved oxygen were measured with each water sample taken. Samples collected in 1995 were sent to Quanta Trace Laboratories in Burnaby, B.C. for analysis. Samples collected in 1996 and 1997 were sent to ASL Labs (now ALS Labs) in Vancouver, B.C.

In June 2000, Expatriate Resources revisited 14 of these stations and collected three replicate samples from several stations for the purpose of identifying site specific variability in water quality.

Water quality sampling continued in 2001 with a more focussed program. Sampling conducted in 2001 was intended to fill temporal gaps in the database and focussed on sites that could be used to define environmental impacts from the then proposed Finlayson Project and impending test mining. Winter low flow sampling was conducted in January 2001 on select stations in Little Wolverine Creek (W9), Go Creek (W12, W15, W16), and Money Creek near Go Creek (W14, W11) to determine low flow water quality conditions. Four new stations were added in June of 2001, intended to bracket potential discharge locations and estimate groundwater quality in the area of the mine workings.

Samples collected in 2000 and 2001 were sent to ASL Labs for analysis. The parameters analyzed and their respective detection limits and methodology are presented in Table 3.23. QA/QC protocols included submission of duplicate samples and field method blanks. In addition, 10% of all samples sent to ASL were subject to duplicate analysis.

Station by station summaries of the water quality sampling are available in Appendix 3B.

Results

Wolverine Drainage

The Wolverine Drainage contains a wide range of water body types, from small streams to the very large Wolverine Lake. Water quality is dependent on the type of water body. The smaller catchments that feed Wolverine Lake have different characteristics than the lake itself. The water quality downstream of Wolverine Lake (Nougha Creek) is similar to the lake. The lake is the major contributor to flows in this creek and the similarities in water quality are not surprising.

The pH throughout the watershed is consistently slightly alkaline (Figure 3.28). Average pH values range between 7.6 and 7.8 at almost all sample stations. Station W1 (Nougha Creek downstream of Wolverine Lake) showed a high range of values for pH, between 8.6 and 7.3. The minimum pH measurement (6.65) for Site W25, inflow to Little Wolverine Lake, is the lowest of all sites measured at Wolverine. Site W32 in the upper watershed of Little Wolverine Creek had the highest average pH of all sites measured (8.15). This site is immediately upstream of the Wolverine deposit.

Total dissolved solids, hardness, and sulphate concentrations show an identical pattern throughout the drainage, indicating the correlation between these variables (Figures 3.29 to 3.31). Concentrations of these parameters are elevated in the small streams that drain into the lake from the north side. Average TDS values in these streams ranged between 197 mg/L and 278 mg/L with a maximum of 379 mg/L TDS in Wolf Creek (W2). Concentrations in Wolverine Lake itself are lower than in tributary streams and show very little variation. Total dissolved solids were consistently measured at around 75 mg/L. The outflow of Wolverine Lake (Nougha Creek) has average values similar to the lake but more variation. Maximum total dissolved solids were measured at 135 mg/L. At the Robert Campbell Highway crossing, average concentrations and range of variation for these parameters has increased.

Nutrient concentrations are lower in the lakes (Wolverine and Wind) than in the contributing creeks (Figure 3.32). Total nitrogen species (nitrate, nitrite, ammonia) in the lakes averaged between approximately 0.04 mg/L and 0.08 mg/L. In the creeks, these values ranged between 0.09 mg/L and 0.18 mg/L.

Concentrations of zinc, copper, arsenic, iron, aluminium and nickel were consistently detected throughout the watershed (Figure 3.33). Detections of silver, cadmium, selenium and lead, were less consistent and were never detected in several of the stations. In three stations (W9, W4 and W2) consistent detections of cadmium, selenium, zinc, and iron indicate correlation of these parameters in these streams. These streams drain the Wolverine and the Fisher exploration targets. An association of detectable lead, nickel, and zinc is also apparent in the W2, W4 and W29 (Wind Lake) stations.

Maximum and average values of copper naturally exceeded the CCME water quality guidelines for the protection of aquatic life at most of the stations throughout the watershed (Figure 3.34). Concentrations of zinc, iron, aluminium, selenium, and silver occasionally exceed these guidelines under natural conditions (Figures 3.35 to 3.38, Figure 3.40). Cadmium always exceeds CCME guidelines due to the extremely low value of the guideline (Figure 3.39). Given that cadmium levels in local streams always exceed the guideline, the CCME guideline for cadmium may not be applicable to this project. Many of these exceedances can be attributed to those streams which drain mineralized areas, namely Viking Creek (W4), Wolf Creek (W2), and Wolverine Creek (W9). Arsenic, Nickel and lead did not exceed the guidelines at any of the stations in the watershed (Figures 3.41 to 3.43). Values for arsenic are seen to exceed the CCME guideline but this is an artefact of high detection limits.

Little Wolverine Lake

Water in Little Wolverine Lake is soft and low in dissolved solids (Table 3.24). Nutrients are detectable, particularly ammonia and phosphate species. Both of these are important for algal growth. Metals concentrations are below CCME criteria for the protection of aquatic life.

In profile, there is a slight increase in dissolved solids with depth. Phosphate and chlorophyll concentrations increase with depth indicating primary productivity occurs at depth. The water is clear (turbidity of 1.7 NTU at 8 m depth) and light penetration is sufficient to sustain primary productivity at the lake bottom.

Inflow to Wolverine Lake

The inflow area to Wolverine Lake from Little Wolverine Lake has very soft water with low levels of dissolved solids (Table 3.25). Ammonia and phosphate are detectable throughout the water column. Concentrations of metals are below CCME guidelines for the protection of aquatic life.

In profile, there is a slight decrease in pH, increase in alkalinity and increase in total calcium with depth. Phosphates and chlorophyll increase with depth indicating increasing primary productivity with depth. The water column is clear (turbidity of 1.6 NTU at 12 m depth) and light penetration sufficient to maintain measurable levels of primary productivity. There is a sharp increase in manganese near the lake bottom.

Wolverine Lake

The water quality in Wolverine Lake is soft and low in dissolved solids (Table 3.26). The water is very clear (turbidity less than 0.4 NTU) and neutral in pH. Ammonia is occasionally detectable at the surface and nitrate is occasionally detectable at depth. Phosphates are detectable throughout the water column and appear higher near the lake bottom. Metals are below CCME guidelines for the protection of aquatic life. Notably, selenium and zinc are below the method detection limits.

Spatially, water quality is consistent throughout the lake. There is a slight increase in dissolved solids with depth. This is accompanied by a slight decrease in pH and increases in hardness and total calcium, magnesium, and sulphates. These trends are very slight but generally consistent. Phosphate concentrations seem to increase sharply at the lake bottom. Primary productivity, as measured by chlorophyll, is lower than the smaller lakes and shows no consistent trends with depth or spatial variation. Distribution is relatively uniform, compared to the smaller water bodies.

Go / Money Creek Drainage

There are no large lakes in this drainage basin and water quality between sample sites is relatively consistent. pH values in this drainage may be slightly less alkaline than the Wolverine drainage (Figure 3.28). Average values ranged between approximately 7.5 and 7.8 with the exception of two sites in the upper watershed (W30 and W31) where average pH was closer to 8.0. Minimum pH values were below 7.3 for half the stations in this drainage.

As with the Wolverine drainage, total dissolved solids, hardness, and sulfate concentrations showed similar patterns, indicating the correlation between these parameters. Go Creek has softer water and there is less variability in these parameters than in Money Creek. Average TDS in Go Creek ranged around 75 mg/L with a maximum around 110 mg/L. In the larger Money Creek, average TDS values ranged between 60 and 110 mg/L with maximum around 190 mg/L at the Robert Campbell Highway crossing.

Nutrient concentrations are varied throughout Money Creek. Average total concentrations of nitrogen species (nitrate, nitrite, and ammonia) ranged between 0.02 and 0.115 mg/L from the headwaters to the Robert Campbell Highway crossing.

As with the Wolverine Drainage, concentrations of zinc, copper, arsenic, iron, aluminium and nickel were detected at most sampling stations throughout the drainage (Figure 3.44). The exception was at sites W30 and W31 (upper watershed) where zinc and nickel were not detected but selenium was frequently detected. Lead, selenium, cadmium, and silver were rarely detected in the watershed.

Similar to Wolverine, copper concentrations exceeded the CCME guidelines for protection of aquatic life at almost every station in the watershed (Figure 3.34). Zinc, iron, and selenium very rarely exceeded their guidelines. Aluminium, arsenic, lead and nickel never exceeded their respective guidelines. Selenium and silver show infrequent exceedances of their guidelines. These are likely an artefact of high detection limits.

3.1.5.5 Groundwater Quality

There has been no direct sampling of groundwater from the Wolverine area. In July 2001, a spring was discovered seeping from the hill near the “Kill Zone” where the Wolverine orebody surfaces. Water was collected from this spring since it may be representative of groundwater quality in that area. The results of the analysis are shown in Table 3.27. The spring water has moderate levels of dissolved solids (117 mg/L) and hardness (95.9 mg/L). The pH is slightly alkaline (8.02) and suphate levels are low (15 mg/L). Nitrate levels are high (0.532 mg/L) relative to other surface water samples. There are detectable levels of total aluminum, copper, iron, lead, and zinc in the sample although only copper was detectable in dissolved form. All metals were below CCME guidelines for the protection of aquatic life (CCME, 1999).

The higher levels of nitrate in this sample would be unusual for a groundwater sample. It may indicate that the water collected from this spring is influenced by surficial organic material near the spring daylight area.

3.1.5.6 QA/QC

Quality control in the water sampling program included collection of duplicate and triplicate samples, travel blanks, filter blanks, and comparisons of total and dissolved metals concentrations.

Duplicate samples serve as a check on the collection and processing methods of samples as well as the potential for site specific variability at sample sites. The results of duplicate comparisons are provided on Table 3.28. Duplicate samples were collected on six occasions. Of these samples, there were 185 analyses that provided detectable concentrations or levels that could be compared. On average, there was a 3% difference in sample values. The standard deviation of sample values was 18%. The maximum difference in sample values was 100%, which occurred with iron and dissolved ortho-Phospate samples. Of all the parameters analysed, Total Suspended Solids had the highest average variability (27%) although only one duplicate was analysed. There was an average variation of 2% for metals samples.

Water quality from a specific sample site is naturally variable over the short term. Triplicate samples provide some estimation of this variability. In June of 2000, triplicate samples were collected from nine sample locations. On average, the standard deviation of these samples was within 10% of the mean value (Table 3.29). Dissolved silver showed the highest degree of site specific variability where the standard deviation was 68% of the mean value for the sample.

Travel blanks are samples of de-ionized water sent from the lab and returned to the lab with the collected water samples. These samples are intended to indicate any sample contamination that may occur during the shipping process. Six travel blanks were analysed during baseline studies (Table 3.30). From these samples, there were nine anomalous readings out of 213 measurements. Most errant readings occurred in one sample (July 15, 1997) in which aluminum, barium, copper, manganese, strontium, and calcium were detected.

Filter blanks are de-ionized water filtered in the field using the same technique as used to filter dissolved metals samples. They are intended to detect errors introduced through the field filtering technique. There are five filter blanks completed during baseline studies (Table 3.31). Out of 160 analyses done on these samples, there were 19 anomalous readings. Most of these readings (18) occurred in two samples (June 14, July 2 1997) where aluminum, antimony, barium, copper, calcium, strontium, tin, and zinc were detected.

Another method for detecting error introduced through the filtering process is by comparison of total and dissolved metals concentrations. Errors in the filtering process will result in addition of metal ions being added to the sample, resulting higher concentrations being detected in the dissolved sample. Of the 10,771 analyses done 1,333 showed higher levels of dissolved ion than total ion. This amounts to 12% of analyses (Table 3.32).

Considering the large numbers of samples collected, the broad geographic area, changes in sampling protocols, changes in sampling personnel, and long period over which the samples were collected, the quality of the water data is generally good. In general, analysis values are replicable and there is little variation introduced through the sampling method or natural variability. Over a short period in June and July 1997, travel blanks and filter blanks show some possibility of contamination. This may be due a bad batch of deionized water sent by the lab, or poor handling technique by the technician collecting the samples during that particular period. Over the entire sampling period 12% of metals analyses showed possibility of metal ions being introduced during filtering.

3.1.5.7 Sediments

Sampling Program

Stream sediment sampling was first initiated in October 1995. This program sampled fine sediments from 18 stream sites. In July of 1996, a second sediment sampling program was conducted and consisted of the following:

- Stream sediments were collected from each of the twenty-four water quality stream monitoring sites; and
- Lake sediments were collected from the deepest sections of Little Jimmy and Little Wolverine Lake and from four deep areas in Wolverine Lake.

The laboratory analysis consisted of determining ICP metals concentrations for two particle sizes:

- less than 0.070 mm; and
- between 0.070 to 2 mm.

Dissolved organic carbon was also analyzed on both of these portions. Particle size analyses were not performed on the samples. Two separate particle size fractions were analyzed as recommended by Environment Canada.

In 2001, stream sediment samples were collected at water quality sampling sites (W12, W30-32, W9, W15, W16) in June and July and lake sediment samples from Little Wolverine Lake in August. Five replicate samples were collected from each site during each sampling event. Samples were sieved to separate the <230 μm fraction and this fraction was analyzed for metals content.

In these programs, samples were collected from an exposed area of the stream bank, generally characterized by the finest grain size evident at each site. All samples were of recently transported streambed load and were collected using a Teflon trowel. Lake sediments were collected from the deepest areas in each of the lakes with an Ekman dredge. The material within the dredge was sub-sampled with a Teflon trowel to ensure that the sample was not in contact with the metal walls of the dredge. The stream and lake sediment samples were collected and placed in labeled ziplock bags and packed with ice for transport to the laboratory. The samples collected in 1995 were analyzed by Quanta Trace Laboratories of Burnaby, B.C. The samples collected in 1996 were analyzed by Chemex Laboratories Limited in Vancouver, B.C. The samples collected in 2001 were analysed by ALS Labs in Vancouver.

The location of the stream and lake sediment sample sites are shown on Figure 3.45. The stream sample location are described on Table 3.22 within the water quality section .

1995-97 Results - Stream Sediments

The concentration levels of metals in sediment are presented in Appendix 3C. Levels of dissolved organic carbon and metals are higher in the smaller size fraction (<0.070 mm) in most samples. Concentrations of copper and chromium exceed the CCME Interim Sediment Quality Guidelines (CCME, 1999) in most samples. Concentrations of zinc and cadmium are highest in Wolverine Creek. Copper levels are highest in Viking Creek. Wolf Creek also shows high levels of zinc, cadmium, cobalt, and nickel. These three streams drain the mineralized areas of the Wolverine and Fisher Zones. Station W-18 (upper tributary to Go Creek) reported the highest iron concentrations, although the levels were only slightly higher than those reported from downstream stations W-17 and W-19.

Metals concentrations appear consistent with sediment quality across the south eastern Yukon. Concentrations seem to range around the 50th percentile of concentrations for the region.

Correlation analysis indicates an association between iron, cobalt, and chromium in sediment, possibly due to co-precipitation reactions (Table 3.33). There is also a possible relationship between manganese and molybdenum and between molybdenum and dissolved organic carbon.

1995-97 Results - Lake Sediments

Concentrations of metals in sediments is presented in Appendix 3C. Unlike stream sediments, most metals concentrations appeared higher in the larger size fraction (between 0.07 mm and 2 mm). The exception was lead which appears to accumulate preferentially in the smaller size fraction (<0.7 mm). The highest concentrations of copper, cadmium, and zinc are found in the sediments of Little Wolverine Lake. Little Jimmy Lake had the lowest concentrations of metals in sediment, with exception of molybdenum which was highest in this lake. Concentrations of cadmium, iron, manganese, molybdenum, and zinc, are generally higher in these lake sediment than average values from regional stream sediments. Concentrations of cobalt, copper, nickel and lead seem relatively consistent with regional stream sediment values. Concentrations of cadmium, chromium, copper, and zinc exceed the CCME Interim Sediment Quality Guidelines (CCME 1999) in Little Wolverine and Wolverine Lakes.

Correlation analysis (Table 3.33) indicates several potential relationships between metals in sediment. Cadmium correlates very well with zinc and copper and moderately with dissolved organic carbon and lead. Cobalt correlates well with copper and moderately with zinc. Chromium shows a similar pattern. Copper correlates very strongly with zinc. Lead and zinc show a possible correlation to dissolved organic carbon. Molybdenum shows a consistent negative relationship with all other metals. This negative correlation is strongest with cadmium, cobalt, copper, and zinc. This may be due to differences in sediment contribution quality on a watershed level or to possible replacement reactions between these metals at binding sites on sediment particles.

2001 Results

The results of sediment analysis in 2001 are shown on Table 3.34 and Figure 3.46. Results are compared to CCME sediment guidelines and regional sediment quality values. The sites sampled in 2001 are located in receiving waters around the proposed mine site and are intended to serve as potential environmental effect monitoring sites in the future.

Results show that concentrations of zinc and cadmium are higher in Little Wolverine Creek than Go Creek and that they exceed probable effect levels and the 95th percentile for sediments in the south eastern Yukon. Go Creek has higher levels of chromium in sediment than Little Wolverine Creek and chromium levels can exceed probable effect levels in some locations. Copper concentrations are similar in both watersheds and consistently exceed the 95th percentile for stream sediments in the south east Yukon. Metals concentrations in Little Wolverine Lake sediments are generally lower than found in streams. In all samples collected arsenic, selenium, lead and silver were undetectable.

3.2 Biological Environment

3.2.1 Aquatic Environment and Fisheries Resources

3.2.1.1 Benthos

Sample Program - 1996

Artificial substrate samplers were used to collect benthic invertebrates from six stream locations. These samplers were chosen as the appropriate method since the water depth, high velocities and larger substrate types encountered at the sites, prevented the successful use of a stream-net sampler (i.e. Hess, Surber, Knapp). These cylindrical wire baskets measuring 26 cm long with a diameter of 17 cm. were filled with washed indigenous gravels collected from the streambed or bank at each site.

Three rock filled samplers were submerged in riffle areas at W-12 (Go Creek), W-14 (Money Creek downstream of Go Creek) and W-23 (Money Creek upstream of Dollar Creek) on the Money Creek drainage; and at W-26 (Wind Creek), W-1 (Nougha Creek at the Wolverine Lake outlet) and W-21 (Nougha Creek near the Robert Campbell Highway) on the Nougha Creek drainage. The samplers were placed in-situ July 15th and 16th, 1996, and left allow the colonization of invertebrates for five weeks. Figures 3.47 and 3.48 provide the locations for benthic invertebrate monitoring stations.

On August 21st and 22nd, 1996, the artificial substrate samplers were retrieved by placing a screened bucket with a 300 micron mesh downstream and under the basket. On shore the basket was opened and the rocks were emptied into the bucket. Individual rocks were then carefully washed in the screened bucket to remove and collect all invertebrates from that sample. The detritus and benthic organisms remaining in the bucket were placed in a one litre nalgene bottle and preserved with 10% formalin.

An Ekman dredge (6 inches x 6 inches x 6 inches) was used to collect bottom fauna from five lake locations; three in Wolverine Lake (B-3 to B-7), one in Little Wolverine Lake (B-10) and one in Little Jimmy Lake (B-1). Triplicate samples were collected at various depths at each site. The sediment contained in the dredge was emptied into the screened bucket to drain off all water. This material was then placed into a one litre nalgene bottle and preserved with 10% formalin.

All benthos samples were sent to Dr. Charles Low, Ph.D., an entomologist in Victoria, B.C. for enumeration and identification. At the lab, all samples were washed through two screens with mesh sizes 1 mm and 180 mm. All of the organisms retained by the coarse screen were counted and identified, whereas the organisms on the 180 micron screen were sub-sampled as necessary. A Folsom plankton splitter was used for the sub-sampling. The majority of the benthos were identified to the genus level.

Sample Program – 1997

Triplicate samples were collected with a surber sampler from Wolverine Creek (W-9) during the intensive sampling program in May, July and September, 1997. These samples were preserved with 10% Formalin and sent to Dr. Charles Low, Ph.D. in Victoria B.C. for identification and enumeration.

Analysis Method

Population indices were used to analyse the benthic data, allowing direct comparison of sample sites and an overall evaluation of community health. A summary and explanation of these indices is included below.

Tolerance Categories (Beak 1965) determine the relative abundance of benthic organisms at each station classified as sensitive, facultative or tolerant fauna. Various groups of benthic invertebrates display different degrees of sensitivity to degradation in habitat quality.

In most cases, sensitive species include Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) which are found primarily in "clean" water conditions containing little contamination or little organic matter. These species have a low tolerance range due to their physiology, which makes them susceptible to disturbance and, therefore, are a good indicator of environmental change.

Facultative species have a moderate tolerance range for temperature, water quality and substrate types. These include Diptera (true flies), Homoptera (aphids), Coleoptera (beetles), Collembola (springtails) and non-insect benthic families. Species in this category make use of a wide variety of habitats from poor to good water quality conditions.

Tolerant species consist mainly of the Oligochaetae (freshwater segmented worms and earthworms) which can survive under conditions adverse to most species.

Various indices were applied to the data to produce quantitative values for community structure. The **Equitability Index** (Pielou, 1966) measures the degree of evenness with which sampled individuals are distributed in the taxa represented in the community. If one species is dominant in the sample, a low index value will represent this population skew. This index has a maximum value of 1.

$$J = \frac{\bar{d}}{K \log s}$$

J = Equitability Index

$\bar{d}$ = Shannon - Wiener diversity index (see below)

K = 3.321928 (constant)

s = number of taxa in the sample

The **Richness Index** (Margalef 1958) is the measure of the "taxonomic wealth" in a benthic community. Species richness indicates the number of taxa represented relative to the population size. The higher the richness in a community, the more organisms (taxonomically) exist, which in turn reflects habitat complexity (i.e., the greater the number of habitat niches that are available for biological use, the greater variety of invertebrate fauna able to colonize, survive and reproduce in a given area).

$$R = \frac{s-1}{\ln N}$$

R = Richness Index
s = number of taxa in the sample
N = number of individuals in the sample

The **Shannon-Wiener Diversity Index** (Shannon and Wiener 1949) is a single measure of the complexity of a community and is determined by the summation of the relative proportions of individuals of one species in the whole sample population. As sample size decreases, the diversity index becomes less reliable. In addition, other qualifiers exist; for example, diversity indices do not consider the taxonomic category of fauna used in the calculation. Studies have shown that a reduction in actual diversity value may be recorded only in the most severe cases of habitat degradation.

$$\bar{d} = -\sum_{i-1}^{s}\left[\frac{N_i}{N} K \log\left(\frac{N_i}{N}\right)\right]$$

$\bar{d}$ = Shannon - Wiener Diversity Index
s = number of taxa
N_i = number of individuals in the i^{th} taxum
N = number of individuals in the sample
K = 3.321928 (constant)

The **Keefe-Bergersen TU Diversity Index** (Keefe and Bergersen 1977), which is a variation of the Shannon-Weiner Diversity Index, is determined from the proportion of taxa represented in the sample in relation to the number of individuals in the sample.

$$TU = 1 - \left(\frac{N}{N-1}\right)\left[\sum_{i-1}^{s} P_i^2 - \frac{1}{N}\right]$$

TU = Keefe - Bergersen diversity index
N = number of individuals in the sample
s = number of taxa in the sample
P_i = proportion of individuals in the i^{th} taxum

The **Dominance Index** (Simpson 1949) implies the extent to which one or a few species dominate the species composition of the sample. This is determined by the proportion of population found in any one taxa in relation to the whole population. A high index number represents high density of one species and a low index shows a more even distribution of individuals among taxa.

$$C = \sum_{i=1}^{s}\left[\frac{N_i}{N}\right]^2$$

C = Dominance Index
s = number of taxa in the sample
N_i = number of individuals in the i^{th} taxum
N = number of individuals in the sample

Stream Benthos

Enumeration and taxonomic identification data for stream benthic samples are presented in Appendix 3D.

1996

A summary of benthic community characteristics and indices for the 1996 sampling program is provided in Table 3.35. The sample sites on Money Creek appear to be very similar in terms of overall productivity and diversity. The upstream station (W23) has a slightly lower proportion of individuals from sensitive taxa. The overall number of taxa is identical at these stations. All community indices are very similar for these two stations.

The station at Wind Creek (W26) showed the highest productivity and the lowest diversity, as measured by the Shannon Wiener Diversity Index. The population at this site is dominated by facultative species. Unidentified juvenile Chironomids were the most numerous taxonomic group, followed by Simulids and two species of Chironomini. There were more taxa identified at this station than at any other, indicating higher habitat complexity. This station also had the highest in-situ conductivity and water temperature. Water depth and velocity were among the lowest of the six sample stations. The higher temperatures may contribute to higher levels of productivity. The high conductivity indicate lower overall water quality which would result in the dominance of a few taxa which are able to tolerate the water quality conditions.

Nougha Creek at the outlet (W1) from Wolverine Lake also had relatively high overall productivity. The proportion of sensitive species is higher than at Wind Creek. Populations of individual taxa were more evenly distributed than at W26, contributing to a higher diversity index value. This station had the lowest number of overall taxa and a low richness index, indicating lower habitat complexity. Water temperature at this station was high compared to other stations, possibly contributing to the high productivity.

Productivity was similar at stations W12 (Go Creek) and W21 (Nougha Creek at the Robert Campbell Highway) and lower than other stations. Higher proportions of sensitive taxa and even population distribution among taxa contribute to higher diversity values. The combination of low taxa count and low overall population contribute to a higher Richness index and indicates higher habitat complexity. Station W21 has the highest richness index of the six sample stations and the second highest taxa count. It also had the highest diversity index and lowest variance, indicating even distribution of the population across the identified taxa.

1997

The sample program in 1997 was designed to monitor changes in the benthic community through time (Table 3.36). Total population numbers and diversity increase over the course of the summer. The population proportion of sensitive taxa increases through the year and is highest in September. There is a noticeable decrease in indices for diversity, richness, and equitability in July. Indices for dominance and variance are the highest during this month. The trend indicated by these indices is an increase in overall population density led by increases in the number of a few taxa. This is combined with no significant change in the number of taxa in the sample. This may be the result of seasonal differences in growth rates for benthic invertebrate species. Some species may mature earlier in the summer and reach sufficient size to be captured in samplers and identified. This could explain the higher number of individuals in only a few of the taxonomic categories.

This tends to be the general trend in freshwater ecosystems. Although there is not a thorough understanding of the life cycles of invertebrates in northern climates such as the Yukon, it is understood that most aquatic insects have one generation per year and often the eggs overwinter in a diapause state (Merrit and Cummins 1984). If the eggs hatch prior to winter, little growth occurs until spring. When benthos samples are collected in spring, a good portion of the instars are too small to be captured by conventional benthos sampling techniques (mesh size is usually 300 microns). Any incidental instars captured would be too small (microscopic) for macro identification. Growth increases throughout the summer with increased temperatures, sunlight and food availability, so that by late summer, the standing biomass is pretty much at its peak. This was observed in the September sample. Diversity was substantially greater in September with more species within Plecoptera and Diptera present.

The life cycle summary described above is highly generalized; the life cycles of aquatic invertebrates are varied even within the same family.

The data was further analyzed by determining the composition of the community for each month. Each community was broken into major taxonomic groups and the percentage of each determined (Table 3.36). Based on this, taxa were classified with respect to their dominance within the community for each month. Diptera was the dominant order on all three occasions, forming over 70% of the communities. Most of the other orders were common although Plecoptera was subdominant in September. Generally, the distribution was similar throughout the summer.

When the background water and sediment quality at Wolverine Creek, W-9, is considered, it was unexpected that there was such a diverse community. In addition, there was representation from the orders Ephemeroptera, Plecoptera and Trichoptera, which are generally recognized as pollution sensitive taxa (Lehmkuhl, 1979 and Winner *el al.*1977).

The majority of the zinc in water was in the dissolved form allowing it to be more readily available than that bound up to suspended sediment particles. The zinc concentrations found at W-9 were four to five times greater than the guideline of 0.03 mg/L of total zinc for the protection of freshwater aquatic life (CCME 2002).

Natural levels of zinc in the stream sediments at W-9 were also very high. The metals appear to be concentrated in the smaller sized fraction of the sediment. As benthic invertebrates, by definition of their name, dwell in intimate contact with the stream sediments, it is probable that they assimilate metals. For example, the Trichoptera *Imania sp* that was found in May and July, ingest mineral particles by scraping the upper surfaces of rocks (Wiggins 1977). Tissue analysis of invertebrates from this location would likely reveal high metals in tissue concentrations.

Several species of insects that have a low tolerance to metals (Lehmkuhl 1977), were present at this site. Specifically they were *Paraleptophlebia sp* of Ephemeroptera and *Despazia sp, Sweltsa sp, Zapada sp* and *Perlomyia sp* of Plecoptera. The Plectopterans were present in significant numbers during the September investigation.

The naturally high levels of metals in the aquatic environment of Wolverine Creek have likely led to adaptation of the local community to these conditions.

Lake Benthos

Enumeration and taxonomic identification data for lake benthic samples are presented in Appendix 3D. A summary of community indices and population characteristics is presented in Table 3.37. Taxonomic diversity in lake samples was similar to that found in creek samples although community composition was quite different. Lake samples had much higher proportions of tolerant organisms and lower populations of sensitive organisms than the stream communities. Community indices showed a similar range of values compared to stream samples.

Little Wolverine Lake showed the highest overall community richness and the highest number of identified taxa indicating a higher degree of habitat diversity. This sample station had the lowest sample depth (0.5 m). The highest diversity index value was measured in Wolverine Lake west of the island. This station had the lowest overall productivity and most even population distribution. The higher numbers of identified taxa and high richness indicates higher habitat complexity at this station. This sample station was the deepest of the lake samples (3.0 m). Diversity indices are similar at all lake stations, indicating a similar degree of population distribution across taxonomic categories. Little Jimmy Lake had the lowest number of identified taxa and the highest proportion of tolerant species compared to the other lake samples. This is interesting considering that the sediments of Little Jimmy Lake had the lowest concentrations of metals. This indicates that other habitat parameters play a more important role in regulating benthic communities.

Zooplankton

Sampling Program

In August 1996, a Wisconsin tow-net with a truncated cone (to improve filtration efficiency), mesh size 76 microns, was hauled horizontally through the water at a depth of one to two metres behind an inflatable boat. Five replicate samples were collected from each of the three lakes (Little Jimmy, Little Wolverine and Wolverine Lakes). The location of the plankton hauls on the lakes is presented in Figure 3.49. The zooplankton were anaesthetized prior to preserving with 10% formalin, and then shipped to Limnotek Research and Development Inc. in Vancouver, B.C. for identification and enumeration of species.

In the laboratory, zooplankton samples were split using a Folsom plankton splitter to a volume which contained not less than one hundred post naupliar stages of the most abundant taxa of crustaceans. For each random sub-sample comprising a known proportion of the samples, species were enumerated, and size (to the nearest 0.01 mm), sex, stage of maturity, and reproductive condition was determined at 5-100x magnification under a GSZ-Zeiss stereo microscope. The number of eggs was counted and size of female was measured for the first ten adult females of the dominant species. Rotifers and nauplii were counted as encountered. Rotifers were identified to the genus level. Cladoceran sizing is included with regular lab procedures. Copepod sizing was added because of the relative abundance of copepods.

Results

Table 3.38 presents a summary of plankton sample data. The locations of the haul sites is shown on Figure 3.49 and the tabulated data for each lake is contained within Appendix 3D. The tables presented in Appendix 3D display zooplankton analysis, measurements of adult copepoda, and measurements and reproductive condition of plankton at Wolverine Lake and Little Wolverine Lake. Measurements and reproductive condition were not determined at Little Jimmy Lake.

Little Jimmy Lake showed the highest overall productivity with over 16,000 organisms per cubic meter. The vast majority of these organisms were copepods. Wolverine Lake had the lowest overall productivity approximately 4,600 organisms per cubic meter. Wolverine Lake had the highest diversity of species. Two species (*Daphnia pulex* and *Diaptomus ashlandi*) were well represented in the Wolverine Lake population and not present in the other lakes.

3.2.1.2 Fisheries Resources

Study Program

Fisheries studies have been conducted on watersheds in the Wolverine area at various times and locations since 1996. Appendix 3E includes various field reports detailing the methods and findings of these investigations. The following is a summary of these studies. This is not a comprehensive summary of fisheries data available for the project area. The scope of previous investigations was adjusted throughout the project history in order to consider the project configuration under consideration at that time. As a result, fisheries data is available for a broad geographic area. The information presented below is intended to focus on those watersheds that may be affected by the currently proposed project configuration.

Overall, six species of fish have been recorded in the project area;

- Arctic Grayling (Thymallus arcticus);
- Lake Trout (Salvelinus namaycush, Walbaum);
- Burbot (*Lota lota*);
- Longnose Sucker (Catostomus catostomus);
- Slimy Sculpin (*Cottus cognatus*); and
- Bull Trout (Salvelinus confluentus).

Go Creek

Studies

Fisheries investigations in Go Creek included electrofishing and minnow trapping throughout the length of the stream at various times of year. Six sample sites were selected (see Figure 3.50) including Hawkowl Creek, a small tributary to Go Creek. Table 3.39 summarizes the fisheries work that has been done on Go Creek. In July of 1996, a total of 1966 seconds of electrofishing was completed at six sites in Go Creek and its tributaries. In September of that year, an additional 89 seconds of electrofishing was done at the mouth of the creek. In September of 1997, a total of 115 hours of minnow trapping was completed using the same sample sites.

In July of 2001, additional sampling was completed using minnow traps and electrofishing. A total of 339 hours of minnow trapping and 2,210 seconds of electrofishing over 680 meters of habitat were completed during this sampling campaign. Sample sites extended throughout the watershed and were consistent with sites used in previous investigations.

Overall, Go Creek has been sampled with 454 hours of minnow trapping and 4,265 seconds of electrofishing. Sampling has been carried out throughout the watershed and in significant tributaries and has been conducted during July and September.

Habitat

There are six distinct reaches in Go Creek based on biophysical characteristics. Reach #1 is comprised of two smaller tributaries in the upper watershed and is approximately 1,500 m long. This is a high gradient (10% to 15%) area with riffles and stepped pool habitat. The substrate is predominantly bedrock and boulders. The channel is well defined and between 1.0 and 1.5 meters wide. Canopy cover is greater than 80% and consists of conifer and overhanging willow.

Reach #2 is approximately 1,200 m long and flows past the northern end of the Wolverine airstrip. Gradients are more gradual (5% to 10%) and the substrate is predominately cobble and boulder. The channel is well defined and up to 2.5 m wide. Canopy cover is greater than 80% and consists of willow and conifer.

Reach #3 is roughly 3,100 m in length and from the northerly end of the Wolverine airstrip to the Hawkowl Creek confluence. At this location gradients are shallow (1% to 2%) and stream flows are predominately run sequences with very few pools. The channel is incised and substrate and bank materials are fines and organics. Canopy cover is greater than 90% and is comprised primarily of willow thickets.

Reach #4 is approximately 2,000 m in length and dominated by beaver pond complexes This reach includes the confluence with Hwakowl Creek. In 2001, there were over 30 beaver dams along this area. Gradients are shallow (1%) and the habitat is dominated by pools created by beaver activity. Substrate and banks are composed of organics and fine materials. The area is heavily overgrown with willows and the stream channel is poorly defined owing to ponding from beaver activity.

Reach #5 (2,750 m) is predominantly riffle and run habitat with shallow gradients (2% to 3%) and cobble substrate. The channel is well defined and incised in a shallow layer of organic and fine materials. Canopy cover is approximately 80% and is comprised of large conifers.

Reach #6 (1,500 m) is mostly run type habitat with very few pools or riffle complexes and includes the confluence with Pup and Money Creeks. Gradients are moderate (2% to 5%). This area is similar to Reach #5 with an incised channel in a thin layer of organic and fine material. The substrate is predominantly cobble and gravel. The canopy cover is more open (approximately 50%) and is comprised mostly of dwarf birch and willow thickets.

Fisheries Resources

Fish utilization of Go Creek seems very limited. All fish collected from this stream were captured within 350 m of the creek mouth. In all, there were four arctic grayling, eleven sculpins, and four bull trout captured. All fish were caught in during the July, 1996 sampling period. It is likely that Go Creek does not support a resident population of fish. Given the lack of fish presence in the upper watershed, concentration of fish presence near the creek mouth, low fish densities, and poor upstream habitat it is possible that Go Creek receives only limited seasonal or irregular use by the resident populations in Money Creek.

Money Creek

Studies

Fisheries investigations in Money Creek included electrofishing, minnow trapping, seine netting, and angling at nine sites throughout the watershed. Sampling was conducted during June, July, and September in 1996, September 1997, and in July of 2001. Aerial assessments of Money Creek were conducted on July 14,1997 in order to provide an overall habitat evaluation for the creek.

A summary of fish sampling efforts in Money Creek is presented in Figure 3.51 and Table 3.40. In 1996, a total of 5,903 seconds of electrofishing effort was expended throughout the watershed. Seine net sampling effort totalled 241 minutes in 1996, and angling effort totaled 95 minutes. In 1997, a total of 1,512 seconds of electrofishing effort was expended, along with 2,519 minutes of seining, and 1,129 hours of minnow trapping. Efforts in 2001 included 1,550 seconds of electrofishing and 97.5 hours of minnow trapping. Due to inconsistency in record keeping, some of the sampling effort in 1997 could not be attributed to a particular sample site in Money Creek, but only to Money Creek in a general sense.

Habitat

Based on aerial surveys, twenty-four separate reaches have been identified in Money Creek as defined by changes in habitat conditions. The first 23 reaches were identified in the 50 km stretch between the creek outlet to Francis Lake and the confluence with Go Creek. The area above Go Creek was defined as one reach.

Overall, Money Creek flows as a high velocity creek with predominantly cobble substrates interspersed with boulders and sorted gravel. Fish habitats are limited and typically small. Concentrated pockets of key habitats exist along the creek, the most notable being the potential over wintering sites near Reach #7. The creek flows clear and shallow with high velocities that provide poor cover and few resting areas for fish.

The lower 1.5 (Reaches 1 and 2) km of the Creek is relatively flat and dominated by glide and riffle/glide type habitats with cobble and gravel substrates. Finer sediments are found in deposits nearer the outlet to the lake.

For roughly 16 km above that point (reaches 3 to 10), the stream is confined to a continuous canyon with fast flows, large boulders, rapids and cascades, and deep pools. For the next 32.5 km (Reaches 11 to 17), it enters a broad valley which presents meanders, broad channels, mixed substrate conditions, wetlands and beaver habitat complexes, and abandoned/side channels.

The area above Go Creek is defined as one reach of undescribed length. This area flows through broad alpine and sub-alpine valleys. The stream is braided and has meanders. Substrate is variable and contains a higher proportion of angular fragments than lower reaches.

Habitat descriptions by reach are provided in Appendix 3E.

Bull Trout Habitat Evaluation

Bull trout are a sub-species of the genus *Salvelinus*, which includes Arctic char, lake trout and dolly varden. The species is wide spread throughout western North America and eastern Asia. Within the dolly varden / bull trout complex numerous forms exist, including northern and southern, anadromous and non-anadromous, stream resident and lake resident populations (Armstrong and Morrow, 1980). The different forms have developed varying life history strategies that make it difficult to confidently describe the Money Creek population based on existing models from other areas.

Although a great deal of information has been compiled on the species understanding, references in this specific type of habitat are limited. The similarities between land locked and anadromous individuals are subtle but distinct enough that the species complex has often been subjected to sub-species classifications, (e.g., bull trout/ dolly varden). The life history and habits of the various forms varies greatly depend on the surrounding environment. The fish in Money Creek correspond most closely with the stream resident form of dolly varden/ bulltrout, typically confined to clear water tributaries of major rivers. However, there are similarities with a form described as a stream-lake resident (Morrow and Armstrong 1980).

Genetic analysis, conducted by the Yukon Territorial Government Fisheries Department, in conjunction with the University of British Columbia, on specimens taken from the Liard River drainage in the Yukon has shown all specimens analyzed to be bull trout. Three specimens taken from the Money Creek watershed during the field assessment were genetically tested at the University of British Columbia by Eric Taylor, Assistant Professor, Department of Zoology. Growth hormone diagnostic testing was conducted and resulted in a positive identification of the specimens as bull trout (*Salvelinus confluentus).*

Timing of field investigations was coordinated after assessing several reference sources. The closest (proximity) bull trout population to have existing information is at Shiltsky Lake, Yukon, where spawning occurred between September 16 and 21, consistently over a five year period. Water temperatures at spawning vary with the reference; the 1995 spawn at Shiltsky Lake was recorded at 12°C, in contradiction to other recorded references which suggests spawning occurs between 5 and 7°C (Blackett 1968) or near 8°C (Scott and Crossman 1974).

Water temperatures in Money Creek were monitored with a data logger located 500 m downstream of the outlet of Go Creek (site W-14). Temperature data was recorded 20 times per day from August 20th to September 12th. During this time period daily temperatures rose to highs of between 9 and 12°C, while night time lows fell as low as 5.7°C. Daily temperatures typically fluctuated from 3 to 5°C.

Thermographic records taken at site W-14 on Money Creek indicate that temperatures were approaching a high of 5 to 7°C on September 12th when the recorder was removed. Temperatures remained at that level until our investigations were conducted. Blackett (1960) reported that anadromous dolly varden in Alaska spawned at temperatures between 5 and 6°C but spawning ceased abruptly after a further 2°C drop in temperature. Temperatures at the time of our field investigations were near 6°C. In light of this, the lack of spawning individuals observed during the surveys may indicate that spawning occurred prior to the investigations.

Spawning did not appear to occur in large aggregations, as few suitable locations were recorded and those investigated showed no signs of a recent spawn. One potential area that large numbers may have spawned in is the gravel shoals located immediately upstream of the outlet of Money Creek to Francis Lake. Alternatively, small pockets of sorted, clean washed gravels were observed under undercut banks during the float surveys. These potential micro-spawning sites were small, usually oblong in shape and less than 0.5 x 0.3 m. Fish of this species complex have been recorded utilizing similar habitats (Armstrong and Morrow 1980, and Blackett 1968).

Money Creek may be used as a spawning and rearing creek for bull trout, with adults utilizing Francis Lake and only entering the creek for spawning. Unpublished data from YTG (Thompson pers. comm..1997) shows that eleven adult dolly varden / bull trout were captured during index gillnetting surveys of Francis Lake conducted in 1990. Of the eleven fish captured, one was taken in the East arm, one was taken in the small lake at the north end of the West arm, and nine were captured just to the south of the Money Creek outlet. This data suggested that the creek is used for spawning and rearing while the lake is used by adults. This model would explain why extensive effort to capture bull trout produced only randomly scattered immature specimens. Considering this model it seems likely that the spawning locations would be located in the lower reaches of the creek. The steep canyon areas and rapids would present a barrier to adult fish migration during spawning in September when water levels are low. These same rapids become more passable to the fry during high water in the spring, allowing the upstream movement of fry that would rear in the creek for as much as several years, or until they reach sexual maturity.

Given the extended effort into locating bull trout in Money Creek and the low numbers of fish captured or observed, it seems likely that the population density and extent of utilization is quite low. Results of fish sampling from this investigation are provided in Appendix 3E (Appendix 2 of the Proposed Access Road Creek Crossings – Fish Habitat Evaluation and Utilization Assessment, 1997 report). The locations of the sample sites are shown on Figure 3.50.

Potential over wintering sites exist in an area only accessible by helicopter. A very tight canyon starting approximately 8 km upstream of Francis Lake extends for a distance of approximately 2.5 km. The canyon has abrupt valley walls, is 100% confined and flows in a narrow channel interspersed with deep pools below abrupt rapids and steep riffles. This canyon area represents a unique habitat on Money Creek. Pools of the same depth occur rarely elsewhere on the creek and definitely do not occur in such a concentrated cluster. The series of pools starts at a small waterfall at coordinates 61°09'17"N / 129°46'45"W. Float surveys were conducted in the uppermost pool of the reach and arctic grayling, in an aggregation of 24 adults and sub adults, were observed. One juvenile bull trout was observed below the pool.

Fisheries Resources

In total, 855 fish were captured or observed in Money Creek. Slimy sculpins are the predominant species (69% of specimens), followed by arctic grayling (27%). Bull trout comprised only 3% of captured specimens and only one burbot was captured.

The average size of the arctic grayling that were measured was 103 mm. The largest one captured was 430 mm. There is no obvious correlation between sample site and fish size, indicating that various life stages of this species can be found throughout the watershed. The average size of slimy sculpins was 62 mm and the largest one captured was 102 mm. The average size of bull trout was 86 mm and the largest one captured was 101 mm. As with grayling, bull trout and sculpins showed no correlation between fish size and sample location.

Based on catch-per-unit effort (CPUE) data, fish densities increase significantly in the area between 18.8 and 34 km from the mouth of the creek (between sites M4 and M5). Site M5 had a CPUE of 0.41, as compared to downstream sites (M1 to M4) that had CPUE's between 0 and 0.06. CPUE data from upstream of site M5 ranged between 0.09 and 0.11. In general, CPUE data indicates that fish distribution is relatively uniform throughout the watershed with potentially slightly higher densities in the upper watershed. The higher CPUE at site M5 indicates that there are likely prefered habitat areas in the stream where dense concentrations of fish can be found. Given that only one of nine sample sites encountered such an area, these prefered habitat areas are likely not a common occurance in Money Creek.

Little Wolverine Creek

Studies

Studies in Little Wolverine Creek have included electrofishing in the lower reach of Little Wolverine Creek in July of 1996 and electrofishing and minnow trapping in July of 2001 in the lower and upper reaches of the stream. In total, there have been 106 hours of minnow trapping and 581 seconds of electrofishing effort in Little Wolverine Creek

Habitat

Little Wolverine Creek can be described as having three reaches based on biophysical characteristics. Reach #1 in the upper watershed is characterised by incised channel in a broad, flat wetland valley. The channel is narrow (50 cm to 100 cm) and deep (up to 75 cm) with gentle meanders through the valley. Riperian vegetation is limited to sparse dwarf birch and willow thickets and long stretches of sedge and grass meadows. Reach #2 in the middle of the watershed is characterized by steep gradients (10% to 30%) and poorly defined channel under thick willow cover. Reach #3 at the bottom of the watershed has moderate gradients (2% to 5%) and a well defined, incised channel. The stream channel is completely underground in several locations. Canopy cover is a mixture of large coniferous trees and willow thickets. A beaver pond complex dominates the mouth of the creek and provide a barrier to fish entering the creek from Little Wolverine Lake.

Fisheries Resources

Fisheries investigations of Little Wolverine Creek have found no fish in the watershed. Beaver dam complexes at the creek mouth, underground flow in Reach #3 and steep gradients in Reach #2 likely prevent fish from using or migrating into this creek.

Little Wolverine Lake

Studies

Fisheries investigations in Little Wolverine Lake have included gillneting, angling, and electrofishing. In July of 1996, there was four hours of gillnetting and in July of 2001 an additional three hours was completed. During both sampling periods, sinking nets with multiple panels with a variety of mesh sizes were used. Sample site locations are show in Figure 3.50. In September of 1996, 25 minutes of angling effort was also done and in July of 1997 a small amount of electrofishing (74 seconds of effort) was completed along the lake shoreline.

Habitat

Little Wolverine Lake is a small (51 ha.) lake at the headwaters of Wolverine Lake. Bathymetric soundings completed in 1996 indicated a maximum depth of 18 m.

Fisheries Resources

Gillnet results from Little Wolverine Lake showed that lake trout comprised 29% of the catch by number but 55% of the catch by weight, Arctic grayling were 66% by number but only 37% by weight. Longnose suckers comprised 5% of the catch by number and 8% by weight from Little Wolverine Lake (Figure 3.53). Length frequency data for Arctic grayling for Little Wolverine and is presented on Figure 3.52.

During fall spawning surveys very few lake trout were recorded in Little Wolverine Lake. The trout that were captured were in a resting state and would not have been involved in the 1996 spawn. Lake trout who utilize Little Wolverine Lake (see Figure 3.54) are likely part of the same population as those utilizing Wolverine Lake. Combined length frequency calculations for lake trout taken in Little Wolverine and Wolverine Lakes are shown on Table 3.41.

Wolverine Lake

Studies

Fisheries studies in Wolverine Lake have included 24.5 hours of gill net sampling at 25 locations around Wolverine Lake (Figure 3.50a) during June of 1996. Non-destructive, sinking nets with multiple panels with a variety of mesh sizes were used.

Habitat

Wolverine Lake is a large lake (782 ha.) with multiple tributaries. Smaller lakes (Little Wolverine Lake, Wind Lake) are connected by short channels or streams to the main body of the lake. The outlet end of the lake is characterized by a smaller pool, separated from the main body of the lake by a glacial esker. Limnological studies indicate that this small pool area is distinct in its hydrological and chemical properties from the main body fo the lake. Formal studies and informal observations indicate that the smaller lakes connected to Wolverine Lake provide important fish habitat and likely play a significant role in the productivity of Wolverine Lake.

Wolverine Lake is very deep. Thermal profiles conducted in 1996 indicated depths in excess of 75 m.

Fisheries Resources

Gillnetting results in Wolverine Lake showed fish populations consisted of 47.5% lake trout and 52.5% Arctic grayling by number, however lake trout comprised 65% of the fish by weight (see Figure 3.53 and Tables 3.42 and 3.43). The locations of small mesh, non-destructive gillnet sets is shown on Figure 3.50a. Length frequency data for Arctic grayling for Wolverine Lake is presented on Figure 3.52.

Longnose suckers did not appear in the catch from Wolverine Lake; however subsequent surveys in Wolverine Lake indicated that suckers were a component of the fish population. The lack of sucker from the gillnet sample record is likely due to the fact that suckers were spawning at the time of the survey (several ripe and exuding suckers were captured in Little Wolverine Lake). Suckers move into creek areas to spawn, thus they were not utilizing the lake proper during the gillnet surveys.

Juvenile burbot were found utilizing the mouths of small tributary creeks entering Wolverine Lake. No adults were recorded during field investigations, although it is assumed that a small population of adults live in the lake.

Metals Concentrations in Fish Tissue

A total of ten slimy sculpin samples (consisting of three to seven individual fish each) and four Arctic grayling samples were taken for heavy metal analysis. The slimy sculpin samples were taken from two tributaries to Little Wolverine Lake, three tributaries to Wolverine Lake, the outlet of Wolverine Lake, and three sites on Money Creek. The Arctic grayling samples were taken from the inlet and outlet of Wolverine Lake (two fish from each site). Arctic grayling samples consisted of both flesh and liver samples. A total of six lake trout were taken for heavy metal contaminant analysis. A set of three samples from each fish was obtained, a back flesh sample, a stomach flesh sample, and the liver.

The results of the analysis are shown in Figure 3.55. Zinc showed the highest potential for tissue accumulation and was highest in the liver tissues and the sculpins. Selenium showed the second highest accumulation and was high in the liver tissues but not the sculpins. Sculpins showed a higher propensity to accumulate arsenic. Lake Trout accumulated lower levels of cadmium in their muscle tissues but higher levels in their livers as compared to other fish.

3.2.2 Vegetation

The Wolverine Lake study area falls within the Pelly Mountains Ecoregion as defined by Oswald and Senyk (1977) and the Ecoregions Working Group (1995).The terrain within the study area is generally over 1200 meters with widespread discontinuous permafrost. Much of the area is treeless with treeline occurring at 1,350 to 1,500 meters. The southern part of the study area was burned by a forest fire in 1994 and is now in the early stage of regenerative growth.

In 1994, vegetation communities and soil types were classified for the Liard Basin and Logan Mountains by the Yukon Department of Renewable Resources (Zoldeski and Cowell 1996). The proposed Wolverine Lake mine site lies immediately to the west of this area.

3.2.2.1 Methodology

Aerial photographs (1:40,000 scale taken in August, 1992) were used to delineate the major vegetation communities in the study area on NTS topographic maps. A ground-truthing of the airphotos was carried out during a vegetation/habitat survey in mid-July, 1996. The vegetation sampling method was adapted from the format developed during the Southeast Yukon Ecosystem Classification (Zoldeski and Cowell 1996).

Sampling plots were selected to represent the vegetation communities identified from the airphotos. Plots were accessed by boat, helicopter and on foot. All sampling plots were 10 m x 10 m (100 m^2). The plant species and their cover-abundance were described for each vegetative layer. Tree species 5 m or more in height constituted the overstorey, while the understorey consisted of three shrub layers (<0.5 m, 0.5-2 m and 2-5 m). The relative abundance of herbaceous plant species, bryophytes and lichens were recorded. Notes on elevation, aspect, slope and moisture regime were also taken. Additional observations of plant communities were taken during the walking transects between sampling plots and during other biophysical surveys in the study area. Locations of sampling plots and transects are shown in Figure 3.56.

Vegetation communities were compared to the vegetation types identified by Geomatics International in the southeast Yukon (Zoldeski and Cowell 1996). The vegetation type classification key provided in the Field Guide to Ecosystem Classification for the Southeast Yukon (Zoldeski and Cowell 1996) was also used in the identification and naming of plant communities.

Plant specimens were identified in the field where possible. Some specimens were preserved for later identification. Floras used in the identification of vascular plants included Hulten (1968) and Porsild and Cody (1980). Vitt *et al.* (1988) and MacKinnon *et al.* (1992) were used in the identification of bryophytes and lichens. Herbariums located at Forest Resources (DIAND), Fish and Wildlife Branch (Govt. of Yukon) and Agriculture Branch (Govt. of Yukon) were also used in specimen identification.

3.2.2.2 Vegetation Communities and Habitat Potential

Vegetation in the Wolverine Lake study area includes bog forests and upland forests, as well as alluvial plain shrub, sub-alpine transition and alpine tundra zones. A map showing vegetation types is presented in Figure 3.57. Polygons representing vegetation zones have been delineated. Several vegetation types may be shown within each polygon. It should be noted that the boundaries between polygons are not always distinct in some vegetation transition zones.

A complete list of plant species observed is given in Appendix 3F. This is not intended to be an exhaustive list of plant species in the study area. A description of individual vegetation types and their extent within the study area is summarized within this section. A description of the strata composition in each vegetation type is presented in Appendix 3F.

Closed Trembling Aspen Forest

A closed canopy of trembling aspen (*Populus tremuloides*) with minor occurrences of willow (*Salix* sp.) make up the tree layer. The low shrub layer consists mainly of soapberry (*Shepherdia canadensis*). Kinnikinick (*Arctostaphylos uva-ursi*), twinflower (*Linnaea borealis*) and common juniper (*Juniperus communis*) form the groundcover. The herb layer, not well developed, is dominated by fireweed (*Epilobium angustifolium*). Bryophytes and lichens are uncommon.

The Closed Trembling Aspen Forest vegetation type (V2) of the 1996 Southeast Yukon Ecosystem Classification best describes these aspen stands.

Closed aspen forests are found on well drained sandy sites on south or west facing slopes. This vegetation type is uncommon in the Wolverine Lake area. A few scattered stands occur in the upland vegetation zone, particularly on the southwest facing slopes above Wolverine and Little Wolverine Lakes.

Closed Balsam Poplar Forest

The closed tree canopy and tall shrub layer consist primarily of balsam poplar (*Populus balsamifera*), with occurrences of willow (*Salix* spp.). Soapberry (*Shepherdia canadensis*) and shrubby cinquefoil (*Potentilla fruticosa*) dominate the low shrub layer. Dwarf shrubs include kinnikinick (*Arctostaphylos uva-ursi*), prickly rose (*Rosa acicularis*) and twinflower (*Linnaea borealis*). The herb cover is not extensive, but includes a variety of species. The moss and lichen layer is not well developed.

This vegetation type resembles the Closed Balsam Poplar Forest (V3) of the 1996 Southeast Yukon Ecosystem Classification.

Closed balsam poplar forests, normally found on active alluvial sites, are uncommon in the Wolverine Lake area. A few scattered upland stands occur on the lower slopes northeast of Wolverine Lake.

Open Alpine Fir Forest

The open canopy overstorey in this vegetation type is dominated by alpine fir (*Abies lasiocarpa*). The dwarf shrub layer is particularly well developed and consists mainly of crowberry (*Empetrum nigrum*) and white mountain heather (*Cassiope tetragona*). Herbs are uncommon in this vegetation type. The non-vascular plant layer is comprised primarily of *Cladina* spp.

This vegetation type is similar to the Open Alpine Fir Forest (V16) of the 1996 Southeast Yukon Ecosystem Classification.

Open alpine fir forests are common throughout the sub-alpine transition zone in the Wolverine Lake area. Alpine fir forests on the upper slopes may transform into krummholtz. The lower extent of these alpine fir stands typically border on white or black spruce forests. On the slopes southwest of Wolverine Lake, alpine fir forests extend almost to the lakeshore.

Open White Spruce Forest

White spruce (*Picea glauca*) dominates the open canopy overstorey. The low and dwarf shrub layer is well developed and consists primarily of shrub birch (*Betula glandulosa*), willow (*Salix* sp.), Labrador tea (*Ledum groenlandicum*) and crowberry (*Empetrum nigrum*). Herbs are poorly represented in this vegetation type. The non-vascular plant layer is dominated by *Pleurozium shreberi* and *Cladina* sp.

This vegetation type resembles the Open White Spruce Forest (V17) of the 1996 Southeast Yukon Ecosystem Classification.

Open white spruce forests are fairly common in the upland vegetation zone, particularly on the slopes northeast of Wolverine and Little Wolverine Lakes. They are typically bordered by black spruce stands in the lower bog forests and extend upslope to open alpine fir forests in the sub-alpine transition zone.

Open Black Spruce Forest - Lowland

An open canopy of black spruce (*Picea mariana*) makes up the overstorey and tall shrub layers. Low shrubs include black spruce and willows (*Salix* spp.). The dwarf shrub consists of a variety of mainly ericaceous shrubs, predominately Labrador tea (*Ledum groenlandicum*). Herbs, not abundant, include graminoids (*Arctagrostis latifolia*). Sphagnum moss (*Sphagnum* spp.) and lichen (*Cladina* spp.) complete the groundcover.

This vegetation type is best described by the Open Black Spruce Forest (Organic Soil) (V19) of the 1996 Southeast Yukon Ecosystem Classification.

A narrow zone of open black spruce forests on organic soils is found on the lowland bog areas around much of Wolverine and Little Wolverine Lakes. It typically borders on the white spruce forest, alpine fir forest or black spruce forest (mineral soil) of the upland forest zone.

Shrub Birch Low Shrub

Shrub birch (*Betula glandulosa)* thickets, less than 2 m in height, form the dominant vegetative cover. A sparsely developed dwarf shrub layer is formed primarily of crowberry (*Empetrum nigrum*) and Labrador tea (*Ledum groenlandicum*). Herbs are uncommon in this vegetative type. The groundcover consists mostly of lichens (principally *Cladina* spp.).

This vegetation type resembles the Shrub Birch Medium/Tall Shrub (V101) of the 1996 Southeast Yukon Ecosystem Classification.

Low shrub birch thickets are common in the upper sub-alpine transition zone on the mountains around Wolverine Lake. It is also common in the alluvial plain shrub zone.

Shrub birch is a major regeneration species following the 1994 forest fire in the southern portion of the study area.

Willow Low Shrub

A low shrub layer of willows (*Salix* spp.) dominates this vegetation type. The tree layer, mostly white spruce (*Picea glauca*), and tall willow (*Salix* spp.) shrub layer are sparsely developed. Dwarf shrubs consist mainly of crowberry (*Empetrum nigrum*) and Labrador tea (*Ledum groenlandicum*). The herb layer is poorly developed. Non-vascular plants are represented by feather moss (*Hylocomium splendens*), sphagnum moss (*Sphagnum girgensohnii*), and foliose lichens (*Peltigera scabrosa*).

The Willow Medium/Tall Shrub (V104) of the 1996 Southeast Yukon Ecosystem Classification is most similar to this vegetation type.

Stands of low willows are found along the upper tributaries to several of the drainages in the Wolverine Lake area. It also occurs as regeneration following the 1994 forest fire in the southern part of the study area.

Shrub Birch - Labrador Tea Low / Dwarf Shrub

The low and dwarf shrub layers are dominated by shrub birch (*Betula glandulosa*) and Labrador tea (*Ledum groenlandicum*). The sparse tall shrub layer consists of willow (*Salix* sp.) and paper birch (*Betula papyrifera*). Herbs, not abundant, are mostly graminoids, particularly *Festuca altaica*. Non-vascular plants are represented primarily by *Cladina mitis* and *Hyloconium splendens.*

The Shrub Birch-Labrador Tea Medium/Tall Shrub type (V102) of the 1996 Southeast Yukon Ecosystem Classification best resembles these vegetation stands.

This shrub vegetation is found in scattered stands throughout lower slopes of the upland forests around Wolverine Lake. It does not constitute a large portion of the vegetative cover in the area.

Labrador Tea Dwarf Shrub

A dwarf shrub layer of Labrador tea (*Ledum groenlandicum*) and a groundcover of lichen (predominately *Cladina stellaris* and *Cladina rangiferina*) characterize this vegetation type. Herbs are uncommon.

This vegetation type does not correspond to any of those described in the 1996 Southeast Yukon Ecosystem Classification.

This dwarf shrub type covers much of the mid elevation hillside southwest of Wolverine Lake. On slopes with north/northeast aspect, this vegetation extends down to the alpine fir krummholtz of the sub-alpine transition zone.

Mountain Avens Dwarf Shrub

A dwarf shrub layer of mountain avens (*Dryas integrifolia*) characterizes this alpine vegetation type. Other dwarf shrubs, including net-veined willow (*Salix reticulata*) and cranberry (*Vaccinium vitis-idaea*), also occur as groundcover. A sparse herb layer includes altai fescue (*Festuca altaica*). Lichens include *Dactylina arctica* and *Cetraria* spp.

The Mountain Aven Dwarf Shrub (V107) of the 1996 Southeast Yukon Ecosystem Classification resembles this vegetation type.

Mountain avens are one of a complex of very low shrub types in the alpine tundra zone. They occur in scattered patches on the well drained upper alpine ridges in the Campbell Range north and east of Wolverine Lake.

Willow Dwarf Shrub

Dwarf shrubs, primarily net-veined willow (*Salix reticulata*) and other dwarf willow species (*Salix* spp.) form the most extensive layer in this vegetation type. The herb layer, although not well developed, includes a variety of species and is dominated by altai fescue (*Festuca altaica*) in the mesic zones and water sedge (*Carex aquatilus*) in the wetter sites. Bryophytes and lichens are sparse in the mesic areas, while feather moss (*Tomenthypnum nitens*) forms extensive mats in the wet areas.

This vegetation type resembles the Willow Dwarf Shrub (V108) of the 1996 Southeast Yukon Ecosystem Classification.

Dwarf willow is a common shrub in the alpine tundra zone. In the Wolverine Lake study area, it occurs on the upper slopes of the Campbell Range.

Alpine Bearberry Dwarf Shrub

This dwarf shrub vegetation type is dominated by alpine bearberry (*Arctostaphylos alpina*). Crowberry (*Empetrum nigrum*) and shrub birch (*Betula glandulosa* are also common. Herbs and mosses are uncommon. Lichens, primarily *Cladina stellaris* and *Alectoria ochroleuca*, form much of the groundcover.

This vegetation type resembles the Alpine Bearberry Dwarf Shrub (V118) of the 1996 Southeast Yukon Ecosystem Classification.

A dwarf shrub type that is relatively uncommon in the Wolverine Lake area, it occurs on alpine ridges such as the one west of Little Wolverine Lake.

Low-Bush Cranberry Dwarf Shrub

Low-bush cranberry (*Vaccinium vitis-idaea*) and net-veined willow (*Salix reticulata*) form the dwarf shrub layer. Other significant groundcover includes fruticose lichens (primarily *Alectoria ochroleuca* and *Cladonia* spp.). The herb layer, not extensive, consists mostly of graminoids, usually altai fescue (*Festuca altaica*).

This vegetation type is similar to the Mountain Cranberry Dwarf Shrub (V121) described in the 1996 Southeast Yukon Ecosystem Classification.

Low-bush cranberry is another component of the dwarf shrub vegetation in the alpine tundra zone. It is found on exposed alpine ridges in the Campbell Range.

Grass Herb

Dense stands of altai fescue (*Festuca altaica*) are the characterizing feature of this vegetation type. A variety of other herb species occur in low abundance. Shrubs are uncommon. The groundcover also includes lichens (predominately *Cladina rangiferina*).

The Mesic Grass Herb (V202) of the 1996 Southeast Yukon Ecosystem Classification is the vegetation type that best corresponds to the these graminoid meadows.

Mesic grass meadows make up only a small component of the vegetation in the Wolverine Lake study area. They occur in moderately well drained depressions in the low alluvial shrub zone.

Sedge Herb

These wet sedge meadows are dominated by the water sedge, *Carex aquatilus*. Shrubs and forb species are uncommon. Extensive layers of brown moss, *Tomenthypnum nitens*, are formed in some areas.

This vegetation type resembles the Wet Sedge Herb type (V206) described in the 1996 Southeast Yukon Ecosystem Classification.

Sedge meadows, although not extensive in the Wolverine Lake area, occur in poorly drained areas in the alluvial shrub zone.

Wet Mixed Herb

Sedges (*Carex aquatilus*) form the dominant cover in this vegetation type. Other herb species, particularly tall Jacob's ladder (*Polemonium acutiflorum*) and swamp cinquefoil (*Potentilla palustris*) are also prevalent. Bryophytes and lichens are uncommon.

The Wet Mixed Herb (V214) of the 1996 Southeast Yukon Ecosystem Classification best describes this vegetation type.

Accounting for a very small component of the vegetative cover in the Wolverine Lake area, mixed herb meadows are found on the better drained lowland sites in the alluvial shrub zone. The open meadows near the creek draining Muskrat House Lake is one such example.

Cetraria - Alectoria Fruticose Lichen

This vegetation type is characterized by a groundcover dominated by fruticose lichens (primarily *Alectoria ochroleuca* and *Cetraria nivalis*). Dwarf shrubs include net-veined willow (*Salix reticulata*), arctic willow (*Salix arctica*) and other willow species (*Salix* spp.). The most prominent herb is alpine holy grass (*Heirochloe alpina*).

This vegetation type is similar to the *Cetraria-Alectoria ochroleuca* Fruticose Lichen (V300) of the 1996 Southeast Yukon Ecosystem Classification.

This high alpine vegetation type occurs on the high windswept ridges of the Campbell Range. It does not comprise a large part of the Wolverine Lake study area's vegetation.

Crustose - Fruticose Lichen

Boulder fields covered with fruticose (*Cetraria* spp.) and crustose (unidentified) lichens characterize this vegetation type. Shrubs are absent and herbs, including mainly altai fescue (*Festuca altaica*), are scarce.

The *Rhizocarpon-Umbilicaria* Crustose Lichen vegetation type (V301) of the 1996 Southeast Yukon Ecosystem Classification best describes these alpine boulder fields.

Relatively uncommon in the Wolverine Lake area, these boulder fields are found on the steeper alpine slopes of the Campbell Range.

Cladina Fruticose Lichen

Extensive mats of the lichen *Cladina stellaris* characterize this vegetation type. The herb layer is thin and dominated by arctic blue grass (*Poa arctica*). Shrubs and mosses are uncommon.

The *Cladina* Fruticose Lichen vegetation type (V302) of the 1996 Southeast Yukon Ecosystem Classification best describes these alpine lichen dominated zones.

Although normally an alpine vegetation type, a few isolated *Cladina* dominated communities occur within the alluvial shrub zone, such as in the Go Creek valley.

Other vegetation types observed but not sampled include:

Open Black Spruce Forest - Upland (V18 of the 1996 Southeast Yukon Ecosystem Classification) occurring on mineral soil on the fringes of the lowland bog forest and occassionally at higher elevations in the upland forest.

Willow -Shrub Birch Low/Tall Shrub (V105 of the 1996 Southeast Yukon Ecosystem Classification) occurring intermittently in the sub-alpine transition zone.

White Heather Dwarf Shrub (V115 of the 1996 Southeast Yukon Ecosystem Classification) occurring on exposed ridges in the alpine tundra zone.

Mesic Mixed Herb (V213 of the 1996 Southeast Yukon Ecosystem Classification) occurring infrequently in the sub-alpine transition zone.

It should be noted that ***Open Tamarack-Spruce Forests*** (V23 of the 1996 Southeast Yukon Ecosystem Classification) occur just north of the Wolverine Lake study area in the Nouga Creek valley, but was not observed in the study area.

3.2.2.3 Metal Concentrations in Vegetation

Vegetation samples were collected from five sites in the study area in order to determine background levels of metal enrichment. The locations of these sampling stations are shown in Figure 3.56. Elevations and UTM coordinates are given below.

Station	Elevation (m)	Location (UTM)	
1	1,150	436850 E	6813350 N
2	1,320	441400 E	6808800 N
3	1,140	431000 E	6816500 N
4	1,770	440550 E	6812100 N
5	1,710	435050 E	6816500 N

Samples of lichens (*Cladina* spp.) and the leaves and twigs from willow shrubs (*Salix* spp.) were collected in mid-July, 1996. These species are common within the study area. The entire above ground portion of lichens and the leaves and twigs from the current year's growth of willows were collected. Samples were shipped to a laboratory. for ashing and ICP analysis for metals.

The results of the metals in vegetation survey are presented in Table 3.44. Willows (both twigs and leaves) appear to accumulate more zinc than lichens. Willow twigs seem to accumulate more copper than willow leaves or lichens.

3.2.2.4 Sensitivity of Vegetation to Disturbance

The sensitivity of vegetation in the Wolverine Lake area to human disturbance depends on factors such as elevation, site moisture, slope and soil texture. Lower elevation vegetation communities generally revegetate more easily, particularly aspen forests and willow and alder thickets which reproduce vegetatively (suckering). Alpine areas revegetate much more slowly because of the slower rate of succession due to climatic conditions and because the thin soil horizons are easily destroyed. The soil erosion hazard increases with the slope and with the silt content in the upper soil horizons. In areas with saturated soils and deep layers of organic materials, the removal of surface vegetation can lead to the melting of permafrost.

The vegetation types most vulnerable to disturbance by human activity in the Wolverine Lake study area include all those in the alpine tundra zone (alpine dwarf shrub and alpine lichen dominated vegetation types). Although soil erosion hazards and terrain constraints in the alpine tundra zone may be minimized by avoiding steep slopes and areas of cryoturbation, reclamation/revegetation of disturbed sites in this zone is difficult.

Removal of the surface vegetation and organic layers (primarily sphagnum peat) from lowland black spruce forests, such as those adjacent to the Wolverine and Little Wolverine Lakes may result in the melting of permafrost.

High water tables and deep organic layers typical of the wet sedge and wet mixed herb meadows that occur in lowlands, such as those along the creek draining Little Jimmy Lake, and in poorly drained areas in the alluvial shrub zone, such as along Go Creek near the airstrip may make these communities sensitive to development as well.

3.2.3 Ecosystems and Wildlife

The Finlayson District is an important area for sport hunting and traditional First Nations land use. Potential effects to wildlife have been a historic concern associated with mining projects in the Finlayson area. Wildlife studies and mitigation plans developed for past projects focused on identification of critical species and habitat in the project area. The objective of these programs was to mitigate direct effects to wildlife populations through overhunting and to avoid disruption to key habitat areas. These studies, in combination with data collected by government agencies, were successful in identifying key wildlife habitats and important species and mitigating potential effects.

Due to lack of regional information and limited project scopes, historic study efforts for wildlife resources did not consider overall habitat requirements for the species in the area. Overall habitat requirements include consideration of forage availability, cover, travel corridors, territory size and boundaries, etc., in addition to the critical components (rutting and calving grounds, nesting sites etc.) that were evaluated in previous studies. Potential effects to wildlife resulting from the Finlayson Project can be more accurately assessed by understanding the regional availability of these general habitat requirements.

Habitat requirements are species dependent and can be described in terms of the general ecosystem components. The term “ecosystem” refers to all physical and chemical components and their interactions in a natural environment. Wildlife are most influenced by the more large-scale considerations of climate, vegetations cover, topography and landscape, drainage conditions, etc. In combination, these are the factors that most influence wildlife populations, both in terms of distribution and abundance, in their natural habitat.

Although climate, vegetation, landscape conditions, and drainage patterns were considered individually for the Wolverine Project, no attempt was made to interpret these attributes from an ecosystem perspective. Such an interpretation will be made for the Wolverine Project Environmental Assessment Report in order to accurately characterize potential cumulative effects to wildlife populations resulting from project development.

The following section is a broad interpretation of ecosystems occurring in the Wolverine Project Area and a brief summary of the wildlife values that occur in the area.

3.2.3.1 Regional Ecosystems

The Finlayson project area occurs at the southern extent of the Tintina Trench at the intersection of three ecoregions, the Pelly Mountains, Liard Basin and Yukon Plateau North ecoregions (ESWG 1995), and includes boreal, sub-alpine and alpine environments. General physiographic conditions within the project area range from the low lying, rolling topography near Finlayson Lake to the high elevation, rugged terrain of the Pelly Ranges. Elevation ranges between approximately 1,000 to 2,000 m within the general project vicinity. Discontinuous permafrost underlies much of the area. Forested areas are contained to valley bottoms and lower slopes with treeline occurring between 1,300 to 1,500 meters. Similar to most areas of Yukon, wildfire exerts an important control over the distribution and seral stage of vegetation communities in the area.

In Yukon, the most commonly used for the description of regional ecosystems is the National Ecological Framework (ESWG 1995). The National Ecological Framework provides a context for the description and comparison of regional ecosystems (i.e. ecoregions) at a scale of 1:1,000,000. While useful for the comparison of broad regions at the national scale, this classification is of limited utility for the assessment of smaller geographic areas such as the Finlayson Project; it does not provide enough resolution to capture the ecological variation that occurs within diverse ecological settings. Figure 3.2 shows the regional setting of the project area.

Within a single Yukon ecoregion, environmental gradients created by elevation perhaps exert the strongest control over the distribution of vegetation communities. The description of this elevation gradient requires such terminology as boreal, sub-alpine and alpine zones. In the Wolverine project area the definition of boreal refers to the forested, low elevation valley bottoms and low-lying terrain surrounding Finlayson and Wolverine Lakes. Most waterbodies and wetlands are associated with this zone. Sub-alpine refers to the zone between the relatively closed-canopy forests in the boreal zone and the dwarf shrub, herb and non-vegetated rock areas in the alpine zone. It should be recognized that the sub-alpine zone represents a broad gradient between these low and high elevation conditions; the sub-alpine zone is dominated by tall shrub vegetation with scattered spruce and fir forests at its lower limits, grading into lower stature shrub and herb communities at upper elevations. The alpine zone is defined by treeless conditions with rock, low shrub and herb communities being characteristic features. The Finlayson Lake project area spans a range of vegetated and non-vegetated boreal, sub-alpine and alpine settings within the Pelly Mountains, Yukon Plateau North and Liard Basin ecoregions. The delineation of these different elevation zones and the different ecosystems within each does not currently exist for the project area.

3.2.3.2 Wildlife Values

The Finlayson region contains very high wildlife values. Wildlife resources in the immediate project area and surrounding region include the Finlayson Caribou Herd, moose, black bear, grizzly bear, wolf, fox, coyote, wolverine, marten, mink, river otter, beaver, several raptors, ptarmigan, various waterfowl, and a variety of other forest birds. The lakes and small ponds/wetlands provide breeding and migratory habitats for waterfowl and other aquatic birds. The Finlayson Lake/River area and the east slope of the Pelly Mountains are part of the Tintina Trench migration corridor and are used extensively by waterfowl and other waterbirds, including trumpeter swans and sandhill cranes, on their north-south migrations.

One of the most significant wildlife resources in the area is the Finlayson Caribou Herd. This woodland caribou herd has been the subject of a significant management effort by the YTG Renewable Resources since the early 1980's. Their studies have included detailed population surveys and radio collaring. Annual rut surveys are flown by YTG Renewable Resources to monitor the caribou population. The data collected by these studies is shown in Figure 3.57a. The Finlayson region was also the site of an extensive wolf control program carried out during the late 1980's to early 1990's, and has contributed to much additional information on ungulate - wolf interactions. The Finlayson herd is highly valued as a subsistence base for the Ross River Dena, by resident sport hunters, the Yukon guiding industry and for their own intrinsic value.

Finlayson region moose are also an important resource for the same user groups, including the Ross River Dena. The Finlayson region contains some of the highest recorded moose densities in Yukon.

Development wildlife programs for the Kudz Ze Kayah and Wolverine Projects recognized that the major species of concern were woodland caribou (Finlayson Caribou Herd) and moose. The study program was developed in consultation with YTG Renewable Resources biologists and the Ross River Dena, and reflects concerns identified during previous consultation processes. Several additional caribou surveys (peak calving survey and post-calving aggregation survey) were added to the study program to provide specific data (peak calving date and cow:calf ratio, respectively) that would be useful in assessing potential impacts following mine development and for future caribou population monitoring. The study area was also significantly expanded for the additional caribou surveys in order to provide population-wide data for the part of the Finlayson herd utilizing the area around the project.

As stated in the original project reports, the Wolverine and Kudz Ze Kayah wildlife programs were developed to provide necessary information to assess wildlife resources and habitat values in the study area, and to provide the basis for an assessment of the impact of mine development, operation and decommissioning. The intent of the programs was not to provide a complete inventory of all wildlife in the project area, but rather to identify critical species and their habitats and to provide or supplement existing information sources. Baseline work was necessary to formulate management strategies for dealing with potential impacts related to mine development, mining activities and to provide a baseline for future monitoring activities. The primary wildlife concerns associated with increased human activity in the project area are:

- Increased hunting pressure facilitated by new access roads;
- Disruption of critical wildlife functions such as breeding and migration;
- Alteration or alienation of habitats such as winter ranges and nesting areas.

Previous Wildlife Studies

In conjunction with specific information collected during the baseline wildlife programs, a number of additional YTG Renewable Resources resources were also utilized. These included caribou studies (Farnell and McDonald 1987; Farnell and Hayes 1992), wolf studies (Hayes and Harestad 1994), and moose surveys (Jingfors 1988; Larsen and Ward 1991). YTG information sources included published and unpublished (draft manuscript) reports, preliminary maps of caribou survey data and population distribution and radio-tracking results. General information on wildlife in the Finlayson region and specifically the Kudz Ze Kayah and Wolverine project areas was also gained through telephone discussions and meetings with Fish and Wildlife Branch staff.

Detailed wildlife survey results of the Kudz Ze Kayah and Wolverine baseline programs are contained in the previous project reports. The following summaries have been prepared based on a synthesis of the previously collected information.

Woodland Caribou (Finlayson Caribou Herd)

In co-operation with YTG Renewable Resources, both the Kudz Ze Kayah and Wolverine projects conducted baseline ungulate surveys in the immediate project area. Aerial surveys were flown at key times in 1995 and 1996 to document caribou distribution and numbers at key periods of the year, corresponding to late winter, calving, post-calving aggregation, and rutting activity. Additional information on caribou was also obtained during a 1995 moose survey. The survey data provided key population characteristics (such as peak calving date, post-calving calf:cow ratio, and numbers on rutting range). Most upper sub-alpine and alpine areas surrounding Wolverine Lake and the Kudz Ze Kayah mine site are considered Key Habitats by YTG Renewable Resources for the Finlayon Caribou Herd during the fall rut. However, survey data indicates that limited calving and post-calving aggregation activity occurs in or immediately adjacent to the Wolverine project area .

The impetus for the Finlayson caribou studies was the declining state of the herd during the early 1980's. YTG Renewable Resources implemented a wolf control program in 1982/83 and again in 1989/90 out of concern for the declining caribou population. The wolf population was substantially reduced in the area occupied by the Finlayson Caribou Herd. In conjunction with wolf control, sport hunting was limited to bull caribou, and First Nations hunters were encouraged to select male over female caribou. Annual monitoring of the caribou herd by YTG is ongoing. Results of the 1994 survey indicate that the Finlayson herd has rebounded from a low of approximately 2,000 in the early 1980s to an estimated 8,000 caribou by the mid-1990's.

Seasonal Movements and Habitat Use

Seasonal distribution of the Finalyson caribou herd is shown in Figure 3.57a. Caribou calve on ridges and upper slopes of basins in late May and by mid-June form aggregations in the uplands. They remain dispersed in small bands in the uplands and upper forests through summer. During late spring through summer, caribou utilize many of the shrub and herb vegetation types that were identified in the vegetation study as well as the open-canopy sub-alpine fir forest on valley slopes.

Caribou form rutting aggregations in early October and occupy the uplands (ridges and plateaus), including the upper elevations of the project area. At this time, caribou may utilize any of the alpine shrub and herb vegetation types. After the rut, caribou disperse throughout the area and occupy the alpine, sub-alpine and upper forests until late fall (mid-November). At this time, they utilize a wide range of vegetation types. By mid-November, caribou start to move down into the boreal forest, which includes the open-canopy black spruce forest vegetation types.

By December-January, caribou have moved down to their traditional winter range in the Pelly River lowlands. Their winter range includes the boreal forest along the Robert Campbell Highway, to the north of the project area. By early to mid-May, caribou once again move to higher elevations, following the receding snow to the uplands on their way to calving areas.

Moose

Data on moose distribution and numbers were obtained through aerial surveys flown in March and November 1995, to document late-winter and post-rut distribution. Additional data on moose were obtained during the course of caribou surveys. Moose may occur on the Kudz Ze Kayah and Wolverine properties throughout the year. Moose are well dispersed in the project area during summer and early fall and congregate in post-rut groups in the upper elevations around the project area. The information indicates that moose spend early winter in the project area and may remain into late winter during some years. In 1991, moose densities in the Frances Lake survey area were 383 moose/1,000 km^2, which was among the highest recorded in the Yukon (Larsen and Ward, 1991).

Seasonal Distribution and Habitat Use

Moose utilize the forested vegetation types during much of the year, although primarily in the winter when they inhabit the lowlands along Finlayson Creek down to the Robert Campbell Highway. Riparian forests and closed conifer stands provide important browse and thermal cover during this time. The tall shrub vegetation types are also utilized into the winter period when moose occur in the upper Go Creek valley. During spring to fall, moose are widely distributed throughout the area and can occur in any of the vegetation types. Alpine areas, due to their poor cover and food availability, are probably not utilized however. During the rut and post-rut, moose occupy upper sub-alpine basins and utilize the tall shrub vegetation types and the open-canopy sub-alpine fir forests.

Thinhorn Sheep

Key habitats for sheep include winter ranges, lambing areas, rutting grounds, mineral licks and migration corridors. These habitats are critical because they are limited in extent, and they are used repeatedly by the sheep. Thinhorn sheep inventories were not carried out in either the Kudz Ze Kayah or Wolverine Lake baseline programs, but incidental sitings were recorded. YTG sheep surveys flown in 1986, 1988 and 1995 suggest that sheep utilize portions of the Campbell Range to the east of Wolverine Lake as late winter range and lambing areas. Between 41 and 72 individual sheep were surveyed during these flights but all occurred outside of the Wolverine Project area. The mountains southwest of Wolverine Lake and north of Money Creek are also believed to be used by sheep as a lambing area and a summer range for nursery bands. A small portion of the mountain range has been designated as a Key Habitat for sheep. Baseline vegetation mapping for the Wolverine project does not indicate that this Key Sheep Habitat contains high sheep values.

Bears

Grizzly bear (*Ursus arctos*) and black bear (*Ursus americanus*) can be found throughout the entire Finlayson area and were occasionally observed near the Wolverine properties during baseline wildlife data collection programs. In north Yukon, grizzly bear home ranges are generally very large and it is likely that one or two grizzlies include the project area as part of their home ranges. No bear den sites were observed during previous wildlife surveys. Grizzlies range throughout the open valleys, sub-alpine and alpine environments of the region, and may occur in any portion of the project area. Grizzlies utilize a variety of habitats throughout the area, focusing primarily on low elevation meadows and wetlands in spring for early green-up vegetation. Sub-alpine and alpine habitats are probably most important during late summer and fall for the variety of berries that can be found throughout these environments.

Black bears are more abundant in the lower forests toward Finlayson Lake and the Robert Campbell Highway. Black bear are not expected to be common in the project area because of the predominance of high elevation sub-alpine and alpine habitats.

Wolves

Wolves (*Canis lupus*) and their predation effects on the Finlayson Caribou Herd has been the subject of intensive study by YTG Renewable Resources. The wolf control program between 1983 and 1989 reduced the wolf population by approximately 85% (Farnell and Hayes 1992). Following the control program, the wolf population was monitored to examine recovery rates and it appears that numbers have recovered to near the pre-control populations. Similar to most areas of Yukon, wolves play an important role in the Finlayson region and are considered to be the primary predator of caribou and moose.

During previous wildlife studies, wolves or their sign were observed infrequently around the Kudz Ze Kayah and Wolverine properties. Any wolf sitings were scattered throughout the uplands of the area. It was acknowledged that mineral exploration related activities concurrent with the 1995 baseline fieldwork programs may have discouraged wolves from fully utilizing some portions of the Finlayson project area.

Furbearers

Beavers (*Castor canadensis*) are moderately abundant in small lakes and ponds of the area. Beavers can be expected throughout the lower and mid-elevation streams and ponds of the area.

Other furbearers which were not recorded during previous wildlife programs but which are known to occur in the region and expected to occur in at least parts of the project area include coyote (*Canis latrans*), lynx (*Lynx canadensis*), marten (*Martes amaricana*), ermine (*Martes erminea*), mink (*Mustela vison*), and river otter (*Lontra canadensis*).

Small Carnivores

Small carnivores in the region include fox *(Vulpes vulpes*), wolverine (*Gulo gulo*), and the least weasel (*Mustela nivalis*).

Small Mammals

No direct information was collected for small mammals in the project area. Similar to most areas of Yukon, snowshoe hares (*Lepus americanus*) occur throughout the region and inhabit most forested and shrub habitats throughout the boreal and sub-alpine of the project area. No information is available on mice and voles.

Ground squirrels (*Spermophilus parryii*) occur on sub-alpine slopes in the area. One observation of a grizzly bear foraging for ground squirrels was recorded in the Kudz Ze Kayah project area. Both snowshoe hares and ground squirrels represent an important food base for avian and mammalian predators.

Birds

Waterfowl/Waterbirds

Waterfowl use of the immediate project area is limited to the few scattered ponds and larger water bodies. Suitable wetlands are restricted to the small lakes and ponds at the top end of Geona Creek and South Creek; these habitats are utilized during spring and fall migrations. Trumpeter swans are known to breed in the lakes and potholes throughout the Pelly lowlands and to migrate through the Finlayson River valley. Whitefronted geese migrate through the Pelly River and Finlayson River valleys in significant numbers from late August until mid September. Common loons are also known to occur on Wolverine Lake. Migrating northern phalaropes were observed in small numbers on ponds near Wolverine Lake.

Sandhill Crane

Approximately 200,000 Alaskan and Siberian breeding Sandhill Cranes migrate northward through the study area in May and June and return southward between late August and late September. Large numbers of these birds are particularly evident in the general Kudz Ze Kayah area during the fall migration along the Tintina Trench.

Raptors

Golden eagles were observed on numerous occasions during the baseline wildlife programs. Bald eagles and gyrfalcons have also been observed in the Kudz Ze Kayah – Wolverine Lake area as well. No raptor nest sites or family groups were observed in the immediate project footprints during previous studies.

Ptarmigan

Ptarmigan are common in the project area. All three species of ptarmigan (willow, rock, and white-tailed) may occur in the region. The various willow, willow/birch, and sub-alpine fir shrub habitats provide abundant cover and food for willow ptarmigan during the breeding season and into the fall. Shrub communities are utilized in the winter for food and cover by all three species.

Critical/Sensitive Habitats

With the current limited extent of vegetation mapping and the lack of a regional framework in which to evaluate the project, it is very difficult to assess habitat rarity and sensitivity.

Within the immediate project area, the most sensitive and potentially important habitats for a range of species include wetlands, open waterbodies and riparian shrub and forest communities. These habitat types are also of limited spatial extent in the Finlayson area; it is not currently possible to quantify their regional distribution. Most upland forest, shrub and alpine habitat types that occur within the direct project area are expected to be common throughout the region.

3.3 Heritage Resources

3.3.1 Background

Little is known about the archaeological and historic site resources in the study area, and generally speaking, the surrounding southeast Yukon country. The lack of site data can probably be best attributed to the little archaeological and historic sites research conducted in this part of the Territory. The fact that the Finlayson Project area is an important habitat for the Finlayson caribou herd, and given the traditional subsistence importance of this herd to the Ross River Dena, suggested that the project area should yield evidence of past human use and occupation.

Sites have been identified in the nearby Ross River/North Canol Road (Gotthardt 1981) and MacMillan Pass (Greer 1982) areas, at Pelly Banks (Gotthardt personal communication 1996), around Frances Lake (Gotthardt 1986, 1993) and the upper Liard and Frances Rivers (Gotthardt 1989a). Although none of these studies has investigated any sites in detail, they nonetheless provide information on what types of sites might be anticipated from the Finlayson Project area.

A study of sites in the Frances Lake area (Gotthardt 1993) recorded both precontact archaeological sites, grave sites, cabins, caches, historic period campsites, as well as the Hudson's Bay Company's 1842-1851 trading post. Sometimes, many of these features occur at one site or locale, such as around the narrows on Frances Lake, or the caribou crossing on the east arm of Frances Lake.

3.3.1.1 Precontact

A chronology of precontact or prehistoric occupations for the southeast Yukon has yet to be developed. The following summation of south Yukon culture history is based largely on syntheses of culture history for the southwest part of the Territory (Gotthardt 1989b; Workman 1978). Four broad cultural phases are recognized in the south Yukon prehistoric sequence; these phases are defined primarily on the basis of changes in stone tool technology.

The oldest cultural phase, Northern Plano/Northern Cordilleran (8,000 to 5,000 B.C.) is characterized by artifacts such as large round-based lanceolate point forms and lithic technology which includes the production of large blades, as well as flakes, as blanks for tool manufacture. Transverse notched burins were also made by these early residents.

The following Little Arm Phase (5,000/6,000 B.C. to 2,500/3,000 B.C.) featured stone tool technology emphasizing the production of composite tools using small blades or microblades. The microblades are believed to have been hafted with a mastic into the lateral edges of bone or antler points and used as knives or projectile points. The ultimate origin of this distinctive technology is believed to be extreme northeast Asia. Some researchers consider the appearance of microblade technology in the western subarctic as marking the arrival in Alaska-Yukon of the distant ancestors of the Na-Dene, that is, speakers of Athapaskan languages such as Kaska, Tutchone, Gwich'in, etc. (Aigner *et al*. 1986; Meltzer 1989). Others (e.g., Clark 1981) consider the relationship between microlithic materials and succeeding occupations of the southern Yukon as uncertain.

The Taye Lake Phase (2,500/3,000 B.C. to A.D. 750) follows Little Arm. Sites or site components of this phase feature a new stone tool technology that is characterized by the production of large side-notched as well as stemmed spear and arrow points. This has led one researcher to propose that an actual migration of new people had taken place (Workman 1978). Continuity or gradual change in tool types from the time of the appearance of the Taye Lake materials to the historic period is evident, however, which suggests that Taye Lake may represent the arrival in the region of the distant ancestors of the Na-Dene, including the Kaska (Workman 1978). Whether the Taye Lake people displaced or assimilated with the resident population was not known.

The Aishihik Phase (A.D. 750 to A.D. 1800+) follows the Taye Lake phase. There is considerable continuity in tool types between the two phases; they are separated on stratigraphic grounds, with Aishihik materials being those found stratigraphically above the White River volcanic ash layer (dated to ca. A.D. 750), while the former is found stratigraphically beneath the ash layer. Some new technological elements do appear in the Aishihik phase, including native copper tools; barbed bone and antler points, and small stemmed or notched projectile points, those small enough to have been used as arrow rather than spear points. Large ground-stone adzes, used to fell trees, were also now being made.

The economy of Aishihik Phase in the southwest Yukon has been suggested to be predominantly small, mobile groups of people pursuing their seasonal round over large stretches of territory (Workman 1978). A similar pattern has been proposed for the Carcross-Tagish area (Greer 1984), and the Macmillan Pass area (Greer 1982). The Macmillan Pass study for example, reported that precontact archaeological sites in that area tended to be small in size, covering an area of less than 100 square metres. These sites were often located in well-drained settings, around lakes (Greer 1982). The collections recovered from precontact sites in the Macmillan Pass area tended to be dominated by flakes, the detritus from the manufacture of stone tools, and bone preservation was rare.

In the southern Yukon, the appearance of European trade goods in the archaeological record marks the beginning of the Bennett Lake Phase, dated ca. A.D. 1800+ to A.D. 1900-. Sites assigned to the Bennett Lake Phase in the southwest Yukon were produced by the direct ancestors of the Southern Tutchone Champagne-Aishihik people, in the Carcross area, by the direct ancestors of the Carcross-Tagish First Nation. In some cases historic personages are known to be associated with particular sites.

There is technological continuity in many elements with the preceding Aishihik Phase, as tools like bone points and scrapers, women's stone scrapers continued to be made. Gradual replacement of certain tools with items of European manufacture, particularly metals, is evident; for example, metal tipped rather than stone, arrow points, were made. Gun shot, beads, buttons, are found in these sites. Sometime during the Bennett Lake Phase, people began constructing cabin villages, which were occupied at least seasonally. A somewhat greater emphasis on trapping fur bearers also characterizes the subsistence orientation of this period.

While these same researchers have considered their past, an adequate history of the Ross River people has yet to be assembled and little information has been compiled on the Ross River Dena perspective of their past. That which is available on the Kaska in general suggests that they have lived in their traditional territory for a long time, since the creator made or restored the earth to its current form (McClellan 1991; Honigmann 1981). While conflicts with neighbouring peoples as recent as the 19th century are reported (Field 1913, 1939) Kaska history has no stories of migrations or of distant homelands.

3.3.1.2 Traditional Land Use and Lifestyle

Prior to contact with non-native outsiders, the economic life of the Ross River Dena is thought to have been similar to that of most aboriginal groups of the subarctic cordillera. It would have included big and small game hunting, fishing and some gathering. Their seasonal round would have involved considerable mobility, with travel mostly by foot, and many different camps would have been used in the course of a year McClellan and Denniston 1981). This precontact land use pattern is believed to have continued well into the 20th century, as evidenced in first hand accounts of the traditional lifestyles observed in 1913 by the trader Poole Field:

> *The Indian generally tries to get into a good game country about the end of August when all game is fat, to put up a cache of dried meat for the winter months. If in the mountains the women catch groundhogs and gophers; they dry them for the winter.* (Field 1957:54).

The Elders interviewed by the anthropologist R. McDonnell in the late 1960s reported that hunting occurred primarily during the fall and winter seasons, except for intercepting game at a salt lick, which could be done year round (McDonnell 1975:162). Gathering was pursued intermittently close to their camps. This activity required considerable technical skill and a detailed knowledge of the resources on the land, in order to predict their occurrence (Ibid.: 163-64).

Snares, made of twisted sinew or babiche tied to stick, were an important component of the traditional technology. They were set on game paths, for example where animals came to a lake to feed or to a lick for salt, and were used to catch moose, sheep, black bear, wolves and wolverine (Field 1957). The local people told the trader Field that traditionally

> *...they used bows and arrows to hunt with, spears, snares and dead falls also. They would make long fences when the caribou and sheep came below timberline, sometimes packing poles to make their fences with up on top of the mountains. They would leave spaces big enough for a caribou or sheep to go through in their fences and set snares in them. Whenever a herd was sighted they would try to surround them and drive them through their fences.* (Field 1957:53)

Traditionally, the usual domestic or residential unit was the extended family. Each local group had to at least have a core of able-bodied and knowledgeable "providers" (McDonnell 1975). The size of local groups likely varied greatly in size, as families came together or dispersed for various seasonal activities.

Details on traditional housing styles are limited, though the trader Field was told of traditional lifestyles during the years he operated trading posts at Ross River and Pelly Banks. He reported that "Years ago they lived in open camps sheltered on three sides by throwing up logs and brush and had a fire in front using a skin covering of caribou skins for a roof." (Field 1957: 52). Many such sites would have been established over the course of a year, as the families travelled around within to harvest the required resources. McDonnell (1975:102), who interviewed Ross River people in the 1970s, estimated that traditionally, the people living in this area may have established 23 different camps over the course of a single year. He adds, however, that more than two-thirds of these campsites would have been established in the short spring season.

It is not known precisely when the Pelly Banks people started building cabins and more permanent residences. Likely these buildings were not constructed until after axes became regularly available from the local trading posts (Pelly Banks, Frances Lake or Ross River) around the turn of the century. It is believed that cabins were first built at these trading posts settlements.

3.3.1.3 Post-contact

Most of the history information available on the Ross River Dena concerns their early involvement with outsiders through the fur trade. While they are understood to have always taken some animals for furs, it was through middlemen that they first became involved in the European first trade at the beginning of the 19th century. Western trade goods may have made their way to the Ross River Dena from European trading ships in the Gulf of Alaska to the west, or from various Hudson's Bay Company trading posts in the Mackenzie basin (Fort Liard, Fort Simpson, and Fort Norman established on the Mackenzie River in 1804, 1804 and 1810, respectively, or Fort Halkett established on the Liard in 1821). Given that long distance travel was common for people at the time, the Ross River Dena may even have visited some of these trading posts themselves.

Historical Chronology of the Finlayson Area	
Precontact	Kaska speakers living in the headwaters country of Liard and Pelly Rivers, including the Wolverine Lake area
1820's	Fort Halkett established on the Liard River (1821)
1830's	Dease Lake Post in operation (1838-1841)
1840's	HBC's Robert Campbell explores Frances Lake, travels overland to the Pelly, and explores it to its mouth (1840). Campbell establishes Fort Frances (1842) and Pelly Banks Post (1846), and Fort Selkirk, at the mouth of the Pelly (1948). Pelly Banks post burnt and not rebuilt (1849).
1850's	HBC closes Fort Frances (1851); Fort Selkirk destroyed (1852).
1880's	George Dawson, geologist travels overland from Frances Lake to the Pelly, reopening the area (1887). Frances Lake trading post reopened briefly (1880). Lower Post established on the Liard River (1887).
1890's	A few Klondike stampeders pass through the area (1897-98)
1900's	J. Lewis and P. Field open post at mouth of Ross River (1900); HBC reopens small post near their old site of Pelly Banks (ca.1901); Taylor and Drury buy Ross River and Pelly Banks posts (1905); white men trapping extensively in the area in this decade, then move out of area.
1910's to 1930's	Pelly Banks and Ross River trading posts generally in operation (some periods of closure). Frances Lake post opened by HBC in 1939. First missionary (Anglican) based at Ross River (late 1930s). Devastating measles epidemic in area (1938).
1940's	Construction of the Canol Road and Pipeline (1942-44), influx of outsiders. Pelly Banks post open (ca.1944-1949). Frances Lake post closes (1947).
1950's	Ross River trading post moved across river to present location (1952); Pelly Banks post closes for last time (1950). Frances Lake post open briefly (1953-54).
1960's	Campbell Highway built (1964), Ross River undergoes boom associated with Faro mine development; day school for Indian children established at Ross River, Indian families forcibly moved across river to present location (1965-66)
1990's	Comprehensive Land Claim, Umbrella Final Agreement signed (1990)

The first direct contact between the Ross River people and non-native outsiders in their homeland came in the 1840's, when the Hudson's Bay Company trader Robert Campbell travelled through their lands (Wright 1976, Wilson 1970). Campbell arrived from the south, his route taking him up the Frances River to Frances and Finlayson Lakes, and then overland to the Pelly River, which he explored to its mouth, before returning south. In 1842 Campbell returned to the area and established the trading post he named Glenlyon House, later Fort Frances, on Frances Lake. Only a few years later, in 1846, Campbell established the trading post known as Pelly Banks, in the upper Pelly River basin.

The Finlayson Project is situated between these two early trading posts, and no doubt the families who used this area visited one or both of these posts (see HBC 1842-44, 1850-51 as cited in Gotthardt 1993:11, for the names of Kaska men trading at the Frances Lake Post). Ready access to these new trade goods was short-lived, however. The Pelly Banks post was destroyed by fire in 1849 and not rebuilt (McDonnell 1975; Denniston 1966). In 1851, difficulties in obtaining trade goods as well as food supplies, plus limited trade results, and trading conflicts lead the company to close Fort Frances (see Gotthardt 1993:10).

In the period 1850-1899, there was little contact between the Ross River people and white men. A trading post was opened by an independent on Frances Lake in 1880, but it lasted only a short time (Gotthardt 1993:12). Some of the Ross River people are known to have made occasional trading trips to posts located farther afield, including the post on the Liard River. In the late 1890s, a few stampeders heading to the Klondike to search for gold passed through the area.

After the turn of the century, however, things changed quickly. In 1900, a pair of independent traders opened a post at the mouth of the Ross River, across the Pelly River from the current settlement. Around 1901, the Hudson's Bay Company reopened a post near the old site of Pelly Banks (McDonnell 1975; Denniston 1966). Both these posts were purchased by the Taylor and Drury firm in 1905. While a store has been open at Ross River settlement more or less continuously since that time, the trading posts at Frances Lake and Pelly Banks were somewhat less reliable. They were operated intermittently up until 1947 and 1954, respectively, when they closed for the last time (see above).

The presence of trading posts is only one measure of outside influence on the life of the Ross River people. With time, slowly other changes came, but it was not until the 1930's that missionaries and the Christian church had a regular presence in the area. They encouraged the people, among other things, to send their children to school, with the only option available being residential schools located in Whitehorse and Carcross, outside their territory.

Major changes came with the construction of the Canol Road and Pipeline in the 1940's, as outsiders entered the area in large numbers. By 1944, this project was terminated, however, and the pipe was salvaged and much equipment was abandoned. While the North Canol Road section was no longer maintained, the South Canol Road opened up the area to mineral exploration. This culminated in the 1960's with the Faro mine discovery and development, a boom economy with the influx of non-native entrepreneurs, and in 1964, the construction of the Campbell Highway from Watson Lake to Ross River. Not too long after the completion of the link between Watson Lake and Ross River, the Robert Campbell was continued through to Carmacks.

The 1960's saw a major increase in direct government influence over the lives of the Ross River Dena. One of the principal means of influence was via the establishment of a day school in Ross River. While reuniting families, this event significantly altered the lifestyle of the Ross River Dena (McDonnell 1975:7). Previously, almost all families had spent the winter in the bush trapping, and in the summer months they may have been involved in some wage labour. Now those families with school aged children had to stay in the village to look after the children. They went from life in the bush, which has been described as an intimate, at times, a vigorous existence (McDonnell 1975:7), to a sedentary one with limited employment opportunities.

The Yukon Comprehensive Land Claim Umbrella Agreement, signed in 1990, gave the fourteen Yukon First Nations, including the Ross River Dena Council, title to some of the lands they have traditionally occupied as well as greater control over other aspects of their lives. The Claim also formally recognizes First Nations' interest in the subject of the present report, the region's archaeological and historic sites. Under the terms of the Yukon Land Claim agreement, First Nations own all archaeological and historic sites on Settlement Lands, as well as all sites that have a direct connection to their history.

A range of site types dating to the historic period have been recognized in the southern Yukon. These include cabins, caches (various types), stores and fur trade posts, road houses, churches, trading sites, campsites, and grave sites.

3.3.2 Wolverine Project Site Investigations

Heritage resource investigations in the Wolverine area were carried out under permit # 96-11ASR (Greer 1996). These studies were conducted in two phases, June 24th to 26th and September 11th to 13th 1996. The June work included both interview work and an overview flight of the general Wolverine Lake area.

Interviews were conducted with Chief and Council and community Elders at Ross River on June 24th, 1996. The following day, Elders Mary Charlie and her son Franklin Charlie and Jim Dick traveled to Wolverine and participated in an aerial reconnaissance of the area. A helicopter was used to survey the area around Wolverine Lake, the upper Money Creek basin, “Sheep Mountain”, North Lakes, and the area north of Wolverine Lake (between Wolverine Lake and the Campbell Highway). A cabin site was relocated and a precontact archaeological site was identified during this trip.

On June 26th, back in Ross River, further interviews were conducted with Elders, in groupings as follows: Jim Dick, Mary Dick (husband and wife) and Amos Dick (brother to Jim); Mary Charlie and Franklin Charlie (mother and son); and Tom Smith and Tilley Smith (husband and wife).

During September additional fieldwork was completed. Harry Atkinson of Ross River acted as a guide and field assistant. Mr. Atkinson had previously worked on the drilling crews for the Wolverine Project, and was familiar with the area, although he had not hunted in the immediate area. Elders Jim Dick and Amos Dick spent one day with the field crew at the Wolverine. During helicopter aerial reconnaissance, they pinpointed the location of their family’s cabin and graves at the north end of the lake, the graves at “Nougha Creek”, and a cabin at “Van Bibber Creek”. They also related more specific information on traditional land use patterns in the study area.

During the September fieldwork potential mine site access routes were flown to look for evidence of old sites and to assess their potential for buried archaeological sites. Ground truthing investigations were conducted in places recognized as being of archaeological and historic site potential, as known from existing Yukon archaeological site location patterns. Specific locales checked include the inlet and outlet of Wolverine Lake, the north shore of Wolverine Lake opposite the island, the area of the tailings area.

All reported camp sightings in the immediate vicinity of Wolverine Lake and the mine development area were checked. In addition to the information noted during the June interview sessions, and the September 11th visit with Jim and Amos Dick, data on potential site locations was made available via a set of working maps compiled by Lorraine Sterriah, Westmin Resources Limited Ross River liaison (Sterriah 1996 maps). The Sterriah maps showed traditional land use data, including place names, cabin and camp locations. These maps are understood to have been compiled primarily from information shared by Grady Tom.

A member of Westmin’s crew also shared information on the location on two historic hunting campsites she had seen in the course of her work.

Standard Yukon archaeological site survey and assessment procedures were followed to identify and evaluate sites. At all locales investigated, the objective was to determine if there are any archaeological or historic remains including artifacts or structures or features on the surface or in buried context. As there were no eroding bank faces in any of the areas checked, sub-surfacing testing was necessary to detect buried archaeological deposits. All locales investigated were recorded on topographic maps; more specific details on the areas surveyed are provided in the project Field Report and field notes.

3.3.2.1 Traditional Land Use Areas

Within the traditional lands of the Ross River Dena, certain areas were well known as habitual winter grazing routes for caribou. Year after year families returned to these places where they could snare, or in more recent times, shoot, caribou (McDonnell 1975:75). The available evidence suggests that the Wolverine Lake area, strategically located within the Pelly Mountains, but a short distance from the Pelly Plateau country, was one of these favoured traditional land use areas. Long term familiarity with the landscape of the Wolverine Lake area is implied in a 1995 interview with Doris Bob (Rutherford 1995).

It appears that people came here both for the resources available within and directly around the lake itself, as well as those food sources such as caribou that were available in the surrounding high country. Shorter-term hunting camps were established in latter. Many hunting camp locations have been reported above 4,500 feet elevation (Greer field notes 1996; Sterriah 1996 maps). Camps are reported to have been established (1) up the creek which drains into “Jack Mackay Point” (on the south shore of Wolverine Lake); (2) in the upper reaches of “Van Bibber Creek”; and (3) the high country above or north of the mine site development area (these basins are referred to as “Hawkowl Creek” and “Campbell Creek”. (Access Mining Resources 1996). Other high elevation camp locations may well have been used as well. The edge of the tree line (Plate 14) seems to have been a preferred area for camp establishment in higher elevation settings.

Closer to the lakeshore, fish camps, staging camps and cabins are reported (Greer field notes 1996). Many of the old sites around the lake are situated near traditionally used fish net set locations (Greer field notes June 1996 and September 1996). These include: the point at the north end of the lake, at the island in the lake (between the island and both the north and south lake shores), and at the lake inlet at the south end. Amos Dick reported that there were big ling cod, lots of trout, as well as whitefish in Wolverine Lake.

The locale known as “Jack Mackay Point”, a broad point on the south shore of the lake, opposite the island, is another important historic land use area. Besides a camping area, used when nets were put in the lake, this is a staging area for trails leading up to the high country to the south, where hunting camps were established. Just north of the point, is where the Jack Mackay cabin was recorded (see below).

The inlet of Wolverine Lake, at the south end is another key land use area around the lake. While a gravesite understood to be located near the lake outlet was not found, an archaeological site was identified in this area. Evidence of recent but traditional style camps (cuttings, stumps, campfire signs) was also seen in this area, including on the point of land where the exploration base camp is situated on the east shore of Wolverine Lake, just north of the inlet. The lake outlet, or more specifically the general north end of the lake, appears to be the most important land use area around the lake proper.

Four lick locations were pointed out by Elders Mary and Franklin Charlie and Jim Dick. The four lick areas are situated west of the Wolverine Lake mine development area; two of the four licks are situated around “Sheep Mountain”, a third by North Lakes, and the fourth, in the Money Creek basin. The locations of these important resource areas are confidential, as requested by the Ross River Dena Council. The Council has also requested that all lick areas receive protection from disturbance and mining development.

The Kaska name for Money Creek, *Elés Tué’* which translates as lick creek, appears to take its name from the lick feature situated there. This lick is actually a cluster of three licks situated in close proximity together. The fact that the creek takes its Kaska name from these licks indicates the importance of these features to the traditional economy.

Further recognition of their significance to the Ross River Dena is indicated in the story Mrs. Charlie shared about these licks. According to Mrs. Charlie, the animals have been coming to the three licks from the beginning of time. Moreover, there is a man-made fence structure leading down to these licks, and it too has been there long time. The feature Mrs. Charlie described could be along an esker ridge near the lick area, which is clearly visible from the air. This suggests that this natural “fence” has likely been used by the Ross River people for catching game for thousands of years.

The three other waterbodies in the Wolverine Lake valley have also seen considerably traditional use. The lake north of Wolverine Lake is known as “Wind Lake” (or Wind Lake #1). A camp used by Robinson Dick is situated along its east shore (Sterriah 1996 maps; location noted in Greer field notes September 1996). Traditional use trails also run along both the west (Sterriah 1996 maps) and east shores of this same lake (Greer field notes September 1996).

A snare set location is understood to have been situated along the west side of “Wind Lake #2”, which is situated south of Wolverine Lake (Sterriah 1996 maps). This feature location was not ground checked during the present project. The inlet of this same lake is also understood to be a net set location (Greer field notes June 1996).

A cabin belonging to Little Jimmy is reported to have been situated along the west side of the lake which is south of “Wind Lake #2” and referred to as Little Jimmy Lake (Sterriah 1996 maps).

The project field notes contain references to other traditional use sites mentioned by the Ross River Elders that are outside the Wolverine Lake study area (Greer field notes 1996), including grave sites at McEvoy and Finlayson Lakes, and hunting camps in the North Lakes area.

3.3.2.2 Archaeological Sites

Eight archaeology sites have been officially registered as a result of the Wolverine investigations.. Archaeological sites are referred to by their respective Borden number, e.g., JiTo-1, following the standardized system of site registration used in Canada, which assigns letter codes to sites based on their geographic location (latitude and longitude). The Wolverine Lake development area falls within the JiTm, JiTn, JiTo, JiTp, JjTm, JjTn, JjTo and JjTp Borden blocks. In some cases, a site name has been suggested. A brief description of each of the registered sites follows. The site locations are shown in Figure 3.58.

JiTn-1 (unnamed site): Precontact archaeological site, at the inlet or south end of Wolverine Lake . The site is situated on a low bench feature (but not the lowest) on the east side of the outlet. A high bench feature immediately behind the site provides a good view down the lake, and is the reported general location of an historic grave which has not been relocated. Stone flakes, the byproducts of stone tool manufacturing and maintenance, were found at this site. These were situated both above and below the volcanic ash layer, which is dated to ca. 1,250 years ago. The archaeological site is not large; its horizontal extent is estimated at less than 100 square metres. Limited archaeological testing was completed at the site, just sufficient to recognize that there are buried archaeological deposits.

JiTn-2 Jack Mackay cabin (suggested name): This cabin is located towards the north end of Wolverine Lake, on the south side, west and north of the island in the lake. The cabin has been seen from the air only, and was not visited on the ground. (Note that Grady Tom, Sterriah 1996 maps, had marked this cabin as being on the north shore of Wolverine Lake; the cabin location on the south side of the lake was pinpointed by F. Charlie during a flight on June 25, 1996. Franklin also provided the identity of the cabin's owner). Cabin location should be visited to verify its condition and associated features.

JiTn-3 (unnamed site): This is an historic hunting campsite that is situated in the mountains north of Wolverine Lake, in the upper “Van Bibber Creek” drainage basin, east of “Nougha Creek”, at an elevation of ca. 1450 m. The site is located is a stand of alpine fir, around the treeline. At one end of the stand of trees a meat drying and smoking area was seen, recognizable by the cross-pole for hanging the meat, with charcoal from the curing fire visible underneath. The campsite area was at the other end of the stand of trees. Here remains of a fireplace (charcoal and charred poles), a windbreak (piled brush), and cut poles that once held the fly that provided shelter were seen. The age of this site is uncertain, though it is not likely particularly old, based on the artifacts (bottle, tobacco tin) seen on the site surface. No items were collected at this site.

JjTn-1 (unnamed site): This site is an historic brush camp, that is located at the north end of Wolverine Lake, northwest of the lake outlet. The structure, which was a short-term use shelter, is situated a couple hundred metres north of (back in the bush from) Franklin Charlie's new cabin. It was probably used by one or two individuals when out hunting or on travelling on the trap-line. The poles from which it was constructed had all been cut with an ax, and the structure did not appear to be particularly old, perhaps, about 50 years. It is also likely that there are other similar structures located elsewhere in the study area. No items were collected at the JjTn-1 site.

JjTo-1 George and Maudie Dick and Johnson and Louise Jules Cabins, plus Graves (suggested name): These cabins are located at the north end of Wolverine Lake, west of the lake outlet and north of the creek that drains into Wolverine Lake from “Wind Lake” to the north. The cabins are situated several hundred metres above and back in from the lakeshore, at an elevation of ca. 3,900 feet in a open stand of spruce trees. One of Westmin’s exploration survey lines lies less than 100 m south of the cabins.

The cabin locations were pinpointed by Amos and Jim Dick during the September fieldwork. The brothers had lived at this site as young children, and provided the information on the cabins and their owners’ family relationships. George Dick and Louise Jules were brother and sister (Greer field notes, Jim Dick interview June 26, 1996, also Amos Dick September 9, 1996). The cabins are thought to have been built in 1924, but the brothers did not know when they were last used.

The two cabins are positioned about 30 to 45 feet apart, with the larger (ca. 18 by 12 feet), Dick family cabin being west of the Jules family cabin. The Dick cabin has a peaked roof, which is now collapsed. Its door is on the south side, and it has windows on the both the east and west walls. All window and door frames of both cabins are hand hewn. While the stove had been removed from the Dick family cabin, remains of the stove pipe ring (made from a blazo can) were recognizable inside the structure, as was part of a home-made bed positioned in one corner. The smaller (ca. 10 by 14 feet) Jules family cabin has its door on the west wall, with windows on the east and south walls. It has a single pitch flat sod roof, which is now collapsed.

The graves were recognizable as depressions behind the Dick family cabin. One of the depressions is marked by an upright stake. Two children of George and Louise Dick are reported by Jim and Amos Dick to have been buried here.

In addition to the graves, various other related camp structures and features were recognizable around the two cabins. These included a collapsed elevated cache in front of the Jules cabin, and a possible in-the-ground refrigerator storage pit, behind the same dwelling. In front of the Dick family cabin was a carved stump used by women for wringing out hides as part of the tanning process. Amos reported that his grandfather also stayed for a while in a tent at this site; the likely location of the tent site was recognized northwest of the Dick family cabin. In this same area the upright poles from a second elevated cache was seen.

No items were collected at this site.

JiTo-1 Johnny Caesar Camp (suggested name): This site is an historic campsite; precontact archaeological deposits, including a possible house pit or storage pit feature are also present at the site . It is located at the north end of Wolverine Lake, west side, south of the creek that drains into Wolverine Lake from “Wind Lake” to the west. The site is situated on high bench feature on the south side of the creek, and provides a good view east over the north end pond area of Wolverine Lake. A trail that goes from the north end of Wolverine Lake west to the North Lakes runs through the site.

The site was located by Amos Dick during the September fieldwork; Amos also provided the name of the former camp’s occupants. The Caesar camp was recognizable by poles which marked the outline of small (ca. 6 by 8 feet) wall tent. A milk can was seen on the site surface, but was not collected, nor was any subsurface testing of the tent area conducted.

Sub-surface testing elsewhere at the site revealed buried archaeological deposits. Two tiny lithic chips, the byproducts of stone tool manufacture and maintenance, that are made of grey chert, were found below the volcanic ash layer dated ca. 1,250 years ago. A depression, measuring less than 2 m by 2 m by 1 m deep, was also recognized at the site. It is uncertain if this feature is a storage pit, the remains of a dwelling structure, or a natural feature. This site is not large; its horizontal extent is estimated at less than 200 square metres.

JjTm-1 Van Bibber Creek Cabin (suggested name): This cabin is situated north of Wolverine Lake, on the east side of a creek which drains into the Finlayson River and that is locally known as “Van Bibber Creek”. The cabin is located just a couple hundred metres south of the Campbell Highway, though it was built long before the highway. According to Amos Dick, the cabin belonged to Little Jimmy. Grady Tom (Sterriah 1996 maps) thought the house may have belonged to Old Bob. This same owner identification may possibly have been implied by Mary Charlie in interview with Doris Bob (see Rutherford 1995, Appendix p 43). The cabin seen from the air only, and was not visited on the ground. This cabin location should be visited to verify the condition of the structure and associated features.

JjTm-2 Nougha Creek Graves (suggested name): This site records two historic graves that are situated in the lower part of the “Nougha Creek” basin, east of the creek, just south of the Campbell Highway, but well south of the Finlayson River. The two graves, marked by fences were seen from the air only, and were not visited on the ground. Elder Mary Charlie reported that these graves were those of Fred Magan’s children, who died when Mary was a child (Greer field notes, 1996). These graves should be visited to verify their condition and vulnerability.

Other signs of traditional land use (cuttings, stumps, etc.) were recognized in the following places, but have not been registered as sites. Recent camps and cabins, have similarly not been registered as sites because they were not old enough (greater than 50 years).

3.3.2.3 Sites Not Yet Documented/Relocated

The **grave** of Peter Mackay, brother of Mrs. Mary Charlie, is reported as being located somewhere in high country between Wolverine Lake and Campbell Highway. It was reported by Mrs. Charlie (Greer field notes, 1996), and Greer, Mrs. Charlie and others searched for it from air in June, 1996, with no success. Greer and Harry Atkinson looked for this grave in September, 1996, also from the air, but again with no success.

The **grave** of Jacob Dick, brother of Jim, Amos, and Robertson Dick is reported as being located on high bench on east side of inlet of Wolverine Lake. It was reported by G. Tom (Sterriah 1996 maps). Greer and Harry Atkinson examined this bench in September, 1996, but saw no above ground structures or features that might represent a grave marker. The landscape feature itself has an irregular ground surface, so a grave depression would not be easily seen.

In June 24th project interviews, Mrs. Mary Charlie mentioned the graves of three people who were killed by a snowslide. Of the three, the Chief who died was buried at

Finlayson Lake; the chief's brother was buried on the mountain somewhere between Wolverine Lake and the Campbell Highway. The third person killed by the slide, a child, was buried somewhere upstream from the mouth of "Nougha Creek".

Another grave was mentioned by Franklin Charlie during the June 24th project interviews. It was reported as being on the south side of the creek between "Wind" and Wolverine Lake. The area mentioned is where the Johnny Caesar camp was identified during the September fieldwork, and while lots of old cuttings signs were seen in this area, a possible grave structure was not observed.

A cabin used by Little Jimmy is reported to have been located on the west side of "Little Jimmy Lake", the small lake located south and upstream from "Wind Lake #2", south of Wolverine Lake, around 61º21'N, 130º10'W. This cabin location was reported by G. Tom (Sterriah 1996 maps). The west side of this lake was examined from the air in September, but no cabin remains were seen. Ground examination of the area is needed. Jim Dick (Greer field notes, 1996), also referred to a house belonging to Little Jimmy as being somewhere on "Nougha Creek".

A man-made moose lick area was reported on the west side of "Wind Lake #2", the small lake located south end of Wolverine Lake, around 61º19'N, 130º10'W (G. Tom, Sterriah 1996 maps). The area was examined from the air in September, but no obvious signs of a lick area were seen. Ground examination of the area is needed. The man-made feature being referred may be the one reported by Mrs. Mary Charlie, that is the fence structure which leads to the licks by Lick Lake; this feature is situated in the next valley west.

Many other campsite locations were reported (Greer field notes, 1996; Sterriah maps 1996). Most of these are understood to be located in the high country and neighbouring higher valleys of the study area. The reported locations are marked on Maps 3. Only one high elevation hunting camp has been relocated, that being the JiTn-3 site.

3.4 Socioeconomic Conditions

3.4.1 Overview of Yukon Land Claims

All Yukon First Nations were involved through the Council for Yukon Indians (CYI) in an extensive set of negotiations on land rights, participation on land use management boards and self government from 1973 to 1993. In May, 1993, an Umbrella Final Agreement (UFA) was signed between the Government of Canada, the YTG and the CYI. The UFA established the framework for final negotiations on individual, comprehensive land claim agreements with each of the 14 Yukon First Nations. These are considered "modern day Treaties" with Constitutional recognition in Canada. The UFA also required self-government agreements with each Yukon First Nation. Although not constitutionally protected, these are nevertheless substantive multi-party "governance" agreements given legislative recognition by Canada through Parliament.. The CYI was established to negotiate the UFA. With that mandate accomplished, the CYI has now evolved into the Council for Yukon First Nations (CYFN) but only represents 11 of 14 Yukon First Nations.

At the present time, there are nine Final Agreements that are in effect, three that are still being negotiated or that are in the ratification process and two that are not in negotiations at the present time.

The Wolverine Project is in Kaska Traditional Territory. The Ross River Dena Council and the Liard First Nation are the two principal aboriginal groups in Ross River and Watson Lake that will be involved in the development and approval of the Wolverine Project. Both the Ross River Dena Council and the Liard First Nation have joined forces with the Kaska Dena Council in British Columbia to deal with land claims negotiations and the approval of development projects such as mining. Yukon Statistics

3.4.2 Demographics and Economy of the Yukon

The Yukon's population as of June 2004 was 30,469 (Bureau of Statistics, Yukon Monthly Statistical Review, July 2004). This represents a 1.6% increase in population from June 2003 (population 29,976) to June 2004. The June 2004 population was 49.8% males and 50.2% females and persons under the age of 15 accounted for 19.3% of the population and 6.7% of the population were aged 65 and over (Bureau of Statistics, Yukon Monthly Statistical Review, July, 2004).

The largest communities in the Yukon are Whitehorse with a population of 22,673, Dawson City 1,800 and Watson Lake 1,553 (Bureau of Statistics, July 2004). About 74.4% of the Yukon's population live in Whitehorse.

The seasonally adjusted unemployment rate for Yukon Territory in July, 2004 was 7.1% which is 0.1 percentage rates lower than the rest of Canada (7.2 %). During July 2003, Yukon’s rate of unemployment stood at 10.3%, which is a decrease of 3.2% percentage points from July 2003 to July 2004. (Source: Yukon Bureau of Statistics).

The economic health of Yukon Territory is closely tied to the health of the Canadian exploration and mining industry. There has been a steady decline in the Yukon economy between 1997 and 2001, which roughly corresponds to the decline of the Canadian minerals industry.

The total GDP for Yukon Territory in 2002 was $1,068,100,000 of which Mining, and Oil and Gas extraction contributed up to 3.3 % of the GDP. The following is a summary of the Real Gross Domestic Product by Industry from 1990 to 2001 for Mining, and Oil and Gas extraction in 1997 Canadian dollars (Source: Yukon Bureau of Statistics):

1990- $ 238.5 million
1991- $ 198.5 million
1992- $ 308.9 million
1993- $ 80.7 million
1994- $ 47.8 million
1995- $ 86.3 million
1996- $ 178.0 million
1997- $ 129.9 million
1998- $ 95.6 million
1999- $ 59.5 million
2000- $ 63.2 million
2001- $ 50.0 million

These figures clearly show the decline in the GDP for the mining industry in Yukon Territory from 1993 to 2001.

The value of mining related exploration activities in Yukon Territory declined between 1998 to 2002. The following summarizes exploration expenditures from 1995 to 2004 in Canadian dollars (Yukon Mineral Exploration Statistics, Department of Energy, Mines and Resources, Government of Yukon):

1995- $ 39.3 million
1996- $ 45.6 million
1997- $ 40.6 million
1998- $ 20.1 million
1999- $ 11.7 million
2000- $ 9.0 million
2001- $ 7.4 million
2002- $ 7.6 million
2003- $ 12.5 million
2004- $ 22.0 million (preliminary estimate)

The Yukon exploration industry was negatively impacted between 1998 and 2002 with the downturn in the Canadian minerals industry. The Yukon has recently experienced an increase in exploration expenditures in the last two years due to increasing metal prices.

3.4.3 Yukon Communities

The Yukon communities that would probably directly benefit from the Wolverine Project includes Ross River, Watson Lake and Whitehorse. These communities can provide the vast majority of services required for a major mining project as well as a trained labor force that would be available to support the Wolverine Project.

3.4.3.1 Ross River

The history of Ross River goes back to about 1900 when a trading post was built at the confluence of the Ross River with the Pelly River. The post became an important trading centre, as it was the navigational limit of steamboats on the Pelly and served aboriginal people in the Pelly, Ross River and Macmillan River areas. The construction of the Canol Pipeline and Road in 1942 to 1944 between Norman Wells, NWT and Whitehorse, created the first road transportation link for Ross River with the Alaska Highway. With the closing of the Canol Road in the 50's, many residents moved to Watson Lake, Whitehorse and Carmacks. Between 1955 and 1964, approximately five extended Indian families, two white families, and a priest lived in the settlement of Ross River (Sharp 1977).

The old Indian village, located around the original trading post, was moved between 1960 and 1963 to the present village site on the south side of the Pelly River.

Major population growth occurred between 1962 and 1968 with the discovery of lead, zinc and silver deposits near Faro. The Canol Road was reopened in 1962 and by 1966 the Anvil orebody was scheduled to become a mine. To facilitate mine development, a road was built from Watson Lake to Faro, by-passing Ross River. An airstrip was built in Ross River. Secondary development occurred along with the mining exploration and mine development, including a motel, bar and beer parlour, department store, a police station, health clinic, water system and other facilities.

The population of Ross River was 327 in June 2004 and 329 in June 2003 (Yukon Monthly Statistical Review, July, 2004). Of the current population in Ross River, approximately 325, or 99%, are Ross River Kaska Dena (Profile of Yukon Aboriginals, 2001 Census).

Ross River is unincorporated. The Ross River Dena Council is recognized as the local First Nations government. Facilities in Ross River include a new school which opened in November 2000 which includes Kindergarten to Grade 10. Students generally go to Whitehorse for Grades 11 and 12. In addition there is a Yukon College community campus for adult education; a highways maintenance facility; a RCMP post; a medical facility (but the nearest doctor is in Faro); a hotel; gas station; restaurant and pub. The Ross River Dena Council also operates a store. Water supply is delivered by truck to the households. Sewage is by pump outs and septic fields. Housing supply is very limited (reported only two or three houses available) and the land base for residential development is quite limited.

3.4.3.2 Watson Lake

The Municipality of Watson Lake is located in southeastern Yukon. It is situated on the Alaska Highway at the junction with the Robert Campbell Highway. The town of Watson Lake grew from the construction of the military airport constructed in 1942 and the construction of the Alaska Highway (the Alcan project), completed in 1942.

The population of Watson Lake in June 2004 was 1,553 (Yukon Monthly Statistical Review, July, 2004). Like most resource based towns the population growth rate of Watson Lake is significantly affected by the level of mining and forest harvesting activities. For example, the unemployment rate in Watson Lake for 1996 was 11.3% compared to the unemployment rate of 6.6% for April 2004; the same percentage rate as Dawson City. (Source: Yukon Bureau of Statistics).

Major economic activities include government services, tourism, transportation, forest harvesting, and mining. Tourism has shown steady growth from an annual summer tourist flow along the Alaska Highway. Watson Lake being a transportation hub has benefited from the steady growth. Watson Lake has served primarily as a transportation, housing and communication centre of the mining industry.

Watson Lake was incorporated as a town in 1984. It is governed by an elected municipal council consisting of a mayor and four councillors, each elected for three-year terms. Watson Lake has a well developed infrastructure of paved roads, adequate water supply from wells, domestic sewage collection and treatment and is served by diesel electric generated power supply. The housing supply had been increased in expectation of mine development and presently the estimated vacancy rate is 25.7% (Bureau of Statistics July, 2004). Other services include a local detachment of the Royal Canadian Mounted Police, court facilities, fire protection, a regional hospital and health centre and a campus of the Yukon College. Watson Lake also has 2 public schools that go from Kindergarten to Grade 7 (Johnson Elementary) and from Grade 8 to Grade 12 (Watson Lake Secondary School).

3.4.3.3 Whitehorse

Whitehorse is the capital and largest city in the Yukon, with a population of 22,673 (Yukon Monthly Statistical Review, July 2004) or about 74.4% of the Yukon population. It is the major centre for transportation, retail and commercial and government services.

With such a large percentage of the Yukon's population, it is reflective of much of the statistics for the Yukon as a whole.

The history of Whitehorse dates back to about 1898. Located at the head of navigation on the Yukon River, Whitehorse started as a transhipment site for prospectors during the Klondike gold rush. In 1900, it became a permanent settlement as the Whitepass and Yukon Railway was completed running from Skagway Alaska to Whitehorse. From 1900 to 1941, Whitehorse was a transportation hub with the railroad, river boats to Dawson and for air freight and mail. It also had supporting services for tourism and mining. The population was about 750 people until 1941 when construction started on the Alcan Highway. Major growth occurred in Whitehorse in 1941 when the Alcan Highway, the Canol Pipeline and northern airfields were constructed for supporting the war effort. Whitehorse became the major staging point for the effort which brought in over 30,000 American and Canadian servicemen and civilians during the construction period. With the completion of the Alaska Highway, Whitehorse became the major transportation center in the Yukon. In 1953, the Territorial government was moved from Dawson to Whitehorse.

Whitehorse is a modern city with essentially all the amenities of any similar size Canadian city.

The housing vacancy rate for Whitehorse in June 2004 was 4.1%. This is a slight decrease from 4.5% in June 2003 (Yukon Monthly Statistical Review, July, 2004). Whitehorse has adequate municipal land that can be used to increase the supply of housing.

3.4.3.4 Faro

Faro is located in south central Yukon and is accessed by the Robert Campbell Highway. Faro is approximately 70 km by road west of Ross River, and 120 km by road east of Carmacks.

The town of Faro was developed in 1966 as a housing and service centre for the Anvil mine. The Robert Campbell Highway was constructed in 1966 from Watson Lake to facilitate the Anvil mine development. Accommodation was constructed for the mainly single 500-person construction work force and then housing was constructed for the operating workforce of approximately 400 people with their families. On June 13, 1969, there was a fire that destroyed the original Faro townsite. The town was rebuilt within several months and expanded services included a hotel, bar, shopping centre and recreational facilities.

The population of Faro has had wide fluctuations, depending on the levels of operation of the Anvil mine. The population in 1966 was approximately 500, increasing to 1,517 in 1991. When the mine shut down in 1992, the population in Faro declined, and was only 515 in 1994 (Bureau of Statistics, 1994). The population has been stable in the last two years. In June, 2004 the population was 360 compared to June 2003 which stood at 363 (Yukon Monthly Statistical Review July, 2004).

The available housing in Faro is very limited. There are some rental apartments available but single family housing is virtually non existent. There is serviced land available to build additional housing but no plans for additional construction have been made.

Faro was originally constructed to support the Anvil mine. Government services in Faro include a school for Kindergarten to Grade 12, a 4-member RCMP detachment, a nursing station, a campus of the Yukon College, restaurants, liquor sales, hotel and service stations. There is an airstrip but no regular scheduled flights.

3.4.4 Transporation

There are two transportation systems in the Yukon, air and road. Both will be used to service the Wolverine project.

3.4.4.1 Air Transport

The air transport system has been well developed, being a major factor in opening up the Yukon. There are excellent airport facilities at Whitehorse, which is served daily by a national airline and is also the base for a number of charter companies. The Watson Lake airport has paved runways and a terminal that is staffed part time. Air connection from Watson Lake to Whitehorse is via charter as there are no scheduled air flights between these two centres.

Ross River and Faro have good quality gravel strips and small terminals. There is little air traffic except for occasional charters and local airline connections to Whitehorse in the summer. None of the airports operate at anywhere near full capacity.

There is a small airstrip adjacent to the Robert Campbell Highway, near Finlayson Lake, about 14 km north of the Kudz Ze Kayah access road junction. This gravel strip is only about 500 metres long and is unsuitable for upgrading to handle twin engine commuter airplanes. There is also a gravel airstrip at the Wolverine exploration camp that is suitable for handling twin engine freight aircraft.

3.4.4.2 Road Transport

There are two major highways in southern Yukon: the Alaska Highway which runs from the B.C. border, through Watson Lake to Whitehorse, then on to Alaska; and the Klondike Highway which runs from Skagway to Dawson City via Whitehorse and Carmacks. There is also the Robert Campbell Highway, which connects Watson Lake and Carmacks via Ross River and Faro (both a few kilometres off the highway).

The Alaska Highway has been upgraded in the last few years and is covered with pavement and “chip seal”. Highway traffic is minimal during the winter months and, although it increases in the summer with the tourist traffic, it is still not yet up to design capacity (YTG). The Klondike Highway is covered with “chip seal” and pavement from Skagway to Carmacks and operates below design capacity all year (YTG).

The Robert Campbell Highway is a secondary gravel highway. Upgrading has been carried out at the north end of the highway from Faro to Carmacks, in order to handle the concentrate trucks from Faro. There has also been some upgrading at the south end between Watson Lake and the Sä Dena Hes mine turn off (42 km). The upgrading on this section should be completed when this mine re-opens. Traffic counts by the YTG Transportation Services have shown that only between eight and 12 vehicles per day travel between Ross River and Watson Lake in the winter months, October to April. During the 1995 summer months this traffic increased to an average of about

60 vehicles per day, with a peak of 86 in July. This is an increase from the 1993/4 average of 44 vehicles per day.

3.5 Valuable Ecological and Cultural Components (VECC)

Those issues that are considered important to local ecology and culture in the Finlayson District have been largely identified through the public consultation processes carried out by Cominco (Kudz Ze Kayah Project,1995-99), Westmin (Wolverine Project, 1996-97) and Expatriate (Finlayson Project, 2000-01). VECC's have been determined to include:

- Air quality;
- Water quality;
- Fisheries resources;
- Wildlife resources;
- Moose populations;
- Finlayson Caribou herd;
- Wilderness setting;
- Recreational fishing and hunting;
- First Nations grave sites;
- Caribou fence sites;
- Ross River group trapline;
- Ross River community issues (jobs, training); and
- Cross cultural understanding of mine employees.

Expatriate Resources Ltd. will consider these environmental and cultural components in their development plans. The Wolverine Project will try to utilize mitigation measures that have proven successful with past projects.

3.6 Additional Studies and Analysis

Given the amount of baseline data available for the project area, very little additional study is anticipated for the Wolverine Project. The baseline investigation study areas from 1995 to 2001 largely cover the development footprint of the project. The only area not covered by the original baseline investigations is the newly identified access road corridor; which has identified some small gaps in the current baseline database of the project area. Those gaps are outlined in the following paragraphs and study plans are proposed to collect the required additional data. The proposed schedule for completion of the studies is shown in Figure 3.59.

3.6.1 Climate

The monitoring of climate conditions at the Wolverine Project will be ongoing throughout development, operations and closure phases of the project. A new automated weather station has been installed (October 2004) at the project site that will monitor rainfall, temperature, humidity, wind speed and direction, and solar radiation. A program of snow pack monitoring will be initiated in the spring of 2005 to gather data on local snowpack conditions.

3.6.2 Soils, Surficial Geology and Terrain Hazards

For the feasibility level study, additional subsoil investigations using backhoe and geotechnical drilling rig will be completed. These additional studies will better determine the foundation conditions at the tailings dam site and plant site to appropriate depths. At the dam site, the potential presence of permafrost and the nature of foundation material on the valley floor below the peat layer and its in situ strength and/or density should be ascertained. Similarly, at the valley slopes of the dam foundation and plant site, possible permafrost condition and depth to competent bedrock will be determined. More detailed topographic maps of the site are required for subsequent studies such that the layout and design of the proposed spillways and diversion ditches can be further refined. Additional geotechnical field investigations and site reconnaissance will be conducted for the ancillary structures including selection of an appropriate landfill location during subsequent studies. Thus, the ground conditions along the proposed spillway and diversion ditch alignments can be determined, and the layout and design of these facilities can be further refined.

Information on ground conditions for the mine access road will be completed in 2005 to a similar standard to those already completed for other project areas. The selected road route will be defined following consultation with Kaska.

3.6.3 Waste Characterization

Additional geochemical testing will be done to characterize tailings and process water quality in 2005. Materials will be produced by pilot plant work to be completed during the feasibility studies. Large-diameter tailings humidity-cell kinetic test program will be conducted in order to confirm the feasibility of adopting a more flexible and cost effective sub-aerial tailings deposition scheme in the impoundment. Tailings process water chemistry data will be reviewed to address the water quality issue of excess water in the tailings impoundment. The tailings process water chemistry data will be reviewed to verify whether the process water needs to be treated prior to release to the environment.

3.6.4 Water Resources

In general, surface water conditions (hydrology, limnology, and water quality) have been adequately characterized for the Wolverine Project area. The regional analysis of surface runoff and flood conditions for the Wolverine Project area will be reviewed and updated for feasibility level design of mine facilities. This data will be used for facility design and analysis of water quality and hydrological effects related to any discharges from the Wolverine operations.

Water quality and hydrology monitoring for the Wolverine Project area will be continued throughout the development, operations, and closure phases of the project. The monitoring programs will focus on the Little Wolverine/Wolverine and Go/Money drainages. The baseline monitoring programs for water quality and hydrology will be expanded in 2004/05 to include major stream crossings for the mine access road. Investigations will follow standards already established in previous baseline monitoring programs.

At present, the only groundwater information available for the Wolverine Project is anecdotal data from exploration drilling. Groundwater conditions in the area of the Wolverine deposit will be characterized during the test mining proposed for early 2005 and early 2005. These studies will include estimation of groundwater inflows to the underground operations and characterization of groundwater quality. Groundwater conditions in the vicinity of the tailing facility will be characterized prior to development and monitored throughout operations and closure.

Sediment quality has been adequately characterized for the Wolverine Project area and no further studies are anticipated prior to development. There is little or no data for major stream crossings along the mine access road. Baseline data on sediment quality at these locations will be collected during the summer of 2005. Monitoring of sediment quality may be considered during operations and closure phases of the project, depending on operation conditions and downstream water quality.

3.6.5 Fisheries and Aquatic Resources

Studies of benthic and periphyton communities in the Wolverine area will be expanded to include the mine access road. The sampling program will be carried out to standards already established in previous baseline work.

Prior studies of fisheries and aquatic resources for the Wolverine Project are extensive. For most aspects, aquatic resources have been characterized. There is a good understanding of the extent of fish presence in the project area, the species present in project area streams, and the relative density and species composition of fish populations. Additional sampling is anticipated in 2004 and 2005 to increase understanding of fish and fish habitat along the mine access road. Selected sites in the Go/Money drainages will be sampled according to standards established in previous baseline investigations.

It should be noted in the fisheries investigations for the Wolverine project area, analysis of metals in fish tissue did not include selenium or mercury, two potentially important metals from an aquatic health perspective. Also, metals in tissue sampling was based on regional composites. Further analysis of metals in fish tissue in Go/Money Creek will be completed for the Wolverine Project Environmental Assessment Report. Studies will focus selection of an indicator species (most likely sculpin) and determination of spatial differences in metals accumulation in these drainages.

3.6.6 Vegetation

Vegetation communities in the Wolverine Project area have been adequately characterized. No vegetation studies have been completed for the mine access road however. Following final selection of the road corridor, vegetation communities will be assessed to the standard established in previous baseline studies.

3.6.7 Wildlife and Ecosystems

The amount of baseline wildlife information collected for the Kudz Ze Kayah and Wolverine projects, in addition to YTG Department of Renewable Resources information, represents some of the most extensive ungulate baseline data collection performed in Yukon. Both wildlife programs were focused on species of regional concern, woodland caribou and moose.

A gap for the Wolverine Project area is the absence of regional ecosystem information. Broad ecosystem mapping will be produced for a much larger area surrounding the project at a scale of 1:250,000. It is anticipated that much of this information will be produced through the use of satellite imagery and the synthesis of existing information sources. Ecosystem maps will be ground truthed in the early summer of 2005.

Wildlife habitat values and a ranking of ecosystem sensitivity will be developed for each map polygon. When used in a GIS environment, this will allow direct and potential project impacts to be quantified.

3.6.8 Archaeology and Heritage Resources

Heritage resource investigations in the Wolverine Project area have located a number of sites and identified additional sites which are purported to be in the area. The area around Wolverine Lake and the proposed mine access road have the potential to host areas of heritage importance. For the Wolverine Project Environmental Assessment Report, the areas specifically proposed for development will be re-examined and mitigation plans developed for any sites that may be disturbed by the Wolverine Project. The findings of the additional investigations and mitigation plans will be reported in the Environmental Assessment Report

Additional investigations will also be completed for the mine access road corridor. Over the winter months in 2004/05, Expatriate will work with Ross River representatives to identify traditional use areas and sites of heritage importance along the proposed mine access road alternatives. In the early summer of 2005, Expatriate will conduct field investigations of the selected road alignment. Study design will follow standards established during previous baseline investigations.

4 ENVIRONMENTAL EFFECTS ASSESSMENT

Environmental Effects Assessment is the principle project-planning tool of an Environmental Assessment Report. In it's most basic form, environmental assessment is the comparison and analysis of environmental conditions and project description information. This allows the identification of project-environment interactions and prediction of effect characteristics using a variety of analysis tools. Based on the potential effects identified, mitigation measures can be developed to eliminate or minimize the environmental effect of the project as a whole.

The following section describes how the environmental effects of the Wolverine Project will be identified, analysed, and presented. It presents a preliminary identification of potential environmental effects and mitigation measures proposed to eliminate or minimize those effects.

4.1 Assessment Process

4.1.1 Assessment Scope

In the environmental effects analysis, the definition of the environment will be extended beyond biological and physical aspects of the project area. The definition of project environment will include consideration of the biological and physical environment, socioeconomic effects, effects on regional and aboriginal land use, effects on archaeological and heritage resources, and effects on human health.

The potential range of the project influence in the environmental component being considered will determine the geographic boundaries limiting the assessment of interactions. For example, the assessment of effects on the physical environment may be limited to areas within the footprint of mine development while assessment of socioeconomic effects will be extended to the communities surrounding or significantly affected by the project.

The assessment of project-environment interactions through time will be achieved by breaking the project development down into four principle phases; construction, operations, and reclamation and decommissioning. The fourth temporal phase, final closure, will be analyzed to assess the final, permanent effects of the project.

The environmental effects analysis of the Wolverine Project will consider this project environment through the following components:

- Analysis of alternative means of carrying out the project and the potential environmental effects of those alternatives;
- Identification of project-environment interactions;
- Potential effects of project-environment interactions;
- Measures taken to mitigate these effects;
- Determination of significance of effects including:
  - Identification of adverse effects;
  - Determination of effect significance; and
  - Likelihood of effect occurrence.

- Analysis of cumulative effects resulting from project development in combination with other regional activities; and
- Identification of potential accidents and malfunctions associated with the project and analysis of their environmental effects.

4.1.2 Assessment Approach

In the initial phase of the assessment, environmental attributes of the project area will be reviewed and a list of valuable ecological and cultural components (VECC's) will be developed. The VECC's will first be selected based on previous consultation carried out by Cominco (Kudz Ze Kayah Project 1995-1999), Westmin (Wolverine Project, 1995-97) and Expatriate Resources (Finalyson Project, 2000-01) and verified through consultation with government agencies, Kaska Dena, and stakeholders. The environmental effects of the Wolverine Project on these VECC's will be analyzed through a four step process:

1. *Analysis of alternative means of carrying out the project.*

For each of the temporal phases identified, a matrix will be developed comparing project development alternatives and environment components. Alternatives to be considered in this process will include various methods, means, and locations for project activities and facilities. Potential project alternative-environment interactions identified through this process will be qualitatively explored and the best alternative identified. A comparison of the project development plan and analysis of alternative means will identify the performance of the Wolverine Project in selecting alternatives with the least potential environmental effect.

2. *Identification of potential project-environment interactions and development of mitigation measures.*

The alternatives analysis matrix will be refined and reduced to include only those alternatives that are selected as part of the project development plan. The identified interactions will be qualitatively identified. Ecological/social relationship will be examined to identify potential secondary or indirect effects. Mitigation measures will be developed to eliminate or reduce the effect of significant adverse interactions. A summary table of the potential effects, corresponding mitigation measures, and residual environmental effects after implementation of mitigation will be provided.

3. *Determination of residual environmental effects*

Each of the residual environmental effects will be described to the extent possible using analysis techniques appropriate for the identified effect. Some examples of the analysis tools that could be used in this process include mathematical models, overlay maps, and consultation with experts.

4. *Determination of significance*

The determination of the significance of environmental effects is an extremely important aspect of an EA. The *Environmental Assessment Act* (EAA) requires that the significance be determined for each environmental effect that is identified, including the cumulative effects of the project. The determination of significance is typically based on:

- Existing environmental conditions;
- Existing scientific, technical and other relevant information;

- Relevant regulatory criteria, standards/objectives, guidelines and thresholds;
- Public comments; and
- Professional judgement.

The significance of effects will be determined qualitatively by considering a number of different criteria. There are many different criteria that can apply, however the ones to be used in this EA are:

- Magnitude (of the effect);
- Geographic Extent (of the effect);
- Duration (of the effect);
- Frequency (of conditions causing the effect);
- Ecological Importance (of resource or attribute);
- Societal Value (of resource or attribute); nad
- Permanence (of effect).

For the purposes of the EA the assessment of the significance of an environmental effect will be undertaken in two steps: (1) automatic designation of significance and (2) assessment of significance by criteria.

1) Automatic Designation of Significance:

As the first step, an environmental effect can be automatically designated to be a negligible effect, a significant adverse effect, a beneficial effect or an uncertain/unknown effect, according to the following definitions. (Not all environmental effects will fit these definitions.)

Negligible Effect (Not Significant) are those environmental effects, which after taking into consideration mitigation measures, are not likely to be measurable beyond the project site area and/or are temporary in duration, and completely reversible within a few days of an activity or disturbance.

Significant Adverse Effects are those environmental effects, which after taking into consideration mitigation measures, are anticipated to: exceed an applicable environmental legal standard, displace or endanger a designated or protected environmental feature or population, or cause proven chronic effects on human health.

Beneficial Effects are those effects that result in improved environmental quality or socioeconomic conditions over baseline conditions.

Uncertain / Unknown Effects are those environmental effects for which there is insufficient information (i.e. either project description, environmental baseline or other) or documented scientific uncertainty or debate.

2) Assessment of Significance by Criteria

In the second step, the remaining environmental effects which could not be automatically designated will need to be assessed carefully by criteria. An environmental effect can be judged to be either a minor adverse effect (not significant) or as a significant adverse effect depending upon its characteristics. The following are suggestions for determining the significance of an affect using several criteria. These will need to be finalized with input from key stakeholders in the EA.

Minor Adverse / Mitigable Effects (Not Significant) are those environmental effects which, after taking into consideration mitigation measures, have magnitudes well below legal regulatory limits, or are otherwise small or moderate in magnitude and exhibit any combination of the following:

- short or moderate in duration;
- occur rarely or sporadically;
- are localized in their geographic extent, and/or
- are quickly reversible.

Significant Adverse Effects are those environmental effects that, after taking into consideration mitigation measures, have a magnitude that is approaching a legal regulatory limit or exhibit any combination of the following:

- occur relatively frequently;
- are long term in duration or permanent effects;
- will affect a large geographic area either on-site or off the mine property; and/or
- will take a long time to recover once the effect ceases.

To better define these decision-rules for the assessment of significance, each criterion may need to be scaled and defined more precisely to allow for a more careful determination of significance and to develop a firm rationale for such determinations. Table 4.1 provides an example of the manner in which the criteria may need to be defined.

4.2 Cumulative Environmental Effects

Cumulative environmental effects will be considered from two perspectives. The cumulative effects to all environmental components resulting from the Wolverine Project will be described in a summary section that concludes the findings of the environmental assessment. The cumulative environmental effects including consideration for other projects and activities in the region will be considered in a separate analysis.

The analysis of cumulative environmental effects on a regional basis will be completed based on the findings of the environmental assessment. Other projects and land uses will be identified within a defined geographic area. The residual effects identified for each of the phases of project development will be compared to available information for potential effects of regional projects and land uses within the time frame of the particular project phase. Effects determined to be negligible will not be considered as part of the cumulative effects analysis. The potential cumulative effects resulting from multiple activities will be identified and qualitatively described. The post-closure effects of the Wolverine Project will be considered in relation to foreseeable projects and activities in the region for a period of ten years following mine closure and completion of reclamation.

The significance of cumulative effects will be assessed using the same methodology as presented above.

Identified potential cumulative effects will be summarized along with active management plans which the company will use to minimize its contribution to cumulative adverse environmental effects in the region.

4.3 Environmental Health and Safety and Accidents and Malfunctions

The discussion of potential accidents and malfunctions will be approached in two parts. In the first part, the project mechanisms, systems, and administration procedures that will be established to respond to accidents and malfunctions will be outlined. This includes description of administrative structure and proposed resources of the environmental health and safety department of the Wolverine Project, the environmental health and safety procedures administered and to be developed by this department, and the Emergency Response and Spill Contingency Plan for the project. An environment and safety monitoring program will be proposed for the mining operations.

In the second part, potential accidents and malfunctions associated with the project will be identified. This will consider malfunction or failure of project components such as preventive engineering features (secondary containment facilities, liners, pumps, etc.), major facilities (tailings dam, waste rock storage facilities, pit walls, underground caving), and potential natural disasters (fire, flood, earthquake). It will consider potential accidents such as vehicle and airplane crashes and equipment accidents. The likelihood and potential environmental effects will be qualitatively described for each malfunction or accident identified. Emergency response procedures and protocols will be associated with identified potential accidents and malfunctions.

4.4 Follow-up Programs

Follow-up, within the context of environmental assessment, is defined in the EAA as a program for:

- verifying the accuracy of the EA of a project; and
- determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project.

A follow-up program provides information about the current status of the project within its environmental setting. This feedback is essential to ensure that those who planned the development and those who manage the environmental affairs of the mine are supplied the information upon which to base their investment and other decisions.

A follow-up program will be developed for aspects of the project with one or more of the following characteristics:

- inadequate baseline environmental information;
- there exists a potential for cumulative environmental effects; and
- there is scientific disagreement over potential effects.

As part of the EAR, a clear statement of the predicted environmental effects and a clear statement(s) of the commitments to mitigation as recommended in the EAR document will be provided. A follow up program including environmental monitoring plans will then be tailored to the most important of these items.

4.5 Preliminary Environmental Assessment and Potential Mitigation Measures

The following section is preliminary assessment of potential effects resulting from the development of the Wolverine Project. Table 4.2 provides a preliminary overview of the direct project-environment interactions anticipated for the Wolverine Project. Indirect effects resulting from interaction between various environmental components are not outlined in this table.

4.5.1 Air Quality

The potential effects to air quality are increases in fugitive dust from disturbed areas, such as borrow areas and roads and emissions from the power plants and incinerator facility.

Fugitive dust would only result during dry periods of the summer months and can be mitigated through watering of roads and some working areas and preventive engineering features on certain equipment (conveyor shrouds, bag houses). Winds in the project areas will quickly disperse any fugitive dust, providing natural mitigation of this potential effect. An additional issue to consider in the assessment of fugitive dust effects is the presence of receptors. In the remote area of the Wolverine Project, there are no human habitants (with the exception of the mine workers) who would be exposed to potential fugitive dust. The local climate, wind conditions, nature of the operation, and lack of human receptors should be considered in the assessment of the overall significance of this effect.

Emissions from the incinerator and power plants are also an issue of minor concern from an air quality perspective. Emissions from these facilities will be very low since modern standard operating procedures will be employed for these facilities including fuel efficiency considerations, regular maintenance, and emissions standards. Local wind conditions will quickly disperse the small amount of emissions that can be expected from such facilities. It is very unlikely that any changes in air quality will be detectable even in the immediate vicinity of these facilities.

The issue of greenhouse gas emissions resulting from project development will be considered as part of the Environmental Assessment Report.

4.5.2 Topography and Landscape Appearance

For the purposes of this assessment, effects to topography and landscape appearance are defined as any changes in aspect, slope, or elevation of the landscape that would likely be visible from an aerial perspective. This definition is adopted as a means of isolating macro changes in the landscape resulting from major earthworks. Although these changes can be considered generally nuetral in their direct environmental effect, the indirect effects of these changes to other environmental components needs to be considered as part of an environmental assessment.

Changes to topography and landscape appearance will result primarily from development of major road corridors, the airstrip, associated borrow areas, and the tailings facility. The extent of topographic change will be quantified in the Wolverine Project Environmental Assessment. Since many components of local ecology are dependent on these basic landscape characteristics, indirect effects can be expected to result in many different environmental compartments as a result of landscape change. The potential indirect effects will be qualitatively described in the Environmental Assessment.

4.5.3 Hydrogeology

For the purposes of the assessment, direct effects to hydrogeology are considered to be changes in phreatic levels and groundwater movement patterns as a result of contact between mine facilities and groundwater resources. For the Wolverine Project, effects to hydrogeology are expected to result from development of the underground mine, the tailings facility, seepage collection pond and diversion ditches.

The underground mine will require dewatering for safety and efficiency of operation. Dewatering will result in a zone of phreatic depression surrounding the mine. Groundwater flow will be directed towards the operation as a result of the head gradient created by the dewatering activity.

The tailings facility will have the opposite effect to that seen from the underground mining operations. The deposition and storage of tailings in this containment facility will result in the development of a localized groundwater “mound” under this facility that will be the combination of natural groundwater and tailings solution captured in tailings mass. The pressure head resulting from the flooded facility will result in a localized zone of groundwater recharge as tailings water moves toward the natural groundwater resource under the facility. The seepage collection pond will have the same type of effect as water contained within the pond connects with underlying aquifers.

The hydraulic connection between tailings pond water and underlying aquifers can be mitigated by reducing the hydraulic conductivity at the base of the facility. This can be accomplished through establishing compacted layer of fine materials or by laying down an impermeable liner at the bottom of the facility. The Wolverine Project Environmental Assessment will model and analyze the effects of various facilities on groundwater and determine what mitigation measures will be needed to minimize groundwater impacts.

In isolation, groundwater levels and movement do not constitute an important ecosystem component. However, groundwater does not behave in an isolated manner and has influence on surface water flow and quality characteristics. The potential indirect effects on surface water resulting from changes to groundwater levels and movement will be identified and described in the Environmental Assessment

4.5.4 Groundwater Quality

During mine operations, effects to groundwater quality may result from operation of the underground mine, tailings facility, and ancillary ponds. The movement of water through these facilities into the surrounding aquifer could result in localized changes to the groundwater quality. As described for hydrogeology, effects on groundwater quality from the tailings facility and seepage collection pond can be mitigated by reducing the hydaulic conductivity between the facility and underlying aquifer. In the underground mine, effects to groundwater quality would result primarily from oxidation of wall rock followed by flooding or flushing of the surface. Soluble materials produced by oxidation are then mobilized into the surrounding aquifer. This process is mitigated by limiting the oxidation process. Exposed walls are in part covered with shotcrete over the short term while the area is being worked and then a neutral backfill containing lime cement is used to fill the area once mining is complete.

Closure of the tailings facility will include creation of a shallow lake. Pore water in the tailings mass may discharge as surface water downstream of the tailing facility. The seepage collection system downstream of the facility and water treatment facilities will continue to operate if required to ensure discharges meet MMER requirement. Over time the tailings mass will consolidate and seepage from the facility will decrease. Closure of seepage ponds will include draining and backfilling the facility. At closure, the mine dewatering system will be shut down, allowing the underground mine to flood. Flooding of the facility will limit oxidation of any exposed wall rock surfaces providing permanent mitigation against impacts to groundwater quality.

The Wolverine Project Environmental Assessment will model and analyze the effects of various facilities on groundwater and determine what mitigation measures will be needed to minimize groundwater impacts.

In isolation, groundwater quality is not an important ecosystem component. However, groundwater does not behave in an isolated manner and has influence on surface water quality characteristics. The potential indirect effects on surface water resulting from changes to groundwater quality will be identified and described in the Environmental Assessment.

4.5.5 Surface Hydrology

For the purposes of this assessment, direct effects to surface hydrology are defined as changes to spatial and temporal aspects of streamflow volumes and distribution resulting from:

- placement of a facility in the path of an existing drainage corridor;
- discharge of effluents to existing streams; and
- extension of a facility through a significant portion of a watershed resulting in potential alteration of surface runoff patterns.

This definition applies to all surface facilities including project infrastructure, access road and airstrip, landfill and backfill borrow areas, water treatment facilities, tailings facility and seepage collection pond. The hydrological effects of operations at Wolverine will be quantified as part of the Environmental Assessment.

The distribution and volume of the annual streamflow is a very important component in ecosystems. Effects on streamflow characteristics can be expected to have secondary effects on several different components of the local ecosystem. The potential secondary effects resulting from changes to the local surface hydrology will be identified and qualitatively described as part of the Environmental Assessment.

4.5.6 Surface Water Quality

Effects on water quality from mine operations can result from discharges of treated mine water, tailings facility seepage and overflow, and use of fresh water from local drainages for potable and process purposes. Mitigation measures to protect local water quality requires development of a water management plan that maximizes water recycle, limits seepage and/or overflow and incorporates water treatment (active or passive) for mine water discharges.

Water quality is a very important component in ecosystems. Effects on water quality can be expected to have secondary effects on several different components of the local ecosystem. Water quality impacts resulting from the Wolverine operations will be quantitatively assessed for the EAR. The potential secondary effects to other ecosystem components resulting from changes to the local surface water quality will be identified as part of the Wolverine Project Environmental Assessment. Results of water quality modelling will be compared to appropriate water quality guidelines to assess potential secondary effects to fish, benthos, and wildlife.

4.5.7 Aquatic Resources

Aquatic resources (fisheries and benthic communities) can be directly effected through physical alteration of habitat for development purposes or indirectly effected by changes in water quality and hydrology resulting from mine operations. Mitigation of impacts to aquatic resources can include development of replacement habitat in uneffected areas.

Impacts to aquatic resources from the Wolverine project will likely be very limited due to the lack of fisheries resources in the immediate project area and small footprint of mine facilities. Direct impacts to aquatic habitat will be quantified in the Wolverine Project Environmental Assessment. Secondary impacts to aquatic resources resulting from changes to water quality will be qualitatively described.

4.5.8 Vegetation

Direct effects to vegetation from mine development are limited to the temporary disturbance of vegetation communities resulting from facility placement and construction. Changes in surface hydrology and drainage may result in shifts in vegetation community composition due to changes in local moisture regime. Mitigation of direct impacts to vegetation is established through ongoing reclamation of disturbed areas. Planting of native species or active encouragement of natural revegetation processes is carried out on a continuous basis throughout the operational life of the mine and is a key component of the closure plan. At closure, surface facilties are decommissioned and exposed surfaces are replanted with native species.

For the Wolverine Project Environmental Assessment, effects to vegetation will be quantified according to the various vegetation associations identified in the project area. Direct effects to vegetation are not likely to be serious since no rare or endangered plants have been identified and the extent of vegetation disturbance is very small.

4.5.9 Wildlife

Project facilities and operations have the potential to affect wildlife in several ways; increased hunting pressure, loss of habitat, and disturbances from operation and transportation activities. The loss and disruption of habitat resulting from the installation of mine facilities and access corridors is another concern. Animal disturbances from the presence of men and equipment has the potential to affect animal calving and migration.

The following sections deal with the potential impacts of the project on wildlife species in the area, with emphasis on caribou and moose. Mitigation measures, developed for previous project by consultation with YTG Renewable Resources' biologists and the Ross River Dena, will minimize potential impacts.

Caribou

Caribou observations in the mine site vicinity are shown in Figure 4.1.

Access Effects

Increased access to the traditional range of the Finlayson caribou herd, especially along their migration route to winter range, has been identified as the primary concern by YTG Renewable Resources and the Ross River Dena. A security station will be maintained near the junction with the Robert Campbell Highway and only authorized vehicles will be allowed on the road. Firearms will be strictly forbidden on site and on the road.

Restricted access along the road and "no hunt" zones will minimize the potential for increased harvest of caribou.

Habitat Effects

Development of the project will remove approximately 680 ha of summer range at the mine site. No unique or especially important habitat types were identified during the vegetation survey. All of the habitat types encountered are typical of the region. Since the habitat that will be impacted is typical and widely distributed in the region, a long-term reduction of the order proposed is not predicted to have an environmental effect.

Caribou depend on sub-alpine basins and ridges for calving and on high ridges and plateaus for rutting. Most calving activity occurs outside of the project area and habitat on rutting ranges adjacent to the development area will not be affected by the project. The project will, therefore, have little impact on habitats that are critical to caribou reproductive activities.

Habitat removed by the road and airstrip during operation of the mine is not expected to result in any significant impact on the Finlayson caribou herd. After decommissioning, this habitat will return through natural succession to productive winter range.

Disturbance Effects

Disturbance to sensitive calving, post-calving, and rutting caribou has the potential to affect the welfare of the Finlayson caribou herd.

The project is not expected to interfere with movements of caribou between their winter range in the Pelly River lowlands and their calving, summer and rutting ranges. The mine site will be relatively compact and mining activity restricted to the upper Go Creek valley. The mine site will not constitute a physical barrier to movements of caribou. Caribou may stay out of the immediate proposed mine site area but it is unlikely that more than the immediate mine site area would be alienated for caribou during construction and operation of the mine.

Information from surveys and from previous YTG radio-collar location surveys suggests that relatively little calving takes place in the project area. The main calving and post-calving aggregation areas are to the west and south of the project area, therefore, interference with these activities from the project is not likely to be significant.

Movements to rutting ranges on adjacent uplands (mostly to the west of the mine site) start by early September and the rut is well underway by early October. Caribou disperse after the rut and inhabit the uplands and lower slopes into mid-November. Caribou surveys indicate relatively few siting of caribou in the mine area. The mine area is located on the eastern edge of the territory used during the rut and in a valley bottom, away from the prefered locations in the upper slopes and sub-alpine areas.

Noise from blasting is not likely to be an issue. All blasting will take place underground and as such, surface noise will be minimal.

Mining activities other than blasting also have a potential to cause impacts on caribou rutting. Given the distance between the mine site and the potential rutting habitat on the uplands (1 to 4 km away), the majority of development and mining related activity (truck traffic, machinery, heavy equipment operation, and camp/office operation) should not interfere with caribou movements or rutting activity.

Available data suggest that relatively little caribou calving takes place near the Wolverine project area. Since 1982 there have been only ten observations of caribou in the post-calving season within 5 km of the mine area.

Reaction of caribou on the calving and rutting areas will be monitored for the first few years of mining activity. Information from this program will provide on-site data that can be used to evaluate the impact.

Road Traffic Effects

The potential for increased caribou mortality and disturbance to traditional range use have been identified as concerns by YTG and Ross River Dena. These aspects are discussed separately for the access road and Robert Campbell Highway.

Access Road

Vehicle and truck traffic along the access road have the potential to affect caribou through collisions and interference with movements of caribou between their seasonal ranges. Measures to reduce the potential for collisions will include:

- driver education;
- setting and enforcing speed restrictions during the migration periods;
- posting warning signs at locations with the greatest potential for animal collisions;
- reporting animal locations by radio to the security gate and other drivers; and
- adjusting speed and frequency of traffic during particularly high risk periods.

Driver training and truck operating procedures will be is presented in the Wolverine Project Environmental Assessment.

Traffic along the access road has the potential to disrupt caribou migrations from their post-rutting range to their winter range. Monitoring of the access road during the mid-November/early January and April/May periods is the key to providing site specific data for managing this potential impact.

Robert Campbell Highway

For other projects proposed for the region, concentrate hauling along the Robert Campbell Highway during the winter has been identified as a concern by YTG Renewable Resources. Heavy truck traffic moving north along the highway towards Faro and Carmacks has the potential to affect caribou on their winter range through direct mortality and through disturbance. The proposed concentrate haul route for the Wolverine Project will travel away from the winter range, moving south along the Robert Campbell highway towards Watson Lake. Historical information indicates that caribou are not common along this portion of the Robert Campbell Highway. Measures to reduce the potential impact related to traffic will be the same as those proposed for the mine access road.

Monitoring of the highway during the mid-November to mid-May period is the key to providing site specific data for managing this potential impact.

Moose

The mine site and mine road should have little impact on moose activities because of the very small areas of site disturbance involved and control of traffic on the road. The noted key habitats will continue to be available and productive. No specific mitigation measures for moose habitat directly affected by the development are considered necessary.

Access Effects

Increased access has been identified by YTG as a concern for local and regional moose populations. This potential impact can be managed by controlling access, as outlined above for caribou.

Habitat Effects

Direct habitat loss is expected to have a minimal impact on moose. The area comprising the mine site provides spring, summer and fall habitat for moose. As with the caribou habitat, the removal of this small amount of moose range in the mine area is not expected to be significant.

The small amount of boreal forest habitat removed for the access road during operation of the mine will not have a significant impact on the regional moose population. These habitats will readily return to suitable moose habitat after decommissioning. Reclamation activities will include re-grading and seeding/planting. Natural regeneration is expected to return these disturbed sites to productive moose habitat within 10 years after decommissioning.

Disturbance Effects

A potential exists for alienation of moose from habitat in the upper Go Creek valley as a result of construction and mining activities. Moose may react by staying out of the mine site and immediately adjacent area, however, moose will still be able to travel through the Go Creek valley to access the upper sub-alpine basins, which are used during the rut and post-rut. The lower portions of these sub-alpine basins and the lower valley slopes are used by moose for calving and will also still be accessible to moose travelling through or inhabiting the Go Creek valley.

Moose movements are expected along the bottom and lower slopes of Go Creek valley. The mine site however is not expected to create a complete barrier to migration either during or after mining. The mine site is relatively small and compact and large mammals will be readily able to move around the mine site features. It has been shown that large mammals adapt very quickly to the presence of industrial activity and readily move through and around a mine site (e.g., Echo Bay's Lupin Mine, Cominco's Red Dog Mine, Expatriate exploration camp).

Road Traffic Effects

Mortality from collisions with vehicles along the access road and the Robert Campbell Highway has a potential to impact the regional moose population. Measures to mitigate and manage this potential impact on moose are the same as those outlined above for caribou.

Wildlife logs will be kept throughout the operating period and will be reviewed annually by YTG Renewable Resources as requested. Although this is not considered a scientific monitoring program, the results can be used to indicate presence and therefore, to a certain extent, displacement and disturbance.

Bears

The reduction of habitat at the mine site and access road should not significantly affect the regional grizzly bear population. Based on home range size in other parts of the Yukon (26 km^2 in south-western Yukon, Pearson 1975), the actual amount of habitat affected for the period of operation would not affect a significant portion of the home range of one or possibly two grizzlies. The habitat types affected by the project are common in the region.

Removal of a small amount of boreal forest along the access road is not expected to have a significant impact on black bears.

Access control will minimize the potential for increased hunting pressure on both black bears and grizzly bears.

The potential for direct mortality of bears through encounters with construction and mine site workers will be reduced through implementation of the following practices:

- recording of all bear sightings;
- warning signs posted and information circulated for workers in the event that bears are regularly observed near the camp and mine site; and

- containment of food wastes in suitable, bear proof containers, daily incineration of food wastes and hauling of residue to a land fill.

Persistent bear problems will be reported to YTG Renewable Resources and any bear control will be dealt with by them.

Wolves

Wolves are a significant component of the wildlife resources of the region. Habitat reduction during life of the project is not significant to wolves, which travel large areas in pursuit of prey. Disturbance associated with the project is likely to keep wolves away from the immediate mine area and result in a loss of hunting terrain during the life of the project. Mitigation for this short term loss of habitat for wolves is not considered necessary. Reclamation and natural succession after decommissioning will return much of project related facilities to suitable hunting terrain for wolves. The long term reduction of habitat at the mine site in upper Go Creek is not expected to have a significant impact on the regional wolf population.

The presence of the access road is likely to result in a minor positive impact for wolves that will take advantage of the road for movement, however, fatalities from collisions with vehicles could result.

Overall, impacts on the regional wolf population are not expected to be significant. Wolves will still be able to travel through the project area, between the boreal forest to the north and the uplands and valleys to the south.

Smaller Carnivores and Furbearers

Impacts on smaller carnivores and furbearers are related to reduction in available habitat. The access road will remove a small amount of boreal forest habitat that is used by upland furbearers (e.g., foxes, marten, weasel). The areas involved will readily return to productive habitat once they are decommissioned and natural succession occurs.

The mine site area provides some habitat for beavers (small ponds on upper Go Creek) and these particular habitats may be indirectly disturbed in the long term. Mitigation for this loss is not considered necessary, given the prevelence of beaver habitat in the area.

Birds

The most significant bird species that rely on the mine site area for habitat is ptarmigan. In terms of direct habitat removal, the mine development will affect willow ptarmigan that breed in the willow, birch and mixed shrub units in the upper Go Creek valley bottom.

Impacts to raptors (mostly golden eagles and gyr falcon) are not expected to be significant. The short term reduction of hunting terrain is not likely to impact local or regional populations of these two species. Breeding by either species has not been documented in the vicinity of the upper Go Creek valley. No nest sites were observed in the area and no family groups were observed in the area during ground work or overflights.

4.5.10 Socioeconomic Conditions, Heritage Resources and Existing Land Use

Effects to socioeconomic conditions cannot be considered to occur as a result of any particular project component. Socioeconomic effects result from the development and operation of the project as a whole. Socioeconomic impacts from development can include changes in local employment and services, changes to existing land use patterns, changes to local demographics (i.e. immigration of workers to local communities). These potential impacts can be influenced by:

- the relatively remote location of the mine;
- Minimize the land area affected, thus minimizing the disturbance of wildlife habitat;
- Control the access to the area and implement a 'no-hunting' policy by employees to minimize the increased hunting pressure on the Finlayson caribou herd;
- Minimize the vehicle traffic thus minimizing the interference with wildlife migration paths;
- Implement a no fishing policy to prevent over-fishing;
- Work with the Ross River Kaska Dena and local outfitters to ensure the long-term conservation of the hunting, fishing, trapping and guiding base in the area;
- Utilize existing infrastructure compatible with current use and long term development plans;
- Employment of the mine workforce from local communities including Ross River, Watson Lake and Whitehorse thus maximizing local employment opportunities;
- Development of a Socioeconomic Participation Agreement between the Ross River Dena and Expatriate Resources to maximize local job and procurement benefits while minimizing the impact on the environment;
- The mine access road from the Robert Campbell Highway will be a private, controlled road. Employees will not be allowed to drive their vehicles on the access road, and will travel to the mine site by bus from the airstrip. Personal use of vehicles for commuting will be discouraged;
- A policy of no guns in camp and no hunting by employees in the immediate project area will be implemented. The no hunting policy on the property will be in effect for all employees whether on duty or not. In addition, the access policy will control the access of vehicles, including off-duty employees, thus eliminating direct access to the area for hunting. In addition, personal use of all terrain vehicles (ATV's) for access around the mine area, that could disturb wildlife or lead to overfishing in North Lakes, will be prohibited; and
- On completion of mining and mine closure, the access road will be removed and obstructions put in place to deter vehicle access.

The project has substantial potential to provide positive long term impacts on employment, income, training and education for local communities and throughout the Yukon.

Assessed impacts and mitigation measures, where appropriate, are discussed in the following sections for community issues, transportation, land use, and heritage resources.

4.5.10.1 Community Issues

Impacts on communities are expected to be mainly positive through increased employment income and through providing or receiving services. The potentially negative impacts include creating a shortage of housing, overcrowded schools, and a need for up-grading water and sewer systems. Indirect impacts may include community disruption by bringing in outsiders to a small community, or social problems such as alcohol or substance abuse.

The project is not expected to exert significant impacts on existing community infrastructures as employees will come from several communities and commute to the mine site. An influx of mine workers is not expected to occur in any of the surrounding communities.

Expatriate is in the process of negotiating a Socioeconomic Participation Agreement with the Kaska Nation to cover the operations at Wolverine. This agreement is expected to include provisions for local employment and benefits.

Potential impacts to surrounding communities will be identified and qualitatively described in the Wolverine Project Environmental Assessment.

Ross River

Ross River is the closest community and will receive benefits from mine development as set out in the Socioeconomic Participation Agreement. Employment preference will be given to Ross River residents and members of the Kaska Nation. However, the need for highly skilled labour for many functions will require recruitment from outside the region. The agreement also provides for specific contracting opportunities to be made available to the Ross River Kaska Dena as well as training.

The population of Ross River is approximately 99% Ross River Kaska Dena. Through the Socioeconomic Participation Agreement, the community will see significant economic benefits with project development.

Potential for negative impacts on Ross River could result from:

- an influx of new residents to Ross River; and
- social-disruption from personnel during construction activities.

The potential for an influx of new residents to Ross River for mine employment will be minimized by the limited availability of houses and land. The Ross River Dena Council has stated that they oppose efforts to increase community population. Since Watson Lake and Whitehorse offer more services, these communities will likely be favoured by most employees.

Some growth in services to support the Wolverine Project may occur, although the growth will likely not be significant. Benefits may flow from joint venture opportunities and participation with service providers. Existing services should see some economic benefits, but locating new service facilities in Ross River will not be promoted by mine operator without agreement with the Ross River Dena.

The potential for impacts on Ross River from construction crews, similar to that experienced during construction of the Anvil Mine, will be significantly reduced. The construction workforce will be housed in camp facilities on site. Private vehicles will be prohibited on the mine access road. The construction workforce will likely work a 7 day week. The 8 hour return drive to Ross River would deter visits, and will be discouraged by the mine operator.

It is not anticipated that the trucking will impact Ross River in a significant way as the trucks will not pass the community.

Whitehorse

Whitehorse will likely see the greatest positive impact. It is expected that the majority of the workforce will reside in Whitehorse, and many services will be procured from Whitehorse. It cannot be estimated very precisely what percent of the mine workforce will reside in Whitehorse, but it will likely be more than 60%. Some of the employees will likely be new residents moving to the Yukon to fill certain skilled job requirements at the mine. The number of new residents is hard to estimate. Given the present level of mining and other industrial activity in the Yukon, there should be an adequate workforce of trained personnel available in the territory.

Watson Lake

Watson Lake will potentially benefit from mine development by employment at the mine and by transportation of concentrates. If the concentrates are hauled past Watson Lake, the majority of the workforce for hauling and truck maintenance are expected to reside in the Watson Lake area.

Watson Lake, with a population of 1,553 as of September, 2000 and a housing vacancy rate of 26%, is expected to be able to absorb any new in-migration workforce.

4.5.10.2 Work Force

The mine operation will require about 121 people in direct employment. This does not consider contracting opportunities for the mine operations which will include:

- trucking and shipping;
- fuels and lubricant supplier;
- reagents supplier;
- gravel and borrow material contracts;
- catering;
- explosives;
- road maintenance; and
- communications and office equipment and supplies.

To account for these employment opportunities and the secondary jobs that will be generated as a result, a multiplier of seven can be applied to the direct employment estimate. The estimated total number of jobs (direct and indirect) that would be generated by the Wolverine Project is about 970.

4.5.10.3 Transportation

Air Transport

The Wolverine Project will include a 1,200 m long airstrip near the mine site. This airstrip will be used by the twin engine commuter aeroplanes moving mine employees in and out of Whitehorse, Watson Lake and maybe Ross River. The operation of this airstrip is not expected to have a significant impact on wildlife. Flight paths will be selected to avoid wildlife calving and rutting areas during sensitive life cycle periods. These sensitive areas and time periods have been identified through field surveys and from YTG data. Flight paths and altitude, with appropriate avoidance windows, will be established.

It should be emphasized that during the mine operating period, most flying activity will be with fixed wing aircraft. Helicopters will likely only be used to carry out environmental sampling and wildlife surveys. Exploration activities carried out in the region will likely continue to use helicopter support but It is impossible to predict how much or when this might occur.

It should also be noted that aerial wildlife surveys themselves have the potential to result in disturbance to wildlife and therefore can result in an adverse impact. As such, additional annual surveys will be kept to the minimum necessary and prudent.

The airstrip is located east of the Tintina Trench that is a migration route for several varieties of large waterfowl. During the migration period, the charter airline would implement procedures to reduce collisions with birds, such as restricting flights in periods of poor visibility.

Transport of personnel by air will minimize road traffic on the Robert Campbell Highway. This airstrip will also provide a better alternative for emergency landings and for medivacs than the current Finlayson Lake strip.

Road Transport

Truck transportation of concentrates and supplies will result in increased traffic on Yukon highways. Impacts may include slowing traffic movement, increasing the potential for accidents, increased noise in communities along the highways and collisions with wildlife. However, these transportation requirements will also provide additional employment for the Yukon and a need for additional services along the trucking route.

The project transportation requirements will result in a minimal percentage increase in load on the Alaska and Klondike Highways. The resulting traffic volume will remain within the design parameters for both these highways.

Concentrate haulage constitutes the major proportion of the trucking requirements. The impacts of the increased truck transportation due to concentrate haulage may be mitigated by contracting with a qualified trucking firm that will:

- Use only experienced, professional drivers;
- Equip all trucks with two-way radio communications; and

- Implement design, safety and operating procedures proven by similar trucking systems utilized in the Yukon.

The increase in traffic load on the Robert Campbell Highway between the site and Watson Lake will be more noticeable during the winter. Unless road upgrades on this section of the Robert Campbell Highway are completed, additional speed restrictions and/or more restrictive operating procedures will be neccessary. The above mitigation measures would also apply.

Road Upgrading

Truck transportation of concentrate and supplies on the Robert Campbell highway could result in upgrading sections of the road. Potential land use impacts could result from this upgrading. Upgrading of the Robert Campbell Highway, while beneficial to the Wolverine Project is not an essential ancillary component of the project. This has been confirmed during review of the Kudz Ze Kayah Project through consultation with the YTG Department of Community and Transportation Services. Consequently, potential affects associated with the upgrading are not within the scope of this review.

During the review process for the Kudz Ze Kayah Project, the YTG Department of Community and Transportation Services reviewed the requirements for road upgrading, including estimates of construction requirements and the schedule.

4.5.10.4 Heritage Resources

During assessment of the Kudz Ze Kayah (Cominco) and Finlayson (Expatriate) Projects, meetings and discussions with the Ross River Dena were held to determine traditional knowledge of the area and existing land use concerns. These meetings and discussions, whether individually or in groups, often included Elders, Chief and Council, various band members, and members of the local environmental committee.

During these meetings, the major concerns identified included:

- The Finlayson Caribou Herd;
- Grave site locations;
- Caribou fence sites;
- Water Resources and water quality;
- Cross-cultural understanding of mine employee; and
- the Group Trapline.

Policies and procedured adopted to address these concerns included:

- A no gun and no hunting policy for mine employees;
- Archaeological assessment of the area to locate grave sites and caribou fence locations, along with other heritage resources. This assessment included oral interviews with elders. No heritage resources were found in the immediate project area;
- Cross-cultural training programs; and

- Provisions to address interruption to trapping in the area included in socioeconomic agreements.

The protection of the Finlayson Caribou Herd was the main focus of the Ross River Dena throughout previous project studies. During the assessment of the Kudz Ze Kayah Project, Band members were involved in the design of wildlife monitoring programs with YTG Renewable Resources personnel and Cominco's consultants. They also participated in the caribou and moose surveys.

Expatriate Resources Ltd. intends to continue the beneficial relationship with the community established in previous years. Expatriate will work with the community to ensure that socioeconomic policies are in line with the interests of the community. Furthermore, Expatriate hopes to finalize its Socioeconomic Participation Agreement shortly and extend the benefits included therein to the Kaska Nation at large.

4.5.10.5 Land Use

Subsistence hunting and trapping will be affected by project development. The Ross River Kaska Dena are the people most likely to be affected. Expatriate Resources Ltd. and Ross River are negotiating a Socioeconomic Participation Agreement. The agreement will include provisions to accommodate Ross River's traditional use of the project area.

In regard to commercial guiding and hunting, the project is in the guiding territory of Ken Reeder of Teslin Outfitters. During the mid and late 90's the degree of exploration activity in the area was having some adverse effect on those operations. The proprieter of Teslin Outfitters at the time (Doug Smarch) was also concerned about greater numbers of people in his guiding area leading to greater hunting pressures. It is not expected that the project will lead to increased impacts on his guiding territory, as these impacts did not involve hunting. The Wolverine Project will mitigate direct impacts by: (1) controlling road access; (2) enforcing a policy of no guns and no hunting along the access road and in the general mine area, (3) limiting use of helicopters during mine development and operation; and (4) maintaining good communication between Expatriate and Teslin Outfitters to identify mining activities that could impact guiding use.

Impacts on fishing use are expected to be minor. At the time of the Kudz Ze Kayah and Finlayson Project reviews, there was fly-in use of the area by Warren LaFave's operations at McEvoy Lake, but he was not using the project area to any significant extent. The potential for direct impacts from increased recreational fisheries use is considered minor due a strict "no fishing" policy set for mine employees.

4.5.11 Archaeological Resources

Archaeological resources can be affected by project activities that disturb surface soils. This includes borrow areas, tailings facility and mine infrastructure. Impacts to archaeological sites can be mitigated by adjusting facility location or design to avoid the site. If site impacts are unavoidable, mitigative salvage of the site can be carried out to collect and preserve artifacts and information about the site before construction activity impacts the site.

The Wolverine Project Environmental Assessment will identify archaeological sites that may be disturbed by project activity. A management plan will be developed for impacted sites and described in the project EAR.

4.5.12 Human Health

The definition of human health used by Health Canada is "a complete state of physical, mental and social well-being and not merely the absence of disease or infirmity" (Health Canada 1999). This definition equates human health to general well being including lifestyles, traditions, spiritual and religious practices, as well as physical health and nutrition. In the perspective of the Wolverine Project, this definition applies most to potential disruption of First Nations traditional lifestyles and disruption of rural lifestyle choices of non-aboriginals living in the area.

During consultation for previous projects in the Finlayson District, Ross River identified community issues including lack of jobs, training, a future for their young people and the implementation of a community based drug/alcohol counselling/treatment program. The Wolverine Project will provide employment and training opportunities for Ross River residents. The mine will be operated as a drug and alcohol free zone.

The project development area falls within the Kaska Nation Traditional Territory and some areas are traditional land use areas. Expatriate intends to work with local First Nations in ensuring that disruption to these areas is minimized. There are no inhabitants in the immediate project area.

The communities and residents along the concentrate haul route will realize an increase in truck traffic along that route. For rural inhabitants, this may be an intrusion to their rural lifestyle choice. For the communities this may also be a disruption to their lifestyle. Expatriate intends to carry out consultation activities that will allow these persons to identify themselves and their concerns and develop mitigation strategies.

The only human health issue related to physical well-being associated with the project is the increased potential for vehicle accidents along the Robert Campbell Highway as a result of increased traffic from concentrate and supply trucks. The impacts of the increased truck transportation may be mitigated by contracting with a qualified trucking firm that will:

- Use only experienced, professional drivers;
- Equip all trucks with two-way radio communications; and
- Implement design, safety and operating procedures proven by similar trucking systems utilized in the Yukon.

5 PUBLIC CONSULTATION

Public and stakeholder consultation is a very important component of the permitting process under EAA. Consultation activities have been carried out for the Kudz Ze Kayah and Wolverine Projects during 1994-97 and for the Finalyson Project in 2000-01. The following is a summary of the historic consultation activities associated with the Wolverine Project and the Finlayson Project.

5.1 Wolverine 1996-97

In July 1996, Westmin presented its proposed baseline studies programs to government technical personnel for review and comment. At each of these meetings, Westmin officials gave an overview of the project, the status and outline of the study plan and proposed work at each meeting. The following is a summary of those meetings. The issues raised at each of these meetings some correspondence relating to those meetings is presented in Appendix 5A.

June 26, 1996	Westmin officials met with DIAND Land Resources representatives. Issues discussed included land use and project access issues and the CEAA review process.
June 27, 1996	Westmin officials met with Department of Fisheries and Oceans. Issues discussed included fisheries management in Wolverine Lake, fisheries assessment programs, and benthic survey techniques.
June 28, 1996	Westmin officials met with DIAND Environment representatives. Issues discussed included First Nations involvement and consultation, land use in the project area, and cumulative effects.
June 28, 1996	Westmin officials met with DIAND Mineral Resources representatives. Issues discussed included Mining Land Use Regulations, project development timeline, First Nations involvement, wildlife, heritage resources, and acid rock characterization.
June 28, 1996	Westmin officials met with DIAND Water Resources representatives. Issues discussed included climate and water quality monitoring and project development plans.
June 28, 1996	Westmin officials met with YTG Renewable Resources. Issues discussed included wildlife, project activity and development plans, cumulative effects, and traditional ecological knowledge.

In February of 1997, Westmin Resources Limited and Atna Resources Limited held an open house in the community of Ross River. The following is a summary of the issues and concerns established in these meetings.

Issue	Predicted Impact	Potential Mitigation (Non-exclusive or Exhaustive)
Sheep	Localized	
Furbearers/Bears	Localized	Garbage management required. Incineration and electric fences.
Moose	• Mortality—Harvest • Mortality—Road Collision (when access road is developed) • Migration/Movement—Barrier Effect	• Fish and Wildlife Management Plan (FWMP) for the area. YTG Renewable Resources committee to work with various stakeholders to assist Ross River Dena Council (RRDC). • Access control. • Continued study. • No hunting policy in camp. • Standard road mitigation, including speed reductions, signage, personnel education, knock down snow berms and other methods. • Westmin/Atna to monitor sightings and report collisions and mortality. • Use of convoys and reduced highway speed. • Baseline studies. • Provide passageway through high use/game trail areas.
Caribou	• Mortality—Harvest • Mortality—Road Collision • Disturbance—Calving • Migration/Movement—Barriers	• YTG Renewable Resources committed to assist RRDC to develop FWMP for the area. • Access control. • Continued studying and monitoring. • Standard avoidance measures—road (*see* **Moose** for same mitigation). • Study haul/transportation corridor options and choose route of least impact. • Use convoys on highway and possibly reduce the speed of haul trucks. • Baseline studies to indicate key areas, avoidance during key times. • Westmin/Atna to monitor effects of cow/calf ratio in area. • Incidental observation. • Baseline studies. • Passageways and signage to be provided for access road.
Fish	• Over-Fishing	• YTG Renewable Resources committed to assist RRDC to develop FWMP. • Westmin/Atna committed to participate in development of the plan. • Baseline studies. • No fishing policy in camp.
Trapper	Economic impact possible due to Disturbance and habitat loss/alteration	Westmin/Atna discussions with RRDC regarding First Nations compensation and other related concerns for the group trapping area.
Outfitter	Localized disturbance and Habitat loss/alteration	Westmin/Atna to discuss with outfitter regarding potential mitigation.

5.2 Finlayson, 2000/01

Expatriate Resources carried out consultation and information sessions with First Nations and government agencies. The following is a list of the meetings conducted and the issues discussed at each meeting. Full summaries of some of these meetings are presented in Appendix 5B.

July 19, 2000	Expatriate officials met with Kaska Nation representatives to provide a general overview of the company and a summary of the Finlayson Project and to discuss development of a socioeconomic Participation Agreement.
October 17, 2000	Expatriate officials met with YTG Renewable Resources to introduce the company and the project and provide a summary of the future activities anticipated for this project.
October 17, 2000	Expatriate officials met with DIAND representatives to introduce the company and project and discuss permitting requirements for the project.
October 18, 2000	Expatriate officials met with DFO, DOE, and DIAND Water Resources to introduce the company and the project and discuss future permitting activities for the project.
October 18, 2000	Expatriate officials met with Kaska Nation representatives to further discussions on the development of a Socioeconomic Participation Agreement. A meeting and issues schedule was established and a resource funding plan developed.
November 22, 2000	Finlayson Project Description Report submitted to DIAND Environment Directorate.
November 22, 2000	Expatriate presents the Finlayson Project at Regional Environmental Review Committee meeting.
November 22, 2000	Public Open House held at the Westmark Hotel in Whitehorse.
November 23, 2000	Public Open House held in Ross River.
November 24, 2001	Meeting with Kaska Negotiators in Ross River on development of the Finlayson Project Socio-economic Agreement.
November 27, 2000	Final agreement on Resource Funding for negotiation of a Socio-economic Agreement signed with the Kaska Nation.
January 18, 2001	Update meeting held in Whitehorse with DIAND to review progress of consultation and Finlayson Project review process.
January 22, 2001	Consultation meeting with Kaska representatives in Vancouver re: Socio-economic agreement.
February 9, 2001	Negotiation session on the Finlayson Project Socio-economic Agreement held in Ross River.
April 18, 2001	Letter correspondence with Kaska regarding Temporary Road Access Proposal of March 19, 2001.
June 6, 2001	Negotiation session on the Finlayson Project Socio-economic Agreement held in Ross River.

5.3 Wolverine 2004

The following negotiation and consultation activities have been carried out in 2004:

March 31, 2004	Negotiation session on the Wolverine Project Socio-economic Agreement held in Ross River.

April 22, 2004	Project overview document entitled “Opportunity for Yukon Silver-Zinc Project Development, Kaska First Nation Traditional Territory, Yukon” prepared for Kaska and the Yukon Government.
July 15, 2004	Negotiation session on the Wolverine Project Socio-economic Agreement held in Ross River.
July 16, 2004	Ross River Chief and Council and Yukon Government representatives tour Wolverine Project area and meet Expatriate Board of Directors.
September 14, 2004	Teleconference negotiation session on the Wolverine Project Socio-economic Agreement
October 14, 2004	Negotiation session on the Wolverine Project Socio-economic Agreement held in Ross River.

5.4 Future Consultation

Expatriate intends to carry out a thorough consultation program throughout the regulatory and review process. The Company will hold open houses in Whitehorse, Ross River and Watson Lake at regular intervals as the project develops. Other potentially affected communities may be identified as the assessment process proceeds and will be included in open house circuit. The open houses will be well publicized and open to all members of the public.

Each open house will present, in a clear and understandable format, up-to-date information on the project and the review process. Expatriate officials and their consultants will be available to answer questions during these open houses. Questionnaires will be distributed to attendees for voluntary completion and return to the Company.

Expatriate Resources will endeavour to identify potentially effected groups and address concerns raised by the public and reviewers. Working groups may be developed, including stakeholders and reviewers, to address specific technical and regulatory issues associated with the project.

The specific details of future consultation plans for the Wolverine Project will be developed in association with stakeholders.

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Tables

Table 2.9: ACID BASE ACCOUNTING RESULTS - Discrete Hanging Wall Samples

December 1996 Data - Westmin Resources Ltd. - Wolverine Project
Data reworked by MEM Inc. November 2000

Sample No.	Drill Hole	Interval (m)			Rock Type	% Total	% Sulfate	Paste	Acid	Neutralization Potential (NP)		
		From	To	Total		Sulfur	Sulfur	pH	Potential	Actual	Ratio	Net
Hanging Wall Samples (15)												
172420	WV96-39	370.8	371.3	0.5	Aphanitic Felsite/rhyolite	2.08	<0.01	7.9	65.0	28.2	0.43	- 36.8
172421	WV96-39	371.3	374.1	2.8	Interbedded rhyolite/argillite	0.82	<0.01	7.9	25.6	174.	6.79	148
172424	WV96-39	379.5	383.7	4.2	Argillite	1.60	<0.01	8.1	50.0	249.	4.98	199
105223	WV96-39	387.1	389.1	2	Carbonaceous Argillite	2.99	<0.01	7.4	93.4	38.1	0.41	- 55.3
105809	WV96-58	73	73.9	0.9	**Argillaceous rhyolite lapilli tuff**	0.79	0.02	7.4	24.1	14.1	0.59	- 10.0
105812	WV96-58	78.2	81.3	3.1	**Silica-pyrite exhalite**	2.14	<0.01	7.7	66.9	24.3	0.36	- 42.6
172410	WV96-63	80.5	83.5	3	Aphanitic Felsite/rhyolite	0.56	<0.01	8.3	17.5	227.	13.0	209
172411	WV96-63	83.5	89	5.5	Interlayered carbonaceous argillite/aphanitic rhyolite	1.11	<0.01	8.1	34.7	234.	6.75	200
172412	WV96-63	89	93.5	4.5	Siliceous argillite	1.16	<0.01	8.2	36.3	155.	4.26	118
172414	WV96-63	96.3	99	2.7	Tuffaceous argillite	2.12	<0.01	8.3	66.3	65.2	0.98	- 1.1
105921	WV96-63	103.3	105.2	1.9	Argillite Fault Gouge	2.69	<0.01	7.9	84.1	151.	1.79	66.7
172337	WV96-72	36.7	39.5	2.8	**Banded magnetite iron formation**	0.73	0.16	7.4	17.8	41.6	2.34	23.8
172340	WV96-72	84.3	84.7	0.4	Argillite Fault Gouge with pyrite	11.9	<0.01	7.8	372	62.9	0.17	-309
172344	WV96-72	88.7	90.3	1.6	Siliceous argillite	1.72	<0.01	8.1	53.8	16.9	0.31	- 36.9
172435	WV96-72	90.3	91.7	1.4	Siliceous argillite	7.60	<0.01	8.4	238	103.	0.43	-135
					Maximum	11.90	0.16	7.4	372	249	13.0	209
					Minimum	0.56	0.02	8.4	17.5	14.1	0.17	-309
					Mean	2.67	0.01	7.8	83.0	106	2.90	22.6
					Median	1.72	<0.01	7.9	53.8	65.2	0.98	- 1.1
					Mean NP/AP						1.27	
Hanging/Foot Wall (between two massive sulphide ore zones) (3)												
172451	WV96-72	96.1	97.1	1	Siliceous argillite	4.04	<0.01	7.4	126	83.7	0.66	- 42.6
172454	WV96-72	100.6	102.7	2.1	Siliceous argillite	2.64	<0.01	7.1	82.5	5.10	0.06	- 77.4
172455	WV96-72	102.7	104.3	1.6	Argillite Fault Gouge	1.78	<0.01	7.1	55.6	28.0	0.50	- 27.6
					Mean	2.82	<0.01	7.2	88.1	38.9	0.41	- 49.2
					Mean NP/AP						0.44	

Table 2.9: ACID BASE ACCOUNTING RESULTS - Discrete Hanging Wall Samples

Sample No.	Al ppm	Sb ppm	As ppm	Ba ppm	Bi ppm	Cd ppm	Ca ppm	Cr ppm	Co ppm	Cu ppm	Fe ppm	La ppm	Pb ppm	Mg ppm	Mn ppm	Hg ppm
Hanging Wall San																
172420	2453	17	<5	44	<2	1.6	6674	57	10	149	25253	3	58	1725	490	<3
172421	2726	9	11	139	<2	0.7	52548	74	17	140	14965	4	168	1910	2831	<3
172424	6297	25	<5	77	<2	1.3	59438	58	10	94	43425	3	117	11944	3495	<3
105223	2247	23	66	34	<2	19.9	14852	48	4	75	23906	5	334	778	214	<3
105809	12044	<5	<5	102	<2	0.6	2842	114	3	91	30041	4	11	2287	98	<3
105812	2055	<5	<5	30	<2	2	7174	107	5	52	23429	<2	209	1025	310	<3
172410	5962	31	21	341	<2	7.8	78306	91	3	169	9322	4	117	2381	646	<3
172411	1267	8	5	80	<2	4.3	83239	69	3	120	13394	2	77	1120	1106	<3
172412	2073	8	<5	84	<2	2.8	57251	115	4	89	15694	3	58	1237	1033	<3
172414	2457	9	53	53	<2	3.8	26100	96	5	62	21774	3	78	753	446	<3
105921	2072	13	116	50	<2	32.7	53899	103	3	169	23799	3	361	1396	643	<3
172337	10465	<5	<5	177	<2	<0.1	3214	122	7	91	41921	3	15	2883	270	<3
172340	2403	36	301	<2	<2	112.9	15062	77	13	1560	90650	<2	4260	4960	632	<3
172344	1810	9	41	52	<2	3.6	5931	71	2	42	15363	5	80	506	131	<3
172435	1411	40	82	16	<2	215.5	34728	54	8	1134	51234	<2	1510	822	602	<3
Hanging/Foot Wa																
172451	2593	48	219	22	<2	15.5	36000	61	5	297	33980	8	59	2605	480	<3
172454	1866	28	39	24	<2	4.3	4371	87	4	58	24043	7	24	403	56	<3
172455	3118	134	52	45	<2	47.1	17038	160	3	397	18511	8	286	820	56	<3

Table 2.9: ACID BASE ACCOUNTING RESULTS - Discrete Hanging Wall Samples

Sample No.	Mo ppm	Ni ppm	P ppm	K ppm	Sc ppm	Ag ppm	Na ppm	Sr ppm	Tl ppm	Ti ppm	W ppm	V ppm	Zn ppm	Zr ppm
Hanging Wall San														
172420	2	70	145	911	<1	0.2	108	26	<10	<100	<5	6	436	9
172421	3	48	684	958	2	0.2	130	189	<10	<100	<5	8	88	3
172424	3	41	218	2195	3	1.1	122	138	<10	197	<5	17	222	6
105223	16	34	649	1028	<1	4.6	124	62	<10	<100	<5	12	2155	14
105809	3	13	827	1013	3	0.2	194	60	<10	<100	<5	35	98	4
105812	11	28	277	818	<1	1	<100	27	<10	<100	<5	12	903	3
172410	1	32	750	393	6	0.4	154	575	<10	<100	<5	8	946	2
172411	2	21	<100	209	5	0.2	109	373	<10	<100	<5	2	556	2
172412	1	30	996	726	1	<0.1	117	213	<10	<100	<5	7	383	5
172414	9	38	935	1549	<1	1	122	132	<10	<100	<5	10	407	17
105921	12	31	389	903	<1	4.1	101	354	<10	<100	<5	11	4152	17
172337	9	37	286	1419	3	0.2	171	118	<10	278	<5	46	174	6
172340	10	49	1046	525	2	25	<100	58	<10	<100	<5	37	15431	14
172344	6	13	352	1016	<1	1.1	106	21	<10	<100	<5	4	437	13
172435	9	24	512	730	<1	14.5	<100	201	<10	<100	<5	12	17663	15
Hanging/Foot Wa														
172451	28	123	4328	957	<1	2.7	117	120	<10	<100	<5	44	1250	12
172454	5	47	1545	757	<1	1.2	<100	14	<10	<100	<5	9	281	11
172455	26	101	7636	1085	<1	7.4	121	65	<10	<100	<5	98	3553	8

Table 2.10: ACID BASE ACCOUNTING RESULTS - Discrete Foot Wall Samples

December 1996 Data - Westmin Resources Ltd. - Wolverine Project
Data reworked by MEM Inc. November 2000

Sample No.	Drill Hole	Interval (m)			Rock Type	% Total	% Sulfate	Paste	Acid	Neutralization Potential (NP)		
		From	To	Total		Sulfur	Sulfur	pH	Potential	Actual	Ratio	Net
Foot Wall Samples (16)												
105227	WV96-39	401.58	403.3	1.72	Chloritic rhyolite lapilli tuff							
105235	WV96-39	416.1	419.1	3	Chloritic rhyolite tuff	0.28	<0.01	8.8	8.8	49.5	5.66	40.8
105831	WV96-58	151.9	154.1	2.2	Argillite	3.31	0.01	7.7	103.1	17.8	0.17	- 85.3
105835	WV96-58	160.6	163.6	3	Quartz-eye feldspar crystal tuff	0.11	<0.01	8.2	3.4	39.1	11.4	35.7
105763+105764	WV96-60 (763)	262.74	263.65	0.91	Sericitic Rhyolite tuff	3.30	<0.01	8.2	103.1	109.	1.06	6.0
	WV96-60 (764)	263.65	265.9	2.25	Pale green sericite - carbonate altered tuffaceous argillite							
105766	WV96-60	268	268.7	0.7	Quartz Vein	0.13	<0.01	8.8	4.1	31.9	7.85	27.8
105773	WV96-60	278.4	280.9	2.5	Argillite Fault Gouge	2.87	0.02	7.7	89.1	82.7	0.93	- 6.4
105777	WV96-60	287.5	288.34	0.84	Sericitic Rhyolite tuff	2.15	<0.01	8.2	67.2	21.5	0.32	- 45.7
105944	WV96-63	135.9	137.7	1.8	Chloritic rhyolite tuff	0.82	<0.01	8.5	25.6	145.	5.65	119
105950	WV96-63	149	151.4	2.4	Pale green sericite - carbonate altered tuffaceous argillite	0.33	<0.01	8.4	10.3	221.	21.4	210
172604	WV96-63	157.7	159.2	1.5	Sericitic Rhyolite tuff	1.59	<0.01	8.1	49.7	99.3	2.00	49.6
175608	WV96-63	164.7	167	2.3	Argillite Fault Gouge with disseminated pyrite	2.06	<0.01	7.7	64.4	23.6	0.37	- 40.8
175609	WV96-63	167	169.6	2.6	Argillite Fault Gouge with disseminated pyrite	5.08	<0.01	7.3	158.8	25.4	0.16	-133
175613	WV96-63	176.6	178.6	2	Tuffaceous argillite	2.19	<0.01	5.8	68.4	22.2	0.32	- 46.2
172460	WV96-72	107.3	109.4	2.1	Argillite	1.70	<0.01	8.4	53.1	345.	6.49	291
172464	WV96-72	117.5	120.4	2.9	Sericitic rhyolite lapilli tuff	0.58	<0.01	8.6	18.1	28.7	1.58	10.6
					Maximum	5.08	0.02	5.8	159	344.6	21.4	291
					Minimum	0.11	<0.01	8.8	3.44	17.8	0.16	-133
					Mean	1.77	0.02	7.0	55.1	84.1	4.36	28.9
					Median	1.70	0.02	8.2	53.1	39.1	1.58	10.6
					Mean NP/AP						1.52	

Table 2.10: ACID BASE ACCOUNTING RESULTS - Discrete Foot Wall Samples

Sample No.	Al ppm	Sb ppm	As ppm	Ba ppm	Bi ppm	Cd ppm	Ca ppm	Cr ppm	Co ppm	Cu ppm	Fe ppm	La ppm	Pb ppm	Mg ppm	Mn ppm	Hg ppm
Foot Wall Sample																
105227	25071	235	161	17	20	303.2	6737	73	40	30758	102423	26	1644	23227	613	7
105235	16500	<5	51	121	<2	2.4	10713	50	5	152	22154	37	26	22883	531	<3
105831	2017	32	52	18	<2	4.7	6665	68	4	123	30036	7	59	359	96	<3
105835	50392	6	30	95	<2	1	6584	70	14	74	69913	19	33	45498	1120	<3
105763+105764	2128	65	98	28	<2	106.9	38281	58	3	585	26186	2	160	1038	423	7
105766	1447	29	50	361	<2	3.4	9914	172	7	71	5442	4	19	1876	234	<3
105773	3751	47	109	38	<2	19.9	36998	60	3	115	24218	4	94	1405	311	<3
105777	2317	7	13	55	<2	1.5	8135	75	3	26	20732	3	35	545	110	<3
105944	33042	<5	15	112	7	12.2	24783	42	18	528	52633	55	118	36628	523	<3
105950	3171	<5	<5	122	<2	2.5	70941	35	4	42	10078	41	20	5300	524	<3
172604	2581	6	9	88	<2	6.5	35636	40	4	15	15433	5	57	1104	345	<3
175608	1818	16	43	55	<2	20.1	8995	40	2	35	17887	7	103	596	94	<3
175609	1837	20	32	30	<2	14.8	10735	69	2	43	42945	4	65	531	105	<3
175613	3227	28	28	73	<2	13.9	16433	97	5	78	18536	11	117	348	45	<3
172460	5418	65	67	109	<2	53.6	66271	32	3	786	25903	18	401	41323	616	3
172464	26325	10	16	52	<2	9.2	5893	25	8	29	40824	47	64	26795	580	<3

Table 2.10: ACID BASE ACCOUNTING RESULTS - Discrete Foot Wall Samples

Sample No.	Mo	Ni	P	K	Sc	Ag	Na	Sr	Tl	Ti	W	V	Zn	Zr
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Foot Wall Sample														
105227	8	6	1159	961	2	244	<100	21	<10	106	<5	13	28283	9
105235	5	3	297	2355	<1	0.1	150	27	<10	106	<5	4	324	19
105831	6	58	1383	818	<1	1.4	102	18	<10	<100	<5	12	691	11
105835	8	2	255	853	2	0.4	<100	16	<10	188	<5	17	470	17
105763+105764	6	7	<100	1077	<1	1.8	105	155	<10	<100	<5	3	10595	16
105766	1	17	<100	671	<1	0.1	107	52	<10	<100	<5	6	423	2
105773	26	74	2446	1436	<1	2.7	101	135	<10	<100	<5	47	1639	10
105777	5	8	574	1217	<1	0.5	<100	35	<10	<100	<5	3	159	6
105944	7	4	351	1277	1	1.2	101	57	<10	147	<5	9	1478	13
105950	4	4	395	1649	<1	0.1	119	143	<10	<100	<5	<2	257	15
172604	4	3	327	1082	<1	0.2	106	77	<10	<100	<5	<2	448	7
175608	14	32	660	727	<1	1.3	106	24	<10	<100	<5	12	973	10
175609	22	61	1423	765	<1	1.5	<100	50	<10	<100	<5	34	773	9
175613	17	107	7514	1263	<1	3.1	117	151	<10	<100	<5	90	876	10
172460	30	32	323	2169	<1	12.2	125	202	<10	<100	<5	26	4207	38
172464	7	6	368	797	<1	0.1	101	14	<10	<100	<5	16	743	20

Table 2.11: ACID BASE ACCOUNTING RESULTS - Discrete Massive Sulphide Samples

December 1996 Data - Westmin Resources Ltd. - Wolverine Project
Data reworked by MEM Inc. November 2000

Sample No.	Drill Hole	Interval (m)			Rock Type	% Total	% Sulfate	Paste	Acid	Neutralization Potential (NP)		
		From	To	Total		Sulfur	Sulfur	pH	Potential	Actual	Ratio	Net
Massive Sulphide (Ore) Samples (11)												
105820	WV96-58	144.6	144.8	0.2	Semi-massive sulphide (PY)	22.2	<0.01	8.2	694	242.	0.35	-452
105824+105825	WV96-58 (824)	147.2	147.5	0.3	Graphitic Argillite Fault Gouge with disseminate pyrite	28.4	0.14	7.8	883	85.70	0.10	-797
	WV96-58 (825)	147.5	147.8	0.3	Massive Sulphides							
105756	WV96-60	252.68	254.67	1.99	Massive Sulphides	44.0	0.11	7.0	1372	85.5	0.06	-1286
105926+105927	WV96-63 (926)	114.6	114.8	0.2	Carbonaceous Argillite	37.2	0.07	7.9	1160	70.5	0.06	-1090
	WV96-63 (927)	114.8	117.35	2.55	Massive Sulphides							
105934+105935	WV96-63(934)	124.66	125	0.34	Carbonaceous Argillite	30.5	0.03	7.0	952	18.0	0.02	-934
	WV96-63 (935)	125	126.5	1.5	Massive Sulphides							
172346	WV96-72	91.7	92.7	1	Massive Sulphides	40.2	0.06	6.9	1254	25.9	0.02	-1228
172348	WV96-72	93.7	94.6	0.9	Massive Sulphides	45.6	0.02	6.3	1424	10.4	0.01	-1414
172350	WV96-72	95.4	96.1	0.7	Massive Sulphides	41.6	<0.01	7.5	1300	54.8	0.04	-1245
172456	WV96-72	104.3	105.7	1.4	Massive Sulphides	32.8	<0.01	7.6	1025	80.2	0.08	-945
172458	WV96-72	105.9	106.7	0.8	Massive Sulphides	33.2	<0.01	7.5	1038	69.6	0.07	-968
172459	WV96-72	106.7	107.3	0.6	Massive Sulphides	32.9	<0.01	7.5	1028	130.	0.13	-898
					Maximum	45.6	0.14	6.3	1424	242	0.35	-452
					Minimum	22.2	<0.01	8.2	694	10.4	0.01	-1414
					Mean	35.3	0.04	7.0	1103	79.3	0.08	-1023
					Median	33.2	0.02	7.5	1038	70.5	0.06	-968
					Mean NP/AP						0.07	

Table 2.11: ACID BASE ACCOUNTING RESULTS - Discrete Massive Sulphide Samples

Sample No.	Al ppm	Sb ppm	As ppm	Ba ppm	Bi ppm	Cd ppm	Ca ppm	Cr ppm	Co ppm	Cu ppm	Fe ppm	La ppm	Pb ppm	Mg ppm	Mn ppm	Hg ppm
Massive Sulphide																
105820	5683	414	246	22	<2	856.5	53365	81	28	3819	157729	<2	405	15395	1527	52
105824+105825	1654	180	233	3	40	855.4	35638	62	84	18236	191256	<2	8970	1087	634	15
105756	698	604	1900	11	<2	750.5	22743	42	16	5162	180694	4	5892	951	585	25
105926+105927	681	120	1867	5	3	673.8	23695	63	30	11660	185148	<2	8170	582	533	14
105934+105935	759	816	650	9	24	2849	1892	62	58	7410	180196	<2	11117	650	173	33
172346	594	359	325	<2	230	936.7	7069	33	44	6352	153395	<2	11869	339	256	48
172348	376	547	1535	<2	54	504.3	2848	37	37	9902	176121	<2	11302	274	157	11
172350	320	260	406	4	17	1027.4	16332	30	34	19329	186076	3	11290	298	448	17
172456	426	472	315	5	6	3310.5	25329	52	17	4242	154317	4	14010	337	755	126
172458	740	346	621	<2	29	1788	20257	30	10	4558	168510	<2	13665	605	441	79
172459	398	275	435	4	<2	3049.4	31518	24	23	2575	170532	<2	13237	747	633	120

Table 2.11: ACID BASE ACCOUNTING RESULTS - Discrete Massive Sulphide Samples

Sample No.	Mo ppm	Ni ppm	P ppm	K ppm	Sc ppm	Ag ppm	Na ppm	Sr ppm	Tl ppm	Ti ppm	W ppm	V ppm	Zn ppm	Zr ppm
Massive Sulphide														
105820	26	71	189	3482	<1	6.2	113	101	<10	<100	<5	180	77168	33
105824+105825	35	127	970	197	<1	78.3	<100	43	<10	<100	<5	91	110218	9
105756	16	22	131	<100	2	147.7	<100	35	<10	<100	<5	22	76172	3
105926+105927	12	31	1153	<100	<1	161	<100	84	<10	<100	<5	20	81400	6
105934+105935	29	166	347	<100	<1	198.2	<100	8	<10	<100	<5	41	248425	4
172346	9	51	442	<100	<1	168.3	<100	21	<10	<100	<5	18	106764	5
172348	7	25	410	<100	<1	186.6	<100	14	<10	<100	<5	10	60211	3
172350	4	20	596	<100	<1	184.6	<100	61	<10	<100	<5	14	103683	3
172456	9	84	419	537	<1	171.2	<100	49	<10	<100	<5	21	273047	3
172458	13	103	501	154	<1	145.8	<100	69	<10	<100	<5	49	143040	11
172459	14	97	186	1004	<1	141	<100	108	<10	<100	<5	30	244990	4

Table 2.12: ACID BASE ACCOUNTING RESULTS - Miscellaneous Discrete Samples

December 1996 Data - Westmin Resources Ltd. - Wolverine Project
Data reworked by MEM Inc. November 2000

Sample No.	Drill Hole	Interval (m)			Rock Type	% Total	% Sulfate	Paste	Acid	Neutralization Potential (NP)		
		From	To	Total		Sulfur	Sulfur	pH	Potential	Actual	Ratio	Net
Dilution Samples (3) - Immediate Foot or Hanging Wall Samples Combined with Massive Sulphide Samples												
105226+105213	WV96-39 (226)	393.3	395.2	1.9	Carbonaceous Argillite (Immediate Hanging Wall)	9.77	0.06	6.4	303.	29.4	0.10	-274.
	WV96-39 (213)	395.2	395.6	0.4	Massive Sulphides (Ore Zone)							
105829+105830	WV96-58 (829)	150	150.45	0.45	Massive Sulphides (Ore Zone)	12.8	0.03	7.7	399.	59.20	0.15	-340.
	WV96-58 (830)	150.45	151.9	1.45	Argillite (Immediate Footwall)							
105938+105939	WV96-63 (938)	130	130.3	0.3	Stringer sulphides (Ore Zone)	6.83	<0.01	7.6	213.	200.	0.94	-14.
	WV96-63 (939)	130.3	130.6	0.3	Argillite (Immediate Footwall)							
Miscellaneous Combined Sample (1)**												
105816+105817	WV96-58 (816)	104.2	105.6	1.4	RHDS	7.14	<0.01	8.1	223.	375.	1.68	152.
	WV96-58 (817)	139.1	141.5	2.4	Stringer sulphides							

** Stringer sulphides are not in an Ore Zone and are not near sample 105816 (a typical hanging wall Rhyolite

Table 2.12: ACID BASE ACCOUNTING RESULTS - Miscellaneous Discrete Samples

Sample No.	Al ppm	Sb ppm	As ppm	Ba ppm	Bi ppm	Cd ppm	Ca ppm	Cr ppm	Co ppm	Cu ppm	Fe ppm	La ppm	Pb ppm	Mg ppm	Mn ppm	Hg ppm
Dilution Samples																
105226+105213	3196	439	369	6	2	376.3	12107	82	17	2678	71521	<2	5585	435	157	7
105829+105830	2509	283	437	11	6	137.1	25059	72	19	3593	90692	4	868	520	313	<3
105938+105939	4511	254	100	16	10	85.7	40168	79	13	13797	60750	11	1305	18007	696	<3
Miscellaneous Co																
105816+105817	3957	277	94	22	<2	233.5	67713	59	5	661	49042	<2	111	33300	2879	19

** Stringer sulphide

Table 2.12: ACID BASE ACCOUNTING RESULTS - Miscellaneous Discrete Samples

Sample No.	Mo ppm	Ni ppm	P ppm	K ppm	Sc ppm	Ag ppm	Na ppm	Sr ppm	Tl ppm	Ti ppm	W ppm	V ppm	Zn ppm	Zr ppm
Dilution Samples														
105226+105213	63	146	1770	758	<1	148.1	119	17	<10	<100	<5	75	36791	12
105829+105830	49	134	2517	910	<1	33.1	<100	60	<10	<100	<5	77	14893	14
105938+105939	22	75	1506	1164	<1	239.2	115	93	<10	<100	<5	38	8528	21
Miscellaneous Co														
105816+105817	13	29	105	1935	2	6.4	115	163	<10	<100	<5	123	22112	5

** Stringer sulphide

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.1

Summary of Precipitation Data from Wolverine Project Area

		Cumulative (mm)
1996	June	5.8
	July	59.8
	August (1-28)	73.1
1997	May (10-30)	19.1
	June	51.2
	July	96.2
	August	49.2

EXPATRIATE RESOURCES LTD
WOLVERINE PROJECT

Table 3.2
Summary of Monthly Temperatures (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Annual
Average	-8.1	-13.7	-10.2	-4.0	2.9	10.2	12.3	8.7	3.7	-2.9	-7.6	-15.4		-2.0
Maximum[1]	3.3	1.6	5	12.8	20	28	30	28	16.1	9.6	1.7	1.8		30
Minimum[1]	-19.8	-32.3	-33.1	-19.7	-7.6	-25	0	-2	-6.9	-17.2	-17.6	-30.5		-33.1
# of days with measurement	58	58	64	89	107	135	134	115	60	62	60	44		986

Note 1: For period of record

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.3
Summary of Monthly Humidity (%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	85	72	66	58	70	58	72	78	79	77	86	83	74
Maximum[1]	100	98	99	99	100	100	100	100	100	100	100	100	100
Minimum[1]	27	28	21	17	21	12	25	28	30	24	53	54	12
# of days with measurement	31	28	31	30	53	106	103	83	30	31	30	31	587

Note 1: For period of record

EXPATRIATE RESOURCES LTD
WOLVERINE PROJECT

Table 3.4
Average Monthly Wind Speed (km/h)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	0.2	0.9	0.8	0.6	1.0	0.8	0.8	1.2	1.1	0.5	0.4	0.5	0.7
Maximum[1]	27	32	27	24	31	32	33	30	30	29	26	26	33
# of days with measurement	31	31	31	31	31	47	42	31	31	31	31	31	399

Note 1: For period of record

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.5
Mean Annual Precipitation for Regional Stations (mm)

Station ID	AES Station	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2101200	Watson Lake Airport	1938-99	31.1	24.6	19.5	15.7	31.6	51.4	55.6	44.3	42.4	35.0	32.3	34.8	418.3
2101135	Tuchitua	1971-99	40.7	30.1	20.7	16.5	42.2	55.9	72.2	50.6	47.2	40.7	41.5	44.8	503.1
2100 FCG	Hour Lake	1982-99	36.1	30.3	25.2	16.6	40.4	58.1	68.0	55.8	47.2	52.2	43.2	41.8	514.6
	mean		36.0	28.3	21.8	16.3	38.1	55.2	65.3	50.2	45.6	42.7	39.0	40.4	478.7

Source: Environment Canada , AES Precipitation Records

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.6
Frequency Analysis of Annual Precipitation

Return Period (years)	Exceedance Probability	Ratio to Mean			Annual Precipitation Estimates (mm)
		Watson Lake Airport (55)*	Tuchitua (13)	Mean Precipitation Ratio	
1.001	0.999	0.187	0.467	0.327	156.68
1.002	0.998	0.258	0.499	0.379	181.31
1.005	0.995	0.357	0.544	0.451	215.79
1.01 (extreme dry year)	0.99	0.435	0.583	0.509	243.72
1.020	0.98	0.514	0.629	0.572	273.58
1.042	0.96	0.601	0.677	0.639	306.07
1.053	0.95	0.628	0.694	0.661	316.47
1.111 (dry year)	0.9	0.725	0.756	0.740	354.41
1.25	0.8	0.833	0.835	0.834	399.29
2	0.5	1.017	0.991	1.004	480.50
5	0.2	1.179	1.159	1.169	559.65
10 (wet year)	0.1	1.256	1.253	1.255	600.61
20	0.05	1.314	1.347	1.331	636.93
25	0.04	1.331	1.356	1.344	643.23
50	0.02	1.374	1.426	1.400	670.25
100 (extreme wet year)	0.01	1.413	1.490	1.451	694.77
200	0.005	1.449	1.548	1.499	717.36
500	0.002	1.488	1.623	1.555	744.57
1000	0.001	1.514	1.675	1.595	763.51

**Number in brackets indicates the number of years of record used in the analysis*
Source: Environment Canada , AES Precipitation Records

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.7

Stage - Discharge Measurements at Station W12 (Go Creek)

Date	Discharge (m^3/s)	Gauge Plate Reading (m)	Pressure Transducer Reading (m)
25-Mar-96	0.04	n/a	n/a
29-May-96	1.18	0.510	0.54
25-Jun-96	0.440	0.355	0.35
5-Jul-96	0.476	0.375	0.37
15-Jul-96	0.431	0.332	0.345
21-Jul-96	0.357	0.310	0.30
6-Aug-96	0.780	0.39	0.375
21-Aug-96	0.357	0.345	0.30
26-Nov-96	0.08		0.17
18-Mar-97	0.023		0.045
28-May-97	0.362	0.331	0.2704
12-Sep-97	0.317		0.2704
14-Jul-97	0.517	0.364	0.324
14-Jun-01	0.809	0.51	0.490
13-Jul-01	0.309	0.28	0.280
4-Aug-01	0.289	0.25	0.250

Table 3.8a
Stage - Discharge Measurements at Station W21

Date	Discharge (m^3/s)	Gauge Plate Reading (m)	Pressure Transducer Reading (m)
25-Mar-96	0.6	n/a	n/a
30-May-96	6.160	0.405	0.41
16-Jul-96	1.904	0.194	0.165
21-Jul-96	1.789	0.172	0.15
22-Aug-96	2.315	0.198	0.18
14-Jul-97	2.376	0.221	0.2
30-May-97	6.489	0.385	0.343

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.8b

Stage - Discharge Measurements at Station W21 (Nougha Creek)

Date	Time	Discharge (m^3/s)	Gauge Plate Reading (m)	Pressure Transducer Reading (m)
25-Mar-96		0.6	n/a	n/a
30-May-96	4:00 P.M.	6.160	0.405	0.41
16-Jul-96	10:00 A.M.	1.904	0.194	0.165
21-Jul-96	5:00 P.M.	1.789	0.172	0.15
22-Aug-96	2:30 P.M.	2.315	0.198	0.18
14-Jul-97	08:40	2.376	0.221	0.2
30-May-97	10:15	6.489	0.385	0.343

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.9
Spot Measurements of Stream Flows in the Wolverine Area

Station ID No.	Station Name	Date	Discharge (m^3/s)
W1	Nougha Creek just below the outlet of Wolverine Lake	25-Mar-96	0.56
		30-May-96	5.16
		6-Jul-96	1.76
		7-Aug-96	1.25
		28-May-97	5.124
		13-Jul-97	2.079
W2	Wolf Creek near mouth	18-Jul-96	0.016
		23-Aug-96	0.015
		28-May-97	0.086
		13-Jul-97	0.027
		11-Sep-97	0.014
W4	Viking Creek near mouth	18-Jul-96	0.008
		23-Aug-96	0.011
		28-May-97	0.007
		13-Jul-97	0.005
		11-Sep-97	0.010
W6	Jasper Creek near mouth	12-Jul-96	0.028
		23-Aug-96	0.033
		30-May-97	0.098
		13-Jul-97	0.031
		11-Sep-97	0.027
W9	Wolverine Creek near the mouth	25-Mar-96	0.002
		29-May-96	0.09
		6-Jul-96	0.0104
		7-Aug-96	0.0227
		26-Nov-96	0.007
W11	Money Creek above Go Creek	25-Mar-96	0.28
		5-Jul-96	3.85
		6-Aug-96	2.77
		28-May-97	2.058
		14-Jul-97	3.549
		12-Sep-97	2.536
W13	Pup Creek near mouth	15-Jul-96	0.058
		21-Aug-96	0.089
		28-May-97	0.108
		14-Jul-97	0.057
		12-Sep-97	0.059
W16	Go Creek upstream of Hawkowl Creek	21-Jul-96	0.121
		27-May-97	0.111
		15-Jul-97	0.119
		12-Sep-97	0.259
W17	Headwaters of Go Creek	21-Jul-96	0.017
		22-Aug-96	0.033
		27-May-97	0.022
		14-Jul-97	0.027
		12-Sep-97	0.018
W18	Tributary upstream of Go Creek	21-Jul-96	0.014
		22-Aug-96	0.014
		27-May-97	0.012
		14-Jul-97	0.019
		12-Sep-97	0.006
W19	Upper Hawkowl Creek	21-Jul-96	0.047
		24-Aug-96	0.047
		27-May-97	0.024
		14-Jul-97	0.074
		12-Sep-97	0.039
W20	Burn Creek upstream of mouth	16-Jul-96	0.001
		20-Aug-96	0.013
		29-May-97	0.024
		15-Jul-97	0.011
		12-Sep-97	0.026
W22	Money Creek at Robert Campbell Highway	25-Mar-96	1.6
		20-Jul-96	4.106
		7-Aug-96	7.60
		28-May-97	4.912
		15-Jul-97	7.582
W23	Money Creek above Dollar Creek	25-Mar-96	0.2
		30-May-96	6.85
		15-Jul-96	0.143
		6-Aug-96	2.40
		28-May-97	2.273
		14-Jul-97	4.109
		12-Sep-97	2.984
W25	Inflow to Little Wolverine Lake	25-Mar-96	0.02
		20-Jun-96	0.262
		6-Jul-96	0.230
		6-Aug-96	0.133
		27-May-97	0.413
		14-Jul-97	0.362
		12-Sep-97	0.232
W26	Wind Creek	30-May-96	1.200
		20-Jun-96	0.0568
		6-Jul-96	0.0925
		7-Aug-96	0.428
		28-May-97	0.507
		14-Jul-97	0.075
W27	Dollar Creek	15-Jul-96	2.6
		21-Aug-96	0.109
		12-Sep-97	0.218
W28	Light Creek at Robert Campbell Hwy	25-Mar-96	0.15
		30-May-96	0.73
		20-Jul-96	0.274
		22-Aug-96	0.393
		28-May-97	0.490
		15-Jul-97	0.440

Table 3.10
Mean Monthly Runoff (mm)

Station ID	Station Name	Period of Record	Drainage Area (km^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
10AB003	King Creek at km 20.9 Nahanni Range Road	1975-88	13.7	5.22	4.23	3.88	3.91	48.09	88.40	53.60	25.56	19.78	18.51	10.54	6.81	288.55
10AA005	Big Creek at km 1084.8 Alaska Highway	1978-99	607	11.65	9.30	9.84	13.50	63.78	88.54	49.67	29.45	30.58	27.12	15.76	13.24	362.44
10AA004	Rancheria River near the Mouth	1984-99	5100	7.83	5.98	5.74	6.40	40.31	84.74	54.96	28.28	25.00	22.54	13.07	9.92	304.78
10AB001	Frances River near Watson Lake	1962-99	12800	6.94	5.04	4.83	5.23	39.09	111.13	77.67	45.71	35.28	29.08	15.32	9.83	385.15
10AA001	Liard River at Upper Crossing	1960-99	33400	7.75	5.74	5.55	6.50	44.87	100.79	63.80	36.12	30.44	25.78	13.24	10.09	350.66
	Mean All Stations		4630	7.91	6.14	6.07	7.26	47.82	93.20	58.97	32.25	27.66	24.31	13.67	9.95	335.23
	Runoff Distribution (%)			2.36	1.83	1.81	2.17	14.26	27.80	17.59	9.62	8.25	7.25	4.08	2.97	100.00
	Mean Small Basins (<1000 km^2)		310	8.43	6.77	6.86	8.71	55.94	88.47	51.64	27.51	25.18	22.82	13.15	10.03	325.49
	Runoff Distribution (%)			2.59	2.08	2.11	2.68	17.19	27.18	15.86	8.45	7.74	7.01	4.04	3.08	100.00
	Mean Large Basins (>1000 km^2)		17100	7.51	5.59	5.37	6.04	41.42	98.89	65.48	36.70	30.24	25.80	13.88	9.95	346.86
	Runoff Distribution (%)			2.16	1.61	1.55	1.74	11.94	28.51	18.88	10.58	8.72	7.44	4.00	2.87	100.00
	% Difference in Runoff Between Small and Large Basins			-0.43	-0.47	-0.56	-0.93	-5.24	1.33	3.01	2.13	0.98	0.43	-0.04	-0.21	

Source: Water Survey of Canada Streamflow Records

Table 3.11
Estimated Mean Monthly Runoff From Mine Sub-Catchment Areas (m3/s)

Station ID	Station Name	Drainage Area (km^2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Mean
W8	Campbell Creek near the Mouth	7.2	0.021	0.018	0.016	0.020	0.129	0.259	0.159	0.087	0.077	0.065	0.038	0.027	0.076
W9	Wolverine Creek	3.3	0.010	0.008	0.007	0.009	0.059	0.119	0.073	0.040	0.035	0.030	0.017	0.012	0.035
W12	Go Creek above Pup Creek	36.4	0.107	0.092	0.083	0.102	0.650	1.309	0.801	0.438	0.388	0.330	1.920	0.135	0.530
W14	Money Creek below Go Creek	238	0.703	0.599	0.540	0.667	4.249	8.558	5.240	2.866	2.540	2.160	1.255	0.884	2.522
W15	Hawkowl Creek near the Mouth	9.8	0.029	0.025	0.022	0.027	0.175	0.352	0.216	0.118	0.105	0.089	0.052	0.036	0.104
W21	Nougha Creek at Robert Campbell Highway	287	0.848	0.722	0.651	0.804	5.124	10.320	6.319	3.456	3.062	2.605	1.514	1.066	3.041
W16	Go Creek above Hawkowl	10.16	0.033	0.026	0.027	0.034	0.218	0.472	0.243	0.131	0.135	0.089	0.051	0.039	0.125

Source: Table 1: Monthly Runoff Distribution, Mean All Stations

Table 3.12
Frequency Analysis of Annual Runoff

Return Period (years)	Exceedance Probability	Ratio to Mean						Annual Runoff Estimates (mm)
		Big Creek (10)*	Frances River (34)	Rancheria River (13)	King Creek (12)	Liard River (39)	Mean Runoff Ratio	
1.001	0.999	0.595	0.553	0.568	0.497	0.555	0.554	185.60
1.002	0.998	0.620	0.582	0.588	0.514	0.582	0.577	193.54
1.005	0.995	0.655	0.623	0.619	0.541	0.620	0.611	204.98
1.01 (extreme dry year)	0.99	0.685	0.658	0.645	0.566	0.652	0.641	214.95
1.020	0.98	0.718	0.697	0.675	0.595	0.687	0.675	226.14
1.042	0.96	0.756	0.735	0.712	0.632	0.730	0.713	239.07
1.053	0.95	0.756	0.755	0.726	0.646	0.744	0.725	243.18
1.111 (dry year)	0.9	0.816	0.806	0.775	0.699	0.798	0.779	261.13
1.25	0.8	0.876	0.871	0.838	0.774	0.863	0.844	282.97
2	0.5	0.994	0.994	0.980	0.960	0.992	0.984	329.83
5	0.2	1.121	1.129	1.152	1.208	1.135	1.149	385.20
10 (wet year)	0.1	1.192	1.194	1.256	1.384	1.213	1.248	418.25
20	0.05	1.251	1.252	1.351	1.544	1.280	1.336	447.75
25	0.04	1.270	1.271	1.379	1.600	1.299	1.364	457.23
50	0.02	1.322	1.323	1.465	1.760	1.358	1.446	484.60
100 (extreme wet year)	0.01	1.370	1.368	1.548	1.920	1.412	1.524	510.74
200	0.005	1.415	1.406	1.629	2.088	1.461	1.600	536.29
500	0.002	1.474	1.458	1.732	2.312	1.523	1.700	569.84
1000	0.001	1.503	1.497	1.809	2.488	1.569	1.773	594.41

**Number in brackets indicates the number of years of record used in the analysis*

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.13
Annual 10-Year 7-Day Low Flows

Station ID	Station Name	Years of Record	Drainage Area (km^2)	Mean Low Flow Date	Record Low ($L/s/km^2$)	Mean 7-Day Low Flow ($l/s/km^2$)	10-Year 7-Day Low Flow ($L/s/km^2$)	25-Year 7-Day Low Flow ($L/s/km^2$)
10AA004	Rancheria River near the Mouth	15	5100	25-Mar	0.629	1.96	1.23	0.896
10AA001	Liard River at Upper Crossing	39	33400	8-Apr	0.958	1.93	1.55	1.44
10AB001	Frances River near Watson Lake	35	12800	31-Mar	1.078	1.68	1.35	1.24
10AB003	King Creek at km 20.9 Nahanni Range Road	11	13.7	2-Apr	0	1.29	0.597	0.471
		Equation of the Trendline*				$y=1.1487x^{0.0499}$	$y=0.4343x^{0.1214}$	$y=0.3184x^{0.1384}$
		Confidence Level (R^2)				0.82	0.99	0.96

**y=Discharge ($L/s/km^2$)   x=Drainage Area (km^2)*

Source: Water Survey of Canada Data Input to Ffame Flood Frequency Analysis Program

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.14
Estimated Low Flow From Mine Sub-Catchment Areas

Station ID	Station Name	Drainage Area (km^2)	Mean 7-Day Low Flow ($l/s/km^2$)	Mean 7-Day Low Flow (m^3/s)	10-Year 7-Day Low Flow ($L/s/km^2$)	10-Year 7-Day Low Flow (m^3/s)	25-Year 7-Day Low Flow ($L/s/km^2$)	25-Year 7-Day Low Flow (m^3/s)
W8	Campbell Creek near the Mouth	7.2	1.268	0.009	0.552	0.004	0.418	0.003
W9	Wolverine Creek	3.3	1.219	0.004	0.502	0.002	0.376	0.001
W12	Go Creek above Pup Creek	36.4	1.374	0.050	0.672	0.024	0.524	0.019
W14	Money Creek below Go Creek	238	1.509	0.359	0.844	0.201	0.679	0.162
W15	Hawkowl Creek near the Mouth	9.8	1.287	0.013	0.573	0.006	0.437	0.004
W21	Nougha Creek at Robert Campbell Highway	287	1.524	0.437	0.863	0.248	0.697	0.200
W16	Go Creek above Hawkowl Creek	10.16	1.290	0.013	0.575	0.006	0.439	0.004

Source: Table 3.13. Annual 10-Year 7-Day Low Flows, Trendline Equations

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.15
Monthly 10 Year 7 Day Low Flows (L/s/km^2)

Station ID	Station Name	Drainage Area (km2)	Years of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10AA004	Rancheria River near the Mouth	5100	13 to 15*	1.99	1.68	1.31	1.22	2.01	13.7	8.3	6.58	5.97	4.23	3.07	2.5
10AA001	Liard River at Upper Crossing	33400	34	1.94	1.68	1.58	1.57	2.99	24.3	11.4	7.75	7.14	4.91	2.75	2.46
10AB001	Frances River near Watson Lake	12800	33	1.75	1.5	1.38	1.36	2.32	23.4	13.8	9.36	8.09	6.05	3.43	2.37
10AB003	King Creek at km 20.9 Nahanni Range Road	13.7	11 to 14*	0.96	0.838	0.511	0.708	1.22	1.7	6.89	15.2	4.01	2.98	1.77	1.09

***some missing data**

Source: Water Survey of Canada Data Input to Ffame Flood Frequency Analysis Program

Table 3.16
Monthly 10 Year 7 Day Low Flows Trendline Equations

Month	Equation of the Trendline*	Confidence Level (R^2)
January	$y = 0.7724x^{0.0936}$	0.9154
February	$y = 0.6752x^{0.0914}$	0.9286
March	$y = 0.3523x^{0.1467}$	0.9936
April	$y = 0.5418x^{0.0987}$	0.9931
May	$y = 0.9027x^{0.1045}$	0.9461
June	$y = 0.6791x^{0.3558}$	0.9898
July	$y = 5.5688x^{0.0721}$	0.6587
August	$y = 18.318x^{-0.0884}$	0.733
September	$y = 3.2247x^{0.0821}$	0.8882
October	$y = 2.4426x^{0.0758}$	0.7973
November	$y = 1.5105x^{0.0737}$	0.7971
December	$y = 0.8392x^{0.1117}$	0.9427

**y=Discharge (l/s/km^2) x=Drainage Area (km^2)*

Source: Figure 3.19. Trendlines

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Table 3.17
Estimated Monthly 10 Year 7-Day Low Flow From Mine Sub-catchment Areas (L/s/km^2)

Station ID	Station Name	Drainage Area (km^2)	Jan	Feb	Mar	Apr	May	Jun	*Jul**	*Aug**	*Sep**	*Oct**	*Nov**	Dec
W8	Campbell Creek near the Mouth	7.2	0.929	0.809	0.471	0.658	1.086	1.371	*6.421*	*0.154*	*3.837*	*2.837*	*0.175*	1.046
W9	Wolverine Creek	3.3	0.864	0.753	0.420	0.610	1.009	1.039	*6.069*	*0.165*	*3.582*	*2.674*	*0.165*	0.959
W12	Go Creek above Pup Creek	36.4	1.081	0.938	0.597	0.773	1.264	2.440	*7.216*	*0.133*	*4.426*	*3.208*	*0.197*	1.254
W14	Money Creek below Go Creek	238	1.289	1.113	0.786	0.930	1.507	4.759	*8.263*	*0.113*	*5.222*	*3.698*	*0.226*	1.546
W15	Hawkowl Creek near the Mouth	9.8	0.956	0.832	0.492	0.679	1.118	1.530	*6.565*	*0.150*	*3.943*	*2.904*	*0.179*	1.083
W21	Nougha Creek at Robert Campbell Highway	287	1.312	1.133	0.808	0.947	1.533	5.087	*8.375*	*0.111*	*5.309*	*3.751*	*0.229*	1.579
W16	Go Creek above Hawkowl Creek	10.16	0.960	0.835	0.495	0.681	1.121	1.549	*6.582*	*0.149*	*3.955*	*2.912*	*0.179*	1.087

**use with caution, low confidence levels*

Source: Table 3.16. Monthly 10 Year 7 Day Low Flows Trendline Equations

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Table 3.18
Maximum Instantaneous Flood Estimates (L/s/km^2)

Station ID	Station Name	Years of Record	Drainage Area (km^2)	mean	2 year	5 year	10 year	20 year	25 year	50 year	100 year	200 year	500 year	1000 year
10AB003	King Creek at km 20.9 Nahanni Range Road	12	13.7	101.0	97.2	123	138	153	158	171	185	198	215	228
10AA001	Liard River at Upper Crossing	21	33400	56.7	54.3	70.5	80.6	90	92.9	102	110	119	130	138
10AB001	Frances River near Watson Lake	37	12800	54.7	52.7	66.1	74.6	82.4	84.9	92.3	99.5	107	116	123
10AA004	Rancheria River near the Mouth	13	5100	66.5	62.0	90.2	108	124	129	143	157	171	189	201
10AA005	Big Creek at km 1084.8 Alaska Highway	10	607	70.1	58.2	96.8	125	153	162	190	217	244	281	308

Source: Water Survey of Canada Data Input to Ffame Flood Frequency Analysis Program

Table 3.19
Maximum Daily Flood Estimates (L/s/km^2)

Station ID	Station Name	Years of Record	Drainage Area (km^2)	mean	2 year	5 year	10 year	20 year	25 year	50 year	100 year	200 year	500 year	1000 year
10AA001	Liard River at Upper Crossing	40	33400	55.4	52.9	68.8	78.8	88.2	91.1	100	109	117	129	137
10AB003	King Creek at km 20.9 Nahanni Range Road	12	13.7	84.4	82.1	103	115	127	130	141	151	160	173	182
10AB001	Frances River near Watson Lake	37	12800	54.3	52.4	65.6	74	81.6	84.0	91.3	98.3	105	114	121
10AA004	Rancheria River near the Mouth	13	5100	62.1	58.4	83.3	99	112	117	129	141	153	168	179
10AA005	Big Creek at km 1084.8 Alaska Highway	11	607	68	59.6	92.3	115	137	143	164	185	205	232	252

Source: Water Survey of Canada Data Input to Ffame Flood Frequency Analysis Program

Table 3.20
Flood Frequency Trendline Equations

Return Period	Equation of the Trendline*	Confidence Level (R^2)
Maximum Instantaneos		
mean	y = 120.75x-0.0766	0.946
10 year	y = 181.27x-0.0764	0.776
50 year	y = 181.27x-0.0764	0.557
1000 year	y = 181.27x-0.0764	0.458
Maximum Daily		
mean	$y = 98.034x^{-0.057}$	0.968
10 year	$y = 143.55x^{-0.0556}$	0.692
50 year	$y = 200.43x^{-0.0544}$	y = 200.43x-0.0544
1000 year	$y = 200.43x^{-0.0544}$	0.439

**y=Discharge (l/s/km^2)   x=Drainage Area (km^2)*

Source: Figure 3.21, 3.22. Trendlines

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Table 3.21
Flood Frequency Estimates for Mine Sub-Catchment Areas (L/s/km^2)

Station ID	Station Name	Drainage Area (km^2)	Instantaneous Maximum				Daily Maximum			
			mean	10 year	100 year	1000 year	mean	10 year	100 year	1000 year
W8	Campbell Creek near the Mouth	7.2	103.80	155.89	229.14	296.24	87.60	128.63	180.02	224.73
W9	Wolverine Creek	3.3	110.20	165.47	243.97	315.76	91.58	134.33	187.83	234.05
W12	Go Creek above Pup Creek	36.4	91.69	137.74	201.15	259.46	79.87	117.55	164.83	206.53
W14	Money Creek below Go Creek	238	79.40	119.33	172.96	222.52	71.76	105.89	148.83	187.28
W15	Hawkowl Creek near the Mouth	9.8	101.38	152.26	223.53	288.86	86.07	126.44	177.03	221.15
W21	Nougha Creek at Robert Campbell Highway	287	78.27	117.64	170.38	219.13	71.00	104.80	147.32	185.47
W16	Go Creek above Hawkowl Creek	10.16	101.10	151.84	222.88	288.01	85.90	126.19	176.68	220.73

Source: Table 12. Flood Frequency Trendline Equations

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Table 3.22
Sampling Schedule for Water Quality in the Wolverine Area

		1995	1996									1997								2000	2001			
SITE DESCRIPTION	**SITE #**	**Oct 2-4**	**Mar. 25-26**	**May 29-30**	**June 20-21**	**July 5-6**	**July 12-21**	**July 19-20**	**Aug. 6-7**	**Aug. 20-24**	**Nov. 26-27**	**Mar 18-19**	**May 27-30**	**Jun 14-15**	**Jul 1-2**	**July 13-15**	**Aug 2**	**Aug 15-16**	**Sept 11-14**	**Jun 14-16**	**Jan 13-14**	**Jun 14-16**	**Jul 11-13**	**Jul 21-**
Nougha Cr. 100 m d/s Wolverine Lake	W-1	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X^{ssv}				
Wolf Cr. 50 m u/s mouth	W-2	X					X			X			X			X			X					
Wolverine Lake mid-transect opposite W-2	W-3	X								X						X			X					
Viking Cr. 50 m u/s mouth	W-4	X					X			X			X			X			X					
Wolverine Lake mid-transect opposite W-4	W-5	X								X						X			X					
Jasper Cr. 30 m u/s mouth	W-6	X					X			X			X^{D}			X			X	X				
Wolverine Lake mid-transect opposite W-6	W-7	X								X						X			X					
Campbell Cr. 30 m u/s mouth	W-8	X					X			X			X			X			X	X^{ssv}				
Wolverine Cr. 50 m u/s beaver dam at mouth	W-9	X	X	X	X	X	X		X	X	X	*	$X^{B, HDL}$	X	X	X^{BD}	X	X	X^{B}	X^{ssv}	X	X^{D}	X	
Little Wolverine Lake mid-transect opposite W-9	W-10	X								X						X			X					
Money Cr. 60 m u/s Go Cr.	W-11	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Go Cr. 20 m u/s Pup Cr.	W-12	X	X	X	X	X	X		X	X	X	X^{HDL}	X	X	X	X	X	X	X	X^{ssv}	X	X	X	
Pup Cr. 20 m u/s mouth	W-13	X					X			X			X			X			X					
Money Cr. 100 m d/s Go Cr.	W-14	X	X	X	X	X	X		X	X	X	X	X^{TDL}	X	X	X	X	X	X	X^{ssv}	X	X	X	
Hawkowl Cr. 30 m u/s Go Cr.	W-15	X		X			X			X			X	X	X	X	X	X	X	X^{ssv}	X	X	X	
Go Cr. 15 m u/s Hawkowl Cr.	W-16	X					X			X			X			X			X	X^{ssv}	X^{D}	X	X^{D}	
Headwaters of Go Cr. (left tributary)	W-17	X					X			X			X			X			X	X				
Headwaters of Go Cr. (right tributary)	W-18	X					X			X			X			X			X					
Upper Hawkowl Cr.	W-19	X					X			X			X			X			X					
Burn Cr. 20 m u/s mouth	W-20	X					X			X			X			X			X					
Nougha Cr. 30 m u/s Robert Campbell Highway	W-21	X	X	X	X	X	X		X	X	X	$X^{D, HDL}$	X	X	X	X	X	X	X	X^{ssv}				
Money Cr. 50 m u/s Robert Campbell Highway	W-22	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X					
Money Cr. u/s Dollar Cr.	W-23		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X					
East Cr.	W-24			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X				
Inflow to Little Wolverine Lake	W-25		X		X	X	X		X	X	X	X	X			X			X	X^{ssv}				
Wind Creek	W-26		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X				
Dollar Creek	W-27						X			X			X			X			X					
Light Creek at Robert Campbell Highway	W-28		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X						
Wind Lake (centre or along shore)	W-29										X	X		X		X**			X			X	X	
Go Creek d/s airstrip	W-30																							
Go Creek u/s airstrip	W-31																					X	X	
Little Wolverine Creek u/s portal location	W-32																					X	X	
Groundwater spring near orebody	W-33																							X
Little Jimmy Lake	M-1							X		X														
Little Wolverine Lake (same as W-10)	L-1							X																
Wolverine Lake (1 mile north of island)	P-1							X																
Wolverine Lake (1/2 way between W2 & W4)	P-2							X																
Wolverine Lake (0.5 miles south of W5)	P-3							X																
Wolverine Lake (1 mile north of W7)	P-4							X																

X denotes that site was sampled
HDL Hydrology data logger installed
TDL Hobo temperature logger installed
B Triplicate benthic samples collected
D Duplicate sample collected
* Creek frozen to bottom, no samples collected
** Sample collected from along the shore
ssv Site-specific variability testing - 3 replicate samples collected

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Table 3.23

Water Quality Analysis Methods and Detection Limits - Wolverine Baseline Program

PARAMETER		DETECTION LIMIT	METHOD
Total and dissolved metals:		(mg/l unless noted)	
Aluminum	Al	0.001	ICP / ICP MS
Antimony	Sb	0.00005	ICP / ICP MS
Arsenic	As	0.00005	ICP / ICP MS
Barium	Ba	0.00005	ICP / ICP MS
Beryllium	Be	0.0005	ICP / ICP MS
Bismuth	Bi	0.0005	ICP / ICP MS
Boron	B	0.001	ICP / ICP MS
Cadmium	Cd	0.00005	ICP / ICP MS
Calcium	Ca	0.05	ICP / ICP MS
Chromium	Cr	0.0001	ICP / ICP MS
Cobalt	Co	0.0001	ICP / ICP MS
Copper	Cu	0.0001	ICP / ICP MS
Iron	Fe	0.01	ICP / ICP MS
Lead	Pb	0.00005	ICP / ICP MS
Lithium	Li	0.001	ICP / ICP MS
Magnesium	Mg	0.05	ICP / ICP MS
Manganese	Mn	0.00005	ICP / ICP MS
Mercury (total)	Hg	0.00005	Cold Oxidation (CVAAS)
Molybedium	Mo	0.00005	ICP / ICP MS
Nickel	Ni	0.0001	ICP / ICP MS
Phosphorus	P	0.05	ICP / ICP MS
Potassium	K	0.2	ICP / ICP MS
Selenium	Se	0.0005	ICP / ICP MS
Silicon	Si	0.05	ICP / ICP MS
Silver	Ag	0.00001	ICP / ICP MS
Sodium	Na	2	ICP / ICP MS
Strontium	Sr	0.0001	ICP / ICP MS
Thallium	Tl	0.00005	ICP / ICP MS
Tin	Sn	0.0001	ICP / ICP MS
Titanium	Ti	0.01	ICP / ICP MS
Vanadium	V	0.001	ICP / ICP MS
Zinc	Zn	0.001	ICP / ICP MS
Total alkalinity	$CaCO_3$	1	Titration to pH=4.5
Ammonia	N	0.005	Colorimetry
Nitrate	N	0.005	Ion Exchange Chromatography
Nitrite	N	0.001	Colorimetry
Nitrite + nitrate	N	0.005	Ion Exchange Chromatography
Sulphate	SO4	0.03	Ion Exchange Chromatography
Total dissolved solids		1 to 5	Filtration/Gravimetric
Total suspended solids		1 to 5	Filtration/Gravimetric
Turbidity		1.0 (NTU)	Nephelometric
Conductivity		1.0 (µS)	Conductivity cell
pH (RelU)		0.1 (RelU)	Potentiometric
Cyanide (total)	CN	0.005	Distillation/UV Detection
Fluoride	F	0.02	Colorimetry
Chloride	Cl	0.5	Colorimetry

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WOLVERINE PROJECT

Table 3.24
Water Quality of Little Wolverine Lake

Depth	(m)	1.0	8.1
General Parameters			
TDS	(mg/L)	64	81
Hardness	(CaCO3)	48.9	63.8
pH		7.53	7.06
NFR	(mg/L)	2	3
Turbidity (NTU)	(NTU)	0.5	1.7
Alkalinity Total	(CaCO3)	43.2	53
Major Anions			
Chloride	(mg/L)	0.5	0.7
Fluoride	(mg/L)	0.08	0.08
Sulphate	(mg/L)	10.2	12
Nutrients			
Ammonia Nitrogen	(mg/L)	0.021	0.02
Nitrate	(mg/L)	<0.005	<0.005
Nitrite	(mg/L)	0.001	0.001
Nitrite/Nitrate	(mg/L)	<0.005	<0.005
Dissolved ortho-Phosphate	ortho - PO4	0.007	0.019
Total Phosphate	PO4	0.016	0.043
Total Cyanide	(mg/L)	<0.005	<0.005
Total Metals			
Aluminum	(mg/L)	0.015	0.014
Antimony	(mg/L)	<0.2	<0.2
Arsenic	(mg/L)	0.00125	0.00252
Barium	(mg/L)	0.04	0.05
Beryllium	(mg/L)	<0.005	<0.005
Bismuth	(mg/L)	<0.1	<0.1
Boron	(mg/L)	<0.1	<0.1
Cadmium	(mg/L)	0.00007	<0.00005
Calcium	(mg/L)	15.2	18.6
Chromium	(mg/L)	<0.0005	<0.0005
Cobalt	(mg/L)	<0.01	<0.01
Copper	(mg/L)	0.0012	0.0008
Iron	(mg/L)	0.03	0.1
Lead	(mg/L)	0.00039	0.00031
Lithium	(mg/L)	<0.01	<0.01
Magnesium	(mg/L)	3.08	3.97
Manganese	(mg/L)	0.008	0.063
Mercury	(mg/L)	<0.00005	<0.00005
Molybdenum	(mg/L)	<0.03	<0.03
Nickel	(mg/L)	<0.02	<0.02
Phosphorus	(mg/L)	<0.3	<0.3
Potassium	(mg/L)	<2	<2
Selenium	(mg/L)	<0.001	<0.001
Silicon	(mg/L)	2.21	3.17
Silver	(mg/L)	<0.00001	<0.00001
Sodium	(mg/L)	<2	<2
Strontium	(mg/L)	0.043	0.054
Thallium	(mg/L)	<0.00005	<0.00005
Tin	(mg/L)	<0.03	<0.03
Titanium	(mg/L)	<0.01	<0.01
Uranium	(mg/L)	0.00035	0.00049
Vanadium	(mg/L)	<0.03	<0.03
Zinc	(mg/L)	0.011	0.006

Depth	(m)	1.0	8.1
Chlorophyll	mg/m3	0.77	1.19
DOC	(mg/L)	3.7	3.7
TOC	(mg/L)	4.0	4.1

Depth	(m)	1.0	8.1
Dissolved Metals			
Aluminum	(mg/L)	0.016	0.009
Antimony	(mg/L)	<0.2	<0.2
Arsenic	(mg/L)	0.00118	0.00203
Barium	(mg/L)	0.04	0.05
Beryllium	(mg/L)	<0.005	<0.005
Bismuth	(mg/L)	<0.1	<0.1
Boron	(mg/L)	<0.1	<0.1
Cadmium	(mg/L)	<0.00005	<0.00005
Calcium	(mg/L)	14.7	18.7
Chromium	(mg/L)	<0.0005	<0.0005
Cobalt	(mg/L)	<0.01	<0.01
Copper	(mg/L)	0.0009	0.0014
Iron	(mg/L)	<0.03	<0.03
Lead	(mg/L)	0.0001	<0.00005
Lithium	(mg/L)	<0.01	<0.01
Magnesium	(mg/L)	2.97	4.15
Manganese	(mg/L)	<0.005	<0.005
Mercury	(mg/L)	<0.00005	<0.00005
Molybdenum	(mg/L)	<0.03	<0.03
Nickel	(mg/L)	<0.02	<0.02
Phosphorus	(mg/L)	<0.3	<0.3
Potassium	(mg/L)	<2	<2
Selenium	(mg/L)	<0.001	<0.001
Silicon	(mg/L)	2.14	3.2
Silver	(mg/L)	<0.00001	<0.00001
Sodium	(mg/L)	<2	<2
Strontium	(mg/L)	0.043	0.054
Thallium	(mg/L)	<0.00005	<0.00005
Tin	(mg/L)	<0.03	<0.03
Titanium	(mg/L)	<0.01	<0.01
Uranium	(mg/L)	0.00037	0.00047
Vanadium	(mg/L)	<0.03	<0.03
Zinc	(mg/L)	0.006	0.006

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.25
Water Quality of inflow to Wolverine Lake

Depth	(m)	1.0	5.0	12.0
General Parameters				
TDS	(mg/L)	56	53	60
Hardness	(CaCO3)	37.7	38.1	39.9
pH		7.36	7.24	6.81
NFR	(mg/L)	2	2	4
Turbidity (NTU)	(NTU)	0.5	0.8	1.6
Major Anions				
Alkalinity Total	(CaCO3)	34.9	35	37.2
Chloride	(mg/L)	0.5	0.5	0.6
Fluoride	(mg/L)	0.11	0.1	0.09
Sulphate	(mg/L)	7.2	7.7	6.9
Nutrients				
Ammonia Nitrogen	(mg/L)	0.021	0.031	0.029
Nitrate	(mg/L)	<0.005	<0.005	<0.005
Nitrite	(mg/L)	<0.001	<0.001	<0.001
Nitrite/Nitrate	(mg/L)	<0.005	<0.005	<0.005
Dissolved ortho Phosphate	ortho - PO4	0.009	0.013	0.037
Total Phosphate	PO4	0.02	0.026	0.068
Total Cyanide	(mg/L)	<0.005	<0.005	<0.005
Total Metals				
Aluminum	(mg/L)	0.007	0.01	<0.005
Antimony	(mg/L)	<0.2	<0.2	<0.2
Arsenic	(mg/L)	0.00087	0.00089	0.00125
Barium	(mg/L)	0.04	0.04	0.05
Beryllium	(mg/L)	<0.005	<0.005	<0.005
Bismuth	(mg/L)	<0.1	<0.1	<0.1
Boron	(mg/L)	<0.1	<0.1	<0.1
Cadmium	(mg/L)	<0.00005	<0.00005	<0.00005
Calcium	(mg/L)	11	11.1	11.4
Chromium	(mg/L)	<0.0005	<0.0005	<0.0005
Cobalt	(mg/L)	<0.01	<0.01	<0.01
Copper	(mg/L)	0.0003	0.0003	0.0004
Iron	(mg/L)	<0.03	<0.03	0.18
Lead	(mg/L)	0.00006	0.00014	0.00011
Lithium	(mg/L)	<0.01	<0.01	<0.01
Magnesium	(mg/L)	2.5	2.54	2.62
Manganese	(mg/L)	0.008	0.01	0.251
Mercury	(mg/L)	<0.00005	<0.00005	<0.00005
Molybdenum	(mg/L)	<0.03	<0.03	<0.03
Nickel	(mg/L)	<0.02	<0.02	<0.02
Phosphorus	(mg/L)	<0.3	<0.3	<0.3
Potassium	(mg/L)	<2	<2	<2
Selenium	(mg/L)	<0.001	<0.001	<0.001
Silicon	(mg/L)	2.38	2.41	3.1
Silver	(mg/L)	<0.00001	<0.00001	<0.00001
Sodium	(mg/L)	<2	<2	<2
Strontium	(mg/L)	0.033	0.033	0.033
Thallium	(mg/L)	<0.00005	<0.00005	<0.00005
Tin	(mg/L)	<0.03	<0.03	<0.03
Titanium	(mg/L)	<0.01	<0.01	<0.01
Uranium	(mg/L)	0.00033	0.00032	0.00031
Vanadium	(mg/L)	<0.03	<0.03	<0.03
Zinc	(mg/L)	<0.005	<0.005	0.01

Depth	(m)	1.0	5.0	12.0
Chlorophyll	mg/m3	0.73	0.91	2.18
DOC	(mg/L)	3.9	4.3	4.1
TOC	(mg/L)	4.4	5.3	4.1

Depth	(m)	1.0	5.0	12.0
Dissolved Metals				
Aluminum	(mg/L)	0.008	0.007	<0.005
Antimony	(mg/L)	<0.2	<0.2	<0.2
Arsenic	(mg/L)	0.00082	0.00084	0.00099
Barium	(mg/L)	0.04	0.04	0.04
Beryllium	(mg/L)	<0.005	<0.005	<0.005
Bismuth	(mg/L)	<0.1	<0.1	<0.1
Boron	(mg/L)	<0.1	<0.1	<0.1
Cadmium	(mg/L)	<0.00005	<0.00005	<0.00005
Calcium	(mg/L)	10.8	10.9	11.4
Chromium	(mg/L)	<0.0005	<0.0005	<0.0005
Cobalt	(mg/L)	<0.01	<0.01	<0.01
Copper	(mg/L)	0.0014	0.001	0.0009
Iron	(mg/L)	<0.03	<0.03	<0.03
Lead	(mg/L)	<0.00005	<0.00005	<0.00005
Lithium	(mg/L)	<0.01	<0.01	<0.01
Magnesium	(mg/L)	2.64	2.66	2.78
Manganese	(mg/L)	<0.005	<0.005	0.111
Mercury	(mg/L)	<0.00005	<0.00005	<0.00005
Molybdenum	(mg/L)	<0.03	<0.03	<0.03
Nickel	(mg/L)	<0.02	<0.02	<0.02
Phosphorus	(mg/L)	<0.3	<0.3	<0.3
Potassium	(mg/L)	<2	<2	<2
Selenium	(mg/L)	<0.001	<0.001	<0.001
Silicon	(mg/L)	2.38	2.37	3.12
Silver	(mg/L)	0.00001	<0.00001	<0.00001
Sodium	(mg/L)	<2	<2	<2
Strontium	(mg/L)	0.035	0.035	0.036
Thallium	(mg/L)	<0.00005	<0.00005	<0.00005
Tin	(mg/L)	<0.03	<0.03	<0.03
Titanium	(mg/L)	<0.01	<0.01	<0.01
Uranium	(mg/L)	0.00036	0.00034	0.00024
Vanadium	(mg/L)	<0.03	<0.03	<0.03
Zinc	(mg/L)	<0.005	<0.005	<0.005

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.26 (contd)
Water Quality of Wolverine Lake

				Dissolved Metals																
Site #	Description	Depth		Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese
		(m)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
P-1	1 mile north of island	1.0		0.007	<0.2	0.0008	0.03	<0.005	<0.1	<0.1	<0.00005	14.9	<0.0005	<0.01	0.0014	<0.03	0.00019	<0.01	4.23	<0.005
P-1	1 mile north of island	9.0		0.01	<0.2	0.00076	0.03	<0.005	<0.1	<0.1	<0.00005	15	<0.0005	<0.01	0.0012	<0.03	0.00012	<0.01	4.28	<0.005
P-1	1 mile north of island	19.0		0.013	<0.2	0.00109	0.03	<0.005	<0.1	<0.1	<0.00005	16.6	<0.0005	<0.01	0.0013	<0.03	0.00012	<0.01	4.78	<0.005
P-2	1/2 way between W2 & W4	1.0		0.007	<0.2	0.00086	0.03	<0.005	<0.1	<0.1	<0.00005	15	<0.0005	<0.01	0.0013	<0.03	0.00015	<0.01	4.21	<0.005
P-2	1/2 way between W2 & W4	5.0		0.011	<0.2	0.00082	0.03	<0.005	<0.1	<0.1	<0.00005	15.1	<0.0005	<0.01	0.0012	<0.03	0.00023	<0.01	4.21	<0.005
P-2	1/2 way between W2 & W4	34.2		0.011	<0.2	0.00091	0.03	<0.005	<0.1	<0.1	<0.00005	15.8	<0.0005	<0.01	0.0011	<0.03	0.0002	<0.01	4.44	<0.005
P-3	0.5 miles south of W5	4.0		0.018	<0.2	0.00086	0.03	<0.005	<0.1	<0.1	<0.00005	15.2	<0.0005	<0.01	0.0014	<0.03	0.00016	<0.01	4.22	<0.005
P-3	0.5 miles south of W5	30.0		0.008	<0.2	0.00091	0.03	<0.005	<0.1	<0.1	<0.00005	15.4	<0.0005	<0.01	0.0013	<0.03	0.00008	<0.01	4.36	<0.005
P-3	0.5 miles south of W5	68.0		0.006	<0.2	0.001	0.03	<0.005	<0.1	<0.1	<0.00005	15.8	<0.0005	<0.01	0.0011	<0.03	0.00008	<0.01	4.47	<0.005
P-4	1 mile north of W7	1.0		0.021	<0.2	0.00084	0.03	<0.005	<0.1	<0.1	<0.00005	14.8	<0.0005	<0.01	0.0014	<0.03	0.0001	0.01	4.31	<0.005
P-4	1 mile north of W7	8.0		0.009	<0.2	0.00083	0.03	<0.005	<0.1	<0.1	<0.00005	14.7	<0.0005	<0.01	0.0012	<0.03	0.00009	<0.01	4.32	<0.005
P-4	1 mile north of W7	30.0		0.007	<0.2	0.00085	0.03	<0.005	<0.1	<0.1	<0.00005	15.2	<0.0005	<0.01	0.0012	<0.03	0.00007	<0.01	4.47	<0.005
P-4	1 mile north of W7	72.0		0.006	<0.2	0.00102	0.03	<0.005	<0.1	<0.1	<0.00005	16.1	<0.0005	<0.01	0.0011	<0.03	0.00008	<0.01	4.58	<0.005

Site #	Description	Depth		Mercury	Molybdenum	Nickel	Phosphorus	Potassium	Selenium	Silicon	Silver	Sodium	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
		(m)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
P-1	1 mile north of island	1.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.97	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00051	<0.03	<0.005
P-1	1 mile north of island	9.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.15	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00052	<0.03	<0.005
P-1	1 mile north of island	19.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	3.2	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00061	<0.03	<0.005
P-2	1/2 way between W2 & W4	1.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.8	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-2	1/2 way between W2 & W4	5.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.74	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-2	1/2 way between W2 & W4	34.2		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.27	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00047	<0.03	<0.005
P-3	0.5 miles south of W5	4.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.73	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-3	0.5 miles south of W5	30.0		<0.00005	<0.03	<0.02	<0.3	2	<0.001	2.2	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-3	0.5 miles south of W5	68.0		<0.00005	<0.03	<0.02	<0.3	2	<0.001	2.83	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00046	<0.03	<0.005
P-4	1 mile north of W7	1.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.67	<0.00001	<2	0.055	<0.00005	<0.03	<0.01	0.00047	<0.03	<0.005
P-4	1 mile north of W7	8.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.7	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-4	1 mile north of W7	30.0		<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.23	<0.00001	<2	0.055	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-4	1 mile north of W7	72.0		<0.00005	<0.03	<0.02	<0.3	2	<0.001	3.09	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00043	<0.03	<0.005

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.26 (contd)
Water Quality in Wolverine Lake

			Total Metals																
Site #	Description	Depth	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese
		(m)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
P-1	1 mile north of island	1.0	0.011	<0.2	0.00078	0.03	<0.005	<0.1	<0.1	<0.00005	15.1	<0.0005	<0.01	0.001	<0.03	0.00040	<0.01	4.15	<0.005
P-1	1 mile north of island	9.0	0.012	<0.2	0.00087	0.03	<0.005	<0.1	<0.1	<0.00005	15.1	<0.0005	<0.01	0.0008	<0.03	0.00027	<0.01	4.2	<0.005
P-1	1 mile north of island	19.0	0.011	<0.2	0.00118	0.03	<0.005	<0.1	<0.1	<0.00005	16.8	<0.0005	<0.01	0.0009	0.03	0.00080	<0.01	4.71	0.009
P-2	1/2 way between W2 & W4	1.0	0.01	<0.2	0.00088	0.04	<0.005	<0.1	<0.1	<0.00005	15.3	<0.0005	<0.01	0.0009	<0.03	0.00033	<0.01	4.15	<0.005
P-2	1/2 way between W2 & W4	5.0	0.01	<0.2	0.00085	0.04	<0.005	<0.1	<0.1	<0.00005	15.3	<0.0005	<0.01	0.0008	<0.03	0.00026	<0.01	4.13	<0.005
P-2	1/2 way between W2 & W4	34.2	0.01	<0.2	0.0009	0.04	<0.005	<0.1	<0.1	<0.00005	15.8	<0.0005	<0.01	0.0007	<0.03	0.00028	<0.01	4.33	<0.005
P-3	0.5 miles south of W5	4.0	0.011	<0.2	0.00086	0.04	<0.005	<0.1	<0.1	<0.00005	15.1	<0.0005	<0.01	0.0008	<0.03	0.00021	<0.01	4.1	<0.005
P-3	0.5 miles south of W5	30.0	0.029	<0.2	0.00092	0.04	<0.005	<0.1	<0.1	<0.00005	15.7	<0.0005	<0.01	0.0007	<0.03	0.00009	<0.01	4.27	<0.005
P-3	0.5 miles south of W5	68.0	0.006	<0.2	0.00106	0.04	<0.005	<0.1	<0.1	<0.00005	16.4	<0.0005	<0.01	0.0007	0.03	0.00010	<0.01	4.49	0.008
P-4	1 mile north of W7	1.0	0.01	<0.2	0.00084	0.03	<0.005	<0.1	<0.1	<0.00005	15	<0.0005	<0.01	0.0008	<0.03	0.00040	<0.01	4.23	<0.005
P-4	1 mile north of W7	8.0	0.011	<0.2	0.00085	0.03	<0.005	<0.1	<0.1	<0.00005	15.1	<0.0005	<0.01	0.0007	<0.03	0.00009	<0.01	4.26	<0.005
P-4	1 mile north of W7	30.0	0.008	<0.2	0.0009	0.03	<0.005	<0.1	<0.1	<0.00005	15.4	<0.0005	<0.01	0.0007	<0.03	0.00016	<0.01	4.36	<0.005
P-4	1 mile north of W7	72.0	<0.005	<0.2	0.00107	0.04	<0.005	<0.1	<0.1	<0.00005	16.5	<0.0005	<0.01	0.0007	0.04	0.00007	<0.01	4.54	0.013

Site #	Description	Depth	Mercury	Molybdenum	Nickel	Phosphorus	Potassium	Selenium	Silicon	Silver	Sodium	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
		(m)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
P-1	1 mile north of island	1.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.86	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00049	<0.03	0.006
P-1	1 mile north of island	9.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.18	<0.00001	<2	0.052	<0.00005	<0.03	<0.01	0.00051	<0.03	<0.005
P-1	1 mile north of island	19.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	3.21	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00061	<0.03	<0.005
P-2	1/2 way between W2 & W4	1.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.8	<0.00001	<2	0.052	<0.00005	<0.03	<0.01	0.00046	<0.03	<0.005
P-2	1/2 way between W2 & W4	5.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.72	<0.00001	<2	0.052	<0.00005	<0.03	<0.01	0.00047	<0.03	<0.005
P-2	1/2 way between W2 & W4	34.2	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.22	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00047	<0.03	0.006
P-3	0.5 miles south of W5	4.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.69	<0.00001	<2	0.052	<0.00005	<0.03	<0.01	0.00045	<0.03	<0.005
P-3	0.5 miles south of W5	30.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.26	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00047	<0.03	<0.005
P-3	0.5 miles south of W5	68.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.86	<0.00001	<2	0.053	<0.00005	<0.03	<0.01	0.00046	<0.03	<0.005
P-4	1 mile north of W7	1.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.65	<0.00001	<2	0.052	<0.00005	<0.03	<0.01	0.00046	<0.03	<0.005
P-4	1 mile north of W7	8.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	1.7	<0.00001	<2	0.052	<0.00005	<0.03	<0.01	0.00047	<0.03	<0.005
P-4	1 mile north of W7	30.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	2.15	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00048	<0.03	<0.005
P-4	1 mile north of W7	72.0	<0.00005	<0.03	<0.02	<0.3	<2	<0.001	3.11	<0.00001	<2	0.054	<0.00005	<0.03	<0.01	0.00044	<0.03	<0.005

EXPATRIATE RESOURCES LTD.
WOLVERINE PROJECT

Table 3.26
Water Quality in Wolverine Lake

			General Parameters					**Major Anions**			
Site #	Description	Depth (m)	TDS (mg/L)	Hardness (CaCO3)	pH	NFR (mg/L)	Turbidity (NTU) (NTU)	Alkalinity Total (CaCO3)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)
P-1	1 mile north of island	1.0	68	54.6	7.67	2	0.3	46.8	0.6	0.1	11.3
P-1	1 mile north of island	9.0	70	55.1	7.42	2	0.5	49.7	0.5	0.1	11.4
P-1	1 mile north of island	19.0	87	61.2	7.15	1	0.4	55.4	0.5	0.1	11.4
P-2	1/2 way between W2 & W4	1.0	73	54.9	7.57	2	0.3	45.8	0.6	0.08	10.9
P-2	1/2 way between W2 & W4	5.0	75	55.1	7.66	2	0.3	45.4	0.6	0.09	11.3
P-2	1/2 way between W2 & W4	34.2	79	57.7	7.39	1	0.2	47.5	0.5	0.09	11.4
P-3	0.5 miles south of W5	4.0	69	55.3	7.66	2	0.3	44.5	0.5	0.09	10.9
P-3	0.5 miles south of W5	30.0	72	56.5	7.41	<1	0.1	47.5	0.5	0.1	11.6
P-3	0.5 miles south of W5	68.0	79	57.9	7.25	1	0.2	49.5	0.6	0.1	11.7
P-4	1 mile north of W7	1.0	67	54.8	7.6	2	0.2	47.3	<0.5	0.08	11.5
P-4	1 mile north of W7	8.0	66	54.5	7.58	2	0.4	47.9	0.6	0.09	11.4
P-4	1 mile north of W7	30.0	69	56.5	7.44	1	0.1	49.5	0.5	0.09	11.7
P-4	1 mile north of W7	72.0	77	59.2	7.24	1	0.3	49.6	0.5	0.1	12.1

			Nutrients							**Organic Parameters**		
Site #	Description	Depth (m)	Ammonia Nitrogen (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Nitrite/Nitrate (mg/L)	Dissolved ortho - PO4	Total PO4	Total Cyanide (mg/L)	Chlorophyll mg/m3	DOC (mg/L)	TOC (mg/L)
P-1	1 mile north of island	1.0	0.006	<0.005	<0.001	<0.005	0.003	0.007	<0.005	0.4	3.9	4.8
P-1	1 mile north of island	9.0	<0.005	<0.005	0.001	<0.005	0.002	0.009	<0.005	0.53	4.4	4.4
P-1	1 mile north of island	19.0	<0.005	0.027	0.001	0.028	0.008	0.015	<0.005	0.62	4.3	4.5
P-2	1/2 way between W2 & W4	1.0	0.006	<0.005	<0.001	<0.005	0.002	0.007	<0.005	0.51	3.4	4.2
P-2	1/2 way between W2 & W4	5.0	<0.005	<0.005	<0.001	<0.005	0.002	0.007	<0.005	0.49	3.1	4.0
P-2	1/2 way between W2 & W4	34.2	<0.005	0.031	<0.001	0.031	0.006	0.008	<0.005	0.54	2.8	3.8
P-3	0.5 miles south of W5	4.0	<0.005	<0.005	<0.001	<0.005	0.003	0.008	<0.005	0.39	3.6	3.9
P-3	0.5 miles south of W5	30.0	<0.005	0.032	<0.001	0.032	0.006	0.009	<0.005	0.29	3.0	4.0
P-3	0.5 miles south of W5	68.0	<0.005	0.055	<0.001	0.055	0.012	0.016	<0.005	0.48	3.4	3.4
P-4	1 mile north of W7	1.0	0.009	<0.005	<0.001	<0.005	0.003	0.008	<0.005	0.51	4.3	4.8
P-4	1 mile north of W7	8.0	<0.005	<0.005	<0.001	<0.005	0.002	0.01	<0.005	0.76	4.3	4.6
P-4	1 mile north of W7	30.0	<0.005	0.031	0.001	0.032	0.005	0.009	<0.005	0.28	4.2	4.5
P-4	1 mile north of W7	72.0	<0.005	0.06	0.001	0.061	0.012	0.016	<0.005	0.22	3.1	3.7

EXPATRIATE RESOURCES LTD
WOLVERINE PROJECT

Table 3.27
Water Quality of Groundwater Spring Near Ore Body

Date	7/21/2001
Conductivity (umhos/cm)	203
Total Dissolved Solids	117
Hardness CaCO3	95.9
pH	8.02
Total Suspended Solids	<3
Turbidity (NTU)	0.2
Alkalinity-Total Ca(	83
Chloride Cl	<0.5
Fluoride F	0.03
Sulphate SO4	15
Ammonia Nitrogen	<0.005
Nitrate Nitrogen	0.532
Nitrite Nitrogen	<0.001
Dissolved ortho-Phosphate P	<0.001
Total Dissolved Phosphate P	<0.002
Total Phosphate P	<0.002

Total Metals		
Aluminum	T-Al	0.048
Antimony	T-Sb	<0.0001
Arsenic	T-As	<0.0001
Barium	T-Ba	0.16
Beryllium	T-Be	<0.001
Boron	T-B	<0.1
Cadmium	T-Cd	<0.00005
Calcium	T-Ca	35.1
Chromium	T-Cr	<0.0005
Cobalt	T-Co	<0.0001
Copper	T-Cu	0.0009
Iron	T-Fe	0.05
Lead	T-Pb	0.00008
Magnesium	T-Mg	2
Manganese	T-Mn	0.029
Mercury	T-Hg	<0.00002
Molybdenum	T-Mo	<0.03
Nickel	T-Ni	<0.001
Potassium	T-K	<2
Selenium	T-Se	<0.001
Silver	T-Ag	<0.00001
Sodium	T-Na	<2
Thallium	T-Tl	<0.00005
Titanium	T-Ti	<0.01
Uranium	T-U	0.0002
Vanadium	T-V	<0.03
Zinc	T-Zn	0.007

Dissolved Metals		
Aluminum	D-Al	<0.005
Antimony	D-Sb	<0.0001
Arsenic	D-As	<0.0001
Barium	D-Ba	0.16
Beryllium	D-Be	<0.001
Boron	D-B	<0.1
Cadmium	D-Cd	<0.00005
Calcium	D-Ca	35.1
Chromium	D-Cr	<0.0005
Cobalt	D-Co	<0.0001
Copper	D-Cu	0.0006
Iron	D-Fe	<0.03
Lead	D-Pb	<0.00005
Magnesium	D-Mg	2
Manganese	D-Mn	<0.005
Mercury	D-Hg	<0.00002
Molybdenum	D-Mo	<0.03
Nickel	D-Ni	<0.001
Potassium	D-K	<2
Selenium	D-Se	<0.001
Silver	D-Ag	<0.00001
Sodium	D-Na	<2
Thallium	D-Tl	<0.00005
Titanium	D-Ti	<0.01
Uranium	D-U	0.0002
Vanadium	D-V	<0.03
Zinc	D-Zn	<0.005
Total Organic Carbon C		1.3

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Table 3.28
Percentage Difference in Duplicate Water Samples

	W21 19-Mar-97	W6 30-May-97	W9 15-Jul-97	W16 13-Jan-01	W9 16-Jun-01	W16 14-Jul-01	Average parameter difference
Physical Tests							
Conductivity (umhos/cm)				95%	100%	100%	98%
Total Dissolved Solids	95%	97%		99%	101%	99%	98%
Hardness CaCO3	101%	99%		99%	100%	101%	100%
pH	100%	99%		98%	102%	99%	100%
Total Suspended Solids	150%	104%					127%
Turbidity (NTU)	171%	81%		111%	140%		126%
Dissolved Anions							
Alkalinity-Total CaCO3	103%	98%		99%	101%	98%	100%
Chloride Cl	100%						100%
Fluoride F	100%	83%		100%	109%	100%	98%
Sulphate SO4	100%	100%		100%	100%	100%	100%
Nutrients							
Ammonia Nitrogen N							
Nitrate Nitrogen N	94%	118%		99%	101%	100%	102%
Nitrite Nitrogen N	100%	100%					100%
Nitrite/Nitrate Nitrogen N	94%						94%
Dissolved ortho-Phosphate P		117%		200%	75%	50%	111%
Total Dissolved Phosphate P				167%	100%	100%	122%
Total Phosphate P				100%	100%	100%	100%
Cyanides							
Total Cyanide CN							
Total Metals							
Aluminum T-Al	129%	108%	110%	100%	94%	100%	107%
Antimony T-Sb		58%	100%		200%		119%
Arsenic T-As	96%	110%	100%		100%		102%
Barium T-Ba	100%	102%	99%	100%	100%	100%	100%
Beryllium T-Be							
Bismuth T-Bi							
Boron T-B							
Cadmium T-Cd		119%	100%		92%		104%
Calcium T-Ca	98%	99%	99%	99%	99%	100%	99%
Chromium T-Cr	111%	100%					106%
Cobalt T-Co		100%					100%
Copper T-Cu	100%	108%	100%	100%	93%	114%	103%
Iron T-Fe	117%	110%	200%	100%	100%		125%
Lead T-Pb	146%	109%			86%		113%
Lithium T-Li							
Magnesium T-Mg	99%	99%	100%	100%	99%	100%	99%
Manganese T-Mn	130%	112%	125%	105%	82%	110%	111%
Mercury T-Hg							
Molybdenum T-Mo		103%	97%				100%
Nickel T-Ni		109%	97%		100%		102%
Phosphorus T-P							
Potassium T-K							
Selenium T-Se	90%		100%		84%		91%
Silicon T-Si	99%	101%	100%	99%			100%
Silver T-Ag							
Sodium T-Na	100%						100%
Strontium T-Sr	100%	100%	101%	98%			100%
Thallium T-Tl							
Tin T-Sn							
Titanium T-Ti							
Uranium T-U		102%	99%	100%	100%		100%
Vanadium T-V							
Zinc T-Zn	55%	108%	101%		97%		90%
Dissolved Metals							
Aluminum D-Al		103%				100%	102%
Antimony D-Sb		63%			100%		81%
Arsenic D-As		106%			100%		103%
Barium D-Ba		99%		100%	100%	100%	100%
Beryllium D-Be							
Bismuth D-Bi							
Boron D-B							
Cadmium D-Cd					99%		99%
Calcium D-Ca		98%		99%	100%	101%	100%
Chromium D-Cr		100%					100%
Cobalt D-Co							
Copper D-Cu		104%		100%	100%	114%	104%
Iron D-Fe		75%					75%
Lead D-Pb							
Lithium D-Li							
Magnesium D-Mg		101%		100%	99%	104%	101%
Manganese D-Mn		104%		94%		100%	99%
Mercury D-Hg							
Molybdenum D-Mo		102%					102%
Nickel D-Ni		100%			100%		100%
Phosphorus D-P							
Potassium D-K							
Selenium D-Se					82%		82%
Silicon D-Si		101%		99%			100%
Silver D-Ag							
Sodium D-Na							
Strontium D-Sr		101%		98%			99%
Thallium D-Tl							
Tin D-Sn							
Titanium D-Ti							
Uranium D-U		103%		100%	100%		101%
Vanadium D-V							
Zinc D-Zn		100%		100%	101%		100%
Organic Parameters							
Total Organic Carbon C				106%	94%	85%	95%

	Overall	Physical Tests	Dissolved Anions	Nutrients	Metals	Organics
# of duplicate comparisons	185	24	16	18	42	3
Average sample difference	3%	6%	1%	6%	2%	5%
Standard deviation	18%	20%	5%	32%	16%	10%
Maximum difference	100%	71%	71%	100%	100%	6%

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Table 3.29
Site Specific Variability of Water Samples
Standard Deviation Expressed as a % of Mean Value of Triplicate Samples

	W14	W12	W25	W21	W9	W1	W8	W15	W16		Average
Total Metals											
Aluminum T-Al	6%	12%	5%	21%	20%	4%	0%	0%	9%		8%
Antimony T-Sb					0%						0%
Arsenic T-As			0%	0%		7%					2%
Barium T-Ba	0%	16%	0%	31%	0%	0%	0%	0%	13%		7%
Beryllium T-Be											
Boron T-B											
Cadmium T-Cd					0%						0%
Calcium T-Ca	1%	9%	4%	9%	0%	1%	1%	0%	1%		3%
Chromium T-Cr											
Cobalt T-Co											
Copper T-Cu	12%	20%	0%	22%	5%	9%	0%	10%	0%		9%
Iron T-Fe	15%	17%	0%	12%	0%	12%			17%		11%
Lead T-Pb	30%	16%		11%				0%			14%
Magnesium T-Mg	2%	52%	7%	39%	1%	1%	0%	7%	0%		12%
Manganese T-Mn	28%	31%	9%	28%		8%			14%		20%
Mercury T-Hg											
Molybdenum T-Mo											
Nickel T-Ni				0%	0%	0%					0%
Potassium T-K											
Selenium T-Se					0%						0%
Silver T-Ag	78%		47%	47%		47%	47%		85%		59%
Sodium T-Na											
Thallium T-Tl											
Titanium T-Ti											
Uranium T-U	0%	108%	0%	67%	5%	0%	0%				26%
Vanadium T-V											
Zinc T-Zn					2%						2%
Dissolved Metals											
Aluminum D-Al	4%	7%	2%	9%		9%	0%	0%	20%		6%
Antimony D-Sb					0%						0%
Arsenic D-As			0%	0%		0%					0%
Barium D-Ba	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%
Beryllium D-Be											
Boron D-B											
Cadmium D-Cd		5%			1%						3%
Calcium D-Ca	1%	0%	3%	4%	1%	0%	2%	1%	1%		1%
Chromium D-Cr											
Cobalt D-Co											
Copper D-Cu	5%	20%	13%	6%	0%	7%	4%	5%	11%		8%
Iron D-Fe											
Lead D-Pb											
Magnesium D-Mg	2%	0%	3%	3%	2%	1%	3%	0%	0%		2%
Manganese D-Mn											
Mercury D-Hg											
Molybdenum D-Mo											
Nickel D-Ni				0%	0%	0%					0%
Potassium D-K											
Selenium D-Se					16%						16%
Silver D-Ag	69%		87%						47%		68%
Sodium D-Na											
Thallium D-Tl											
Titanium D-Ti											
Uranium D-U	0%		25%	12%	0%	0%	0%				6%
Vanadium D-V											
Zinc D-Zn			17%		0%		0%				6%

Overall Average 10%

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Table 3.30
Results of Water Quality Travel Blank Water Samples

	May-97	Jul-97	Aug. 1997	Sep-97	Jan-01	Jul-01		***# of detections***
Physical Tests								
Total Dissolved Solids						<1		***0***
Hardness CaCO3					<0.6	<0.6		***0***
Total Suspended Solids					<3	<3		***0***
Turbidity (NTU)					<0.1	<0.1		***0***
								0
Dissolved Anions								***0***
Alkalinity-Total CaCO3					<1	1		***1***
Chloride Cl					<0.5	<0.5		***0***
Fluoride F					<0.02	<0.02		***0***
Sulphate SO4					<1	<1		***0***
								0
Nutrients								***0***
Ammonia Nitrogen N					<0.005	<0.005		***0***
Nitrate Nitrogen N					<0.005	<0.005		***0***
Nitrite Nitrogen N					<0.001	<0.001		***0***
Dissolved ortho-Phosphate P					<0.001	<0.001		***0***
Total Dissolved Phosphate P					<0.002	<0.002		***0***
Total Phosphate P					<0.002	<0.002		***0***
								0
Total Metals								***0***
Aluminum T-Al	<0.001	0.004	<0.001	<0.001	<0.005	<0.005		***1***
Antimony T-Sb	<0.00005	<0.00005	<0.00005	<0.00005	<0.0001	<0.0001		***0***
Arsenic T-As	<0.00005	<0.00005	<0.00005	<0.00005	<0.0001	<0.0001		***0***
Barium T-Ba	<0.00005	0.00011	<0.00005	<0.00005	<0.01	<0.01		***1***
Beryllium T-Be	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.001		***0***
Bismuth T-Bi	<0.0005	<0.0005	<0.0005	<0.0005	<0.1			***0***
Boron T-B	<0.001	0.003	<0.001	<0.001	<0.1	<0.1		***1***
Cadmium T-Cd	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Calcium T-Ca	<0.05	1.62	<0.05	<0.05	<0.05	<0.05		***1***
Chromium T-Cr	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005		***0***
Cobalt T-Co	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		***0***
Copper T-Cu	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001		***1***
Iron T-Fe	<0.01	<0.01	<0.01	<0.01	<0.03	<0.03		***0***
Lead T-Pb	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Lithium T-Li	<0.001	<0.001	<0.001	<0.001				***0***
Magnesium T-Mg	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1		***0***
Manganese T-Mn	<0.00005	0.00031	<0.00005	<0.00005	<0.005	<0.005		***1***
Mercury T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00002	<0.00002		***0***
Molybdenum T-Mo	<0.00005	<0.00005	<0.00005	<0.00005	<0.03	<0.03		***0***
Nickel T-Ni	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.001		***0***
Phosphorus T-P	<0.3	<0.3	<0.3	<0.3				***0***
Potassium T-K	<2	<2	<2	<2	<2	<2		***0***
Selenium T-Se	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005		***0***
Silicon T-Si	<0.05	<0.05	<0.05	<0.05	<0.05			***0***
Silver T-Ag	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001		***0***
Sodium T-Na	<2	<2	<2	<2	<2	<2		***0***
Strontium T-Sr	<0.0001	0.0007	<0.0001	<0.0001	<0.005			***1***
Thallium T-Tl	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Tin T-Sn	<0.0001	<0.0001	<0.0001	<0.0001				***0***
Titanium T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		***0***
Uranium T-U	<0.00001	<0.00001	<0.00001	<0.00001	<0.0001	<0.0001		***0***
Vanadium T-V	<0.001	<0.001	<0.001	<0.001	<0.03	<0.03		***0***
Zinc T-Zn	0.003	<0.001	<0.001	<0.001	<0.005	<0.005		***1***
# of detections	***1***	***7***	***0***	***0***	***0***	***1***		***9***

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Table 3.31
Results of Filter Blank Water Samples

	18-Mar-97	12-Sep-97	15-Jul-97	2-Jul-97	14-Jun-97		***# of detections***
Dissolved Metals							***0***
Aluminum D-Al	<0.005	<0.001	<0.001	0.001	0.003		***2***
Antimony D-Sb	<0.2	<0.00005	<0.00005	0.0003	<0.00005		***1***
Arsenic D-As	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Barium D-Ba	<0.01	<0.00005	<0.00005	0.027	0.00041		***2***
Beryllium D-Be	<0.005	<0.0005	<0.0005	<0.0005	<0.0005		***0***
Bismuth D-Bi	<0.1	<0.0005	<0.0005	<0.0005	<0.0005		***0***
Boron D-B	<0.1	<0.001	<0.001	0.02	<0.001		***1***
Cadmium D-Cd	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Calcium D-Ca	<0.05	<0.05	<0.05	0.06	<0.05		***1***
Chromium D-Cr	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		***0***
Cobalt D-Co	<0.01	<0.0001	<0.0001	<0.0001	0.0001		***1***
Copper D-Cu	<0.0001	<0.0001	<0.0001	0.0006	0.0004		***2***
Iron D-Fe	<0.03	<0.01	<0.01	<0.01	<0.01		***0***
Lead D-Pb	<0.00005	<0.00005	<0.00005	<0.00005	0.00034		***1***
Lithium D-Li	<0.01	<0.001	<0.001	<0.001	<0.001		***0***
Magnesium D-Mg	<0.05	<0.05	<0.05	<0.05	<0.05		***0***
Manganese D-Mn	<0.005	<0.00005	<0.00005	0.00022	0.00018		***2***
Mercury D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Molybdenum D-Mo	<0.03	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Nickel D-Ni	<0.02	<0.0001	<0.0001	<0.0005	<0.0001		***0***
Phosphorus D-P	<0.3	<0.3	<0.3	<0.3	<0.3		***0***
Potassium D-K	<2	<2	<2	<2	<2		***0***
Selenium D-Se	<0.0005	<0.001	<0.001	<0.001	<0.001		***0***
Silicon D-Si	0.05	<0.05	<0.05	<0.05	<0.05		***1***
Silver D-Ag	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001		***0***
Sodium D-Na	<2	<2	<2	<2	<2		***0***
Strontium D-Sr	<0.001	<0.0001	<0.0001	0.0016	0.0001		***2***
Thallium D-Tl	<0.1	<0.00005	<0.00005	<0.00005	<0.00005		***0***
Tin D-Sn	<0.03	<0.0001	<0.0001	0.0002	<0.0001		***1***
Titanium D-Ti	<0.01	<0.01	<0.01	<0.01	<0.01		***0***
Uranium D-U		<0.00001	<0.00001	<0.00001	<0.00001		***0***
Vanadium D-V	<0.03	<0.001	<0.001	<0.001	<0.001		***0***
Zinc D-Zn	<0.005	<0.001	<0.001	0.017	0.004		***2***
# of Detections	***1***	***0***	***0***	***10***	***8***		***19***

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Table 3.32
Total vs. Dissolved Metal Concentrations in Water Samples

	# of anomolous readings	# of analyses	% error
W1	83	594	14%
W2	25	198	13%
W3	9	132	7%
W4	23	198	12%
W5	8	132	6%
W6	19	231	8%
W7	9	132	7%
W8	20	231	9%
W9	90	660	14%
W10	12	132	9%
W11	94	674	14%
W12	91	693	13%
W13	21	198	11%
W14	101	693	15%
W15	93	495	19%
W16	49	330	15%
W17	24	231	10%
W18	21	197	11%
W19	22	198	11%
W20	21	198	11%
W21	74	594	12%
W22	72	561	13%
W23	71	528	13%
W24	55	528	10%
W25	49	396	12%
W26	72	561	13%
W27	18	198	9%
W28	62	495	13%
W29	15	165	9%
W30	5	66	8%
W31	1	66	2%
W32	4	66	6%
TOTAL	1333	10771	12%

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Table 3.33
Correlation Between Concentrations of Metals in Sediments, Wolverine Area

STREAMS

	Cadmium	Cobalt	Chromium	Copper	Iron	Manganese	Molybdenum	Nickel	Lead	Zinc	DOC
Cadmium		-0.075	-0.399	0.242	0.057	-0.142	-0.107	-0.097	-0.078	0.483	-0.331
Cobalt	-0.075		0.777	0.529	0.967	0.298	0.108	0.431	-0.149	0.007	0.029
Chromium	-0.399	0.777		0.537	0.730	0.218	0.005	0.684	-0.068	-0.115	-0.084
Copper	0.242	0.529	0.537		0.513	-0.089	-0.165	0.316	0.037	0.020	-0.268
Iron	0.057	0.967	0.730	0.513		0.289	0.087	0.410	-0.224	-0.024	0.002
Manganese	-0.142	0.298	0.218	-0.089	0.289		0.789	0.147	-0.248	0.501	0.321
Molybdenum	-0.107	0.108	0.005	-0.165	0.087	0.789		-0.325	-0.447	0.335	0.757
Nickel	-0.097	0.431	0.684	0.316	0.410	0.147	-0.325		0.148	0.047	-0.545
Lead	-0.078	-0.149	-0.068	0.037	-0.224	-0.248	-0.447	0.148		0.198	-0.492
Zinc	0.483	0.007	-0.115	0.020	-0.024	0.501	0.335	0.047	0.198		-0.269
DOC	-0.331	0.029	-0.084	-0.268	0.002	0.321	0.757	-0.545	-0.492	-0.269	

LAKES

	Cadmium	Cobalt	Chromium	Copper	Iron	Manganese	Molybdenum	Nickel	Lead	Zinc	DOC
Cadmium		0.641	0.699	0.929	0.015	-0.145	-0.756	0.270	0.773	0.981	0.843
Cobalt	0.641		0.377	0.820	0.578	0.557	-0.853	0.696	0.266	0.719	0.192
Chromium	0.699	0.377		0.747	-0.399	-0.374	-0.248	0.465	0.391	0.780	0.650
Copper	0.929	0.820	0.747		0.212	0.013	-0.783	0.556	0.522	0.968	0.651
Iron	0.015	0.578	-0.399	0.212		0.583	-0.523	0.355	-0.304	0.018	-0.346
Manganese	-0.145	0.557	-0.374	0.013	0.583		-0.323	0.244	-0.177	-0.066	-0.571
Molybdenum	-0.756	-0.853	-0.248	-0.783	-0.523	-0.323		-0.507	-0.587	-0.738	-0.495
Nickel	0.270	0.696	0.465	0.556	0.355	0.244	-0.507		-0.097	0.396	0.058
Lead	0.773	0.266	0.391	0.522	-0.304	-0.177	-0.587	-0.097		0.691	0.850
Zinc	0.981	0.719	0.780	0.968	0.018	-0.066	-0.738	0.396	0.691		0.768
DOC	0.843	0.192	0.650	0.651	-0.346	-0.571	-0.495	0.058	0.850	0.768	

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Table 3.34
Average Concentrations of Metals in Stream and Lake Sediment

	W32		W9		Little Wolverine Lake		W30		W16		W12		CCME		Metals concentrations in sediments in southeast Yukon	
	(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		ISQG	PEL	50th percentile	95th percentile
Total Metals*	Average	S.D.	Average	S.D.	Average	S.D.	Average	S.D.	Average	S.D.	Average	S.D.				
Aluminum T-Al	15480	914.9	19340	2055.0	4392	615.0	31740	2684.8	30740	1161.0	23300	894.4				
Antimony T-Sb	ND		ND		ND		ND		ND		ND					
Arsenic T-As	ND		ND		ND		ND		ND		ND		5.9	17		
Barium T-Ba	1660	177.3	693.2	29.2	177.8	41.2	313.4	99.2	667.6	172.7	515	33.4				
Beryllium T-Be	ND		1		ND		ND		ND		ND					
Bismuth T-Bi	ND		ND		ND		ND		ND		ND					
Cadmium T-Cd	36	7.7	22	2.0	5	2.9	ND		6.25	1.3	ND		0.6	3.5	0.6	4.4
Calcium T-Ca	14480	978.3	13020	432.4	2624	560.4	22460	1809.1	21280	1042.6	12140	1230.0				
Chromium T-Cr	35.2	2.8	46.8	3.6	9.8	1.6	101.4	12.3	94.2	2.9	64.2	2.6	37.3	90		
Cobalt T-Co	17.4	3.8	13	0.7	2.8	0.4	22	1.9	24.6	1.1	14.8	0.4			10	23
Copper T-Cu	134.6	6.9	114.4	17.4	17	2.2	99	7.2	81.4	4.8	153.8	32.0	35.7	197	29	69
Iron T-Fe	77600	21559.5	36940	1324.0	14370	5920.4	57520	6974.7	52440	8508.7	38260	1455.3				
Lead T-Pb	ND		ND		ND		ND		ND		ND		35	91.3	14	45
Lithium T-Li	9	0.7	12.6	0.5	2.8	0.4	19.4	1.5	20.6	0.5	16.4	0.5				
Magnesium T-Mg	5396	434.4	12460	884.9	2324	429.7	17920	1878.0	17240	279.3	11200	400.0				
Manganese T-Mn	13082	5681.0	1596	80.8	244.8	87.7	1068.2	358.7	7468	3044.8	2036	177.3			345	2130
Molybdenum T-Mo	11.5	5.1	ND		ND		ND		ND		ND				1	8
Nickel T-Ni	122.4	11.6	106.2	3.7	15	3.7	55.8	4.1	56	1.6	46.4	2.9			37	121
Phosphorus T-P	2202	193.8	2096	58.1	742.2	314.0	933.4	130.4	1202	83.2	876	25.3				
Potassium T-K	1688	135.5	3172	502.1	545.2	71.3	1300	162.6	1580	66.0	2460	296.4				
Selenium T-Se	ND		ND		ND		ND		ND		ND					
Silver T-Ag	ND		ND		ND		ND		ND		ND					
Strontium T-Sr	93.6	5.2	73.2	3.9	13.38	3.3	77	9.1	70.4	7.1	52	4.2				
Thallium T-Tl	ND		ND		ND		ND		ND		ND					
Tin T-Sn	ND		ND		ND		ND		ND		ND					
Titanium T-Ti	1094.4	207.1	1842	348.7	382.8	76.1	6048	615.4	5078	505.5	2926	274.9				
Vanadium T-V	52.2	3.1	99.6	11.9	18.4	3.8	120	12.0	107.2	9.1	83	4.3				
Zinc T-Zn	2480	270.6	4314	115.5	462.2	209.1	101.6	18.7	315.2	73.3	153.4	10.8	123	315	131	504

* all concentrations hsown in mg/kg

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Table 3.35
Summary of Stream Benthic Invertebrate Communities - Wolverine Area

Station	Nougha Cr @ outlet W1		Go Creek W12		Money Cr d/s Go Cr W14		Nougha Cr @ Hwy W21		Money Cr u/s Dollar W23		Wind Cr W26	
Date Sampled (1996)	Aug 22		Aug 21		Aug 21		Aug 22		Aug 21		Aug 22	
Sensitive	709		349		1493		616		709		266	
Facultative	9816		1201		1750		1250		2664		15735	
Tolerant	91		53		52		28		46		0	
Total	10616		1604		3295		1894		3418		16002	
%												
Sensitive	6.7		21.8		45.3		32.5		20.7		1.7	
Facultative	92.46		74.9		53.1		66.0		77.9		98.3	
Tolerant	0.86		3.3		1.6		1.5		1.3		0.0	
# of Taxa	45		46		50		52		50		63	
Shannon Wiener Diversity	3.07		3.35		3.03		3.92		3.02		2.83	
Dominance	0.21		0.19		0.22		0.10		0.24		0.22	
Equitability	0.56		0.61		0.54		0.69		0.54		0.47	
Richness	4.75		6.10		6.05		6.76		6.02		6.40	
TU Diversity	0.79		0.81		0.78		0.90		0.76		0.78	
Variance	0.12		0.11		0.08		0.02		0.14		0.08	
Date	July 16	Aug 22	July 15	Aug 21	July 15	Aug 21	July 16	Aug 22	July 15	Aug 21	July 16	Aug 22
Temp (°C)	11.9	10.5	5.9	5.4	6.1	5.7	9.8	9.7	8.3	8.1	15.6	10.0
D.O. (mg/L)	10.2	11.5	11.3	12	11.2	12.9	10.3	10.9	10.1	11.9	18.8	10.1
D.O. (% Sat.)	109	120	102	112	106	121	103	109	100	117	218	105
Cond (µS/cm)	134.4	140.7	128.6	139.4	124.3	136.3	174.9	188.6	95.5	104.6	294	299
pH	9.02	8.73	8.44	8.27	7.76	7.95	8.53	8.16	7.73	8.02	8.73	7.98
Depth at Basket (m)	0.3 - 0.4		0.4		0.5 - 0.6		0.2 - 0.3		0.5		0.2	
Velocity at Basket (m/s)	0.8		0.4		0.6		1.1		0.2		0.1	

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Table 3.36
Summary of Little Wolverine Creek Benthic Community

Station	Little Wolverine Creek W9		
Date Sampled (1997)	May	July	September
Density (#/m^2)	280	1367	4103
Sensitive	27	157	793
Facultative	240	1200	3233
Tolerant	13	10	77
%			
Sensitive	9.52	11.46	19.33
Facultative	85.71	87.80	78.80
Tolerant	4.76	0.73	1.87
# of Taxa	18	20	39
Shannon Wiener Diversity	2.88	2.20	2.92
Dominance	0.22	0.36	0.22
Equitability	0.69	0.51	0.55
Richness	5.102	3.864	6.315
TU Diversity	0.804	0.642	0.779
Variance	0.081	0.222	0.097

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Table 3.37
Summary of Lake Benthic Invertebrate Communities - Wolverine Area

Station	Wolverine Lake west of island W3a	Wolverine Lake in bay near mouth of Wolf Creek W5a	Wolverine Lake off point 1 km east of Viking Creek W7a	Little Wolverine L. near outlet W10a
Date Sampled	23-Aug-96	23-Aug-96	23-Aug-96	20-Aug-96
Sensitive	11	1	0	6
Facultative	513	2692	1832	1583
Tolerant	128	735	439	510
Total	652	3428	2272	2099
%				
Sensitive	1.6	0.0	0.0	0.3
Facultative	78.8	78.5	80.6	75.4
Tolerant	19.6	21.4	19.3	24.3
# of Taxa	48	43	36	54
Shannon Wiener Diversity	3.92	3.26	3.21	3.89
Dominance	0.11	0.18	0.18	0.11
Equitability	0.70	0.60	0.62	0.68
Richness	7.25	5.16	4.53	6.93
TU Diversity	0.89	0.83	0.82	0.89
Variance	0.03	0.07	0.07	0.02
Date	July 15	July 15	July 16	July 15
Temp (°C)	11.0	11.2	11.3	11.7
D.O. (mg/L)	10.2	9.9	10.2	12.5
D.O. (% Sat.)	107	107	108	135
Cond (µS/cm)	116.9	116.9	116.6	114.9
pH	8.16	8.16	8.31	7.90
Average Depth of Samples (m)	3.0	1.2	2.5	0.5

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Table 3.38
Summary of Zooplankton Data for Lakes in the Wolverine Area

		Little Wolverine	Wolverine
Density (#/m^3)			
Cladocerans		192	12
Copepods		3,591	3,177
Rotifers		7,322	1,412
Total		11,105	4,601
Average size (microns)			
Cladocerans			
DAPHNIA pulex			2128
BOSMINA longispina		654	615
Copepods			
HETEROCOPE septentrionalis	Female	2436	3073
	Male	2339	2998
DIAPTOMUS pribilofensis	Female	1547	1438
	Male	1413	1288
DIAPTOMUS ashlandi	Female		801
	Male		781

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Table 3.39
Fisheries Investigations of Go Creek

				Species					
Date	Site	Technique	Effort	Arctic Grayling	Lake Trout	Slimy Sculpin	Burbot	Longnose Sucker	Bull Trout
7/15/1996	G1	Electrofishing	80 sec	0	0	1	0	0	1
7/15/1996	G1	Electrofishing	152 sec	0	0	4	0	0	1
7/15/1996	G1	Electrofishing	512 sec	1	0	6	0	0	2
7/17/1996	G2	Electrofishing	447 sec	3	0	0	0	0	0
7/17/1996	G3	Electrofishing	232 sec	0	0	0	0	0	0
7/17/1996	G4	Electrofishing	90 sec	0	0	0	0	0	0
7/17/1996	G5	Electrofishing	209 sec	0	0	0	0	0	0
7/17/1996	HO1	Electrofishing	244 sec	0	0	0	0	0	0
9/25/1996	G1	Electrofishing	89 sec	0	0	0	0	0	0
7/12/2001	G5	Electrofishing	220 sec	0	0	0	0	0	0
7/12/2001	G4	Electrofishing	660 sec	0	0	0	0	0	0
7/14/2001	G3	Electrofishing	200 sec	0	0	0	0	0	0
7/14/2001	G2	Electrofishing	300 sec	0	0	0	0	0	0
7/13/2001	G1	Electrofishing	450 sec	0	0	0	0	0	0
9/15/1997	G1	Gee trapping	23 hrs	0	0	0	0	0	0
9/15/1997	G2	Gee trapping	23 hrs	0	0	0	0	0	0
9/15/1997	G3	Gee trapping	23 hrs	0	0	0	0	0	0
9/15/1997	G4	Gee trapping	23 hrs	0	0	0	0	0	0
9/15/1997	G5	Gee trapping	23.2 hrs	0	0	0	0	0	0
7/12/2001	G5	Gee trapping	52.5 hrs.	0	0	0	0	0	0
7/12/2001	G4	Gee trapping	43.5 hrs	0	0	0	0	0	0
7/14/2001	HO1	Gee trapping	60 hrs	0	0	0	0	0	0
7/14/2001	G3	Gee trapping	60 hrs	0	0	0	0	0	0
7/14/2001	G2	Gee trapping	62 hrs	0	0	0	0	0	0
7/13/2001	G1	Gee trapping	51 hrs	0	0	0	0	0	0

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Table 3.40
Summary of Fish Sampling Work - Money Creek

	June			July			September		
	1996	1997	2001	1996	1997	2001	1996	1997	2001
M1	**EF** MT **SE** **ANG**	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF **MT** SE ANG	EF MT SE ANG
M2	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF **MT** SE ANG	EF MT SE ANG
M3	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT SE **ANG**	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF **MT** SE ANG	EF MT SE ANG
M4	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT **SE** ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** **MT** SE ANG	EF MT SE ANG
M5	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT **SE** ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF **MT** **SE** ANG	EF MT SE ANG
M6	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT SE **ANG**	EF MT SE ANG	**EF** **MT** SE ANG	EF MT SE ANG	EF **MT** **SE** ANG	EF MT SE ANG
M7	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT SE ANG	EF MT SE ANG	**EF** **MT** SE ANG	**EF** MT SE ANG	EF **MT** SE ANG	EF MT SE ANG
M8	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG
M9	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	**EF** MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG	EF MT SE ANG

EF Electrofishing
SE Seining
ANG Angling
MT Minnow Trapping

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Table 3.41
Mean Length, Weight, and Condition Factor (K) by Species, Wolverine Area Fisheries Surveys, 1996

			Length (mm)		*Weight (g)*		*K*	
Location	***Species***	***N***	***mean***	***Range***	***mean***	***Range***	***mean***	***Range***
Wolverine Lake	Arctic grayling	63	370.8	(263 - 479)	603.4	(200 - 850)	1.15	(0.59 - 1.51)
	lake trout	57	431.6	(87 - 846)	1284.7	(50 - 7500)	1.18	(0.90 - 1.46)
Little Wolverine Lake	Arctic grayling	57	333.2	(262 - 398)	395.9	(175 - 675)	1.04	(0.82 - 1.29)
	lake trout	25	453	(338 - 786)	1344	(425 - 6500)	1.18	(0.89 - 1.45)
	longnose sucker	4	442.5	(400 - 480)	1156.3	(875 - 1400)	1.32	(1.26 - 1.39)

N refers to number of fish collectec

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Table 3.42
Catch Composition by Lake, Species, and Mesh Size for Index Gillnetting in the Wolverine Area

Location	Species	mesh size (cm) 3.8	6.4	8.9	total
Wolverine Lake	**Arctic grayling**				
	N	3	28	32	63
	Kg of fish	1.7	14.28	22.04	38.02
	Lake Trout				
	N	5	27	25	57
	Kg of Fish	1.83	21.65	48.52	72.00
	TOTALS				
	N	8	55	57	120
	Kg of Fish	3.53	35.93	70.56	110.02
	Species	mesh size (cm) 3.8	6.4	8.9	***total***
Little Wolverine Lake	**Arctic grayling**				
	N	5	30	22	57
	Kg of Fish	1.92	11.2	9.45	22.57
	Lake Trout				
	N	5	11	9	25
	Kg of Fish	5.28	14.83	13.5	33.6
	Longnose sucker				
	N	0	0	4	4
	Kg of Fish	0	0	4.63	4.63
	TOTALS				
	N	10	41	35	86
	Kg of Fish	7.19	26.03	27.58	60.79

N represents number of fish

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Table 3.43
Species Composition from Spring Index Gillnetting Surveys, Wolverine Area 1996

Location	Species	% Catch by Number	% Catch by Weight
Wolverine Lake	Arctic grayling	52.5	35
	lake trout	47.5	65
Little Wolverine Lake	Arctic grayling	66	37
	lake trout	29	55
	longnose sucker	5	8

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Table 3.44
Metals Concentrations in Vegetation

		Al (ppm)	Sb (ppm)	As (ppm)	Ba (ppm)	Be (ppm)	Bi (ppm)	Cd (ppm)	Ca (ppm)	Cr (ppm)	Co (ppm)	Cu (ppm)
Willow Leaves	Minimum	< 50	< 0.05	< 0.1	20	< 0.20	< 1.00	1.00	2400	1.0	< 0.50	6.5
5 samples	Maximum	50	< 0.05	0.2	160	< 0.20	< 1.00	2.60	9800	2.5	2.50	15.5
Willow Twigs	Minimum	< 50	< 0.05	0.2	45	< 0.20	< 1.00	1.20	3000	2.0	< 0.50	14.5
5 samples	Maximum	< 50	< 0.05	0.2	305	< 0.20	< 1.00	4.40	7000	11.0	1.50	71.0
Lichens	Minimum	50	< 0.05	0.1	5	< 0.20	< 1.00	< 0.20	550	1.5	< 0.50	1.0
5 samples	Maximum	250	< 0.05	0.2	85	< 0.20	< 1.00	0.20	1250	4.5	< 0.50	4.0

		Ga (ppm)	Au (ppb)	Fe (ppm)	La (ppm)	Pb (ppm)	Mg (ppm)	Mn (ppm)	Hg (ppm)	Mo (ppm)	Ni (ppm)	P (ppm)
Willow Leaves	Minimum	< 5	1.7	< 50	< 0.1	< 0.50	1350	57	< 1	< 0.50	1.5	2370
5 samples	Maximum	< 5	7.6	50	1.3	2.5	3500	780	< 1	1.00	11.0	4420
Willow Twigs	Minimum	< 5	3.4	< 50	< 0.1	1.0	1050	49	< 1	< 0.50	2.5	2170
5 samples	Maximum	< 5	3.4	50	< 0.1	2.5	2700	550	< 1	1.00	10.5	4100
Lichens	Minimum	< 5	0.4	50	< 0.1	1.0	200	55	< 1	< 0.50	0.5	305
5 samples	Maximum	< 5	5.0	250	0.2	2.5	400	210	< 1	.50	2.0	645

		K (ppm)	Sc (ppm)	Ag (ppm)	Na (ppm)	Sr (ppm)	Tl (ppm)	Ti (ppm)	W (ppm)	U (ppm)	V (ppm)	Zn (ppm)
Willow Leaves	Minimum	5900	< 2	< .10	< 50	13.0	< 5	< 50	< 2	< 5	< 0.5	54
5 samples	Maximum	8900	< 2	< .10	< 50	51.0	< 5	< 50	< 2	< 5	< 0.5	220
Willow Twigs	Minimum	6900	< 2	< .10	< 50	12.0	< 5	< 50	< 2	< 5	< 0.5	79
5 samples	Maximum	160000	< 2	< .10	100	44.0	< 5	< 50	< 2	< 5	< 0.5	240
Lichens	Minimum	650	< 2	< .10	< 50	1.5	< 5	< 50	< 2	< 5	< 0.5	10
5 samples	Maximum	1800	< 2	< .10	50	5.5	< 5	< 50	< 2	< 5	< 0.5	36

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WOLVERINE PROJECT
Table 4.1
Sample Significance Criteria Definitions

Criterion	Low	Moderate	High
Magnitude (of the effect)	Effect is evident only at or nominally above baseline conditions	Effect exceeds baseline conditions however is less than regulatory criteria or published guideline values	Effect exceeds regulatory criteria or published guideline values
Geographic Extent (of the effect)	Effect is limited to the project site/footprint.	Effect extends into areas beyond the project site/footprint boundary	Effect extends beyond the boundary of the Airport Authority.
Duration (of the effect)	Effect is evident only during the construction phase of the project	Effect is evident during construction and/or the operational phase of the project.	Effects will be evident beyond the operational life of the project.
Frequency (of conditions causing the effect)	Conditions or phenomena causing the effect occur infrequently (i.e. < once per year)	Conditions or phenomena causing the effect occur at regular intervals although infrequent intervals (i.e. < once per month)	Conditions or phenomena causing the effect occur at regular and frequent intervals (i.e. < once per year)
Ecological Importance (of resource or attribute)	Resource is of little recognized value in terms of uniqueness, rarity, importance to the ecosystem or scientific knowledge.	Resource is recognized to be of some, yet limited value in terms of uniqueness, rarity, importance to the ecosystem or scientific knowledge.	Resource is recognized to be of significant value in terms of uniqueness, rarity, importance to the ecosystem or scientific knowledge.
Societal Value (of resource or attribute)	Resource is of little recognized value in terms of uniqueness, rarity, importance to the the public or community.	Resource is recognized to be of some, yet limited value in terms of uniqueness, rarity, importance to the public or community	Resource is recognized to be of significant value in terms of uniqueness, rarity, importance to the public or community.
Permanence (of effect)	Effect is readily reversible over a short period of time (i.e. one growing season)	Effect is not readily reversible during the life of the project.	Effect is permanent.

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WOLVERINE PROJECT

Table 4.2
Potential Direct Project - Environment Interactions for the Wolverine Project

		Environmental Attribute											
		Air Quality	Topography and Landscape Appearance	Hydrogeology	Groundwater Quality	Surface Hydrology	Surface Water Quality	Aquatic Resources	Vegetation	Wildlife	Socio-economic Conditions, Heritage Resources and Existing Land Use	Archaeology Sites	Human Health
Project Component/Activity	Underground mine			✘	✘								
	Backfill Borrow Area	✘	✘			✘			✘			✘	
	Tailings Storage Facility		✘	✘	✘	✘	✘	✘	✘			✘	
	Waste Rock Stockpiles	✘	✘	✘	✘	✘	✘		✘			✘	
	Infrastructure - cumulative					✘			✘			✘	
	Staging and works areas												
	backfill plant												
	shotcrete plant												
	concentrate plant												
	worker housing												
	incinerator	✘											
	water and sewage treatment plants						✘						
	pipelines, ponds, and sumps			✘	✘								
	power plant	✘											
	Mine Access Road	✘	✘					✘					
	Cumulative Operations									✘			
	Cumulative Project										✘		✘