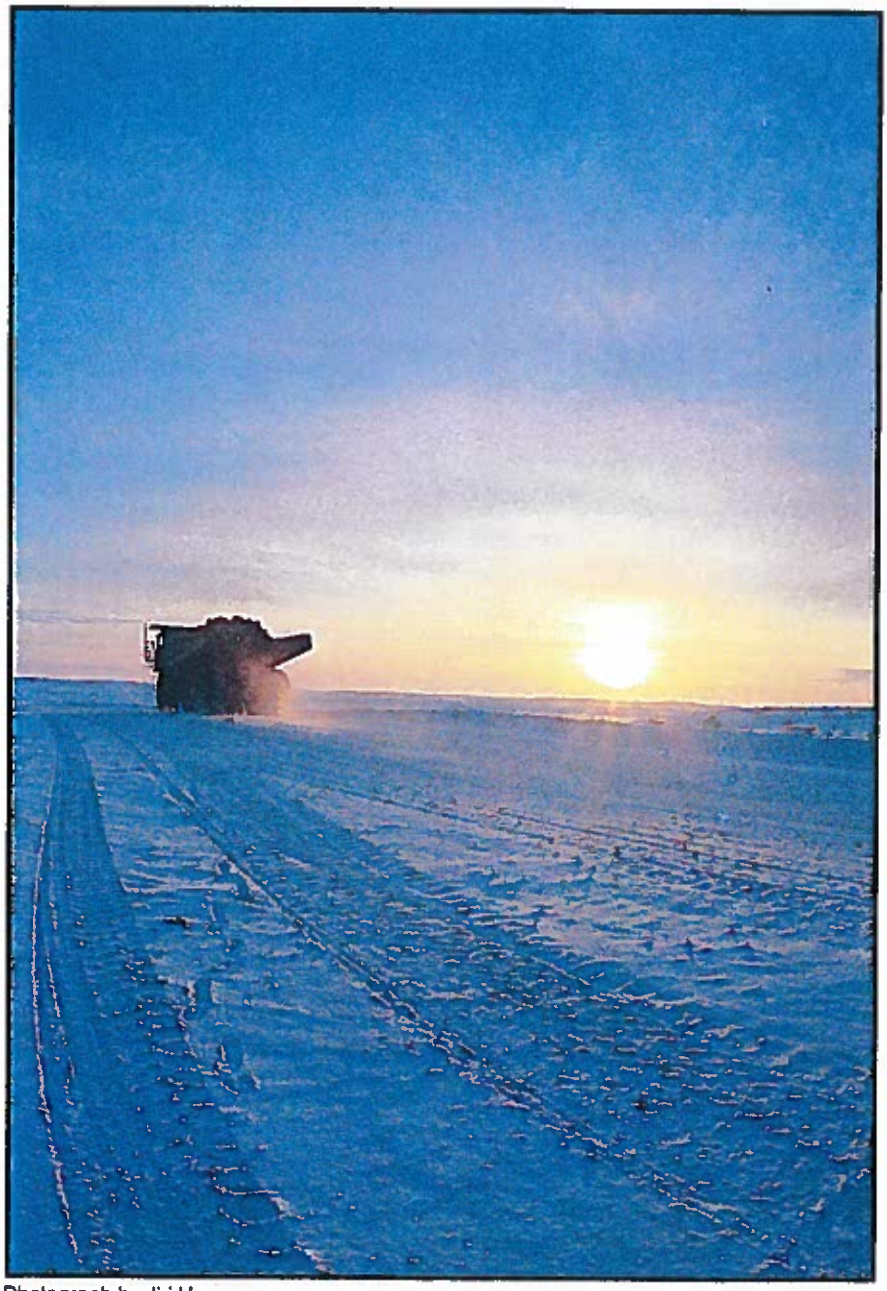
Ekati diamond mine

EKATI™ Diamond Mine

Northwest Territories

Environmental Assessment Report for

Sable, Pigeon and Beartooth Kimberlite Pipes



Photograph by Jiri Hermann

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April 2000

ACKNOWLEDGEMENTS

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The Environmental Assessment Report (EAR) for the Sable, Pigeon and Beartooth pipe development at the EKATI™ Diamond Mine (EKATI™) was prepared by BHP Diamonds Inc. with the assistance of a number of Canada's leading consultants, specialists and support companies. Many of these people have had extensive experience with the mine since the beginning of the project in 1992/93. BHP Diamonds Inc., as the managing partner of EKATI™, wishes to acknowledge the important contributions made by each of the participants involved in preparing this report.

The Environmental & Resource Planning Department at BHP Diamonds Inc. had the lead responsibility for coordinating all internal and consultant contributions for the EAR. Strong support was provided by many other departments at EKATI™. This report represents the culmination of more than eight months of effort by BHP and its consultants.

Rescan™ Environmental Services Ltd. (Rescan) was assigned primary responsibility for preparing this document. Rescan was responsible for preparing the original 1995 Environmental Impact Statement for the NWT Diamonds Project and has been involved in much of the ongoing environmental monitoring at EKATI™. EBA Engineering Consultants Ltd. (EBA) has been providing geotechnical arctic environmental engineering services and processed kimberlite management services at EKATI™ since 1993. EBA had the primary responsibility for producing the Project Description report (October 1999) and a lead role in preparing the civil/geotechnical engineering components of the EAR.

Other contributors included:

Consultants	Contribution
ARC Wildlife Services Calgary, Alberta	Wildlife and Habitat
Bair, Jerry, Consultant Galveston, Texas	IBAs, Socio-economics and Legal Consultant
Davis and Company Yellowknife, Northwest Territories Vancouver, British Columbia	Legal Services
Dillon Consulting Limited Yellowknife, Northwest Territories	Hydrology, Aquatic Habitat Enhancement
EBA Engineering Consultants Ltd. Yellowknife, Northwest Territories	Project Description Report, Geotechnical and Arctic Engineering, and Tailings Management
Ellis Consulting Services Yellowknife, Northwest Territories	Economic Analysis
Envirologic Consulting Inc. Vancouver, British Columbia	Fish and Fish Habitat

Lunde, Karen Vancouver, British Columbia	Technical Editing
Lutra Associates Ltd. Yellowknife, Northwest Territories	Socio-economic Analysis
Outcrop Ltd. Yellowknife, Northwest Territories	Executive Summary Design and Production
Points West Heritage Consulting Ltd. Edmonton, Alberta Langley, British Columbia	Archaeological/Heritage Resources
Rescan™ Environmental Services Ltd. Yellowknife, Northwest Territories Vancouver, British Columbia	Environmental Assessment Report co-ordination and preparation, Description of Existing Environment, Environmental Effects Analysis
Traynor, Fiona Yellowknife, Northwest Territoires	Executive Summary, Editing
Wierzchowski, Jack	Wildlife Habitat GIS Mapping

BHP Diamonds Inc. wishes to thank Diavik Diamond Mines Ltd., Winspear Resources Ltd., Echo Bay Mines Ltd., Tahera Corporation, and Nuna Logistics for providing information for this report. Dogrib Treaty II, Akaitcho Treaty 8, the Kitikmeot Inuit Association, and the North Slave Metis Alliance have all provided comments on the preparation of this assessment. Finally BHP Diamonds Inc. would like to thank the members of the NWT Barrenland Caribou Outfitters Association for the information provided by their members.

DISCLAIMER

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The material contained in this Environmental Assessment Report (EAR) has been prepared in response to the Environmental Assessment Terms of Reference for the proposed development of the Sable, Pigeon and Beartooth kimberlite pipes, issued by the Mackenzie Valley Environmental Impact Review Board (MVEIRB), dated December 13, 1999.

The contents of the EAR represent BHP Diamond Inc.'s best efforts to respond to the Terms of Reference and thereby provide the MVEIRB and other parties with sufficient information to understand the environmental and socio-economic consequences of the additional development proposed at the existing EKATI™ mine.

Any estimates or forecasts of levels of production, ore grades and reserves have been prepared for purposes of the environmental assessment only. They have not been prepared in accordance with securities regulatory requirements pertaining to disclosure of future-oriented financial information, and accordingly may not be relied upon for investment purposes.

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TABLE OF CONFORMITY

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The following table indicates where items identified in the Environmental Assessment Terms of Reference issued by the Mackenzie Valley Environmental Impact Review Board (MVEIRB) in December 1999 are addressed in BHP's Environmental Assessment Report (EAR). Where a particular line in the Terms of Reference refers to: a section heading (*e.g.*, 1. Introduction); directions from the Review Board; editorial commentary; a hyphen (–) has been identified in this table.

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	**Description**	
5	**1. INTRODUCTION**	–
41	**1.2 Public Consultation**	–
64-65	BHP Diamonds Inc. shall describe public consultation objectives including programs and activities undertaken and committed to regarding:	6.1
66-67	I. Methods used to identify, inform and solicit input from potentially interested parties	6.2
68	II. Those that provided comments and input	6.2.2, 6.2.3
69-70	III. Outcomes of consultation including any additional information provided by those consulted	6.2
71	IV. Key concerns identified	1.3, 6.3
72	V. Major differences in views between those consulted	6.3
73-74	VI. Agreements or commitments to agreements with interested participants and/or communities	2.1.2.1, 2.1.2.2, 2.1.2.3
75	VII. Issues tracking and management; and	6.2
76-78	VIII. An indication of how consultation affected the outcome of predicting impacts and determining mitigation, as well as, affecting the design of the proposed development.	1.3, 5.3, 5.3.1, 6.3
84	**1.3 Traditional Knowledge**	–
85-87	BHP shall make all reasonable effort to collect and facilitate the collection of traditional knowledge, relative to the proposed development, for integration into the environmental assessment report in collaboration with aboriginal communities and organizations.	1.3, 5.3, 5.3.1, 6
88-89	Where traditional knowledge is not available to the developer, in a timely manner, despite appropriate diligence, the developer will describe efforts taken to obtain it.	1.3, 5.3, 5.3.1
91-92	BHP shall describe where and how traditional knowledge was used, and the effect that it had on predicting impacts and determining mitigation.	1.3, 5.3.1
93	**2. SCOPE OF DEVELOPMENT**	–
97-98	The EAR will be structured according to the scope of the development.	–

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
131	**2.5 Existing EKATI™™ Diamond Mine**	–
132-134	For the purposes of this environmental assessment, the Diamond Mine is the project as described and considered in the NWT Diamond Project Report of the Environmental Assessment Panel dated June 1996.	–
136-137	Describe changes, if any, to existing facilities infrastructure and facilities as a result of the proposed development, including:	–
138-139	I. Existing equipment, infrastructure, and facilities to be used for processing, disposal, storage and transportation	Chapter 1, 2.2.1, 2.2.2, Project Description (attached CD-ROM)
140	II. Solid waste management and containment areas	2.2.3
141-142	III. Surface structures (process plant, power plant, magazines, camp(s), roads, airstrip, *etc.*); and	Chapter 1, 2.2.1, Project Description (attached CD-ROM)
143	IV. Petroleum and chemical storage areas.	2.2.1
145	**2.6 Related Considerations**	–
146	**2.6.1 Development Sequence**	–
147-151	Describe the proposed EKATI™ Diamond Mine extension development sequence, in the context of the entire mining operation including traffic on existing haul roads and transportation corridors, current and anticipated exploration activities that will utilize the proposed development infrastructure, and exploration plans as they relate to the proposed development.	2.2.6
151-152	Also, include a clear rationale for the proposed development sequence in terms of economic risk and uncertainty	2.2.6
153	**2.6.2 Hazardous Materials**	–
154-155	Plans for transporting, handling, storing, using and disposing of hazardous materials forming part of the proposed development.	5.2.5
156	**2.6.3. Accidents and Malfunctions**	–
157-159	Probability, potential magnitude, and contingencies in the event of an accident and/or malfunction occurrence, related to the proposed development including, but not limited to:	–
160	I. fuel and other hazardous material spills	4.10.1
161	II. water inputs, which exceed retention capacity of the containment areas	4.10.2
162-163	III. key development components such as the tailings (processed kimberlite) containment areas and dikes	2.2.3.1, 2.2.4, 4.10.2
164-165	IV. use of pumping as a long-term water management activity to direct surface flow around the Beartooth pit	4.10.2
166-168	V. the tailings (processed kimberlite) containment areas, waste rock (country rock), ore stockpile and overburden storage sites, open pits, sewage facilities and underground workings in the event of a temporary shutdown	2.2.3, 4.10.2

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
169	VI. general emergency situations (*i.e.*, fire, natural disasters); and	4.10.1
170-171	VII. earthquakes, and the low probability hazard from nearby earthquake loads on dikes/containment structures, including failure under earthquake loads.	4.4.2.3, 4.10.2
172	**2.6.4 Closure and Reclamation**	–
173-174	Describe, report and evaluate, in relation to the proposed development, the level of confidence associated with implementing and or amending or modifying, the following:	–
175	I. salvaging soils (volume and type) and lake bottom sediments	5.5.1
176	II. re-establishing plant communities and a productive landscape	5.5.2
177	III. reclamation of containment areas	5.5.4
178	IV. reclamation of the waste (country) rock piles	5.5.5
179	V. reclamation of all weather haul roads	5.5.6
180	VI. reclamation of the dikes	5.5.7.1
181	VII. reclamation of the open pits (mine sites); and	5.5.3, 5.5.7.2, 5.5.10
182	VIII. re-establishing stable surface drainage and lake recharge.	5.5.7
184-188	Describe opportunities, plans, or amendments to existing plans for progressive reclamation, experimentation and research work that can begin as early as possible in the life of the proposed development; and how the design of proposed development components can assist in meeting the objectives for reclamation. Also, describe the sequence and reclamation costs of the proposed development.	5.5.8, 5.5.9, 5.5.11
189	**3. ENVIRONMENTAL ASSESSMENT**	–
190-193	The environmental assessment of impacts associated with the proposed development, shall to the extent possible, build upon the 1995 Environmental Impact Statement, and subsequent environmental management and monitoring commitments.	–
195-201	BHP shall provide information on the environment and how it could be affected by the proposed development. BHP shall also provide a sufficient base for the prediction of positive and negative impacts, and the extent to which negative impacts may be mitigated by planning, development design, construction techniques, operational practices, and reclamation techniques.	Chapter 3 Chapter 4 Chapter 5
203-204	Where a determination on significance is provided in the EAR, BHP shall identify and explain the criteria used in forming its views.	4.2.2 (see specific sub-sections for each VEC)

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
207	**3.1 Environmental Assessment Methodology**	–
208-211	Respecting baseline, management, monitoring, and reporting efforts undertaken as part of the 1995 BHP Environmental Impact Statement, and in the subsequent construction and operations phases, BHP shall, to the extent possible, use existing models and data for impact prediction.	4.2.1.2, Chapter 7
212-214	Explicit documentation of the assumptions, models, information sources used, as well as information limitations and associated levels of uncertainty shall support all steps of the environmental assessment report.	4.1, 4.2, Chapter 7
214-217	The analysis should be quantitative where data are available, but where data or models are lacking, best professional judgement may be used. The approach and methodologies used to identify and assess cumulative effects shall be explained.	4.1, 4.2, 4.9, Chapter 7
218	**3.1.1 Alternatives**	–
219-225	Include a description of the main development/production/technical alternatives considered for implementing the proposed development. Focus on alternatives related to key elements (infrastructure or activities) of the proposed development, in particular those associated with alternative mine design; alternative sites for waste rock and tailings disposal such as back-filling depleted pits; alternative technologies for tailings management; alternative transportation modes or routes; and decommissioning and reclamation options.	2.3.1, 2.3.2, 2.3.3, 2.3.4
227-228	Alternative kimberlite pit development sequencing, and mitigation measures considered, shall be reported and reasons provided for their rejection.	2.2.6, 2.3.3
229	**3.1.2 Description of the Existing Environment**	–
230-232	BHP shall provide sufficient information on the existing environment, as it pertains to the proposed development, including the existing mining operation, where appropriate, to give a brief but clear picture of the existing environment and its use.	Chapter 3
232-235	Enough information shall be provided for the prediction of positive and negative impacts, and the extent to which negative impacts may be mitigated by *e.g.*, planning, project design, construction techniques, operational practices and reclamation techniques.	Chapter 3
235-236	Baseline data in existing reports and documents should be appropriately referenced.	Chapter 7, see References
236-239	BHP shall clearly and succinctly describe the following environmental components, as they relate to the proposed development, and all changes to the approved EKATI™ Diamond Mine, as a result of the proposed development:	–
240	I. air quality and climate	3.1, 4.3

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
241	II. surface and ground water quality and quantity	3.3, 3.4, 4.4.1.2
242	III. aquatic organisms and habitat	3.5
243	IV. wildlife and wildlife habitat, including migratory birds	3.7
244	V. vegetation and plant communities	3.6
245	VI. terrain, surficial geology, bedrock geology, seismicity, geological hazards, permafrost, soils, and lake sediments	3.2, 3.6
247	VII. human health	3.9.1.2, 3.9.2.2, 3.9.3.2, 3.9.4.2
248	VIII. economy	3.9.1.6, 3.9.2.6, 3.9.3.6, 3.9.4.6
249	IX. employment, education and training	3.9.1.3, 3.9.1.4, 3.9.1.5, 3.9.2.3, 3.9.2.4, 3.9.2.5, 3.9.3.3, 3.9.3.4, 3.9.3.5, 3.9.4.3, 3.9.4.4, 3.9.4.5
250	X. infrastructure	3.9.1.7, 3.9.2.7, 3.9.3.7, 3.9.4.7
251	XI. government revenues, cost; and	3.9.1.6
252	XII. social and cultural resources.	3.9
253	**3.1.3 Spatial Boundaries**	–
254-257	Spatial boundaries shall be scoped based on the maximum zone of influence of the proposed development for each valued ecosystem component that BHP is monitoring. The developer is not required to provide a comprehensive baseline description of the environment, but shall provide sufficient detail to address the relevant impact issues.	4.2.1.3, 4.9.5
258	**3.1.4 Temporal Boundaries**	–
259-262	In assessing the impact of the proposed development, the developer shall consider, describe and evaluate the environmental impacts of the proposed development for all phases of the proposed development including construction, operation, care and maintenance, closure and post-closure.	4.2.2, 4.9.5
263	**3.1.5 Impact Description and Predicted Outcomes After Mitigation**	–
264-268	Describe the impacts resulting from the proposed development, after mitigation, and present those in sufficient detail, including the method used in the analysis and prediction of impacts, to ensure reviewers can easily understand how the direct and indirect impacts were analyzed, and how residual impacts were determined. Information gaps shall be identified along with actions needed to remedy them.	4.3, 4.4, 4.5, 4.6, 4.7, 4.8
270-272	BHP shall describe each impact identified and the proposed mitigation measure(s) for all phases of the proposed development (*i.e.*, construction, operation, care and maintenance, closure and post-closure).	4.3, 4.4, 4.5, 4.6, 4.7, 4.8
274-276	BHP shall describe planned mitigation measures and consequences (environmental impacts) of potential failure. The residual impacts should be described at least in terms of the following parameters.	4.3, 4.4, 4.5, 4.6, 4.7, 4.10

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
277	I. magnitude	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
278	II. geographic extent	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
279	III. timing	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
280	IV. duration	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
281	V. frequency	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
282	VI. irreversibility of impacts	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
283	VII. ecological resilience; and	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
284	VIII. probability of occurrence and confidence level.	4.2.2, 4.3, 4.4, 4.5, 4.6, 4.7
286	Distinguish between ecological parameters and social/cultural parameters.	–
287	**3.1.6 Environmental Optimization**	–
288-289	The environmental assessment report shall report the comparative costs of proposed development alternatives and the corresponding environmental benefits.	2.3.5
289-291	Any assumptions or uncertainty surrounding implementation of mitigation measures, such as untested technology, will be reported.	2.2.3.3, 2.3, 5.3, 5.4.3, 5.5
291-293	The reporting of development impacts should provide readers with a summary, and comparative understanding of development impacts.	4.8
294	**3.1.7 Land Use**	–
295-297	Describe land and resource uses potentially impacted by the proposed development. Include maps of these land and resources uses in relation to the proposed development. For additional clarity, describe at least the following land and resource uses:	–
298	I. rare or ecologically significant areas	3.6.2, 4.4.1.3
299	II. traditionally or spiritually significant areas	3.8.1, 3.8.2, 3.8.3, 3.8.7
300	III. renewable resource harvesting areas	3.8.8, 4.9.6.2
301	IV. seasonal camp areas	3.8.7
302	V. permanent camp areas	3.8.7
303	VI. recreational and tourism land uses	3.8.8, 4.9.6.2
304	VII. snowmobile trails	3.8.7
305	VIII. wildlife outfitting area	3.8.8, 4.9.6.2
306	IX. Echo Bay winter road; and	3.8.9, 4.9.6.1
307	X. Echo Bay winter road camps and quarry land use permits.	3.8.9, 4.9.6.1
309	**3.2 Environmental Impacts**	–
310-312	Environmental assessment report shall report impacts resulting from proposed development on physical, biological and social, economic and cultural components of the environment.	–
313	**3.2.1 Air Quality and Climate**	–

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
314-317	Report the impacts of the proposed development on air quality. The analysis shall include a discussion of measures considered to minimize the release of air contaminants (dust, particulate exhaust fumes and other air contaminants). The analysis should also include:	4.3
318	I. atmospheric dispersion of emissions on a local and regional scale	4.3
319	II. greenhouse gas emissions including, but not limited to, Nox and SOx	4.3
320	III. atmospheric conversion processes of emissions (*e.g.* secondary particulates) and linkages between secondary particulates, the environment, and human health	4.3, 4.4.1.3
323	IV. impact on biological receptors such as vegetation and wildlife; and	4.3, 4.4.1.3, 4.6.1.1, 4.6.1.2
324-325	V. potential environmental impacts from particulate matter deposition should be addressed, *e.g.*, dust emissions from road traffic and construction.	4.3, 4.4.1.3, 4.6.1.1, 4.6.1.2
326	**3.2.2 Terrain**	–
327-330	Report the impacts on the environment when surficial geology, bedrock or soils are disturbed, or used for construction purposes. The environmental assessment shall report impacts resulting from, or on, the terrain and geological components. These should include, but not be limited to:	4.4
331-334	I. impacts on the Long Lake processed kimberlite containment area resulting from any changes in tailings disposal management and/or accelerated water inflow resulting from the Pigeon pipe development (including impacts on existing frozen-core dams, or changes to capacity)	2.2.1, 2.2.3.1, 2.2.4
335-336	II. impacts of alternatives such as "backfilling" the mined out kimberlite pits with waste rock (especially for pipes that are close together).	2.3.4
337	III. the proposed development's impact on the thermal milieu, including:	4.4.1.1
338-339	· impact of pit mining activities and infrastructure on permafrost physical conditions (including physical strength characteristics) and thermal regime	4.4.1.1, 4.4.2.4
340	· potential for thermal erosion in relation to altered drainage	4.4.1.1
341-342	· permafrost temperatures and ground ice conditions at mines and roadways, and in material being moved	4.4.1.1
343-344	IV. sensitivity of boggy / wetland terrain to drainage and thermal alterations (notably in relation to Pigeon pipe development)	4.4.1.1, 4.4.1.3

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
345-347	V. with respect to aggregate use, including massive ground ice and granular resource extraction, limitations on volumes of resource material and minimization of terrain disturbance associated with ground ice thaw	2.2.5, 4.4.1.1
348-349	VI. rock types, including the chemistry of pipes and stability of kimberlite by-products	2.2.3.3
350	VII. slope stability of pit walls	4.4.1.1, 4.4.2.4
351	VIII. seismicity and potential for rock heave	4.4.2.2, 4.4.2.3
352	IX. amount of overburden, sediments, and rock to be removed.	2.2.2
353-354	X. acid rock drainage potential and associated mitigation (including sub-aqueous disposal option); and	2.2.3.3
355	XI. impact of remedial actions at the mine site (waste dumps, tailings).	4.4.1.1, 4.4.1.3, 5.5.10
356	**3.2.3 Vegetation and Plant Communities**	–
357	The EAR shall analyze impacts of the proposed development on:	–
358-359	I. local plant communities classified as vegetation cover types in the existing monitoring program	4.4.1.3
360	II. rare or highly valued species	4.4.1.3
361	III. long-term, direct and indirect, habitat loss or alteration	4.4.1.3, 4.6.1.1
362	IV. biodiversity; and	4.4.1.3
363	V. vegetation productivity.	4.4.1.3
365-366	This should include a quantitative account of loss of plant communities and could be presented in conjunction with wildlife habitat data.	4.4.1.3, 4.6.1.1, 4.6.1.2
367	**3.2.4 Water Quality and Quantity**	–
368-370	The environmental assessment report shall provide an analysis of proposed development impacts on surface and ground waters. This analysis shall include the impacts on water quality and quantity, catchment areas and permafrost in relation to:	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5, 4.5.6
371-372	I. dredging, in-filling, and impacts of blasting and its associated residues, in particular, nitrogen	4.5.1.7, 4.5.2.2, 4.5.3.2, 4.5.4.2, 4.5.5.2
373	II. lake bed sediment placement and control of runoff	4.5.1.5, Project Description (attached CD-ROM)
374-375	III. impact of Pigeon and Sable kimberlite pipe development on the Exeter watershed	4.5.1, 4.5.2.1, 4.5.4.1
376-378	IV. dewatering of 393,000 m^3 of water from Sable to Two-Rock Lake and resulting impacts on the water balance, lake levels, outflow rates, *etc.* in October and November in Two-Rock Lake	4.5.2.1

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
379-382	V. dewatering lakes in October and November and related impacts on Panda Lake and the diversion channel, nutrient loading (in particular phosphorus), and effects on water bodies down stream where changes may occur that are greater then background variation	4.5.1.1, 4.5.2.1, 4.5.2.2, 4.5.4.1, 4.5.4.2, 4.5.5.1, 4.5.5.2, Project Description (attached CD-ROM)
383-384	VI. impact on ephemeral streams and permanent streams which collect and disperse surface water flow	4.5.1, 4.5.2.1, 4.5.3.1, 4.5.4.1, 4.5.5.1
385-387	VII. impact on water quantity, including changes in timing, volume and deviation of peak and minimum flows due to physical changes in topography, landscape and drainage patterns	4.5.2.1, 4.5.3.1, 4.5.4.1, 4.5.5.1
388	VIII. impact on the surface and groundwater flows to associated wetlands	4.4.1.3, 4.5.4.1
389	IX. siltation effects, *e.g.*, runoff along roadways and drainage channels	4.5.1, 4.5.2.2, 4.5.2.3, 4.5.3.2, 4.5.3.3, 4.5.4.2, 4.5.4.3, 4.5.5.2, 4.5.5.3
390-391	X. subaqueous disposal of potentially acid-generating rock and impact on water quality and aquatic organisms in the subject lake(s)	2.2.3.3.3
392	XI. the road to the Sable kimberlite pit and water crossings	4.5.1.8, 4.5.3
393	XII. nutrient passage in fish and non-fish bearing water courses	4.5.1.7, 4.5.2.2, 4.5.3.2, 4.5.4.2, 4.5.5.2
394-395	XIII. design, and rationale of using pervious rather then impervious dikes for waste water containment at the proposed Sable Kimberlite pit	2.2.2.1 EBA[1] (2.6)
396	XIV. Water chemistry impacts of surface runoff	4.5.1.5, 4.5.2.2, 4.5.3.2, 4.5.4.2, 4.5.5.2
397-399	XV. pit dewatering impacts including the experience gained from previous and on-going BHP EKATI™ Diamond mine operations, and other comparable operations and its applicability to this proposed development;	4.5.1.2, 4.5.2.2, 4.5.4.2, 4.5.5.2
400-401	XVI. ground water seepage impacts (through water retention dikes, into pits and underground); and	4.4.1.2, 4.10.2, EBA[1] (4.6.4)
402-403	XVII. contingencies for dealing with icing on the pit walls as well as ice removal from the pits.	4.4.2.4
404	**3.2.4.1 Water Balance**	–
405-406	A water balance shall be prepared that incorporates the proposed development's components into the existing water balance of the mine.	2.2.4
406-408	The water balance shall include water from the Beartooth and Pigeon kimberlite pits, the Sable kimberlite pit retention pond, and the Long Lake processed kimberlite containment area.	2.2.4

[1] EBA Engineering Consultants Ltd. 2000. *Preliminary Design of the Water Control Structures For The Sable, Pigeon, and Beartooth Developments*. Report prepared for BHP Diamonds Inc.

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
409	**3.2.4.2 General Water**	–
410-411	The assessment of proposed development impacts on water quality should also consider:	–
412-413	I. contaminant loading and dispersion (including surface runoff and airborne contaminants)	4.5.1, 4.5.2.2, 4.5.3.2, 4.5.4.2, 4.5.5.2
414	II. acid rock drainage, metal leaching and geochemistry	2.2.3.3
415	III. sedimentation (plumes and dispersion); and	4.5.1, 4.5.2.2, 4.5.2.3, 4.5.3.2, 4.5.3.3, 4.5.4.2, 4.5.4.3, 4.5.5.2, 4.5.5.3
416	IV. associated kimberlite toxicity and implications for aquatic wildlife.	4.5.1.2
417	**3.2.5 Aquatic Habitat**	–
418-422	The impacts on aquatic organisms and their habitat shall be considered taking into account predicted water quality and quantity impacts from the construction of additional open pits from the dewatering of lakes, excavation of on-land pipes and the associated effects of this activity on fish, fish habitat, and local drainage patterns. The analysis of development impact shall include:	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5, 4.5.6
423-424	I. productive capacity of aquatic systems during construction, operations, closure and post-closure	4.5.1, 4.5.2.3, 4.5.3.3, 4.5.4.3, 4.5.5.3
425	II. impacts of works and activities such as creek diversions, and pit restoration	4.5.1, 4.5.2.3, 4.5.3.3, 4.5.4.3, 4.5.5.3
426-428	III. impact on all lakes likely to have changes to fisheries resources including, but not limited to Two Rock, Beartooth, Pigeon Pond, Ulu, Sable, Upper Panda, and Exeter Lakes, and streams associated with these lakes	4.5.1, 4.5.2.3, 4.5.3.3, 4.5.4.3, 4.5.5.3
429	IV. habitat loss or alteration	4.5.1, 4.5.2.3, 4.5.3.3, 4.5.4.3, 4.5.5.3
430	V. rare and/or sensitive fish species and habitat; and	4.5.1, 4.5.2.3, 4.5.3.3, 4.5.4.3, 4.5.5.3
431	VI. mortality (includes fishing).	4.5.1, 4.5.2.3, 4.5.3.3, 4.5.4.3, 4.5.5.3
432-437	The principle of No Net Loss (Policy for the Management of Fish Habitat, DFO, 1986) of fish habitat is to be addressed when the loss of lake and stream habitat is being considered and when various proposed development components are restored (*i.e.* dikes and waste rock piles). As such, the environmental assessment report shall include an overview of how this principle will be achieved during the construction, operation, care and maintenance and closure stages of the proposed development.	4.5.1.1, 4.5.1.6, 5.5.7, 5.6.2.2
438	**3.2.6 Wildlife and Wildlife Habitat**	–
439-442	The environmental assessment report shall provide an analysis of the proposed development's impacts, (both direct and indirect), on wildlife and wildlife habitats, including migratory birds, giving consideration to and demonstrating linkages between predicted physical and biological changes resulting from the proposed development.	4.6, 4.6.1, 4.6.1.1, 4.6.1.2

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
443-444	Special consideration shall be given to species listed as vulnerable or endangered on the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) list.	4.6.1.3, 4.9.4.5
444-445	The analysis of development should include:	–
446-447	I. Impact of loss of terrestrial habitat, and the quality of lost habitat for relevant species, that was not covered in the 1995 EIS	4.6.1.1, 4.6.1.2, 4.6.1.3
448	II. habitat loss or alteration (*e.g.* fragmentation, connectivity)	4.6.1.1, 4.6.1.2, 4.6.1.3
449	III. disturbance of feeding, nesting, denning or breeding habitats	4.6.1.1, 4.6.1.2, 4.6.1.3
450	IV. improved or altered access impacts	4.6.1.1, 4.6.1.2, 4.6.1.3
451	V. wet-land habitat alteration, loss	4.4.1.3, 4.6.1.1, 4.6.1.2, 4.6.1.3
452	VI. physical barriers to wildlife	4.6.1.1, 4.6.1.2, 4.6.1.3
453-454	VII. disruption, blockage, impediment and sensory disturbance, of daily or seasonal wildlife movements (*e.g.* migration, home ranges, *etc.*)	4.6.1.1, 4.6.1.2, 4.6.1.3
455-457	VIII. rare, vulnerable, threatened or endangered species as outlined in the Canadian Organization of the Status of Endangered Wildlife in Canada (COSEWIC), as well as, species of international significance	4.4.1.3, 4.6.1.3, 4.9.4.5
458	IX. direct wildlife mortality	4.6.1.1, 4.6.1.2, 4.6.1.3
459	X. indirect wildlife mortality	4.6.1.1, 4.6.1.2, 4.6.1.3
460	XI. reduction in wildlife productivity	4.6.1.1, 4.6.1.2, 4.6.1.3
461-462	XII. implications of the proposed development acting as an attractant for particular species; and	4.6.1.1, 4.6.1.2, 4.6.1.3
463	XIII. displacement impacts.	4.6.1.1, 4.6.1.2, 4.6.1.3
465-466	The report should assess the implication of these impacts on the overall health of wildlife populations, communities, and ecosystems.	–
468	**3.3 Social, Economic and Cultural Components**	–
469	**3.3.1 Cultural and Heritage Resources**	–
470-471	Describe potential impacts of the proposed development on cultural and heritage resources.	4.2.2.5, 4.4.1.4, 4.9.4.2.4
472	**3.3.2 Land and Resources Use**	–
473-474	Assess the impacts of the proposed development on the use of land, water and renewable resources, including:	–
475	I. traditional land use and occupation	3.8.3.7, 4.7.9, 4.9.6.3
476	II. existing land use and occupation	3.8.8, 4.7.9
477	III. hunting, trapping, and outfitting, recreational, commercial and sport fishing	3.8.8, 4.7.9, 4.9.6.2
478-479	IV. availability, abundance and quality of wildlife, fishing, gathering, recreational and commercial land and water-based areas; and	4.7.9

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
480	V. protected areas.	1.1.2.3
481	**3.3.3 Economy**	–
482-483	The impact of the proposed development on the economy, having regard to direct, indirect and induced impacts on income and employment.	4.7
483-486	Any changes from the context of the 1995 EIA, or the BHP Socio-Economic agreement shall be reported including the effects of changes to the pace and scale of the development should be assessed. Consideration must be given to:	4.7
487-488	I. wage and salary employment by skills category over the life of the proposed development, including estimates of local and aboriginal participation	4.7.4.2, 4.7.8
489	II. activities such as tourism, outfitting, harvesting and recreation	4.7.9
490-492	III. opportunities for local, regional and territorial businesses to supply goods and services both directly to the proposed development and to meet the demand created by the expenditure of contractors and new employees	4.7.5
493-494	IV. opportunities to diversify the northern economic base to produce and to supply new goods and services	4.7.6
495	V. barriers to employment	4.7.7
496	VI. availability and use of skilled workers in the NWT to meet job requirements	4.7.8
497	VII. the impacts on the subsistence economy	4.7.9
498	VIII. impacts to hunters, trappers	4.7.9
499	IX. federal and territorial revenues and costs	4.7.4
500	X. local government finances	4.7.4
501	XI. inflation and the cost of living impacts; and	4.7.10
502	XII. economic diversification.	4.7.6
503	**3.3.4 Human Health**	–
504-507	The environmental assessment report shall analyze the potential development impacts on human health, as they relate to the proposed development, (*i.e.* physical health, including death and disease rate, psychological, emotional, spiritual, or mental health and wellness).	4.7.11
509-513	Information shall also be provided on the toxicological risks associated with substances hazardous to human health and human exposure to identified hazards via water, air, vegetation and wildlife. Routes of exposure to human populations using an environmental pathway analysis shall be provided, including both routine and accidental release of materials or disposal of waste products.	4.7.11

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
514	**3.3.5 Government**	–
515-520	Assess the impacts of the proposed development on revenues and costs accruing to federal and territorial governments, and the net incremental benefits or costs to these governments arising from the proposed development. BHP shall also report other fee structures/costs BHP will incur such as quarry royalties, changes to security deposits, and incremental abandonment and restoration costs resulting from the proposed development.	2.1.1.4, 4.7.4
521	**3.3.6 Infrastructure**	–
522-525	Assess the impacts of the proposed development on existing social, institutional and community services, transportation facilities, services, infrastructure (*e.g.* transportation safety), and permanent changes to the infrastructure and services arising from the proposed development.	4.7.12
526	**3.3.7 Noise**	–
527-529	Assess the impact of the proposed development on the environment resulting from changes to ambient noise levels, continuous exposure versus acute exposure (*i.e.*, blasting) and the effect of these changes on humans and wildlife	4.3.2, 4.6.1.1, 4.6.1.2
530	**3.3.8 Visual and Aesthetic Resources**	–
531-532	Assess the visual and aesthetic impact of the proposed development. Report design components that mitigate visual and aesthetic impacts.	4.4.1.5
534	**3.4 The Effect(s) of the Environment on the Proposed Development**	–
535-540	BHP shall assess the effect(s) of the environment on the proposed development, and activities forming part of the proposed development, and existing components of the BHP mine modified as a result of the proposed development. The environmental assessment shall include a discussion of the impacts of the environment on the proposed development, and what BHP has learned to date that it will incorporate into the proposed development.	4.4.2
540-541	BHP shall consider such things as severe weather, climate change, (*e.g.*, global warming) precipitation and temperature.	4.4.2
543-546	The discussion must specifically describe and assess how the potential for climate change could affect permafrost and soils with high ice content in relation to the integrity of the proposed development infrastructure, particularly the tailings (processed kimberlite) containment impoundment, water retention dikes and waste rock piles.	4.4.2.1, 4.4.2.2

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
548	**3.5 Cumulative Impact**	–
549-552	For the purposes of this development, the environmental assessment shall include an evaluation of cumulative effects that are likely to result from the proposed development in combination with other developments; and developments within the regulatory process on the day these Terms of Reference are issued.	4.9
554-555	BHP shall include, as a minimum, the existing BHP EkatiTM Diamond Mine, Diavik Diamond project, and the Echo Bay Mines Ltd. Winter Road and Lupin mine.	4.9.6
555-557	BHP shall also report and describe developments considered but not included in the cumulative effects assessment, and rationale for the decision.	4.9.6
559-561	BHP shall provide confirmation that all existing facilities, infrastructure, *etc.*, BHP plans to use can adequately handle the demands generated by the proposed development. Include cumulative impacts in relation to:	Chapter 1, 2.2.2
563	I. the environment	4.9
564	II. social environment	4.9
565	III. economic environment	4.9
566	IV. cultural environment	4.9
567	V. heritage resources; and	4.9.2.4.2
568	VI. visual and aesthetic resources.	4.4.1.5, 4.9
570-572	Explicit documentation of the assumptions, models, information sources used as well as information limitations and associated levels of uncertainty shall support all steps of the CEA in the environmental assessment report.	4.9, Chapter 7
572-574	The analysis should be quantitative where data are available but where data or models are lacking, best professional judgement may be used.	4.9
574-575	The approach and methodologies used to identify and assess cumulative effects shall be explained.	4.9
577	**3.6 Abandonment and Restoration**	–
578-580	BHP shall provide a complete description of regulations (regulatory framework), industry standards and government agreements that are needed with respect to the closure phase of the proposed development.	5.6.1, 5.6.2, 5.6.3, 5.6.6
580-582	Where regulatory requirements, industry standards or government agreements exist, their minimum standards, criteria, *etc.* shall be reported.	5.6.1, 5.6.2, 5.6.3, 5.6.6

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
582-585	Based on the implementation of regulatory requirements, government agreements and industry standards, BHP shall identify and report and describe environmental impacts resulting from the proposed development, and mitigation taken to address the impacts.	5.6.1, 5.6.2, 5.6.6
585-586	BHP shall provide a clear (visual and textual) description of the proposed development site at closure, and after restoration.	5.5.10
588	**3.7 Follow-up Programs**	–
589-591	Follow-up programs should focus on addressing any new concerns and environmental management questions that result from the proposed development. Proposed follow-up programs shall be clearly described.	2.1.2, 5.4
593-597	Describe reporting (feedback) procedures, proposed amendments to existing procedures and any changes within the company's organization in regards to the environmental impacts monitoring program. The intent is to ensure that remedial actions are taken if the results of a monitoring program deviate from any established operational standards on environmental performance or predictions on environmental impacts.	5.4.2, 5.4.3
599-603	Provide information on any proposed environmental impacts monitoring program(s) or amendments to existing environmental monitoring program(s), designed to determine the actual environmental impacts as compared with those predicted during the environmental assessment process, measure the performance and of the mitigation measures, and identify unexpected environmental impacts and alternatives.	5.3, 5.4.3, 5.4.5
603-605	Adaptive management practices already undertaken and incorporated in the mitigation measures should be clearly identified.	1.1.2.5, 5.3, 5.4.3
607-610	Provide information on any proposed environmental management plans or amendments to existing environmental management plans such as air quality, water quality, materials management, wildlife, traffic, aquatic life, waste, quarry and environmental monitoring and social, economic and cultural monitoring as required.	5.4.5
612	**3.8 Compensation**	–
613-616	The developer shall provide key elements of its policy on individual compensation and on compensation agreements, contracts or other forms of compensation they have or will negotiate as it relates to mitigating adverse environmental impacts, within the confines of confidentiality.	2.1.2.4, 5.6.3

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
617-618	**4. ADDITIONAL DIRECTION FOR THE ENVIRONMENTAL ASSESSMENT**	–
619	**4.1 Executive Summary**	–
620-623	BHP shall provide a concise description of all the key facets of the proposed development including the need and purpose for the proposed development in appropriate languages, including the following aboriginal languages; Dogrib, Inuvialuktun, and Chipewyan.	Executive Summary (stand-alone document)
623-624	This executive summary shall also provide a general outline of the key impacts, issues and proposed mitigation strategies and measures.	Executive Summary (stand-alone document)
624-626	A succinct description of information distribution, as well as First Nations and public consultation measures taken shall be included.	6.2.2, 6.2.3, 6.2.5, 6.2.6
628	**4.2 Developer Identification and Performance Record**	–
629-630	BHP shall provide developer information including name of company representatives managing the proposed development.	1.1.1.1, 1.1.1.2, 1.1.1.5
630	Include company incorporation and structure.	1.1.1.1, 1.1.1.2, 1.1.1.5
631-632	Briefly summarize, the developer's corporate history in Canada and the Northwest Territories, and that of its partners.	1.1.1.3, 1.1.1.4
632-635	The brief discussion shall include proposed development ownership, organizational structure identifying organizational responsibilities for mine development and operations, and an environmental performance record at the current site.	1.1.1.5, 1.1.1.6
637-638	BHP shall include a brief and succinct compliance report from the independent environmental monitoring agency.	See Appendix A
638-642	BHP shall provide (as pertaining to the proposed development) a summary of adaptive and incremental improvements incorporated to date in the construction, operations, remediation, and reclamation of the mine, and measures that have contributed to mitigating and/or improving the environmental, economic and human effects of the existing mining operation.	5.3, 5.4.3
644	**4.3 Tenure**	–
645-646	Clearly delineate the surface and subsurface extent that BHP to intends to secure through lease or other tenure arrangements for the proposed development.	2.1.1.3
648	**4.4 Developer's Policies**	–
649	BHP Diamond Inc.'s shall provide its corporate policies on the following:	–
650	I. preserving the environment	1.1.2.1
651	II. limiting the use of fresh water (*i.e.*, recycle, re-use)	1.1.2.2
652	III. the Protected Areas Strategy	1.1.2.3

MVEIRB Terms of Reference		BHP Diamonds Inc. Responses
Line	Description	
653	IV. abandonment and reclamation and progressive reclamation	1.1.2.4
654	V. reporting and sharing of adaptive management or learned experiences	1.1.2.5
655	VI. measures to encourage contractors to hire northerners	2.1.2.2, 2.1.2.3, 4.7.3, 4.7.4, 4.7.7, 4.7.8
656-657	VII. education for appropriate personnel to ensure they are aware of their role in the protection of the environment and in emergency response plans;	1.1.2.6
658-659	VIII. contracting and procurement, including those which promote local sourcing, participation of local businesses and opportunities for northern businesses	4.7.5, 4.7.6
661	**4.5 Regulatory Regime**	–
662-664	Provide a table and map summarizing and showing relevant licenses, permits and other authorizations that are required, or require amendment to allow the proposed development to occur.	2.1.1.3
664-666	Include, for reference purposes, existing permits and other authorizations that remain in force, and do not require amendment to allow the proposed development to occur, and their respective durations.	2.1.1.2
667	**5. PRESENTATION**	–
668	**5.1 Conformity**	–
669-672	The environmental assessment report shall include a conformity table outlining to reviewers the areas in the report (including appendices and technical reports) that address the specific sections, and where appropriate line items, of the Terms of Reference.	Provided
674	**5.2 Format**	–
675-677	The format of the environmental assessment report is largely left to the discretion of the developer although reviewers must be able to clearly identify where specific issues have been addressed and directions followed.	–
679	**5.3 Appendices**	–
680-681	Detailed data shall be contained in appendices and technical reports submitted in support of the primary environmental assessment report.	See Appendices
683	**5.4 Data Presentation**	–
684-686	The developer should present the environmental assessment report in the clearest language possible. Where technical language is used a glossary defining technical words and acronyms should be included.	See Glossary
686-688	BHP should provide charts, diagrams and maps wherever useful to clarify the text. Where possible, maps should be of common scale and orientation to allow for comparison and overlap of mapped features.	Provided
688-689	BHP shall also provide the EAR report in electronic format (*e.g.* CD-ROM).	To be provided

GLOSSARY AND ABBREVIATIONS

Glossary

Abiotic Factors	Environmental influences that arise from non-living entities, *e.g.*, climate.
Ablation Till	A heterogeneous mixture of soil and rock particles transported on or within a glacier that is deposited on the ground after the ice stagnates and melts. The landform that it created is often called a hummocky moraine.
Aggrade	To spread or grow (permafrost).
Air Contaminant	Any solid, liquid, gas or odour, or combination thereof, which, if emitted into the air, would create or contribute to the creation of air pollution.
Air Pollution	A condition of the air, arising wholly or partly from the presence of one or more air contaminants, that endangers the health, safety or welfare of persons; interferes with normal enjoyment of life or property; endangers the health of animal life; or causes damage to plant life or to property.
Alluvial	Clay, silt, sand and gravel material deposited by running water.
Ambient Air Quality	The surrounding air quality present at a particular site.
Amorphous	Substances lacking any crystal structure or order; usually used with reference to oxides or organic matter.
Anthropogenic	Caused by human activity.
Arctic Air Inversion	A layer in the troposphere in which there is an increase in air temperature with height. This differs from normal conditions in which temperature decreases with height from the surface.
Autonomous	Existing or capable of existing independently.
Basal Till	Unsorted glacial debris at the base of the soil column where it comes into contact with the bedrock below.
Basic Rock	An igneous rock, relatively low in silica and composed mostly of dark-coloured minerals.
Bedrock	The more-or-less solid, undisturbed rock in place either at the ground surface or beneath superficial deposits of gravel, sand or soil.
Bedrock Geology	The study of the origin, composition, structure and history of bedrock.
Benthic	Pertaining to the bottom region of a water body.
Benthos	Assemblage of animals living in or on the bottom sediments of a lake and dependent upon the decomposition cycle for most if not all of its basic food supply.
Bifaces	A stone tool used by ancient peoples. A type of artifact that has been chipped from a larger stone on both sides.
Biodiversity	The variety of organisms that exist on the planet and the varieties within these species and the ecosystems they inhabit.
Biogenic	Arising from or associated with biological sources.

GLOSSARY AND ABBREVIATIONS

Blasthole	A hole drilled for purposes of blasting rather than to obtain exploration or geological information.
Bulk Sample	A large sample of mineralization, frequently involving hundreds of tonnes, selected in such a manner as to be representative of the potential ore body being sampled. Used to determine metallurgical characteristics, verify grade and obtain diamond quality information.
Carat	A unit of weight for precious stones (200 milligrams).
Carnivore	A flesh-eating mammal.
Catch Per Unit Effort (CPUE)	The number of fish caught per 24-h soak time per 100 m of gillnet; or per 24-h soak time for trapnets.
CEAA	Canadian Environmental Assessment Agency.
Clarification	Process of cleaning dirty water by removing suspended material.
Climatology	The study of the long-term, prevailing weather conditions in a given area.
Coefficient of Habitat Effectiveness (CHE)	The CHE provides a measure for estimating potential habitat disturbance within the zone of influence (ZOI) of a particular disturbance.
Concentrate	The product of the crushing, grinding and cleaning process contains valuable mineral and from which most of the waste material in the ore has been eliminated and discarded as tailings (processed kimberlite at EKATI™).
Core	A long, cylindrical piece of rock recovered by diamond drilling.
Crater	A circular depression formed by extrusion of volcanic material and its deposition in a surrounding rim.
Craton	A portion of a continent that has attained stability and has not been subjected to major deformation for a prolonged time, typically since Precambrian or Early Paleozoic time.
Critical Depth	The depth in a lake at which sufficient light penetrates to enable photosynthesis in plants to equal their respiration.
Crown Pillar	A column of ore left at the top of the kimberlite orebody to support overlying rock and protection from wall sloughing above.
Crusher	A machine for crushing rock, such as a gyrating crusher or a cone crusher.
Cumulative Effects	Changes to the environment that are caused by an action in combination with other past, present and future actions.
Cycle Time	Total time required for a loaded haul truck to leave the shovel in the pit, plus travel to its dumping location, dump the load, and then return back to the shovel to be loaded again.
Debitage	Pieces of stone removed during the manufacture of stone tools.
Decibel (dB)	The basic unit for measuring the magnitude of sound pressure levels. The entire range of audible sound pressure (a range of more than 10 million to one for individuals with normal hearing) can be compressed into a practical scale of sound pressure levels from 0 to 140 dB. One decibel is the minimum difference in loudness that is usually perceptible.

Decline	An inclined underground opening connecting levels to allow machine access from level or from surface; also called a ramp.
Decommissioning	The process by which a mining operation is shut down and closed.
Demographics	The analysis of factors such as births, marriages, diseases and other vital statistics, which allow the assessment of a population in a given area.
Detritus	Unconsolidated material composed of both inorganic and dead and decaying organic material.
Development	Any undertakings or part of an undertaking, that is carried out on land or water, and includes work carried out to provide access to the mineral ore and facilities associated with production activities.
DFO	Department of Fisheries and Oceans.
Diabase	A common basic igneous rock usually occurring in dykes or sills.
Diagenesis	The sum of all chemical, physical and biological influences on sediment composition.
Diamond	The hardest known mineral, composed of pure carbon.
DIAND	Department of Indian Affairs and Northern Development
Diatom	Common name for Bacillariophyta; a type of phytoplankton.
Diatreme	A breccia-filled volcanic pipe that was formed by a gaseous explosion.
Dip	The angle at which a structure or rock bed is inclined from the horizontal as measured at right angles to the strike.
Diurnal	Daily.
DOE	Department of Environment Canada.
Dorsal	Pertaining to the back.
Dorsal Fin	A fin on the back of a fish, usually central in position and supported by rays or spines.
Dyke	An earth-fill structure similar to a dam designed to impound water or saturated material such as tailings.
Ecology	The study of the interactions between organisms and their environment.
Ecosystem	A community of interacting organisms considered together with the chemical and physical factors that make up their environment.
Ecosystem Approach	A holistic, interdisciplinary method of studying a system that seeks to integrate biophysical and socioeconomic factors with input from a variety of sources.
Ecosystem Integrity	A measure of the overall health of an ecosystem.
Effect	A change to a Valued Ecosystem Component (VEC) due to human activities. For instance, building a road can change caribou migration routes. An effect is not necessarily a negative impact; an effect may be neutral or even positive. For example, a change in caribou migration routes may not adversely impact the caribou. Replacing one fisheries habitat with another may enhance the fishery.
EKATI™	EKATI™ Diamond Mine.
Emission Rate	The rate at which a source releases air contaminants.

Englacial	Contained, embedded or carried within the body of a glacier or ice sheet.
Environment	The components of the Earth including land, water, and air, and all layers of the atmosphere. Also all organic and inorganic matter and living organisms and the interacting natural systems of such, including the cultural, social and spiritual components.
Environmental Assessment and Review Process (EARP)	The process previously used by the federal government to consider the environmental implications of all proposals for which the federal government had decision-making authority. This process was replaced by the Canadian Environmental Assessment Act (CEAA).
Environmental Assessment Report (EAR)	A report completed by the developer describing the development, impacted environment, potential environmental effects and proposed mitigation.
Environmental Impact Statement (EIS)	An assessment document designed to identify, predict, interpret and communicate information about the effect of an activity on human health and well-being, including the well-being of ecosystems on which human survival depends under the EARP. With the Mackenzie Valley Resource Management Act, an EIS would also include the results of public consultation undertaken by the proponent.
Environmental Quality Objectives	Goals or purposes toward which an environmental control effort is directed, including goals or purposes stated in quantitative or qualitative terms.
Ephemeral Stream	A stream that lasts for only a short time.
Esker	Sinuous ridge of weakly stratified gravel and sand deposited by a stream flowing in (or beneath) the ice of a retreating glacier, and left behind when the ice melted.
Euphotic Zone	A zone near the water surface into which sufficient light penetrates for photosynthesis to take place.
Eutrophic	Nutrient rich waters with high primary productivity.
Face	The end of an underground drift or crosscut, or of an open pit bench, in which mining is progressing.
Fault	A break in the Earth's crust caused by tectonic forces that have moved the rock on one side with respect to the other; faults may extend for many kilometres or be only a few centimetres in length; similarly, the movement or displacement along the fault may vary widely.
Fecundity	Potential ability of an organism to produce eggs or young.
Filtration	The process used in water treatment to remove suspended solid particles remaining after chemical coagulation and sedimentation.
Flake	A piece of rock intentionally removed from another rock that may be further modified to become a tool, or left unmodified as debitage or detritus.
Fork Length	Distance from the proximal tip of the head to the tip of the middle ray of the caudal fin.
Freshet	Increased volume of flow over a relatively short period of time (*e.g.*, snowmelt).
Frost Boil	An unsorted circle of fresh soil material formed by frost action and commonly found in fine-grained sediments underlain by permafrost.

Fry	Young fish, newly hatched, after the yolk has been used up and active feeding has commenced.
Gaussian Dispersion	The dispersion of a pollutant after it leaves the top of the stack; often follows a pattern similar to the so called "bell-shaped curve."
Geology	The science concerned with the study of the rocks that compose the Earth.
Geomorphology	The study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface features.
GIS	Geographic Information System.
Glaciofluvial Deposits	Unconsolidated rock material deposited by meltwater streams flowing from glaciers.
Glory Holes	An open pit from which ore is extracted, especially where broken ore is passed to underground workings before being hoisted.
Granite	A coarse-grained (intrusive) igneous rock consisting of quartz, feldspar and mica.
Granitoid	A granitic rock.
Gyratory Crusher	A machine that crushes ore between an eccentrically mounted crushing cone and a fixed crushing throat.
Heavy Medium Separation (HMS)	A unit process in which crushed ore is washed in rotary drum scrubbers to break up agglomerated ore particles and remove soft fines and clay minerals.
Herbivore	An animal that feeds on plants.
Holistic	A total interrelated system perspective.
Host Rock	The rock surrounding an ore deposit.
Hydrology	The study of the properties of water and its movement in relation to land.
IBA	Impact Benefits Agreements: benefits agreements negotiated between BHP and the four Aboriginal groups that have traditonally used the claim block: Dogrib Treaty 11; Akaitcho Treaty 8; North Slave Metis Alliance; and Inuit of Kugluktuk.
Ice Wedge Polygon	A large polygon characterized by borders of intersecting ice wedges, found only in poorly drained areas of permafrost regions and formed by contraction of frozen ground. The fissured borders may be either ridges or shallow troughs underlain by ice wedges.
IEMA	Independent Environmental Monitoring Agency established in 1997 to serve as a public watchdog for environmental management at the EKATI™ Diamond Mine as per the Environmental Agreement.
Igneous	A rock formed by the solidification of magma.
Impact	An effect on a Valued Ecosystem Component (VEC) that adversely affects the utility or viability of that VEC. For instance, decreased oxygen levels in lakes will at a certain level and/or after a certain time, kill fish. Similarly, an increase in particles in the water (suspended solids) that inhibit light penetration, can reduce the productivity of plants that depend on that light. Building a road can result in caribou being killed by vehicle collisions.
Index Gill Netting	Standard sampling design (used in the 1994 project area) where small-mesh gillnets are set perpendicular to shore beginning at depths of 2 m to 3 m.

Indigenous Knowledge	Working definition from the Inuit Circumpolar Conference (1993): *"... comprised of information and concepts about the environment and ecology that are known, but usually not formally recorded by individuals who belong to a particular culture group that has occupied an identifiable territory over a long period of time. It includes facts, concepts and theories about the characteristics which describe the objects, events, behaviours and interconnections that comprise both the animate and inanimate environments of indigenous peoples."*
Insolation	The rate of radiation from the sun received per unit of the Earth's surface. Insolation is a strong determining factor for atmospheric stability.
Invertebrates	Collective term for all animals without a backbone or spinal column.
Isolated Find	An archaeological site with a single artifact.
Kame	A mound, knob or short irregular ridge composed of stratified sand and gravel. The deposit can be formed by a subglacial stream as a fan or delta at the margin of a melting glacier, by a superglacial stream through a hole on the surface of the glacier, or as a ponded deposit on the surface or at the margin of sedentary ice.
Kettle	A depression in a glacial deposit formed by the melting of a detached block of ice buried in the deposit.
Kimberlite	An ultrabasic igneous rock that consists mainly of the mineral olivine and is found in volcanic pipes. The name is derived from Kimberley, South Africa, where the rock contains diamonds.
Labile	Rocks and minerals that are easily decomposed.
Lacustrine	Pertaining to, or produced by, a lake.
Lag	A residual accumulation of coarse rock fragments on a surface after the finer material has been blown away by winds.
Lake Overturn	Vertical mixing of layers in a body of water brought about by seasonal changes in temperature.
Larva	The immature stage, between egg and pupa, of an insect with complete metamorphosis.
Leaching	A natural process by which groundwaters dissolve minerals, thus leaving the rock with a smaller proportion of some of the minerals than it contained originally.
Leq	The maximum allowable noise exposure level for a specified length of exposure time.
Level	A system of horizontal underground workings connected to the shaft; the basis of operations for excavation of ore above or below.
Limnology	The study of fresh water, including biological, geological, physical and chemical aspects.
Lithic	Of or pertaining to stone.
Littoral	Region of a lake from the highest water level to the depth at which photosynthesis ceases.
Long Lake Containment Area	An engineered storage site used to confine the fine fraction of the processed kimberlite (*i.e.* tailings) in Long Lake at the EKATI™ mine.
Lotic	Flowing freshwater environments (*e.g.*, streams and rivers).

Macroinvertebrate	An aquatic insect visible to the naked eye. This term generally applies to insects found in flowing waters, and includes groups such as the larval caddis fly, mayfly, dragonfly and stone fly.
Macrophyte	A macroscopic photosynthetic organism growing submerged, floating or emergent in the water.
Mesotrophic	Waters with moderate primary productivity.
Microclimate	The weather variations in a very local area.
Mineral	A naturally occurring, homogeneous substance having definite physical properties and chemical composition and, if formed under favourable conditions, a definite crystal form.
Mineral Claim	A portion of land held by either a prospector or a mining company under federal or provincial law.
Mitigation	An activity aimed at avoiding, controlling or reducing the severity of adverse physical, biological and/or socioeconomic impacts of a project activity.
Mixing Height	The effective depth of the atmosphere, measured from ground level, through which the dispersion of pollutants can take place.
Moraine	A mound or ridge of unstratified glacial sediments, chiefly till, deposited by direct action of glacier ice.
MVCIMP	Mackenzie Valley Cumulative Impact Monitoring Program. A program coordinated by DIAND as part of the land claims agreements to assist with the development of a regional cumulative effects monitoring framework.
MVLWB	Mackenzie Valley Land and Water Board
MVEIRB	Mackenzie Valley Environmental Impact Review Board.
MVRMA	Mackenzie Valley Resource Management Act, which provides for an integrated system of land and water management in the Mackenzie Valley. Replaced CEAA within the NWT in December 1998.
Oligotrophic	Nutrient deficient waters with low primary productivity.
Open Pit	A surface mine, open to daylight, such as a quarry. Also referred to as open-cut or open-cast mine.
Ore	A mineral, or group of minerals, that can be extracted from the ground at a profit under existing economic conditions.
Otolith	Inner ear bone found in bony fishes (flat and oval in structure).
Outcrop	An exposure of rock or mineral deposit that can be seen on surface *i.e.*, not covered by overburden or water.
Pectoral Fins	The most anterior or uppermost of the paired fins of a fish.
Pelagic	Inhabiting the open water of a lake, in contrast to the lake bottom (benthic region).
Periphyton	Community of microbiota (algae, bacterial, fungi, rotifers, nematodes, protozoans and detritus) that are loosely attached to submerged substrata that may be inorganic, organic, living or dead.

Phytoplankton	Small floating plant life in aquatic ecosystems, sometimes microscopic.
Pipe	The vertical conduit along which gas and magma ascend to the surface, usually filled with breccia and may be mineralized; a more or less vertical, cylindrical ore body.
Piscivorous	Fish eating.
Planktivorous	Plankton eating.
Plant Site	A centralized area containing the process plant, permanent camp, equipment maintenance facilities and other infrastructure required to support the mining and diamond production operations.
Plunge Pool	The water occupying a deep hollow scoured in the bed of a stream at the foot of a waterfall; also, the hollow or basin itself.
Portal	The surface entrance to a tunnel or adit.
Post-decommissioning	The time after which an operation has closed and equipment and facilities have been removed from the site.
Primary Production	Production by photosynthetic organisms.
Primary Productivity	Rate at which energy is stored by the photosynthetic activity of plants.
Processed Kimberlite	The residual material left behind when the processing of kimberlite ore has been completed to extract the diamonds.
Process Plant	A building in which crushed ore is washed, screened, concentrated and sorted for the recovery of diamonds.
Profundal	Region of a lake lying below the euphotic zone.
Proponent	The organization, company or institution planning to initiate a project.
Pupa	The stage between larva and adult in insects with complete metamorphosis.
Pyrite	The most widespread and abundant of all the sulphide minerals and occurs in all kinds of rocks; a common yellow mineral with a brilliant metallic lustre.
Pyroclastic	Pertaining to clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic vent.
Quaternary Geology	Rocks from the Quaternary, a period of the Cenozoic era, which began two to three million years ago and extends to the present.
Radiation Inversion	A condition in which rapid cooling of the ground by radiation causes ambient temperatures to increase with height.
Raise	An underground opening driven upward from one level to another.
Reclamation	An activity aimed at rehabilitating a disturbed site to some level of ecological productivity.
Recruitment	In biology, an addition to the population by reproduction of new individuals.
Redox Conditions	A measure of electron activity of an environment (*i.e.*, sediments); high redox conditions mean oxygen-rich environments, low redox conditions mean oxygen-poor

	environments.
Residual Effects	Effects that persist after mitigation measures have been applied.
Retouch	A type of modification used in the manufacture of stone tools.
Riffle	Shallow areas in a stream or river section characterized by increased habitat heterogeneity, sediment size, stream velocity, and sometimes oxygen content.
Rock	Any natural combination of minerals; part of the Earth's crust.
Rock Mass Rating (RMR)	A geomechanic classification of a rock slope or drill core that provides quantitative data for the purpose of mine design and ground reinforcement. RMR values range from 0 (very poor rock) to 100 (very good rock).
Rotary Drill	A machine that drills holes by rotating a rigid, tubular string of drill rods attached to a bit. Commonly used for drilling large diameter blastholes in open pit mines; recovers chips rather than rock core.
Run-of-Mine	Typical excavated ore or waste rock that has not been upgraded, sorted or otherwise processed.
Salmonid	Family of freshwater or anadromous fishes; dominant family in northern waters of North America (includes lake trout, round whitefish, arctic grayling).
Sample	A small portion of rock or a mineral deposit, taken so that the metal content can be determined by assaying.
Sampling	Selecting a fractional but representative part of a mineral deposit for analysis.
Scoping Sessions	Public meetings where all relevant issues and concerns related to a proposed project or activity are identified.
Secondary Production	Production by consumer organisms.
SGP	Slave Geological Province
Shaft	A vertical or inclined excavation in rock for the purpose of providing access to an ore body. Usually equipped with a hoist at the top, which lowers and raises a conveyance for handling workers and materials.
Sill	An intrusive sheet of igneous rock of roughly uniform thickness, generally extending over considerable lateral extent, that has been forced between the bedding planes of existing rock.
Solifluction	The slow downslope movement of saturated earth materials resulting from alternate freezing and thawing of ground ice.
Sorted Circle	A dominantly circular form of patterned ground, developed singly or in groups, that has a sorted appearance commonly due to a border of stones surrounding finer material.
Sound Level Meter	The basic instrument used to measure sound pressure variations.
Standing Crop	Amount of living organic matter found in a given area or volume of water at a given time; expressed as number per unit area or unit volume.
Steady-state Noise	Noise that may be characterized as having a steady magnitude (usually measured in dBA) and a prolonged duration. Examples would be noise generated by fans, diesel power plant engines and any other heavy equipment at normal operating state.

Stockpile	A supply of material, for example, blasted rock or crushed ore, set aside for future use.
Striation	One of a series of fine parallel straight lines cut into a bedrock surface by rock fragments embedded at the base of a moving glacier, or cut on the rock fragments themselves.
Stripping Ratio	The ratio between the unit amount of overburden/waste rock that must be removed to obtain a unit amount of ore (kimberlite).
Sublevel	A system of horizontal underground workings, normally within stoping areas only, required for ore production.
Supraglacial	Carried at the top of a glacier or ice sheet.
Surficial Geology	The study of material at or near the surface of the earth, usually unconsolidated soil or rubble.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Tailings	Ground waste material and water (slurry) rejected from a mill or process plant after most of the valuable minerals have been extracted.
Tailings Pond	An engineered storage site used to confine tailings (*i.e.* Long Lake Containment Facility).
Talik	A layer or body of unfrozen ground below the active layer in a permafrost area.
Thermocline	Layer in a thermally stratified body of water in which temperature changes rapidly relative to the remainder of the body.
Thermokarst	The process by which characteristic karst-like landforms result from the thawing of ice-rich permafrost, forming cave-in bogs, caverns, pits and other small depressions.
Till	Unstratified rock material deposited directly by glaciers, consisting of a mixture of clay, silt, sand, gravel and boulders ranging widely in size and shape.
Traditional Environmental Knowledge (TEK)	As defined by the Dene Cultural Institute: *"...a body of knowledge and beliefs transmitted through oral tradition and first hand observation. It includes a system of classification, a set of empirical observations about the local environment and a system of self-management that governs resource use. Ecological aspects are closely tied to social and spiritual aspects of the knowledge system."*
Trophic Levels	Functional classification of organisms in an ecosystem according to feeding relationships, from first level autotrophs through succeeding levels of herbivores and carnivores.
Turbidity	A condition of reduced transparency in water caused by suspended colloidal or particulate material.
Valued Ecosystem Components (VECs)	An environmental attribute or component having scientific, social, cultural economic or aesthetic value. For instance, caribou are a VEC. So too are fisheries and good water quality.
Waste Rock	Barren rock or rock too low in grade to be mined or processed economically.

Whitehorse Mining Initiative	An accord reached in 1994 by representatives of the Mining Association of Canada, senior governments, labour unions, Aboriginal peoples and the environmental community which adopted "...a strategic vision for a healthy mining industry, in the context of maintaining healthy and diverse ecosystems in Canada, and for sharing opportunities with Aboriginal peoples."
WKSS	West Kitikmeot Slave Study Society
YOY (young of the year)	Juvenile fish during the period from the last larval stage to adulthood, or one year of age, whichever comes sooner.
Zone of Influence (ZOI)	The ZOI is a horizontal measure of the area in which an animal (*e.g.* bear) could be affected by a particular disturbance.
Zooplankton	Small floating or weakly swimming invertebrate animals in freshwater and marine ecosystems.

Abbreviations

Ampere	A
Annum	a
Billion years	Ga
Canadian dollar	$ or CDN$
Carat	ct
Carats per stone	ct/stone
Centimetre	cm
Cubic metre	m^3
Cubic metres per hour	m^3/h
Cubic metres per minute	m^3/min
Cubic metres per year	m^3/a
Day	d
Days per week	d/wk
Days per year	d/a
Degree	°
Degrees Celsius	°C
Gram	g
Grams per cubic centimetre	g/cm^3
Grams per kilowatt hour	g/kWh
Grams per litre	g/L
Grams per tonne	g/t
Greater than	>
Hectare	ha
Hertz	Hz
Horsepower	hp
Hour	h
Hours per day	h/d
Hours per year	h/a
Kilogram	kg
Kilograms per cubic metre	kg/m^3
Kilograms per hour	kg/h
Kilograms per tonne	kg/t
Kilograms per year	kg/a
Kilojoule	kJ
Kilometre	km
Kilometres per hour	km/h
Kilopascal	kPa
Kilovolt	kV
Kilovolt-ampere	kVA
Kilowatt	kW
Kilowatt hour	kWh
Kilowatt hours per tonne	kWh/t
Kilowatt hours per year	kWh/a
Less than	<
Litre	L
Litres per year	L/a
Litres per hour	L/h
Litres per minute	L/min
Litres per second	L/s
Megahertz	MHz
Megajoules per litre	MJ/L
Megapascal	MPa
Megavolt-ampere	MVA
Megawatt	MW
Megawatt hour	MWh
Metre	m
Metres per day	m/d
Metres per minute	m/min
Metres per second	m/s
Metric tonne	t
Micrometre (micron)	µ
Microsiemens	µS
Microsiemens per centimetre	µS/cm
Milligrams per litre	mg/L
Millimetre	mm
Million years	Ma
Minute	min
Month	mo
Parts per million	ppm
Percent	%
Plus or minus	±
Revolutions per minute	rpm
Second	s
Square kilometre	km^2
Tonne	T
Tonnes per cubic metre	t/m^3
Tonnes per day	t/d
Tonnes per hour	t/h
Tonnes per year	t/a
U.S. dollar	US$
Volt	V
Water gauge	w.g.
Watt	W
Week	wk
Year (annum)	a

1. INTRODUCTION

This Environmental Assessment Report (EAR) has been prepared by BHP Diamonds Inc. to meet the requirements of the *Mackenzie Valley Resource Management Act* (MVRMA), as part of the approval process to develop and mine three kimberlite pipes in the vicinity of the existing EKATI™ Diamond Mine – the Sable, Pigeon and Beartooth pipes. These pipes will be integrated into the current mine plan once the regulatory process is complete. This addition will not change the existing EKATI™ development. The addition presents no new challenges to the operating framework of the mine. BHP will remain committed to the environmental programs currently in place, to hiring Northerners and Aboriginal people and to purchasing goods and services locally.

The objective of the mine plan is to provide a reliable, continuous supply of kimberlite ore to the central EKATI™ Process Plant. A consistent production of rough diamonds, both in quality and quantity, is important for marketing diamonds. During the first years of operation EKATI™ will process 9,000 tonnes per day (t/d) of kimberlite ore. By the year 2007, as ore grades decrease, the processing rate will be doubled to 18,000 t/d. The addition of the pipes will result in BHP having eight kimberlite pipes from which to extract ore. Six of these pipes (Panda, Koala, Fox, Pigeon, Beartooth and Koala North) are near the central processing and accommodation complexes, while the other two (Sable and Misery) are more distant from the central hub.

The previously identified and assessed Leslie Pipe was found to be uneconomic and was eliminated from the original mine plan in early 1997. The addition of Sable, Pigeon and Beartooth will effectively extend the current life of the mine from 15 to 18 years. Good exploration targets remain to be tested, and the discovery of additional economic reserves could well result in a further increase in mine life. The mine plan is expected to change in future years in response to exploration results and overall market conditions.

A mix of innovative and proven technology is currently being used successfully at EKATI™, including frozen core dams and open pit mine designs that are responsive to arctic conditions. Experience gained at the existing operations will be fully implemented in the new development. Sable, Pigeon and Beartooth will be mined by the same open pit methods currently in use at the Panda Pit. Ore will be hauled with Cat 777 and 793 trucks from the existing mine fleet.

No additional power will be required for ore processing beyond that planned for the ramp-up to 18,000 t/d. Power supply for the planned two-bay maintenance shop at Sable will be provided from a small on-site diesel generating facility. The requirements for annual re-supply via the Echo Bay Winter Road will remain within the estimates presented by BHP in the 1995 Environmental Impact Statement (EIS). The existing Process Plant operations will not require a change to the facilities or processes with the inclusion of the three pipes to the overall mine plan. In addition, there is no change to the existing airstrip infrastructure and operations, emulsion facility and operations, and accommodation complex due to this three-pipe development.

The revision of the overall mine plan will have little effect on existing water, waste management and utility requirements. There will be no increase in fresh water demand from Grizzly Lake, and water for process use will continue to be supplied from the Long Lake Containment Facility. The Long Lake Containment Facility has more than sufficient capacity to accommodate the processed kimberlite from the new pits. Wastes such as used oil generated from mining the new pipes will be handled in accordance with the existing waste management plan that forms part of EKATI™'s Operating Environmental Management Plan (OEMP).

BHP is fully committed to operating the EKATI™ Diamond Mine in an environmentally responsible manner to protect and sustain the northern environment throughout the life of the mine, and for future generations. BHP has demonstrated a strong commitment to environmental protection at EKATI™ since advanced exploration began in 1993. This commitment now encompasses ongoing environmental monitoring plans, the use of technical innovations where appropriate and an adaptive management strategy based on identifying and implementing lessons learned. The Sable, Pigeon and Beartooth pipes will be developed under BHP's comprehensive environmental management and monitoring programs. These include the Aquatic Effects Monitoring Program (AEMP) and the Wildlife Effects Monitoring Program (WEMP).

BHP will continue to follow all plans developed for the current EKATI™ Type A Water Licence and the OEMP. BHP will update its existing management plans to accommodate any new requirements following the regulatory phase of permitting. The thirteen plans contained in the OEMP are specified under the mine's Environmental Agreement with the Government of Canada (Canada) and the Government of the Northwest Territories (GNWT).

BHP, as managing partner of EKATI™, submitted the first Project Description for Sable, Pigeon and Beartooth in November 1998, under the *Canadian Environmental Assessment Act* (CEAA) guidelines, to the Northwest Territories (NWT) Water Board and the Department of Indian Affairs and Northern Development (DIAND) Land Managers. The Project Description was revised in February 1999, based on comments received from DIAND. A preliminary environmental screening of the proposed development was subsequently conducted by the responsible federal authorities (RAs) – DIAND, the Department of Fisheries and Oceans (DFO) and Environment Canada (DOE). The RAs recommended that the NWT Water Board refer the proposed Sable, Pigeon and Beartooth development to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) for environmental assessment. The referral was made in April 1999.

The MVEIRB operates under the mandate of the new MVRMA. Section 126 (1) of the MVMRA states:

> *The Review Board shall conduct an environmental assessment of a proposal for a development that is referred to the Review Board following a preliminary screening pursuant to Section 125.*

The MVEIRB is mandated to assess the potential for environmental, social, economic and cultural impacts as they relate to the incremental development of the Sable, Pigeon and Beartooth pipes. In April of 1999, while taking direction from the Review Board, BHP initiated community consultations to advance the environmental assessment process.

Based on direction from the MVEIRB in a July 2, 1999, letter and from ongoing consultations with the Board's staff, BHP prepared and submitted a third version of the Project Description report in November 1999. The final submission included revisions to answer questions received from the MVEIRB, to respond to further comments by the RAs and to integrate responses to the comments from the public.

The MVEIRB prepared Draft Terms of Reference for an Environmental Assessment Report on November 1, 1999, and issued the final Terms of Reference on December 13, 1999. This EAR has been prepared in accordance with those Terms of Reference.

1.1 EKATI™ Diamond Mine Overview

BHP Diamonds Inc. is a Canadian subsidiary of BHP Minerals, one of the three main business groups of its parent company, Broken Hill Proprietary Company Limited. The mine is a joint-venture of BHP Diamonds (51%), Dia Met Minerals Ltd. (29%), Charles E. Fipke (10%) and Dr. Stewart L. Blusson (10%). BHP Diamonds is the operator of the EKATI™ Diamond Mine, which mines and processes kimberlite ore to recover rough diamonds.

BHP and its joint-venture partners established the NWT Diamonds Project, as EKATI™ was then known, to explore, develop and mine mineral claims in the Lac de Gras region of the Northwest Territories. After the first diamond-bearing pipe was discovered, the group invested substantial resources to advance the project to the permitting stage. The Government of Canada approved the development of EKATI™ in November of 1996 after a comprehensive review by the Federal Environmental Assessment Review Panel (EARP). By January 1997, BHP had in place a Socio-Economic Agreement; an Environmental Agreement; a fisheries authorization, water licence and land leases; and signed two Aboriginal Impact and Benefit agreements.

Construction was substantially completed by August 1998, and the mine was brought safely into production – on time and within budget – on October 14, 1998. This was a remarkable accomplishment given the harsh winter conditions and logistical challenges of mobilizing equipment and supplies over the Echo Bay Winter Road. Seven years had elapsed between the discovery of the first kimberlite pipe and initial diamond production. The total capital cost of the mine and its facilities, including exploration, infrastructure, personnel, equipment and systems, was approximately $1 billion Canadian.

The EKATI™ Diamond Mine is about 300 km northeast of Yellowknife (Figure 1.1-1) within the Lac de Gras Watershed at the headwaters of the Coppermine River Drainage Basin. This region of the central Northwest Territories - north of the treeline - is referred to as the barrenlands. Boulder fields and numerous lakes with interconnecting streams

Location of the EKATI™ Diamond Mine in the Northwest Territories, Canada

FIGURE 1.1-1

characterize the tundra terrain. There are more than 8,000 lakes within the 3,400 km^2 BHP mineral claim block. The area is one of continuous permafrost, with a shallow active surface layer that thaws during the brief summer. Summers are short and cool, while winters are up to eight months long and cold. Daily temperature extremes vary from 25°C in summer to -30°C in winter. Precipitation is low, averaging less than 350 mm annually, most of which falls as snow.

1.1.1 The Proponent and Performance Record

1.1.1.1 Broken Hill Proprietary Company Ltd.

Broken Hill Proprietary Company Ltd. is an Australian industrial and natural resources company (Figure 1.1-2) that employs approximately 48,000 employees in more than 50 countries. BHP was incorporated in 1885 to mine the lead/zinc/silver discovery at Broken Hill, in New South Wales, Australia. While retaining its position as one of the world's largest mining companies, BHP has grown to become an international producer of steel and petroleum. Its global assets are valued at more than AUS$31.5 billion, with annual sales exceeding AUS$19.2 billion.

1.1.1.2 BHP Diamonds Inc.

BHP Diamonds Inc. is part of the Non-Ferrous and Industrial Materials division of BHP Minerals (see Figure 1.1-2). It functions as the Canadian diamond exploration and development branch of BHP Minerals. BHP Minerals is a business unit of BHP. BHP Diamonds Inc. is an incorporated company based in Vancouver, B.C. In December 1993, an office was opened in Yellowknife, Northwest Territories, to provide support for the EKATI™ Diamond Mine, then known as the NWT Diamonds Project. As of December 31, 1999, BHP Diamonds Inc. employed a total of 516 direct, permanent employees.

For the purposes of this report, BHP Diamonds Inc. is referred to as BHP unless specifically stated otherwise.

1.1.1.3 Dia Met Minerals Ltd.

Dia Met Minerals Ltd. is a mineral exploration and development company engaged principally in the exploration for, and development of, diamond deposits. Its head office is in Kelowna, B.C.

Dia Met was founded in 1983 by Charles E. Fipke to finance the systematic exploration for diamonds in Canada. Dia Met continues to investigate new exploration opportunities.

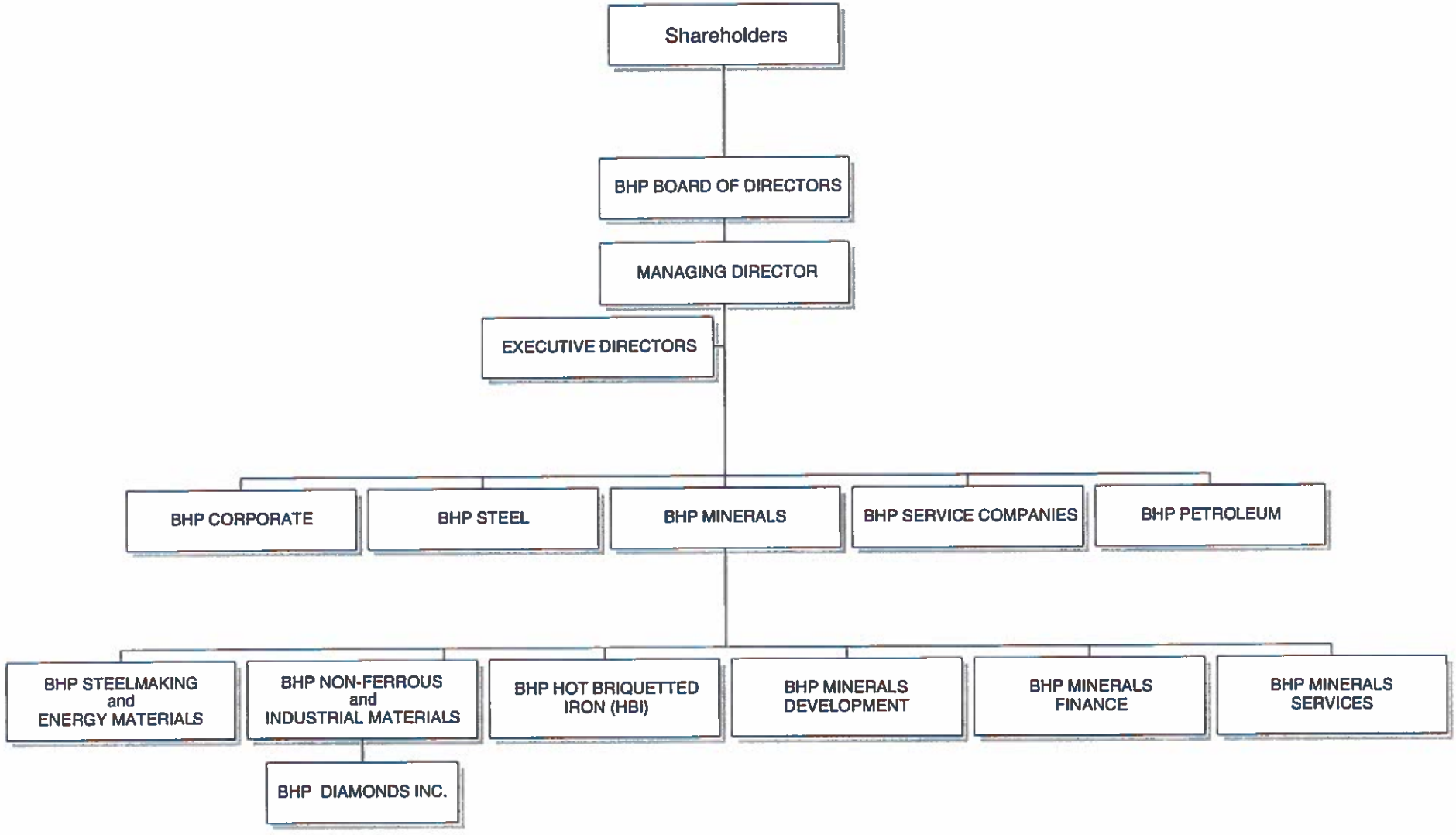


FIGURE 1.1-2

Corporate Organization of Broken Hill Proprietary Company Limited (March 1, 2000)

BHP

Ekati diamond mine

1.1.1.4 The Joint Venture

Dia Met began staking mineral claims in the NWT in 1989. The company discovered a significant diamond indicator mineral find in 1990. At that time Dia Met sought a major joint-venture partner to provide financing and technical experience. BHP was invited to participate based on its demonstrated expertise in large-scale mining projects.

In 1991, Charles Fipke, with the Dia Met and the BHP exploration teams, discovered and drilled the first diamond-bearing pipe under Point Lake. As of September 27, 1999, 121 kimberlite pipes have been found on the claim block.

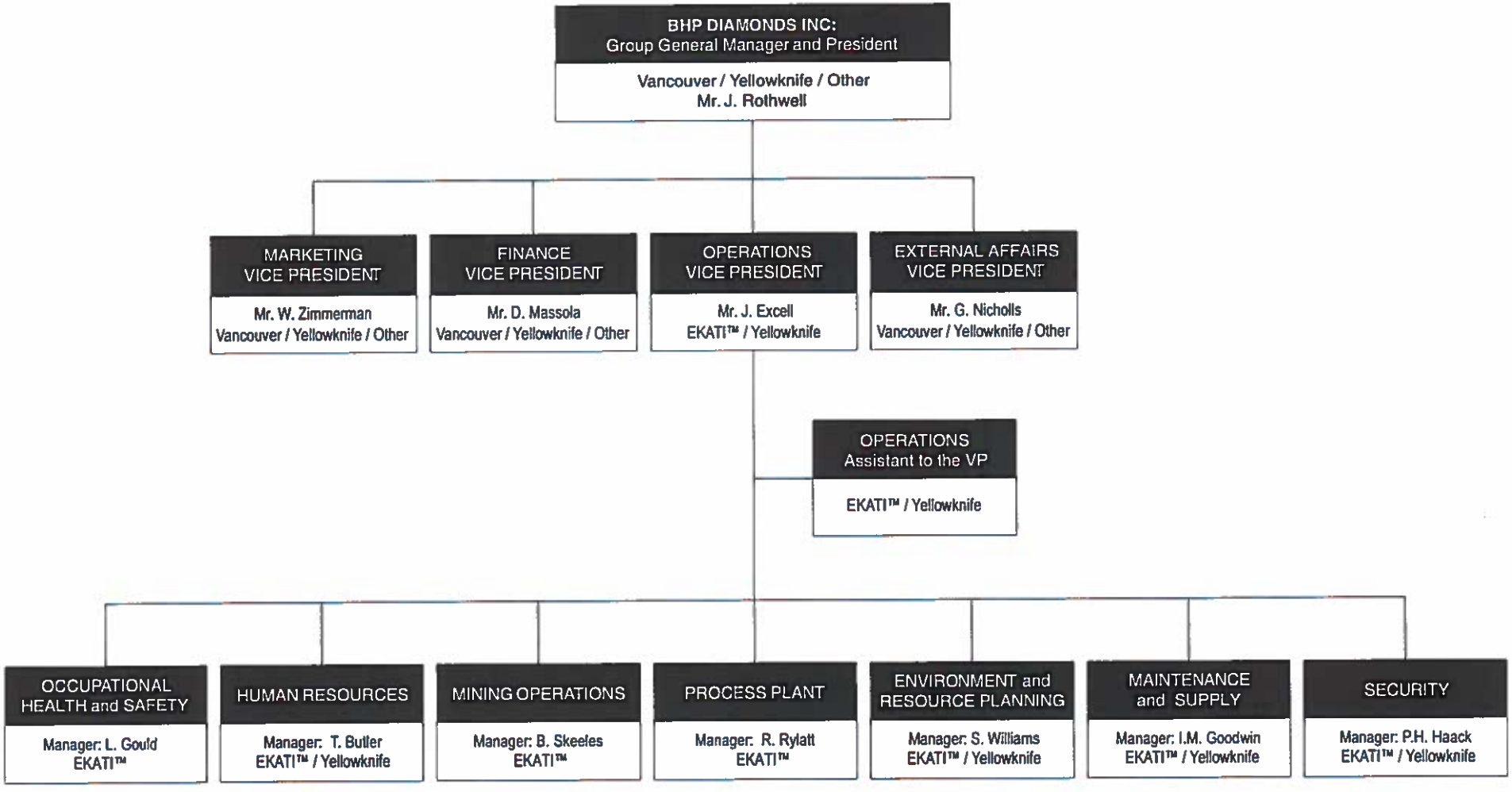
1.1.1.5 Responsibility for Environmental Management

BHP is responsible for implementing the global environmental management framework at all the corporation's operations. This framework includes guideline documents such as the Environmental Policy. Preparing the company annual environmental report and assessing global environmental performance is a corporate function. BHP expects all businesses to meet or exceed the regulatory requirements in the country of operation. Businesses are encouraged to identify and implement methods to continually improve operations.

At BHP Diamonds, the responsibility for environmental management lies with the mine's management team. Making the department heads responsible for environmental management within their own areas results in environmental issues and management being factored into day-to-day operations. Therefore, environmental management is a core line function rather than a separate function handled by a separate environment department. The Environment Department at EKATI™ is a service organization that provides expertise to line managers, monitors potential environmental effects, documents compliance, recommends mitigation and provides a link between the mine and regulators.

As illustrated in Figure 1.1-3, the Manager, Environment and Resource Planning, at EKATI™ reports directly to the Vice-President of Operations. He in turn has a Manager, Environment, who reports directly to him with responsibility for the day-to-day management of environmental programs at site. The Environment Department is an integral part of the mine operation organization. It is responsible for successful implementation of the company's Environmental Policy, compliance with licences, permits, authorizations and the Environmental Agreement, discussed in Section 2.1.2.1.

BHP's OEMP is a requirement of the Environmental Agreement (Article VI, Section 6.3). The OEMP provides the framework for the management and protection of the environment at the EKATI™ Diamond Mine.



BHP Diamonds Inc. Management Team (March 1, 2000)

FIGURE 1.1-3

1.1.1.6 Environmental Record

1.1.1.6.1 EKATI™ Diamond Mine

EKATI™ Diamond Mine is a new operation that officially began production in October 1998. BHP is committed to responsible environmental stewardship at all of its operations. BHP's comprehensive approach to environmental management has been developed to meet or exceed the requirements of the Environmental Agreement and the regulatory authorizations. These include a Type A Water Licence, four land leases, quarry and land use permits, a fisheries authorization and others.

As an indication of BHP Diamonds' performance to date and in accordance with Section 4.2 of the MVEIRB's Terms of Reference, Appendix A of this EAR includes an environmental compliance report issued by the Independent Environmental Monitoring Agency (the Agency). Regarding ongoing environmental compliance, the following was stated:

> *The Agency has detected no serious compliance issues with respect to overall environmental management of the site. Generally, the company's performance, and compliance with environmental regulations, standards and policies has been acceptable.*

The Panda Diversion Channel was constructed between 1994 and 1997 as compensation for lost stream fish habitat. Following its commissioning in 1997, a quantity of silt was deposited in Kodiak Lake. Though BHP had installed a silt curtain in May 1997, prior to spring breakup, it was overwhelmed by the unanticipated quantity of silt released from the Grizzly lowlands due to permafrost deterioration in early June of that year. The Department of Fisheries and Oceans has conducted an investigation. BHP Diamonds will respond appropriately when, and if, proceedings are initiated. To the knowledge of the company, no other legal proceedings are either contemplated or in progress with regard to mine activities.

BHP has a positive record of environmental management elsewhere in Canada, as demonstrated in its management of the Island Copper Mine and the Hope Bay Gold Project.

1.1.1.6.2 Island Copper Mine

Production at the Island Copper Mine, B.C., began in 1971. At its peak of production in 1989, Island Copper was the third largest copper mine in Canada, with 900 employees. Some 263,000 tonnes of copper concentrate and 5,700 tonnes of molybdenum concentrate were being produced at that time. The mine closed in December 1995 upon depletion of the ore body. BHP continues to be present and will actively manage the decommissioning and reclamation programs until such time as the company and the Province of British Columbia are satisfied with the status of the rehabilitated lands and waters.

More than 98% of the 500 ha of disturbed land have been remediated since progressive reclamation programs began in the 1970s. Five million tonnes of topsoil stockpiled over the 25 years of mining operations have been spread over the site, and more than 600,000 trees have been replanted. Bear, deer and geese, which were present on the site throughout the operating years, are now seen in increasing numbers in this remediated habitat.

The open pit – once described as the lowest surface depression on earth at 402 m – is now a 215 ha lake, flooded with seawater from adjacent Rupert Inlet in July 1996. Since then, rain and surface water runoff have formed a fresh water cap on the surface of the saltwater lake. Drainage from the revegetated waste rock dumps, previously recycled through the mill, is now being discharged into the flooded pit through two pipelines at a depth of 220 m. The huge volume of water dilutes the drainage and heavy metals are precipitated to the bottom, effectively treating any acid rock drainage.

Areas contaminated during the operation by fuel, process chemicals or product concentrate are being rehabilitated to provincial government environmental standards as the mill, warehouse, maintenance and other buildings are decommissioned. A forestry company is in the process of purchasing a number of buildings, as well as the dock facilities, for a proposed sawmill and lumber kiln.

Both waste rock and mine tailings were deposited in Rupert Inlet when the mine was operating. A few months after the mine closed, recolonization of the affected area was evident. Populations of juvenile salmon, dogfish shark, six-gill shark, rock cod, sea perch, and greenling and Dungeness crab have returned to population levels reported in the early 1970s when mining started. The environmental monitoring program, established when the mine first opened, is to continue through 2000.

Island Copper received the 1997 Environment Award from the Prospectors and Developers Association of Canada, and previously received four environmental awards from the British Columbia Ministry of Energy, Mines and Petroleum Resources and the Mining Association of B.C. Many of the mining and milling techniques developed at Island Copper have since been used by the international mining community.

1.1.1.6.3 Hope Bay Belt Gold Project

BHP recently sold its Hope Bay property, located in Nunavut. As part of the purchase agreement, the new owners were required to put security deposits in place to properly reclaim the facilities if a mine is not built. As such, BHP's actions go beyond the standards set by Canada and the Inuit landowners for security deposits.

1.1.2 Developer's Policies

1.1.2.1 Preserving the Environment

BHP makes every effort to be a good corporate citizen. The protection and well-being of the environment, its employees, local communities and the host nation are priorities in all its activities and operations.

BHP follows a company-wide Environmental Policy that defines its commitment to high standards of environmental care in the conduct of its business. BHP's approach to environmental management seeks continuous improvement in performance. Figure 1.1-4 is the BHP Environmental Policy signed by Paul Anderson, the Managing Director and CEO of BHP.

The BHP Environmental Policy applies to all businesses for which the company has operating responsibility.

1.1.2.2 Limiting Use of Fresh Water

Water is common to many of the EKATI™ Diamond Mine's main environmental issues. Hydrologic conditions and the state of surface water systems are key factors influencing the mine's ecological footprint. Water is a primary pathway for potential contaminants to reach the environment. Water control measures are used to manage potential contaminants, thereby minimizing risks to the aquatic environment.

Four issues dominate all others:

- surface water quality;
- seepage from waste rock storage areas;
- management of the Long Lake Containment Facility; and
- reclamation to restore natural water systems.

These issues are effectively controlled by stringently restricting water use at the operation. Every day, a total of 9 million litres of water from the Long Lake Containment Facility is recycled through the Process Plant. This is 92% of the water used in the Process Plant; the remaining 8% comes from the kimberlite itself. No fresh water is used in the Process Plant except for potable purposes.

BHP's policy of continuous performance improvement at EKATI™ ensures that water issues are assessed and prioritized with regard to maintaining the quality of surface waters, maximizing water re-use and addressing other water-related matters.

ENVIRONMENTAL POLICY

It is BHP's policy to achieve a high standard of environmental care in conducting its business as a resources and industrial company contributing to society's material needs. BHP's approach to environmental management seeks continuous improvement in performance by taking account of evolving scientific knowledge and community expectations.

Specifically, it is BHP's policy to:

- comply with all applicable laws, regulations and standards; uphold the spirit of the law; and where laws do not adequately protect the environment, apply standards that minimise any adverse environmental impacts resulting from its operations, products and services;

- communicate openly with government and the community on environmental issues, and contribute to the development of policies, legislation and regulations that may affect BHP;

- ensure that its employees and suppliers of goods and services are informed about this policy and aware of their environmental responsibilities in relation to BHP business;

- ensure that it has management systems to identify, control and monitor environmental risks arising from its operations;

- conduct research and establish programs to conserve resources, minimise wastes, improve processes and protect the environment.

Paul M. Anderson
Managing Director and Chief Executive Officer

FIGURE 1.1-4

BHP

BHP Environmental Policy

Ekati diamond mine

1.1.2.3 Protected Area Strategy

During the 1995/1996 assessment of EKATI™ by the EARP, participating environmental groups identified a need to balance mineral development in the Slave Geologic Province with an enhanced system of protected areas in the NWT. The desirability of establishing a network of protected areas was previously acknowledged in the Whitehorse Mining Initiative. The process to create the NWT Protected Areas Strategy grew out of the 1995/1996 BHP-EARP assessment.

As existing mineral claim blocks are exempted from the protected areas, the incremental mineral development on the BHP claim block will not affect the creation of a system of protected areas in the NWT. In BHP's opinion, the conclusions of the EARP panel are still appropriate. That panel concluded:

> *With regard to the proposed Project, the Panel concludes that approval would not compromise the development of protected areas in the region. The Project has already been developed to the bulk sampling stage and is located close to an existing winter road. The Project would not increase the access to the area because an all-weather road is not part of the proposal. Neither is the Project located in any area that has been designated for protected area status and no rare or unique features have been identified in the Project area. (1996)*

BHP, as an active member of the Chamber of Mines, has contributed to the development of a Protected Area Strategy in the NWT, along with local community leaders, government resource managers and non-governmental organizations (NGOs). A consensus of opinion is now emerging that all potential stakeholders – not simply select environmental interest groups – should be included in the discussions and implementation of the Protected Area Strategy. Signed by Canada and GNWT in 1999, the strategy focuses on finding the best areas for conserving ecosystems and renewable resources without relinquishing sustainable economic development and the ability to provide goods and services to the citizens of the NWT. By balancing the goals of conservation and development, the Protected Areas Strategy will continue to be relevant to local residents, conservation groups and industry. This approach aims to expand the geographic scale of protected areas in the NWT in order to cover representative ecosystems.

1.1.2.4 Abandonment and Reclamation Plans

The BHP Policy (see policy below) on reclamation is driven by three primary goals:

- to re-establish safe/stable landforms;
- to protect the water resources in the local area; and
- to facilitate natural recovery of areas affected by mining.

The establishment of safe/stable landforms (primarily slopes and drainage) increases the effectiveness of revegetation efforts and reduces maintenance requirements. Protection of water resources minimizes the impact of mining activities on aquatic systems and habitats. Facilitating natural recovery of disturbed areas allows natural plant succession to occur. This results in the development of landscapes that will blend with adjacent, undisturbed areas. To encourage natural recovery, BHP will, where needed, create micro-habitats that initiate the revegetation process. Using various larger-scale agricultural techniques can also facilitate natural recovery. These include scarification, seeding, transplanting and application of fertilizer.

Resident animals such as grizzly bears and migratory species such as caribou and wolves are common throughout the EKATI™ region. Wildlife will continue to use habitat created by the decommissioning of infrastructure after the mine closes.

Evidence of historical and recent Aboriginal land use has been documented within the claim block. Aboriginal use is recognized as an important ongoing land use; therefore, safe and stable landforms are important considerations in final reclamation.

Revegetation research was started in 1994 and is now an ongoing program at EKATI™. The results from this work will help to refine reclamation techniques used at the mine. The research suggests that revegetation is most appropriate where a substrate of soil is available and site conditions are favourable for plant growth. These conditions include adequate soil moisture, protection from prevailing winds and solar aspect.

Progressive reclamation will be performed throughout the life of the mine. This approach will allow for the development of solutions for problem areas by modifying reclamation techniques, implementing new mitigation measures and assessing reclamation success.

Under the terms of the Environmental Agreement (13.2), BHP will review with government every two years the amount of the security deposit the company is required to post for EKATI™ under that agreement. The security deposit posted under the Type A Water Licence will be reviewed when that document is up for renewal at the end of 2004. Security deposits will change over the years depending on the scope of the mine plan and the status of ongoing progressive reclamation at the site.

1.1.2.4.1 BHP Policy on Decommissioning, Rehabilitation and Closure

BHP's corporate policy is stated below.

Intent

Decommissioning of facilities and rehabilitation and closure of sites are planned and undertaken in an environmentally responsible manner.

Guidance on Performance Requirements

In regard to each of BHP's projects and facilities, management shall:

- *determine decommissioning, rehabilitation and closure requirements and objectives which enable sites and facilities to be left in a safe and stable condition, and which take account of potential beneficial uses of the site and surrounding land;*
- *incorporate decommissioning, rehabilitation and closure requirements and objectives into plans and programs for each stage of a project's or facility's lifecycle, commencing with conceptual design during the feasibility stage;*
- *implement rehabilitation programs commensurate with the nature of the operations and the rate of disturbance;*
- *monitor and review rehabilitation performance and periodically review and refine rehabilitation plans to account for changing legislative requirements, public expectations and environmental and cultural heritage values;*
- *determine and periodically review rehabilitation, closure and decommissioning liabilities and ensure adequate provision is made in accordance with accounting standards;*
- *ensure plant and materials are decommissioned and disposed of in a manner which minimizes adverse effects on the environment; and*
- *determine long-term responsibilities for land and facility management, including monitoring, maintenance and record-keeping.*

1.1.2.5 Adaptive Management Strategies

Lessening the potential environmental effects of diamond mining in the barrenlands requires clear goals and objectives; potential environmental concerns must be considered in the mine planning process. Environmental monitoring is a key element of the EKATI™ operations. Regular reviews of monitoring results allow BHP to learn from experience and to adapt its management practices to decrease the potential environmental impact of EKATI™.

To achieve industrial leadership in environmental management, EKATI™ Diamond Mine employs a management strategy that stresses iterative learning, long-term planning, exchange of knowledge and cooperation between organizations. This strategy, known as adaptive management, is a formal process for formulating and continually improving resource management policies and practices by learning from the results of ongoing operational programs. Through the application of this strategy, available information is used to make the most appropriate management decisions, while concurrently fine-tuning the information collection process as necessary to make more informed decisions over time. Of key importance to adaptive environmental management is the acknowledgement

that various sources of uncertainty are inherent in both biological systems and management efforts.

The key steps of the adaptive management process that lead to continuous improvement at EKATI™ are depicted in Figure 1.1-5.

Adaptive management affords better understanding on many levels. While the immediate focus is on program objectives and short-term interactions, the practice of adaptive management also forces the practitioner to examine the overall effects of the development on the environment. Adaptive management is therefore described as having a dual purpose: to simultaneously address the immediate and the long-term effects of management actions. Further information on BHP's approach to adaptive management is provided in Section 5.2.

1.1.2.6 Education of Appropriate Personnel

All employees and contractors working at the EKATI™ Diamond Mine are required to participate in a formal orientation program. The program includes awareness of the environmental issues at the site and individual responsibilities. Additionally, an Environmental Handbook, which covers these topics, is distributed to everyone. Job-related environmental training is also provided when necessary.

The EKATI™ Diamond Mine promotes practices that reflect a serious commitment to protecting the environment. This is emphasized in one of the Core Guiding Principles for the EKATI™ Diamond Mine:

Conduct all activities as responsible stewards of the environment.

Environmental awareness training at EKATI™'s includes strategies to:

- minimize disturbance to flora, fauna and heritage sites;
- undertake progressive reclamation of disturbed areas;
- minimize wastes;
- conserve resources such as water and energy;
- avoid fuel, oil and chemical spills; and
- develop contingency plans for environmental incidents and emergencies.

1.1.3 Award Winning Mine

The EKATI™ Diamond Mine has received recognition for various outstanding achievements as a new mine in the emerging Canadian diamond industry. Despite engineering, environmental, construction and logistical challenges, BHP and its consultants successfully constructed this world-class mining operation on schedule, on budget and with an excellent safely record. To date, the following awards have been received:

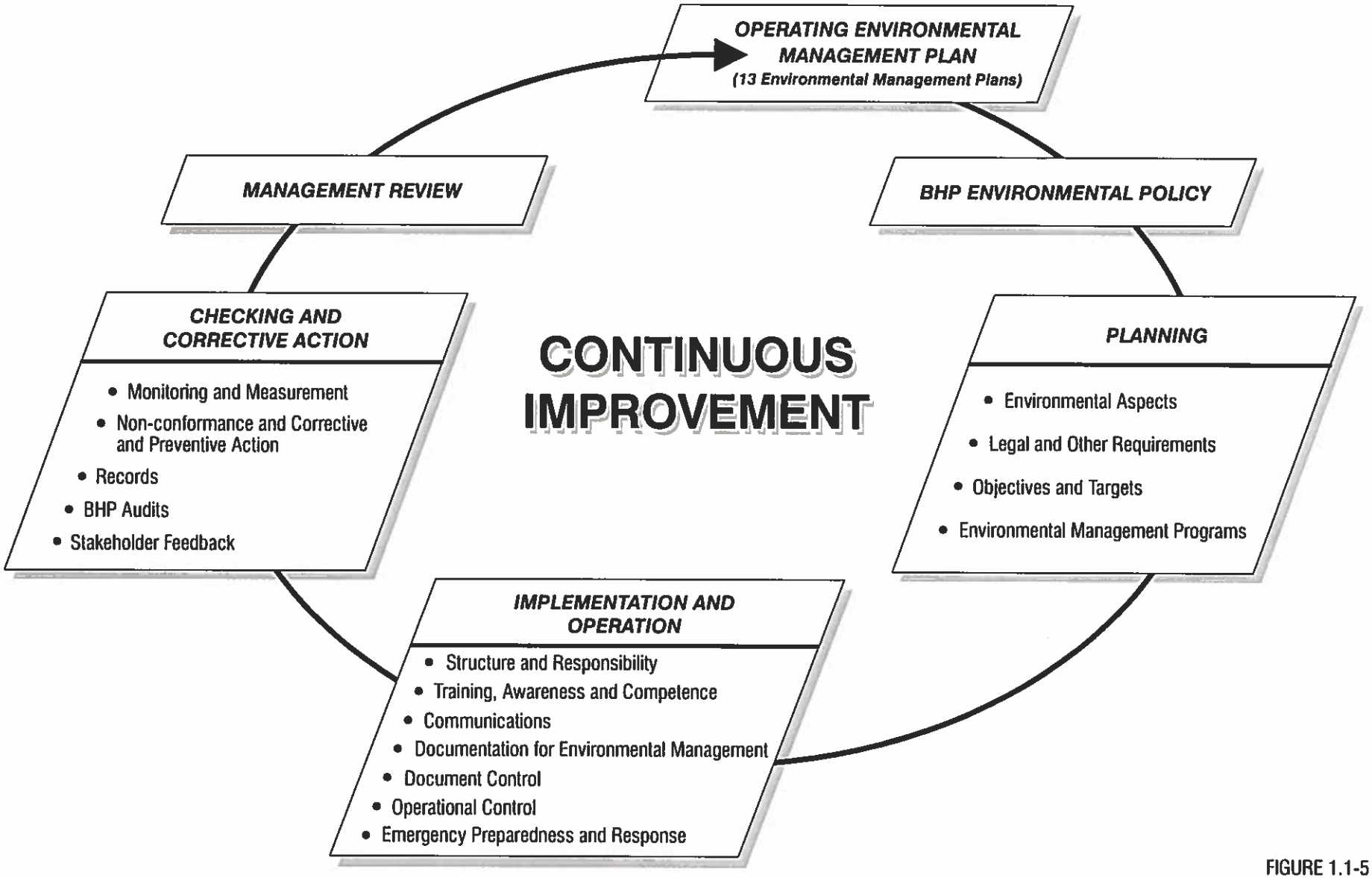


FIGURE 1.1-5

Adaptive Environmental Management Process

BHP

Ekati diamond mine

- The Consulting Engineers of Alberta (CEA) recognized EBA Engineering Consultants Ltd. with the "Award of Excellence – Resource Development" and the "Award of Merit – Technology Innovation" for the Long Lake Outlet Dam Frozen Core design. The innovative design allowed BHP and EBA to effectively utilize one condition readily available in the north – the cold winters.

- CEA recognized A.D. Williams Engineering Inc. with the "Award of Merit – Resource Development" and the "Award of Merit – Technological Innovation" for the design of the EKATI™ Diamond Mine Permanent Camp Facility and Truck Maintenance Facility.

- The Canadian Council of Canadian Engineers recognized BHP and H.A. Simons Inc. with the "National Award for Exceptional Engineering Achievement" for the largest mining construction project ever undertaken in the Canadian subarctic.

- The Alberta Chamber of Resources – 1998 Resource Person of the Year Award received by Jim Excell, Vice-President of Operations, BHP Diamonds Inc.

- BHP's Mine Rescue Team won "Best Team Overall in the Northwest Territories" in the 1999 mine rescue competition.

- BHP's First Aid Team won "Best Team" in the 1999 WCB/St. John's Ambulance first aid competition for the Northwest Territories.

This list demonstrates BHP's commitment to excellence and to safety.

1.2 Purpose of Proposed Development

The 1995 Environmental Impact Statement for the then NWT Diamonds Project clearly identified that BHP would seek to develop additional kimberlite pipes peripheral to its current EKATI™ Diamond Mine operations. In the cumulative effects section of the EIS, the company presented a probable additional three-pipe development within 30 km of EKATI™. Pipes at Sable Lake, Pigeon Pond and Beartooth Lake have now been identified as resources that BHP plans to develop in the near future. This document is an assessment of the specifics of that proposed development.

Prior to BHP authorizing the expenditures required for detailed design and pre-development work for Sable, Pigeon and Beartooth, a Type B Water Licence, land leases and a quarry lease must be in place. A fisheries authorization under the *Fisheries Act* and authorization under the *Navigable Waters Protection Act* must also be acquired before actual site development commences.

Over the last four years, the Sable, Pigeon and Beartooth kimberlite resources have been evaluated and are considered to have economical potential, given current regulatory, market and fiscal conditions. Table 1.2-1 identifies the advanced exploration schedule for these pipes.

Table 1.2-1
Kimberlite Pipe - Discovery and Feasibility Stages

Kimberlite Pipe	Discovered	Bulk Sampled	Feasibility
Sable	1995	1996	1996/7
Pigeon	1995	1998	1998
Beartooth	1995	1998	1998

The addition of these pipes to the mine plan is subject to environmental assessment, regulatory permitting, market conditions and final approval by the Owners. The mine plan in BHP's EIS (1995) was based on geological, engineering and market data from 1992 to 1995. The EIS identified five kimberlite pipes: Panda, Misery, Koala, Fox and Leslie. Since that time, BHP's additional geological and engineering work determined that the Leslie kimberlite ore was not economic. BHP and its joint-venture partners produced and delivered a feasibility study to their respective Board of Directors in 1996 to approve capital expenditures:

- to build EKATI™ Diamond Mine; and
- to support the long-term economic viability of the mine.

The Sable kimberlite resource was included in that feasibility study. In March of 1997, Dia Met Minerals released the results of the study to the public and to its shareholders. Through its ongoing exploration efforts on the BHP/Dia Met mineral claim block, BHP discovered and evaluated the economic viability of the Sable, Pigeon and Beartooth pipes. BHP has integrated environmental, safety, operational, social and cultural considerations into this decision-making process to proceed to the environmental assessment and permitting stages of developing these resources.

1.3 Integration of Traditional Knowledge

BHP has been working on Traditional Knowledge studies with the Aboriginal groups potentially affected by the EKATI™ Diamond Mine since 1995. The original studies were undertaken as part of the EARP review. They were intended to give Aboriginal people the opportunity to share their traditional knowledge and to discuss the potential impacts of the EKATI™ Diamond Mine.

Following the EARP review, BHP funded research initiated by the Dogrib of Treaty 11, the Yellowknives Dene, the Kitikmeot Hunters and Trappers Association, the Chipewyan of Lutsel K'e and the Metis Heritage Association to help organize their traditional knowledge. In this way the Aboriginal groups have been encouraged to develop tools that will allow them to work with BHP to integrate traditional knowledge into the environmental management of the EKATI™ Diamond Mine. Each Aboriginal group has determined its level of participation in these studies in accordance with the Environmental Agreement. With some projects, BHP has been an active partner and with

others a silent one; each Aboriginal group has determined the role of the company in its research. The current status of these studies is as follows:

- The Yellowknives Dene completed a traditional land use study in 1998. It discussed the Yellowknives' territory lying between the City of Yellowknife and Lac de Gras. In 1999, BHP supported a second phase that focused on the EKATI™ mine site.
- The Kitikmeot Hunters and Trappers Association (KHTA) has nearly completed a land use screening tool built on a Geographic Information System (GIS). It is based on Inuit land use of the Kitikmeot portion of the Slave Geologic Province.
- Dogrib Treaty 11 is finishing a traditional plant study that focuses on issues relative to biodiversity on part of the BHP claim block. The field research was undertaken in 1998.
- The Lutsel K'e Dene Band is currently working on a GIS-based traditional land use inventory.

These studies will assist the Aboriginal groups and BHP as community consultations proceed on the Sable, Pigeon and Beartooth development proposal.

In 1996, the Kugluktuk Angoniatit Association (KAA) proposed a method to remove fish from lakes before mining. The procedure was developed by a KAA elder and his assistant, who trapped the EKATI™ mine site in the 1970s, working with a fisheries biologist from Rescan™ Environmental Services Ltd. As part of the procedure, the Inuit evaluated the lakes that would be affected by the mine development to determine if any were potential traditional winter fisheries. This was done because, from an Inuit perspective, people would pass through the mine site mainly during the winter to trap white fox. Their evaluation involved inspecting each lake outlet to see if it would be distinct under snow cover and would generate enough current to prevent thick ice formation compared to the rest of the lake, and as such would be suitable for setting nets or jigging. None of the lakes inspected passed the test as potential Inuit winter fisheries.

Though the lakes were not traditional fisheries, the Inuit did not want the fish wasted. KAA informed BHP that it did not want the fish relocated to other lakes in order to avoid disturbing existing fish populations in lakes that would not otherwise be affected. They preferred that BHP arrange to have Aboriginal people harvest as many fish as possible from each lake before dewatering. An Inuit trapper indicated that all fish suitable for human consumption should be shipped to the communities for distribution to elders who could no longer fish for themselves. He requested that waste fish be sent out to mushers for dog food. The KHTA asked BHP to have younger Aboriginal people assist the fisheries biologist in recording the fish data so that the young people could learn more about the biologist's occupation.

Inuit, Chipewyan and Dogrib crews have subsequently used this method to successfully remove the fish from Panda, Koala, Airstrip, Misery and Long lakes. A similar process will be implemented at Sable, Two Rock, Big Reynolds and Beartooth lakes prior to mining.

In the mid-1990s, Dogrib and Inuit elders collaborated with a Resources, Wildlife and Economic Development biologist to experiment with traditional caribou fences. One of the objectives of this research, which was sponsored by the West Kitikmeot Slave Study Society (WKSS), was to find passive means to direct animals safely around mine sites. Preliminary findings at the Lupin Mine suggested that rope fences decorated with flags could be effective. Rope fences are suggestive of traditional cut-tree drive lanes, decorated with coloured ribbons. The challenge in building a modern rope fence is that it is intended to function as a stand-alone structure, whereas traditional caribou fences incorporated people into the system.

BHP built a rope fence around the EKATI™ airport in 1997. The fence was improved with suggestions from the Yellowknives and Inuit. While the fence seemed somewhat effective initially, caribou frequently breached it in 1999. After consulting further with the Aboriginal groups and biologists, BHP replaced the rope fence with an electric "bear" fence late in 1999.

Over the past two years, elders and members of the various Land and Environment Committees have made regular visits to EKATI™. These visits provide the elders with an opportunity to become familiar with the EKATI™ operation and to work with environmental scientists. Representatives of the Yellowknives Dene, Lutsel K'e, Dogrib Treaty 11 and Kitikmeot Inuit Association have participated in sessions on archaeology, wildlife, habitat, water management, waste management and the proposed Sable, Pigeon and Beartooth development. The improved knowledge of these groups with regard to EKATI™ is evident at the multi-stakeholder Aquatic Effects and Wildlife workshops sponsored by BHP and the recent consultations on the proposed development. The workshops are held each February to review the key results of the environmental monitoring programs and recommend to improvements for continuing monitoring work.

Before completing the final draft of the Sable, Pigeon and Beartooth Project Description, BHP offered to consult with the four Aboriginal groups that have IBAs in place. Briefings were held with the Inuit of Kugluktuk, the Yellowknives Dene, the Chipewyan of Lutsel K'e and the North Slave Metis Alliance. The Yellowknives Dene Land and Environment Committee required more information than was provided at the basic information session, and BHP held a series of meetings with them. In response to suggestions by the Yellowknives Dene, BHP subsequently modified the proposed Sable footprint for the development plan in this area.

BHP is planning to return to the communities in 2000 to discuss this EAR for the Sable, Pigeon and Beartooth development. BHP will again offer elders and Land and Environment Committees opportunities to visit EKATI™ and participate in environmental monitoring programs. Items proposed for review at this time include archaeology, waste management, caribou migration and esker management.

BHP has recently responded positively to a request by Lutsel K'e to revive the Traditional Knowledge Working Group on environmental management; initial discussions will take place in 2000. BHP will continue to support other suitable proposals for community-based traditional knowledge projects and programs relevant to

EKATI™ so that Aboriginal people can participate in the environmental management of the mine. Section XI of the BHP Environmental Agreement establishes the principles for the incorporation of all available traditional knowledge into environmental planning at EKATI™.

1.4 Previous Slave Geological Province Reviews

During the last six years, two major environmental/socio-economic assessments have been conducted involving prospective diamond mines in the Slave Geological Province. One was the original BHP review by EARP and the second the CEAA review of the proposed Diavik Diamonds Project. Following is a brief review of the results of these significant initiatives as they relate to BHP's proposed development.

1.4.1 NWT Diamonds Project (EKATI™ Diamond Mine)

In December 1994, a federal Environmental Assessment Review Panel (EARP) was appointed to review the short- and long-term environmental and socio-economic effects of the NWT Diamonds Project. After conducting scoping meetings to identify issues of concern, the Panel issued guidelines in May 1995 for the preparation of an Environmental Impact Statement (EIS). BHP prepared an EIS (BHP, 1995) in response to those guidelines and submitted it to the Panel in July 1995.

Extensive public hearings were held in the potentially affected communities identified by EARP in the western Northwest Territories (and present day Nunavut) in January and February 1996. In June 1996, the Panel concluded that the environmental effects of the proposed EKATI™ Diamond Mine were largely predictable and mitigable. The Panel also concluded that any effects not predicted would be detected through monitoring programs and dealt with through BHP's environmental management plans and adaptive management strategy. Regarding possible cumulative effects the Panel stated that:

> *...the cumulative environmental effects of additional development by BHP on the Lac de Gras claim block are unlikely to be significant. It has reached this conclusion for several reasons. First, mining of additional pipes would extend the life of the mine and would not result in development of additional processing capacity. Secondly, tailings would be deposited in mined-out pits and no expansion of the Long Lake tailings impoundment or creation of a new impoundment would be required. Thirdly, if additional pits were developed, the Proponent and government would have some years of experience in managing the effects of the Project. Nevertheless, continued monitoring and adaptive management would be required, especially if the new pits were located in previously undeveloped watersheds. Finally, the Panel agrees with the Proponent's conclusion that the cumulative socio-economic effects entailed by extending the life of the mine are likely to be positive since extension of the life of the mine would provide economic stability. However, continued socio-economic monitoring would still be required to determine actual effects and to ensure that any negative or cultural effects are identified and mitigated... (EARP, 1996)*

The Panel recommended that the Government of Canada approve the project subject to 29 recommendations. Of these, 13 were largely directed to government, 15 to BHP and one to the West Kitikmeot Slave Study Society, the latter being a regional study supporting traditional knowledge and environmental studies in the 250,000 km^2 Slave Geological Province. The Government of Canada accepted the Panel report without change.

1.4.2 Diavik Diamonds Project

The Diavik Diamonds Project is a proposal by Rio Tinto PLC. and Aber Diamond Mines Ltd. to mine four diamondiferous kimberlite pipes under Lac de Gras, 30 km south of the EKATI™ mine. Broad-ranging public consultations related to this proposed project were initiated in 1993 and continued throughout the 1998/1999 review under the *Canadian Environmental Assessment Act* (CEAA).

The CEAA process was triggered in March 1998 when the Diavik Project Description was filed. Between April and June 1998, the responsible authorities (RAs) were identified, and a steering committee involving Aboriginal groups, Canada and the GNWT was established. A decision was made at this time to undertake a Comprehensive Study Report (CSR) rather than a full Panel review.

Following consultations with the GNWT, non-governmental organizations (NGOs) and members of the public, the federal government completed and released the Environmental Assessment Guidelines to the proponent in August 1998. The guidelines were scoped broadly to ensure that the requirements of the GNWT and the then-impending *Mackenzie Valley Resource Management Act* were considered.

The proponent submitted its Environmental Assessment Report in September 1998. This was followed by seven months of public comment, including more consultations and technical workshops to address remaining technical concerns. After the public comment period ended in March 1999, the federal RAs drafted the CSR with the advice and assistance of the GNWT, the Government of Nunavut and the Steering Committee. In June 1999, the Minister of Indian Affairs and Northern Development submitted the CSR to the Minister of the Environment on behalf of the responsible authorities. CEAA then provided further opportunity for public comment from June to October 1999.

During this time, the MVEIRB, as mandated in subsection 159(2) of the MVRMA, reviewed the Diavik Diamonds CSR. The MVEIRB submitted its views to the Minister of the Environment on October 8, 1999. On November 3, 1999 (CEAA, 1999a), the federal Minister of the Environment concluded that with implementation of all the mitigation measures identified in the CSR, the proposed Diavik Diamonds Project is not likely to cause significant adverse environmental effects.

Pertaining to the subject of cumulative effects, the CSR report (CEAA, 1999b) concluded:

> *...the potential for the Diavik Project to interact with other known projects and activities in the regional study area (principally BHP's EKATI™ Diamond Mine) to produce significant cumulative adverse effects is unlikely...*

The CSR identified the need to develop a regional cumulative effects management framework to address future potential developments in the NWT. This recommendation was supported by the Aboriginal groups, the public, NGOs and, in particular, the MVEIRB.

The Minister of the Environment directed that:

> *...a regional cumulative effects management framework, in which the project proponent will participate, will be designed and implemented. All appropriate federal, territorial and Aboriginal governments, regulatory agencies, non-governmental organizations, as well as appropriate industry, including Diavik, should be involved in the design and implementation of the management framework. This framework must consider both scientific and traditional knowledge, and be used in conjunction with adaptive management to ensure sustainable development, as suggested in comments by the Mackenzie Valley Environmental Impact Review Board and others. An action plan to finalize the framework should be developed with interested parties and presented to ministers by March 31, 2000, and the final framework should be implemented by April 1, 2001...*

BHP is strongly committed to participating in the development and implementation of this framework. The company has been actively involved in all activities regarding the development of the framework to date.

ENVIRONMENTAL ASSESSMENT REPORT FOR SABLE, PIGEON AND BEARTOOTH KIMBERLITE PIPES

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2. SCOPE OF DEVELOPMENT

2. SCOPE OF DEVELOPMENT

2.1 Development Setting

This chapter describes the proposed scope of the Sable, Pigeon and Beartooth development. It contains information needed for the environmental assessment and the subsequent regulatory phase of permitting. A more detailed project description is available in the Project Description document for the proposed development (BHP, 1999c; Revision 3).

2.1.1 Regulatory Environment

The environmental assessment and regulatory processes in the Northwest Territories that affect this proposed development are outlined below. BHP is committed to develop, mine and reclaim the Sable, Pigeon and Beartooth kimberlite pipes based on principles of continuous improvement and in compliance with:

- all relevant federal and territorial legislation; and
- all its permits, licences, leases, authorizations and agreements.

2.1.1.1 Mackenzie Valley Resource Management Act and Environmental Assessment

Environmental assessment in the Slave Geological Province is now administered under the *Mackenzie Valley Resource Management Act* (MVRMA). This new federal legislation transfers the regulatory approval process from the NWT Water Board and DIAND, and the environmental assessment process from the Canadian Environmental Assessment Act (CEAA), to the MVRMA. The responsibilities of the NWT Water Board and DIAND have been given to a series of co-management boards established under the MVRMA and settled First Nations Land Claim Agreements. The MVRMA was created to implement obligations made to the Gwich'in and Sahtu Dene/Metis in their Comprehensive Land Claim Agreements settled in 1992 and 1993, respectively. The Act is being implemented across the entire southern section of the Northwest Territories but does not apply in the Inuvialuit Settlement Area. Figure 2.1-1 depicts the geographical area covered by the MVRMA. The key elements and principles of the MVRMA, as compared to the previous system, include:

- decentralization of decision-making to co-management boards;
- a greater role for Aboriginal people;
- more involvement at the community level;
- enhanced recognition of heritage resources; and
- an increased emphasis on social, economic and cultural factors in the assessment process.

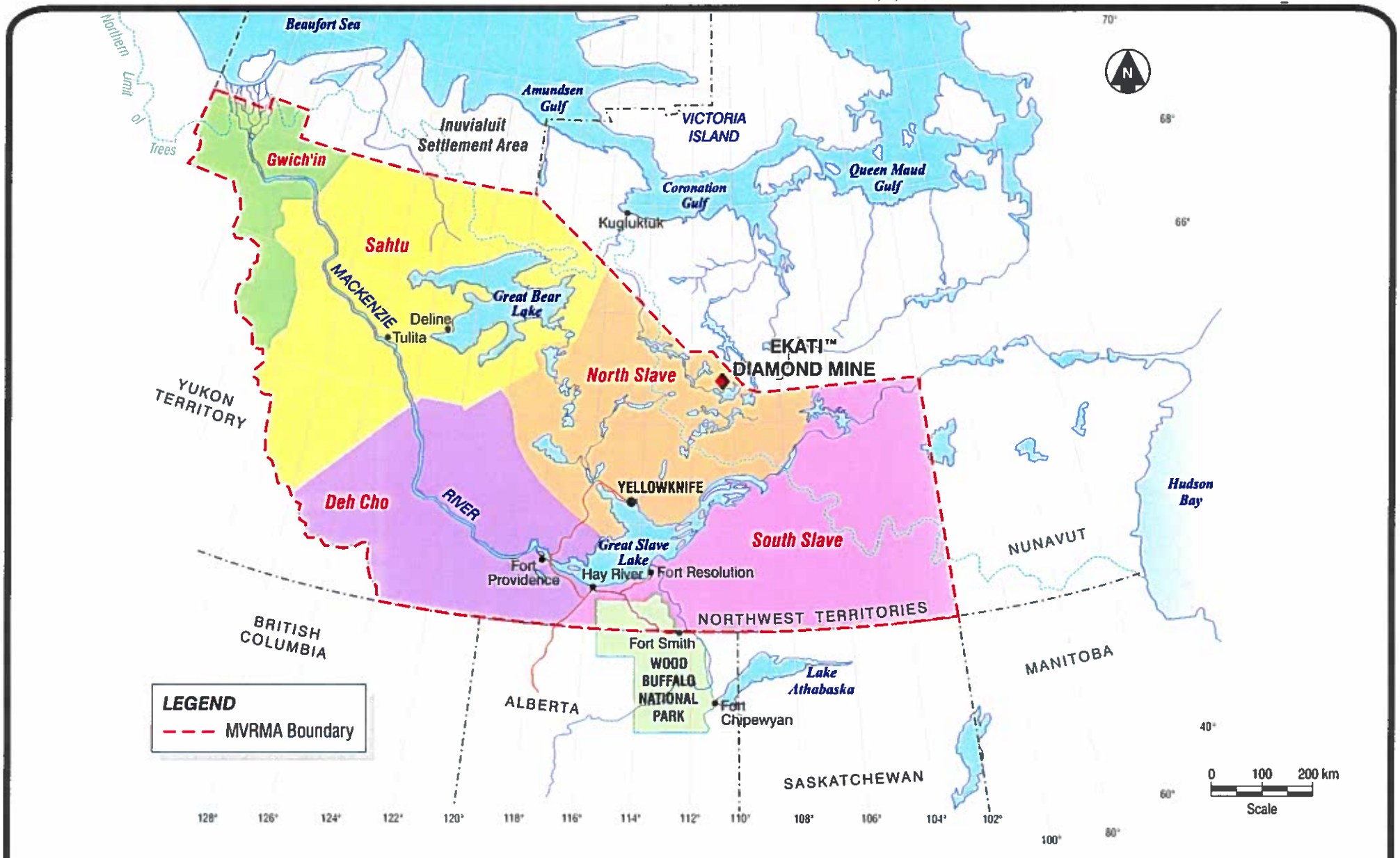


FIGURE 2.1-1

Location of the EKATI™ Diamond Mine in Relation to the MVRMA Jurisdictional Boundary

Source: Mack[illegible] Valley Resource Management Act (MVRMA)

The MVRMA established new institutions of public government – boards – responsible for land and water management, land use planning and environmental impact assessment. These new public boards play an integral part in resource management and development in the Mackenzie Valley. The following boards have been established to date under the MVRMA:

- Sahtu Land and Water Board;
- Gwich'in Land and Water Board;
- Mackenzie Valley Land and Water Board (April 2000); and
- Mackenzie Valley Environmental Impact Review Board.

The legislation describes the Environmental Impact Assessment process as having three stages: preliminary screening; environmental assessment; and environmental impact review. Not all developments go through each of the three stages. Most go through the first – preliminary screening – and continue on through the permitting process (Source: http://users.internorth.com/~mveirwg).

Under the MVRMA, developers will apply for permits to the appropriate regulatory authority. For land and water permits, this will be the three Land and Water boards described above. As a regulatory body, each will conduct a preliminary screening. The purpose of preliminary screening is to identify the potential for significant adverse environmental effects or to identify public concern. The regulatory body will refer the development to the MVEIRB for subsequent environmental assessment if either of these reasons, or triggers, is identified. Upon referral to the MVEIRB, the permitting process stops. While the MVRMA defines these triggers, it does not define significance.

The MVEIRB is required to conduct an environmental assessment for all proposals that are referred to it. During the environmental assessment process, regulatory authorities (RAs) with relevant technical expertise are consulted to evaluate the potential effects of a development proposal and to provide advice on mitigation measures.

Similar to the preliminary screening process, the MVEIRB will determine if there are any adverse environmental effects or public concerns. Again, if either of these reasons is triggered, then the development proposal would proceed to environmental impact review.

The environmental effect review stage is a more detailed and comprehensive analysis, which is normally reserved for development projects where the environmental effect is greater. Public consultations and hearings are a required part of this process (Source: http://users.internorth.com/~mveirwg).

Table 2.1-1 provides a summary of the progressive stages of environmental assessment and regulatory approval currently required in the North Slave Region, where the BHP claim block is located. Aboriginal land claims have not yet been settled in this region.

Table 2.1-1
Stages of Environmental Assessment and Regulatory Approval

Stage	Process	Responsible Board
I	Preliminary Screening	NWT Water Board MVLWB (April 2000)
II	Environmental Assessment	MVEIRB
III	Environmental Impact Assessment	MVEIRB
IV	Issuance of Land Use Permits and Water Licences Issuance of Land Leases	MVLWB DIAND

The pre-production, operation and decommissioning phases of the proposed Sable, Pigeon and Beartooth development are subject to environmental assessment under the MVRMA.

2.1.1.2 Current Regulatory Instruments at EKATI™

Section 1.2 of BHP's Operational Environmental Management Plan (OEMP) provides a contemporary, tabulated summary of relevant permits, licences, leases and authorizations. The following licences, agreements, authorizations, permits, leases and registrations form the current regulatory framework for the EKATI™ Diamond Mine:

1. Six Land Leases, Numbers
   - 76 D/9-3-2 (Misery Open Pit Mining)
   - 76 D/9-4-2 (Misery Area Facilities)
   - 76 D/10-2-2 (Koala Mining and Related Facilities)
   - 76 D/10-5-2 (Koala Area Facilities)
   - 76 D/10-3-2 (Tailings Disposal and Associated Facilities)
   - 76 D/10-4-2 (Airstrip)

   Issued: January 7, 1997 ***Expiry:*** November 30, 2026

2. Mining Leases
   - # 3473 to 3522 (Panda, Koala, Misery, Fox, Leslie and under the Misery Road Corridor

   Issued: September 11, 1996 ***Expiry:*** April 10, 2017

   - # 3589 to 3597 (under the Sable, Pigeon and Beartooth Road Corridor)

   Issued: June 26, 1997 ***Expiry:*** June 26, 2018

3. NWT Water Board, Water Licence Number N7L2-1616. The purpose of the Licence is for water use, and lake dewatering and disposal of industrial waste in diamond mining processing kimberlite ores.

   Issued: January 1, 1997 ***Expiry:*** December 31, 2004

4. Authorization for the Harmful Alteration, Disruption or Destruction of Fish Habitat Pursuant to Section 35(2) of the Fisheries Act. Including a Fish Habitat Compensation Agreement between Her Majesty the Queen in right of Canada (as represented by the Minister of Fisheries and Oceans) and BHP.

   Fisheries Authorization

   Issued: January 7, 1997 ***Expiry:*** Not Applicable

   Fish Habitat Compensation Agreement

   Issued: January 7, 1997 ***Expiry:*** January 6, 2007

5. Navigable Waters Protection Act Authorization under the Navigable Waters Protection Act. The authorization allows the construction of the mine and its infrastructure (water intakes, water diversion, dewatering of lakes, processed kimberlite disposal, discharge/outfalls, dams/dykes, spillway discharge channel, water crossings and compensation structures) in Lac de Gras area.

   Issued: December 17, 1996 ***Expiry:*** Not Applicable

6. Environmental Agreement between Her Majesty the Queen in right of Canada (as represented by the Minister of Indian Affairs and Northern Development) and the Government of the Northwest Territories (as represented by the Minister of Resources, Wildlife and Economic Development) and BHP.

   Issued: January 6, 1997 ***Expiry:*** End of Mine, subject to 5 year reviews.

7. Hazardous Waste Generator Registration Number NT G000090.

   Issued: January 30, 1997 ***Expiry:*** Not Applicable

8. Class A Land Use Permit N1999C0046 Mineral Exploration Lac de Gras.

   Issued: July 30, 1999 ***Expiry:*** July 29, 2001

9. Wildlife Research Permit

   Issued Annually

10. NWT Archaeologists Permits

    Issued Annually

11. Socio-Economic Agreement between Government of the Northwest Territories (as represented by Resources, Wildlife and Economic Development) and BHP.

    Issued: October 22, 1996 ***Expiry:*** End of Mine

12. Explosives Magazine Permit Numbers, Workers Compensation Board,
    - Approval No. 97903 ***Issued:*** January 20, 1997 ***Expiry***: End of Mine
    - Approval No. 99601 ***Issued:*** March 28, 1996 ***Expiry***: End of Mine
    - Approval No. 97904 ***Issued:*** January 20, 1997 ***Expiry***: End of Mine
    - Approval No. 97019 ***Issued:*** February 9, 1998 ***Expiry***: End of Mine
    - Approval No. 97020 ***Issued:*** February 9, 1998 ***Expiry***: End of Mine
    - Approval No. 97021 ***Issued***: February 9, 1998 ***Expiry***: End of Mine
13. Licence to Manufacture Explosives, Licence Number F2000(03)-415, as pursuant to the Explosives Act. This licence is held by Polar Explosives Ltd. of Yellowknife, BHP's explosives supplier and manufacturer, and is renewed annually.

2.1.1.3 Required Regulatory Instruments for Sable, Pigeon and Beartooth Development

The development, operation, monitoring and decommissioning phases of the Sable, Pigeon and Beartooth pipes requires a land use permit, land leases (also termed Land Tenure Agreements), a Type B Water Licence and a fisheries authorization. As discussed in Section 2.1.1.2, BHP currently holds the mineral leases in the areas proposed for the incremental development. Mining leases grant the exclusive right to mine and produce minerals within the boundaries of the lease. They do not grant the right to use the surface of the land where the claims are located, the right to use water or the right to affect other resources in the area.

The kimberlite pipes BHP is proposing to add to the EKATI™ Mine Plan are all located on federal crown lands under the control of the Minister of the Department of Indian Affairs and Northern Development (DIAND). The disposition of surface and subsurface rights for the BHP mineral claim block area is currently administered by DIAND. Surface lands are managed pursuant to the *Territorial Lands Act*. Subsurface mineral rights are issued under the *Canada Mining Regulations* (CMR).

Part 4 of the MVRMA, proclaimed on April 1, 2000, established the Mackenzie Valley Land and Water Board (MVLWB) to assume responsibility for the issuance of land use permits and water licences in the Lac de Gras area. Under the MVRMA, BHP will require a land use permit for activities conducted on the surface of any new leased lands as well as on untitled crown lands. BHP will therefore require a land use permit to cover development activities for Sable and Pigeon. Beartooth, which is located on current BHP Surface Lease 76D/10-2-2, will be grandfathered under the old lease system by virtue of the transitional provisions found in the MVRMA. It will not require a land use permit.

Under Part 4 of the MVRMA, land use permits will be issued and administered by the MVLWB, but surface leases will be administered by DIAND. DIAND will continue to provide inspection and enforcement for both permits and surface leases.

The use of water and the deposition of waste associated with BHP's Sable, Pigeon and Beartooth development includes dewatering and water diversion, which requires a Type B Water Licence under the *NWT Waters Act*. The Water Licence will be issued by the MVLWB. Under the new legislation, a Type B Water Licence will still be the appropriate instrument. DIAND will provide inspection and enforcement for the Licence.

The proposed development will disrupt the fish habitat of Pigeon Pond; Sable, Two Rock and Beartooth lakes; and Big Reynolds Pond. BHP will require a fisheries authorization issued under the *Fisheries Act*. Ulu Lake was also included in the original fisheries authorization; however its use for waste rock storage has been eliminated from the mine plan for the Sable Pipe.

As required under the *NWT Mine Health and Safety Act and Regulations* Section 14.02, BHP will need to obtain explosives magazine permit(s) for each magazine to be located at the Sable Pit. The Act also requires BHP to submit an annual report to the Chief Inspector of Mines that specifies the mine plan, mineral leases, surface leases, mineral claim boundaries, affected areas and site infrastructure information.

Table 2.1-2 summarizes the key environmental and tenure requirements for the proposed development of the Sable, Pigeon and Beartooth pits. Figure 2.1-2 shows the relevant current BHP leases and the general land lease boundary for the proposed development. The lease boundary may need to change as a result of the environmental assessment process and detailed mine planning and design, and should not be considered final at this time. BHP will provide a final drawing in its lease application, which will be filed after the environmental assessment process is complete.

Table 2.1-2
Permitting Status of Sable, Pigeon and Beartooth Kimberlite Pipes

Proposed Development	Water Licence	Surface Lease	Mineral Lease	Fisheries Authorization	Land Use Permit for Mining	Land Use Permit for Exploration
Sable	Need	Need	Have	Need	Need	Have
Pigeon	Need	Need	Have	Need	Need	Have
Beartooth	Need	Have	Have	Need	Not Required	Have

2.1.1.4 Regulatory Costs

The cost of integrating Sable, Pigeon and Beartooth pipes into the EKATI™ mine plan will be met by BHP and its joint-venture partners. The development will involve an evaluation of the water security deposit by BHP with the MVLWB for the new Type B Water Licence, and of the land-based security deposit specified under the Environmental Agreement with DIAND, the GNWT and the Independent Environmental Monitoring Agency (Agency).

2.1.1.4.1 Security Deposit

Two instruments bear on the issue of the amount and the terms and conditions of the EKATI™ security deposit. The mine currently has two security deposits, each separate and distinct from the other.

The first instrument is the Water Licence issued by the NWT Water Board pursuant to the *Northwest Territories Water Act* and Regulations as Licence Number N7L2-1616 dated January 1, 1997, which expires December 31, 2004. Item 2 of Part B of the Licence requires BHP Diamonds to post security in various amounts pursuant to s.17(1) of the Act and s.12 of the Regulations. Item 3 of Part K of this Licence requires an annual updated estimate of the restoration liability. Currently, a letter of credit for $10,500,000 is held with the Crown.

The second instrument requiring a security deposit is the Environmental Agreement. This agreement provides for security in varying amounts to be deposited over the life of the mine plus a guarantee by BHP, the parent corporation. The security and the guarantee are in addition to, and not in substitution for, the security that BHP is required to provide pursuant to the Water Licence. Under this agreement, and in addition to the security posted for the Water Licence, a letter of credit in the sum of $6,000,000 plus the BHP parent corporate guarantee of $20,000,000 is held with the Crown. The Environmental Agreement also provides that every two years after the commencement of commercial production, there will be a review of the security deposit. The review will consider the current scope of development and the progress that has been made with regard to ongoing reclamation. Based on the bi-annual review, the Environmental Agreement security deposit may be adjusted.

2.1.1.4.2 Quarry Fees

The *Territorial Quarrying Regulations*, enacted pursuant to the *Territorial Lands Act*, an Act of the Parliament of Canada, permits mining companies to take and use gravel, sand or stone provided that the mining company holds a quarry lease. Such a lease is acquired first by staking the area in compliance with the regulation, then by applying to the Minister of DIAND for a lease. The application is filed with the territorial land agent of the district in which the land is situated within 30 days from the date upon which it was staked. A fee of $150 must accompany the application. Once the lease is granted, it is subject to a rental fee of $100 per hectare. In addition, the holder must pay a royalty of $1.50 per cubic metre of sand or gravel used, or $1.25 per cubic metre for any other building material used. It is estimated that approximately 200,000 m^3 of material is required from the Ursula Esker for the proposed construction work. The cost to BHP Diamonds for material extracted from the esker will be $300,000.

2.1.1.4.3 Land Use Permits

Land use permits are issued based on the *Territorial Land Use Regulations* which, in turn, are made pursuant to the *Territorial Lands Act*, an Act of the Parliament of Canada.

BHP currently obtains land use permits for EKATI™ and the surrounding area from the DIAND office in Yellowknife. After April 1, 2000, land use permits will be obtained from the MVLWB, following the proclamation of Part 4 of the MVRMA. The current fees are $150.00 for an application plus $50.00 if the land proposed to be used is less than or equal to two hectares. If the lands proposed to be used are greater than two hectares, then the fee is $50.00 plus $50.00 per hectare for each hectare or portion of a hectare in excess of two hectares. Land use permits are required for exploration and mining activities located outside of BHP's current surface leases.

2.1.2 BHP Agreements

In addition to the legal and regulatory context within which BHP currently operates, other contractual agreements and internal policies determine terms and conditions governing BHP's activities on the claim block for the duration of the life of the EKATI™ Diamond Mine. These agreements are the results of extensive negotiations between the parties.

The following discussion covers the Environmental Agreement, the GNWT/BHP Socio-Economic Agreement, the four Aboriginal Impact and Benefits Agreements (IBAs) and BHP's policy on compensation. These agreements and policies represent the substantive and procedural circumstances of BHP's commitments to various stakeholders in the mine development. All these agreements include provisions for consultation, communication, systematic analysis and monitoring of potential effects, procedures for adaptive management and the effective resolution of disputes. All the agreements are being implemented.

The Sable, Pigeon and Beartooth pipes are located within the existing BHP mineral claim block and therefore come under the application of these agreements. Preliminary results from the implementation of the BHP agreements during construction and operations are provided throughout this report. These results illustrate the effectiveness of the agreements in dealing with the environmental, social, cultural and economic issues related to the EKATI™ Diamond Mine.

2.1.2.1 Environmental Agreement

The Environmental Agreement is a legally binding document whose purpose is to provide for mine-related environmental matters that go beyond those governed by legislation and regulations. Many of the recommendations made by the EARP Panel that could not be addressed by legislation or regulatory instruments are addressed in the agreement.

The four Aboriginal groups whose interests and rights may be affected by the management and regulation of the mine were involved in the finalization of the agreement; representatives of the four groups initialed the final draft. The agreement is to terminate upon full and final reclamation of the EKATI™ mine.

The agreement provided for the establishment of an Independent Environmental Monitoring Agency (Agency). Its seven members have been selected by BHP, Canada, GNWT and the four Aboriginal groups. The Agency's mandate, in part, is to serve as a public "watchdog" of the regulatory process and implementation of the Environmental Agreement. The Agency is to compile, review and provide recommendations on relevant environmental plans, programs and reports prepared by BHP. In relation to government, the Agency is to review monitoring, regulatory and related management programs of Canada and the GNWT. One particular responsibility of note is to provide recommendations on the integration of traditional knowledge into environmental plans and programs.

In addition to establishing the Agency, the Environmental Agreement requires BHP to prepare annual environmental reports and management plans. It also requires BHP to consult with the Aboriginal groups on the management of archaeological sites and the inclusion of traditional knowledge into environmental management. The Environmental Agreement states that BHP shall:

- prepare and submit to governments, the Agency and the Aboriginal peoples an Annual Report summarizing the results and findings of environmental monitoring programs, amongst several other items;
- prepare and submit to governments, the Agency and the Aboriginal peoples a comprehensive report (Environmental Impact Report) every three years, starting in Year 2000, that assesses the longer-term effects of the EKATI™ Diamond Mine; and
- make each Annual Report and Environmental Impact Report available to the public and arrange for public meetings to review and discuss each report.

Consultation on these reports is a natural continuation of the public communication program initiated during the pre-development phase of EKATI™. These reports provide additional mechanisms, outside of the regulatory instruments, to monitor the environmental performance of EKATI™ Diamond Mine. Each of the aforementioned reports is accompanied by a "plain English" summary.

Similar to the Water Licence, BHP Diamonds must post a security deposit to ensure that its land-based obligations under the Environmental Agreement are met. The deposit increases progressively each year, reaching a maximum of $11,075,000 after eight years of the agreement. In addition to the security deposit, BHP, as the parent company of BHP Diamonds, provided an irrevocable guarantee of $20,000,000.

2.1.2.2 Socio-Economic Agreement

The EARP Panel recognized in 1996 that EKATI™ had the potential to have a positive economic effect on the NWT, but felt that the potential cultural effects could be mixed. They concluded that BHP and governments could address social effects resulting from the EKATI™ Diamond Mine through appropriate programs and policies. BHP and the GNWT signed the Socio-Economic Agreement on October 22, 1996.

Under the agreement, BHP has a responsibility to make available, to the greatest degree practicable, on-the-job training, employment and business opportunities to Aboriginal and Northern residents. The goal is to ensure that benefits accrue to Northern residents and local business and that the potential for adverse social effects are minimized. The GNWT is responsible for providing such programs as pre-employment training and monitoring of community wellness. The agreement envisions that it is the role of government to help the people of the NWT take advantage of the opportunities arising from the operation of EKATI™. Each party is responsible for preparing an annual report that monitors its progress in meeting its respective responsibilities as set out in the agreement. BHP's 1999 Annual Report on Northern and Aboriginal Employment and Annual Report on Local Purchases are provided in Appendix B.

The addition of Sable, Pigeon and Beartooth to the mine plan will not change the socio-economic benefits and opportunities provided by EKATI™ under the terms of the Socio-Economic Agreement. Aboriginal and Northerners will continue to receive benefits and opportunities from EKATI™ for the duration of this new development. Opportunities flow from the mine operations via two main channels – employment opportunities and the supply of goods and services to EKATI™. The size of the labour force is not anticipated to change significantly with the introduction of the three pipes to the mine plan. There may, however, be a need for additional contracting services for earthmoving and construction of the Sable Road and for preparation of the mine site facilities. The contracting services will be subject to the same commitments made under the Socio-Economic Agreement.

BHP and the GNWT agreed on standards, baseline data and selected socio-economic indicators that would be used to assess the success of the respective commitments. The objective is to promote activities that strengthen benefits to the people of the NWT and to mitigate the potentially negative effects of social change. The agreement provides for annual meetings and consultations with the affected communities defined by EARP in order to review the results of both the BHP and the GNWT annual reports.

The monitoring provisions yield information on the economic benefits that Aboriginal people and Northern residents are obtaining under the Socio-Economic Agreement. Monitoring results related to employment targets - including the employment of women in non-traditional roles - as well as recruitment strategies, training programs and business opportunities are discussed in Section 4.7. This section also contains information on provisions of the agreement related to monitoring community wellness. The provisions of the existing Socio-Economic Agreement will apply to the proposed Sable, Pigeon and Beartooth development.

2.1.2.3 Impact and Benefits Agreements

The key variable in determining the context of Impact and Benefits Agreements (IBAs) in Northern Canada is the status of Aboriginal land claims. Where land claims are not settled, the negotiation of IBAs is complicated by the presence of unresolved and overlapping claims to rights in land and resources. Such is the case with EKATI™, where the Crown owns both the surface and subsurface lands, and various groups claim

Aboriginal rights to the area. Rather than waiting for a resolution of land claims, BHP voluntarily initiated IBA discussions in 1995 for its mining operations on the whole claim block. These agreements, which were privately negotiated, have been completed and implemented with the four Aboriginal groups that have traditionally used the claim block:

- Dogrib Treaty 11;
- Akaitcho Treaty 8;
- North Slave Metis Alliance; and
- Inuit of Kugluktuk.

The primary purpose of the IBAs is to ensure that employment, training and business opportunities flow preferentially from EKATI™ to the Aboriginal communities. The agreements also provide means to mitigate potential adverse environmental, social, economic and cultural effects resulting from BHP's operations. Any conflict between the IBAs and the Socio-Economic Agreement will be resolved in favour of the IBAs. Royalties are not a part of the IBAs and are determined and administered by DIAND.

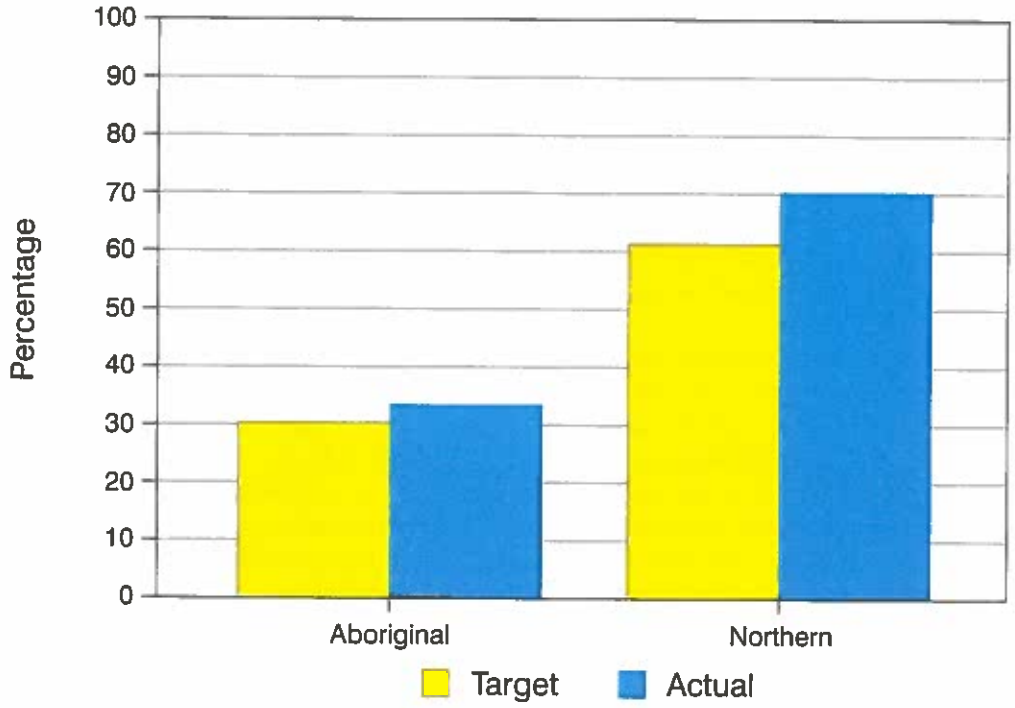
The proposed Sable, Pigeon and Beartooth development falls within the BHP claim block and is, therefore, subject to the existing provisions of the IBAs. The updated mine plan will not change the socio-economic benefits and opportunities under the IBAs, *e.g.*, there will be no increase in employment levels or significant increase in the supply of goods and services for EKATI™. The three pipes simply continue the mine life and thereby maintain the available benefits and opportunities.

While the specific terms of each IBA are confidential, the preliminary results of BHP's commitments under the agreements are provided in aggregate in BHP's Socio-Economic Agreement Annual Reports. These reports show the number of Aboriginal hires and purchases made from local Aboriginal businesses from 1997 to 1999. This information is summarized in Figure 2.1-3.

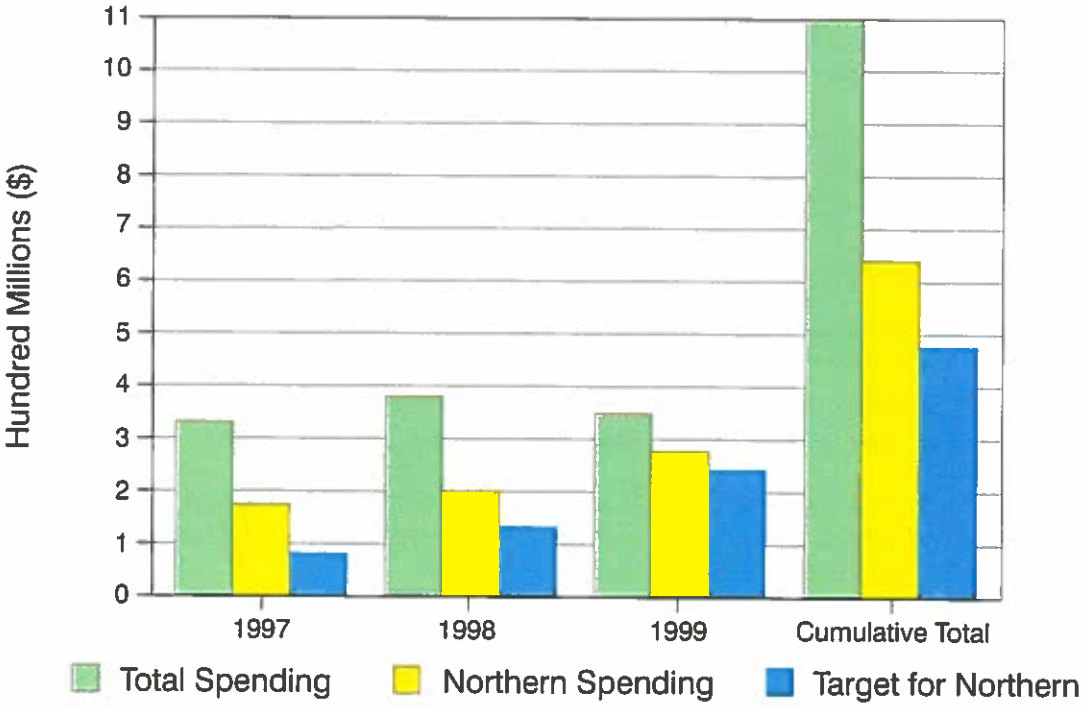
In addition, each of the IBAs provides mechanisms for communication and consultation between the parties that will allow:

- BHP to explain the project development and operations on its claim block; and
- Aboriginals to voice their concerns.

The company-community interactions specified under the IBAs are independent of other regulatory or contractual agreement requirements. They are intended to foster better understanding and long-term cooperation between the parties. Similar provisions for required community consultation exist in the Socio-Economic and Environmental agreements. Additionally, framework agreements to the IBAs facilitate company-community interaction; this includes the mechanisms for dispute resolution that are available to the parties under the IBAs.



BHP Hiring Targets



BHP Northern Spending Targets

FIGURE 2.1-3

BHP

Ekati diamond mine

The IBAs provide for the appointments of key personnel to facilitate communications and consultations between the parties. Each of the four Aboriginal groups has a designated IBA representative whose role is to ensure that implementation, communication and monitoring take place. The IBA representatives work with BHP to improve the effectiveness of the agreements. An Aboriginal employment coordinator also plays a key role in promoting Aboriginal employment and communication. Provisions for reporting and monitoring of the agreements are contained in the IBAs. In addition, BHP has on staff a senior Aboriginal Affairs Advisor.

Although the IBAs are not compensation agreements, substantial funding provisions exist to provide mitigative resources for the anticipated costs of dealing with the potential effects of BHP's operations. Scholarships, implementation provisions, community support and cultural/heritage preservation are funded by the IBAs. This funding will continue for the life of the mine, including the period of operation of Sable, Pigeon and Beartooth. Funds are made available to the Aboriginal leadership to determine the needs of their respective communities, create additional opportunities and mitigate potential problems. BHP is of the opinion that the Aboriginal groups are in the best position to determine and act on the effects of EKATI™ on their communities.

2.1.2.4 BHP's Compensation Policy

The 1996 EARP report on the NWT Diamonds Project recommended that BHP's compensation policy set out firm procedures for seeing disputes through to resolution. The compensation policy subsequently developed by BHP for mitigating potential impacts to commercial and/or subsistence users remains unchanged for the proposed development.

Generally, the compensation policy states that BHP shall take all the necessary measures to mitigate adverse effects on the environment, wildlife and harvesting rights of a party that can be mitigated and which arise as a result of the mine operations.

The procedure for mitigation and compensation, involves:

- discussions with a claimant to determine whether BHP's activities have adversely affected the commercial or subsistence land use of the claimant; and
- whether these activities solely have caused the interference or whether other factors or other companies' activities were involved.

If it is determined that BHP's activities caused the interference, the claimant and BHP will determine practical measures that can be undertaken by BHP immediately and in the future to mitigate the interference.

If a financial loss has resulted from BHP's activities, then a claimant must clearly demonstrate the basis of the loss by introduction of evidence, subject to the claimant's duty to mitigate damages, of its entitlement to compensation and a basis for quantifying the compensation.

BHP and the claimant will negotiate in good faith to resolve the claim. Should amicable resolution not be achieved, the matter would be subject to arbitration or dispute resolution provisions, if applicable, of the Aboriginal IBAs.

Aboriginal IBAs, the GNWT Socio-Economic Agreement, and the Environmental Agreement mitigate potential impacts of the mine but are not compensation agreements and therefore are discussed elsewhere in this document.

2.2 Development Description

2.2.1 Introduction

The focus of this document is a revision of the EKATI™ mine plan to incorporate three additional kimberlite pipes – Sable, Pigeon and Beartooth – and thereby extend the life of the mine. The new pits will be developed by methods and technology already in use at EKATI™, as described in detail in the 1995 BHP Environmental Impact Statement (EIS) for the mine, known at that time as the NWT Diamonds Project. Process Plant operations and waste management will be essentially the same under the revised plan. The source of the feed will vary from the sequence originally proposed in the EIS, but current plant production rates and disposal practices for processed kimberlite will be unchanged.

An all–weather access road will be constructed to connect the new pits to the main EKATI™ development area. Twenty-five km of new road construction will be required. Office, warehouse and equipment maintenance facilities will be provided at Sable because of its distance from the main site. Pigeon and Beartooth are close to the central EKATI™ operations and will require less support infrastructure. All satellite buildings and facilities will be container or modular type structures.

Water management facilities will be provided at all three pit areas to control natural runoff as well as development–induced flows. The small lakes above the Sable and Beartooth pipes will be dewatered following procedures developed for Panda and Koala pits. Turbid residual lake and pit water from Pigeon and Beartooth will be directed to the Long Lake Containment Facility, whereas turbid water from Sable will be stored in a reservoir until it meets criteria for discharge to the environment.

Water management structures will consist of low dams and diversions. A complete description of each structure and its design basis is provided in a report prepared by EBA Engineering Consultants Ltd., entitled "Preliminary Design of Water Control Structures for Sable, Pigeon and Beartooth Developments" (EBA, 2000). These designs are consistent with the Project Description (BHP, 1999; Revision 3), with the exception of the reservoir at Sable. That facility has been expanded somewhat since the Project Description was submitted to provide greater contingency storage for turbid pit water. Additional site–specific geotechnical and topographic data are required to advance the design of the water management structures from preliminary to the final stage.

This environmental assessment should be read in conjunction with the Project Description document, which provides more details on the proposed layout of facilities at each pit. The Project Description (BHP, 1999; Revision 3) is provided in Adobe Acrobat format on the attached CD.

The winter road constructed annually between Yellowknife and EKATI™ will continue to be the only means of surface transport beyond the site boundaries. The winter road is used to deliver bulk commodities (*i.e.*, fuel, explosives, *etc.*) needed to support year–round mining operations. The existing agreement conditions for use of the road,

including speed and load size restrictions, will remain applicable for all traffic. Since the time of its initial opening, trucks have safely hauled thousands of loads during the short, three-month winter road season.

The development at EKATI™ will induce no increase in traffic on the winter road beyond the estimates presented in the EIS. The actual number of truck loads delivered to date over the road, during both construction and operations, has been lower than anticipated, therefore, the estimated maximums presented in the EIS are still applicable. During operations, approximately 1,952 truckloads of supplies will be required annually at EKATI™ to 2002; 2,087 truckloads each year between 2003 and 2006; and 2,813 truckloads each year from 2007 and thereafter until mine closure. The estimated types and quantities of goods to be shipped by winter road during these periods are summarized in Table 2.2-1.

Table 2.2-1
Anticipated Annual Quantities of Supplies Shipped via the Winter Road

	Shipped Annually From		
Item	**To 2002**	**2003 to 2006**	**2007 onwards**
Fuel	52,400,000 L	56,000,000 L	79,600,000 L
Truckloads (38,000 L/truckload)	1,380	1,475	2,095
Supplies	14,300 t	15,290 t	17,956 t
Truckloads (25,000 kg/truckload)	572	612	718
Total Truckloads	**1,952**	**2,087**	**2,813**

Note: Fuel storage at EKATI™ is consistent with the EIS (1995). No additional storage is required for the Sable, Pigeon and Beartooth development.

The winter road passes within 1.5 km of the Diavik Diamonds Project site, and will serve as the surface transportation route for that development as well. Diavik has suggested that it will require 2,200 to 2,400 truckloads per year during construction, decreasing to 1,500 to 1,700 loads per year during operations (Diavik, 1998b). Based on the highest forecast volumes of EKATI™ Diamond Mine, Diavik Diamond Mines and the Lupin Mine, the peak traffic volume over the winter road would be approximately 6,000 round trips per year (GNWT, Department of Transportation).

The following sections describe the proposed Sable, Pigeon and Beartooth development at EKATI™ in more detail, particularly with regard to water management, waste rock management and the requirements for granular construction materials associated with the new pits. The plans take into account experience gained by observation and monitoring during the first year of mine operation and provide for the collection and assimilation of new data into final design, where appropriate.

2.2.2 Mining Plan

The locations of the proposed Sable, Pigeon and Beartooth development sites within the overall claim block and with respect to existing and currently permitted development are

shown in Figures 2.2-1 and 2.2-2, respectively. The ore and waste production schedules for the overall mine development are shown in Figures 2.2-14 and 2.2-15 in Section 2.2.6.

The Sable, Pigeon and Beartooth pipes will be developed by means of the open pit mining methods already in use at EKATI™. These methods for mining, hauling, processing, waste and water management, and logistical support have been described and assessed previously within the framework of the 1995 Environmental Assessment Review Process. No new processes or methods are proposed.

The proposed pipe developments represent an extension of existing operations. As such, the existing facilities at the main EKATI™ site will be used whenever practical. All kimberlite will be processed at the EKATI™ Process Plant, and processed kimberlite will be disposed of within the existing Long Lake Containment Facility. All newly erected structures will be modular units and containers. No new waste streams will be generated as a result of the proposed developments. All wastes (sewage, garbage, used oils, *etc.*) will be collected and returned to the main EKATI™ site for handling and disposal in accordance with established procedures. Bulk explosives will be supplied to the three pits in mobile units from the main EKATI™ facilities.

A productive post-closure lake will be developed within each exhausted pit in accordance with DFO policy of no net loss to fish habitat. Reclamation of each development site will be performed as laid out in the existing Abandonment and Restoration Plan, which will be updated appropriately to incorporate the three new pits. Select areas will be sloped back at a shallow angle to form beaches. Within the constructed littoral zone, screened esker material and/or crushed granite will be used as substrate along with strategically placed boulders to provide wave breaks and refuge areas for smaller fish. The upper walls of the pits will be modified and the pits subsequently flooded. During the final stages of flooding, the pit lakes will be monitored to determine any need for nutrient supplement or fish re-stocking.

To accelerate flooding of the exhausted Sable and Pigeon pits, water will be pumped from a large water source within close proximity of each respective site. In the case of Beartooth, processed kimberlite will be used to partially backfill the pit before filling it with fresh water. This plan differs slightly from the one presented in the Project Description document (October, 1999; Revision 3).

2.2.2.1 Sable Pipe

The Sable Pipe is located beneath Sable Lake, approximately 15 km north of Panda Pit. Sable Lake is a headwater lake with a small catchment area and no significant inflow. Sable Lake lies within the overall Exeter Lake catchment and it is also close to the Ursula Lake catchment. Care has been taken to position waste rock storage piles solely within one watershed (Exeter Lake). The proposed development concept for the Sable Pit is presented in Figure 2.2-3.

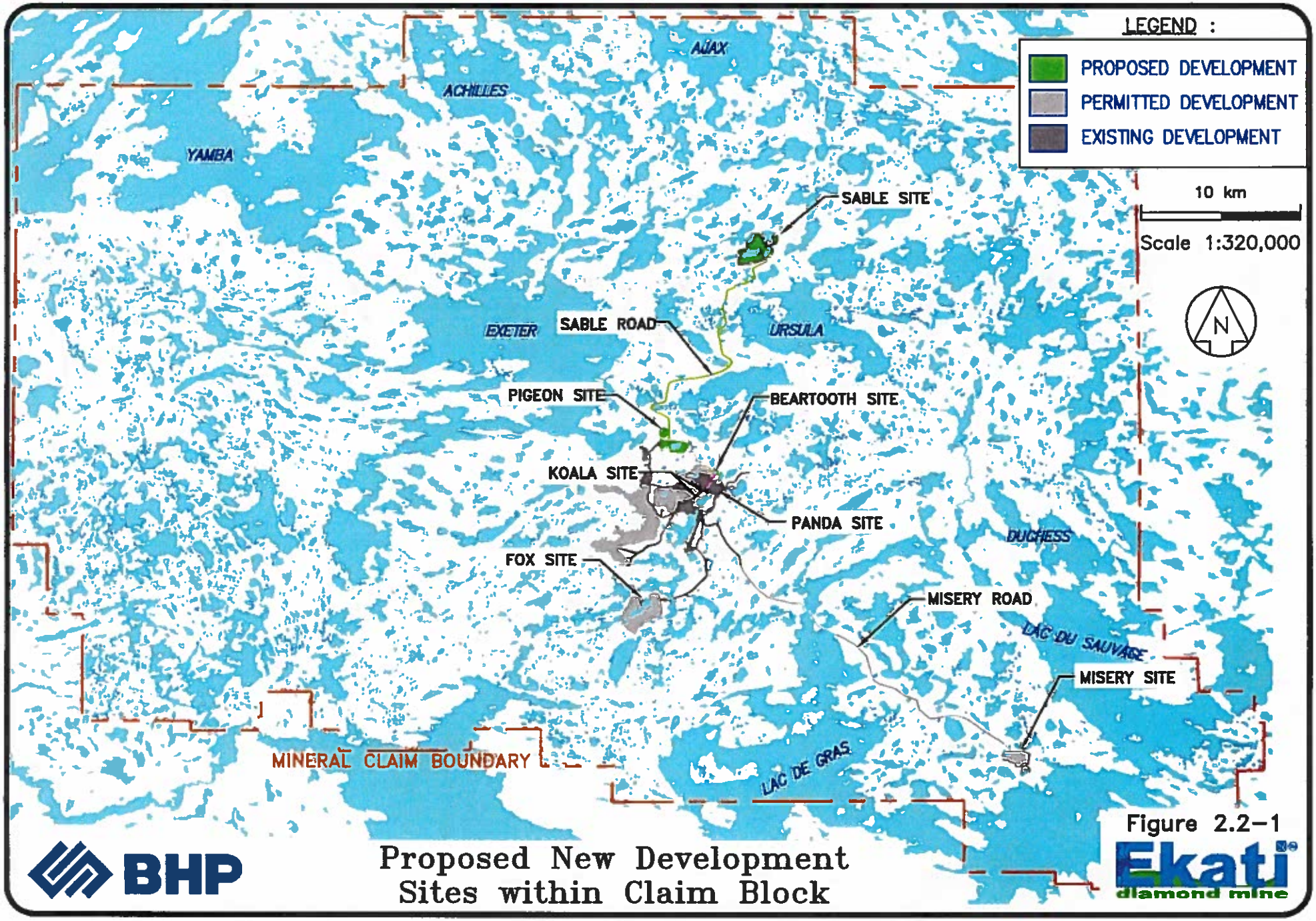
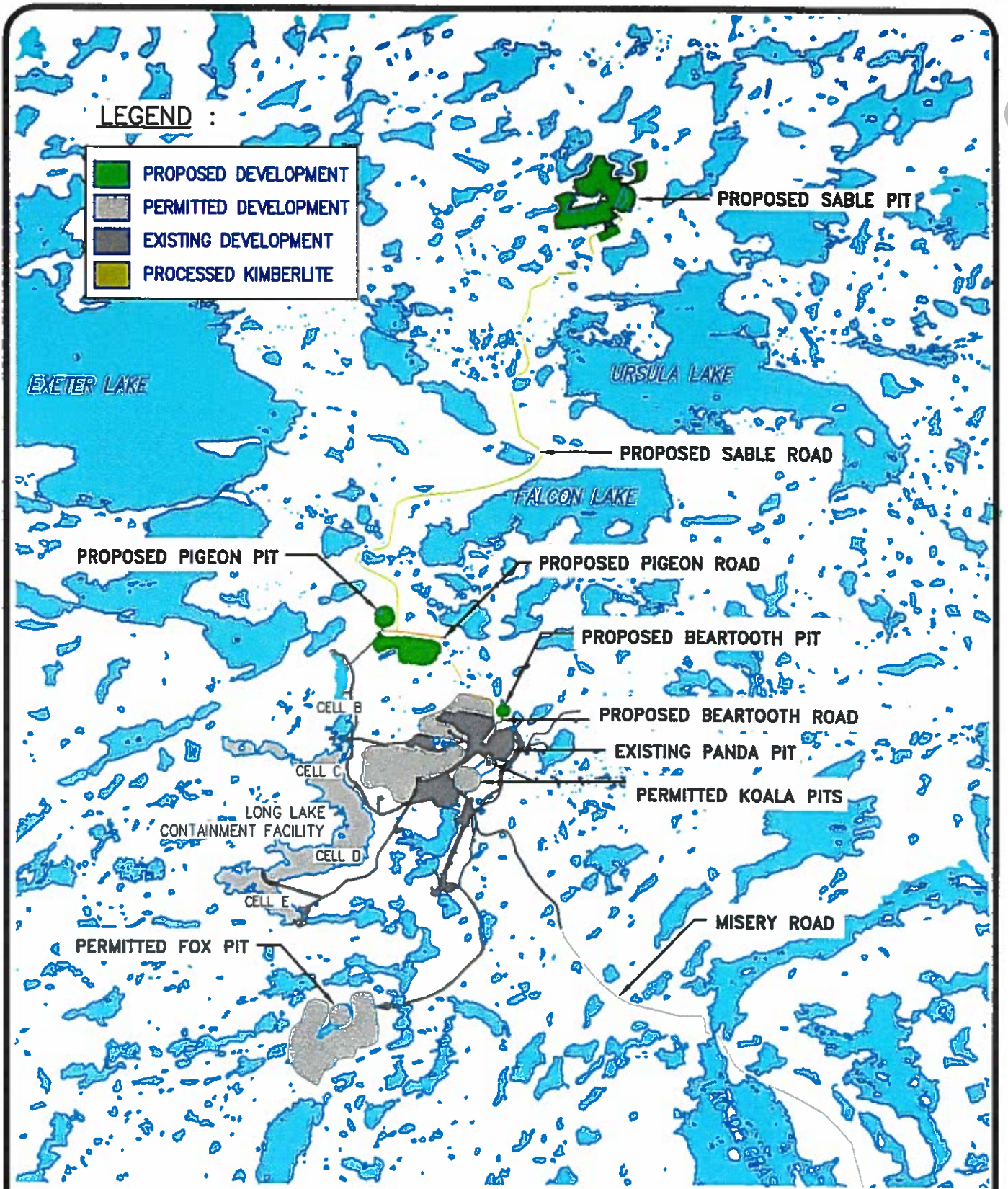


Figure 2.2-1

Proposed New Development Sites within Claim Block

BHP

Ekati diamond mine



General Location Plan
Proposed Development of Sable, Pigeon and Beartooth Kimberlite Pipes

Figure 2.2–2

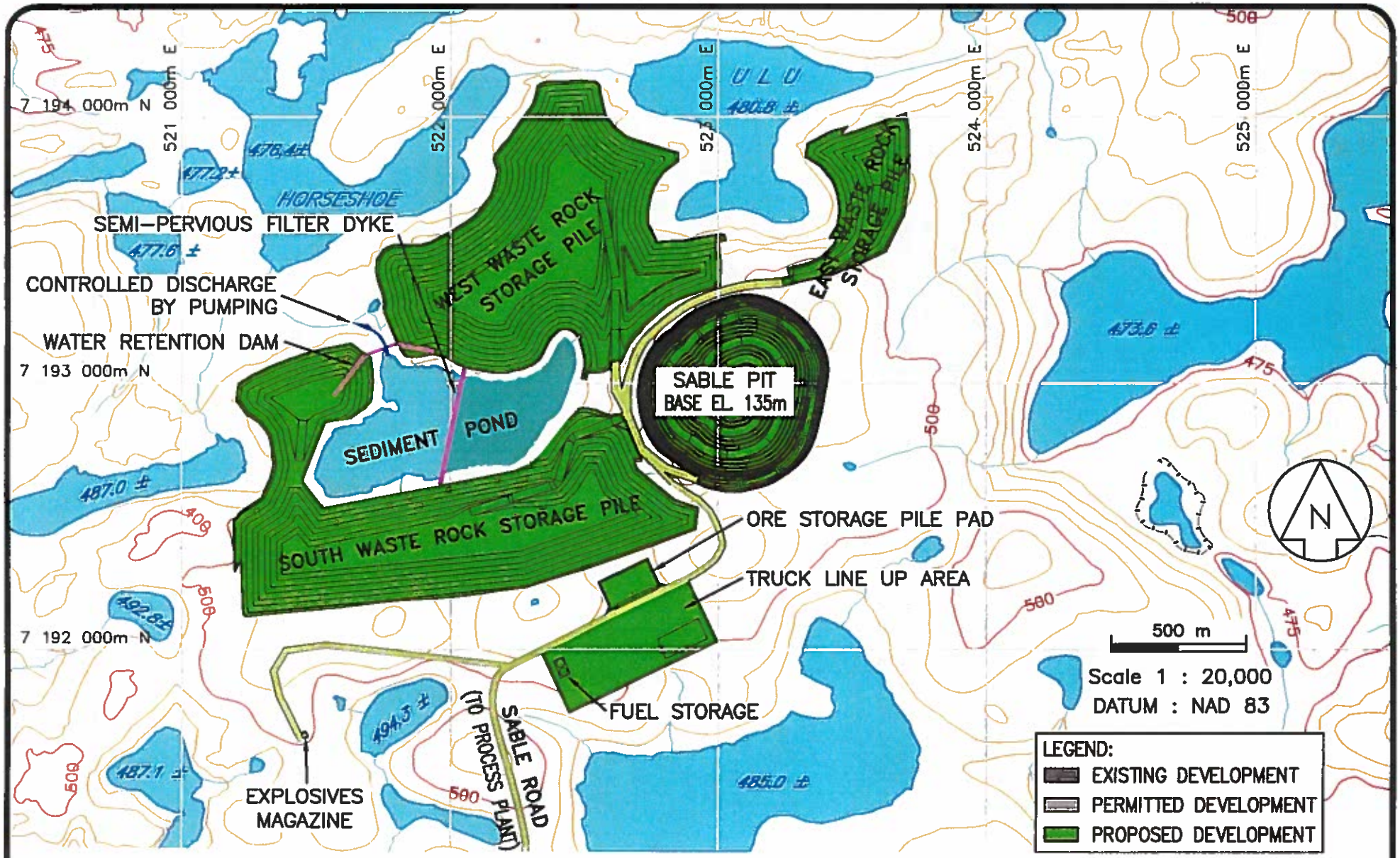
0 2.5 5.0 7.5 km

Scale 1 : 150,000

BHP

Ekati diamond mine

Cad No. C1156 Sht. 8 View C1 Job No. 571–6 BHP 1999 EA Report Ref : EBA Figure X_X–2 03/29/2000– 10:18am EKATI_AP



Source : BHP 1999C

Figure 2.2-3

Sable Lake Area
Proposed Development Concept

The Sable Pipe will be mined to a depth of 360 m (El. 135 m) below the existing lake level. Approximately 120.8 million tonnes of waste rock and 12.9 million tonnes of kimberlite will be excavated, leaving a final pit volume of 50.6 million m^3 at closure.

Sable Lake must be dewatered to gain access to the kimberlite ore. Clean lake water will be discharged to the outlet stream from Two Rock Lake, immediately downstream of Sable Lake. Two Rock Lake will serve as a sediment pond (reservoir) for turbid water from Sable during the latter stages of lake dewatering and pit development. Turbid water will be retained within Two Rock Lake behind a water retention dam. A rock-fill dam with a frozen core will be constructed. This design principle has been used successfully for this purpose elsewhere at EKATI™. A semi-pervious filter dyke will be constructed within Two Rock Lake to divide it into two ponds (cells). During pit development, mine water will be pumped into the upstream cell, allowing suspended solids to settle and filter from the water that seeps through the dyke into the downstream cell. Water from the downstream cell that meets established discharge criteria will be pumped over the retention dam for release to the environment during the summer months. The filter dyke concept was used in the design and construction of the Long Lake Containment Facility intermediate dykes.

The fish population in Sable and Two Rock lakes will be harvested before these development activities begin.

Support facilities at Sable will consist of a small, independently powered warehouse and field office complex complete with a lunchroom, washrooms, first aid room and emergency accommodations. Fuel storage with secondary containment will be provided adjacent to the laydown and truck ready line areas. An explosives magazine to house primers, detonators and other blasting supplies will be established at a safe distance from the pit. Mine employees will be housed at the existing EKATI™ accommodations complex and be bussed to and from the Sable site each shift.

2.2.2.2 Pigeon Pipe

The Pigeon Pipe is situated 4.5 km northwest of the existing Panda Pit and lies beneath an overburden cover rather than a lake. Pigeon Pond is located 250 m west of the pipe centre. The upstream catchment area of Pigeon Pond includes several small- and medium-sized lakes. Pigeon Pond drains through Pigeon Stream into Fay Lake, which ultimately flows into Upper Exeter Lake.

The Pigeon Pipe will be mined to a depth of 200 m (El. 280 m) below the existing ground surface. Approximately 51.2 million tonnes of waste rock and 5.3 million tonnes of kimberlite ore will be excavated, leaving a final pit volume of 22 million m^3 at closure. The proposed development concept for the Pigeon Pit is presented in Figure 2.2-4.

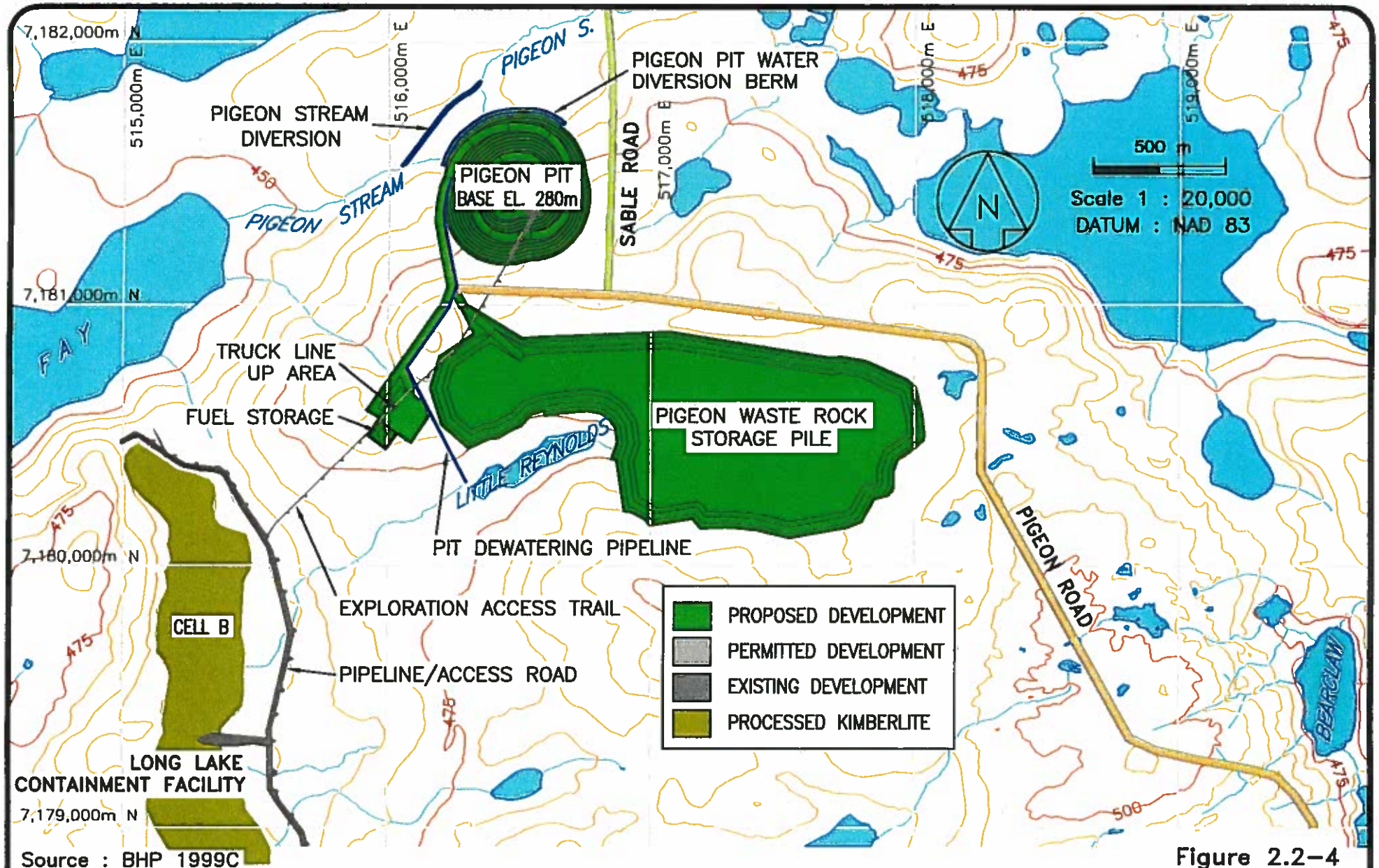


Figure 2.2-4

Pigeon Pond Area
Proposed Development Concept

BHP

Ekati diamond mine

Pigeon Pond and a part of Pigeon Stream will be temporarily displaced during the development of Pigeon Pit. A short (440 m) stream diversion will be constructed to realign Pigeon Stream and maintain drainage. The design and construction plan for this stream will allow seasonal fish passage.

Water that collects within the pit sump will be recycled for road watering (dust control) and drilling operations to the maximum extent possible. Any remaining pit water will be pumped to Little Reynolds Pond, which drains naturally into the Long Lake Containment Facility.

A small lunch room, office and washroom facility with temporary emergency shelter and supplies will be constructed at the Pigeon site. Fuel storage with secondary containment will be provided adjacent to the laydown and truck ready line areas.

2.2.2.3 Beartooth Pipe

The Beartooth Pipe lies beneath Beartooth Lake less than 1 kilometre northwest of North Panda Lake. Pit development will proceed to a depth of 155 m (El. 310 m) below the existing lake level. Approximately 16.8 million tonnes of waste rock and 1.4 million tonnes of kimberlite will be mined from Beartooth. The final pit volume at closure will be 6.9 million m^3. The proposed development concept for the Beartooth site is presented in Figure 2.2-5.

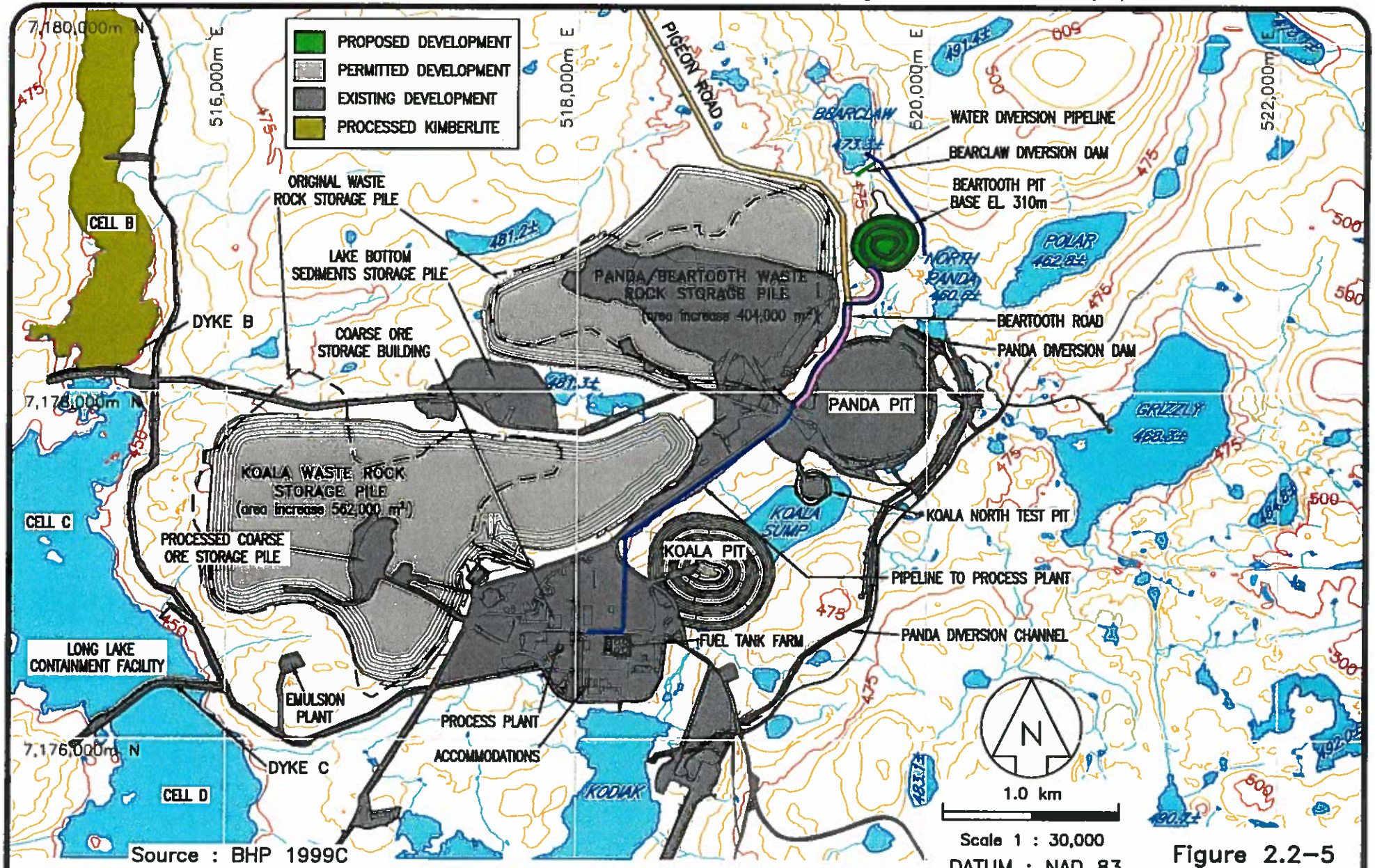
To permit dewatering of Beartooth Lake, incoming flows from Bearclaw Lake, immediately upstream, will be diverted by means of a pipeline to the upper reaches of Beartooth Stream at the outlet of Beartooth Lake. A dam will then be constructed at the outlet of Bearclaw Lake. Water draining into Beartooth Pit during mining operations will be collected in a sump and pumped through a pipeline to the Process Plant or directly into the Long Lake Containment Facility. Because of its close proximity to the central EKATI™ site, Beartooth will be supported completely by the existing facilities.

2.2.2.4 Site Access Roads

All-weather roads will be constructed to provide access from the existing EKATI™ facilities and to the three new pit areas. The overall alignment will include a main roadway from EKATI™ to Sable with short spurs to the local site infrastructure and development. The Beartooth Road section will be 0.7 km long, the Pigeon Road 4.3 km long and the Sable Road 18.4 km long.

Most traffic on the road system will be the haul trucks required to transport kimberlite ore to the Process Plant. Traffic volumes during mining operations at the Sable Pit have been estimated based on Cat 777 haul trucks operating 24 hours per day, 365 days per year. Haul traffic on the Sable Road will commence during the last quarter of calendar year 2005. The estimated haul truck traffic volumes are summarized in Table 2.2-2.

Cad No. C1161 SHT. 15 View C1 Job No. 571-6 BHP 1999 EA Report Ref : EBA Figure 4.3-3 03/29/2000- 10:09am EKATI_AL



Source : BHP 1999C

Figure 2.2-5

Beartooth Lake Area
Proposed Development Concept

BHP

Ekati diamond mine

Table 2.2-2
Sable Road: Estimated Traffic Volumes

Year	Projected Loads/Day
2005	15
2006	15
2007	30
2008	35
2009	63
2010	99
2011	85
2012	28

Design standards and criteria have been established based on operational requirements in conjunction with regulatory compliance (*i.e., Northwest Territories Mine Health and Safety Act and Regulations*). The road structure will consist of continuous fill placed on the existing tundra surface, with precautions taken to ensure the underlying permafrost remains undisturbed. The road will be constructed in such a manner to minimize the need for safety berms, which would not only trap snow but also obstruct migrating caribou. In areas where significant caribou movement is apparent, side slopes will be flattened to allow easier passage across the road and to enhance visibility for equipment operators.

Culverts will be installed where necessary to ensure that water continues to flow unimpeded through the roadway. The road will require two types of culverts: those at defined stream crossings, and equalization culverts to prevent impoundment adjacent to the toe of the slope during runoff events. The road alignment intersects seven creek beds, three of which are defined stream crossings where drainage is readily apparent. Hydrology studies will be conducted to determine culvert locations along the proposed road alignment. Where required, the culverts will be sized and installed to allow fish passage through the structure.

2.2.3 Waste

The mining and processing of kimberlite from the Sable, Pigeon and Beartooth pits will generate solid wastes in the form of overburden/waste rock and processed kimberlite. Management of these wastes relative to the proposed development is discussed below.

2.2.3.1 Processed Kimberlite Disposal

Processed kimberlite is discharged from the Process Plant as a coarse sand fraction (0.5 to 8 mm) and a fine fraction (<0.5 mm). The sands are trucked to a dry stockpile area within the Koala Waste Rock Storage Area. The fines are pumped as a soil-water slurry to the Long Lake Containment Facility, where soil separates from surplus water by means of sedimentation and filtration. The disposal areas for coarse and fine processed kimberlite are shown in Plates 2.2-1 and 2.2-2, respectively.

Plate 2.2-1 Processed Coarse Ore Stockpile

Plate 2.2-2 Processed Kimberlite Deposition

The operation and design of the Long Lake Containment Facility are described in the following reports:

- Wastewater and Tailings Management Plan, EKATI™ Diamond Mine (EBA, 1998).
- Final Design Report, Long Lake Intermediate Dykes, EKATI™ Diamond Mine (EBA, 1998).
- Final Design Report, Long Lake Outlet Dam, NWT Diamonds Project (EBA, 1997).

The proposed development will not change the operational plan for the Long Lake Containment Facility. The rate of accumulation of processed kimberlite and water is determined solely by the capacity of the Process Plant. Processed kimberlite produced from bulk samples taken from the three pipes was observed to behave in a similar manner to kimberlite currently being produced from Panda Pit. The material characteristics are within the parameters established for the design of the Long Lake Containment Facility. The overall capacity of the facility exceeds the current mine life even under the worst-case settling and consolidation conditions. The material and water balance for the Long Lake Containment Facility is discussed in Subsection 2.2.4.

The first stage of the Long Lake Containment Facility was constructed in 1997/1998 and the facility was commissioned in October 1998. More than one year of operating data have been collected since then. These data confirmed that the original design criteria were realistic and that the processed kimberlite and surplus water are effectively separating in the basin. The settling characteristics of the slurry, coupled with filtration through granular-lined dykes, have proven effective in producing water at the discharge point that readily meets the environmental criteria established under the Type A Water Licence.

2.2.3.2 Processed Coarse Ore

As discussed in previous Section 2.2.3.1, processed kimberlite discharged from the Process Plant consists of coarse a sand fraction (0.5 to 8 mm) and a fine fraction (<0.5 mm). The sand fraction is referred to as processed coarse ore or coarse rejects, and makes up approximately 29% of the total processed ore. The processed coarse ore is discharged by conveyor into a temporary stockpile adjacent to the Process Plant, then loaded and trucked to a designated dry stockpile area within the Koala Waste Rock Storage Pile.

The processed coarse ore from the Process Plant has a moisture content of approximately 18%. Some of the water drains from the material when it sits in the temporary stockpile. This water is collected in a sump and pumped back into the plant to be recycled. Any excess water or runoff from the material after it reaches the disposal site would flow toward the Long Lake Containment Facility.

The processed coarse ore will eventually be encapsulated within waste rock, which reduces the potential for degradation. The material is set back far enough into the storage

pile to prevent it from influencing pile stability. Permafrost will eventually form within the stockpiled material and eliminate any stability concerns.

2.2.3.3 Waste Rock

2.2.3.3.1 Waste Rock Geochemistry

Two main geochemical issues must be considered in the evaluation of waste rock management for the proposed development:

- the potential for acid generation and acidic drainage; and
- the potential for metal leaching at alkaline, neutral and acidic conditions.

These issues pertain to both operations and the eventual closure of the mine and waste rock storage piles. Static testing, primarily acid base accounting (ABA), is used to evaluate the potential for acid generation and neutralization in a sample. Kinetic testing is required to evaluate metal leaching and drainage water chemistry from the rock samples, and as the basis for predicting field geochemistry and water quality from waste rock storage piles.

A suite of drill core samples was selected by BHP geologists to represent the range of rock types and spatial distribution of the waste rock for each of the proposed Sable, Pigeon and Beartooth pits. A set of ore samples selected by BHP geologists was also submitted for static testing. These samples were tested for metal content (by ICP analysis) and acid base account (ABA using the modified Sobek method) at the Canadian Environmental and Metallurgical Laboratory in Vancouver, B.C.

Acid base accounting tests are used to evaluate the balance between the potentially acid generating minerals (primarily sulphides) and potentially acid consuming minerals (primarily alkaline carbonate minerals). The acid potential (AP) and neutralization potential (NP) are expressed in terms of kg $CaCO_3$ equivalent per tonne. These results are assessed in terms of the net neutralization potential (NNP) and ratio of NP to AP. In general, a ratio of 1:1 or less indicates that the sample is potentially acid generating. A ratio of 3:1 or greater for waste rock indicates that the material would be net acid consuming. Samples with NP:AP ratios between 1:1 and 3:1 typically require kinetic testing to determine the net acid generation potential.

Determining the metal content of the solids is useful for evaluating potential metal leaching issues and comparing rock types with the existing database for other pits. Metal content in solids is not necessarily directly proportional to metal leaching rates; these depend on mineralogy and geochemical controls. Kinetic testing is required to determine metal leaching rates and water quality.

The results of the testing for each of the three proposed pipes are discussed below. As kinetic testing has not yet been conducted, the conservative criterion of 3:1 NP:AP ratio

defining acid generation potential has been used in this interpretation. In general, the waste rock samples are net acid consuming or essentially inert with respect to acid generation, with very low sulphur content and low neutralization potential. Therefore, no significant concerns with respect to alkaline drainage or acid generation and resultant metal leaching have been identified in the testwork to date. However, some samples do show slightly elevated sulphide contents and, until kinetic testing is done, it would be prudent to assess the quantities of this material and incorporate contingencies for special handling into the waste management plan.

2.2.3.3.1.1 Sable

The results of the static testing on the Sable waste rock samples are summarized in Appendix C (Tables 1 and 2) and presented graphically in Figure 2.2-6.

A total of 42 waste rock samples were tested for Sable, comprising 23 samples of two-mica granite, 14 samples of biotite granite and samples of biotite schist, migmetite and diabase. Overall, the Sable test results show a slightly greater range of sulphide content and neutralization potential than the Pigeon or Beartooth results. The sulphide content is consistently low, however, as is the neutralization potential. Samples of biotite schist, migmetite, biotite granite and two-mica granite show a potential for net acid generation with NP:AP values of less than 3:1, although the majority of the samples are net acid consuming.

An estimated 120.8 million tonnes of waste rock will be mined from Sable, of which the majority will be two-mica granite (80%), with lesser biotite granite (6%) and a mixed zone (13%). This indicates that, while net acid generation from the Sable waste rock is not expected, there is very little alkalinity to provide buffering of local zones of oxidation. While no consistently elevated zones of sulphide were noted from these test results, sulphide sulphur contents of approximately 0.1% S (as sulphide) were measured occasionally in samples of the granite, schist and diabase. To assess the occurrence and effect of these sulphide contents on the waste rock geochemistry, the next stage of assessment will include quantification of the amount of waste rock represented by these samples, and kinetic testing to assess reactivity and water chemistry. At this time, contingencies for water and waste rock management have been provided for in the environmental management planning.

2.2.3.3.1.2 Pigeon

The results of ABA and metal analyses for the 11 Pigeon waste rock drill core samples are presented graphically in Figure 2.2-7. The data are summarized in Appendix C (Tables 3 and 4).

The ABA results show that the Pigeon samples are inert (with respect to acid generation) to slightly acid consuming. The biotite granite samples contain no sulphide and no (carbonate) alkalinity. The biotite schist sample shows a low sulphide content of 0.05%

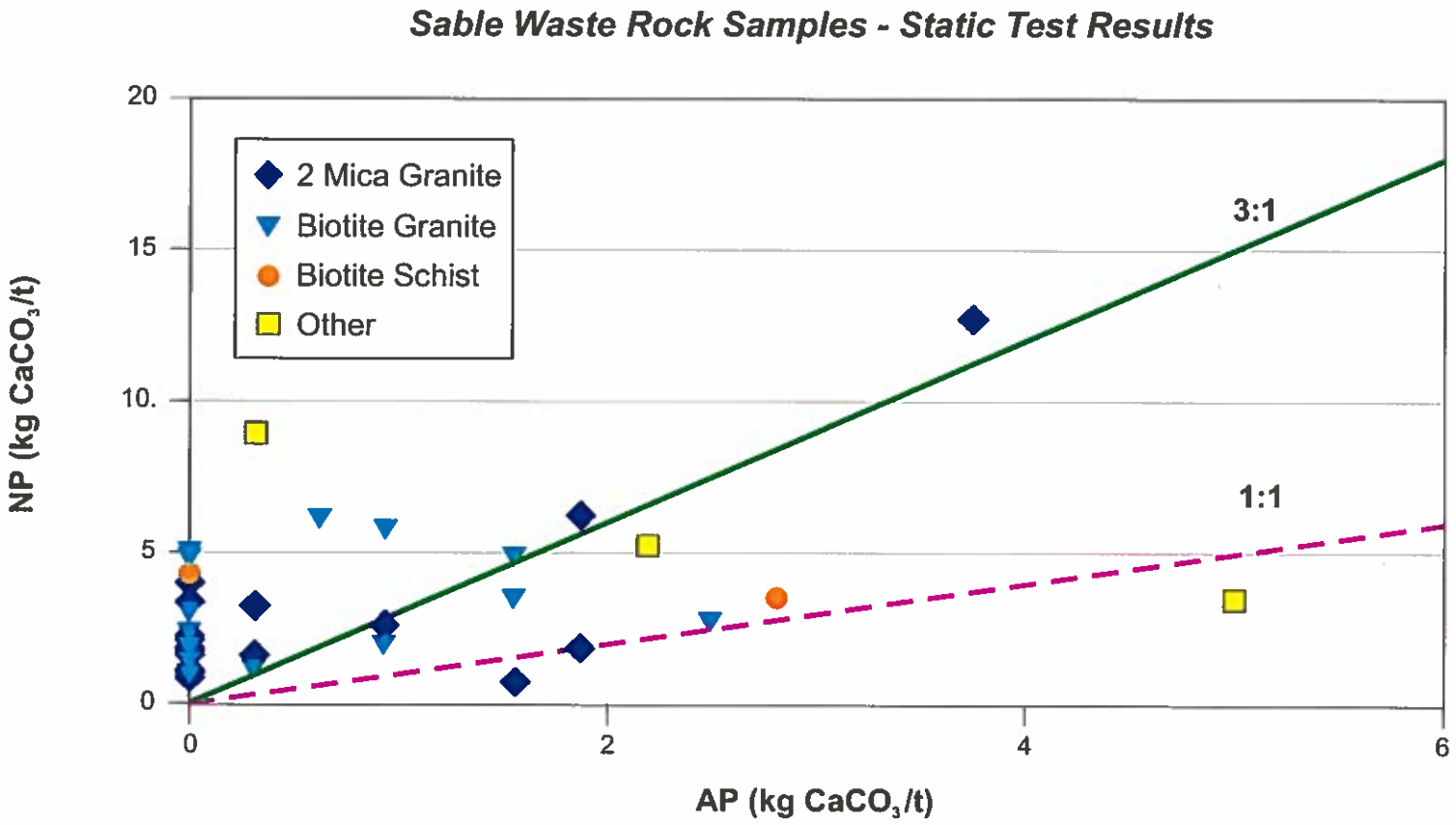


FIGURE 2.2-6

Acid Base Accounting Data for Sable

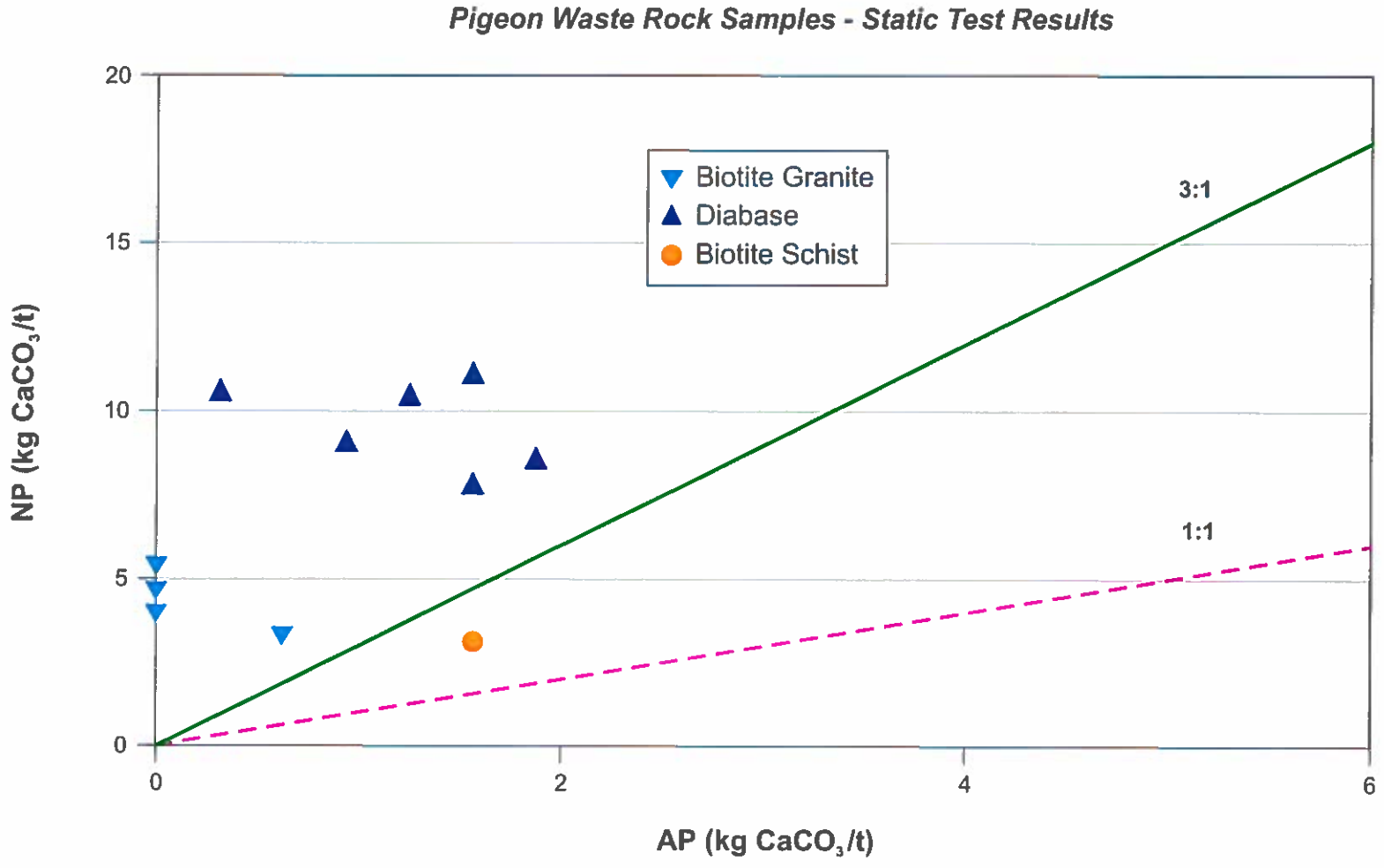


FIGURE 2.2-7

Acid Base Accounting Data for Pigeon

sulphide sulphur and very low alkalinity. The diabase samples contain up to 0.06% sulphide sulphur and very low alkalinity at about 10 kg $CaCO_3$ equivalent/t. The diabase and biotite schist samples tend to show the highest metal content (*e.g.*, copper, zinc, lead). No kinetic testing to evaluate water quality has been completed to date.

Drilling and mine planning information to date indicates that the 51.2 million tonnes of waste rock at Pigeon comprise in the order of 50% granite and 50% combined biotite schist and diabase. However, the drilling has not attempted to represent the spatial and geochemical distribution of waste rock; this would be assessed as part of further drilling and operational waste management.

Based on these sample test results, net acid generation is not expected from the Pigeon waste rock. Kinetic testing would be required to determine if there is any metal leaching potential. In the absence of net acid generation, metal leaching is not expected to represent a major water quality issue.

2.2.3.3.1.3 Beartooth

The results of static testing on the Beartooth waste rock samples are summarized in Appendix C (Tables 5 and 6) and presented graphically in Figure 2.2-8.

Acid base account testing on the biotite granite, diabase and granite materials shows that the samples are generally inert to slightly net acid consuming. Carbonate alkalinity is very low, with NP values at less than 10 kg $CaCO_3$ equivalent/t. Sulphide content is also low, with the highest value of 0.05% sulphide sulphur measured in a biotite granite sample. All samples show alkaline pH values, and there is no evidence of oxidation or net acid generation.

Mine planning to date indicates that a total of 16.8 million tonnes of waste will be excavated at Beartooth. Of this amount, 98.3% is granite, up to 1.3% is diabase and the remainder is biotite schist. Based on the sample test results, net acid generation is not expected from the Beartooth waste rock. Kinetic testing would be required to determine if there is any metal leaching potential. In the absence of net acid generation, metal leaching is not expected to represent a water quality issue.

2.2.3.3.1.4 Further Work

Testwork in support of waste rock management planning to date indicate minimal potential for net acid generation and "acid rock drainage". The potential for metal leaching has not been addressed but will be included with the next phase of pit design. Provisions have been made in the waste and water management planning for elimination or control of drainage from the waste rock piles for each pit. This is discussed in Section 2.2.3.3.3.

The following additional waste rock characterization work is planned for each of the three pipes:

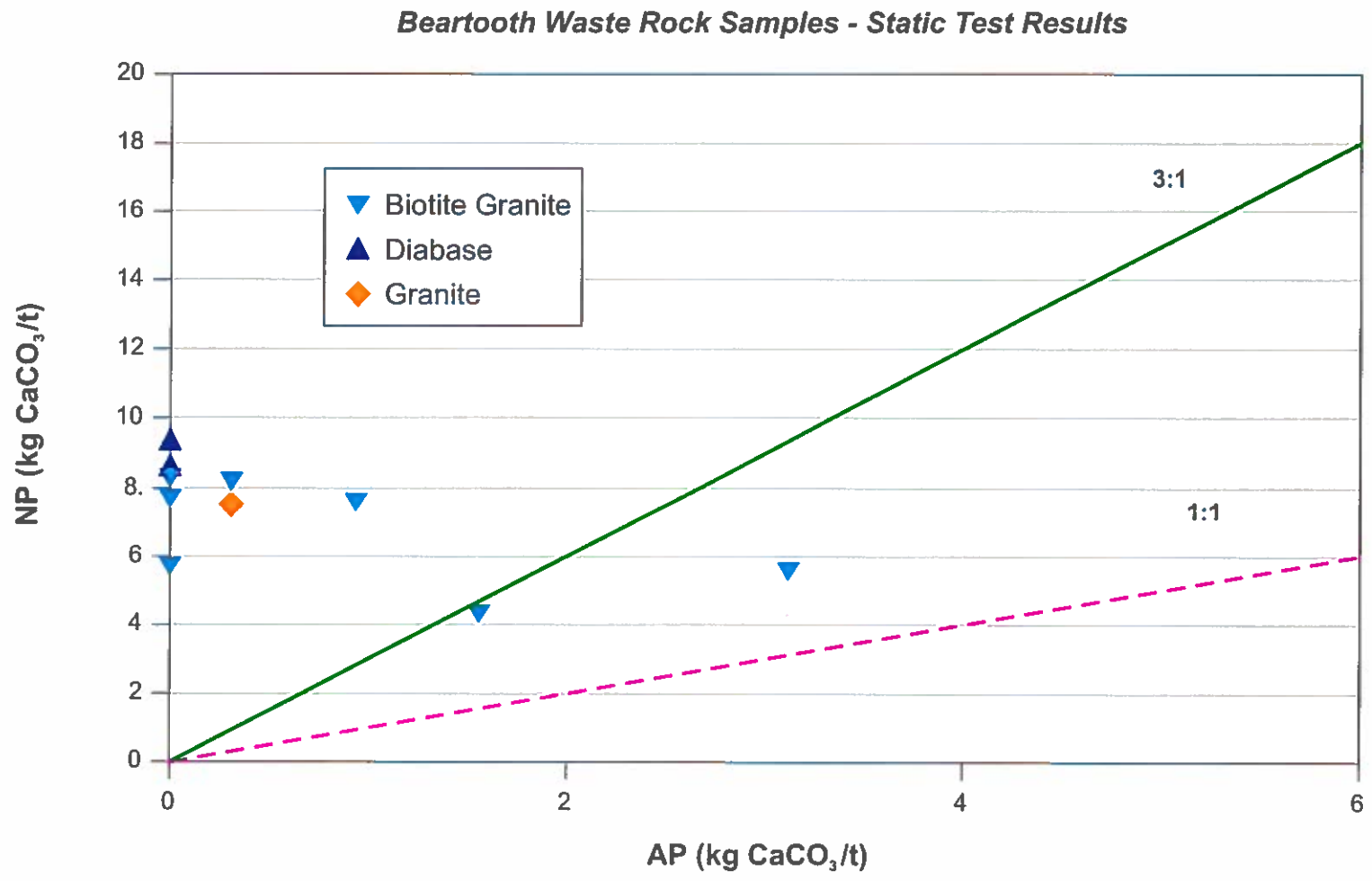


FIGURE 2.2-8

Acid Base Accounting Data for Beartooth

- kinetic testing to address metal leaching potential;
- quantification of the amount, location and scheduling of the different types of waste rock from the pit, and potential for segregation of this material during mining;
- potential and methods for segregation of this material if so indicated by kinetic testing results. Alternatively, if there is no significant metal leaching, this material can possibly be disposed of with other waste rock types that may contain sufficient alkalinity to buffer the acidity;
- definition of the sampling program during mining to identify potentially "reactive" (*i.e.*, generate acidity and/or leach metals) rock and development of criteria for segregation;
- provision for drainage water monitoring and collection, if required.

These evaluations will be used to refine the waste rock and water management programs for the three proposed pits.

2.2.3.3.2 Kimberlite Samples

The kimberlite samples from Sable, Pigeon and Beartooth are all consistently net acid consuming with high alkalinity values. Results from the ABA testing are presented in Tables 7, 8 and 9 in Appendix C. Sulphur values range from 0.02% to 0.42% of S as sulphide. Results of the ICP analysis for Sable, Pigeon and Beartooth samples are presented in Tables 10, 11 and 12 in Appendix C, respectively.

2.2.3.3.3 Waste Rock Placement

The volumes of waste rock to be excavated from the proposed pits are as follows:

- Sable 120.8 million tonnes
- Pigeon 51.2 million tonnes
- Beartooth 16.8 million tonnes

The geochemistry of the waste rock and its potential to generate acidic runoff has been described in Section 2.2.3.3.1. The data obtained from testing to date has identified no potential for acid generation that cannot be readily managed by proper waste rock pile construction practices. Those practices include using the natural cold climate and natural permafrost formation to advantage in order to minimize the risk of undesirable runoff. Sub-aqueous disposal is not being considered as a waste rock disposal option.

The proposed sites of the waste rock storage piles are shown on the general location plan in Figure 2.2-2. Disposal will be as follows:

- The Sable waste rock storage pile will be adjacent to the Sable Pit (Figure 2.2-3). Runoff from the pile could possibly flow into the Sable Pit, Two Rock Sediment Pond or Ulu and Horseshoe lakes.

- The Pigeon waste rock storage pile will be south of the Pigeon Pit (Figure 2.2-4). Drainage from this storage pile could only flow into the Long Lake Containment Facility.
- Waste rock from the Beartooth Pit will be incorporated into the Panda waste rock storage pile (Figure 2.2-5), slightly increasing the overall pile footprint. Most of the runoff from the Panda storage pile flows towards the Long Lake Containment Facility, with lesser amounts towards Panda Pit, Beartooth Pit and Bearclaw Lake.

The waste rock disposal strategy is described in more detail in the Project Description (BHP, 1999c; Revision 3). The principal objectives of the strategy are to achieve long-term stockpile stability and to minimize or eliminate runoff.

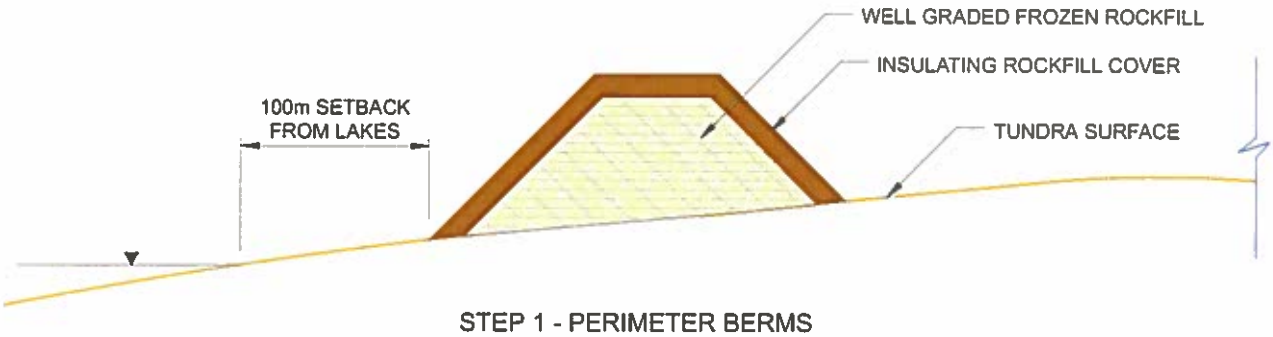
Data obtained to date from monitoring at the toe of the existing Panda waste rock storage pile indicate that concentrations of aluminum and ammonia exceeded Water Licence requirements. The excess ammonia is a product of blasting residue that may be liberated by melting snow trapped in the fill during placement. It is believed to present a short-term potential effect on the surrounding watercourses that do not drain to a controlled catchment site, such as the Long Lake Containment Facility.

The following operational procedures have been modified to reduce the potential for elevated ammonia levels:

- an explosives handling procedure to minimize spillage during loading and other blast operations;
- a dewatering plan to limit explosives-water contact, which can result in degradation and dissolution of ammonium nitrate; and
- a plan to direct waste rock from any misfire areas to a part of the waste rock storage pile that does not drain into a freshwater body.

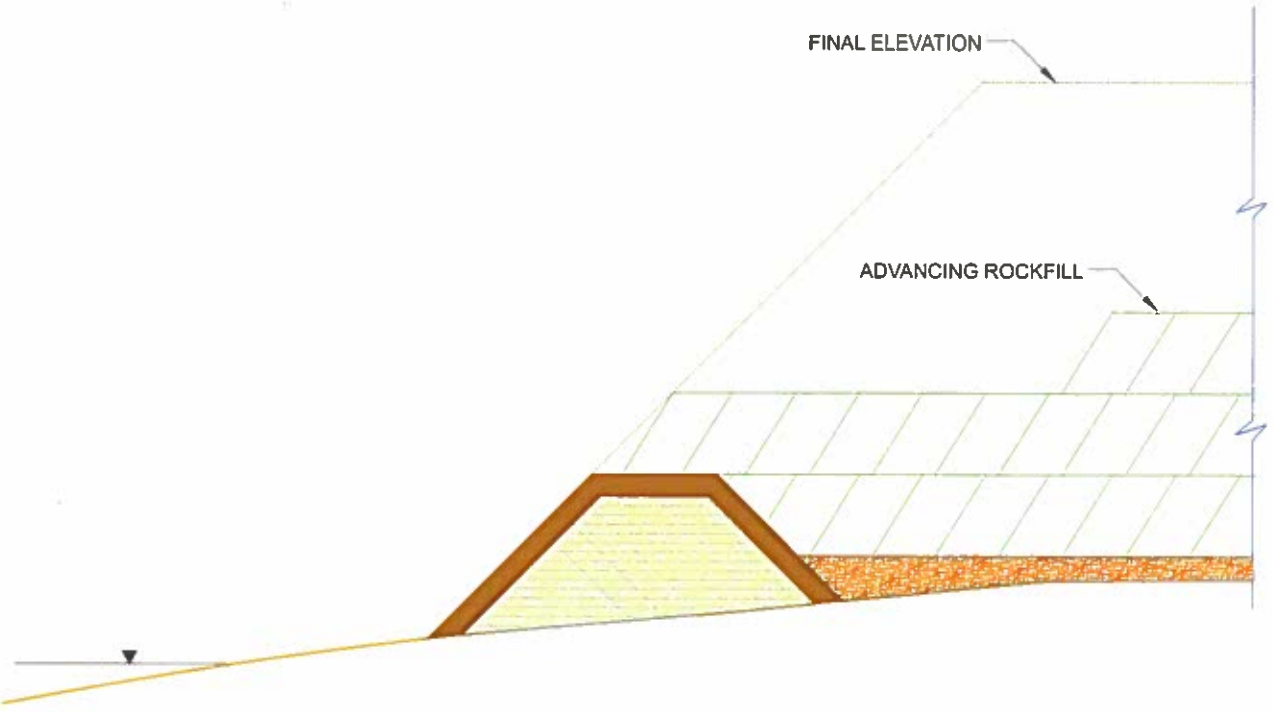
To provide a buffer zone for ammonia concentrations, the rock storage piles will be set back a minimum of 100 m from fresh water bodies. In addition, where a pile is near a freshwater body, it will be constructed in a manner that encourages early permafrost formation in the outer fringes of the pile. Frozen rockfill will be placed within the downslope toe so that water that infiltrates the pile from above will be trapped and frozen into the voids of the fill. The area behind and above the frozen toe will therefore act as a reservoir, progressively filling with ice.

The sequence of waste rock placement is presented in Figure 2.2-9. A berm of well-graded rockfill will initially be placed around the downslope perimeter of the waste rock pile. It will be constructed similar to a road, with thin lifts spread and compacted over the tundra surface during winter. The perimeter berm will be placed one year ahead of substantial rock placement upslope to allow time for thermal equilibration to normal permafrost ground temperatures of -5°C. A coarse rockfill blanket will be placed on the tundra upslope of the berms to provide a reservoir within the void spaces to trap initial precipitation and runoff without creating an open pond. The final rock placement will advance toward and over the perimeter toe berm.



STEP 1 - PERIMETER BERMS

STEP 2 - ROCKFILL BLANKET



STEP 3 - WASTE ROCK PLACEMENT

Waste Rock Storage Pile Placement Concept

FIGURE 2.2-9

A plan to collect geotechnical data and construct a full-scale test fill at EKATI™ is currently in preparation. The data and observations from that test will allow the proposed fill placement methods to be refined to ensure freezing within the voids of the rockfill.

2.2.4 Water Balance

A schematic of the water balance for the Long Lake Containment Facility is shown in Figure 2.2-10. The original water balance will not change significantly with the proposed development except that pit water from Pigeon and Beartooth pits will be added and a small amount of processed kimberlite will be directed to the exhausted Beartooth Pit. Water from Sable Pit will not flow into Long Lake and so does not affect the water balance. An estimate of the pit water quantities is presented in Table 2.2-3.

Table 2.2-3
Estimated Annual Water Quantity from Open Pits and Underground Operations

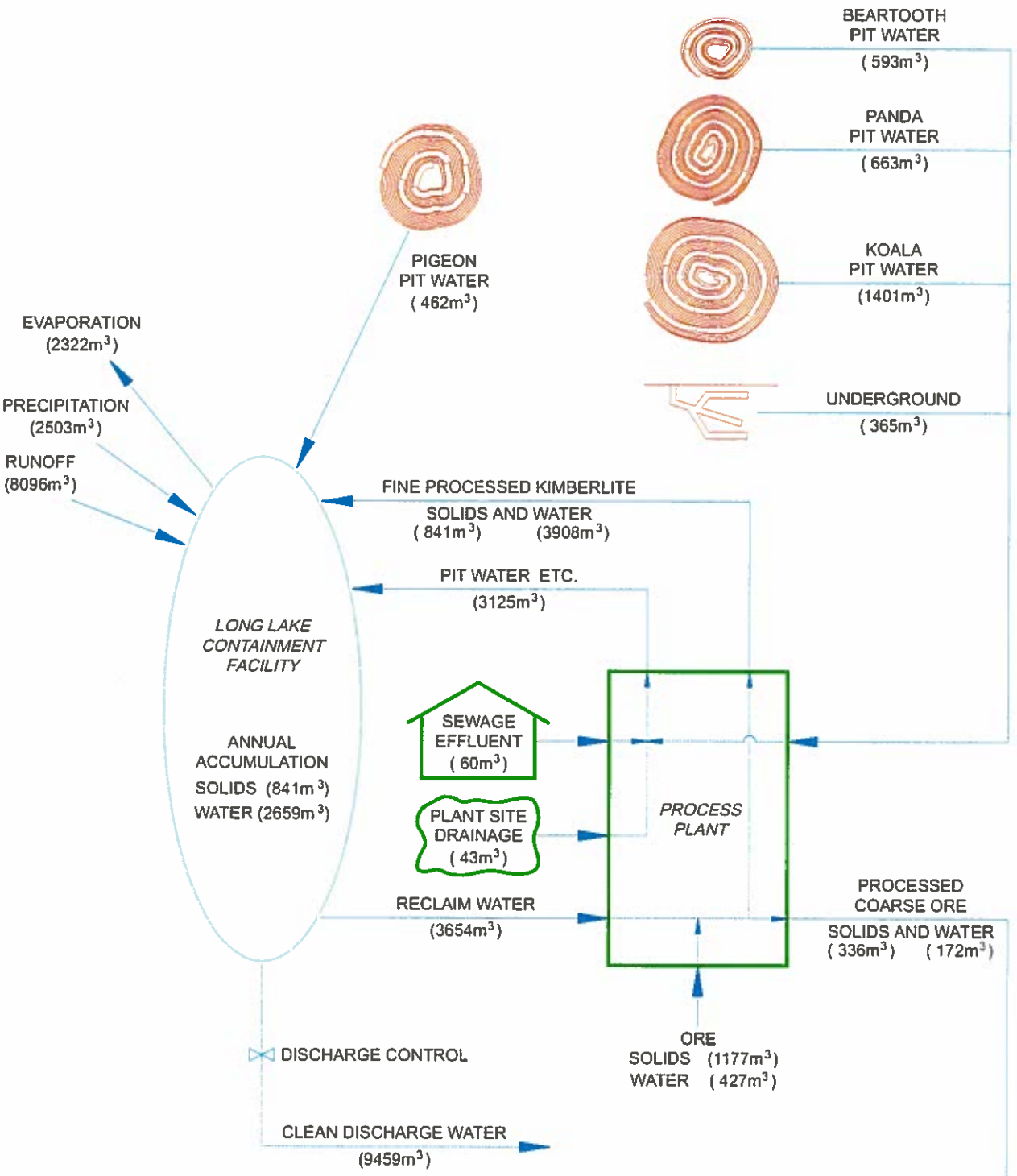
	Groundwater[1] (m^3)	Runoff[2] (m^3)	Direct Precipitation[3] (m^3)	Total Annual (m^3)
Panda	365,000	120,000	178,000	663,000
Koala	365,000	900,000	134,000	1,399,000
Underground	365,000	0	0	365,000
Beartooth	365,000	190,000	37,000	592,000
Pigeon	365,000	54,000	97,000	462,000

Based on:
1. **1,000 m^3/d groundwater (upperbound estimate).**
2. **224 mm/a runoff.**
3. **345 mm/a direct precipitation plus 10% to account for snow over-catch.**

The original water balance was based on assumptions developed from operational data obtained from the pilot process plant (*i.e.*, Koala Camp). With more than one year of operating data now available from the full-scale operation, the water balance has been recalculated to incorporate revised input parameters and the appropriate pit water from the proposed development. The original and revised assumptions for the water balance are presented in Table 2.2-4.

The following assumptions have changed:

- The design parameters for precipitation and runoff have increased by 11% and 24%, respectively, based on analyses of site data obtained to date. This is partially offset by an increase of 28% in annual evaporation. This will increase the amount of water discharged from the Long Lake Containment Facility, but the estimated average discharge volumes are still well within the maximum flow rates specified in the Type A Water Licence.



NOTES:

(1) 9000 TONNE/DAY OPERATION

(2) QUANTITIES VARY YEAR BY YEAR

(3) VALUES 1000m^3

Typical Annual Water Balance
Long Lake Containment Facility

FIGURE 2.2-10

- The amount of processed coarse ore directed to the dry stockpile area has decreased from 40% to 29% of total processed ore. More solids will therefore be directed to the Long Lake Containment Facility.
- The active life of the Long Lake Containment Facility has been reduced by three years, providing an additional three years of excess or contingency capacity.
- Processed kimberlite will be deposited into the abandoned Beartooth Pit during the summer of 2008 and 2009.

Table 2.2-4
Processed Kimberlite Water Balance Design Basis

	Original Design Criteria (EBA, 1998)	Revised Criteria
Mine Life	Mining to year 2022	Mining to year 2014
Long Lake Containment Facility Life	Deposition until 2017	Deposition until 2014
Precipitation	Normal – 310 mm	Normal – 345 mm
Runoff	Normal – 180 mm	Normal – 224 mm
Evaporation	Average annual – 250 mm	Average annual – 320 mm
Process Plant Production	9,000 t/d until 2007 18,000 t/d until 2022	9,000 t/d until 2007 18,000 t/d until 2014
Processed Coarse Ore (0.5 to 8 mm) Trucked to Dry Stockpile Area	40% of total processed ore	29% of total processed ore
Average Solids Content of Processed Kimberlite slurry	40%	37.5%
Average Moisture Content of Coarse Ore	13%	18.3%
Average Moisture Content of Ore	17.6%	13%
Production up to and including November 1999	3.6 million tonnes	3.2 million tonnes
Specific Gravity of Ore and Processed Kimberlite	2.79	2.79
Void Ratio of Partially Consolidated Processed Kimberlite	2.2	2.2
Sewage Effluent Pumped into Long Lake Containment Facility	0 m^3/a	60,000 m^3/a

The analysis assumes that some seepage will occur through the intermediate dykes within the Long Lake Containment Facility. Extreme cases of no leakage and 100% leakage through the dykes were examined during the facility design (EBA, 1998). The seepage flow has been estimated by assuming a differential head across the intermediate dykes of 4 m, or the maximum water above the solids level of 4 m. This assumption is based on the maximum recorded head of approximately 3 m across Dyke B observed during winter 1999.

Typical annual volumes of solids and water entering and exiting the Long Lake Containment Facility are illustrated in Figure 2.2-10. The actual volumes vary slightly year by year depending on which pits are in operation, the open water area within the Long Lake Containment Facility, precipitation and runoff, and the production rate. The typical year shown in Figure 2.2-10 is at maximum pit development when the process plant throughput is 9,000 t/d.

Estimated water and solid levels for a partially consolidated density in the Long Lake Containment Facility are illustrated in Figure 2.2-11. The processed kimberlite is expected to reach a partially consolidated density within one year after placement and 90% consolidated density some time thereafter. Further details on the influence of density is discussed in the "Wastewater and Tailings Management Plan, EKATI™ Diamond Mine" (EBA, 1998).

The analysis indicates that Cells A, B and C are filled within the operational life of the mine and that only a small amount of processed kimberlite will be deposited in Cell D. Approximately 7 million m^3 of solids will be placed in Cell D to an elevation of 435 m at the end of year 2014. The design solids capacity of Cell D is 31 million m^3 at an elevation of 455 m; therefore, Cell D has surplus capacity of 24 million m^3. It would take 4.5 additional years of production at 18,000 t/d to fill Cell D to its design capacity.

It would be possible to eliminate Cell D from the operational plan entirely by depositing more processed kimberlite in the abandoned pits (*i.e.*, Panda Pit). This option would enhance the site reclamation plan and is therefore being examined as more data is collected.

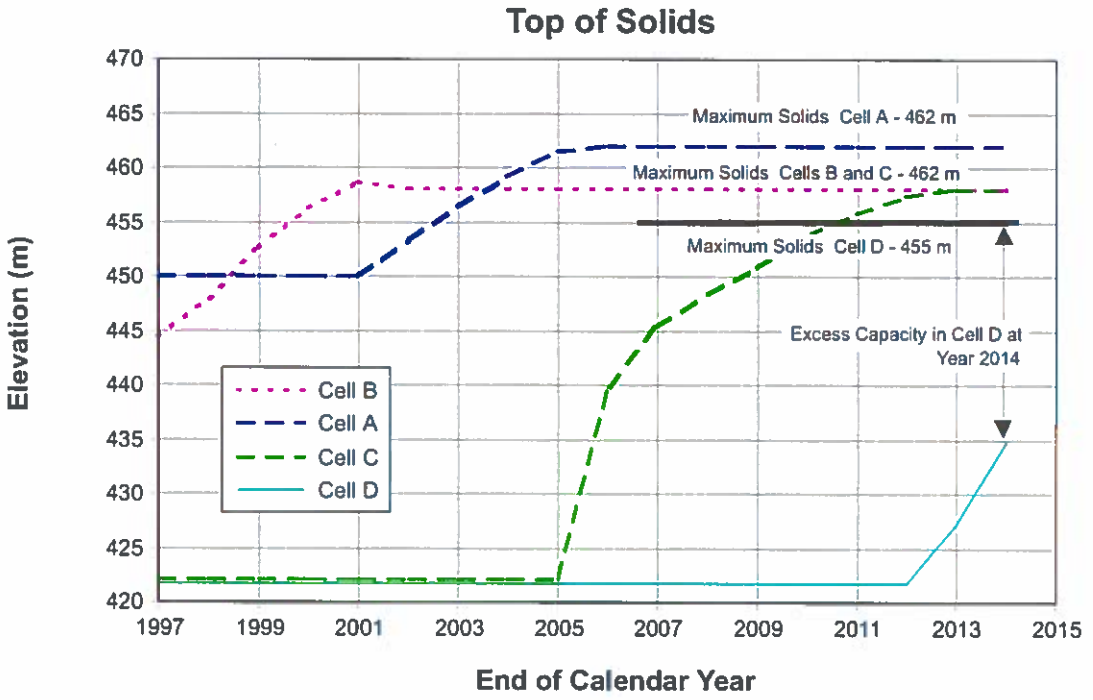
2.2.5 Ursula Esker Granular Quarry

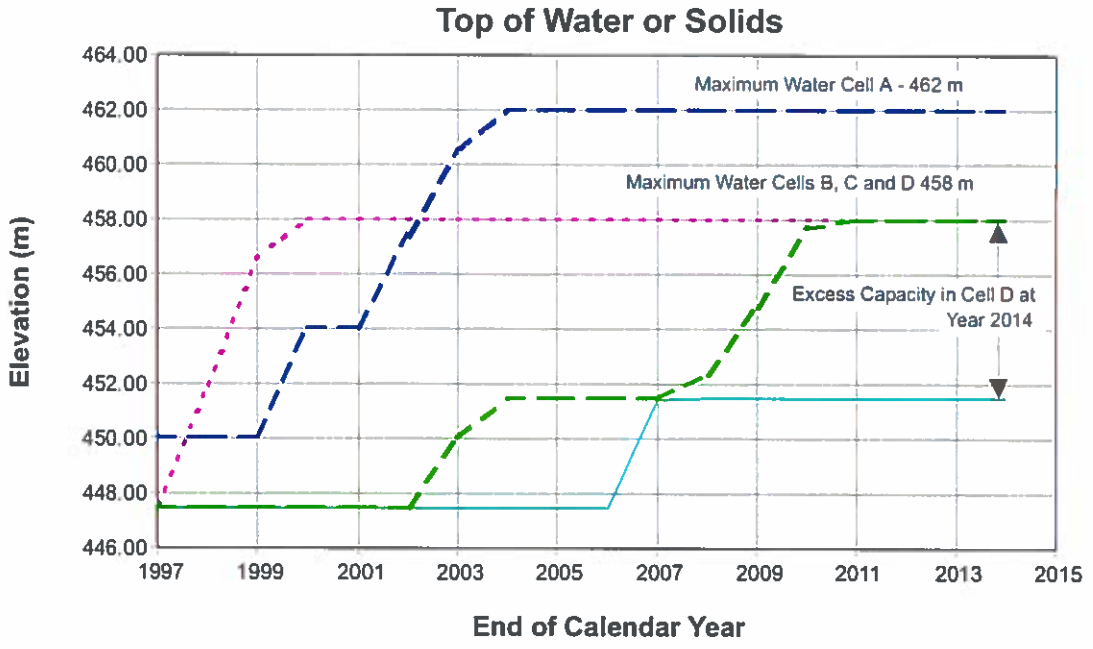
Most of the general construction fill required to support the proposed development of Sable, Pigeon and Beartooth pipes, including road fills and foundation pads, will consist of waste rock from mining operations. Select granular material will be needed for road surfacing and for laydown pads and berms at the Sable and Pigeon pits. The total amount of granular material required during the development, mining and reclamation phases is estimated to be 200,000 m^3.

Substantial volumes of natural granular construction material occur as eskers near the proposed development areas. Eskers are a type of glaciofluvial sediment deposited englacially or supraglacially in long, sinuous ridges of sand and gravel. The scarcity of other granular materials in the proposed development areas, high cost of crushing and increased area of disturbance associated with bedrock quarries make eskers an important source of construction materials. It is planned to use a small part of the Ursula Esker as a borrow source for the new development.

Potential impacts of esker development are of public, environmental and cultural concern. While eskers *per se* are not a Valued Ecosystem Component (VEC), they are often used for carnivore denning, bird nesting and as travel corridors by caribou and other wildlife. As such, eskers are associated with the wildlife VEC. In addition, some eskers have been found to have archaeological significance as Heritage Sites.

Archaeological, wildlife and geotechnical assessments will be undertaken to define a specific, narrow area within the discontinuous Ursula Esker complex suitable for development use. The initial assessments will determine whether particular areas are of archaeological and/or wildlife significance, and an airphoto analysis will be completed to





Estimated Water and Solids Elevations in Long Lake Containment Facility FIGURE 2.2-11

BHP Ekati diamond mine

assess potential borrow locations. This information will then be used to select the most likely borrow areas during a site reconnaissance visit. A geotechnical program will ultimately be conducted to optimize the site selected and develop a quarry management plan.

The quarry management plan will be included in the pending quarry lease application. The plan will be developed using the Environmental Guidelines for Pits and Quarries (INAC, 1994) as the guide for design and operation of the quarry. The defined area will be excavated to its maximum to minimize the extent of surface disturbance and overall impact on the esker.

2.2.6 Development Sequence

The development schedule and periods of mining-related activities at the existing, currently permitted and proposed pits are presented in Figure 2.2-12. The overall schedule for the Sable, Pigeon and Beartooth developments is shown in Figure 2.2-13. The schedules indicate when the pipes will be developed as well as the required pre-production activities. Details on traffic volumes and site access roads are presented in Section 2.2.2.4.

At this time, no further exploration activities are planned for the Sable, Pigeon and Beartooth pipes. However, the proposed infrastructure, when established, could be utilized to support future exploration in the area.

The role of the Sable, Pigeon and Beartooth pipes in the overall development sequence for EKATI™ has been formulated to maintain plant production and obtain an optimum balance between engineering and processing parameters, safety, economics, grade, diamond value per carat and the overall marketing plan. Lower value pipes must be combined with higher value pipes to ensure an adequate return on investment by providing a product that can be marketed according to EKATI™'s business plan. In addition, the ores from some pipes present processing complexities and can only be fed to the plant at a certain rate regardless of grade and value. Ore movement and pipe sequencing are shown in Figure 2.2-14, followed by the schedule for annual waste rock movement in Figure 2.2-15.

The project schedules illustrate that pre-stripping and site infrastructure construction requirements vary from one to four years to bring each pipe into production. Changing their development sequence or failing to bring them into production on schedule would affect the current optimized mine plan for EKATI™. The mine plan provides for consistent product output in terms of diamond quality and quantity to meet the marketing plan. Not mining the Sable, Pigeon and Beartooth pipes at all would reduce the mine life at EKATI™ by three years.

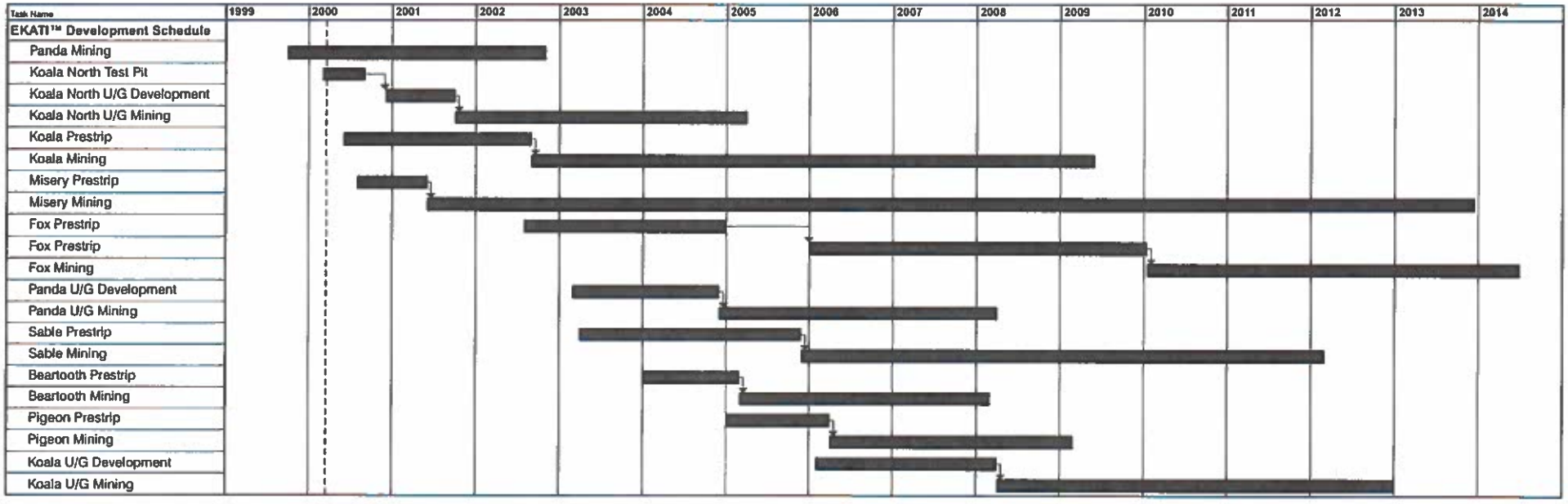
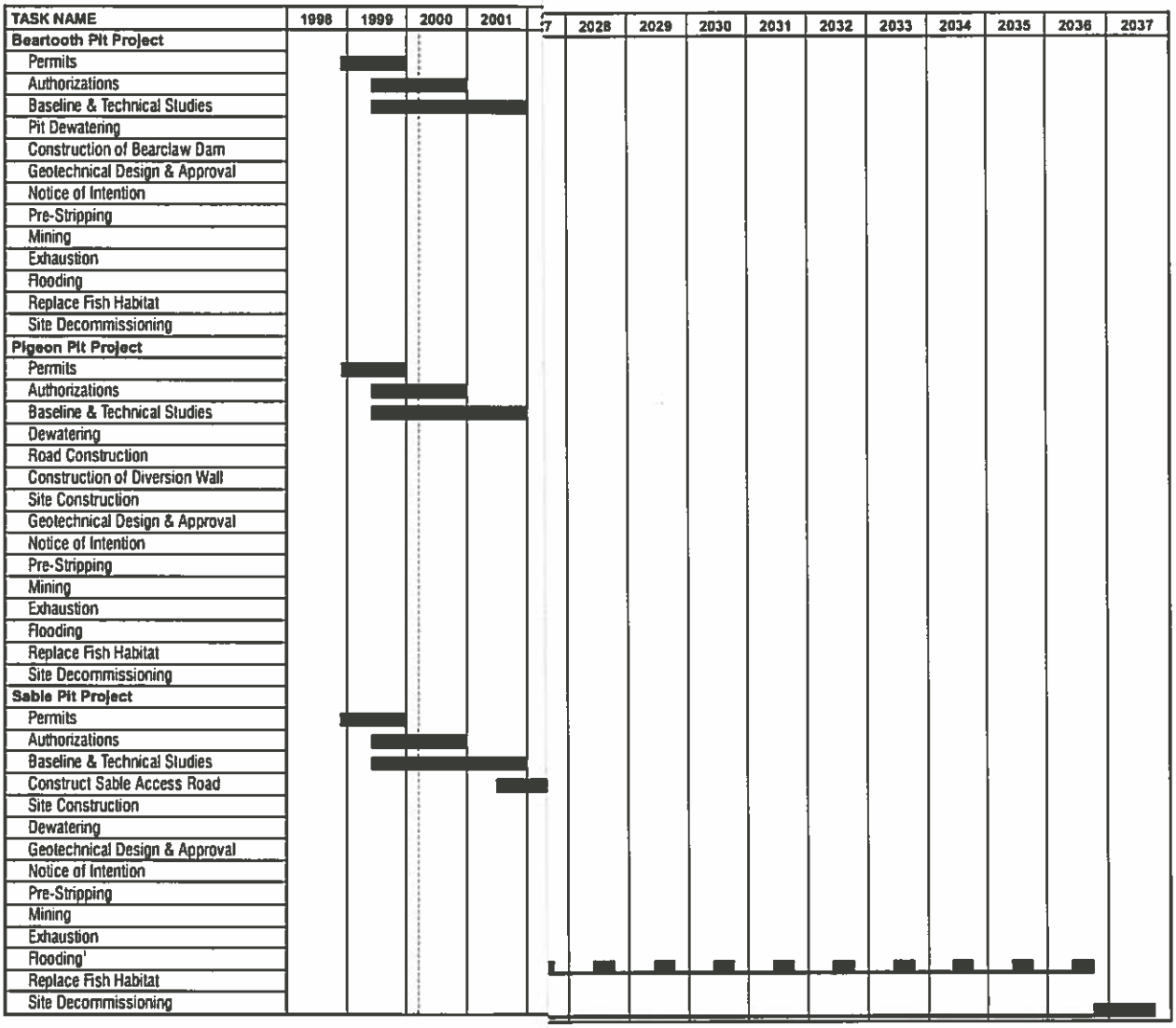


FIGURE 2.2-12

Mining Schedule

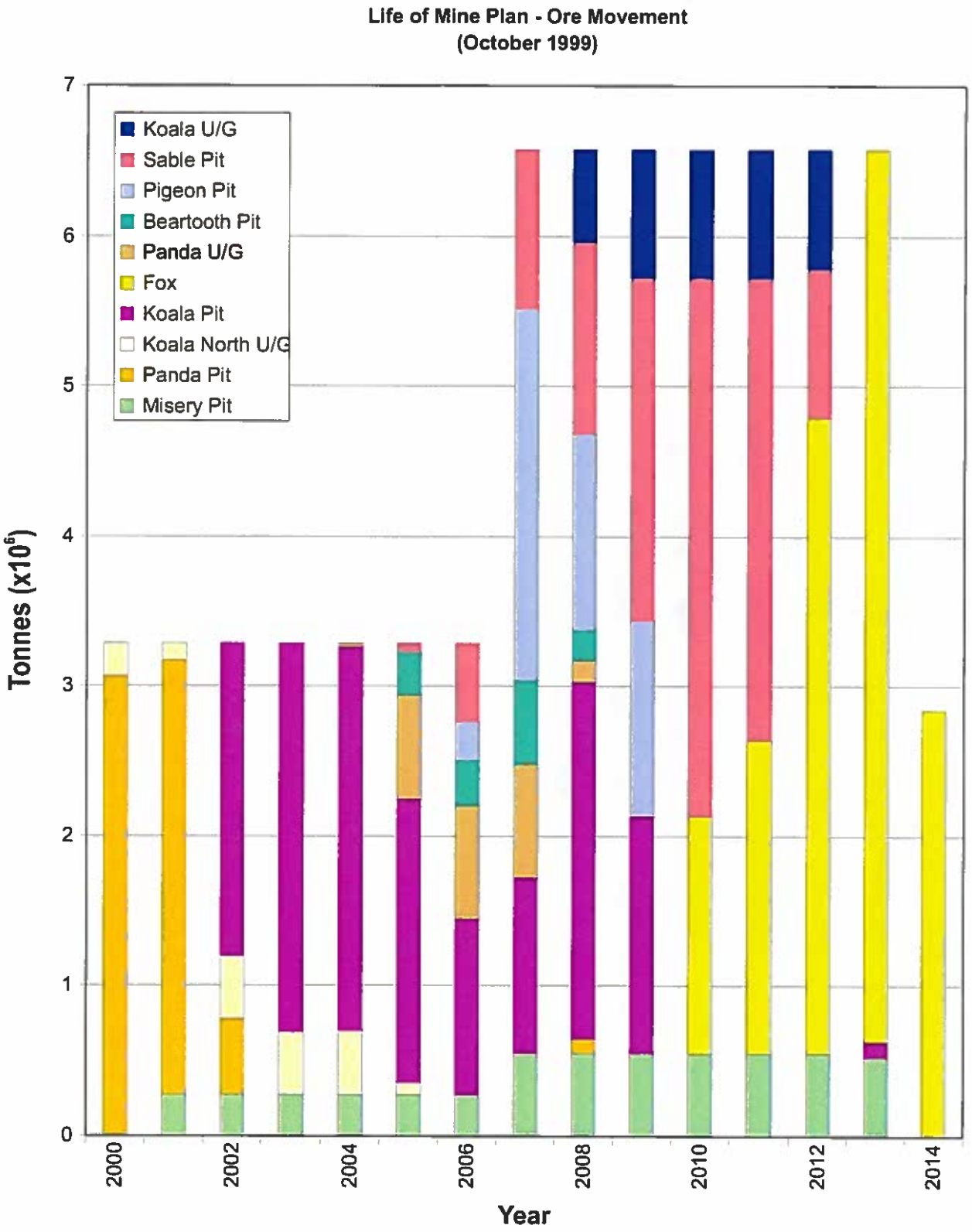


1: Sable Pit flooding has been estimated to take from
The upper bound estimate of 25 years has been ac

FIGURE 2.2-13

BHP

Ekati diamond mine



Note: Ore tonnage presented includes proven, probable and possible categories.

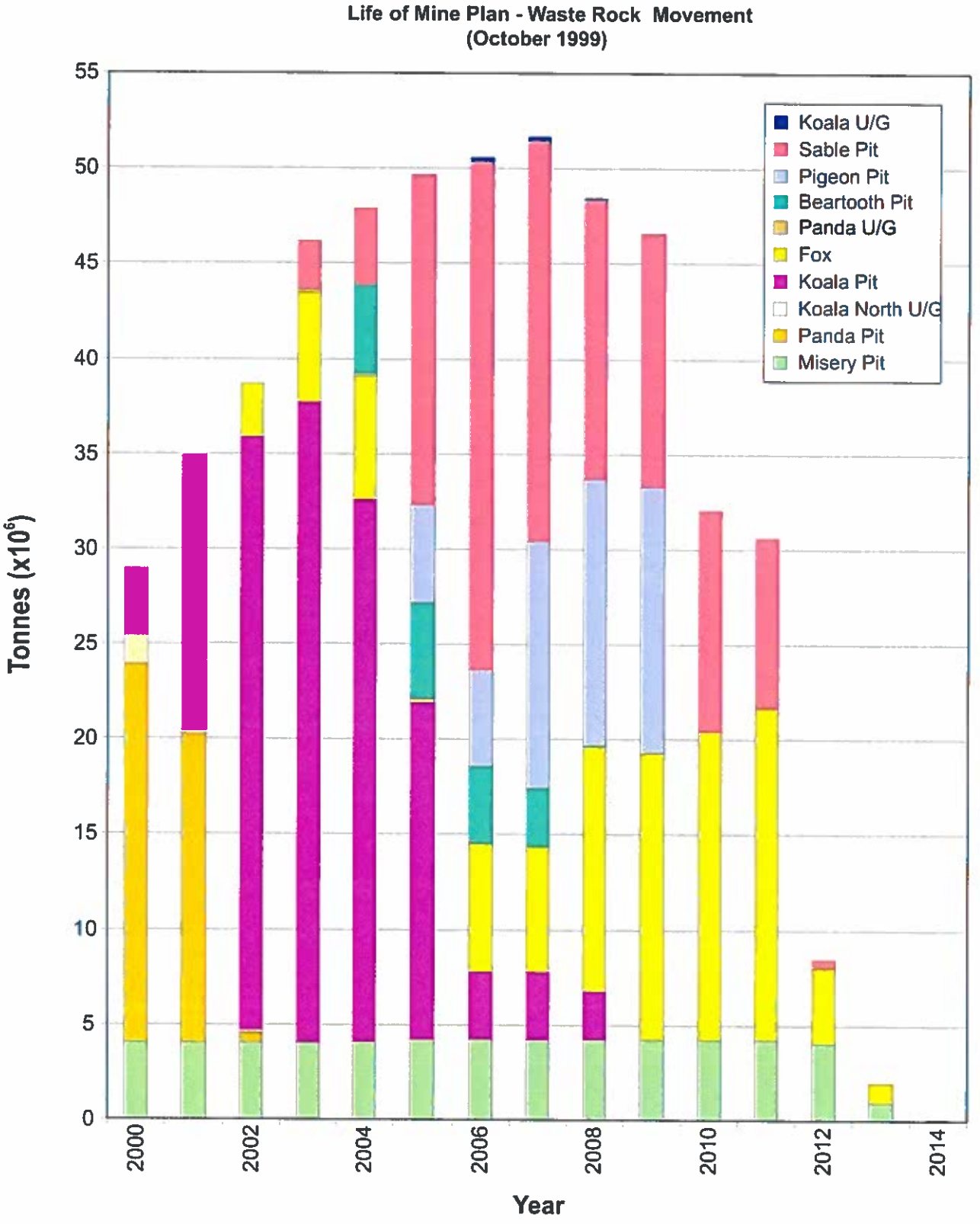
FIGURE 2.2-14

BHP

Annual Ore Tonnage

Ekati diamond mine

Source: BHP Diamonds Inc., 1999



Note: Waste rock tonnage generated during underground mining operations are not apparent as they are small volumes in relation to the scale.

FIGURE 2.2-15

BHP

Annual Waste Rock Tonnage

Ekati diamond mine

Source: BHP Diamonds Inc., 1999

2.3 Alternatives and Environmental Optimization

In the MVEIRB Terms of Reference for this Environmental Assessment Report, the Board requested that BHP examine possible alternatives for the proposed development implementation plan. BHP has identified no major alternatives to existing methods or technology with significant potential for operational or environmental improvement since the EIS (BHP, 1995) was prepared for the EKATI™ Diamond Mine. The EIS presented a comprehensive assessment of development options in the areas of mining and processing methods, waste management and disposal, and infrastructure requirements. This provided the rationale for the decisions made with regard to mine planning and construction. The current Sable, Pigeon and Beartooth development presents no new challenges that cannot be dealt with within the framework of the existing EKATI™ operation.

In accordance with the MVEIRB request and to ensure optimization of the mine plan, previously identified alternatives in three major areas are reviewed in this section: the disposal methodology and locations for processed kimberlite; alternative mining methods; and backfilling of pits. A fourth issue that pertains specifically to the new Sable Pit – the need for an all-weather access road – is also discussed in terms of logistics, safety and cost.

2.3.1 Disposal of Processed Kimberlite

Alternatives for the storage of processed kimberlite were documented in detail in the EIS (BHP, 1995). Issues such as alternative sites, management methods and construction methods were addressed at that time.

The options for alternative sites are very limited. The nature of the topography and of the foundation conditions is similar throughout the region, and no topographic features are more favourable than the site now in use. Given the large volume of processed kimberlite and the low topography throughout the area, any attempt to maximize the amount of land versus waterbodies used for processed kimberlite deposition would substantially increase the area affected by this waste material. An on-land site would also involve the construction of extensive and costly retention structures.

Three alternatives to the sub-aerial slurry deposition system adopted were identified in the EIS:

- dewatered "dry" tailings;
- paste tailings; and
- sub-aqueous deposition.

These were all rejected in the EIS analysis for various physical, technical, economic, environmental or aesthetic reasons. BHP's assessment for the purpose of this EAR remains the same.

BHP currently holds the necessary permits with regard to construction and operation of the Long Lake Containment Facility currently in use. Since potential effects on water quality is one of the main concerns relating to processed kimberlite, it is desirable that as much processed kimberlite as possible be deposited within the same watershed.

Kimberlite ore from the three new pipes will be processed and disposed by utilizing existing facilities, equipment and technology. The revised water balance analysis for the Long Lake Containment Facility is presented in Section 2.2.4.

BHP does intend to direct a quantity of processed kimberlite to Beartooth Pit when the ore is exhausted. In addition, BHP intends to investigate further the possibility of directing processed kimberlite to other exhausted open pits as they become available.

2.3.2 Sable Access Road

The only potential alternative to the proposed all-weather road to Sable Pit is a winter road, sometimes referred to as an "ice road." Use of a winter road would be limited to the period of time when the ice is thick enough to support the loads and the tundra surface is frozen to prevent rutting. A pad of granular material would be required over portage segments to smooth irregularities in the tundra surface and to protect the underlying permafrost from degradation. Once the winter road is in use, truck movement would be more intense than over an all-weather road in order to optimize the available season.

All-weather roads and winter roads are both technically proven options in this region. However, the economics of a winter road operation would have a significant impact on the mine operation, without positive environmental benefits. A substantially larger fleet of haul units would be needed to transport ore from Sable to the Process Plant to compensate for the shorter season and the reduced travel speeds. This, in turn, would increase infrastructure requirements to manage both preventative maintenance and unscheduled repairs. A fleet of winter road construction and maintenance equipment would also be required to ensure that the winter road operation is not restricted in any manner.

The relative costs, benefits and unknowns associated with the two road types are summarized below:

All-Weather Road

- Lowest operating costs;
- Lower working capital requirements;
- Year-round operation, therefore steady employment; and
- Lowest operational risk.

Winter Road

- Highest operating costs;
- Captive equipment that would be idle most of the year;
- High demand for operators and maintenance personnel (seasonal employment) during a short period; and
- Weather risks, with associated delays and costs.

Other operational factors make a winter road to Sable untenable as well. The design of a winter road must meet the load criteria for ice crossings, and the design conditions for the Sable Road – heavy loads, high traffic frequency and long use life (seven winter seasons) – are unprecedented. Transporting kimberlite over a winter road also raises serious safety concerns. A winter road could not support the ore truck currently in service (100 tonne payload capacity vehicle). Using a smaller truck will substantially increase the traffic fleet and associated traffic volumes, which increases the probability of a malfunction or accident. Potential spills of kimberlite ore, diesel fuel or ammonium nitrate due to trucking mishaps are even greater safety and environmental risks. In the worst case, a truck could fall through the ice. In addition, exhaust emissions will be intensified during the winter road operating period.

If ore transport is done during the winter only, a large pad will be required for the storage of mined ore during the ice-free months. This will increase the size of the proposed development footprint in the Sable Pipe area. As evidenced by operational experience during the winter of 1998/1999, the kimberlite ore storage pile will undoubtedly freeze, requiring secondary blasting and increasing operating costs.

With winter access only and no fixed link to the existing EKATI™ site, a permanent camp and ancillary facility to house employees, along with camp catering personnel, will be required to support a year-round mining operation. This will increase overall terrain disturbance and impose additional environmental concerns. The impact on pit economics would, of course, be negative. Safety would also be an issue because the employees would be isolated from the existing mine infrastructure, especially medical facilities.

Mining only within the winter window is not a viable option because of the material volume requirements.

2.3.3 Mining Method

Multiple, isolated and relatively small orebodies (kimberlite pipes) must be developed and mined simultaneously to maintain stable feed to the Process Plant. Selection of the mining method best suited to each kimberlite pipe is dependent on several factors:

- location of the deposit (kimberlite pipe) with respect to major surficial features such as lakes, eskers, *etc.*;

- location of the deposit with respect to other developed pipes and existing EKATI™ infrastructure;
- geometry and size of the deposit;
- geotechnical properties of the kimberlite and the host rock;
- physical properties of the kimberlite and its associated processing characteristics;
- kimberlite pipe diamond grade and grade distribution within the pipe;
- carat values or net value of the resource ($/tonne);
- overall marketing and business plan for EKATI™; and
- similarity to existing developed deposits at EKATI™.

In considering alternative mine designs for the Sable, Pigeon and Beartooth pipes, BHP utilized past studies and experience to essentially arrive at two alternatives, open pit and underground mining. It is important to note that all kimberlite pipes in production around the world started with open pits, with only a few proving viable as underground mines later in their development. The characteristics of open pit and underground mining of kimberlite are detailed in Volume I of the EIS (BHP, 1995).

Open pit mining would be similar to the existing Panda Pit operation. For Sable and Beartooth, the fish population would be harvested and the overlying lakes dewatered. Lake bottom sediments and overburden would then be removed to permit pit development to proceed with conventional open pit drill, blast and excavation techniques. The Pigeon Pipe is overlain with overburden, and a small pond. Lake dewatering is a minor component of the development. Once overburden is removed, pit development and production would follow.

Underground mining would be via the sub-level caving method. Conventional underground development techniques would be used to excavate the required sub-levels and underground infrastructure. Caving would be induced with conventional drill-and-blast methods.

Non-caving underground mining methods are not economically viable because of lower production and extraction ratios, higher unit costs, higher capital and infrastructure costs, and the difficulty of supporting weaker rock masses such as kimberlite. Underground mining with non-caving methods would require a substantial amount of kimberlite to be left in place as a crown pillar. The crown pillar, or approximately the top third and largest portion of the pipe, would be sterilized or left in place and would render the Sable, Pigeon and Beartooth pipes uneconomic. All underground mining in kimberlite to date has been in South Africa using caving methods exclusively, varying from block caving and sub-level caving through to "glory holes" and a form of stope shrinkage unique to diamond mines.

The environmental effects of both open pit and underground mining are similar. Both require the same fish harvesting, lake dewatering and overburden removal. Underground

mining would produce a smaller waste dump and overall surface depression, but the post-closure lake would be smaller than in the case of open pit mining.

Open pit mining is the best alternative for the Sable, Pigeon and Beartooth pipes for the following reasons:

- Open pit mining has been proven technically in operational experience on the Panda Pipe. The reduced technical risk minimizes risk for all stakeholders.
- The method provides better conditions for employee safety.
- Higher production rates are possible with less risk of production interruptions.
- Process Plant production requirements can only be met by open pit mining.
- Less dilution is present, which allows the recovery of lower grade ore than would be possible with underground mining.
- Open pit mining affords better employment opportunities for less skilled workers.
- Mining costs per tonne of ore are lower, which make the pipes economically feasible.
- Existing operational equipment, personnel and infrastructure are better utilized.

2.3.4 Backfilling of Pits

The alternative of backfilling pits with various materials, such as waste rock, processed coarse ore and overburden materials, is discussed in Volume I of the EIS.

The pit mining sequence and production schedule for EKATI™ is shown in Figure 2.2-14. The pit mining sequence defines the rate and source of waste rock, known as the waste production schedule. The pit locations and waste production schedules define where the waste rock can be stored and the ultimate volume required for storage area. Thus, once an open pit has been exhausted, it may present a suitable place to dispose of various types of waste materials. For the exhausted pit to be considered suitable for waste rock disposal, the following criteria must be met:

- The active mining pit must be located relatively near the exhausted pit to provide for an economical waste haul.
- The exhausted pit must also be exhausted of underground reserves. Backfilling open pits while underground mining is ongoing poses significant safety risks to employees.

Considering the integration of the Sable, Pigeon and Beartooth pipes into the EKATI™ mine plan:

- The Sable Pit will not be close enough to any exhausted pits for any economic backfilling because the waste hauls will be prohibitively long.
- Although Beartooth Pit will be located near the Panda and Koala pits, these three pits will be mined and exhausted around the same time. Beartooth is scheduled to receive processed kimberlite during the summer of years 2008 and 2009.

- As with Sable Pit, Pigeon Pit is not close enough to any other pits for backfilling to be an economic option. Upon completion of Pigeon Pit, the active open pits will include the Fox, Misery and Sable.

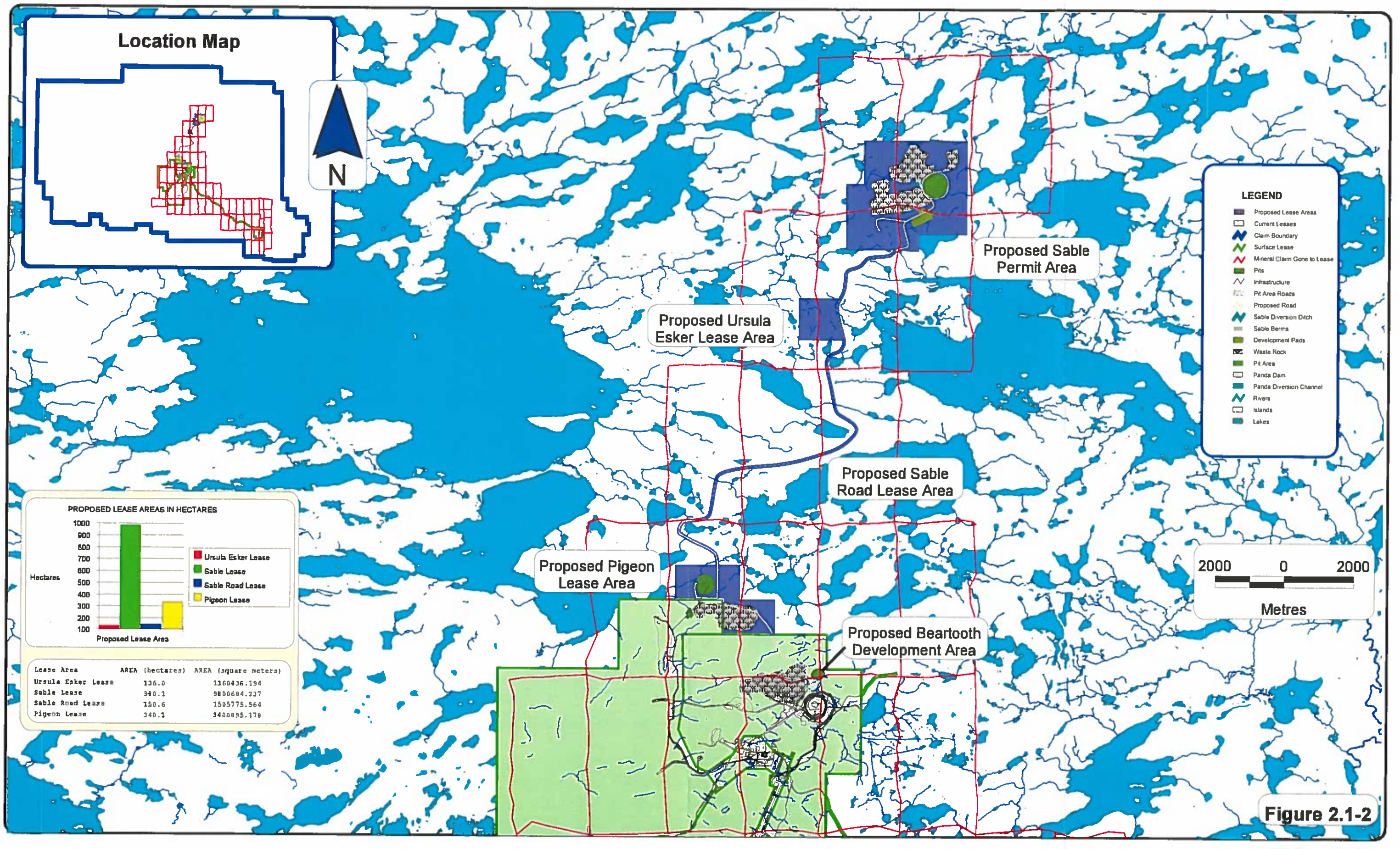
Although backfilling abandoned pits with waste rock provides an opportunity to reduce effects on the environment, this process is not economically feasible with regard to Sable and Pigeon. As discussed previously, Beartooth Pit is scheduled to receive processed kimberlite in the summers of 2008 and 2009.

2.3.5 Environmental Optimization

The results of the preceding review of development alternatives show no technical, environmental or economic advantage to methods other than those already in use at EKATI™ and as presented in this EAR for the Sable, Pigeon and Beartooth development. No obvious advances in technology or mining methods have become apparent since the EARP hearings in 1995 and 1996 that would justify changes to BHP's resource extraction and business activities. Operational and environmental optimization has been demonstrated throughout the EKATI™ feasibility and EIS stages and again with the Project Description for the current mine plan.

Proven and accepted mining and environmental management methods, similar to those now in place for the Panda Pit operation will be used in the continued development. Open pit mining is more economical than underground mining on a cost per tonne basis and is inherently more secure. Final development costs for the pipes will be determined just prior to initiating the work.

Sound application of BHP's Operating Environmental Management Plan will continue to ensure that the environment of the mine and the regional ecosystems will be protected.



Lease Area	AREA (hectares)	AREA (square meters)
Ursula Esker Lease	136.0	1360436.194
Sable Lease	980.1	9800684.237
Sable Road Lease	150.6	1505775.564
Pigeon Lease	340.1	3400895.178

Figure 2.1-2

BHP

Proposed Lease Areas For Sable, Pigeon and Beartooth Developments

Ekati diamond mine

3. DESCRIPTION OF EXISTING ENVIRONMENT

The Environmental Assessment Terms of Reference issued by the MVEIRB require BHP to:

> *...provide sufficient information on the existing environment, as it pertains to the proposed development, including the existing mining operation, where appropriate to give a brief but clear picture of the existing environment and its use. Enough information shall be provided for the prediction of positive and negative impacts, planning, project design, construction techniques, operational practices and reclamation techniques.*

The following description of the existing environment in the area of the EKATI™ Diamond Mine and the surrounding region is intended to satisfy this requirement. The information presented in this chapter has been drawn from various sources as referenced, including the 1995 Environmental Impact Statement for the EKATI™ Diamond Mine, then known as the NWT Diamonds Project; the 1998 Environmental Assessment Report for the Diavik Diamonds Project; reports from the ongoing environmental monitoring programs carried out at EKATI™; and information generated from various government, Aboriginal and industry-sponsored initiatives including the West Kitikmeot Slave Study Society.

3.1 Climate and Air Quality

The EKATI™ Diamond Mine is located in the central barrenlands of the Northwest Territories in an area classified for climate purposes as arctic tundra with a continental polar climate. Summers are short and cool, and winters are long and very cold. Daily temperatures are often below -30°C during winter, while summer temperatures rise up to 25°C. Precipitation is sparse, ranging from 200 to 400 mm annually, most of which falls as snow (BHP, 1995).

Characterization of the climate in the development area has been necessary for both impact assessment and project planning purposes. The climatic conditions of the EKATI™ area and the region were described previously in BHP's 1995 Environmental Impact Statement (BHP, 1995) and more recently in Diavik's Environmental Assessment Submission (Diavik, 1998a). Meteorological monitoring at the EKATI™ Diamond Mine site has been conducted annually since 1993, and air quality has been monitored over the last three years.

The following description of the climate and air quality in the project area draws on these previous studies.

3.1.1 Regional Climate

The climate in the general area of the EKATI™ Diamond Mine and BHP's claim block reflects the large-scale wind patterns of the northern hemisphere. Essentially, the earth-

atmosphere system responds to solar energy. That incoming energy changes seasonally with latitude, particularly in the higher latitudes. During winter, a semi-permanent Aleutian Low pressure system occurs in the Gulf of Alaska, which generates south and southeast winds over British Columbia and Alaska. The polar front moves south. The effect of the rotating earth (*i.e.*, the Coriolis force) tends to create northeasterly winds over the project area and the Lac de Gras portion of the Arctic. Depending upon the strength of the Aleutian Low, the location of the polar front (and the jet stream) and other factors such as El Niño, other wind patterns can occur, including southwesterly winds. The more local wind pressure pattern tends to be dominated by high pressure over the Mackenzie Valley and, more distantly, a trough of low pressure over the Davis Strait-Baffin Bay area. The high pressure area is variable depending upon the southward movement of the polar air. In general, the western part of the Canadian Arctic tends to be colder and less stormy than the eastern part. The diurnal cycle of temperature becomes less pronounced closer to the Arctic Circle. Changes in air mass, wind speed, fog and other factors tend to have a greater effect on temperature patterns than the variation in diurnal temperature.

Another factor is the small angle of incidence of the sun's rays, especially over the winter period, with short days, and long nights. Due to the long duration of snow and ice cover, much of the incident radiation is reflected. The minimal benefit of incoming solar energy can, together with other factors (*e.g.*, lack of open lakes to moderate cold temperatures), lead to very cold winter temperatures.

In summer, the Aleutian Low shifts inland over Alaska and Yukon and is replaced by the Pacific High. The polar front moves northward to a mean location at about the Arctic Circle. This tends to create more westerly and northwesterly winds. Daylight becomes predominant and nights are shorter.

The continental Northwest Territories has the greatest annual variation of temperature in Canada. However, while the Canadian Arctic may be perceived by some as a hostile environment, Environment Canada notes in the *Climate of Canada* that "Canada holds none of the world's major weather records. Worse storms and greater extremes of cold, heat, wetness and dryness occur elsewhere" (Diavik, 1998a).

3.1.2 Site Meteorology

Climatological monitoring on site began in 1993 with the installation of the EKATI™ automated meteorological station near the Koala exploration camp. The station is powered with a rechargeable battery and 20 Watt solar panel and has been in almost continuous operation from its date of installation to the present. The station is controlled by a Campbell Scientific CR10 datalogger and has sensors mounted on a 10-m-high aluminum tower. Data collection includes wind speed and direction (two-minute, ten-minute and hourly average), air temperature (one-minute and hourly average), relative humidity (hourly average) and total rainfall (hourly and daily total). Daily summaries are recorded and include the one-minute maximum wind speed and the maximum and minimum one-minute air temperature.

A second automated meteorological station was installed at Pointe de Misère, approximately 30 km southeast of the exploration camp, on a ridge overlooking Lac de Gras in July 1994 to determine climatic variability due to a lake effect. This station operated until October 3, 1996, when it was damaged by wildlife. It was decided at that time not to repair the station. Climatological data from the Diavik Diamonds Project, 28 km southeast of the exploration camp, were used in place of the missing Pointe de Misère data.

In 1993, a Nipher snow gauge was installed near the EKATI™ meteorological station to provide snow-water-equivalent data. The gauge consists of a metal, cylindrical snow collector surrounded by a shield in the shape of an inverted bell. Snow caught by the gauge is melted, and the snow-water-equivalent is measured with a special glass graduated cylinder.

Evaporation is an important component of the water balance calculation for water supply reservoirs and tailing ponds. Open water evaporation rates have been calculated from a Class A evaporation pan monitoring program and from data collected by a dedicated, automated micrometeorological station in operation since 1994. The Class A evaporation pan simulates open water evaporation conditions. During the open water season, water is either added or subtracted on a daily basis to maintain a constant static water level in the pan. A manual rain gauge installed next to the evaporation pan monitors precipitation into the pan. The manual rain gauge is also read on a daily basis during the open water season.

The special floating micrometeorological station has been in use during the open water season, on either Long Lake (1994, 1995, 1996) or Polar Lake (1997, 1998, 1999). The station had to be moved from Long Lake to Polar Lake at the end of the 1996 season because Long Lake was scheduled for dewatering to prepare it for the storage of processed kimberlite from the Process Plant. The station is controlled by a Campbell Scientific CR10 datalogger mounted on a raft with 205 L drums as pontoons. At the beginning of the 1998 monitoring season the station was moved from the northwest shore of Polar Lake to the south shore.

Data collected by the automated evaporation station are used to calculate open water evaporation using a combined energy balance/aerodynamic mathematical model known as the Penman Combination Model. The following parameters are monitored at the station: air temperature and relative humidity at sensor heights of approximately 90 cm and 200 cm (hourly and daily average); water temperature for depths of approximately 10 cm and 50 cm (hourly and daily average); wind speed at sensor heights of 280 cm (hourly samples and 15-minute and hourly average) and 50 cm (hourly average); wind direction at 280 cm (hourly samples and 15-minute average); incoming short-wave radiation (hourly and daily average); net radiation on top of the water surface (hourly and daily average); and rainfall (hourly and daily total). In addition, daily summaries are recorded for air temperature (minimum and maximum one-minute average) and maximum wind speed (instantaneous, two-minute and ten-minute) with time and direction.

3.1.2.1 Air Temperature

Air temperatures in the region have been higher than normal over the past several years. During the summer of 1999, Canada as a nation was 0.6°C warmer than normal. This marks Canada's ninth consecutive summer of above-normal temperatures. Seven of the ten warmest summers (nationally) have occurred in the last 20 years. Conversely, three of the ten coolest summers have occurred in the past 20 years (Environment Canada, 1999).

Environment Canada has divided the nation into 11 climatic regions. The EKATI™ Diamond Mine site is located in the Mackenzie District climatic region. Temperature statistics indicate that the greatest trend towards warmer temperatures over the past 52-year period of record is in the Mackenzie District (+1.1°C). Air temperatures in the District were above normal for winter 1999 (December 1998, January and February 1999) and spring 1999 (March, April, May) and near-normal for summer 1999 (June, July, August), where the departure from the long-term mean was +0.3°C. The warmest year on record for the Mackenzie District was 1998 (Environment Canada, 1999).

Annually the coldest and warmest months are January and August, respectively. The extremely high annual range of temperature, 76.6°C, is indicative of the continental climate. In the past six years, the annual one-minute maximum temperature ranged from 23.0°C (August 16, 1993) to 29.4°C (July 30, 1996). The annual one-minute minimum temperature ranged from -37.8°C (January 11, 1999) to -47.2°C (January 11, 1994). Table 3.1-1 summarizes the extreme one-minute air temperatures as measured at the EKATI™ site for the six years of available data.

Table 3.1-1
EKATI™ Extreme Maximum and Minimum Air Temperatures (ºC)

Year	Maximum	Date	Minimum	Date
1993[1]	23.0	August 16	-43.5	December 23
1994[2]	25.4	July 25	-47.2	January 11
1995	25.4	June 11	-40.6	March 3
1996	29.4	July 30	-45.1	January 16
1997	25.1	July 22	-41.0	February 15
1998[3]	26.5	August 3	-39.8	January 28
1999[4]	26.3	June 18	-37.8	January 11

1: Data collection begins August 1993.
2: No data available for April, May, June 1994.
3: No data available for September 1998.
4: Data collection ends September 20, 1999.

Table 3.1-2 compares the mean temperatures at EKATI™ for the October to September period in 1995, 1996, 1998 and 1999. Statistics from 1993, 1994 and 1997 are not included because of insufficient data resulting from sensor or datalogger malfunction. The comparatively high 1998 and 1999 mean annual air temperature confirms regional results, which indicate that both of these years were warmer than normal based on these seasonal data.

Table 3.1-2
EKATI™ Mean Annual Air Temperatures (ºC)
for the October to September Period

Year	Temperature
1995	-9.3
1996	-9.9
1998	-7.2
1999	-7.4

Source: Rescan, 1999a.

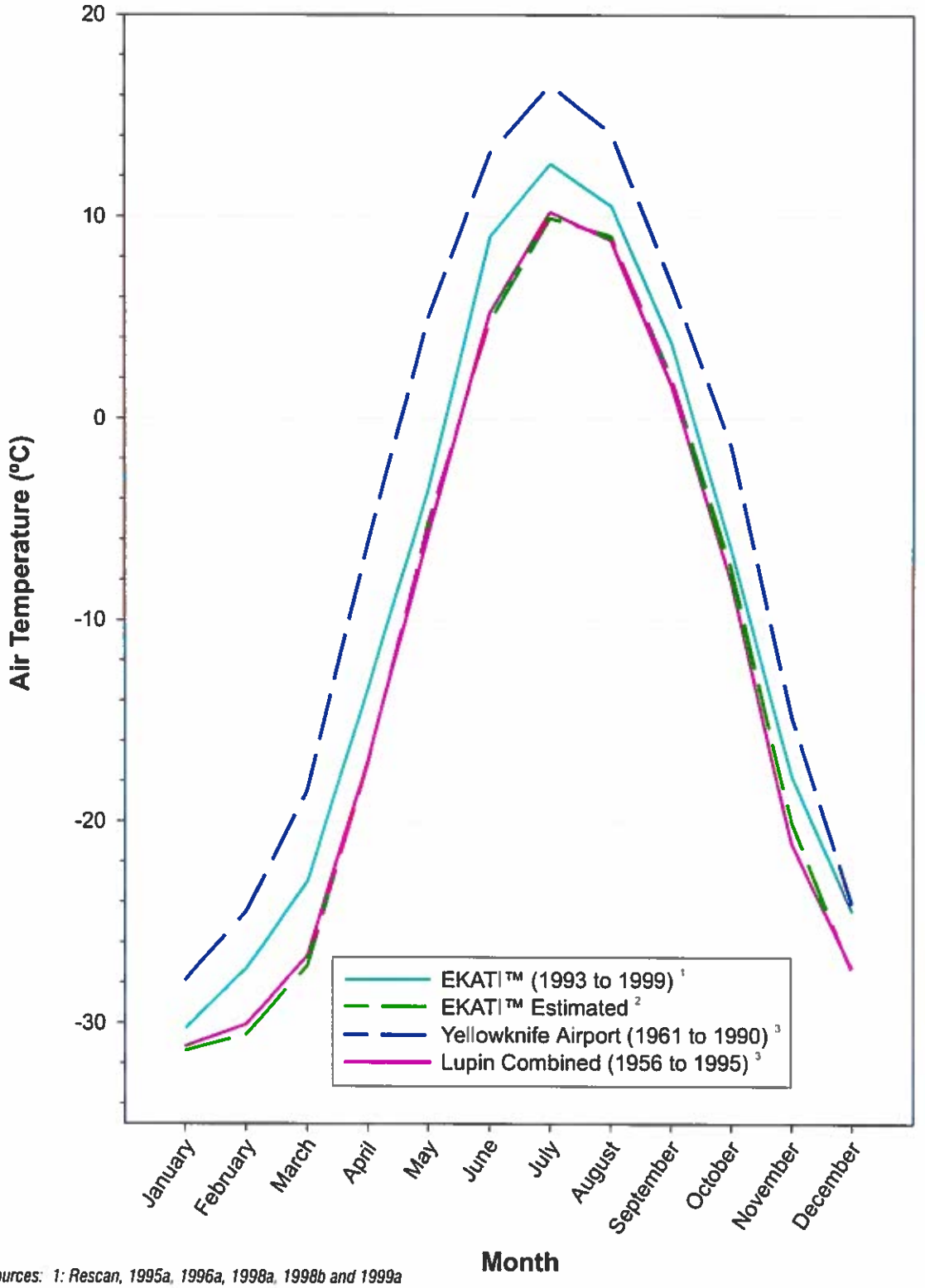
Regional meteorological stations are operated by Environment Canada-Atmospheric Environment Service (AES). The closest regional AES stations to EKATI™ are located at Lupin, Kugluktuk (Coppermine) and Yellowknife Airport. It should be noted that prior to 1982, the station in the Lupin area was on the west shore of an island in Contwoyto Lake and was referred to as the Contwoyto Lake Station. The AES replaced this station as the monitoring site for the area with one at Lupin, which is further north on the west side of Contwoyto Lake (Diavik, 1998a). For the purposes of this assessment, the data from the two stations have been combined to provide a longer period of record and are referred to as the Lupin Combined data set.

The monthly long-term annual average air temperatures for EKATI™, Yellowknife Airport and Lupin Combined are summarized in Table 3.1-3 and Figure 3.1-1. The approximate mean annual temperature of -9.2°C shown for EKATI™ represents the discontinuous period of data collected from the meteorological station. At -11.7°C, the mean annual air temperature at Lupin, approximately 100 km north of EKATI™, is lower than at either EKATI™ or Yellowknife (-5.2°C).

Diavik (1998a) reported a mean annual temperature of -11.7°C based on 40 years of data collected at Lupin Combined. In order to calculate a more accurate mean annual air temperature for EKATI™, a month-by-month comparison of air temperatures was carried out for the EKATI™ meteorological station and Lupin Combined for a common period of record. Months where data were missing were excluded from the calculations. The common period of record for the two stations encompassed 59 months. EKATI™ was 0.88°C warmer than Lupin Combined for the 59-monthly period of record. This difference was added to the 40-year mean annual air temperature for Lupin Combined (-11.7°C) to arrive at a best estimate of -10.8°C for the long-term mean annual air temperature at EKATI™.

3.1.2.2 Precipitation

Precipitation in the Mackenzie District has been near normal for the past several years. Precipitation was near normal for the winter of 1998/99, higher than normal during spring 1999 and substantially higher than normal, by 19.8%, during the summer of 1999.



Sources: 1: Rescan, 1995a, 1996a, 1998a, 1998b and 1999a
2: BHP, 1995
3: Diavik, 1998a

Mean Monthly Air Temperatures for EKATI™, Yellowknife Airport and Lupin Combined Meteorological Stations

FIGURE 3.1-1

BHP

Ekati diamond mine

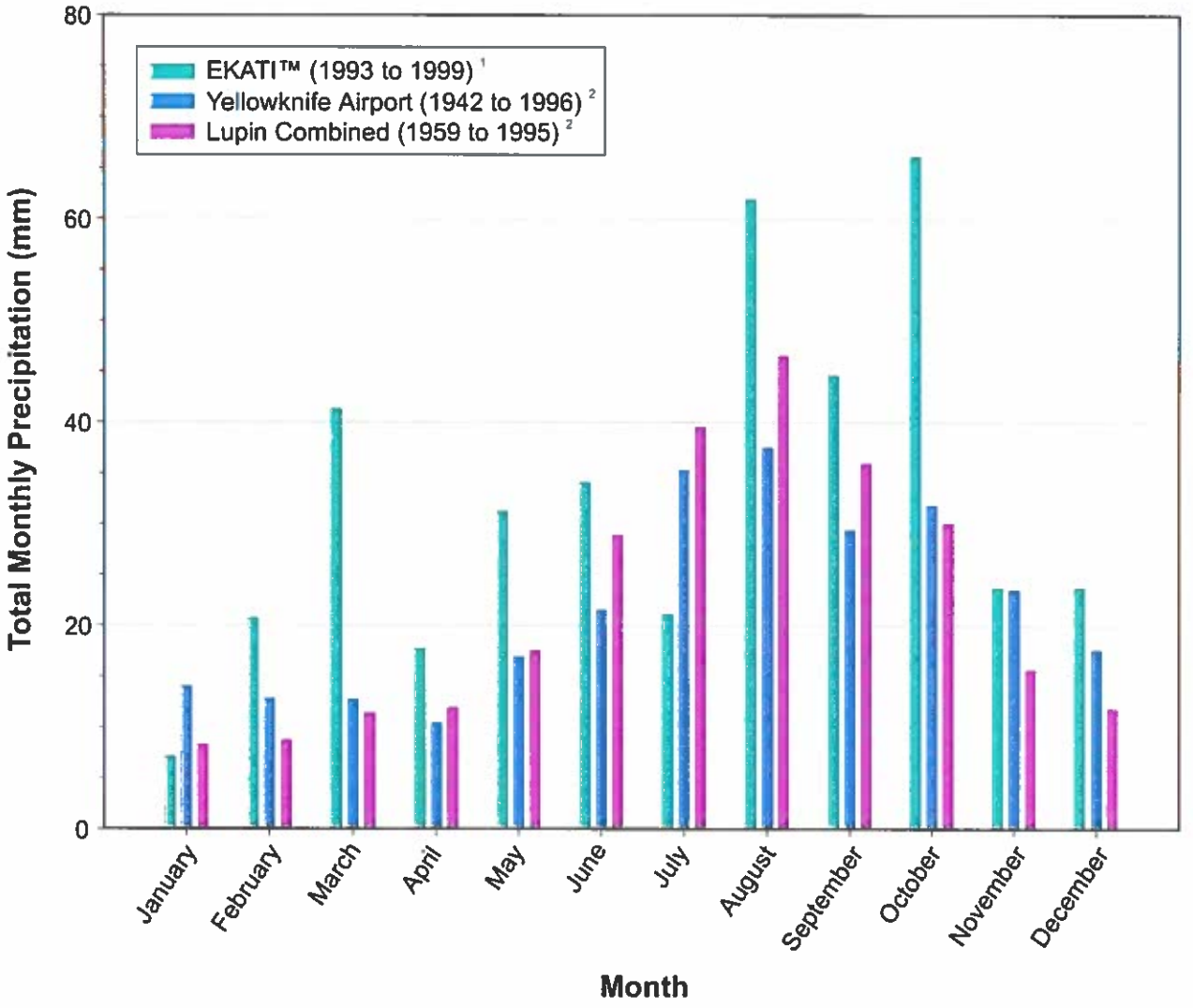
Table 3.1-3
Mean Monthly Air Temperatures for EKATI™, Yellowknife Airport and Lupin Combined

Month	EKATI™[1] (1993 to 1999)	Yellowknife Airport[2] (1961 to 1990)	Lupin Combined[2,3] (1956 to 1995)
January	-30.3	-27.9	-31.2
February	-27.3	-24.5	-30.1
March	-23.0	-18.5	-26.7
April	-13.4	-6.2	-17.0
May	-3.5	5.0	-5.8
June	9.0	13.1	5.2
July	12.6	16.5	10.2
August	10.5	14.1	8.8
September	3.7	6.7	1.7
October	-6.6	-1.4	-8.1
November	-17.8	-14.8	-21.1
December	-24.5	-24.1	-27.3
Mean	**-9.2**	**-5.2**	**-11.7**

1: Rescan, 1995a, 1996a, 1998a, 1998b, 1999a.
2: Diavik, 1998a.
3. Lupin Combined refers to two slightly different locations.

For the 52 years of available record the summer of 1999 was the fifteenth wettest. For Canada as a whole, eight of the ten wettest summers have occurred in the past 20 years and the last five seasons have been above normal. Nationally over the last 20 years, only two summers have had below-normal precipitation (Environment Canada, 1999).

In the Mackenzie District, precipitation levels are usually highest during the late summer to early winter period, although some precipitation usually falls in all months of the year. Half or more of the annual precipitation may fall as snow, generally between October and April (BHP, 1995). Table 3.1-4 and Figure 3.1-2 summarize the monthly total precipitation for EKATI™, Yellowknife Airport and Lupin Combined. It can been seen that monthly precipitation varies considerably between EKATI™ and the other two stations. Overall annual precipitation is higher for EKATI™ (393.0 mm) than Yellowknife (263.5 mm) or Lupin Combined (266.1 mm), due mainly to higher recorded snowfall during the winter and rainfall during the summer. Whether snowfall is actually higher at EKATI™ than at Lupin is uncertain, however, as blowing snow may constitute a significant fraction of the measured snow-water-equivalent. The Nipher snow gauge at EKATI™ is monitored sporadically when there is evidence of fresh snow, whereas the gauge at Lupin is monitored every six hours, regardless of weather conditions, and data are corrected for accumulation of blowing snow. No attempt has been made to correct for accumulation of blowing snow at the EKATI™ site. Future snow monitoring will include more detailed studies such as snow course surveys to monitor the contribution of snow to total annual precipitation and runoff more accurately.



Sources: 1: Rescan, 1995a, 1996a, 1998a, 1998b and 1999a
2: Diavik, 1998a

Monthly Total Precipitation for EKATI™, Yellowknife Airport and Lupin Combined

FIGURE 3.1-2

Table 3.1-4
Monthly Total Precipitation (mm) for EKATI™, Yellowknife Airport and Lupin Combined

Month	EKATI™[1] (1993 to 1999)	Yellowknife Airport[2] (1942 to 1996)	Lupin Combined[2] (1959 to 1995)
January	7.1	14.0	8.3
February	20.7	12.8	8.7
March	41.3	12.7	11.4
April	17.7	10.4	11.9
May	31.2	16.9	17.5
June	34.1	21.5	28.9
July	21.1	35.3	39.5
August	61.9	37.5	46.5
September	44.6	29.4	35.9
October	66.1	31.8	30.0
November	23.7	23.5	15.6
December	23.7	17.6	11.8
Total	**393.0**	**263.5**	**266.1**

1: Rescan, 1995a, 1996a, 1998a, 1998b, 1999a.
2: Cirrus, 1998.

Precipitation data have been collected at EKATI™ since August 1993. Because of the gaps in the data due to equipment failure, as referenced previously, and to permit year-to-year comparison, a common period of record – from February to September – was selected. Comparison of the precipitation rates during this eight-month period over several years provides a general indication of which years were wetter or drier than others. Mean precipitation for the February to September period at EKATI™ from 1994 to 1999 is 284 mm (Table 3.1-5). This period was drier in 1999 than in 1995 and 1996, but wetter than in 1994, 1997 and 1998.

Table 3.1-5
EKATI™ Total Annual Precipitation (mm)

Year	February to September	October to September
1994	193	280
1995	381	519
1996	414	510
1997	163	n/a
1998	200	371
1999	355	458
Average	**284**	**428**

Precipitation data are invaluable for hydrologists in order to estimate runoff. As a general convention the hydrologist will study a 12-month period known as the "water

year," which begins October 1 and ends September 30 the next year. These dates are based on the assumption that the snow pack begins to accumulate on October 1 each year and has completely melted by September 30. Obviously, this does not occur every year, but it serves as a basis for year-to-year precipitation comparisons. As indicated in Table 3.1-5, the regime for total precipitation in terms of water years is similar to that for the eight-month comparison, with 1995, 1996 and 1999 being relatively wet years and 1994 and 1998 being relatively dry years.

The EIS (BHP, 1995) estimated annual precipitation in the EKATI™ area to be in the range of 250 to 350 mm based on approximately 17 months of site-specific data. As part of ongoing efforts to define precipitation patterns, a frequency analysis was performed for the Lupin Combined (Contwoyto Lake/Lupin) data set, which covers a period of record of 38 years (1959 to 1999, excluding 1982, 1983 and 1998). Frequency analysis fits existing data to the most appropriate distribution to facilitate long-term predictions of precipitation events; specifically, previous experience has shown that the Gumbel Distribution best represents total annual precipitation data such as the available Lupin Combined data set. Based on the 38 years of data, the mean annual precipitation was estimated to be 298 mm. The one in two-year event, which has a probability of occurrence of 0.50, was used for this estimation. With precipitation at EKATI™ estimated to be roughly 17% higher than at Lupin Combined, mean annual precipitation at EKATI™ was calculated to be 345 mm. This falls within the range estimated in the 1995 EIS. Estimated total annual precipitation levels for Lupin Combined and EKATI™ for various return periods are shown in Table 3.1-6.

Table 3.1-6
Estimated Total Annual Precipitation (mm)
for Lupin Combined and EKATI™

	Total Annual Precipitation (mm)	
Return Period (years)	Lupin Combined	EKATI™
2	295	345
5	348	407
10	385	450
20	420	491
25	432	505
50	464	543
100	500	585
200	535	626

Further studies and more diligent monitoring of the Nipher snow gauge at EKATI™ will be conducted to determine a more accurate site-specific annual precipitation. In addition, snow course surveys will be implemented to further delineate the contribution of snow-water-equivalent to annual precipitation and runoff.

3.1.2.3 Wind Speed and Direction

The EKATI™ meteorological station monitors wind speeds and directions from a 10 m height and provides the longest period of record inside the mineral claim block. Over this time, the prevailing winds have been from the east or the northwest (Table 3.1-7). Exceptions were 1997, when the most common wind direction was southwest; 1998, when the second most common wind direction was southeast; and 1999, when the second most common wind direction was northeast.

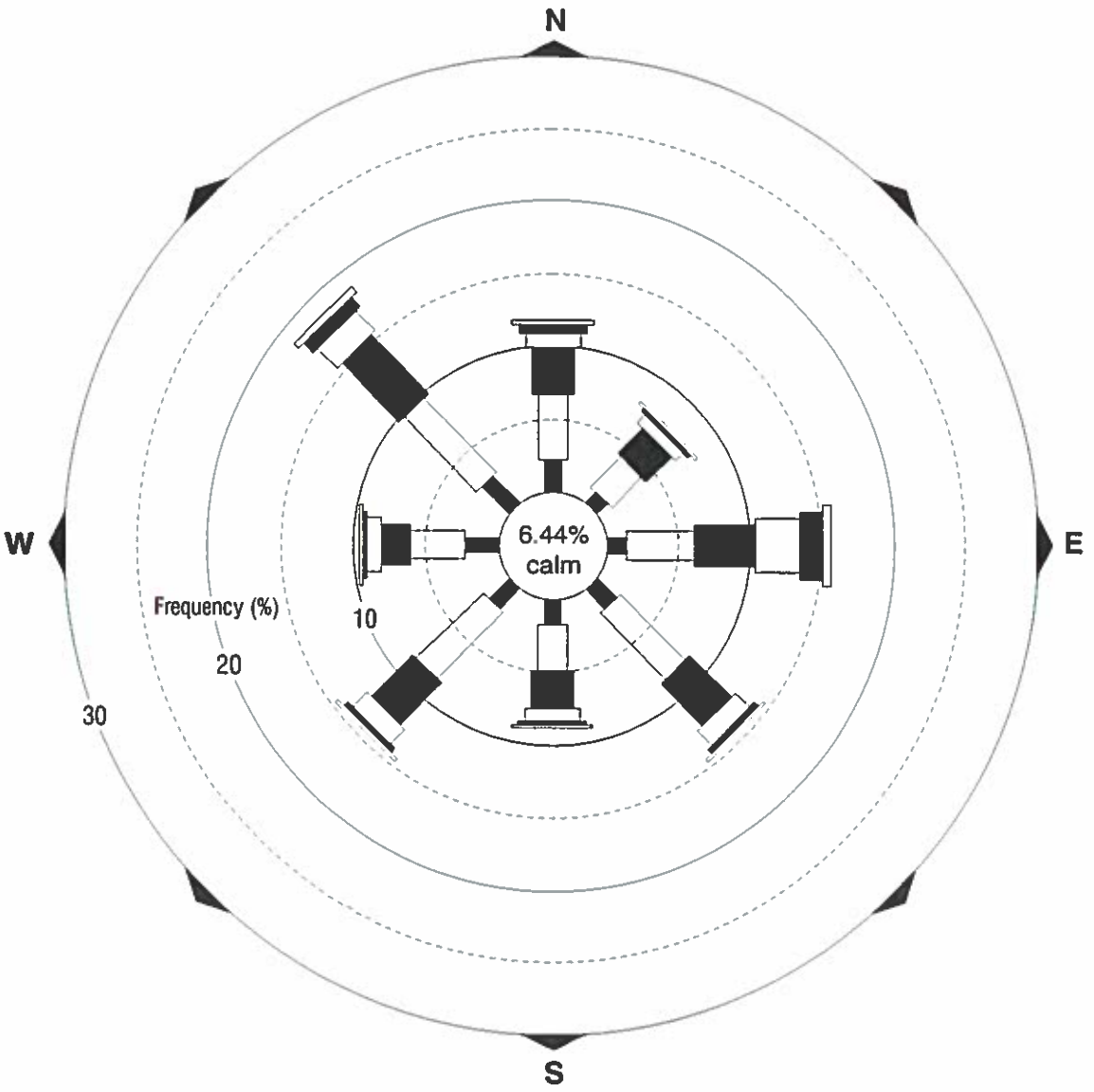
Table 3.1-7
Prevailing Wind Directions and Percentage of Occurrence

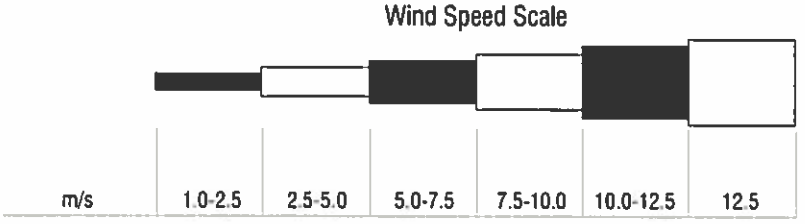
Year	Most Common Wind Direction	Second Most Common Wind Direction
1994	NW (18.6%)	E (15.5%)
1995	E (19.7%)	NW (14.0%)
1996	E (19.4%)	NW (17.0%)
1997	SW (21.6%)	E (17.8%)
1998	E (23.4%)	SE (16.0%)
1999[1]	E (15.3%)	NE (13.8%)

1: Wind data were not available from the meteorological station; therefore, data from the micrometeorological station were used.

A wind rose for 1999 is not available for the EKATI™ meteorological station because of equipment failure. However, the wind rose from the EIS report (BHP, 1995) was found to be most representative of the database, since it summarized approximately 15 months of data between August 1993 and January 1995. The wind roses appearing in the environmental data reports issued subsequently to the EIS were based on less than one year of data. Figure 3.1-3 summarizes the wind distribution for EKATI™.

Calm conditions occur approximately 4% to 11% of the time. Calm conditions are defined by those hours with an average wind speed of less than 1 m/s. Wind gusts at the station occasionally exceed 12.5 m/s (45 km/h). For the 15 months of data reported in the EIS report, the hourly average wind speed was greater than 12.5 m/s approximately 1.5% of the time. The highest instantaneous wind speed recorded at the EKATI™ over the past six years was 25.3 m/s (91 km/h, February 1, 1994, 2210 hours; wind direction from 320°). The maximum instantaneous wind speeds for the other five years of available record were all between 20 and 25 m/s. No consistent trend was shown for date, time of day and wind direction for the annual maximum instantaneous wind speeds.





Notes: *Data available from August 14, 1993 to January 3, 1995.*
All data collected during icing events and when the sensor was removed for repair has been excluded from these calculations.
Source: BHP, 1995

BHP

EKATI™ Weather Station
Wind Rose

FIGURE 3.1-3

Ekati diamond mine

3.1.2.4 Lake Evaporation

Open water evaporation is an important component of the water balance(s) for the Long Lake Containment Facility and for hydrological analysis. The open water season at EKATI™ is approximately 20 weeks long and extends from late May/early June to early October. As discussed previously in Section 3.1.2, two methods have been employed to estimate evaporation at EKATI™, a Class A evaporation pan and the Penman Combination Model. The micrometeorological station at Polar Lake provides the data required by the Penman Combination Model. Data synthesis and evaporation calculations were performed in accordance with the methods reported in recent studies by Indian and Northern Affairs personnel in the NWT (Reid, 1998). Table 3.1-8 summarizes the open water evaporation calculations from the Class A evaporation monitoring and the Penman Model since monitoring began in 1994.

Table 3.1-8
Summary of Open Water Evaporation at EKATI™

Year	Duration of Open Water Season (days)	Pan Coefficient	Mean Daily Evaporation[1] (mm)	Evaporation Calculated from Class A Pan (mm)	Evaporation estimated from Penman Model (mm)
1994	124 (June 19 to October 20)	0.75	2.21	270	220
1995	124 (June 19 to October 20)	0.75	2.22	275	n/a
1996	124 (June 19 to October 20)	0.75	2.87	356	n/a
1997	124 (June 19 to October 20)	0.75	2.25	279	n/a
1998	134 (May 26 to October 6)	0.75	2.64	354	327
1999	135 (May 21 to October 2)	0.75	2.47	334	311
Mean	**127**	**0.75**	**2.45**	**311**	**286**

1: Calculated from the Class A pan evaporation and the duration of the open water season.

Few regional Class A evaporation monitoring stations are available to provide information for comparison with the EKATI™ data. In the early 1990s, the Class A pan network in the Northwest Territories consisted of only five stations; these usually indicated that pan evaporation was greater than precipitation (Rescan, 1995a). Contour maps are available for evaporation but, because of the low density of monitoring stations, are not considered accurate enough to determine an open water evaporation rate for EKATI™. The Yellowknife Airport, approximately 300 km southwest of EKATI™, operated a Class A evaporation pan until 1995. Given its geographic location, Yellowknife has a longer open water season and correspondingly higher annual open water evaporation rate. Previous studies have indicated that the annual open water evaporation rate for EKATI™ is approximately 67% that of Yellowknife (Rescan, 1995a).

A stable isotope mass balance method for calculating open water evaporation has been employed at lakes and tailings ponds at Lupin Mine. The mean evaporation rates for small lakes at Lupin for 1992 and 1993 were 3.2 and 2.6 mm/d, respectively (Rescan, 1995a). These rates compare favourably to the EKATI™ data (Table 3.1-8), which indicate a mean daily evaporation rate of 2.4 mm.

Evaporation studies have been conducted by DIAND at the abandoned Salmita tailings pond located 80 km south of EKATI™. Total open water evaporation rates for Salmita and EKATI™ estimated according to the Penman Method are summarized in Table 3.1-9. The rates compare favourably and are within 5% of each other.

Table 3.1-9
Penman Method Estimated Open Water Evaporation

	Salmita		EKATI™	
Year	Open Water Evaporation (mm)	Duration of Open Water Season (days)	Open Water Evaporation (mm)	Duration of Open Water Season (days)
1994	336	124	220	124
1995	261	115	n/a	124
1996	283	105	n/a	124
1997	242	114	n/a	124
1998	348	124	327	134
1999	295	n/a	311	135
Mean	**294**	**116**	**286**	**127**

3.1.3 Air Quality

Air quality is considered a valued ecosystem component (VEC) because of its intrinsic importance and aesthetic value in terms of visibility, odour, effects on worker health and safety, and importance to wildlife and vegetation. Generally, the air in the Lac de Gras region is free of any anthropogenic contamination, as there are no major emitting sources of gaseous pollutants in the region. The EKATI™ Diamond Mine involves heavy industrial equipment, construction and open pit mining activities - all of which have an impact on air quality. The use of diesel and gasoline powered equipment for diamond exploration and mining has caused a localized increase in gaseous and particulate air emissions in the area. The air emissions are attenuated and quickly diluted by the ambient air. The dispersion of air emissions is enhanced by the temperature difference between ambient air and the gas emissions and by the persistent winds in the area (*i.e.*, wind speeds of less than 1 m/s occur approximately 4% to 11% of the time). The buoyancy of the air emissions and turbulent mixing ensure that air emissions are quickly dispersed and carried away from the source.

The air quality monitoring program at EKATI™ consists of baseline studies, which were completed in 1994 for the EIS (BHP, 1995), and operational monitoring, which began in 1997 and continues. The baseline studies and operational monitoring involved the use of high volume air samplers to determine 24-hour average concentrations of total suspended particulate (TSP). The TSP method captures airborne particles with a diameter of less than 30 µm. Table 3.1-10 and Figure 3.1-4 summarize the results of the EKATI™ baseline and operational TSP monitoring programs since they began.

Table 3.1-10
Summary of EKATI™ High Volume Air Sampling Program

Year	Number of Samples	Maximum TSP Concentration (µg/Nm^3)	Minimum TSP Concentration (µg/Nm^3)	Arithmetic Mean (µg/Nm^3)	Geometric Mean (µg/Nm^3)	Number of Samples Exceeding CAAQO[1]
Fox, Panda and Koala Lakes						
1994	33	320.0	4.0	53.7	28.7	4
EKATI™ Accommodations Complex (TSP1)						
1997	16	37.6	2.6	15.7	11.4	0
1998	17	137.9	1.9	50.0	28.1	2
1999	15	117.0	2.6	40.4	21.9	0
Grizzly Lake Pumphouse (TSP2)						
1999	15	19.9	0.0	4.5	3.3	0

1: Canadian Ambient Air Quality Objectives = 120 µg/Nm^3

Table 3.1-10 indicates that the highest TSP concentrations were observed during the 1994 baseline studies. Smoke and fire particulate from nearby tundra fires documented in the region at that time were most likely the cause of these high concentrations; the fires also resulted in reduced visibility. The benchmark for comparison of measured TSP values is the Canadian Ambient Air Quality Objectives (CAAQO). The CAAQO specify three ranges of air quality: acceptable, desirable and tolerable. The acceptable range of quality, which provides protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being, has been selected for comparison purposes for this document. The acceptable CAAQO for TSP is 120 µg/Nm^3.

Table 3.1-10 indicates that 4 of 33 samples from EKATI™ exceeded the CAAQO during the baseline monitoring program, most likely due to forest fire smoke. None of the 16 TSP samples collected in 1997 exceeded the CAAQO, two of 17 samples exceeded the criterion in 1998 and none of 15 samples exceeded it in 1999. The concentrations of TSP at the Grizzly Lake Pumphouse (TSP2) appear to be very close to undisturbed baseline levels, with an arithmetic average of 4.5 µg/Nm^3 and a maximum value of 19.9 µg/Nm^3. It should be noted that several values were near 2 µg/Nm^3, which is the lower end of the detection limit (40CFR50, App. B, 3.0). For comparison, about 30 measurements of TSP at the Diavik Diamonds Project were used to determine a background level of

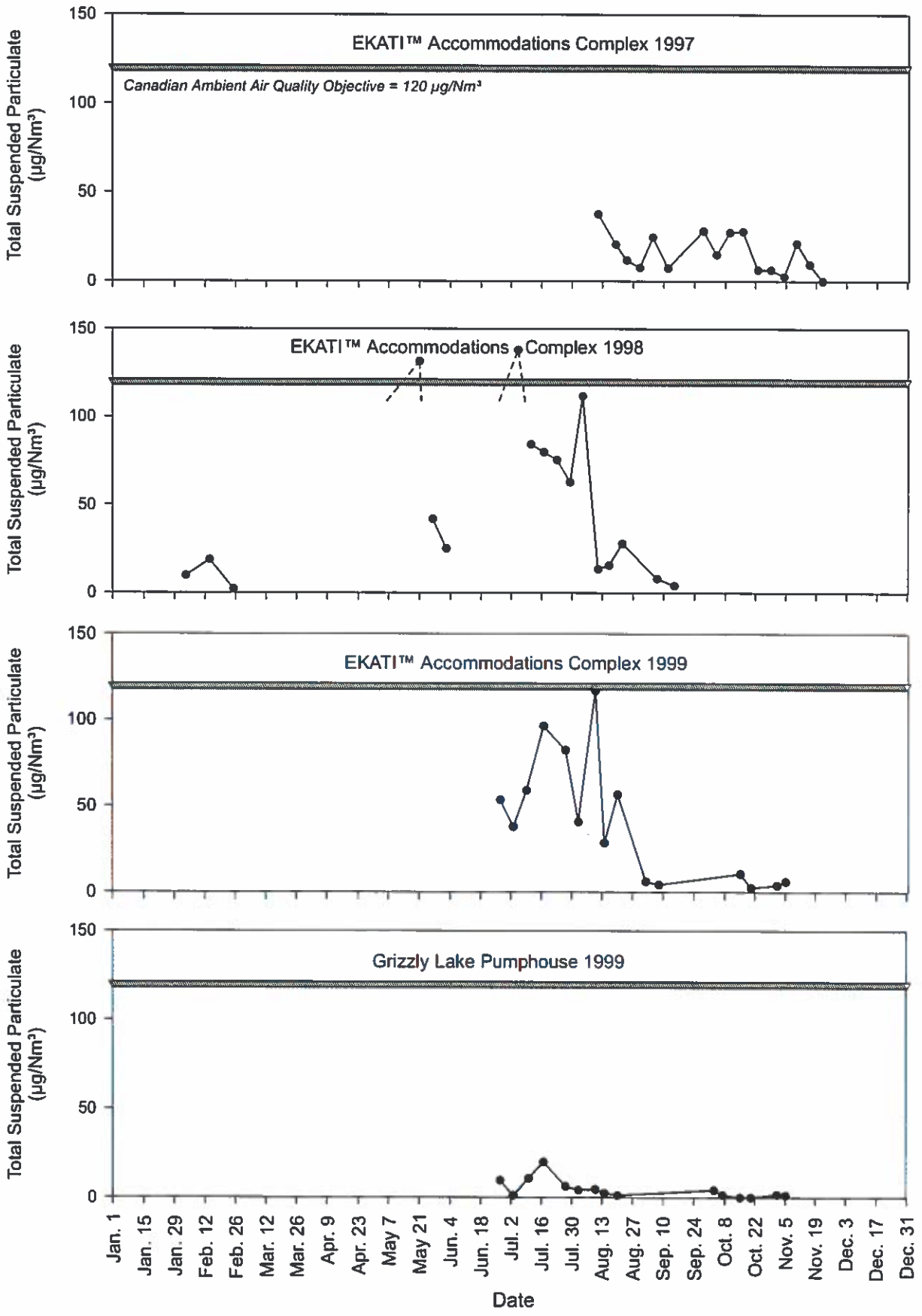


FIGURE 3.1-4

EKATI™ High Volume Air Sampling Summary: 1997 to 1999

Source: BHP Diamonds Inc., 1999e

10 $\mu g/Nm^3$ (Diavik, 1998a). Several of the TSP filters were analyzed for metals during the 1994 baseline program. It was concluded at that time that none of the metal concentrations in the airborne particulate were of concern.

Baseline monitoring for gaseous pollutants was not deemed necessary because of the lack of anthropogenic sources in undisturbed tundra. However, for purposes of air dispersion modelling, background concentrations of SO_2, NO_2 and O_3 needed to be identified. Background levels are approximately 4 $\mu g/Nm^3$ for SO_2 100 $\mu g/Nm^3$ for CO, 21 $\mu g/Nm^3$ for NO_2 and 80 $\mu g/Nm^3$ for O_3 (Diavik, 1998a).

3.2 Surficial Geology and Permafrost

The EKATI™ Diamond Mine lies within the northwestern Canadian Shield physiographic region where the landscape is bedrock controlled. Surficial, mostly glacial materials are thin and discontinuous, and permafrost is present near the surface everywhere except beneath lakes and rivers. The surficial geology of the project area was previously described in the 1995 Environmental Impact Statement (BHP, 1995). The following material has been excerpted from BHP (1995) and updated as appropriate for the current development.

3.2.1 Regional Terrain Conditions

Terrain conditions in the Lac de Gras region of the NWT were initially described by Dredge *et al.* (1994) and mapped at a scale of 1:25,000 by Ward (1992). Subsequently, Rampton (1994) prepared detailed maps of the Quaternary geology of the entire BHP claim block (Exeter Lake, referred to here as the "claim block"). This was based upon interpretation of 1:60,000 scale air photos and subsequent field reconnaissance, with map compilation at a scale of 1:50,000. The information in this section has been adapted from Rampton (1994) and from contributions appearing in Fulton (1989). The areal extent of the claim block mapping is shown in Figure 3.2-1.

The Lac de Gras region is typical of the northwestern Canadian Shield physiographic region, with rolling hills and relief limited to approximately 50 m, all controlled by near-surface, resistant Precambrian bedrock. Numerous lakes fill topographically low areas, which are interconnected by shallow, commonly ephemeral streams.

The region has been subjected to multiple Quaternary glaciations; however, the current landscape can be attributed to the last, the Late Wisconsinan Laurentide Ice Sheet (Dike *et al.*, 1989). The claim block was inundated by glaciers flowing in a variety of directions during this period. Glacial striations indicate that the earliest ice-flow direction was to the southwest, and subsequent flow was to the west and west-northwest. Varying thicknesses of till were deposited on bedrock over most of the area.

Deglaciation involved retreat in a generally east-northeasterly direction across the NWT and concurrent lowering of the Laurentide Ice Sheet surface elevation. The successively reduced ice mass remained active until very near the end, which occurred in the Lac de Gras region approximately 9,500 years ago (Dike and Dredge, 1989). There was an abundant supply of meltwater during the early stages of deglaciation. A complex network of meltwater streams formed, initially on the surface of the ice mass, but quickly passing through the ice to subglacial positions.

Erosional and depositional landforms include scallops flanking till uplands, plunge pools and whirlpools filled with boulders, and eskers that in some cases enter and exit plunge pools and whirlpools. A trunk or main esker crosses the claim block in a west-northwest direction from just north of Duchess Lake to south of Yamba Lake. Eskers and

glaciofluvial corridors south of the trunk esker (the main mine development area) generally have a north-northwest trend, whereas eskers north of the trunk esker trend from west to southwest (Figure 3.2-1).

As the inactive ice mass continued to melt, meltwater movement caused more areally extensive erosion and deposition. Newly exposed till plains were extensively eroded; in some cases the till was completely removed. Glaciofluvial materials were deposited as irregular hills and knolls, transverse ridges, sheets and bar-like features. Lag concentrations of boulders, and small patches and blankets of sand and gravel, were commonly deposited on the remaining till and bedrock surfaces.

Following deglaciation, the levels of some lakes were higher than at present, as evidenced by strandlines. High lake levels were short-lived, however, as indicated by the lack of deltas and well-developed beaches. There is no evidence that the marine limit extended into the region.

Through the remainder of the Holocene, periglacial processes have caused mechanical breakdown of bedrock and coarse glacial materials and contributed to gravity transport of both glacial soils and products of periglacial grinding. Thin alluvial deposits have formed along some streams, and pond deposits have accumulated in shallow depressions. Organic deposits have also formed on some poorly drained floodplains and low flat areas.

Early isostatic ground emergence rates reported for the central Keewatin district are believed to be approximately 10 metres per century when averaged over the first 1,000 to 2,000 years of record, although rates would have been higher by a factor of two to three times over the approximate 200 years of deglaciation. Late Holocene and ongoing emergence rates are estimated to be somewhat more than one metre per century (Dike and Dredge, 1989).

3.2.2 Surficial Materials

Surficial deposits covering the claim block range in age from Late Wisconsinan to Holocene. Table 3.2-1 lists the deposits from youngest to oldest and includes brief descriptions of their composition, estimated thickness, geomorphology, drainage and origin. A description of each deposit according to the same chronological order follows.

3.2.2.1 Postglacial Lacustrine Deposits

Lacustrine deposits owe their existence to postglacial lakes dammed by decaying glacier ice and to postglacial isostatic adjustments. Most deposits lie within a few metres of present lake levels. Their upper limit is occasionally marked by poorly developed strandlines. The brief existence of the postglacial lakes and short fetches resulted in limited long-shore drift. The materials comprising the shorelines are re-worked tills where fines have been removed, in some areas leaving only boulder lags (Plate 3.2-1). The lacustrine deposits are primarily silt, silty sands and gravelly sands.

Table 3.2-1
Description of Surficial Deposits in the BHP Claim Block

Unit	Composition	Estimated Thickness (m)	Geomorphology and Drainage	Origin
Organic Deposits	Undercomposed organics and muck; may contain lenses of mineral sediment, especially in lower part.	0.5 to 2.0	Cover flat depressions and swells; imperfectly to poorly drained.	Forms from accumulation and decomposition of organic material.
Alluvial Deposits	Silt to gravel size stratified sediment with few lenses and layers of organic detritus; commonly cobbly or bouldery; may have organic cover.	1.0 to 3.0	Floodplains and low alluvial terraces; subject to intermittent flooding; commonly imperfectly drained.	Cobbly, bouldery deposits formed by streams eroding glacial deposits; stratified sediments deposited by streams.
Lacustrine Deposits	Mainly silt and sand with few lenses of organic detritus; sand and pebbly gravel in bars, beaches and spits; locally boulder lags.	0.5 to 3.0	Lacustrine plains; gentle slopes lying immediately above present lakes; bars, beaches and spits; drainage varies from imperfect to good.	Sediments derived by wave erosion and winnowing of fines in former lake beds; erosion and redeposition of glaciofluvial deposits by waves and long-shore drift to form bars, beaches and spits.
Glaciofluvial Deposits (outwash)	Mainly sand and gravel; few beds of silt; locally, mainly cobbles and boulders.	1.0 to 15.0	Glaciofluvial blanket forms flat featureless cover or bar-shaped forms on bedrock or till. Kame and kettle complexes can show rolling topography or sharp hills and ridges. Eskers form sharp continuous linear ridges; well drained.	Glaciofluvial blankets are streambeds from subglacial meltwater sheet flow; the sediments are formed by erosion and winnowing of till; eskers are deposited from major subglacial streams; kames are deposited along subglacial, englacial and proglacial stream channels.

Source: Rampton (1994).

(continued)

Table 3.2-1 (continued)
Description of Surficial Deposits in the BHP Claim Block

Unit	Composition	Estimated Thickness (m)	Geomorphology and Drainage	Origin
Till	Compact diamicton (unsorted sediment) with a silty sand matrix; contains pebbles, cobbles and boulders; in places very bouldery; locally may contain lenses and layers of outwash; locally upper part may be loose and contain less silt; patches of outwash and boulders may cover surface; large areas may be covered by boulders; locally bedrock may be exposed, especially in areas of till veneer.	0.5 to 15.0	Till veneers and blankets cover bedrock, and slopes generally reflect bedrock topography. Rolling ground moraine consists of ridges and hills with gentle to moderate slopes that may be a result of primary glacial deposition or may reflect underlying bedrock topography. Generally well drained, although some depressions may be imperfectly drained.	Deposited mainly as lodgement and meltout till at base of glacier. Loose sandy surface layers winnowed of fines by subglacial processes during deposition; extensive boulder lags due to meltwater erosion of till matrix and smaller clasts; patches of outwash from subglacial streams.
Morainal Deposits	Complex of diamicton (till) and glaciofluvial deposits (outwash). Till may be compact to loose. Outwash is commonly silty. Some complexes may be primarily a mixture of sandy and/or silty outwash.	3.0 to 15.0	Hilly terrain with either rolling topography or sharp hills and ridges; short esker segments, kames and rimmed ridges can be common; well drained; isolated depressions may be poorly drained.	Primarily deposited supraglacially or on "dead ice"; much of the till is meltout and has been re-worked by gravity flow in a melting ice surface.
Exposed Bedrock	Granitoids, phyllites, slates, greywackes, schists. Patches of outwash may be present on some surfaces; frost-shattered heaved bedrock blocks on other surfaces.	N/A	Varies from flat plain to rugged hilly terrain; cliffs and steep valley walls.	Exposed bedrock is primarily from glacial erosion and removal of till from surfaces, especially where patches of outwash are present on its surface; heaved bedrock blocks result from frost shatter and heaving.

Source: Rampton (1994).

Plate 3.2-1 Surface covered with boulder lag of a till deposit (foreground). Lacustrine lowland deposit located beyond the till deposit (beige-coloured area).

3.2.2.2 Glaciofluvial Deposits

Glaciofluvial deposits cover a large portion of the claim block because of extensive meltwater activity. The meltwater appears to have moved as subglacial and interglacial streams and as supraglacial channels, the latter showing increased influence as the deglacial period progressed.

Eskers and hummocky kames contain the best-sorted glaciofluvial material. The extent of washing and sorting suggests significant transport distance. Kame and kettle complexes, which have gentle to moderate slopes, and glaciofluvial blankets containing moderately and poorly sorted sediments comprise landforms that have been subject to less transport and washing by meltwater.

These landforms are composed of well-sorted sand and sandy gravel (Plate 3.2-2). This allows good drainage and limits ground ice formation during annual re-freezing, which results in a thick active layer. These conditions enhance habitat opportunities for burrowing animals, hence eskers are frequent denning sites for larger mammals. The ecological significance of eskers and other surficial geological deposits is discussed further in Section 3.6, Terrain and Vegetation, of this document.

Plate 3.2-2 The most distinct glaciofluvial deposits are the eskers that form sharp continuous linear ridges.

Boulder lags and cobbly bouldery gravels are found in areas where much of the till has been removed by meltwater. These materials are believed to have been subject to little transport from where they were eroded out of the till or dislodged from the bedrock.

3.2.2.3 Glacial Deposits

Glacial deposits, including ablation and basal or lodgement till, cover much of the claim block. These deposits generally have a sandy texture with a minor silt component. The texture is relatively coarser in ablation till, and the fines content (mainly silt) is relatively higher in areas underlain by metasediments than in areas underlain by granitoids. Surface examination indicates that tills in some areas have a higher boulder content, but this may also be due to glaciofluvial erosion and deposition. Some areas of till veneer and till blanket were formed by erosion of formerly thicker basal or lodgement and ablation till units by meltwater.

3.2.2.4 Ablation Till

Ablation till represents the accumulation of glacial debris during melting. Deposits are commonly stratified, a reflection of the interaction between ice and meltwater depositional environments that characterize a decaying ice mass. Accordingly, the deposits include complexly interbedded coarse till with glaciofluvial gravels and, occasionally, glaciolacustrine sand and silt deposits.

3.2.2.5 Basal or Lodgement Till

Most till in the claim block is basal or lodgement till, the product of plastering or smearing of ground up bedrock material on the surface underlying the glacier. Generally the closer the till is to the underlying bedrock interface, the closer the up-glacier bedrock source of the constituent particles.

3.2.2.6 Bedrock

Glacial meltwater completely stripped bedrock of its till cover over large areas in meltwater corridors (Plate 3.2-3). Indeed, most bare bedrock throughout the claim block may owe its exposure to meltwater activity. The action of the meltwater has resulted in gaps in eskers where bedrock is exposed and patches of glaciofluvial materials over bedrock in meltwater corridors.

Plate 3.2-3 Bedrock outcrop is exposed, having been stripped of overlying glacial till by subglacial meltwater.

In areas of metasediments where till is thin, frost-shattered and occasionally frost-heaved bedrock blocks are common. Where boulder concentrations have resulted from meltwater erosion, it is frequently difficult to distinguish glacially transported boulders from *in situ*, frost-heaved blocks, although the latter tend to be more angular.

3.2.3 Permafrost

3.2.3.1 Regional Permafrost

A major feature of northern circumpolar regions, and one of considerable ecological and engineering importance, is permafrost. Permafrost underlies approximately 50% of Canada, mostly at higher latitude, including polar glaciers and parts of the continental shelf in the Arctic Ocean, and at higher elevations as far south as the 49th parallel. Permafrost is defined as soil or rock whose temperature has been below 0°C for at least two years. It is generally broken down into continuous and discontinuous zones (Boyd *et al.*, 1981; Brown *et al.*, 1981). The development area and the Lac de Gras region lie within the continuous permafrost region.

The thin zone at the ground surface, known as the active layer, thaws and re-freezes annually. The active layer thickness depends upon the nature of the soil constituents and vegetation cover. The active layer in the Lac de Gras region ranges from about 40 cm thick in organic soils to several metres thick in areas of exposed rock.

A widely accepted ground ice descriptive system, which is commonly used in the broader sense to describe permafrost, has been developed by the National Research Council (Pihlainen and Johnston, 1963; Linell and Kaplar, 1966). Although the delineation of permafrost has nothing to do with moisture or ice content, the importance of ground ice in both geomorphology and engineering has given rise to this practice. The fundamental breakdown is based upon visible versus non-visible ground ice and whether the volume of water present is in excess of that which would fill void spaces when the material is thawed. Visible and excess ice is commonly associated with fine sand, silt and clay, and organic soils, but it can also be found in coarse sands and gravels (Plate 3.2-4) as well as along discontinuities in rock masses.

3.2.3.2 Local Permafrost

Permafrost data, including ground temperatures, in the development area have been gathered and reported by EBA Engineering Consultants Ltd. in a number of documents since 1994. Ground temperatures at the site have been measured to a depth of 280 m. These data indicate that permafrost thickness is approximately 320 m.

In general, the mean annual ground temperatures at the depth of zero annual amplitude (approximately 15 m) range from -4°C to -6°C. The permafrost table drops steeply at the shore of deep lakes, and ground temperature data below deep lakes confirm the absence of permafrost. This has been verified in bulk sampling tunnels that encountered thawed zones below the lakes. Deeper than normal thaws have also been recorded below streams at the outlets of some lakes.

Plate 3.2-4 Ground ice exposed during gravel extraction operations at the EKATI™ Diamond Mine.

The depth of the active layer varies as a function of soil type, ranging from 0.4 to 2.5 m. A thin active layer is associated with peat-covered low-lying areas where abundant soil moisture and insulating properties of organic soils support a well-developed vegetation cover. A thick active layer is associated with well-drained till uplands, esker ridges and kames that are devoid of vegetation. Exposed bedrock has an even deeper summer thaw depth than above-mentioned relief features. The depth of the active layer has been measured to be approximately 5 m at bedrock outcrops.

Ground ice conditions vary significantly with terrain type. On uplands or sloping terrain, basal tills composed of compact silt, sand and gravel matrix with cobbles and boulders are relatively free of excess ice. Where they underlie peat or lacustrine deposits, they are moderately ice-rich, with stratified lenses up to 10 mm in thickness being commonplace. Ablation tills are less dense and contain a greater volumetric ice content. A massive body of ground ice, approximately 10 m thick, was encountered in hummocky moraine sampled at the north end of Long Lake. The thin lacustrine silt and sand deposits that occupy lowlands bordering lakes are commonly ice-rich. Ground ice conditions in eskers are highly variable. Massive ground ice bodies have been encountered in eskers, most frequently near their basal contact with the underlying till. A massive body of ground ice, approximately 5 m thick, was encountered in the Airstrip Esker. Retrogressive thaw of massive ice near the lower slopes of eskers has resulted in arcuate thermokarst depressions that sometimes give the eskers a scalloped appearance.

The following types of patterned ground, a periglacial landform indicative of permafrost, are found in the development area:

- Ice-wedge polygons are found in low-lying areas underlain by organic and lacustrine deposits.
- Sand-wedge polygons occur on flat or gently sloping surfaces of esker ridges.
- Frost boils, micro-landforms that belong to the group of the nonsorted circles, occur on till planes, where surface is underlain by fine-grained material.
- Stony earth circles, micro-landforms that belong to the group of the nonsorted circles, occur on till planes where surface is underlain by coarser material.
- Sorted circles are weakly developed on poorly drained till planes.

Permafrost-related slope forming processes, such as solifluction, thaw slumping, *etc.*, are not present to any significant degree. Some small lakes are probably of thermokarst origin, thus being indicative of the occurrence of excess ground ice.

3.2.4 Terrain Characteristics in the Proposed Development Area

The following sections provide a brief description of the surficial terrain characteristics in the vicinity of the proposed Sable, Pigeon and Beartooth development sites and along the proposed Sable Road alignment. The analysis for the road route begins near the existing facilities at Panda Pit and continues north along 27 designated mapping segments to the Sable area.

3.2.4.1 Sable Pit

Rolling ground moraine up to 15 m thick underlies terrain south, east and northeast of Sable Lake. The glacial deposits are anticipated to be somewhat thinner west and northwest of the lake, ranging from 1 to 5 m. Outcropped bedrock forms a cliff at the shoreline along the east shore of the lake. Individual and concentrated boulders are found on the ground surface at some locations. Patterned ground such as non-sorted and sorted circles, stone polygons and rings are well defined on the elevated flat and gently sloping windblown surfaces.

The terrain in the area west of Ulu Lake is predominately covered with a relatively thin till veneer less than 2 m thick. Patches of till blanket up to 5 m thick and bedrock protruding through the till cover are present at isolated locations. Immediately to the east of Ulu Lake the terrain is characterized by rolling ground moraine composed of till up to 15 m thick. Further east of this ground moraine, the landscape is typified by exposed washed bedrock with localized thin patches of glaciofluvial sediment, concentrations of boulders and patches of till.

Rolling ground moraine composed of thick till (up to 15 m) surrounds most of the Two Rock Lake perimeter. The till thickness is anticipated to be considerably less in the

vicinity of the easternmost tip of the lake. Bedrock, exposed as a cliff along a 120 m section of the north shore, is indicative of a somewhat thinner till cover east of the outlet of Two Rock Lake. Patches of exposed bedrock and isolated boulder fields occur between the east end of Two Rock Lake and the southwest corner of Ulu Lake. Patterned ground, represented by well-defined frost boils, is widespread on the gently sloping surfaces around Two Rock Lake.

Lacustrine and organic deposits that may contain excess ground ice underlie a poorly defined, elongated flat depression just south of Horseshoe Lake, to the north of the outlet of Two Rock Lake. The depression is vegetated with dwarf birch and willows. A few boulders are scattered across the surface of the depression, and a concentration of boulders is found at the outlet of Two Rock Lake.

Thin patches of potentially ice-rich lacustrine sediments exist at isolated locations in the vicinity of Sable, Ulu and Two Rock lakes.

3.2.4.2 Pigeon Pit

Pigeon Stream flows into Pigeon Pond from the north and exits to the west, crossing flat, low-lying wetland terrain underlain by organic peat and silt deposits. Small ice-wedge polygons are evident north of the pond along the east side of the creek. A few boulders occur at surface in the low-lying area in close proximity to both the creek and the pond.

Northwest of the pond, beyond the wetland area, the surface rises slightly, reflecting the underlying bedrock topography. The area is covered with a thin till veneer (less than 2 m thick) with well-defined stony earth circles on its surface.

An isolated kame consisting of partially water-sorted and crudely stratified sand and gravel lies approximately 500 m north of Pigeon Pond. The kame is shaped like an equilateral triangle with an approximate surface area of 11,000 m^2.

South and east of Pigeon Pond the terrain consists of rolling ground moraine covered with glacial till up to 15 m thick. Concentrations of boulders on the surface of the moraine at some locations suggest that the boulder content within the till is variable. The exposed boulder fields are the result of meltwater running off the glacial ice mass, causing erosion of finer material, possibly combined with some frost jacking.

3.2.4.3 Beartooth Pit

The topography of the Beartooth Lake area is characterized by rolling hills that reflect the morphology of the bedrock surface. West and south of Beartooth Lake the bedrock appears to have been washed of most of its surficial cover by meltwater flowing away from the glacial ice. A few thin patches of glaciofluvial sediments overlie the uneven bedrock surface at isolated locations.

Northeast of Beartooth Lake the bedrock is overlain by a till blanket up to 5 m thick. The surficial features throughout this area consist of well-defined, non-vegetated circular soil patches known as frost boils and stony earth circles. These features are generally restricted to windblown, and thus substantially snow-free, exposed ground (Williams and Smith, 1989). A few small boulder accumulations and individual boulders and bedrock blocks are disseminated across the ground surface. These features are the result of cumulative upward displacement caused by frost jacking.

A small stream flows through a vegetated area (dwarf birch and willows) from Bearclaw Lake, north of Beartooth Lake, into Beartooth Lake. Exposed boulders in the vicinity of the stream are the result of erosion of the fine-grained matrix material and/or material dislodged from the bedrock.

Glaciofluvial deposits underlie the area to the southeast between Beartooth Lake and North Panda Lake.

3.2.4.4 Sable Road

An all-weather access road will be constructed to connect the existing EKATI™ facilities to the three new pit areas. The first part of the road is the Beartooth section, 0.7 km long, which begins just northwest of the existing Panda Pit and departs from the previously constructed Panda perimeter road. The next section continues 4.3 km northeasterly to the Pigeon development site, followed by the main-18.4 km-long road from Pigeon to the Sable Pit area. The proposed alignment for the Sable Road is shown in Figure 3.2-1.

The topography along the general road alignment is characterized by low to moderate relief with undulating glacial and glaciofluvial ridges and hills having gentle to moderate slope that reflect the morphology of the underlying bedrock. Topographic variations correspond to lithological changes, from highly resistant, competent granitic rocks expressed by the elevated relief features to less-resistant biotite-schist that corresponds to the low-lying relief. Permafrost-related features, such as well-defined patterned ground and landforms created by glacial deposition and erosion, and glaciofluvial features (eskers, kames, glacial outwash and their complexes) found along the proposed alignment are indicative of soil composition and ground ice occurrence.

Most of the route traverses gently undulating and rolling ground moraine composed of compact till that consists of silt, sand and gravel matrix containing cobbles and boulders. The till cover ranges from 0.5 to 5 m thick along the southern portion of the alignment to 15 m thick along the northern portion. The glacial deposits are underlain by predominately granite bedrock. The terrain is generally well drained.

Northeast of Pigeon Pond the road will cross Pigeon Stream, which is underlain by organic and alluvial deposits that may contain excess ground ice. Further north, the road traverses glaciofluvial sediments between several kames. At some locations, such as west of Ursula Lake, the road will cross exposed bedrock with thin patches of glacial outwash material. To the southwest of Ursula Lake, elongated narrow flat depressions are filled with organic deposits.

The proposed route passes between discontinuities in two major esker complexes of the region - the Exeter and the Ursula. The Exeter Esker complex in the vicinity of the alignment is not as well defined in the present-day topography as the Ursula Esker complex. The main part of the Exeter Esker appears to wind across the terrain with disregard to details of local topography. The road route crosses a flat, low-lying section of reworked glaciofluvial outwash sediments situated to the east of the main esker ridge.

In the Ursula Lake area, the well-defined main esker takes form in the typical sinuous shape with relatively steep slopes and low-lying discontinuities in the esker ridge. The proposed alignment traverses between one of the discontinuities, following partially exposed bedrock with patches of glaciofluvial material.

The majority (94%) of the Sable Road alignment traverses terrain that is considered as having low to medium sensitivity with regard to potential permafrost disturbance. The remaining 1.3 km (6%) crosses surficial materials that are considered as having a high sensitivity. The sections where the surficial conditions are of high sensitivity are generally no more than 100 to 200 m in length.

A more detailed terrain analysis for the 27 segments from south to north along the proposed Sable Road is provided in Table 3.2-2.

Table 3.2-2
Sable Haul Road Terrain Analysis

Segment	Start (km)	Length (km)	Terrain Analysis Description	Permafrost Sensitivity
1	0.0	3.6	Exposed washed bedrock with patches of outwash material composed of sand and gravel with some cobbles and boulders. Well drained.	Low
2	3.6	2.4	Rolling ground moraine: 5 to 15 m thick, consisting of hills and ridges with gentle to moderate slopes. Compact till composed of silt, sand and gravel matrix with cobbles and boulders. Local concentrations of boulders on the ground surface. Generally well drained.	Low
3	6.0	0.1	Elongated flat depression (Pigeon Stream). Organic and alluvial deposit up to 2 m thick. Contains excess ice. Poorly drained.	High
4	6.1	0.4	Rolling ground moraine: 5 to 15 m thick, consisting of hills with gentle to moderate slopes. Compact till composed of silt, sand and gravel matrix with cobbles and boulders. Local concentrations of boulders on the ground surface in elongated shallow depressions. Generally well drained.	Low
5	6.5	0.1	Elongated flat area underlain by organic deposit up to 2 m thick. Contains excess ice. Poorly drained.	High

(continued)

Table 3.2-2
Sable Haul Road Terrain Analysis (continued)

Segment	Start (km)	Length (km)	Terrain Analysis Description	Permafrost Sensitivity
6	6.6	0.70	Kame and kettle complex: mainly sand and gravel, 3 to 15 m thick. Contains excess ice. Well drained.	Medium
7	7.3	0.2	Low-lying area underlain by lacustrine deposits 0.5 to 3.0 m thick. Mainly silt and sand with lenses and layers of organic detritus. Contains excess ice. Imperfectly drained.	High
8	7.5	0.7	Till veneer: 0.5 to 2 m thick. Surface mimics shape of underlying bedrock; includes patches of bedrock and till veneer. Generally well drained.	Low
9	8.2	0.3	Relatively low-lying gently sloping surface underlain by a thin layer of outwash located just east of the Exeter Esker. Mainly well-sorted sand and gravel. Well drained.	Low
10	8.5	0.2	Low-lying area underlain by lacustrine deposits 0.5 to 3.0 m thick. Mainly silt and sand with few lenses and layers of organic detritus. Contains excess ice. Poorly drained.	High
11	8.7	2.1	Till blanket: 1 to 5 m thick, composed of compact silt, sand and gravel matrix with cobbles and boulders. Surface expression is fluted and drumlinized; includes patches of bedrock and till veneer. Generally well drained.	Low
12	10.8	0.2	Low-lying area underlain by lacustrine deposits 0.5 to 3.0 m thick. Mainly silt and sand with few lenses and layers of organic detritus. Contains excess ice. Poorly drained.	High
13	11.0	2.8	Till blanket: 1 to 5 m thick, composed of compact silt, sand and gravel matrix with cobbles and boulders. Surface expression is fluted and drumlinized; includes patches of bedrock and till veneer. Generally well drained.	Low
14	13.8	0.4	Till veneer: 0.5 to 2 m thick. Surface mimics shape of underlying bedrock; includes patches of bedrock and till veneer. Generally well drained.	Low
15	14.2	0.1	Low-lying area underlain by lacustrine deposits 0.5 to 3.0 m thick. Mainly silt and sand with few lenses and layers of organic detritus. Contains excess ice. Poorly drained.	High
16	14.3	0.8	Till blanket: 1 to 5 m thick, composed of compact silt, sand and gravel matrix with cobbles and boulders. Surface expression is fluted and drumlinized; includes patches of bedrock and till veneer. Generally well drained.	Low

(continued)

Table 3.2-2
Sable Haul Road Terrain Analysis (continued)

Segment	Start (km)	Length (km)	Terrain Analysis Description	Permafrost Sensitivity
17	15.2	0.1	Elongated flat depression. Organic deposit up to 2 m thick. Contains excess ice. Poorly drained.	High
18	15.3	0.9	Till blanket: 1 to 5 m thick, composed of compact silt, sand and gravel matrix with cobbles and boulders. Surface expression is fluted and drumlinized; includes patches of bedrock and till veneer. Generally well drained.	Low
19	16.2	1.8	Exposed washed bedrock with patches of outwash material composed of sand and gravel with some cobbles and boulders. Well drained.	Low
20	18.0	0.1	Partially exposed bedrock overlain by a thin layer of well-sorted glaciofluvial material. Low-lying discontinuity between well-defined ridges of the Ursula Esker complex. Well drained.	Low
21	18.1	0.1	Low-lying area underlain by organic deposits up to 2 m thick. Contains excess ice. Poorly drained.	High
22	18.2	0.2	Exposed washed bedrock with patches of outwash material composed of sand and gravel with some cobbles and boulders. Well drained.	Low
23	18.4	0.1	Low-lying area underlain by organic deposits up to 2 m thick. Contains excess ice. Poorly drained.	High
24	18.5	0.4	Till veneer: 0.5 to 2 m thick. Surface mimics shape of underlying bedrock; includes patches of bedrock. Generally well drained.	Low
25	18.9	0.4	Till blanket: 1 to 5 m thick, composed of compact silt, sand and gravel matrix with cobbles and boulders. Surface expression is fluted and drumlinized; includes patches of bedrock and till veneer. Generally well drained.	Low
26	19.3	0.1	Elongated flat area underlain by organic deposit up to 2 m thick. Contains excess ice. Poorly drained.	High
27	19.4	4.0	Rolling ground moraine: 5 to 15 m thick, consisting of hills and ridges with gentle to moderate slopes. Till composed of compact silt, sand and gravel with cobbles and boulders. Boulder fields. Generally well drained.	Low
End: 23.4 km				

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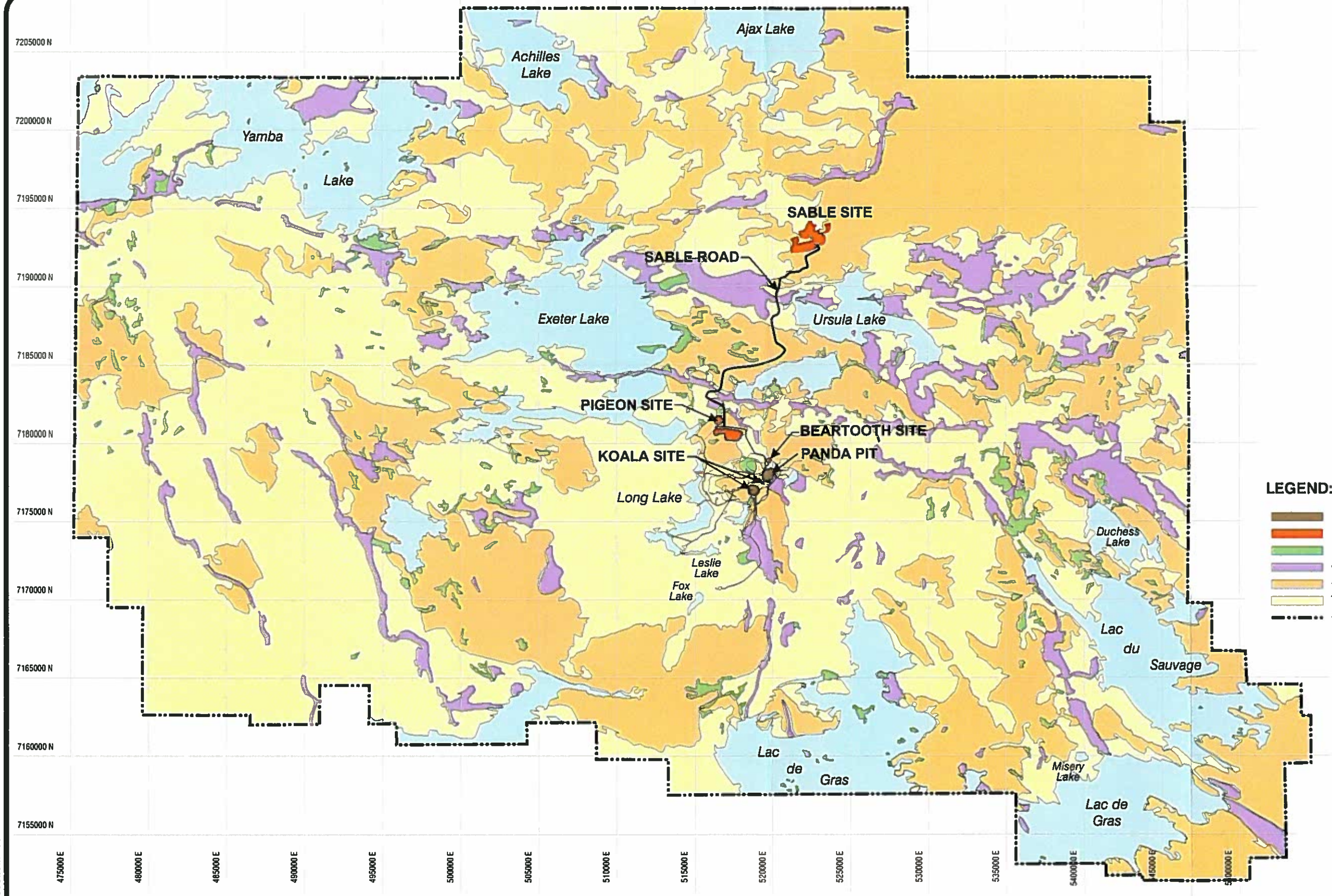

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FIGURE 3.2-1

Terrain Conditions Common to Claim Block

BHP

Ekati diamond mine

Adapted from Rampton 1994

3.3 Hydrology

BHP's claim block is located in the upper reaches of the Coppermine River Drainage Basin (Figure 3.3-1). The basin is 520 km long and has a total drainage area of approximately 50,800 km^2. The Coppermine River winds about 845 km from its headwaters in the Lac de Gras Watershed until it empties into Coronation Gulf near Kugluktuk (GeoNorth, 1997).

To date, development activities at the EKATI™ Diamond Mine have been limited to the Lac de Gras Watershed (3,980 km^2) and, within this area, the Koala Watershed (185 km^2) (BHP, 1995). The proposed development of the Sable and Pigeon pits and associated infrastructure will begin to impinge upon two small headwater areas of the Yamba/Exeter Watershed (3,070 km^2). These are the Horseshoe Lake drainage area (88.9 km^2) and the Pigeon drainage area (11.3 km^2). The physiographic characteristics of this region have also produced a landscape that contains approximately 8,000 lakes within the BHP claim block, representing approximately one-third of the total land mass in this area.

The hydrological characteristics of the potentially affected watersheds around the EKATI™ Diamond Mine have been studied and monitored to various degrees of intensity since 1994. In particular, water flows in the Koala drainage basin have been monitored continuously for the past six years (BHP, 1995; Rescan, 1996a, 1998a, 1998b, 1999a).

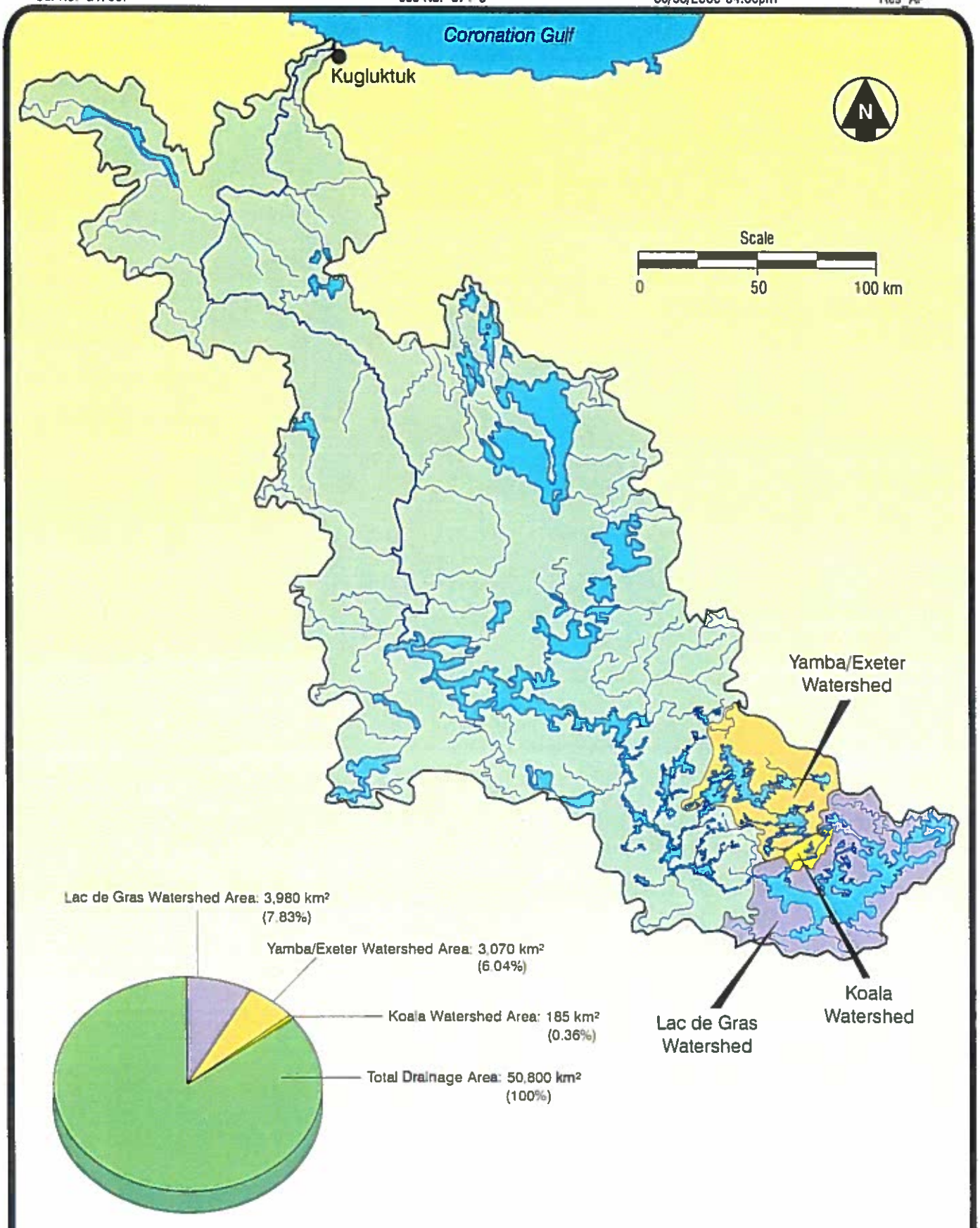
The information generated from the Koala Watershed work is directly applicable to the proposed development activities and infrastructure in the vicinity of the future Beartooth Pit. In its present form, Beartooth Lake drains into Upper Panda Lake and through the downstream Koala Watershed into Lac de Gras.

The data generated for the Koala Watershed area are also useful and can be applied to other adjacent watersheds, including the small ephemeral streams and waterbodies in the Yamba/Exeter Watershed that may be affected by the proposed Sable and Pigeon pit and Sable Road development activities in this area.

3.3.1 Koala Watershed

The Koala Watershed has been studied continuously since 1994. This includes monitoring of all major waterways and of lake levels. Monitoring locations are listed in Table 3.3-1.

The hydrologic cycle of the Koala Watershed is controlled by the temperature regime of the area. The onset of freezing temperatures in October marks the end of the open water season. Snow that accumulates from October to May contributes to freshet flows as temperatures rise above the freezing mark in the spring. Peak freshet flows generally



Coppermine River Drainage Basin

FIGURE 3.3-1

Table 3.3-1
Monitoring Locations in
Koala Watershed Waterways and Lakes

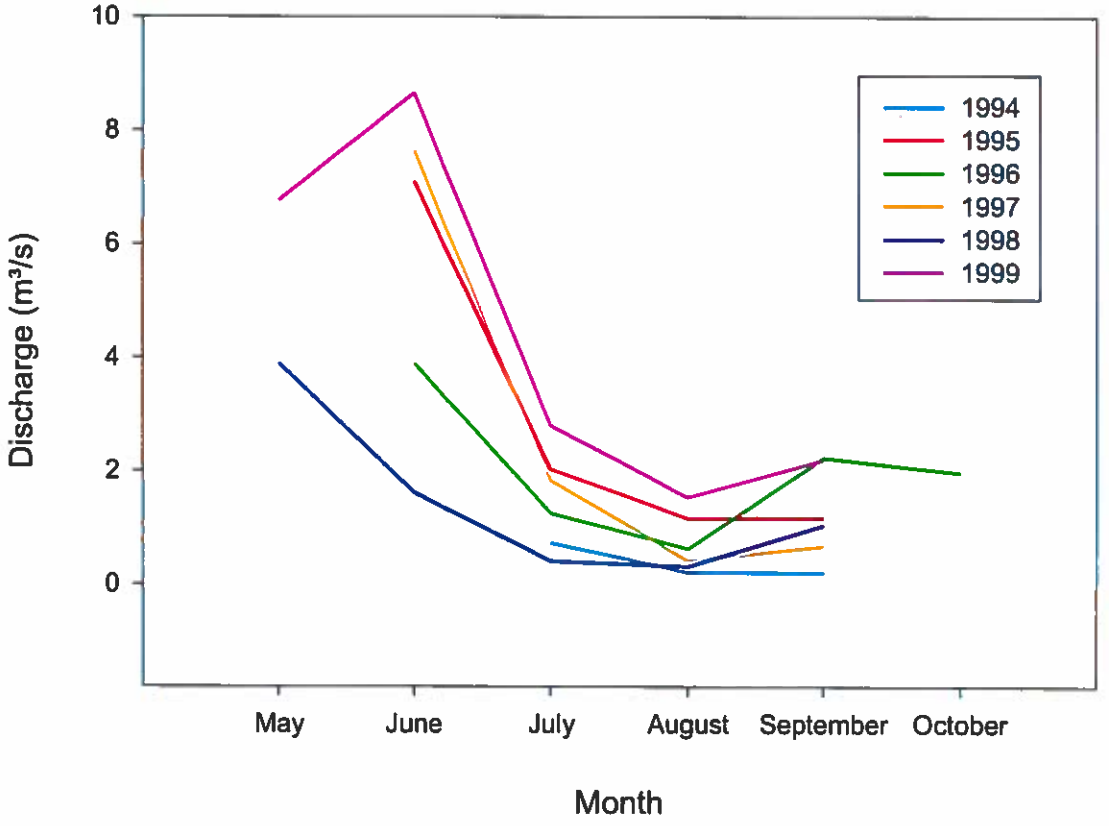
Waterways	Lakes
Long Lake Outflow (WGS-02)	Long (WGL-01, 02, 03)
Slipper-Lac de Gras (WGS-24)	White (WGL-45)
Nema-Martine (WGL-30)	Moose (WGL-34)
Moose-Nero (WGL-34)	Panda (WGL-09)
Kodiak-Little (WGL-10)	Kodiak (WGL-10)
North Panda Outflow (WGS-38)	Koala (WGL-12)
Vulture-Polar (WGS-14)	Larry (WGL-16)
Grizzly Outflow (WGS-37)	Martine (WGL-16)
	Fox 1 (WGL-18)
	Leslie (WGL-31)
	Nora (WGL-19)

occur in late May to early June. Flows decline thereafter and reach minimum values in mid to late August. Flow levels then respond to late summer rainstorms until freezing temperatures return, which completes the hydrologic cycle.

Figure 3.3-2 shows long-term mean monthly data for Slipper-Lac de Gras; this station is located at the final exit point of the Koala Watershed. Yearly changes in the magnitude of freshet flows are directly influenced by precipitation conditions. High peak flows in 1995, 1997 and 1999 are reflective of heavy winter snow accumulation and heavy spring rainstorms. Flows within the Koala Watershed respond in a predictable fashion to the climatic conditions of the area. For example, the onset of freshet flows can generally be predicted by average daily air temperature; furthermore, the magnitude of freshet flows is correlated with precipitation data.

Flow conditions are predictable not only at Slipper-Lac de Gras but throughout the entire Koala Watershed. Figure 3.3-3 presents the 1999 hydrographs for all the sites monitored within the Koala Watershed. All peak freshet flows occurred on June 5, followed by declines in unit yield until the onset of late summer rain events. From the five monitoring locations, only the magnitude in peak freshet flows at Vulture-Polar and Moose-Nero deviated from the other locations. The extremely high peak seen at Vulture-Polar can be explained by an ice dam that formed downstream on the Panda Diversion Channel. This ice dam blocked the passage of water for some time and possibly created backflow conditions. Abnormally high water levels persisted until the blockage was cleared.

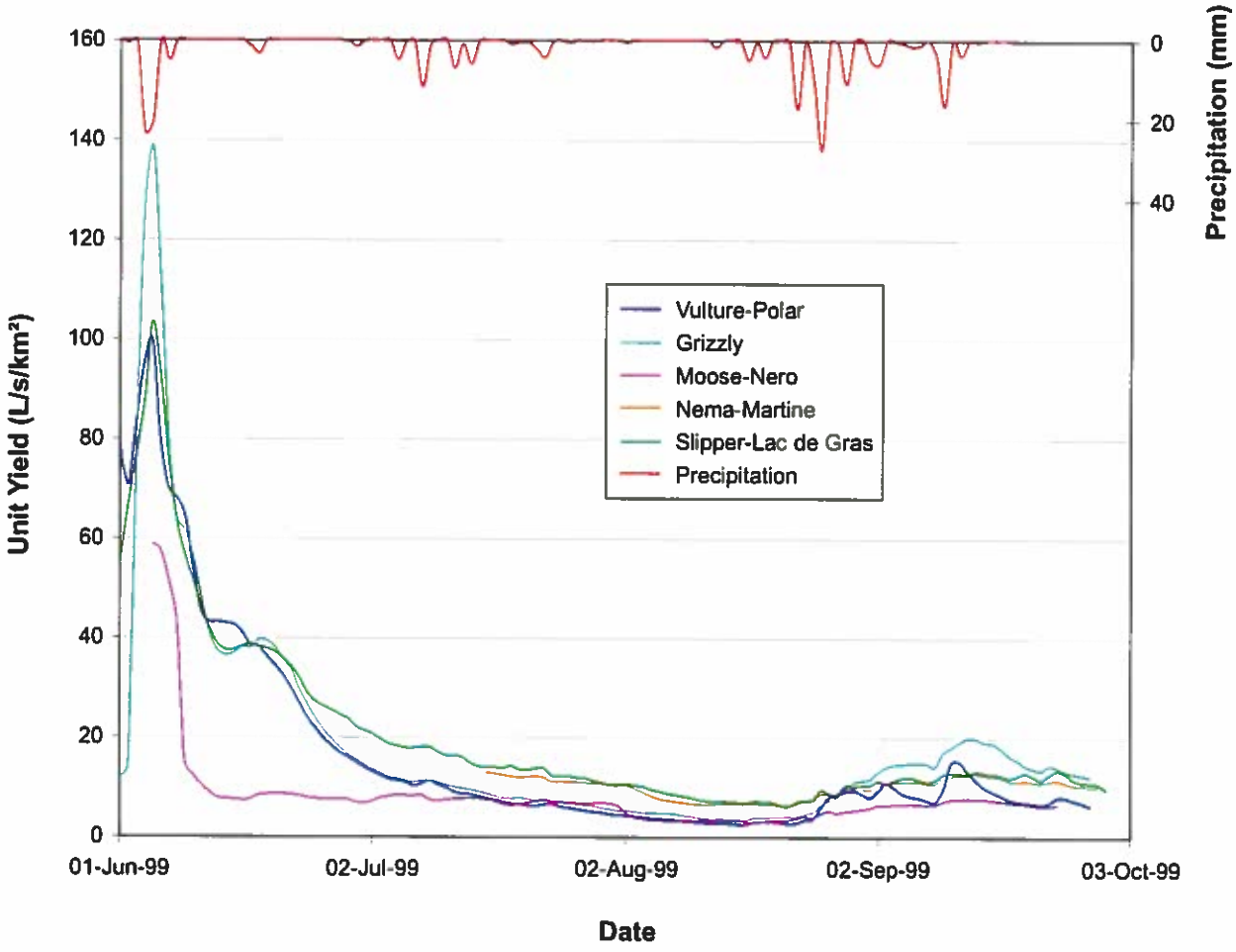
The hydrology within the Koala Watershed is also comparable to the hydrology of two reference watersheds: King-Cujo and Counts Lake, approximately 20 km and 30 km southeast of the Koala Watershed, respectively. Flow patterns, including the timing and magnitude of peak freshet and minimum flows, are very similar among the three



Monthly Mean Discharge at Slipper-Lac de Gras (WGL-24) from 1994 to 1999

FIGURE 3.3-2

Source: Rescan, 1999a



Unit Yield for Site-Specific Gauges for the Entire Open Water Season in 1999

FIGURE 3.3-3

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Source: Rescan, 1999a

watersheds. Table 3.3-2 provides minimum flows and data of occurrence for Vulture-Polar, Moose-Nero, Nema-Martine, Slipper-Lac de Gras and Counts monitoring stations. The lowest daily flows at Moose-Nero were influenced by dewatering activities at Long Lake.

Table 3.3-2
Summary of Lowest Daily Flow at Six Monitoring Locations

	Minimum Daily Flows (m^3/s) with Date of Occurrence				
	1995	1996	1997	1998	1999
Vulture-Polar	n/a	n/a	0.008	0.006	0.017
	n/a	n/a	(Aug 20)	(Aug5)	(Aug 22)
Moose-Nero	n/a	n/a	0.020	0.003	0.015
	n/a	n/a	(Aug 25)	(July 6)	(July 1)
Nema-Martine	n/a	0.086	0.246	0.074	0.704
	n/a	(Aug 8)	(Aug 21)	(July 23)	(Aug 22)
Slipper-Lac de Gras	0.910	0.135	0.208	0.100	1.15
	(Aug 27)	(Aug 7)	(Aug 22)	(Aug 5)	(Aug 22)
Counts Outflow	n/a	n/a	0.026	0.003	0.009
	n/a	n/a	(Aug 19)	(Aug 22)	(Aug 22)

n/a: not available

The Hydrological Atlas of Canada (Canadian National Committee for the International Hydrological Decade, 1978) indicates that annual runoff in the Koala Watershed area for the entire open flow season is approximately 100 to 200 mm. Recently, Rescan has refined this information by the use of two factors: precipitation data from the EKATI™ meteorological station, and an estimated a runoff coefficient applicable to the Koala Watershed. Based on this information the 1:10, 1:20 and 1:100 year total runoff depths are 294, 320 and 382 mm, respectively. Table 3.3-3 provides runoff depth for a common period of record dating back to 1995. Differences from year to year are driven by fluctuations in precipitation.

Table 3.3-3
Runoff Depth (mm) for a Common Period of Record

	1995	1996	1997	1998	1999
Vulure-Polar	n/a	n/a	n/a	40	88
Moose-Nero	n/a	n/a	37	42	29
Nema-Martine	n/a	54	63	23	n/a
Slipper-Lac de Gras	102	60	83	25	123

Note: The common period of record is June 14 to September 13, 1999.

The 1999 calculated runoff depths within the Koala, Counts and King-Cujo Watersheds do not show a consolidated relationship with drainage area (Figure 3.3-4). Usually, the correlation of runoff depth and drainage area is vice versa (Baumgartner *et al.*, 1990). This unique trend was also seen in previous years' data, though the correlation was not as strong. Establishing this relationship requires the monitoring of flows from the on-set of the open water season to winter freeze-up in October.

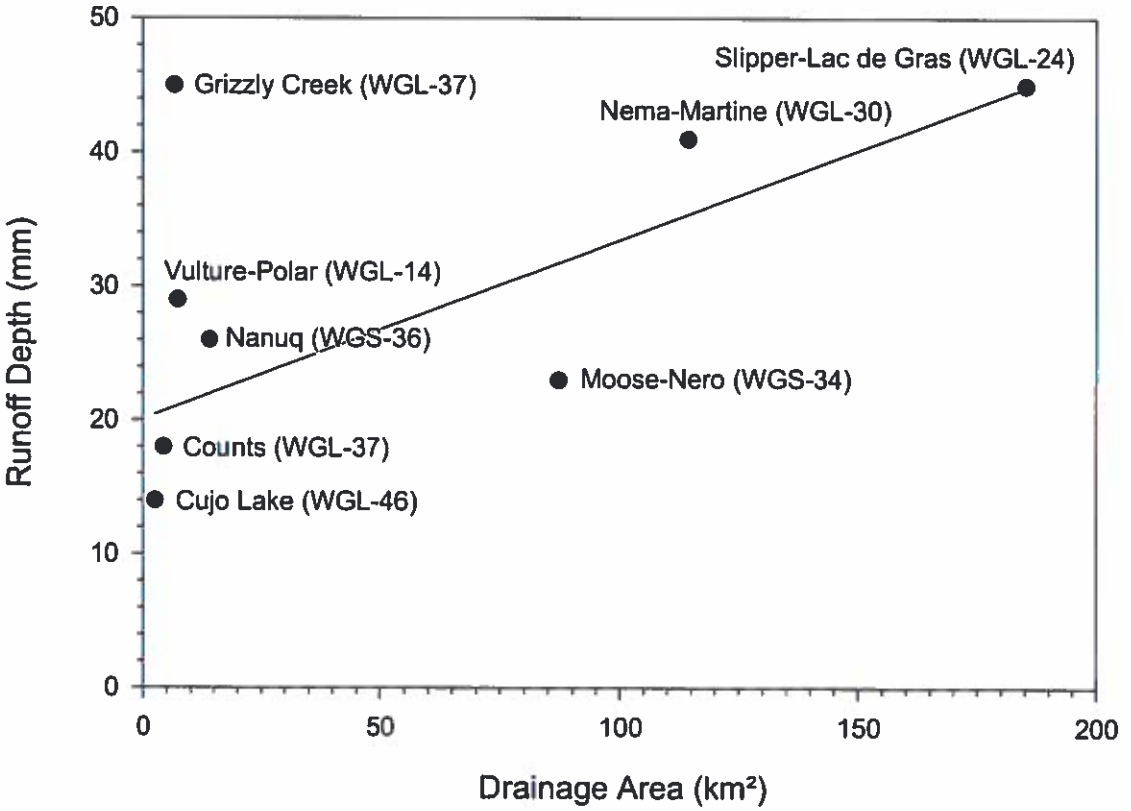
To date, six years of flow data have been collected from the Koala Watershed. In addition, more than 20 years of flow data are available from a nearby watershed, Indin River. The monitoring station at Indin River was established by Environment Canada and is still in operation. Information obtained from Indin River is in general agreement with that obtained from the Koala Watershed. It is therefore possible to extrapolate long-term hydrological data from Indin River to the Koala Watershed, while considering a correction factor. Knowledge of extreme events - required for the design of engineered structures - could then be estimated for the Koala Watershed.

The compatibility of the hydrologic conditions within the Koala Watershed and those of the surrounding watersheds reflects the similar climatic and physical conditions within the area. Large fluctuations in temperature and precipitation are not expected to occur in a localized area such as that encompassed by Koala, Counts and King-Cujo watersheds. Furthermore, the physical features of the area are similar throughout the claim block.

3.3.2 Yamba/Exeter Watershed

The Yamba/Exeter Watershed is situated northwest of the Lac de Gras Watershed. To date, no specific long-term hydrological data are available for the Exeter/Watershed. However, because the overall climatic and physical conditions are similar, data from long-term monitoring of the Koala Watershed are useful for application on adjacent watersheds.

A small basin of the Yamba/Exeter Watershed, the Pigeon drainage area, was monitored during the 1999 open water season. Three automated hydrometric stations were monitored from June 2 to September 29, 1999. During this time, water levels were monitored at half-hour intervals. Stream flow measurements were also taken to generate a stage discharge rating curve for three locations along Pigeon Stream. Monitoring results showed similar hydrologic conditions between Pigeon Stream and the Koala Watershed. The timing of peak and minimum flows on Pigeon Stream were comparable to those recorded for the Koala Watershed. The general shape of the hydrographs produced for Pigeon Stream were also similar to those of the Koala Watershed.



Note: The common period of record for these stations was August 4 to September 24, 1999. The correlation between runoff depth and drainage area was calculated excluding data from Grizzly Creek.

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Runoff Depth vs. Drainage Area of Site-Specific Drainage Basins

FIGURE 3.3-4

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Source: Rescan, 1999a

3.4 Water and Sediment Quality

Water and sediment quality within the watersheds of the BHP claim block play an important role in defining the local aquatic ecosystems of the project area, as well as those of receiving waters further downstream in the Coppermine River Drainage Basin (BHP, 1995). Stakeholders, especially members of the community of Kugluktuk, located near the mouth of the Coppermine River, remain very concerned about possible impacts that EKATI™ Diamond Mine and other proposed developments may have on the overall health of the Coppermine River system.

In recognition of this continuing concern, BHP has collected water and sediment quality data from various claim block streams and lakes from 1993 to the present time.

This section begins with a description of water quality conditions in the Coppermine River Drainage Basin, followed by reviews of the water and sediment quality data obtained for the BHP claim block and surrounding region.

3.4.1 Water Quality in the Coppermine River Drainage Basin

Environment Canada (1988) and GeoNorth (1997) have both reviewed water quality conditions in the Coppermine River Drainage Basin. Water quality is influenced primarily by the underlying rock formations (GeoNorth, 1997). The igneous rock-dominated Slave Geological Province to the south and the sedimentary rock-dominated Bear Geological Province to the north represent two distinct geochemical and metallogenic areas. As the waters in the Coppermine River Basin flow northward, natural sediment loadings, pH, alkalinity, conductivity and metal concentrations of the water all increase. Generally, the shift in water quality occurs between Redrock Lake and Fairy Lake River and is roughly coincident with the boundary between the two geological provinces. It is important to note that the basin experiences seasonal trends in water quality as well. Generally, the waters are higher in conductivity, calcium, magnesium and alkalinity from June to September (Environment Canada, 1988).

Two main spatial trends were observed in the Coppermine Basin study (Environment Canada, 1988). The first trend was an increase in the pH of Coppermine River water as it flowed downstream. Water in the upper basin exhibited a pH of approximately 6.6, increasing to 7.8 to 8.0 further downstream. This trend corresponds to the geology of the upper and lower basins. The upper basin consists mostly of Canadian Shield granitic material, whereas the lower basin is laden with more alkaline dolomitic sediments.

The second major spatial trend was a natural increase in conductivity from the upper basin to the lower sections of the river. Water in the upper basin showed conductivity levels of 10 and 11 µS/cm, similar to the level of 14 µS/cm measured in the Koala Watershed. The conductivity level of water in the lower basin increased to 83 µS/cm.

The Coppermine Basin study also reviewed metal concentrations in the Coppermine River downstream from Lac de Gras. All metal concentrations measured below detection limits, with the exception of arsenic (0.0002 mg/L) and nickel (0.002 mg/L). These concentrations were close to those detected in the initial baseline studies of the Koala Watershed (0.0002 mg/L for arsenic and 0.0025 mg/L for nickel; BHP, 1995).

Aluminum and lead concentrations were below detection limits in the Coppermine Basin study, although they were slightly elevated in the baseline studies of the Koala and surrounding watersheds. As reflected in the data, the lead levels were probably superficially high due to contamination from aerosols of unknown origin at the time of sampling (BHP, 1995). Elevated aluminum levels in the Koala Watershed have been linked to the presence of alumino-silicates in kimberlite pipes subjected to exploration drilling.

Water chemistry in the Koala and surrounding watersheds was compared with other aquatic systems in the Arctic (Schindler *et al.*, 1974; Welch and Legault, 1986; Cornwell, 1992). While concentrations of potassium and magnesium in the vicinity of the EKATI™ Diamond Mine were similar to those found in other arctic watersheds, concentrations of sodium and calcium were considerably lower (Table 3.4-1). This is likely the result of the Koala Watershed being in close proximity to the headwaters of the Coppermine River Drainage Basin. Natural waters have not traversed sufficient distances to accumulate major ions, and therefore represent little more than modified rainwater.

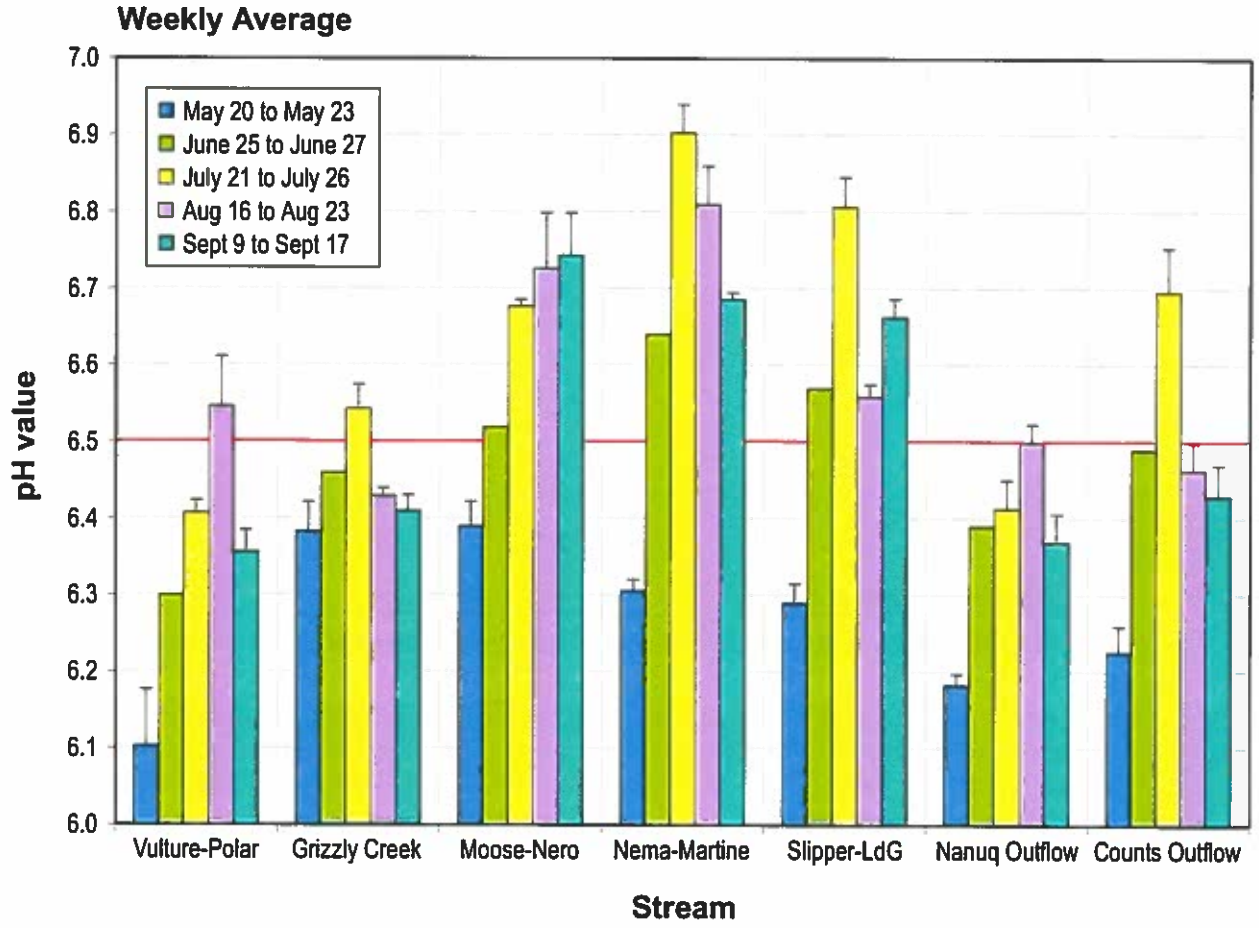
3.4.2 Water Quality in the BHP Claim Block

This section briefly describes the existing water quality in undisturbed lakes within the BHP claim block and other lakes that might potentially be affected by the proposed development.

3.4.2.1 Water Quality of Undisturbed Lakes within the BHP Claim Block

The waters of undisturbed lakes and streams within the BHP claim block are generally very clear and soft and have low concentrations of nutrients during the open water season. Lakes are oligotrophic, supporting very low phytoplankton biomass concentrations. Most metals are found in very low concentrations.

Water quality parameters change seasonally. Many parameters exhibit their highest concentrations during freshet (streams) or shortly after ice-off (lakes). Total suspended solids (TSS), turbidity, ammonia, nitrate, total phosphorus, total aluminum, total arsenic, total chromium, total copper and total nickel all exhibit this seasonal trend. As well, pH is lowest during these periods, as illustrated by the seasonal stream pH data presented in Figure 3.4-1.



Note: Error bars represent standard error

Seasonal Variation in pH, BHP Claim Block Streams

FIGURE 3.4-1

Source: Rescan, 1998b

Table 3.4-1
Major Ion Concentrations from Snow, Rain and Streams at Several High-Latitude Arctic Lakes

Lake	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)
Char Lake, NT				
Snow	0.92	0.20	2.08	0.58
Rain	0.80	0.20	19.56	0.73
Stream	8.39	0.90	33.59	6.64
Saqvaqjuac, NT				
Snow	0.28	<0.04	0.12	0.05
Rain	1.06	<0.04	0.24	0.10
Meadow	3.31	0.74	9.98	1.00
N&N	2.44	0.59	3.17	0.73
Far	2.25	0.35	3.01	0.70
Spring	4.69	0.74	4.25	0.87
Jade	2.32	0.47	4.05	0.68
Saqvaqjuac	1.75	0.39	5.65	0.80
Barrow, AK				
Snow	3.56	0.23	2.40	0.70
Rain	3.13	0.12	1.80	0.34
Toolik, AK				
Snow	0.23	0.06	1.20	0.15
Rain	0.07	0.05	0.24	0.07
Koala Watershed	0.53	0.46	0.85	0.56

Compiled from Schindler *et al.*, 1974; Welch and Legault, 1986; Cornwell, 1992; BHP, 1995.

The water pH values of undisturbed lakes typically range from approximately 6.2 to 7.1. Total suspended solid concentrations are generally below 3.0 mg/L, and turbidity values are generally below 2.0 NTU. Nitrate and total phosphorus concentrations are both typically below 0.008 mg/L.

Most metals of environmental concern are found in very low concentrations, with total concentrations of cadmium, chromium, silver, arsenic and lead being close to or below their respective detection limits. As well, most metal parameter concentrations fall well below the Canadian federal guidelines for the protection of fresh water aquatic life (CCREM, 1987). For example, total arsenic concentrations are typically two orders of magnitude below the criterion. Exceptions are total aluminum, which frequently exceeds criterion, and total copper, which occasionally exceeds criterion. The total aluminum criterion is pH-dependent; waters with a pH of <6.5 should not exceed 0.005 mg/L total aluminum. Waters within the claim block often fall below this pH value, especially during freshet. When this occurs, criterion levels are exceeded. However, total aluminum values are naturally high within the claim block, as illustrated from baseline data and from data obtained from reference lakes.

3.4.2.2 Water Quality of Two Rock, Ulu, Sable and Beartooth Lakes

Table 3.4-2 presents selected water quality parameters for BHP claim block lakes and for other lakes that will likely be affected by the proposed development. Water quality samples were collected from Two Rock and Ulu lakes on one occasion during the open water season of 1999 (Rescan, 2000a). Water quality samples from Sable Lake were collected once in July 1996 and again in July 1997 (Rescan, 1996b, 1998c). Samples from Beartooth Lake were collected once in July 1997 (Rescan, 1997a).

Table 3.4-2
Selected Water Quality Parameters for Lakes Affected by Development

Parameter	Units	Two Rock Lake Aug. 1999	Ulu Lake Aug. 1999	Sable Lake July 1996, 97	Beartooth Lake July 1997	BHP Claim Block Lakes
pH	pH units	6.5	6.4-6.5	6.4-6.7	6.1	6.2-7.1
Conductivity	µmhos/cm	14.2-14.7	16.8-17.1	32.0-42.0	14.0	9.4-22.0
TSS	mg/L	<3	<3-4	2-28	1-2	1-5
Turbidity	NTU	0.20-0.40	0.24-0.27	10.00-26.00	1.10	<0.10-3.00
Nitrate	mg/L	<0.006	<0.006	<0.005-0.012	<0.005	<0.005-0.010
Total Phosphorus	mg/L	0.004-0.006	0.005-0.009	0.014-0.203	0.006	0.001-0.010
Total Aluminum	mg/L	0.0170-0.0179	0.0152-0.0172	0.5780-0.7850	0.0680	0.0020-0.0175
Total Arsenic	mg/L	0.00016-0.00017	0.00020-0.00021	0.00040	0.00030	<0.00010-0.00040
Total Chromium	mg/L	0.00067-0.00077	<0.00006-0.00092	0.0020	<0.0005	<0.0005
Total Copper	mg/L	<0.0006-0.0006	0.0007-0.0008	0.0015	0.0015	<0.0005-0.0013
Total Iron	mg/L	0.020-0.022	0.033-0.038	0.54-0.71	0.08	<0.005-0.026
Total Lead	mg/L	<0.00005	<0.00005	0.00033-0.00042	0.00010	<0.00005-0.00008
Total Nickel	mg/L	0.00034-0.00045	0.00033-0.00076	0.01000	0.00250	0.00018-0.00050

Note: Values reported for BHP claim block lakes are derived from baseline data and data from reference lakes only.

3.4.2.2.1 Two Rock and Ulu Lakes

Concentrations of the physical parameters of Two Rock and Ulu lakes were similar to those measured in undisturbed lakes within the BHP claim block. The pH values ranged from 6.4 to 6.7, conductivity values from 14.0 to 17.1 µS/cm and hardness from 4 to 5 mg/L; total suspended solids remained below 5 mg/L. Nutrient concentrations (nitrate, ammonium, orthophosphate) were very low. This is similar to concentrations found in undisturbed lakes within the BHP claim block.

Total metal concentrations in Two Rock and Ulu lakes were low and well below the federal criteria for the protection of fresh water aquatic life. The only exception was total aluminum concentration, which exceeded the federal criterion and was measured at pH values below 6.5. However, total aluminum values measured in August were within the range of values measured for undisturbed BHP claim block lakes.

Overall, the water quality of Two Rock and Ulu lakes is similar to that of undisturbed lakes within the BHP claim block.

3.4.2.2.2 Sable Lake

Large-diameter exploration drilling was conducted at Sable Lake from February 7 to March 29, 1996, during which time BHP measured TSS and pH in the water column. Open water season samples were collected in July 1996 and again in July 1997 (Rescan, 1996b, 1998c).

The water quality of Sable Lake in 1996 was clearly affected by the winter exploration drilling, with TSS (15 to 28 mg/L), turbidity (20 to 26 NTU) and total phosphorus (0.05 to 0.20 mg/L) being higher than in other lakes in the area. Total metal concentrations were not measured in 1996, but they can also be assumed to have been elevated.

By 1997, the water clarity of Sable Lake had improved considerably, with TSS (~2 mg/L), turbidity (9 to 10 NTU) and total phosphorus (0.014 to 0.015 mg/L) all being lower in July 1997 than July 1996. Turbidity levels in Sable Lake were still higher compared to other lakes in the area, but it is likely that the water clarity has continued to improve with time and that the other water quality parameters are the same.

In 1997, total metal concentrations, including aluminum, chromium, iron, lead and nickel, were very elevated in Sable Lake compared to other lakes in the area and undisturbed BHP claim block lakes. This is likely the result of the bulk sampling activities that took place during the winter of 1996.

Overall, before winter drilling, the water quality (physical and nutrient parameters) of Sable Lake was similar to that of other lakes within the BHP claim block. It is unknown whether metal concentrations were ever the same in Sable Lake as in undisturbed lakes. It is also unknown whether total metal concentrations in 1999 have returned to pre-drilling levels.

3.4.2.2.3 Beartooth Lake

Small-diameter winter drilling was carried out in Beartooth Lake in May 1997. Water quality samples were collected in July 1997 during the open water season (Rescan, 1997a). The drilling season did not appear to have affected the quality of the upper water column in the lake. The samples indicated that the water was slightly acidic and clear, similar to other lakes in the area. Nutrient concentrations were low. Metal concentrations were low and mostly below detection limits. The low nutrient concentrations along with the high water transparency indicate that the lake is oligotrophic, similar to other lakes in the BHP claim block.

Total aluminum, iron and nickel concentrations in Beartooth Lake measured in July 1997 were elevated compared to those in undisturbed lakes within the BHP claim block. This may have resulted from the earlier winter exploration drilling activity.

Overall, the water quality of Beartooth Lake prior to winter drilling activity was probably similar to that of other lakes within the BHP claim block.

3.4.3 Sediment Quality in the BHP Claim Block

3.4.3.1 Sediment Quality of Lakes within the BHP Claim Block

Lake sediments in the undisturbed lakes within the BHP claim block typically consist of silt- to clay-sized particles, with occasional sandy fractions. Most sediments are unconsolidated and are fairly homogeneous (lacking distinct horizontal layers). Surficial sediments are typically oxic and dark yellowish brown or moderate olive brown in colour.

Many chemistry parameters of the sediments in the lakes are found at their highest concentrations at the greatest water depths. Nutrient and organic parameters are typically higher at depth than in shallow waters. This is also the case for aluminum, chromium, copper and nickel. Arsenic is the only metal that does not exhibit clear trends associated with depth.

Federal sediment quality guidelines (probable effect level) for nickel are typically exceeded at most lake sites. The sediment arsenic criterion is also often exceeded. These elevated concentrations of arsenic and nickel in lake sediments are a natural occurrence.

3.4.3.2 Sediment Quality of Two Rock, Ulu, Sable and Beartooth Lakes

Table 3.4-3 presents selected sediment chemistry parameters for undisturbed lakes within the BHP claim block and for Two Rock and Ulu lakes. Of the potentially affected lakes, only Two Rock and Ulu have been sampled. The sediment samples were collected on August 5 and August 4, 1999, respectively (Rescan, 2000a).

3.4.3.2.1 Two Rock and Ulu Lakes

Sediment concentrations of total organic carbon (TOC), available phosphorus and total nitrogen measured in Two Rock and Ulu lakes were within the range of or overlapped with values measured in undisturbed lakes within the BHP claim block.

Sediment concentrations of most metals measured in Two Rock and Ulu lakes were similar those in undisturbed lakes within the BHP claim block. During the 1999 sampling, Two Rock and Ulu lakes remained undisturbed. Any data obtained from these two lakes reflect naturally-occurring concentrations.

Table 3.4-3
Selected Sediment Quality Parameters for Two Lakes Affected by Development

Parameter	Units	Two Rock Lake Aug. 1999	Ulu Lake Aug. 1999	BHP Claim Block Lakes
TOC	%	1.96-9.03	8.04-10.4	<0.05-9.98
Available P	mg/kg	10-103	50-123	3-175
Total N	%	0.16-0.72	0.56-0.77	0.01-0.69
Aluminum	mg/kg	19,600-35,000	25,200-31,400	4,590-33,400
Arsenic	mg/kg	12-36	13.5-20	0.8-170
Chromium	mg/kg	44-79	59-73	13-86
Copper	mg/kg	51-116	81-91	3-120
Iron	mg/kg	27,900-64,900	27,300-49,100	6,880-144,000
Lead	mg/kg	7-13	7-12	<2.0-13
Manganese	mg/kg	280-430	339-389	127-992
Nickel	mg/kg	39.0-71	43.0-54	7.0-80
Zinc	mg/kg	106.0-165	134.0-282	20.0-235

Note: Values reported for BHP claim block lakes are derived from baseline data and data from reference lakes only.

3.4.3.2.2 Sable and Beartooth Lakes

No sediment samples have been collected for either Sable or Beartooth lakes.

3.5 Aquatic Life

The aquatic life of the region and within the BHP claim block is considered to be a very important component of the ecosystems inhabiting the streams and lakes of the area by all parties and is therefore recognized as a VEC (Valued Ecosystem Component). In order to assess the potential effects that BHP's proposed development may have on the aquatic environment it is imperative to gain an understanding of the existing aquatic ecosystems in the region and the proposed development area.

Thus, this section begins with a brief description of the aquatic ecosystems within the region that includes the BHP claim block. This is followed by site-specific information on the primary and secondary producers and fish resources of the BHP claim area obtained from baselines studies and aquatic monitoring programs conducted since 1993 to the present.

3.5.1 General Ecology of Northern Ecosystems (Lakes and Streams)

With total precipitation of less than 350 mm/a, much of arctic Canada is considered a polar desert. Snow cover lasts for more than six months of the year, and snowmelt can account for as much as 75% of annual total stream flows. With the ground still frozen in the spring, meltwater quickly runs off. Consequently, stream discharge is greatly controlled by temperature and precipitation.

The ecoregion in which the BHP claim block is situated arose out of the recession of the last period of glaciation, some 10,000 years ago. The lakes and streams in the claim block were formed by a number of different actions. The small, shallow lakes were formed from melt kettles and the melting and slumping of permafrost. Larger, deeper lakes were formed primarily by glacial action and less frequently by glacial debris dams. These lakes are cold, oligotrophic (low in nutrients and primary productivity) and isothermal in the ice-free season. They are also ice-covered for most of the year, a factor that limits gas exchange with the air. Each year a considerable proportion of the annual heat budget is used to melt the surface ice.

Arctic streams are subject to large annual variations in discharge rates and channel morphology. During the winter, flow ceases in the smaller channels and the streams freeze solid (BHP, 1995). Seventy-five percent of the annual flow discharges through the streams during a one-month period surrounding freshet. Anchor ice and surface ice alter flow patterns during freshet, leading to the scouring of new channels.

3.5.1.1 Northern Lake Aquatic Ecosystems

Figure 3.5-1 presents a simplified schematic of a typical northern lake ecosystem. Pelagic primary producers (phytoplankton) utilize the sun's energy to fuel their own

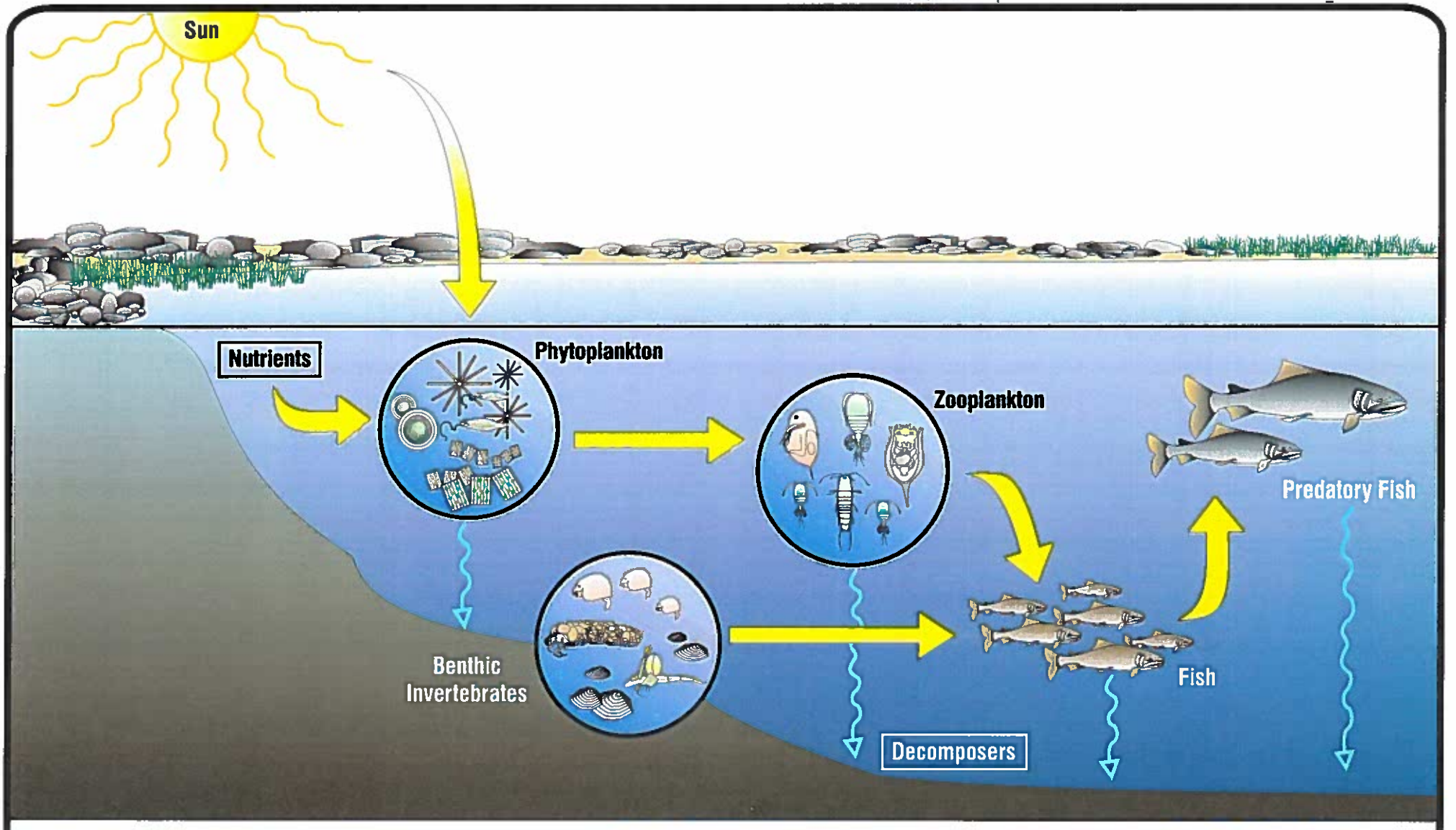


FIGURE 3.5-1

Schematic Representation of a Northern Lake Ecosystem

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growth. Enough solar radiation is available for phytoplankton growth as early as April, when there is still ice on the lakes (Schindler *et al.*, 1974; Kalff and Welch, 1974). Hence, primary productivity increases during the spring even though the lakes are ice-covered.

Phytoplankton biomass as well as taxonomic composition can fluctuate during the short open water season. Phytoplankton assemblages are affected by "bottom-up" parameters such as light, dissolved nutrients and trace metals, and by "top-down" parameters such as grazing pressure by zooplankton.

Zooplankton are the main consumers of phytoplankton. Zooplankton are controlled by the availability of their food and also influence their food source by grazing. Zooplankton constitute a major portion of the diet of some fish, especially in the summer when plankton densities in the water column are greater. Zooplankton biomass as well as taxonomic composition can also fluctuate during the short open water season. Different life stages of organisms occupy differing depths in the water column. Some stages remain near or on the bottom sediments and are not in the water column at all.

Fishes compose the upper trophic levels of the Arctic aquatic ecosystems. Being at the top of the "food-web," fishes exert a degree of control and structure on the lower trophic levels. However, lake fish biomass is ultimately dictated by the biomass of the primary producers (Welch and Klings, 1996). The fish community exhibits the most structural stability of the constituent components of northern aquatic ecosystems. This stability is derived from fishes being larger, longer-lived and containing large stores of energy.

A generalized trophic pyramid is presented in Figure 3.5-2. As can be seen, primary producers constitute the majority of biomass in an aquatic system. Transfer of biomass between trophic levels is not 100% efficient, as respiration and other losses (excretion, cell lysing and sinking, egg production) occur. Transfer efficiency is in fact typically only 10% to 15% between trophic levels. The trophic pyramid illustrates how a large amount of primary and secondary producer biomass is required to support fish, the top consumers of these ecosystems.

In summary, Arctic lakes have a high degree of bottom-up control and a lesser degree of top-down control. The amount of nutrients available to the primary producers ultimately limits the amount of fish biomass within a lake, resulting in bottom-up control of the fish populations. However, fishes also exert a top-down control on the trophic level organization and structure of lakes. The foraging of higher level organisms affects the abundance and composition of the species in the lower trophic levels. Community stability increases with increasing trophic level. Due to organisms in higher trophic levels tending towards larger sizes, fewer numbers, and greater energy stores, the resulting effect is of increasing community stability with increasing trophic level.

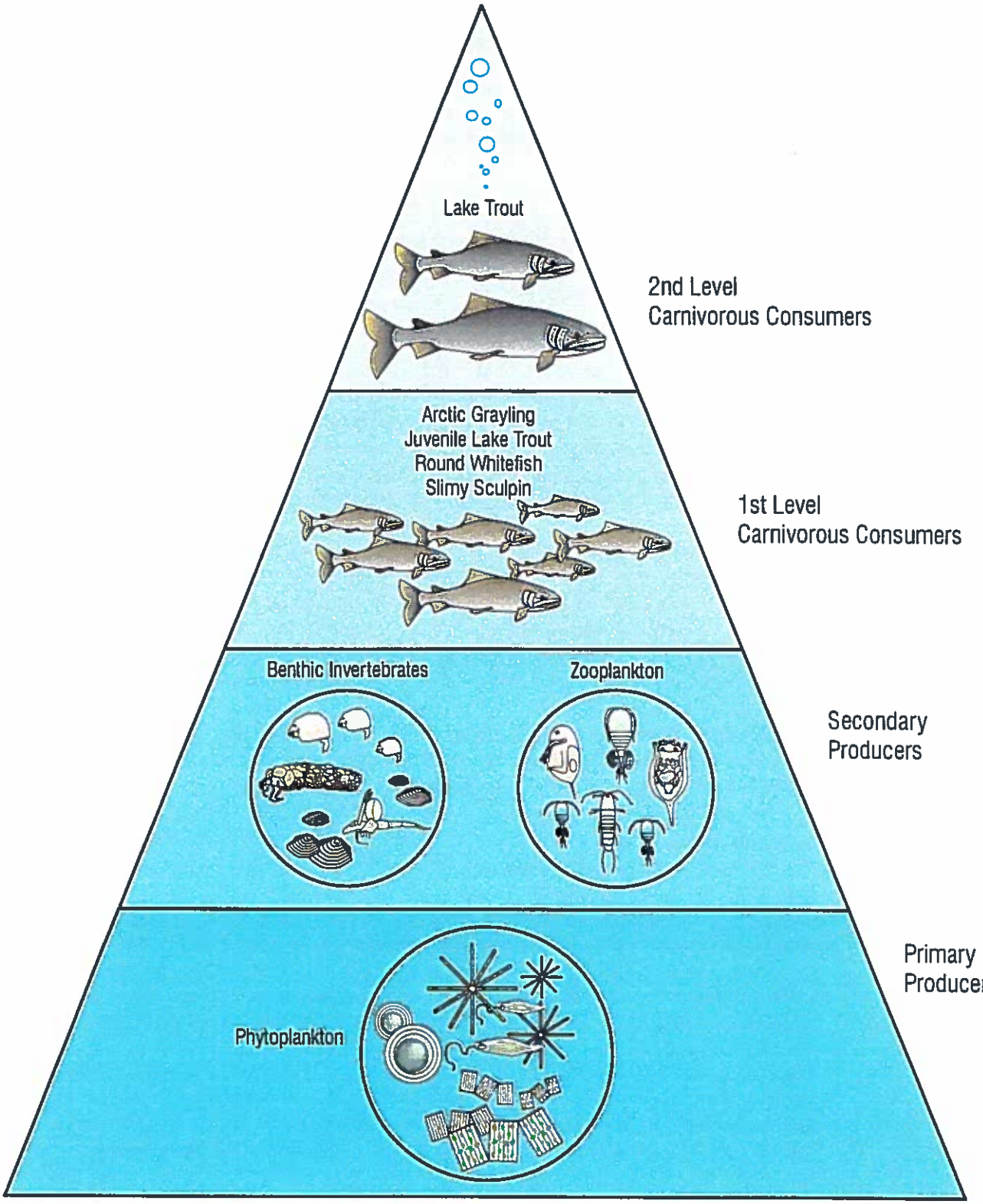

FIGURE 3.5-2

Trophic Pyramid of a Northern Lake Ecosystem

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3.5.1.2 Northern Stream Aquatic Ecosystems

The stream ecosystems in these northern drainages are variable and sometimes very short-lived, as described earlier. A schematic representation of a stream aquatic ecosystem is given in Figure 3.5-3.

The main primary producers in the stream ecosystem are attached algae, collectively referred to as periphyton. Periphyton actually consist of non-photosynthetic organisms such as fungi and bacteria as well as photosynthetic algae. The term periphyton in this document will refer to the photosynthetic organisms only.

Periphyton biomass and the taxonomic composition of periphyton assemblages can vary considerably throughout the open water season. Abiotic factors such as water flow velocity, water level and suspended solids can all affect periphyton assemblages. Organisms must be able to remain attached to substrates such as rocks in order to survive. Ice chunks, debris or high sediment loading can all scour or scrape attached cells from substrates. As periphyton are unicellular algae, the same bottom-up factors affecting phytoplankton affect periphyton (light, nutrients, trace metals). The primary top-down control, besides the abiotic factors mentioned above, is grazing by invertebrates.

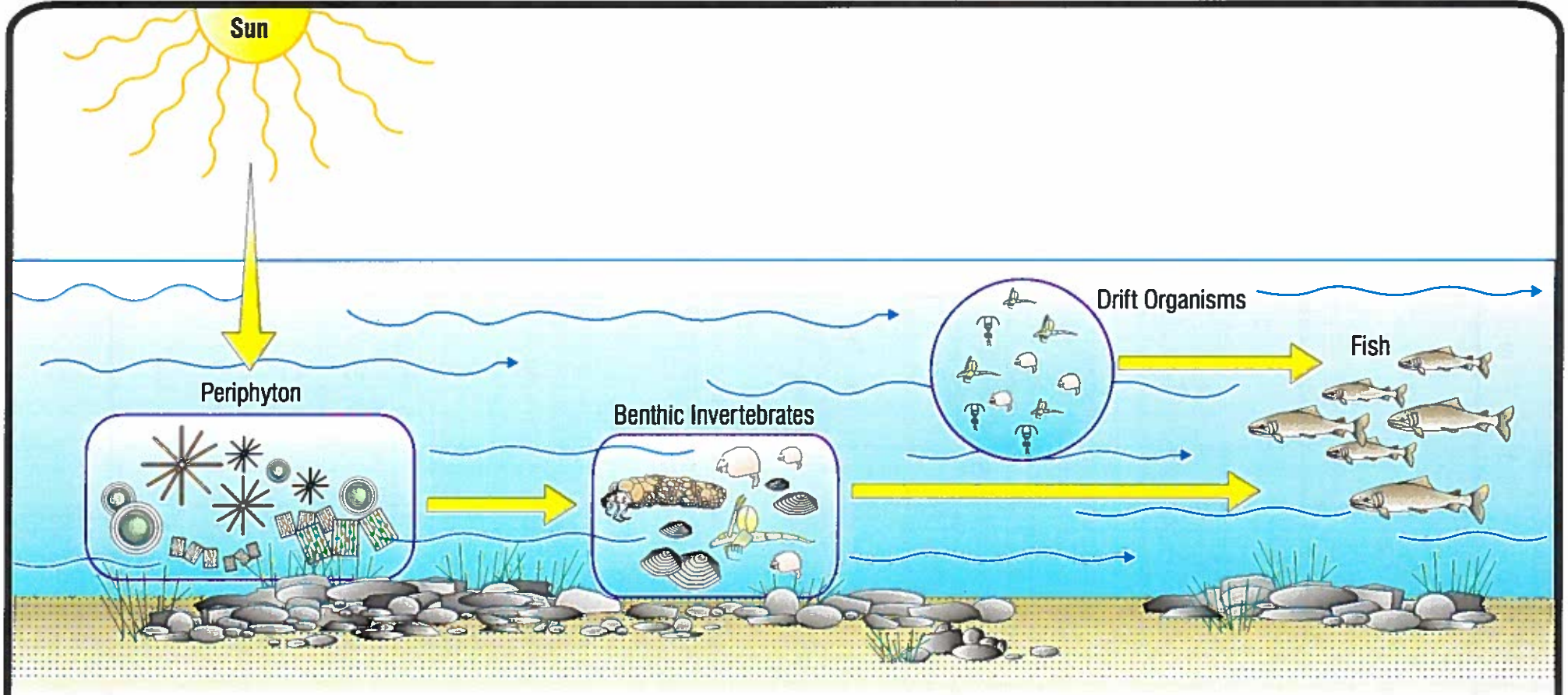
Stream invertebrates (benthos) constitute a major food source for fish in streams. As well, they are the primary grazers of periphyton. Their density, distribution and taxonomic composition are highly variable, which is to be expected given the variable nature of stream habitats.

Larval drift is composed of the larval stages of various organisms of benthic origin that are floating free in the water. These organisms constitute a major food source for stream-feeding fish. Larval drift abundance and composition vary according to the life cycles of different organism, which vary considerably.

The fish populations utilizing the streams are extensions of fish populations that typically live in down-stream lakes. Fish utilize the inflow streams of a lake to find spawning habitat, to feed and to seek protection from predators (piscivorous fish).

3.5.1.3 Northern Fish Communities

Fresh water Arctic fishes are typically slow growing and long lived and tend to be alternate-year spawners. Consequently, the period between generations tends to be longer, and the adaptive processes of natural selection function more slowly than at lower latitudes. When this is combined with the relatively short period of time that Canadian Arctic aquatic ecosystems have existed, it is generally considered that Arctic fresh water fishes are acclimated, pre-adapted species (Powers, 1997). That is, Arctic communities have not existed long enough for any extensive adaptation to have occurred. As a result of the low degree of specialization, these fishes can make use of a broad range of habitat types



Schematic Representation of a Northern Stream Ecosystem

FIGURE 3.5-3

BHP

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(*e.g.*, Arctic grayling may inhabit lakes, rivers or a combination of the two). The stages in fish lifecycles are rather plastic, especially in the genus *Salvelinus* (lake trout and Arctic char).

Arctic fish communities may have several different trophic level structures, based upon the species of fishes present (Welch and Klings, 1996). Lake trout will graze down and extirpate forage fishes from lakes. The lake trout (*Salvelinus namaycush*) population will then stratify to partially fill the remaining niches. Arctic char (*S. alpinus*) cut off from access to the ocean will continue as landlocked populations. These communities are easily perturbed, yet can show a high degree of resilience (Welch and Klings, 1996). However, because of the low productivity, commercial fishing cannot be sustained on most lakes.

The Arctic stream communities tend to be composed of juvenile fishes and are essentially extensions of the lake communities. Because the smaller streams freeze solid during the winter months, fishes utilizing the streams must retreat to the lakes to overwinter. As the fish grow they become more lacustrine in their habitat selection. The short, ephemeral lives of Arctic streams also limits the migration and exchange of fishes, especially lake trout and whitefishes, between lakes. This tends to isolate fish communities.

It is difficult to specifically determine what limits fish populations in northern lakes. The primary production of a lake can dictate the limit for fish biomass within a lake. However, the availability of essential habitat can also limit fish populations. There are four essential habitat components within the Arctic fish lifecycle: spawning grounds, rearing areas, adult feeding areas and overwintering areas. Limits in any one of these components can limit the maximum size of the population. The maximum spatial extent of northern fish populations and community structures are most likely limited by a combination of energy availability through forage and competition for limited habitat areas.

3.5.2 Primary and Secondary Producers

3.5.2.1 Phytoplankton Assemblages

The following sections describe the major groups of primary and secondary producers residing within lakes and streams in the area. For each major group, a description of the organisms within undisturbed waterbodies in the BHP claim block is provided, followed by specific information on the waterbodies that are predicted to be affected by the proposed development.

3.5.2.1.1 Phytoplankton Assemblages of Undisturbed Lakes within the BHP Claim Block

Lakes within the BHP claim block are oligotrophic and host low levels of phytoplankton biomass. Phytoplankton biomass concentrations such as chlorophyll *a* are usually less

than or equal to 1.0 µg/L. Seasonal data collected in 1999 indicated that no significant seasonal trends occur in phytoplankton biomass concentrations.

Phytoplankton abundances are typically less than 2,000 cells/mL. There can be significant seasonal differences in phytoplankton abundances; in 1999 abundances were lower in July than in August or September.

The diversity of phytoplankton assemblages is generally high, with diversities measured by the Shannon diversity index ranging from 1.3 to 2.1 and diversities as measured by the Simpson diversity index ranging from 0.5 to 0.8. Assemblages can consist of between 9 and 19 different genera. Phytoplankton assemblages comprise chrysophytes, chlorophytes and cyanobacteria; diatoms can also be present.

3.5.2.1.2 Phytoplankton Assemblages of Potentially Affected Lakes: Two Rock, Ulu, Sable, Beartooth

Phytoplankton samples were collected from Two Rock and Ulu lakes on one occasion during the open water season of 1999 (Rescan, 1999). Phytoplankton samples were collected from Sable Lake once in July 1996 (Rescan, 1996) and from Beartooth Lake on one occasion in September 1996 (Bryant, 1996).

3.5.2.1.2.1 Two Rock and Ulu Lakes

August phytoplankton biomass concentrations in Two Rock and Ulu lakes ranged from 0.36 to 1.07 µg/L. August phytoplankton abundances ranged from 482 to 4,459 cells/mL for Two Rock and Ulu lakes. Phytoplankton biomass concentrations and abundances measured in Two Rock and Ulu lakes were within the range or overlapped with values measured in undisturbed lakes within the BHP claim block.

August phytoplankton assemblages consisted of between 11 and 25 genera for Two Rock and Ulu lakes. Shannon diversity indices ranged from 1.2 to 2.4, and Simpson diversity indices ranged from 0.5 to 0.8. The composition and diversity of phytoplankton assemblages in Two Rock and Ulu lakes were similar to those of other undisturbed BHP claim block lakes.

3.5.2.1.2.2 Sable Lake

An average phytoplankton biomass of 0.68 µg/L was measured in Sable Lake in July 1996. The average phytoplankton abundance was 69 cells/mL. Phytoplankton biomass concentrations measured in Sable Lake in 1996 were within the range of concentrations in undisturbed BHP claim block lakes. Phytoplankton abundances were low in Sable Lake compared to other undisturbed lakes. Diversity indices were not calculated for phytoplankton assemblages residing in Sable Lake in 1996.

3.5.2.1.2.3 Beartooth Lake

The one-time value for phytoplankton biomass measured in Beartooth Lake in September 1996 was 1.0 µg/L (Bryant, 1996). This value is within the range of values measured within the BHP claim block. Neither phytoplankton abundance nor diversity was measured in 1996.

3.5.2.2 Zooplankton Assemblages

3.5.2.2.1 Zooplankton Assemblages of Undisturbed Lakes within the BHP Claim Block

Zooplankton biomass concentrations are typically low and below 100 mg dry weight/m^3. However, an undisturbed reference lake in the area has hosted zooplankton biomass concentrations of up to 350 mg dry weight/m^3. There can be significant seasonal differences in zooplankton biomass; in 1999 biomasses were lower in July than in August and September.

Zooplankton abundances are typically lower than 30,000 organisms/m^3 but can be as great as 90,000 organisms/m^3 in undisturbed lakes. High abundances can be due to the presence of nauplii, which are very small and do not contribute much to biomass. There were no significant seasonal differences in zooplankton abundances in reference lakes in 1999.

The diversity of zooplankton assemblages range from 0.8 to 1.6 as measured by the Shannon diversity index and from 0.4 to 0.7 as measured by the Simpson diversity index. Assemblages can consist of between 7 and 11 genera. Organisms present in resident zooplankton assemblages include calanoid copepods, cyclopoid copepods, rotifers and occasionally cladocerans.

3.5.2.2.2 Zooplankton Assemblages of Potentially Affected Lakes: Two Rock, Ulu, Sable Beartooth

Zooplankton samples were collected from Ulu and Two Rock lakes on one occasion during the open water season of 1999 (Rescan, 2000a). Zooplankton samples were collected from Sable Lake one time in July 1996 (Rescan, 1996b) and from Beartooth Lake on one occasion in September 1996 (Bryant, 1996).

3.5.2.2.2.1 Two Rock and Ulu Lakes

August zooplankton biomass concentrations in Two Rock and Ulu lakes ranged from 22 to 58 mg dry weight/m^3. August zooplankton abundances ranged from 45,300 to 63,600 organisms/m^3 for Two Rock and Ulu lakes. Zooplankton biomass concentrations and abundances measured in Two Rock and Ulu lakes were similar to values measured in undisturbed lakes within the BHP claim block.

August zooplankton assemblages comprised between 6 and 7 genera for Two Rock and Ulu lakes. Shannon diversity indices ranged from 1.2 to 1.3, and Simpson diversity indices

ranged from 0.6 to 0.7. The composition and diversity of zooplankton assemblages in Two Rock and Ulu lakes were similar to those of other undisturbed BHP claim block lakes.

3.5.2.2.2.2 Sable Lake

Zooplankton biomass concentrations were not measured in Sable Lake in 1996. The average abundance of zooplankton was 11,196 organisms/m^3. Zooplankton abundances were low in Sable Lake compared to other undisturbed lakes in 1996, possibly due to the high turbidity of the lake resulting from winter drilling activities. Diversity indices were not calculated for zooplankton assemblages residing in Sable Lake in 1996.

3.5.2.2.2.3 Beartooth Lake

Zooplankton biomass concentrations were not measured in Beartooth Lake in 1996. The one-time value for zooplankton abundance measured in September 1996 was 16,599 organisms/m^3 (Bryant, 1996). Zooplankton abundances were low in Beartooth Lake compared to other undisturbed lakes within the BHP claim block in 1996.

3.5.2.3 Lake Benthos Communities

3.5.2.3.1 Lake Benthos Communities of Undisturbed Lakes within the BHP Claim Block

Lake benthos densities are generally greater at shallow (0.0 to 5.0 m) depths than at mid (5.1 to 10.0 m) and deep (>10.1 m) depths within a lake. Shallow benthos densities can be as high as 35,000 organisms/m^2, while mid and deep depth benthos densities are typically below 10,000 organisms/m^2.

Lake benthos communities largely consist of organisms from the insect order Diptera. Nematodes can also be prevalent. Dipteran communities can consist of between 0 and 11 different genera. The diversity of dipteran communities ranges from 0.0 to 2.1 as measured by the Shannon diversity index and 0.0 to 0.9 as measured by the Simpson diversity index.

3.5.2.3.2 Lake Benthos Communities of Potentially Affected Lakes: Two Rock, Ulu, Sable, Beartooth

Lake benthos samples were collected from Two Rock and Ulu lakes on one occasion during the open water season of 1999 (Rescan, 2000a). Lake benthos samples were collected from Sable Lake once in July 1996 (Rescan, 1996b) from Beartooth Lake on one occasion in September 1996 (Bryant, 1996).

3.5.2.3.2.1 Two Rock and Ulu Lakes

The density of shallow lake benthos communities ranged from 311 to 2,356 organisms/m^2. Mid and deep community densities ranged from 222 to 4,133 organisms/m^2. Lake benthos densities measured in Two Rock and Ulu lakes were within the range of values measured in undisturbed lakes within the BHP claim block.

Lake benthos dipteran communities comprised between 0 and 8 genera for Two Rock and Ulu lakes. Shannon diversity indices ranged from 0.0 to 1.9, and Simpson diversity indices ranged from 0.0 to 0.8. The composition and diversity of lake benthos communities in Two Rock and Ulu lakes were similar to those of other undisturbed BHP claim block lakes.

3.5.2.3.2.2 *Sable Lake*

The average density of shallow lake benthos communities was 12,086 organisms/m^2. Average densities of mid and deep depth communities ranged from 119 to 310 organisms/m^2. Shallow benthos densities measured in Sable Lake in 1996 were within the range of densities found in undisturbed BHP claim block lakes.

Benthos communities were composed of mainly nematodes at shallow depths and dipterans at mid and deep depths. Diversity indices were not calculated for lake benthos dipteran communities sampled in Sable Lake in 1996. The general taxonomic composition of lake benthos communities sampled in Sable Lake was similar to undisturbed lakes within the BHP claim block.

3.5.2.3.2.3 *Beartooth Lake*

Lake benthos samples were collected once in September 1996 from Beartooth Lake. Dipterans and oligochaetes dominated the benthos community (Bryant, 1996). The general taxonomic composition of lake benthos communities sampled in Beartooth Lake was similar to that in undisturbed lakes within the claim block.

3.5.2.4 Periphyton Assemblages

3.5.2.4.1 Periphyton Assemblages of Undisturbed Streams within the BHP Claim Block

The quantitative sampling of periphyton in BHP claim block streams has been conducted utilizing artificial substrate samplers. As such, the following information reflects periphyton assemblages sampled by the artificial sampler and may not reflect assemblages existing on rocks, vegetation and debris within the streams.

Periphyton biomass as chlorophyll *a* in undisturbed BHP claim block streams ranges from 64 to 640 $\mu g/cm^2$. Stream periphyton densities range from 280,000 to 1,900,000 cells/cm^2. Densities can be spatially variable within a stream and also vary seasonally.

Periphyton assemblages can consist of between 9 and 14 genera. The diversity of stream periphyton assemblages can range from 0.6 to 1.4 as measured by the Shannon diversity index and from 0.2 to 0.6 as measured by the Simpson diversity index. The predominant type of photosynthetic organisms found in periphyton assemblages are diatoms (pennate), with chlorophytes and cyanobacteria also being present.

3.5.2.4.2 Periphyton Assemblages of Potentially Affected Streams: Two Rock, Ulu, Sable and Beartooth Outflows

No samples for periphyton have been obtained for Two Rock, Ulu, Sable or Beartooth outflows. Periphyton samples were obtained from Sable Lake, but assemblages found within the outflow stream and the lake cannot be assumed to be similar, and the lake data are not presented here.

3.5.2.5 Stream Benthos Communities

3.5.2.5.1 Stream Benthos Communities in Undisturbed Streams within the BHP Claim Block

Stream benthos densities in undisturbed BHP claim block streams are generally less than 10,000 organisms/m^2. Densities can be spatially variable within a stream and also vary seasonally.

Stream benthos communities typically consist of mostly dipterans, with nematodes also being prevalent. Stream dipteran communities can consist of between 2 and 9 genera. The diversity of stream dipteran communities can range from 0.3 to 1.3 as measured by the Shannon diversity index and from 0.1 to 0.6 as measured by the Simpson diversity index.

3.5.2.5.2 Stream Benthos Communities of Potentially Affected Streams: Two Rock, Ulu, Sable and Beartooth Outflows

No samples for stream benthos have been obtained from these outflows.

3.5.3 Fish Communities

An overall description of the present watershed, limnological and stream characteristics surrounding the Sable, Pigeon and Beartooth pipes is provided in Sections 3.3 and 3.4 of this report and in the Project Description report for this development (BHP, 1999c). The following sections provide existing information regarding the fish and fish habitat of each of the waterbodies that will be potentially affected by mine development.

3.5.3.1 Sable Pipe

3.5.3.1.1 Site Description and Development Plans

Sable Pipe underlies Sable Lake, about 15 km north of the Panda Pit. Sable Lake is a nutrient-poor, oligotrophic headwater lake with a surface area of 8.9 ha. Two ephemeral watercourses flow into Sable Lake, one from the southwest and the other from the southeast. Sable Lake discharges to the north through an outflow stream that drains into Two Rock Lake. Two Rock Lake then drains toward Horseshoe Lake through the Two Rock-Horseshoe Stream. Two Rock Lake is also fed by a 450 m ephemeral stream

flowing from the south. Sable Lake and Two Rock Lake lie in the Exeter Lake catchment.

To permit open pit mining, Sable Lake will be dewatered after the fish population is harvested (BHP, 1999c). Two Rock Lake will be used as a settling pond for lake water from Sable Lake and subsequent mine water pumped from the pit. Consequently, the fish population of Two Rock Lake will be fished out prior to its use as a sedimentation and polishing pond.

Ulu Lake lies immediately to the north of Sable Lake but is not part of the Sable Lake drainage. Ulu Lake will not be directly affected by development of the Sable Pipe. However, the Sable east and west waste rock storage piles (see Figure 4.1-3 in BHP, 1999c) will lie within about 100 m of Ulu Lake. For this reason, Ulu Lake was included as part of the 1999 aquatic survey and will be described below from a fish and fish habitat context.

3.5.3.1.2 Fish Populations

Sable Lake

The only known comprehensive survey of the fish community of Sable Lake was conducted in 1997 by Rescan™ Environmental Services Ltd. on behalf of BHP Diamonds Inc. Details of this sampling program and its results can be found in Rescan (1998c). The following summarizes the results of this sampling program.

Only lake trout (*Salvelinus namaycush*) were captured during index gill net surveys conducted from July 16 to July 27, and again on September 5 and 6, 1997. In addition, two slimy sculpin (*Cottus cognatus*) were captured by electrofishing along the lakeshore on June 30, 1977.

The lake trout population in Sable Lake for fish susceptible to 3.8 cm (1.5 inch) stretched mesh is estimated to be 99 fish (95% confidence interval ranges from 62 to 108), based on the adjusted Peterson estimate method for calculating populations from mark-recapture sampling. These fish were divided into two distinct size groupings centred around the 220 to 239 mm (fork length) size class and the 360 to 379 mm size class (Figure 3.5-4). The smaller size group was composed of fish four to seven years of age while the larger size group was made up of fish aged 13 to 16 years (Figure 3.5-5). Based upon investigations in lakes of similar latitude where lake trout mature as late as 13 years of age (Scott and Crossman 1990), it is likely that the larger size group in this study represents fish that have reached reproductive maturity.

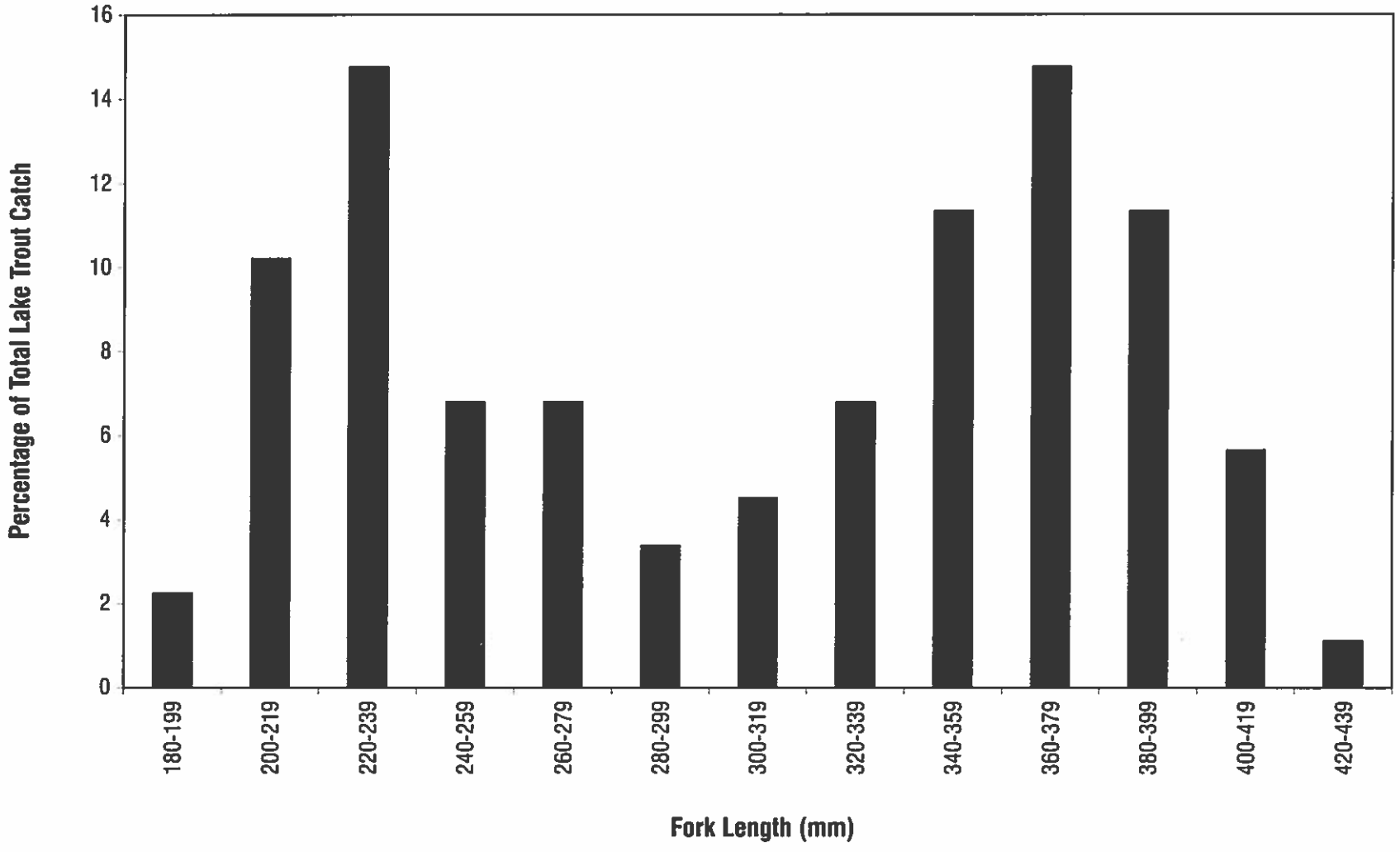

FIGURE 3.5-4

Fork Length Frequency Distribution of Lake Trout Caught in Sable Lake, 1997

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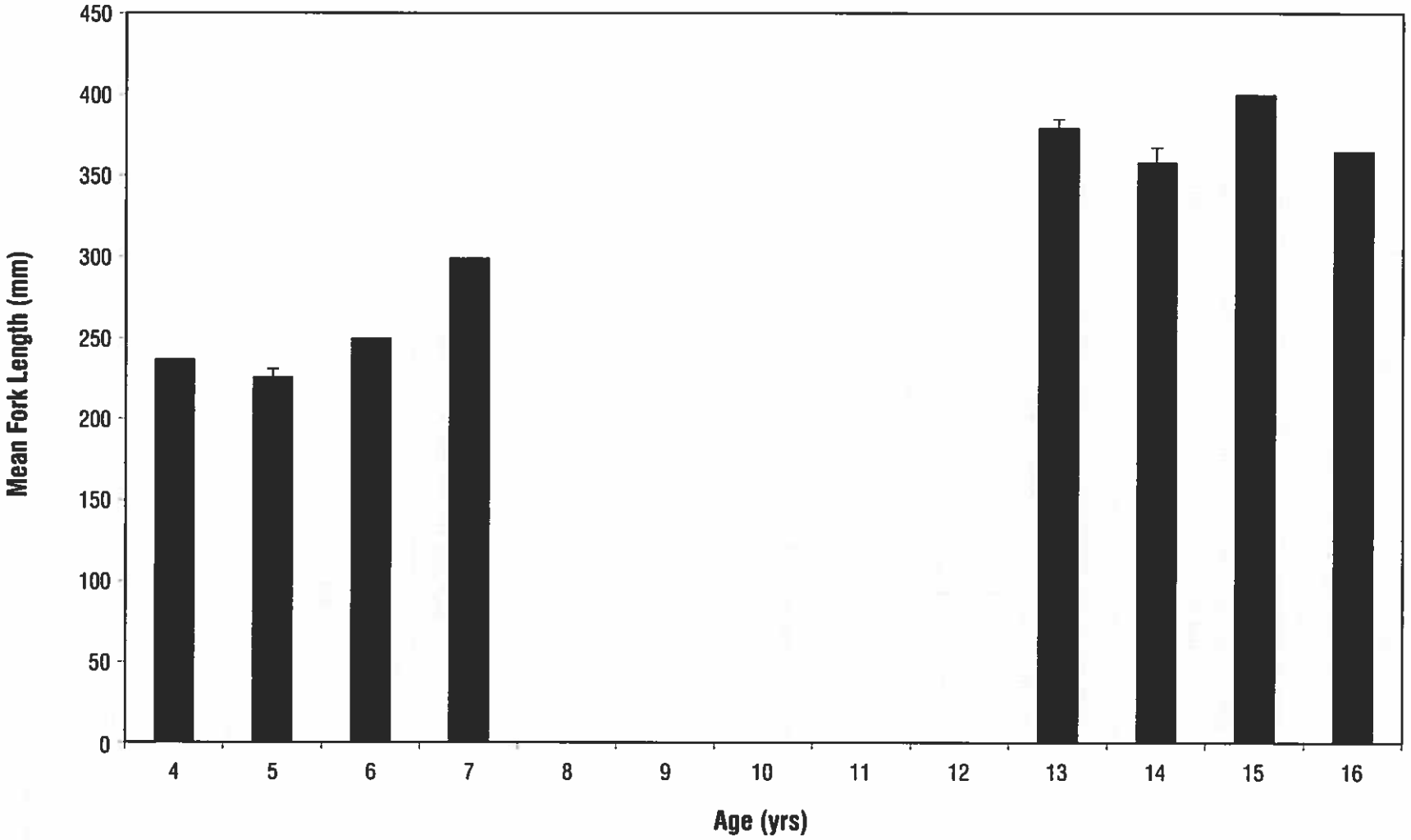
Source: Resc 8c



Mean Fork Length by Age of Lake Trout Caught in Sable Lake, 1997

FIGURE 3.5-5

Source: Rescan, 1998c

As shown in Figure 3.5-6, catch-per-unit-effort (CPUE) declined through the month of July but then increased somewhat in early September. This likely reflects variations in lake trout feeding activity due to seasonal changes in both water temperatures and nutritional requirements. The overall CPUE for lake trout in Sable Lake was lower than for any of the other lakes in the BHP Diamonds claim block sampled in previous years, with the exception of Beartooth Lake (Rescan 1995a, 1995b, 1996, 1997a, 1997b, 1998b). This may be due to the fact that turbidity in Sable Lake was higher than in the other sampled lakes in the claim block, probably as a result of past exploration activities (Rescan, 1998a). Possibly for similar reasons, condition factors for lake trout from Sable Lake were generally less than those from Koala watershed lakes. Reduced visibility would hinder the lake trout's ability to find and catch prey, thereby both reducing feeding activity and diminishing fish condition (expressed as a weight:length ratio).

Stomach contents of two 220 to 239 mm size class lake trout were analyzed. It was found that virtually all prey items (99.7%) were of the Diptera family Chironomidae. Since these fly larvae inhabit deeper areas of the lake, it is apparent that the sampled fish were feeding below the littoral zone. This has significance for the reestablishment of suitable conditions for fish in Sable Lake following closure of the pit.

Two Rock Lake

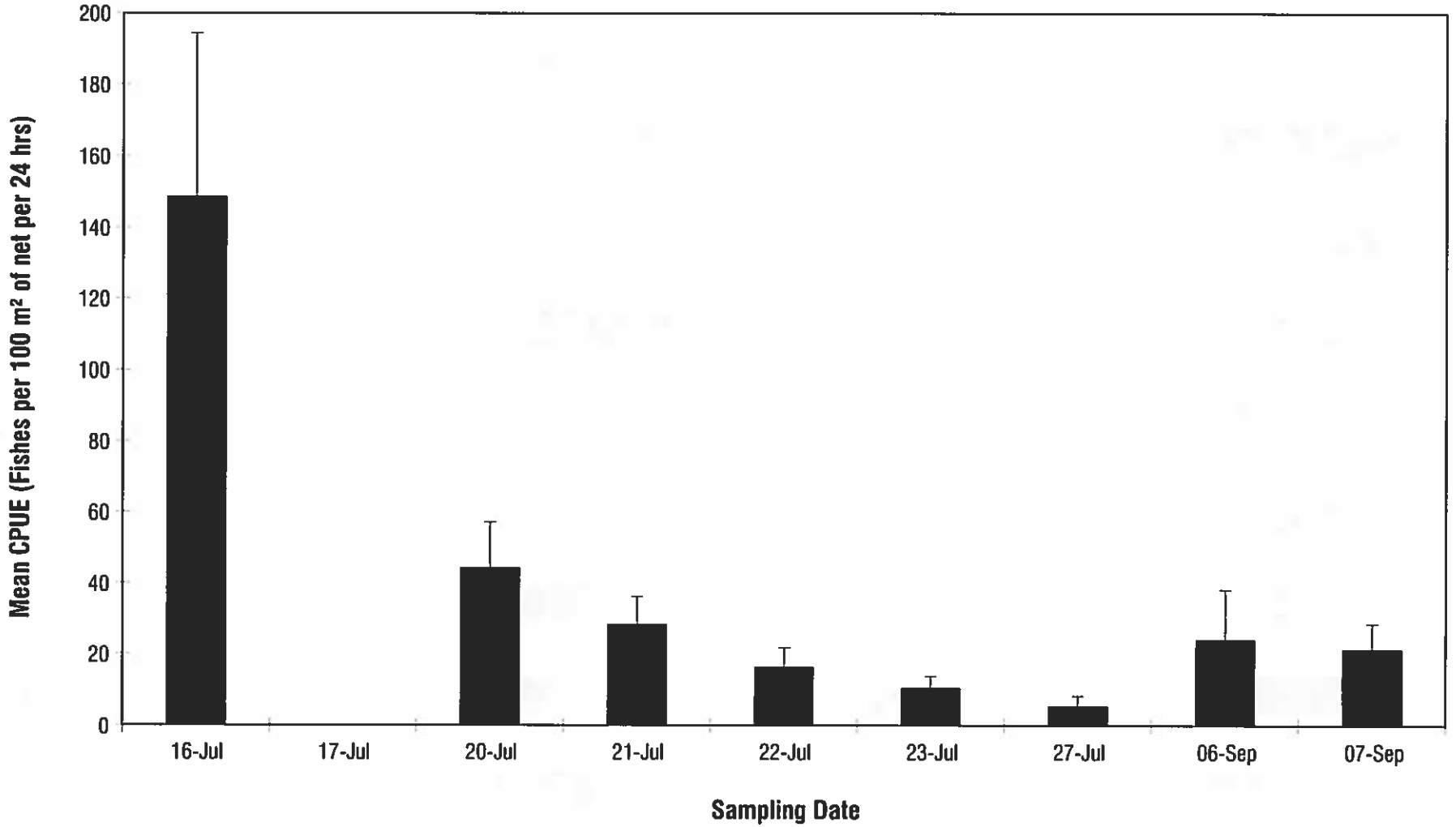
The fish population of Two Rock Lake was surveyed during the summer of 1999. Details of the results of these investigations are provided in Rescan (2000a). A summary of these results is provided below. There is no evidence that any previous fish or fish habitat studies have been conducted in this lake.

In 27 index gill net sets, a total of 77 round whitefish (*Prosopium cylindraceum*) and 54 lake trout were captured. Population characteristics of both these species are illustrated in Table 3.5-1 and Figures 3.5-7 and 3.5-8, respectively.

Table 3.5-1
Summary of Parameter Means ± Standard Error for Fishes Caught in Index Gill Nets, Two Rock Lake, 1999

Parameter	Lake Trout	Round Whitefish
Number Caught	54	77
Mean Fork Length (mm)	386 ± 7.8	321 ± 5.7
Mean Weight (g)	632 ± 38.4	419.6 ± 19.9
Mean Age (yr)	12.01 ± 13.4	7.3 ± 5.7
Mean Condition Factor	1.05 ± 0.01	1.18 ± 0.01
Mean Catch-per-Unit-Effort (fish)	69.9 ± 11.7	103.6 ± 15.5
Mean Biomass-per-Unit-Effort (kg)	44.0 ± 7.3	44.3 ± 6.9
Relative Abundance	41.2%	58.8%

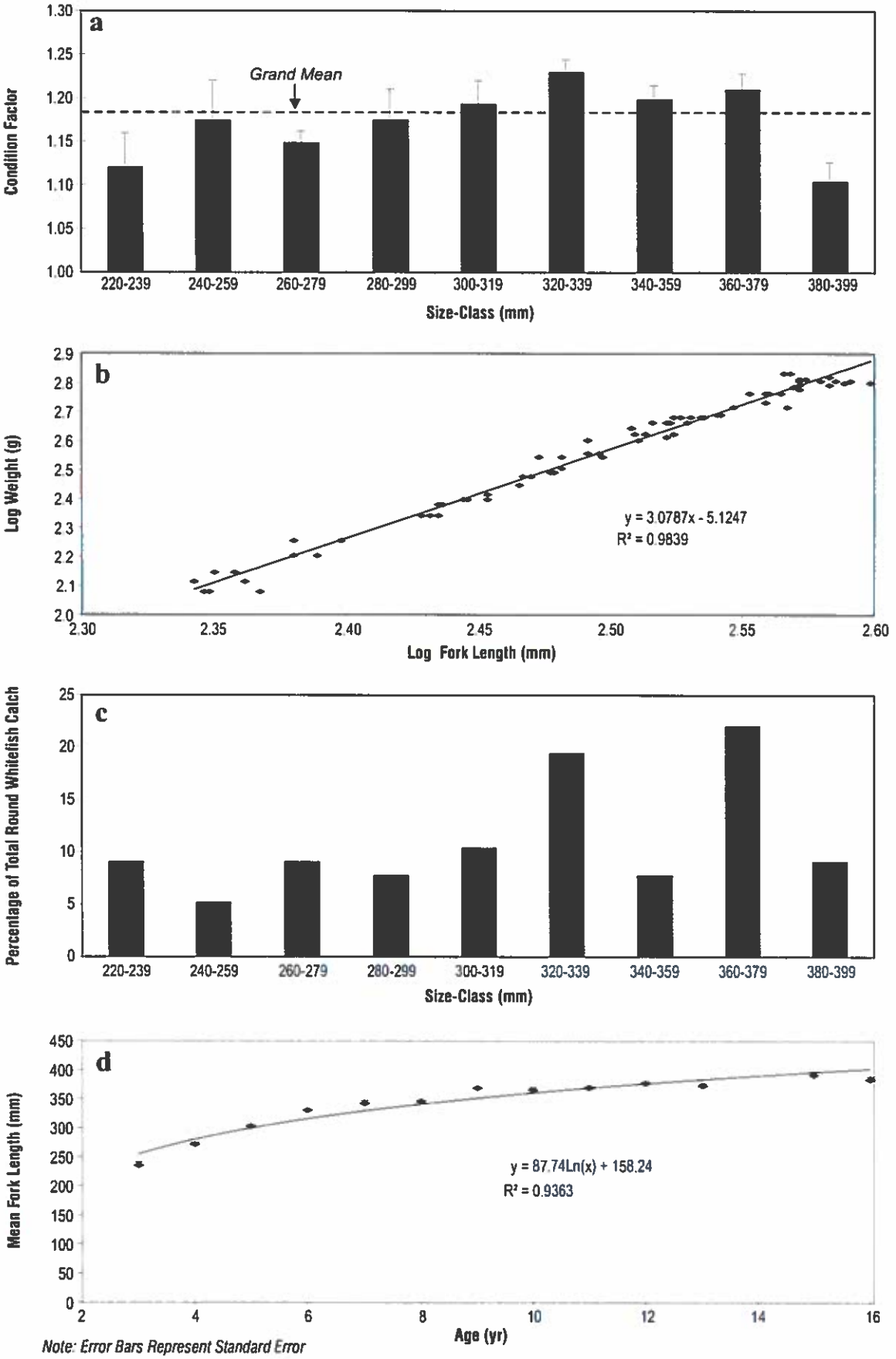
Source: Rescan, 2000a.



Mean Catch-per-Unit-Effort by Sampling Date of Lake Trout Caught in Sable Lake, 1997

FIGURE 3.5-6

Source: Rescan, 1998c

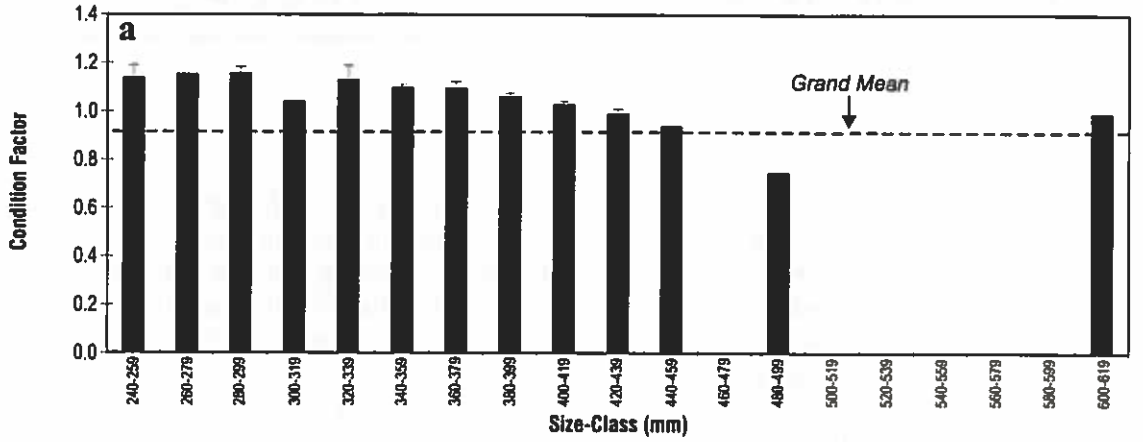


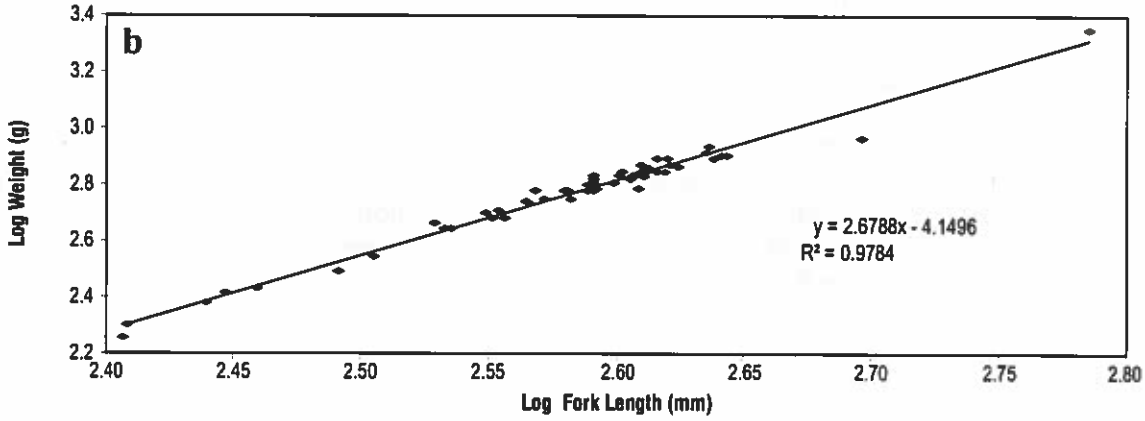
Note: Error Bars Represent Standard Error

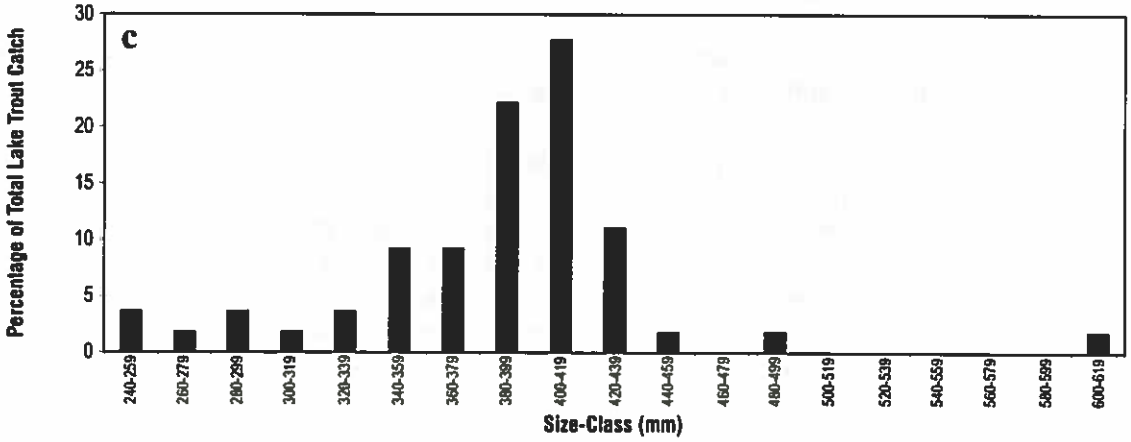
Population Characteristics of Round Whitefish Caught in Two Rock Lake, 1999

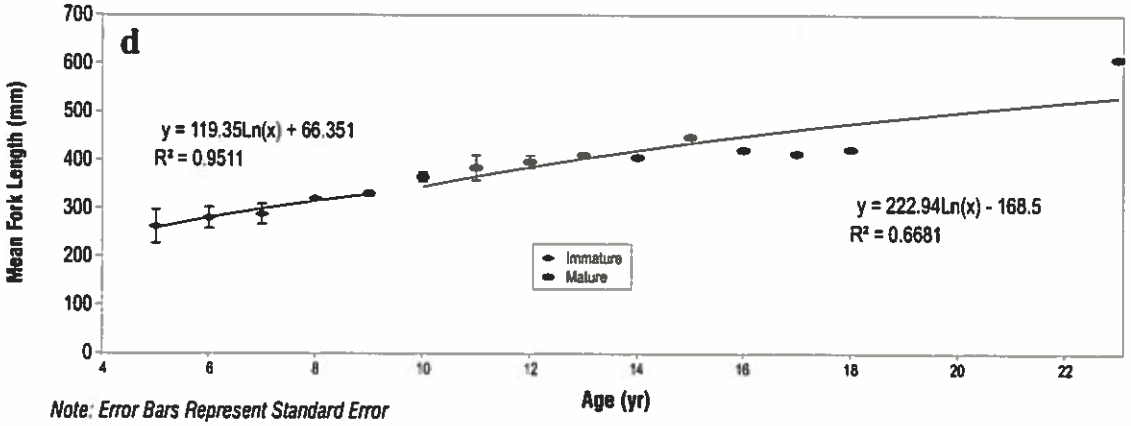
FIGURE 3.5-7

Source: Rescan, 2000a









Note: Error Bars Represent Standard Error

Population Characteristics of Lake Trout Caught in Two Rock Lake, 1999

FIGURE 3.5-8

Source: Rescan, 2000a

Round Whitefish

Round whitefish condition factor generally increased with fish length but then declined in the largest size classes (Figure 3.5-7a). The increase in condition factor reflects increasing energy storage as these fish grow. The length frequency plot for round whitefish showed two peaks, one at the 320 to 339 mm size class and the other at the 360 to 379 mm size class. The former corresponds to six-year-old fish while the latter is represented by fish aged 9 to 17 years (Figure 3.5-7d). This wide spread in ages for the larger size class occurs because the distinction among age cohorts based on fish size diminishes after maturity.

Lake Trout

Lake trout condition in Two Rock Lake is high and fairly constant among fish ranging from 240 to 379 mm in length. Condition then declines with size, possibly reflecting a decrease in condition following maturity. The majority of sampled lake trout fell in the 380 to 399 mm and 400 to 419 mm size classes (Figure 3.5-7c). Most of these fish were mature (Figure 3.5-7d).

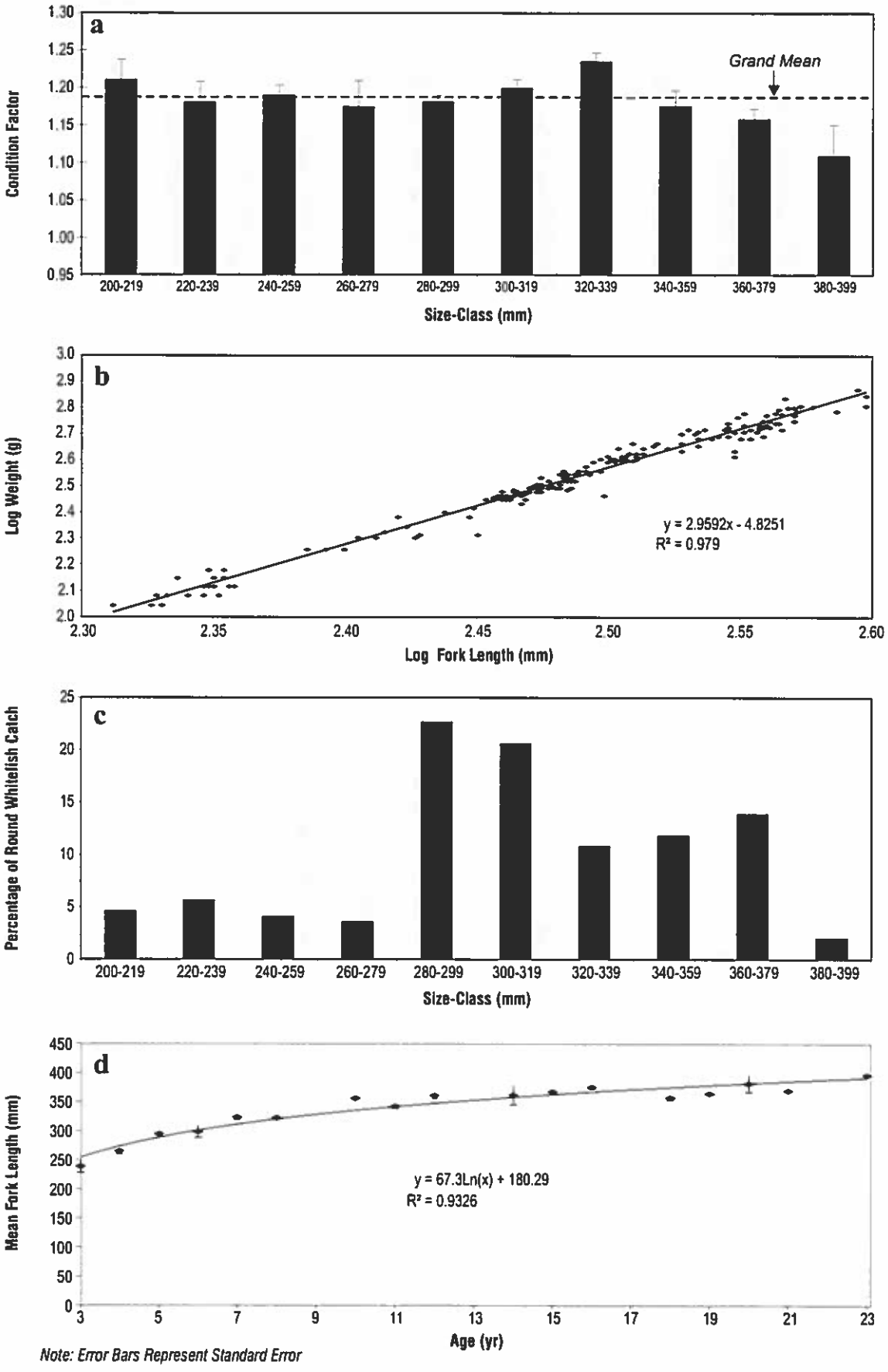
Ulu Lake

The fish community of Ulu Lake was sampled using index gill netting in the spring and autumn of 1999. There is no previous record of any previous fisheries studies in this lake. Details of the methods and results from the 1999 survey are provided in Rescan (1999b). The following summarizes those results.

A total of 233 fish were caught in 27 index gill net sets. This catch was made up of 194 round whitefish, 35 lake trout and 4 Arctic grayling (*Thymallus arcticus*). The large proportion of the catch represented by round whitefish (83.3%) is generally higher than in other lakes sampled in the BHP claim block (1998b). Population characteristics for all species are summarized in Table 3.5-2. Figures 3.5-9 and 3.5-10 provide detailed condition factor, growth and age information for round whitefish and lake trout, respectively. Insufficient numbers of Arctic grayling were caught to permit population analysis.

Round Whitefish

The condition of round whitefish was relatively stable among fish smaller than 340 mm. Fish condition then declines with increasing fish size (Figure 3.5-9a). The length-frequency plot (Figure 3.5-9c) shows two peaks, one at 280 to 299 mm, corresponding to 5-year-old fish (from Figure 3.5-9d), and another at 360 to 379 mm, corresponding to 12- to 23-year-old fish. It is apparent that the distinction among age cohorts becomes blurred after the onset of maturity, making it impossible to discern the age of these fish from their size.

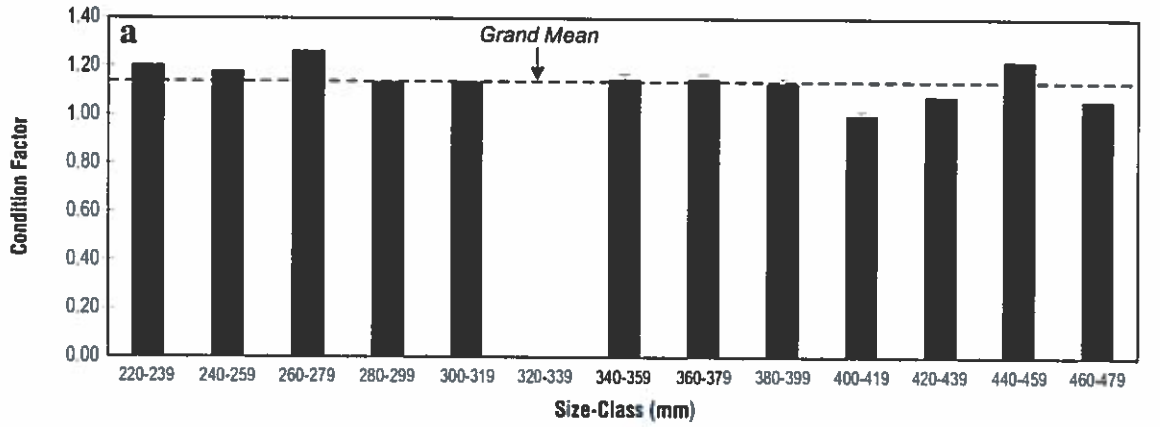


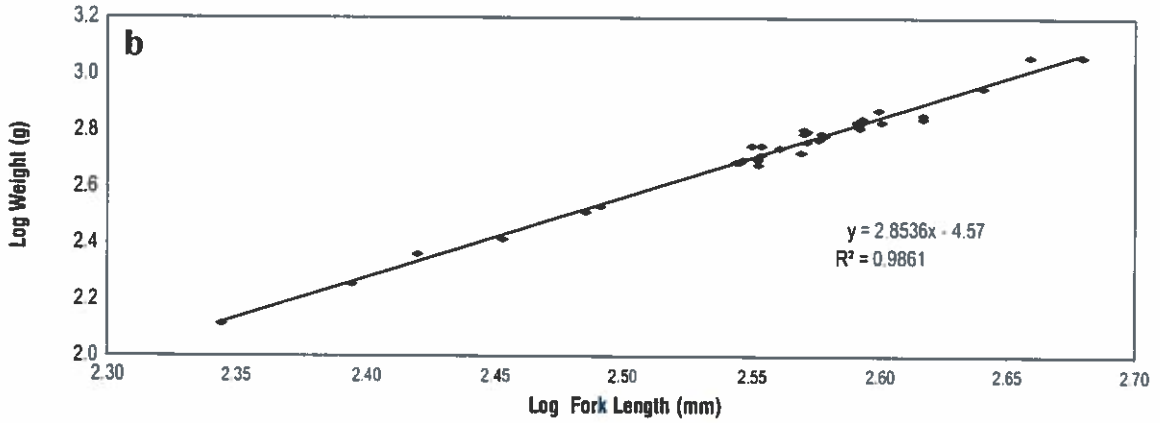
Note: Error Bars Represent Standard Error

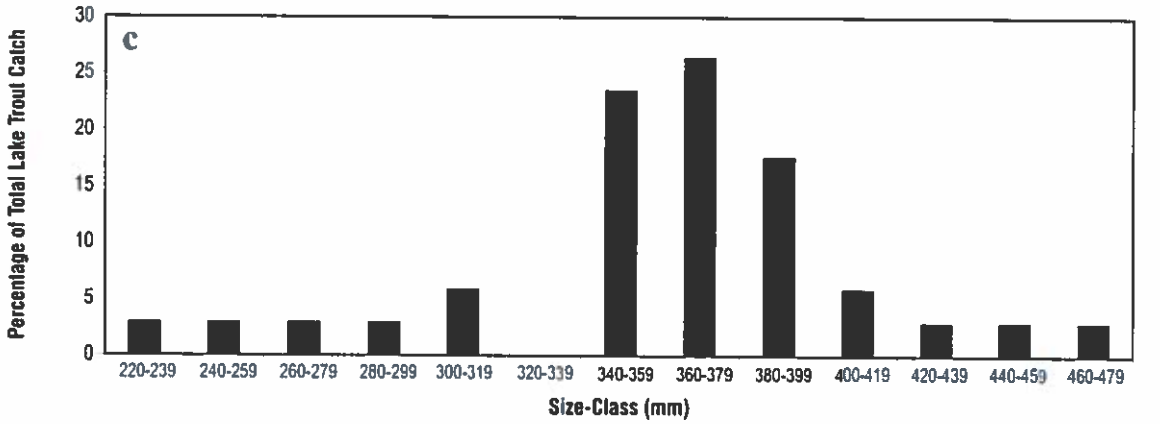
FIGURE 3.5-9

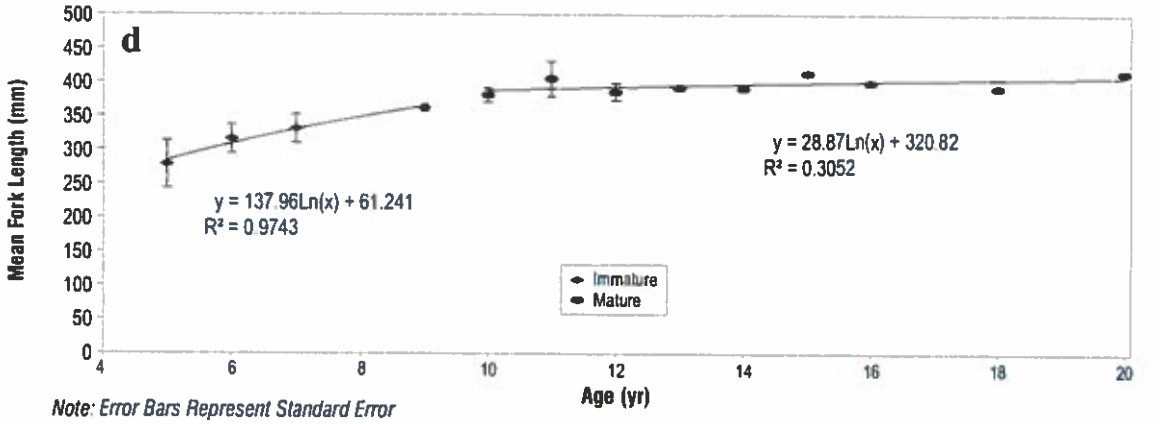
Population Characteristics of Round Whitefish Caught in Ulu Lake, 1999

Source: Rescan, 2000a









Note: Error Bars Represent Standard Error

Population Characteristics of Lake Trout Caught in Ulu Lake, 1999

FIGURE 3.5-10

Source: Rescan, 2000a

Table 3.5-2
Summary of Parameter Means ± Standard Error for Fishes Caught in Index Gill Nets, Ulu Lake, 1999

Parameter	Arctic Grayling	Lake Trout	Round Whitefish
Number Caught	4	35	194
Mean Fork Length (mm)	351 ± 3.7	364 ± 9.2	308 ± 3.2
Mean Weight (g)	513 ± 4.79	580 ± 38.4	367 ± 10.3
Mean Age (yr)	10.3 ± 0.75	10.1 ± 0.62	8.6 ± 0.62, n=71
Mean Condition Factor	1.18 ± 0.03	1.14 ± 0.01	1.18 ± 0.01
Mean Catch-per-Unit-Effort (fish)	5.7 ± 4.0	42.7 ± 7.4	228.5 ± 37.9
Mean Biomass-per-Unit-Effort (kg)	2.9 ± 2.1	23.7 ± 4.5	82.7 ± 12.8
Relative Abundance	1.7%	15.0%	83.3%

Source: Rescan, 2000a.

Lake Trout

The pattern of fish condition for lake trout in Ulu Lake is similar to that in Two Rock Lake. Condition remains relatively high and stable in smaller fish but then declines somewhat in fish larger than 399 mm (Figure 3.5-10a). This pattern is not necessarily consistent among lakes in the region (Rescan 1997a, 1998c, 1999a).

The length-frequency distribution for lake trout shows a distinct peak at the 360 to 379 mm length class, corresponding to a 9-to 10-year-old fish (Figure 3.5-10c,d). This pattern is similar to that for lake trout in Two Rock Lake, although lake trout there tend to be larger (Rescan, 2000a).

The plot of fork length against age (Figure 3.5-10d) shows rapid growth in young fish, which then declines as the fish mature. This rapid growth in young lake trout exceeds that of fish in Two Rock Lake but is similar to the growth rate for young trout in Sable Lake (Rescan, 1998c) and Kodiak Lake (Rescan, 1999a). This rapid growth in young fish is characteristic of a fish population that has been subjected to higher than normal mortalities. The reduction in the population below carrying capacity results in increased food availability for younger fish, which then undergo rapid growth. However, there is no evidence of any event or increased fishing pressure in Ulu Lake that would have resulted in increased mortalities.

Sable Lake Inflow and Outflow Streams

The streams flowing into and out of Sable Lake were surveyed on June 30, 1997, to determine fish presence. At that time, no flow was observed in the stream entering the lake from the southeast. The stream flowing into the lake from the southwest discharges meltwater over terrestrial grasses and not through a distinct channel. Electrofishing was therefore only possible at the mouth of this stream. Two slimy sculpins were caught among boulders in this area.

The outflow stream from Sable Lake to Two Rock Lake flows mainly through a bouldergarden. Fish sampling was therefore restricted to electrofishing among boulders at the head of the stream. No fish were captured.

Two Rock Lake Inflow and Outflow Streams

The results of the fish survey for the Sable-Two Rock stream are provided above. The only other inflow stream to Two Rock Lake flows from a small (<1 ha) pond south of Two Rock Lake. Electrofishing was not possible in this stream because the channel was undefined and water flow at the time of the survey was too low to provide sufficient water depth for sampling. Given these conditions, it was concluded that fish use of this stream is unlikely.

The outflow stream from Two Rock Lake (Two Rock-Horseshoe Stream) was sampled in early June 1999. In the few portions of the stream accessible to electrofishing, no fish were captured.

Ulu Lake Inflow and Outflow Streams

An unnamed inflow stream enters the northeast end of Ulu Lake. This stream drains a small pond and flows 300 m in an undefined channel to the lake. Elecrofishing was not possible because the very low flow was dispersed through a bouldergarden nearly the whole length of the stream. However, it is not expected that this stream supports fish.

The Ulu-Horseshoe Stream was surveyed by electrofishing in June 1999. One adult female Arctic grayling was captured and nine adult grayling were observed, all within 100 m of the outlet of Ulu Lake. Since few areas downstream of the stream were accessible to electrofishing, it is likely that these grayling originated in Ulu Lake.

3.5.3.1.3 Habitat Surveys

Sable Lake

A habitat assessment of Sable Lake was carried out during August and September of 1997. Rescan (1998c) provides details of the methods used to conduct the habitat surveys and the results obtained. The results of this survey are shown in Figure 3.5-11.

In summary, the littoral zone comprises 59% of the lake area of 88,909 m^2. Some 90% of the littoral zone is made up of boulders and broken rock while the remainder consists of fines. The area providing the best potential for lake trout spawning is on the west side of the lake. This mixed boulder and fines habitat makes up about 20% of the littoral zone.

The ratio of basin to littoral zone in Sable Lake is typical of other lakes overlying kimberlite pipes in the area (Table 3.5-3).

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Job No. 571–6 BHP 1999 EA Report
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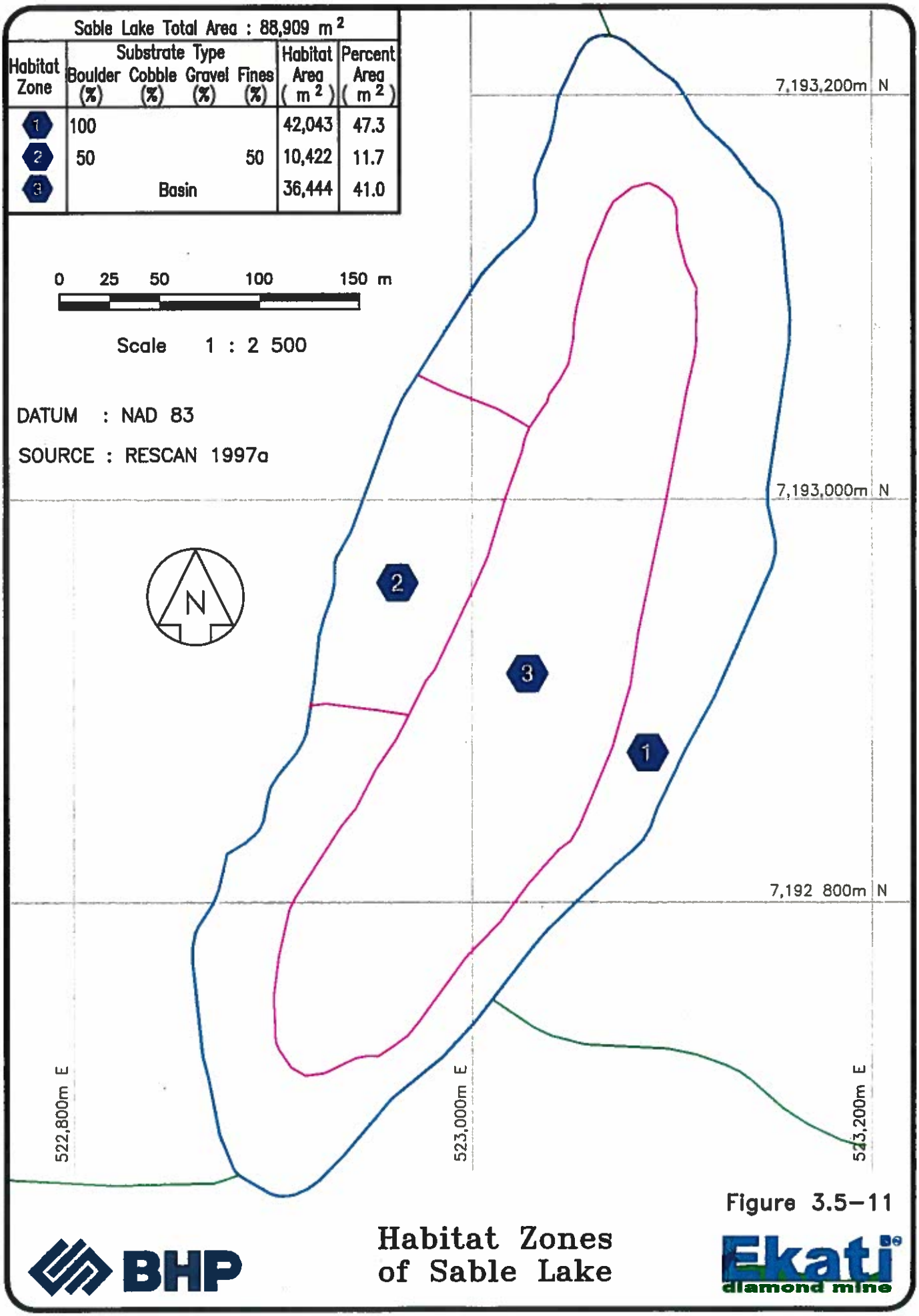


Figure 3.5–11

Habitat Zones of Sable Lake

BHP

Ekati diamond mine

Table 3.5-3
Proportion of Lake Habitat Zones in Six Lakes Overlying Kimberlite Pipes in the BHP Claim Block

		Littoral Zone Dominant Substrate	
Lake	Basin Zone (%)	Boulder (%)	Fines (%)
Fox1	62.2	37.8	0.0
Koala	55.8	39.4	4.8
Leslie	16.5	83.5	0.0
Misery	61.2	38.8	0.0
Panda	43.3	52.0	4.7
Mean	**47.8**	**50.3**	**1.9**
Sable	**41.0**	**53.1**	**5.9**

Two Rock Lake

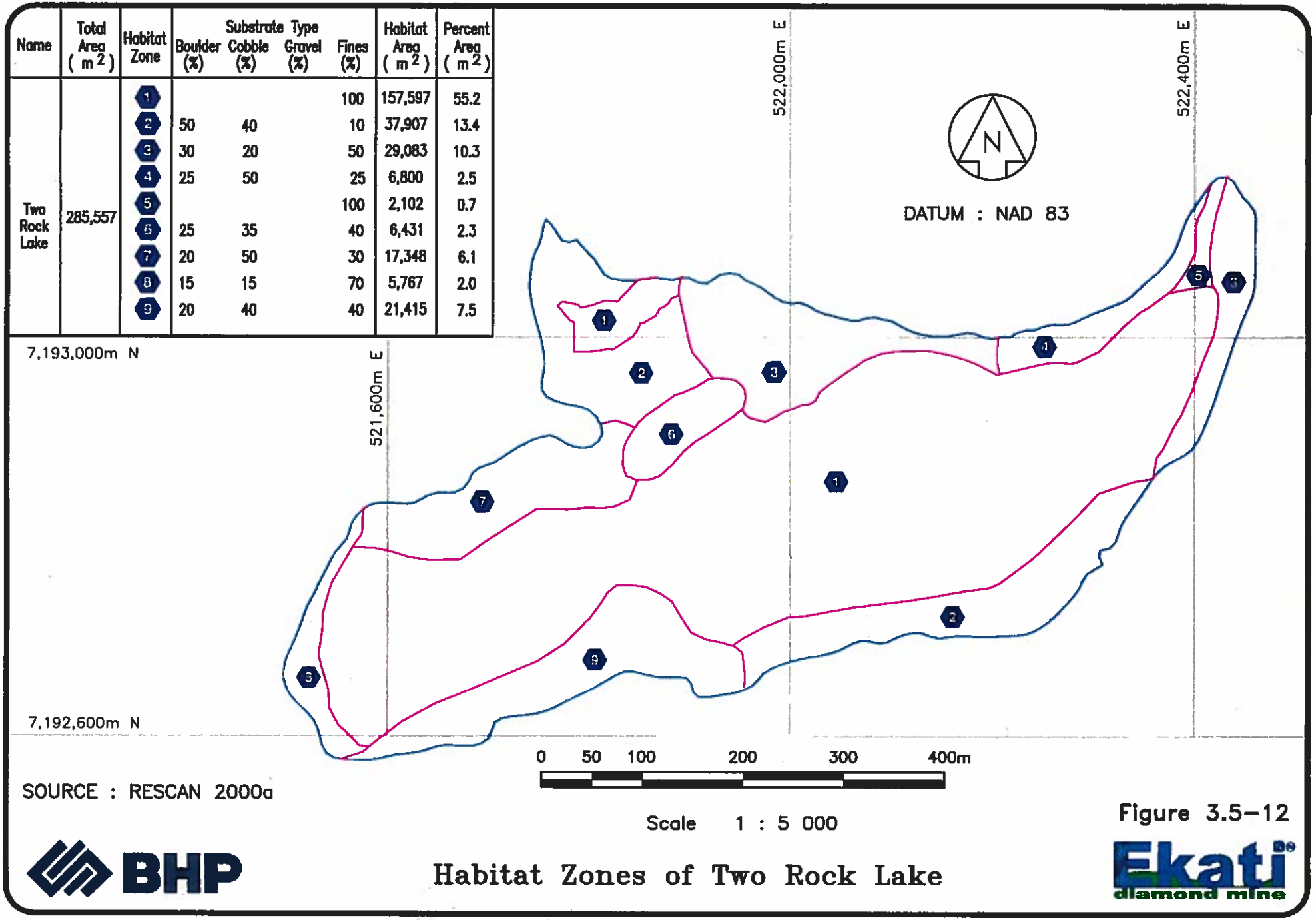
Previous work (Rescan, 2000a) has identified and quantified habitat zones in Two Rock Lake, as shown in Figure 3.5-12. Lake trout and round whitefish spawn in the fall and have similar spawning habitat requirements (Scott and Crossman, 1998). These fish prefer to spawn in relatively shallow areas over cobble and rubble substrates that are relatively free of silt.

Based only on the above criteria, it is apparent from Figure 3.5-12 that zones 2, 4, 6, 7 and 9 possess adequate conditions for spawning, making up about 31% of the total surface area of the lake. However, much of this littoral area is less than 2 m deep, the minimum depth to which freezing likely occurs in winter. Therefore, the total area available for spawning is probably very limited.

The relative proportions of littoral zone to deep basin habitat and the proportions of boulders and fines in the littoral zone habitat of Two Rock Lake are shown in Table 3.5-4. The ratio of deep basin to littoral zone in Two Rock Lake more closely resembles that in kimberlite lakes (Table 3.5-3) than in non-kimberlite lakes. Similarly, the littoral zone in Two Rock Lake has a relatively low proportion of fines compared to most non-kimberlite lakes. The low content of fines suggests that spawning and rearing habitats in Two Rock Lake are of good quality.

Since over half the area of Two Rock Lake is within the deep basin zone, it is apparent that there is an abundance of overwintering habitat. It is more likely that spawning and rearing habitats would limit fish biomass in this lake, if habitat is the limiting factor governing fish production.

Name	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (m^2)
Two Rock Lake	285,557	1				100	157,597	55.2
		2	50	40		10	37,907	13.4
		3	30	20		50	29,083	10.3
		4	25	50		25	6,800	2.5
		5				100	2,102	0.7
		6	25	35		40	6,431	2.3
		7	20	50		30	17,348	6.1
		8	15	15		70	5,767	2.0
		9	20	40		40	21,415	7.5



SOURCE : RESCAN 2000a

Scale 1 : 5 000

Figure 3.5-12

Habitat Zones of Two Rock Lake

Table 3.5-4
Proportion of Lake Habitat Zones in Twelve Lakes Not Overlying Kimberlite Pipes in the BHP EKATI™ Mine Claim Block

Lake	Basin Zone (%)	Littoral Zone Dominant Substrate	
		Boulder (%)	Fines (%)
Arnie	0.0	55.0	45.0
Cujo	29.9	32.2	37.9
Fox3	27.8	72.2	0.0
King	0.0	41.9	58.1
Kodiak	6.8	82.2	11.0
Larry	43.9	39.3	16.8
Little	20.2	41.8	38.0
Long	49.5	49.8	0.7
Mark	0.0	50.3	49.7
Moose	11.5	58.2	30.3
Nema	22.8	77.2	0.0
MEAN	19.3	54.6	26.1
Two Rock	55.2	31.8	13.0

Source: Rescan, 2000a.

Ulu Lake

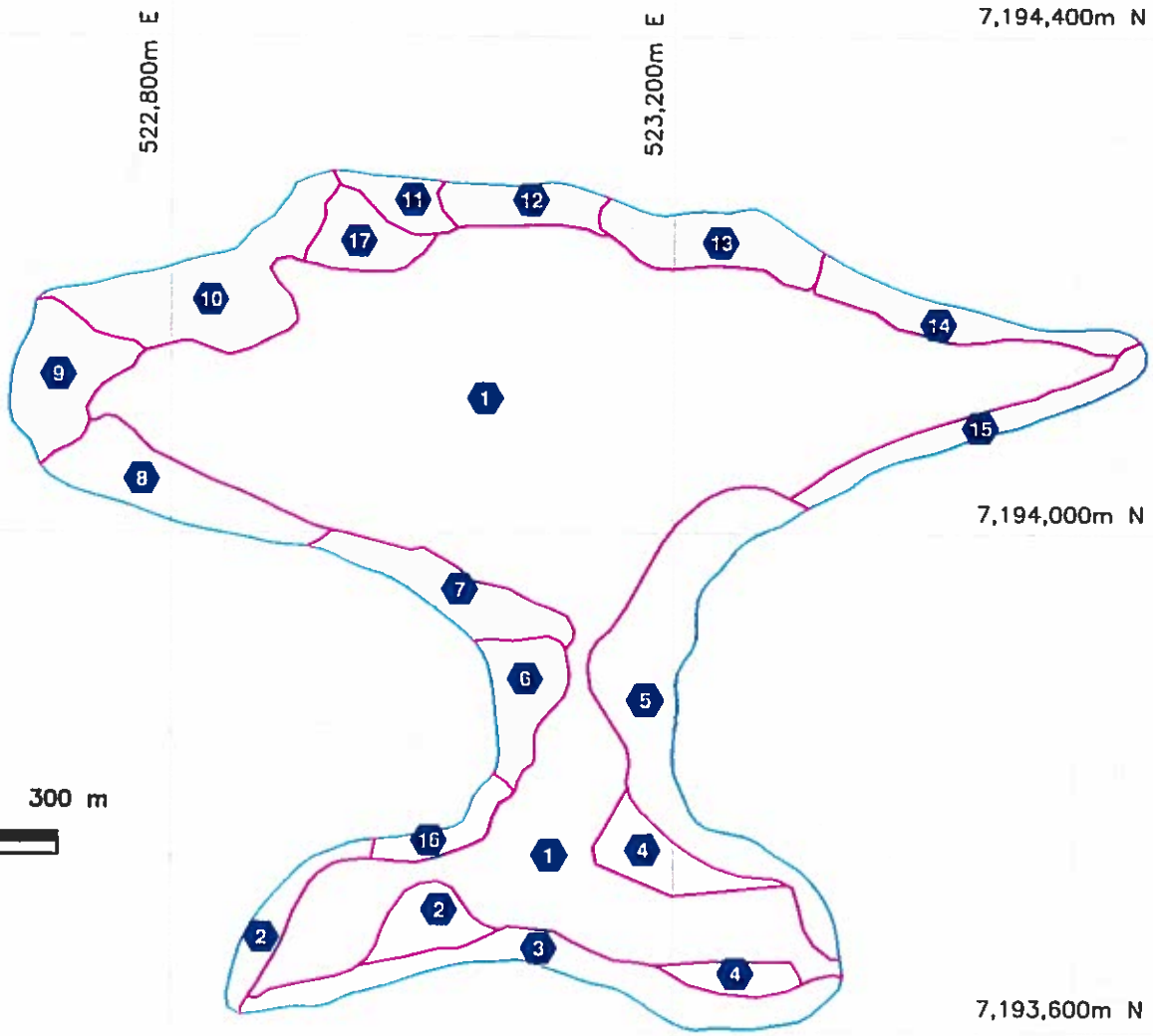
Just over 20% of the surface area of Ulu Lake has habitat conditions suitable for lake trout, round whitefish and Arctic grayling (zones 3, 5, 7, 9, 10 and 15; Figure 3.5-13). The remainder of the littoral zone contains a considerable amount of fine particulate material. The area available to lake trout or round whitefish for spawning is therefore small. Arctic grayling spawn in the spring just after ice-melt and are therefore able to use more of the littoral area for spawning.

The deep basin zone makes up 58.3% of the 28.7 ha surface area of Ulu Lake, boulder habitat makes up 30.6% and fines comprise the remaining 11.1%. These proportions more closely resemble conditions in kimberlite lakes than in those not overlying kimberlite pipes.

The relatively low proportion of littoral zone habitat in this lake, combined with the poor migration habitat in the Ulu-Horseshoe Stream (Rescan, 2000a) may contribute to the low Arctic grayling abundance in Ulu Lake (as indicated the very low CPUE for this species; Rescan, 2000a).

As in Two Rock Lake, deep basin habitat is abundant, suggesting that if any habitat is limiting in this lake, it is likely to be spawning and/or rearing habitat. The shallow depth

Name	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (m^2)
Ulu Lake	287,415	1				100	167,641	58.3
		2	10	10		80	6,997	2.4
		3	25	75			11,354	4.0
		4	10	20		70	7,033	2.4
		5	50	45		5	19,160	6.7
		6	30	60		10	5,152	1.8
		7	40	50		10	6,766	2.4
		8	10	45		45	9321	3.2
		9		70		30	7,720	2.7
		10	60	30		10	13,376	4.7
		11		5		95	2,727	0.9
		12	10	5		85	4,231	1.5
		13		40		60	7,233	2.5
		14	20	50		30	5,627	2.0
		15	35	60		5	5,621	2.0
		16	80	20			2,646	1.0
		17				100	4,080	1.4



0 50 100 200 300 m

Scale 1 : 6,000

DATUM : NAD 83

SOURCE : RESCAN 2000a

Figure 3.5-13

BHP

Habitat Zones of Ulu Lake

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of Ulu Lake (maximum depth 6.0 m) compared with Two Rock Lake (maximum depth 11.0 m) might explain the relatively high CPUE for round whitefish, a species that prefers foraging in shallow habitats.

Sable Lake Inflow and Outflow Streams

Details of the habitat surveys conducted in the Sable Lake inflow and outflow streams are provided in Rescan (1998c). The two inflow streams are ephemeral. They carry significant volumes of water only during snowmelt in undefined channels over tundra vegetation. Neither channel is considered to possess fish habitat.

The outflow stream flows 720 m from Sable Lake to Two Rock Lake. The upstream 600 m of this stream flows through bouldergarden interstices and then into a series of steep cascades before being dispersed through terrestrial grasses before entering Two Rock Lake. The cascades and the bouldergarden exclude upstream and downstream fish migration. It was therefore concluded that the outflow stream does not provide habitat for any species of fish.

Two Rock Lake Inflow and Outflow Streams

The habitat of the main inflow stream to Two Rock Lake, the Sable-Two Rock Stream, has been described in the previous section. The small unnamed stream flowing from the south through terrestrial grasses into Two Rock Lake likely carries water only during freshet during the period of snowmelt. Even at that time there is little flow, measured in June at only 30 L/s. For these reasons this stream is not considered to possess fish habitat.

The outflow watercourse from Two Rock Lake, the Two Rock-Horseshoe Stream, was surveyed in early June and late August 1999 (Rescan, 2000a). This stream is ephemeral. It carries water during snowmelt but likely dries each year in mid-summer. No flow was observed during the August survey. The stream flows 350 m between Two Rock Lake and Horseshoe Lake. The uppermost section of the stream is contained within a well defined channel composed of boulders, cobble, gravel and sand. After this first 25 m, the stream then flows for 130 m through a bouldergarden before emptying into a small, shallow pond (< 1 ha in area; < 1.5 m in depth). The pond discharges into another bouldergarden covered by dense willows. This section of the stream is 175 m long, contains one 0.6 m waterfall and generally consists of subsurface flow. Because of the intermittent, subsurface flow and the one obstruction (waterfall), it is unlikely that this stream possesses useful fish habitat.

Ulu Lake Inflow and Outflow Streams

The unnamed inflow stream flowing into the northeast corner of Ulu Lake runs almost entirely through a bouldergarden. Much of the flow is subsurface. During a survey of the stream in August, no flow was discernible. It is likely that this channel carries water only during snowmelt.

The Ulu-Horseshoe Stream was surveyed in June and in August. The stream is 325 m in length. The uppermost 150 m of this channel is made up of bouldergarden with dispersed flow. This then changes to a series of cascades, runs and riffles connecting bouldergardens. Only in the lowest 80 m of the stream is the channel well defined. This section of the stream provides potential spawning and rearing habitat for Arctic grayling. However, the rest of the stream offers little opportunity for spawning, rearing or migration. Further, no flow was observed in this stream during the August survey. No fish were found in the downstream section of the stream during sampling in the spring, even though the habitat there would apparently be suitable for both spawning and rearing.

Sable Haul Road

The development plan proposes the construction of an all-weather haul road to the Sable Pit. The road will link up all-weather roads currently leading to the site of the proposed Pigeon Pit. The suggested road alignment is shown in Figure 3.5-14. As illustrated, this road would cross seven stream channels. The proposed route was flown by helicopter on June 15, 1999, to examine and evaluate the fish habitat at each of the stream crossing sites. This assessment was conducted by a biologist with knowledge of northern fish habitat requirements and experience in habitat assessments. A description of the streams at each road crossing site is provided below. Site numbers refer to locations indicated on Figure 3.5-14.

Site SR1: This crossing is located on Pigeon Stream, upstream of Pigeon Pond. A description of the habitat in this channel is provided in Section 3.5.3.2.

Site SR2: At this location the road would cross a wetland area with only a limited flow running between a very small pond and Pigeon Stream. The flow likely occurs only during spring freshet. The pond at the head of this wetland is very small and shallow and would not support a fisheries resource. The stream is not considered to possess fish habitat.

Site SR3: The proposed road at this location crosses braided, defined channels flowing between two small lakes. Approximately two-thirds of the distance along its length, water flow is subsurface in an area dominated by boulders. Flow from these lakes leads to Fay Lake on Exeter Lake. Fish migration may be possible at high flows during the spring, allowing Arctic grayling to migrate into the lake upstream of the SR3 crossing. However, it is unlikely that this stream supports spawning or rearing for any fish species. As well, it does not provide overwintering habitat due to its shallow depth.

Site SR4: This stream crossing would occur in a wetland area draining to a series of small lakes that ultimately empty into Exeter Lake. Even though the survey was conducted during the period of freshet, flows in this area were very low. The channel above the stream crossing does not lead to any lake or pond. It can be assumed that this channel is not used by fish.

Site SR5: At this location the road would cross a well-defined channel running from the east into Big Pond. The stream drains a marshy area and widens upstream into two small ponds. Big Pond is shallow and would not likely support a year-round fisheries resource.

Since the stream to be crossed at SR5 does not originate from a lake, it can be assumed that migration, if it occurs at all, would be limited to a small number of fish, presumably grayling, that might head upstream to spawn from lakes downstream of Big Pond. However, because of the shallowness of both the stream and of Big Pond, young-of-the-year fish and juveniles would have to migrate to lakes downstream of Big Pond before freeze-up. It can therefore be assumed that the stream at SR5 is unlikely to be inhabited by fish.

Site SR6: The stream at this proposed road crossing was not examined during the aerial survey because the alignment has been changed since that time. However, an examination of aerial photographs reveals that the lake being drained by this crossing appears to be deep, as are the two downstream lakes that then flow into Ursula Lake. This implies the possibility that these lakes contain year-round populations of fish. It also appears that the channel at SR6 is fairly well defined suggesting that this watercourse may support fish populations for at least part of the year and possibly provides a suitable channel for both upstream and downstream migration.

Site SR7: Water flow is very limited at this location, in a channel that runs diffusely through grasses and marsh. This watercourse does not drain any lake or pond. It can be concluded that it does not support fish life.

3.5.3.2 Pigeon Pipe

3.5.3.2.1 Site Description and Development Plans

The Pigeon Pipe is about 4.5 km northwest of the existing Panda Pit. The pipe centre is approximately 250 m to the east of a small pond that lies roughly midway along Pigeon Stream. As planned, the Pigeon Pit development will displace this pond, requiring diversion of Pigeon Stream around the north wall of the pit (BHP, 1999c).

Pigeon Stream flows southwesterly a distance of 1.9 km from a small unnamed lake to Fay Lake, which flows into the northeast end of Upper Exeter Lake (BHP, 1999c). The pond referred to above lying midway along Pigeon Stream is, in effect, a large pool or widening in the stream (Rescan, 2000c).

Waste rock from the Pigeon Pit will be deposited, in part, in Big Reynolds Pond. This 17.1 ha pond is 3.5 km northwest of Panda Pit and 0.75 km south of the proposed Pigeon Pit (BHP 1999c; Rescan, 2000a). Big Reynolds Pond flows through a short channel to Little Reynolds Pond and then southwest to Cell B of the Long Lake Containment Facility. Big and Little Reynolds ponds lie in the extreme headwaters of the Lac de Gras watershed.

Little Reynolds Pond will not be directly affected by waste rock deposits. However, Pigeon Pit water is to be discharged into Little Reynolds Pond.

Aquatic surveys, including fish and fish habitat sampling, were conducted in 1999 in Pigeon Stream (including Pigeon Pond), Big Reynolds Pond and Little Reynolds Pond. These surveys did not include the inflow and outflow streams of Little Reynolds Pond, since these were included as part of the original EKATI™ Diamond Mine Habitat Compensation Agreement and Fisheries Authorization with the Department of Fisheries and Oceans.

N

DATUM : NAD 83

Date of Photography :
August, 1993 unless otherwise shown

0 0.5 1.0 2.0 3.0 km

Approx. 1 : 46,000

525 000m E

515 000m E

7 190 000m N

7 185 000m N

7 180 000m N

TWO ROCK L.

Sable Pit

SR7

URSULA L.

Ursula Esker

EAGLE L.

SR6

BIG POND
Shallow

SR5

URSULA L.

Sable Road

SR4

FALCON L.

Exeter Esker

SR3

SR2

SR1

Pigeon Pit

Fay L.

Big Reynolds

Pigeon Road

Little Reynolds

Date of Photography :
September 3, 1999

Vulture L.

Beartooth Road

Beartooth Pit

Koala North Test Pit

Koala Pit

Date of Photography: September 3, 1999

Source : BHP, 1999C

Sable, Pigeon and Beartooth Road Alignments Showing Stream Crossings

Figure 3.5-14

BHP

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A synopsis of the results of fish and fish habitat sampling in Pigeon Stream, Big Reynolds Pond and Little Reynolds Pond is provided below. Details of the methodology used and the results obtained are provided in Rescan (2000a).

3.5.3.2.2 Fish Populations

Pigeon Pond

Although Pigeon Pond is little more than a large pool within Pigeon Stream, it was sampled in mid-June and again in August 1999 using index gill nets. Ten mature Arctic grayling were captured during gillnetting in June; none were caught during similar sampling in August. Since the grayling captured in June were running and spent, it was concluded that these fish had entered the stream during spring to spawn and were holding in the pool.

Population characteristics for grayling caught in Pigeon Pond are included with those caught elsewhere in the stream and are summarized in the following section.

Pigeon Stream

Fish sampling was conducted in June and again in August. During the June survey, box traps were installed at the stream mouth (at Fay Lake) and near the headwater and were left in place for 19 days. Synoptic electrofishing (to determine fish presence and relative abundance) was also carried out in mid-June between the stream mouth and the headwater of the stream. In August, a synoptic electrofishing survey was again carried out from the stream mouth to the headwater.

Four species of fish were caught in Pigeon Stream: Arctic grayling, slimy sculpin, lake trout and burbot (Lota lota). Only the first two of these species were caught in appreciable numbers; lake trout and burbot were incidental in the catch. Table 3.5-5 summarizes catch and population statistics for fish caught in Pigeon Stream.

Table 3.5-5
Summary of Parameter Means ± Standard Error for Fishes Caught in Pigeon Stream, 1999

Parameter	Arctic Grayling	Burbot	Lake Trout	Slimy Sculpin
Number Caught	76	2	3	12
Mean Fork Length (mm)	150 ± 12.4, n=68	116 ± 16.3	509 ± 119.6	293 ± 10.2
Mean Weight (g)	265 ± 54.0, n=20	78 ± 2.9	1257 ± 516.0	n/a
Mean Age (yr)	5.0 ± 1.15, n=10	n/a	n/a	n/a
Mean Condition Factor	0.98 ± 0.03, n=20	n/a	0.93 ± 0.21	n/a

Source: Rescan, 2000a.

Fourteen Arctic grayling juveniles and two lake trout, one adult and one juvenile, were captured in the downstream box trap. All the grayling were captured moving upstream.

The adult lake trout was moving downstream while the juvenile lake trout was captured while moving upstream.

Three mature, running grayling and one immature grayling were caught during electrofishing in June. Forty-eight juvenile and young-of-the-year (YOY) grayling were captured during electrofishing in August, along with 12 slimy sculpin and one burbot.

The information provided through box trap, gillnet and electrofishing surveys suggests that mature grayling enter the stream in the spring to spawn and then drop back to the lake. Following freshet, juvenile grayling likely enter the stream and, along with YOY grayling, utilize this habitat for the duration of the summer.

To determine if different areas of Pigeon Stream were used preferentially by grayling and slimy sculpin (the only species caught in sufficient numbers to permit analysis), catch-per-unit-effort (CPUE) for fish caught during the August survey was plotted against the seven reaches that make up this stream (Figure 3.5-15). For juvenile and YOY grayling considered together, there was a significant exponential increase in CPUE proceeding upstream. This relationship was also strong for juvenile grayling but was more moderate for YOY grayling. Conversely, the CPUE for slimy sculpin showed a moderate but negative correlation with stream reach.

The apparent preference for upstream reaches by juvenile grayling is supported by a plot of relative abundance against stream reach for fish caught in August 1999 (Figure 3.5-16).

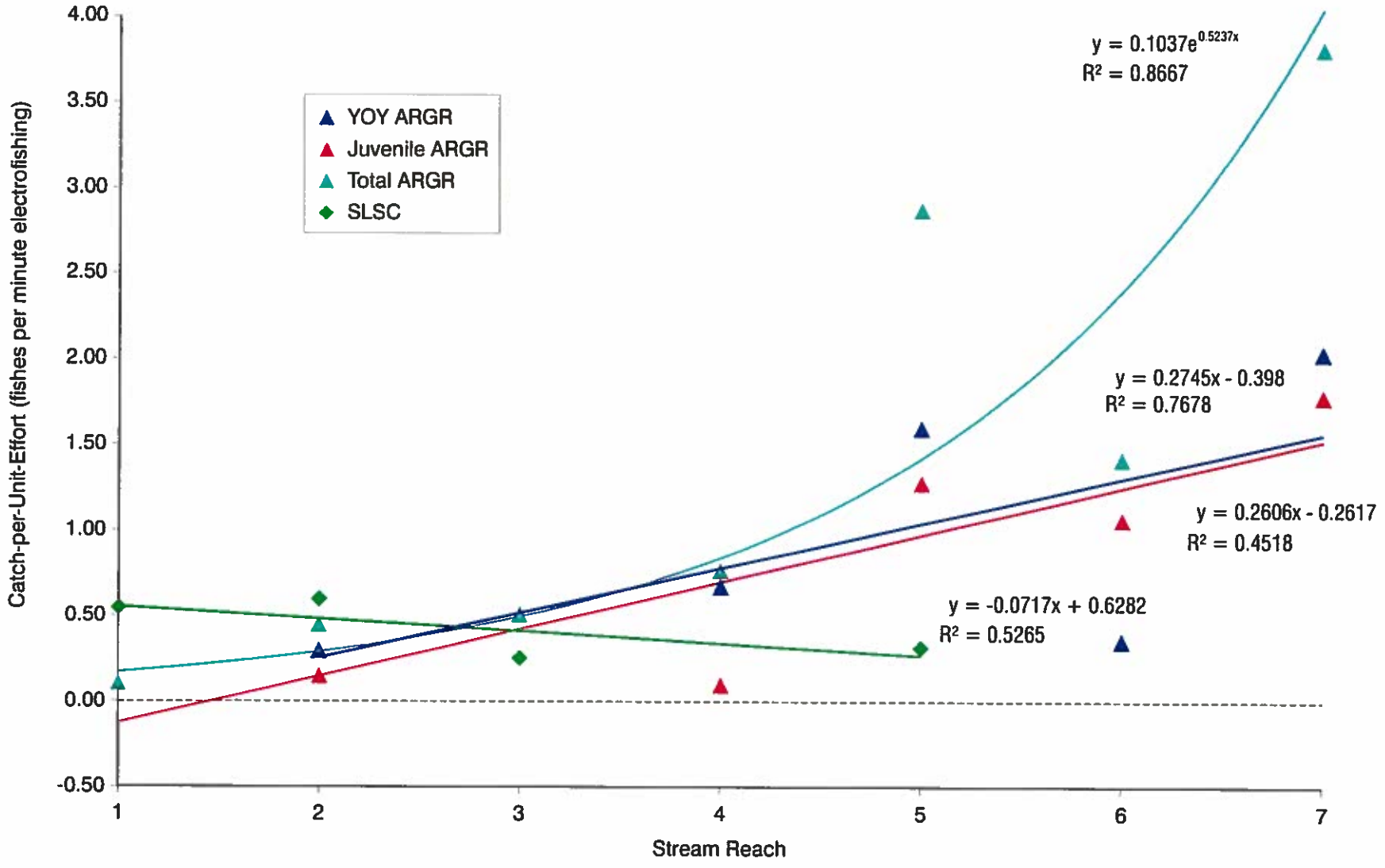
These analyses indicate that reaches 5 to 7 are particularly important as rearing habitat for juvenile Arctic grayling and, to a lesser extent, for YOY grayling. The lower reaches are preferred by slimy sculpin and are important for migration. From the small number of juvenile grayling captured in June, it is likely that these fish do not overwinter in Pigeon Stream.

Population characteristics for all grayling caught during the Pigeon Stream surveys are shown in Figure 3.5-17. Fish condition was relatively uniform across all size classes (Figure 3.5-17a). Juveniles made up the largest proportion of captured grayling (50%), followed by YOY grayling (42%; Figure 3.5-17c).

Big Reynolds Pond

Index gillnetting was conducted in Big Reynolds Pond during August, 1999. A total of 37 arctic grayling were captured during this sampling. No other fish were caught. Catch and populations statistics for Arctic grayling caught in Big Reynolds Pond during this survey are shown in Table 3.5-6.

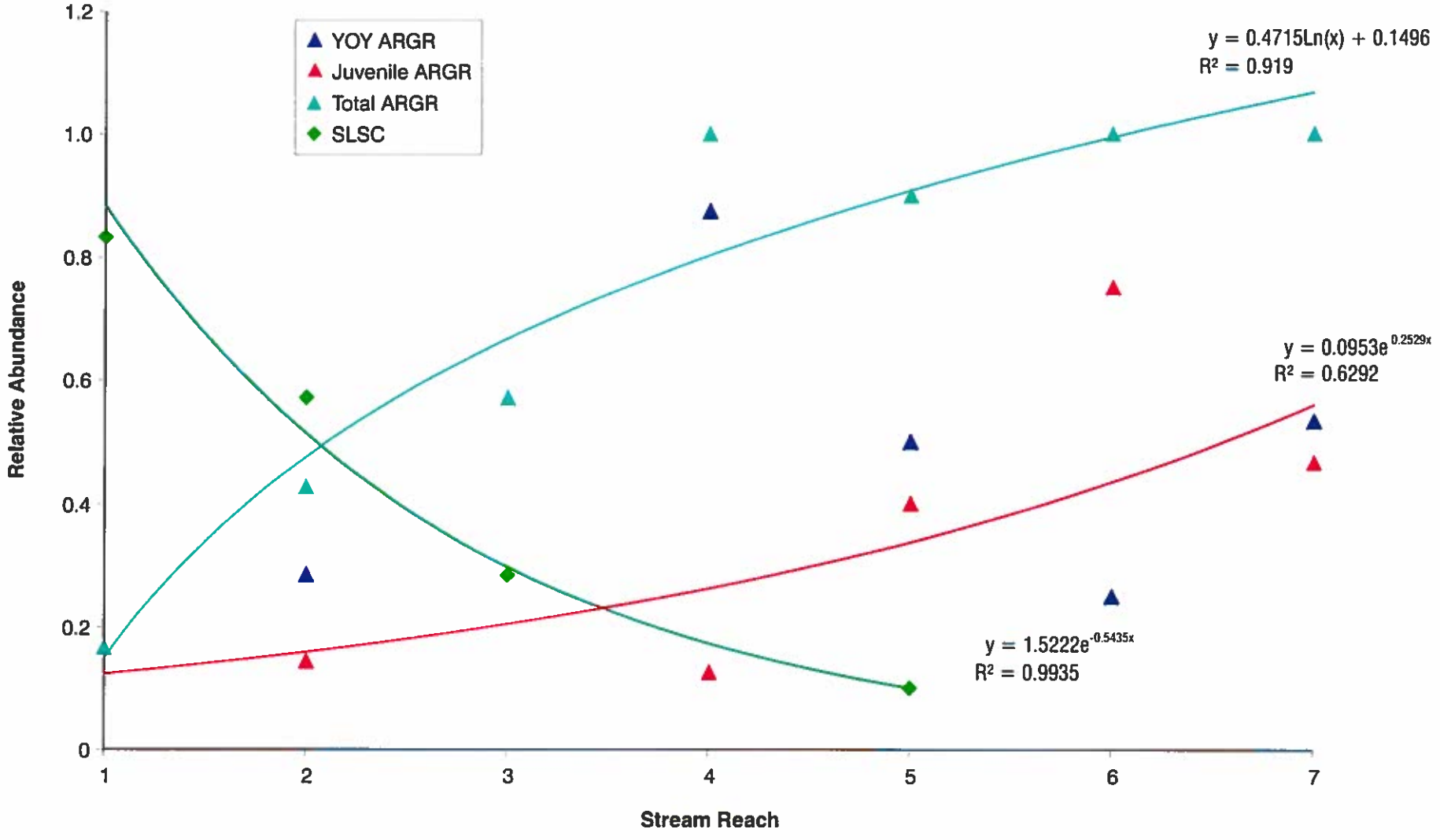
Figure 3.5-18 illustrates population characteristics of the grayling captured during the sampling program. The plot of condition against fish length shows that condition declines somewhat with size class. This implies that smaller, younger fish in the pond are relatively more successful than larger fish at obtaining food.



Catch-per-Unit-Effort of Arctic Grayling in Pigeon Stream, August 1999

FIGURE 3.5-15

Source: Rescan, 2000a



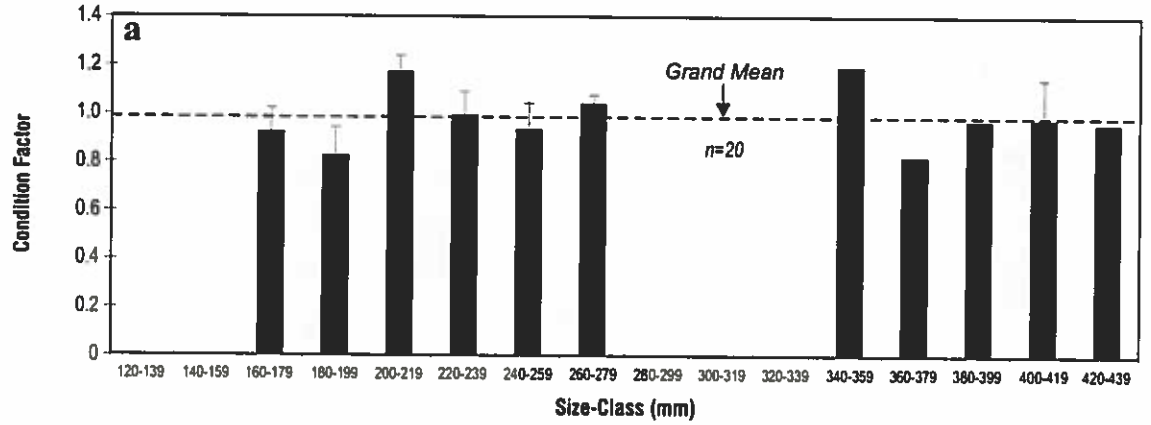
Relative Abundance of Fishes Caught in Pigeon Stream, August 1999

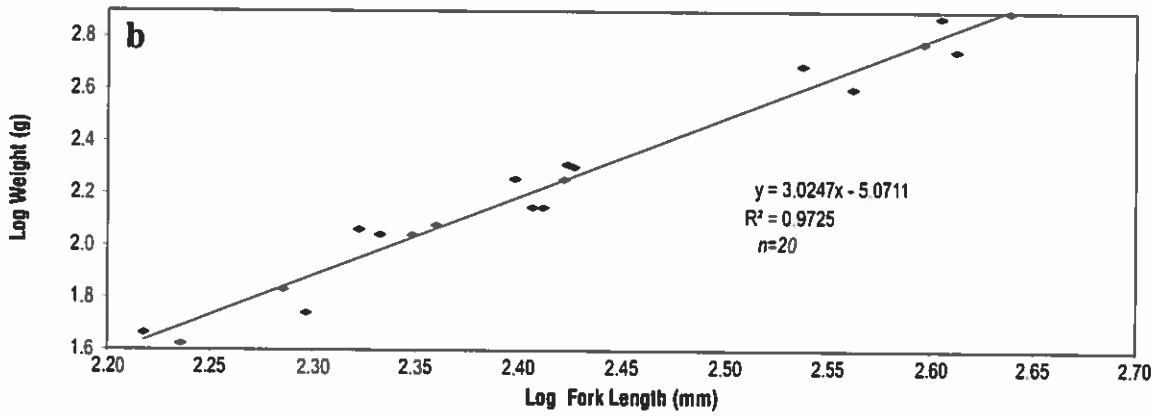
FIGURE 3.5-16

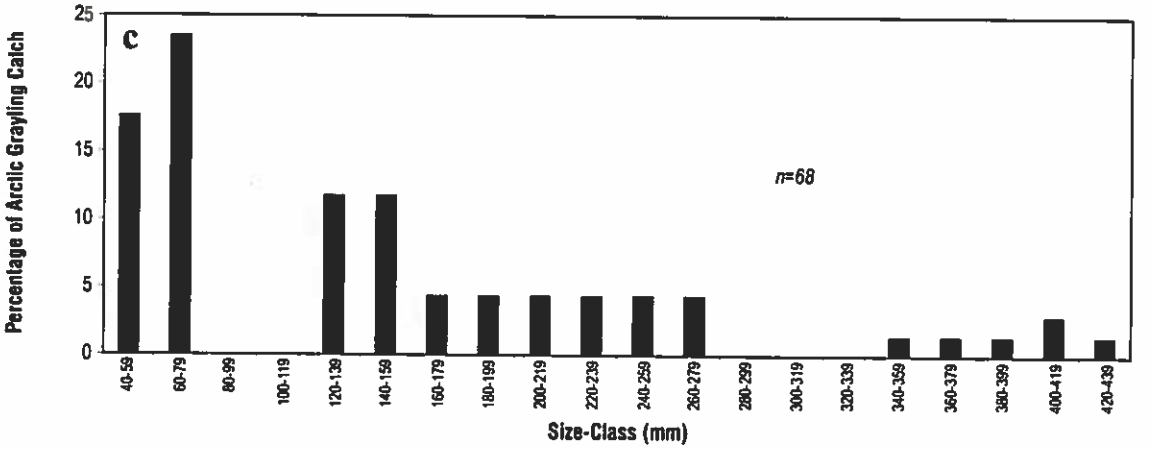
BHP

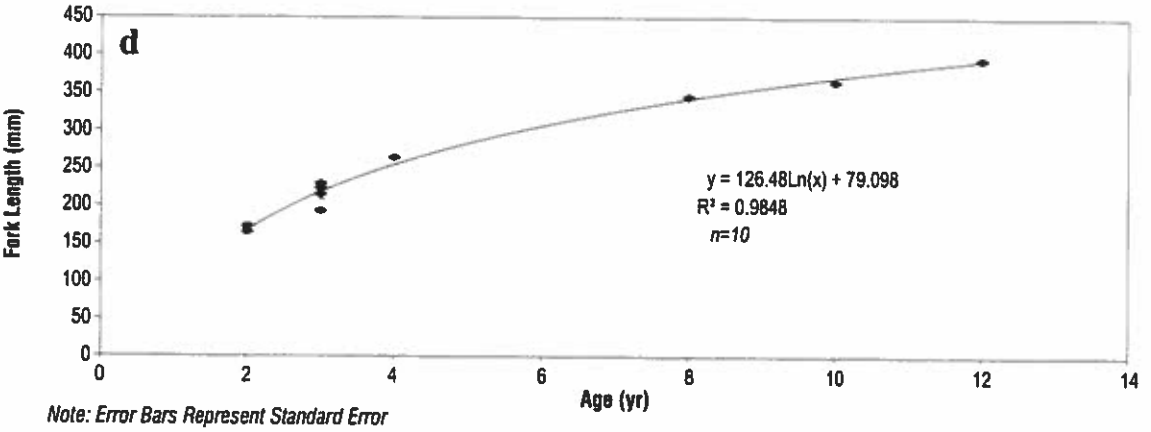
Ekati diamond mine

Source: Resca[illegible]a







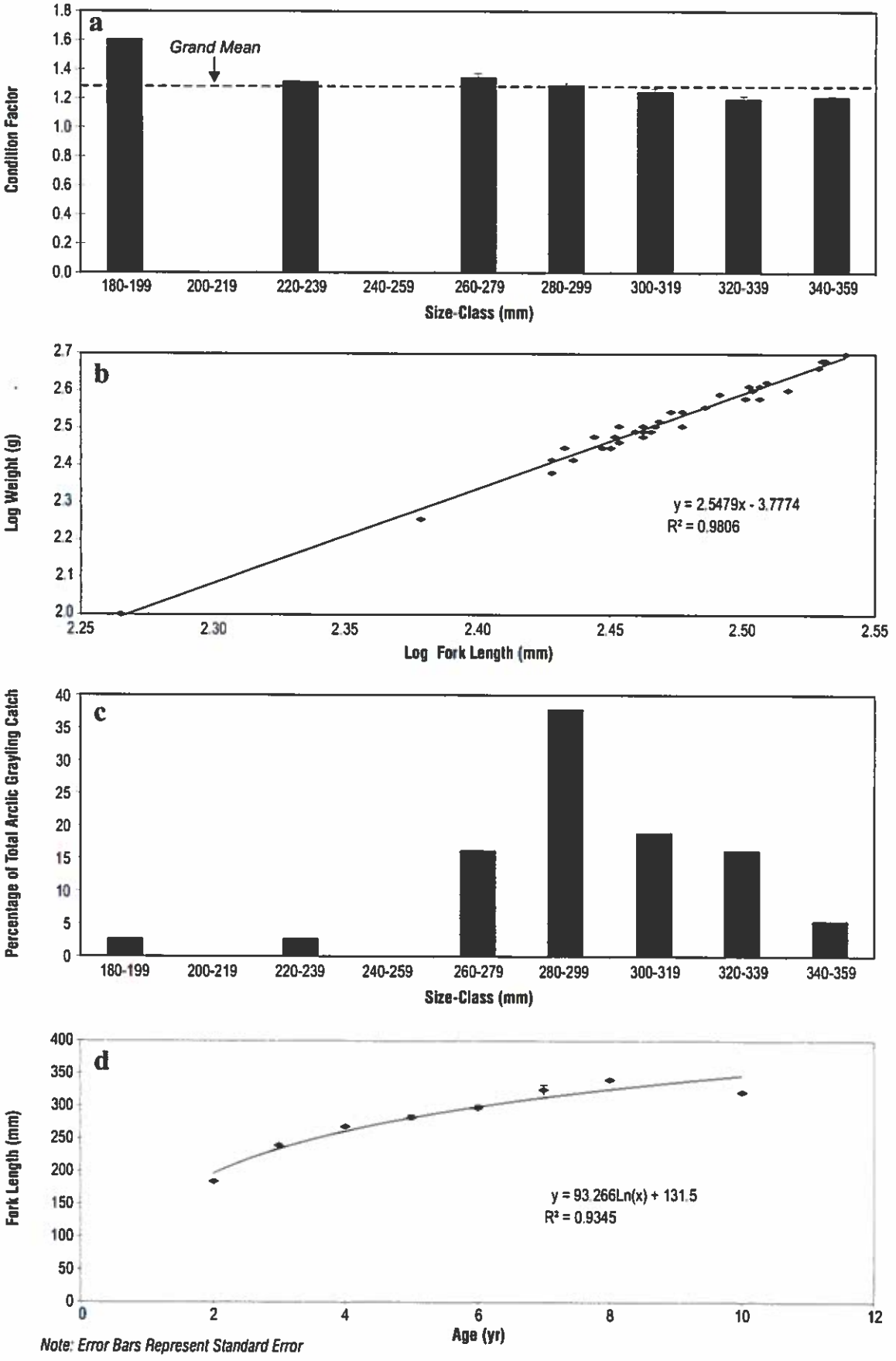


Note: Error Bars Represent Standard Error

Population Characteristics of Arctic Grayling Caught in Pigeon Pond, 1999

FIGURE 3.5-17

Source: Rescan, 2000a



Note: Error Bars Represent Standard Error

Population Characteristics of Arctic Grayling Caught in Big Reynolds Pond, 1999

FIGURE 3.5-18

Source: Rescan, 2000a

Table 3.5-6
Summary of Parameter Means ± Standard Error for Arctic Grayling Caught in Index Gill Nets, Big Reynolds Pond, 1999

Parameter	Arctic Grayling
Number Caught	37
Mean Fork Length (mm)	295 ± 5
Mean Weight (g)	335 ± 13
Mean Age (yr)	5.8 ± 0.22
Mean Condition Factor	1.28 ± 0.01
Mean Catch-per-Unit-Effort (fish)	70.4 ± 12.8
Mean Biomass-per-Unit-Effort (kg)	23.4 ± 3.6
Relative Abundance	100.0%

Source: Rescan, 2000a.

The length-frequency distribution (Figure 3.5-18c) shows one peak, at the 280 to 299 mm size class. This length corresponds to 4- and 5-year-old fish, the age at which grayling have been found to mature in other lakes within the claim block.

Little Reynolds Pond

Attempts to sample the fish population of Little Reynolds Pond were not successful (Rescan, 2000c). This pond is too shallow to deploy gill nets or operate a boat. Further, the unconsolidated nature of the substrate prevented wading to deploy seine nets. It is unlikely that this pond supports any significant fish population. Its very shallow depth suggests that it would freeze to the bottom in winter. As well, Little Reynolds Pond flows into Cell B of the Long Lake Containment Facility, which has been receiving processed kimberlite. Other cells in the Long Lake Containment Facility have been fished out.

3.5.3.2.3 Habitat Surveys

Pigeon Stream

The entire length of Pigeon Stream was surveyed in August 1999 to identify the quality and quantity of fish habitat. The stream was divided into seven reaches. Detailed descriptions of the habitat in each reach are provided in Rescan (2000a); the habitat characteristics are summarized in Table 3.5-7.

The fish population survey results conform well with the observed habitat characteristics of Pigeon Stream. Reaches 4 to 7 provide the best spawning and rearing habitat, and most of the juvenile and YOY fish were found there. Very little adult feeding habitat exists in the stream. This likely accounts for the absence of adults in the fish population surveys conducted in August.

There are no substantial barriers to migration in Pigeon Stream. While upstream fish passage may be hindered during low flows at the cascades in Reach 2, this would likely be temporary and would not impede downstream fish passage to Exeter Lake. It is expected that water would freeze to the bottom in all seven reaches and that Pigeon Stream provides no overwintering habitat for fish.

Table 3.5-7
Pigeon Stream Habitat Characteristics

Channel Characteristics	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
Length (m)	150	400	400	350	200	250	325
Gradient (%)	<1	5	1	<1	2.5	3.5	
Mean Depth (m)	0.75		0.45	0.4	0.4	0.45	0.25
Mean Width (m)	2.5	0.8	2.5	1.5		1.0	2.1
Habitat Type	80% Run 5% Riffle 10% Pool	55% Riffle 25% Cascade 20% Run	95% Run 5% Riffle	55% Run 40% Riffle 5% Pool	50% Riffle 40% Run 10% Pool	60% Riffle 30% Run 10% Pool	75% Run 20% Riffle 5% Bouldergarden
Substrate	Organic with some boulders	90% Boulder Cobble Organics	Boulder Organics	35% Boulder 35% Sand 20% Gravel 10% Organics	Boulder Sand Small Gravel Organic s	45% Gravel 45% Sand 5% Cobble 5% Organics	75% Sand Boulder Organics Gravel
Cover	Pool, Overhanging vegetation	80% cover Overhanging vegetation Boulders	30% cover Boulders	85% cover Macrophytes Boulders Undercut banks Pools	Boulders Macrophytes Undercut banks Pools	90% cover Boulders Macrophytes Undercut banks Pools	40% Cover Boulder Macrophytes Undercut banks Pools
Habitat Quality	Migration	Migration, Low quality rearing	Migration Low quality spawning and rearing	Spawning Rearing Migration	Rearing Migration Spawning Adult feeding	Spawning Rearing Migration	Spawning Rearing Migration

From Rescan, 2000a

Big Reynolds Pond

The results of the habitat survey of Big Reynolds Pond are shown in Figure 3.5-19. Over half of the area of this lake (56.7%) is composed of shallow, littoral zone habitat generally made up of cobble and boulder substrate interspersed with sand. However, differences in substrate composition were apparent at different depths. The shoreline area was composed of boulders and broken rocks; cobble and sand predominated further offshore; and fines and organics dominated the deeper basin zone.

Because Big Reynolds Pond is shallow, the entire basin is within the euphotic zone and is therefore all littoral habitat. It is expected that much of the lake freezes to the bottom due to its shallow depth. This would preclude spawning in most areas, including those that provided suitable spawning substrates.

Little Reynolds Pond

The very shallow nature of this pond, coupled with a substrate composed almost entirely of organic matter and silt, precludes its ability to sustain populations of fish. From a habitat perspective, this pond only has value as a possible migration corridor between the Long Lake and Big Reynolds Pond. However, fish migration from Long Lake is no longer likely due to the deposition of processed kimberlite in Cell B of the Long Lake Containment Facility and Cells C and D are fished out.

3.5.3.3 Beartooth Pipe

3.5.3.3.1 Site Description and Development Plans

Extraction of diamonds from the Beartooth Pipe will require Beartooth Lake to be dewatered. This lake is located immediately upstream of North Panda Lake, which was studied as part of the Environmental Impact Statement for the initial BHP Diamonds development proposal (BHP, 1995). The southern end of Panda Lake has been dewatered to permit mining of the Panda Pit.

Beartooth Lake is 4.8 ha in area and has a maximum depth of 13 m (Rescan, 1997a). Bearclaw Lake is located just upstream of Beartooth Lake and drains into it through a 160 m long channel (Bearclaw-Beartooth Stream). The 260 m outflow stream from Beartooth Lake empties into North Panda Lake.

Beartooth Pit will be mined as an open pit development similar to the Panda Pit (BHP, 1999). It is expected that fish from the lake will be harvested before the lake is dewatered. Waste rock from the Beartooth Pit will be stored within the existing Panda Waste Rock Storage Pile Area. Lake bottom sediments will be stored within the Lake Bottom Sediments Storage Pile area.

Current development plans include the diversion of water from Bearclaw Lake around the Beartooth Pit by pumping water through a diversion pipeline into the upstream end of the Beartooth-Panda Stream.

Big Reynolds Pond Total Area : 171,203 m^2						
Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (m^2)
1	20	60		20	14,535	8.5
2	10	30		60	14,424	8.4
3	15	75		10	53,539	31.3
4	15	50		35	14,588	8.5
5	BASIN				74,117	43.3

Scale 1 : 3 500

DATUM : NAD 83
SOURCE : RESCAN 2000a

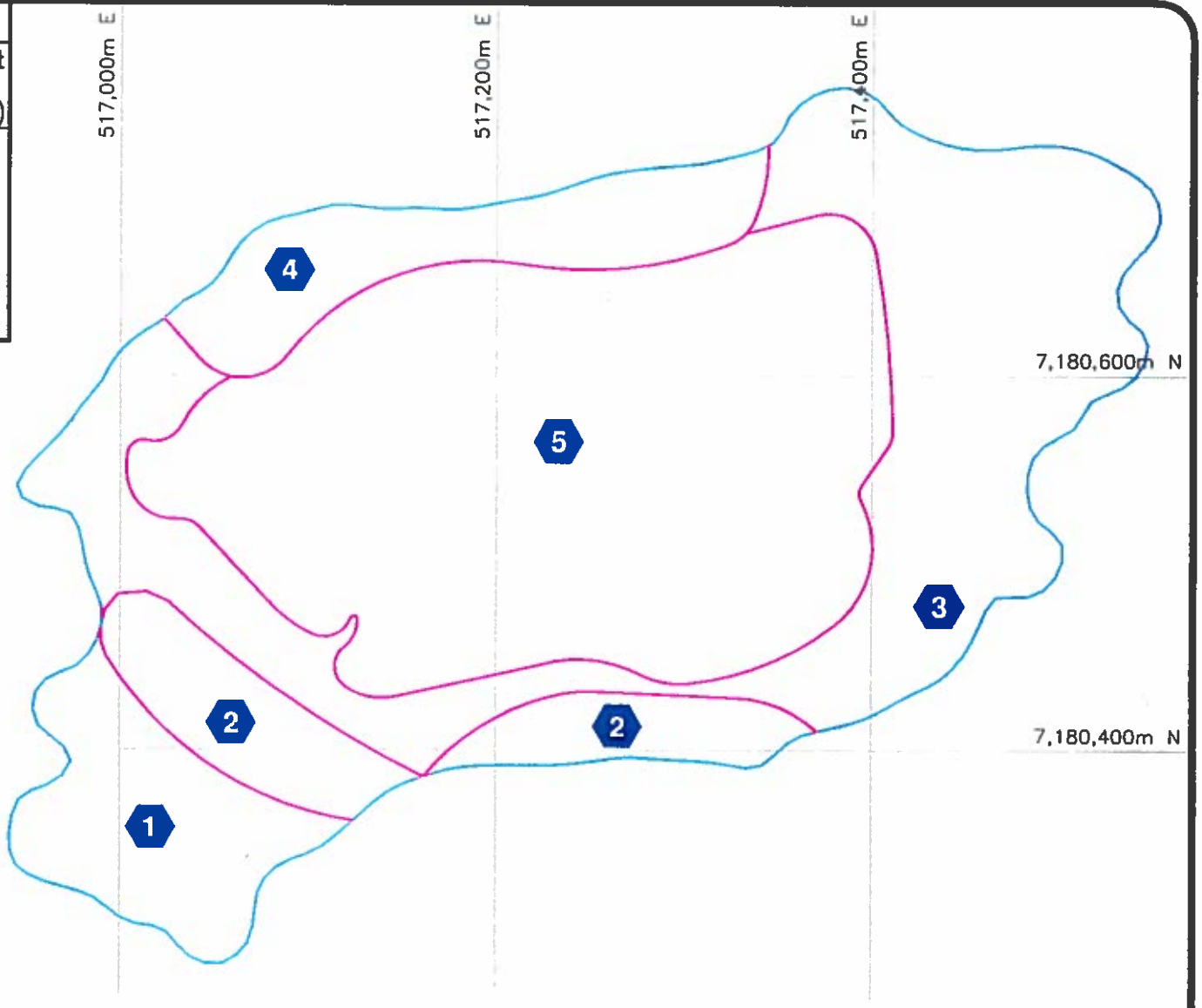


Figure 3.5-19

BHP

Habitat Zones of Big Reynolds Pond

Ekati diamond mine

Fish and fish habitat sampling was conducted in 1997 in Beartooth Lake and its inflow and outflow streams (Rescan, 1997a) as part of environmental baseline studies carried out prior to bulk sampling drilling. In addition, environmental baseline studies (not including fish or fish habitat) were carried out in 1996 on Beartooth and Bearclaw lakes (Bryant, 1996). Following is a description of the fish populations and fish habitat in Beartooth Lake and its inflow and outflow streams based on those reports.

3.5.3.3.2 Fish Populations

Beartooth Lake

Fish sampling was conducted in Beartooth Lake by gillnetting, electrofishing, beach seining and angling. Table 3.5-8 indicates the numbers of fish caught by each method. The majority of the fish were caught by gill net. Only grayling and lake trout were caught in large enough numbers to permit analysis.

Table 3.5-8
Results of Four Methods Used to Sample Fish in Beartooth Lake, Summer 1997 (after Rescan, 1997a)

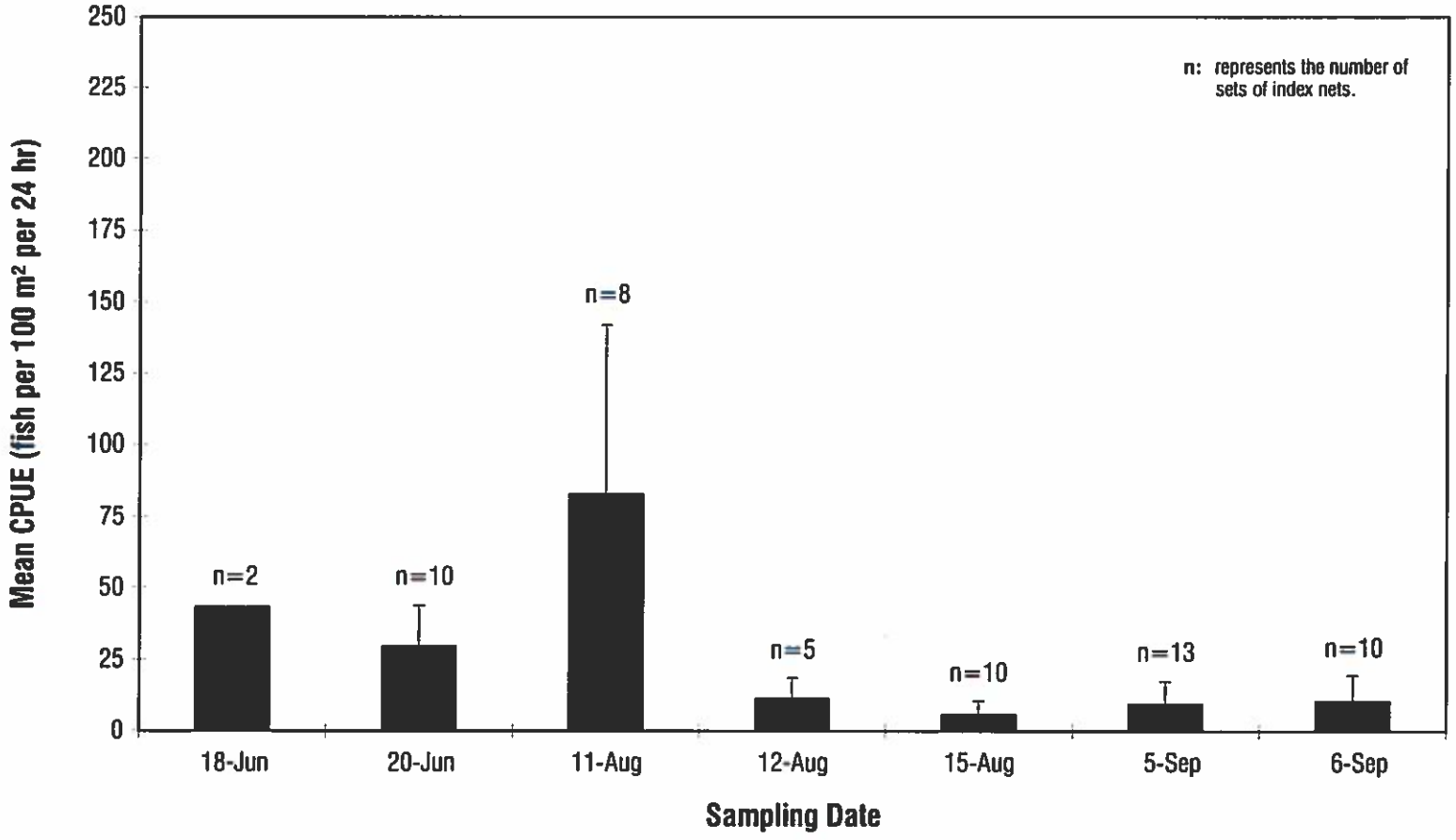
Sample Methods	Arctic Grayling	Burbot	Lake Trout	Slimy Sculpin	Total
Gillnet	50	1	38	--	89
Electrofishing	1	--	1	2	4
Beach seine	17	6	--	--	23
Angling	1	--	--	--	1
Species Catch	69	7	39	2	117

Arctic Grayling

Catch-per-unit-effort (CPUE) for grayling was high early in the season and then declined to a lower, stable rate from mid-August to the end of the summer (Rescan, 1997a). The average CPUE was higher for grayling in Beartooth Lake than in other lakes in the BHP claim block in previous years (Rescan, 1995b; Rescan, 1996a).

Mean condition factors for Arctic grayling were marginally higher in smaller fish than in those greater than 220 mm in length (Figure 3.5-20). The reason for this is not clear, since the decline in the value of the condition factor does not seem to be related to maturation in these fish. At least three size classes of grayling were caught during index gillnetting in Beartooth Lake. These size classes correspond to fish aged 1 and 2, composing the smallest size class; ages 3 to 5, making up the middle size classes; and 8 to 11 years, composing the largest size class.

The plot of age against fork length for grayling (Figure 3.5-21) shows that fish aged 6 and 7 years were missing entirely from the sample. This may indicate a failure in spawning success in those natal years. The population estimates for Arctic grayling in Beartooth Lake ranged from 98 to 138, with the actual population likely to be towards the upper end of the confidence interval (Rescan, 1997a).



Mean Catch-per-Unit-Effort with Standard Error by Sampling Date of Arctic Grayling Caught in Beartooth Lake, Summer, 1997

FIGURE 3.5-20

BHP

Ekati diamond mine

Source: Resca[illegible]7a

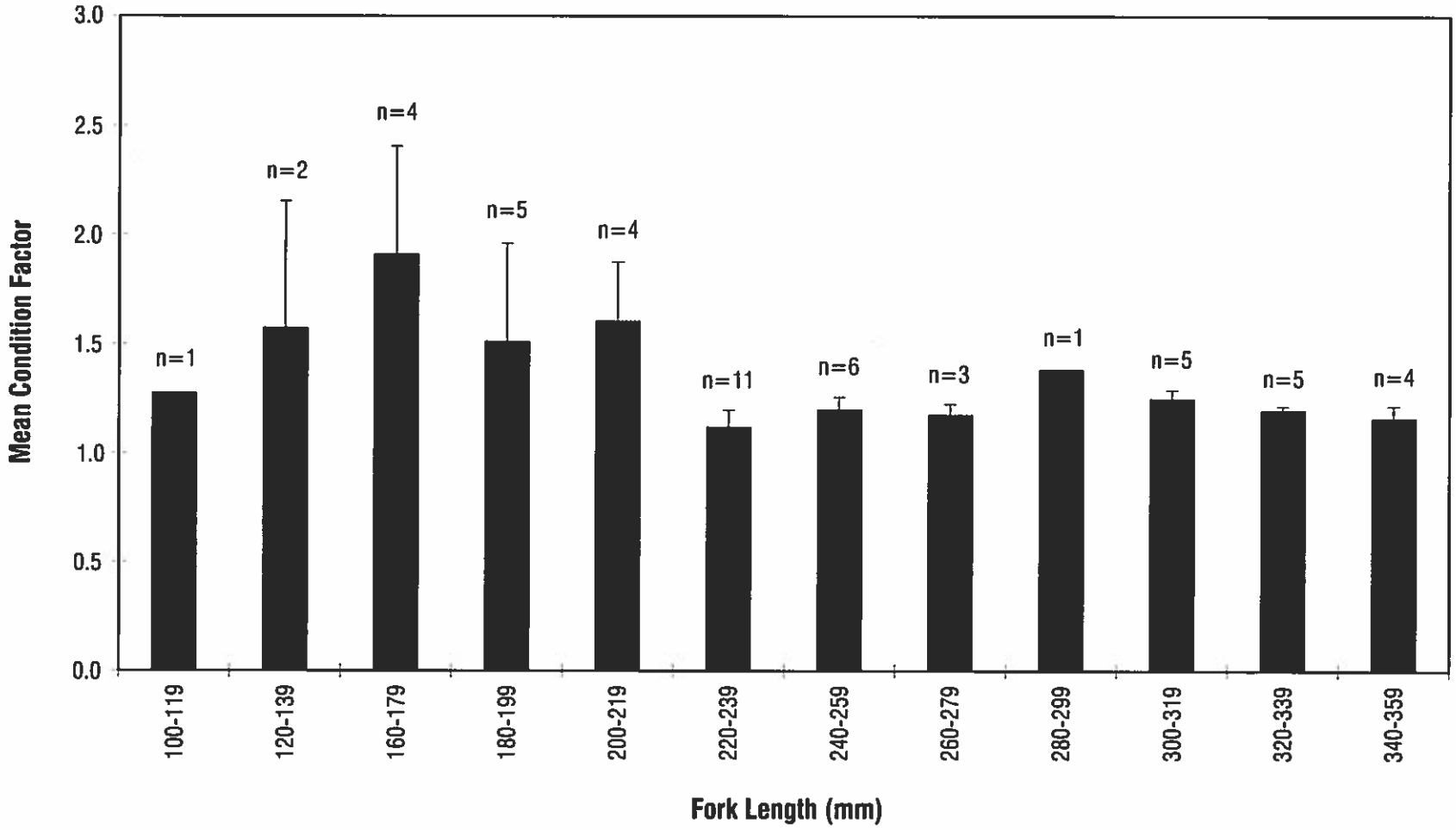


FIGURE 3.5-21

Mean Condition Factor with Standard Error by Fork Length Class of Arctic Grayling Caught in Beartooth Lake, Summer, 1997

Source: Rescan, 1997a

Lake Trout

A plot of CPUE for each sampling day is provided in Figure 3.5-22. CPUE increased from June 18 to August 11 and then declined to a stable, lower rate. This likely indicates a change in fish activity over the sampling season. However, since water temperatures were similar in June and September, some other factor must be regulating fish activity (Rescan, 1997a).

Mean condition factors for lake trout were generally similar for all size classes of fish (Figure 3.5-23). The 39 lake trout caught during sampling ranged in size from about 80 to 560 mm and in age from 1 to 26 years. The largest proportion of captured lake trout (21%) fell into the 240 to 259 mm size class. These fish are normally 4 and 5 years old in Beartooth Lake (Rescan, 1997a).

The population of lake trout in Beartooth Lake is estimated to range from 42 to 46 fish.

Beartooth Lake Inflow and Outflow Streams

Synoptic electrofishing surveys were conducted in the Beartooth Lake inflow and outflow streams in late June, 1997. Only one juvenile lake trout and one juvenile Arctic grayling were caught in the Bearclaw-Beartooth Stream. Two juvenile slimy sculpins were caught in the Beartooth-Panda stream. All fish were caught within 30 m of Beartooth Lake.

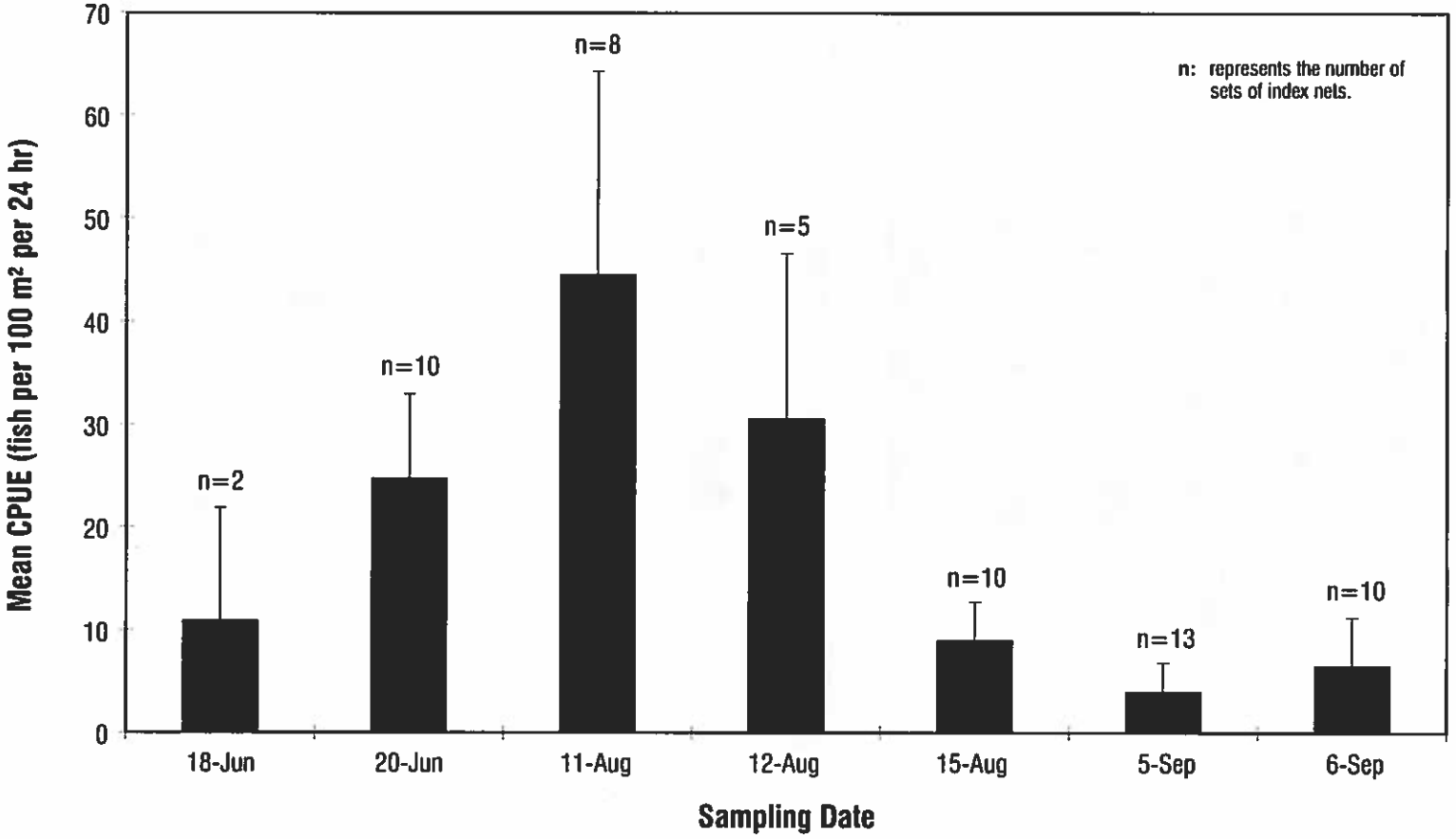
3.5.3.3.3 Habitat Surveys

Beartooth Lake

For the purposes of comparison with habitat surveys carried out in other lakes in the BHP claim block, potential lake trout spawning habitat was identified and mapped in Beartooth Lake (Rescan, 1997a). The results of this survey are shown in Figure 3.5-24.

Forty percent of the littoral zone, the area potentially available to lake trout for spawning, was found to be less than 3 m deep. Since much of this shallow zone would freeze to the bottom, it is not suitable for lake trout spawning. Habitats considered most suitable for lake trout spawning in Beartooth Lake are made up of a mixture of boulder and cobble. This habitat (Zone 1 on Figure 3.5-24) makes up 33.8% of the lake area (16,230 m^2). However, considering that approximately 40% of this zone is too shallow to support successful lake trout spawning, only about 9,700 m^2 of spawning habitat would be available to lake trout.

The ratio of littoral to basin zone in Beartooth Lake is similar to that in other lakes overlying kimberlite pipes (Table 3.5-9). However, substantially more of the littoral zone is composed of fines in Beartooth Lake compared to other kimberlite lakes, and it has



Mean Catch-per-Unit-Effort with Standard Error by Sampling Date of Lake Trout Caught in Beartooth Lake, Summer, 1997

FIGURE 3.5-22

Source: Rescan, 1997a

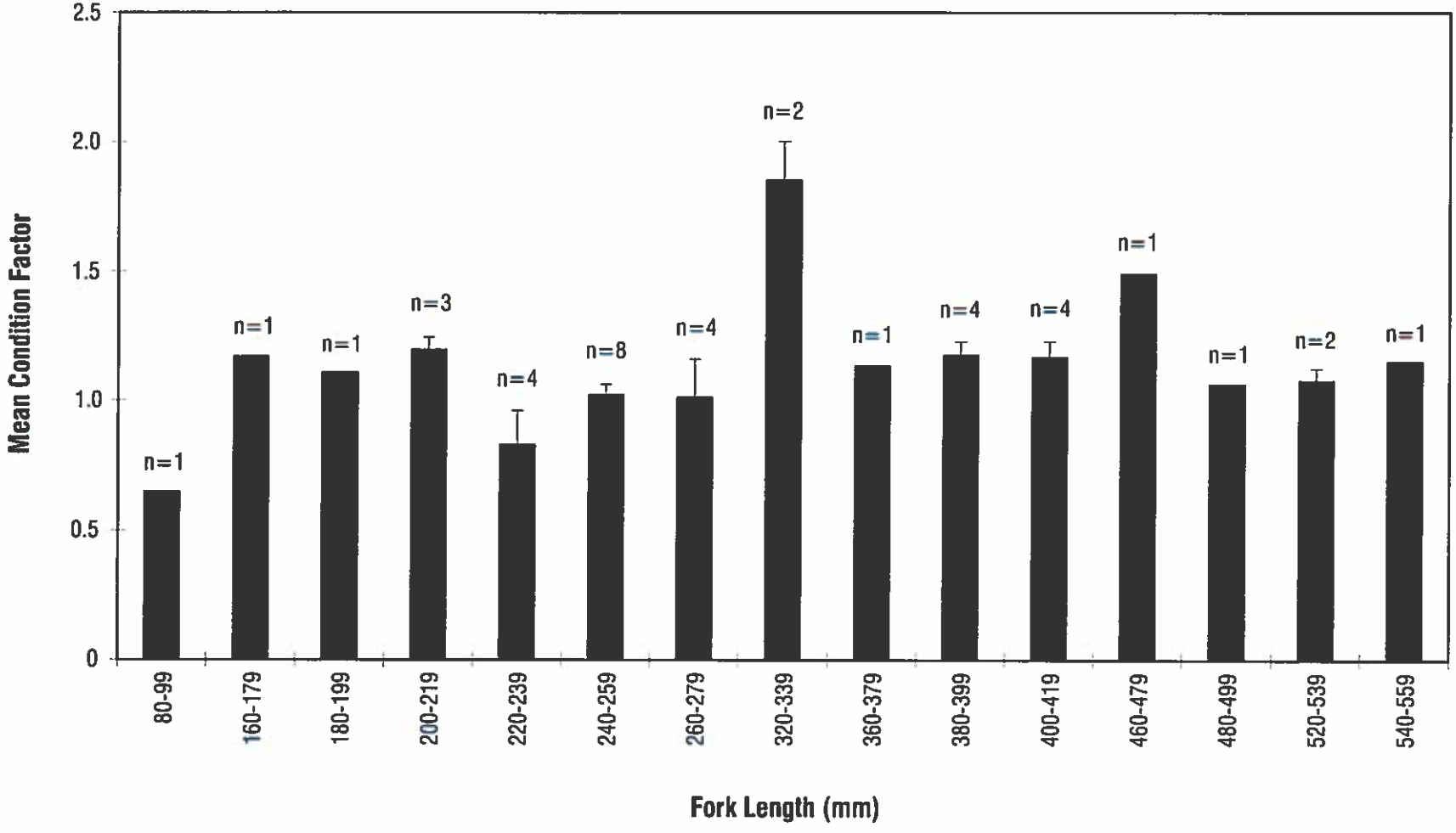


FIGURE 3.5-23

Mean Condition Factor with Standard Error by Fork Length Class of Lake Trout Caught in Beartooth Lake, Summer, 1997

BHP

Ekati diamond mine

Source: Rescan

03/27/2000– 11:47am EKATI_AP
Ref : fa2846s
Job No. 571–6 BHP 1999 EA Report
Sht 24 View C2
Cad No. Ch..d

0 25 50 100 150 200 m

Scale 1 : 2 500

Beartooth Lake Total Area : 48,042 m^2

Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (m^2)
1	80	10		10	16,230	33.8
2				100	625	1.3
3	5			95	7,179	14.9
4	40			60	2,573	5.4
5			Basin		21,435	44.6

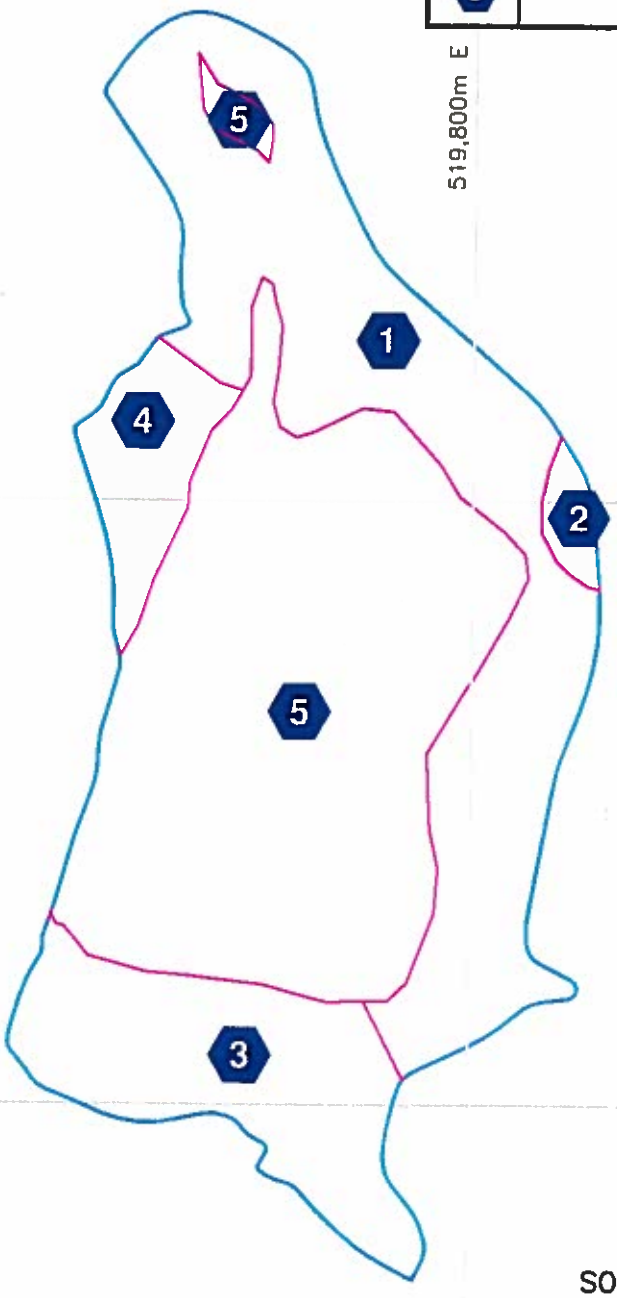
7,179,200m N

519,600m E

519,800m E

7,179,000m N

7,178,800m N



N

DATUM : NAD 83

SOURCE : RESCAN, 1997a

Habitat Zones of Beartooth Lake

BHP

Figure 3.5–24

Ekati diamond mine

Table 3.5-9
Proportion of Lake Habitat Zones in Six Lakes Overlying Kimberlite Pipes in the BHP EKATI™ Mine Claim Block

		Littoral Zone	
		Dominant Substrate	
Lake	Basin Zone (%)	Boulder (%)	Fines (%)
Fox1	62.2	37.8	0.0
Koala	55.8	39.4	4.8
Leslie	16.5	83.5	0.0
Misery	61.2	38.8	0.0
Panda	43.3	52.0	4.7
Mean	*47.8*	*50.3*	*1.9*
Sable	**44.6**	**33.8**	**21.6**

correspondingly less boulder habitat. This implies that Beartooth provides proportionately less spawning habitat for lake trout and burbot and less rearing habitat for Arctic grayling than other lakes overlying kimberlite pipes in the BHP claim block.

Beartooth Inflow and Outflow Streams

The Bearclaw-Beartooth Stream is 160 m in length and has two distinct reaches. Habitat characteristics of each reach are provided in Table 3.5-10. It is unlikely that this stream provides habitat for fish because it is ephemeral, very shallow and has an average gradient of 11%. Given the high gradient and shallow water depths, migration between Beartooth and Bearclaw lakes is probably not possible.

Table 3.5-10
Bearclaw-Beartooth Stream Habitat Characteristics

Channel Characteristics	Reach 1[1]	Reach 2
Length (m)	80	80
Gradient (%)	11	11
Mean Depth (m)	0.3	Subterranean Flow
Habitat Type	Cascades Runs Riffles Pools	Bouldergarden
Substrate	Boulders Flooded Vegetation	Boulder
Cover	Boulders Pools Cut banks Overhanging vegetation	
Habitat Quality	None	None

Source: Rescan, 1997a.
1. Reach 1 is the downstream reach.

The Beartooth-Panda Stream is 260 m long and can be divided into three distinct reaches:

- *Reach 1:* This upstream reach is 40 m long and consists of diffuse flow through predominantly bouldergarden habitat. Cover in this reach is provided by boulders.
- *Reach 2:* Emerging from bouldergarden, the stream channel becomes defined in this reach for a distance of 70 m. Habitat in this reach consists of shallow runs and riffles interspersed with shallow pools and flats. The small amount of cover is provided by shallow pools and cutbanks.
- *Reach 3:* The remaining 140 m of stream consists of diffuse flow through terrestrial grasses.

No flow was apparent during site visits to this stream in August and September 1997, indicating the probable ephemeral nature of this stream.

The Beartooth-Panda Stream does not have suitable habitat characteristics to sustain populations of fish. The shallow, intermittent flow precludes overwintering; there are only limited areas for spawning and rearing; and, the shallow, often subterranean flow through bouldergarden severely restricts migration.

3.6 Terrain and Vegetation

The BHP Diamonds claim block covers approximately 3,400km^2. As part of the work completed for the NWT Diamonds Project 1995 Environmental Impact Statement, a series of comprehensive baseline ecosystem (terrain and vegetation) maps was developed for a study area encompassing 1,900 km^2 around the current EKATI™ Diamond Mine (BHP, 1995a). This study area, shown in Figure 3.6-1, included most of the area to be affected by the current development proposal. The only area(s) not explicitly covered at that time were the area in the vicinity of the proposed Sable Pit and the last 500 m of the proposed haul road leading to the Sable Pit.

This area was, however, subsequently mapped by RWED using Landsat™ satellite data and its ecological land classification system for use in the ongoing wildlife monitoring program at the EKATI™ Diamond Mine (Golder, 1998). The study area for this program covers approximately 1,600 km^2 and extends well north of the Sable Lake area (Figure 3.6-1).

The following review of the terrain and vegetation characteristics in the proposed new development areas is drawn from these earlier mapping and ecological land classification efforts as cited.

3.6.1 Terrain Map Units

The mapping work carried out by BHP in 1995 resulted in the production of 30 comprehensive colour-coded base maps presenting the results of the terrain analysis for the BHP study area. Figure 3.6-2 represents the composite map for the terrain analysis. Larger-scale terrain-related information for the areas in the vicinity of the proposed Pigeon and Beartooth pits and the haul road to the proposed Sable Pit is provided in Figure 3.6-3.

The terrain mapping themes used to colour-code the recurring landform units on the terrain maps are listed in Table 3.6-1.

3.6.2 Vegetation-Ecosystem Mapping

The detailed ecosystem mapping (terrain and vegetation) conducted by BHP in 1994-1995 classified a total of 12 ecosystem units within the 1,900 km^2 study area around the current EKATI™ Diamond Mine, including most of the proposed new development area (Table 3.6-2).

Although ecosystems units are floristically uniform, they may occur on a variety of landforms and soil types. Thus a number of ecosystem modifiers were also developed (Table 3.6-2) to distinguish ecosystem units that occur on different landforms, or other variables (such as shrub height) that are important for management.

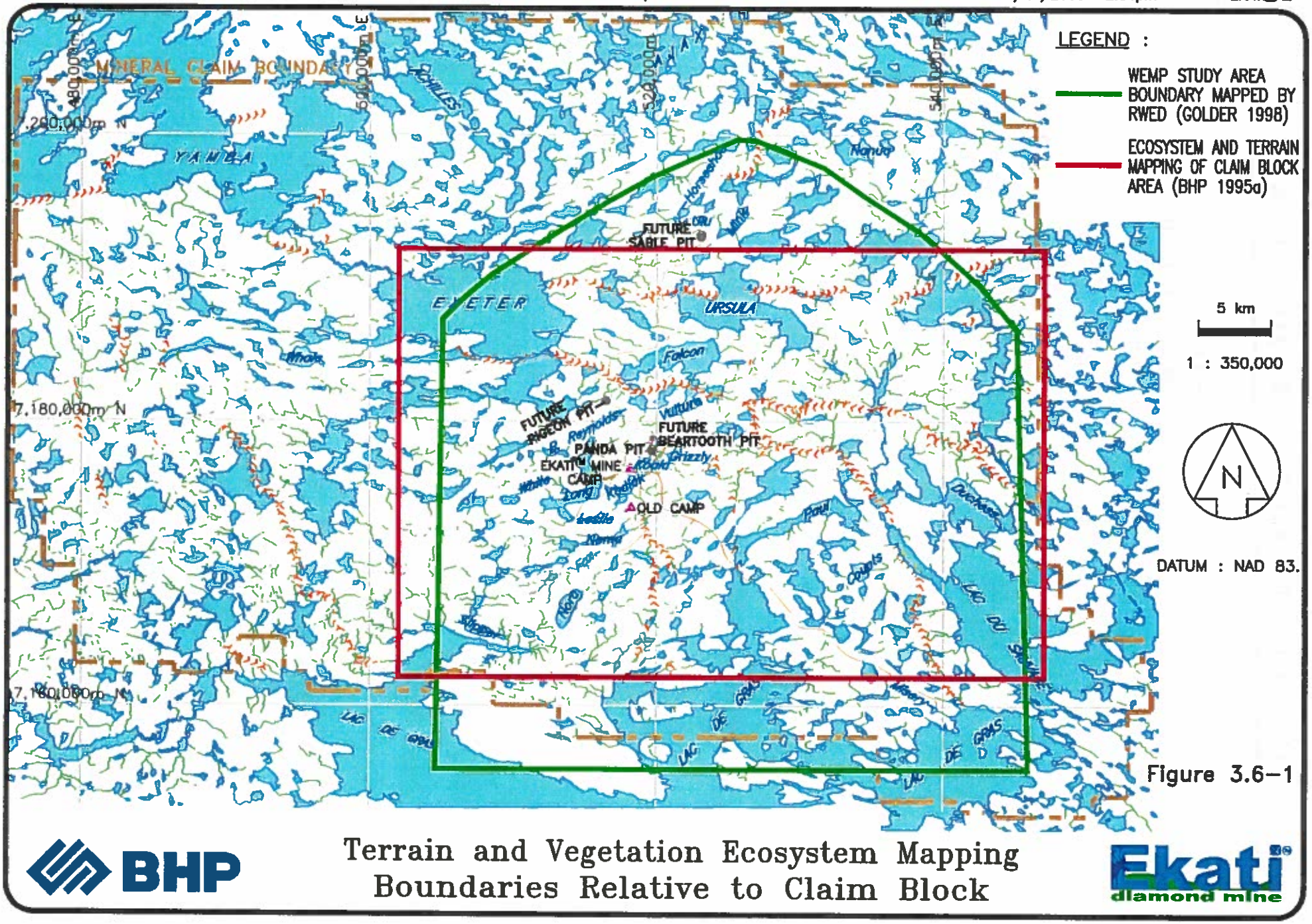


Figure 3.6-1

Terrain and Vegetation Ecosystem Mapping Boundaries Relative to Claim Block

BHP

Ekati diamond mine

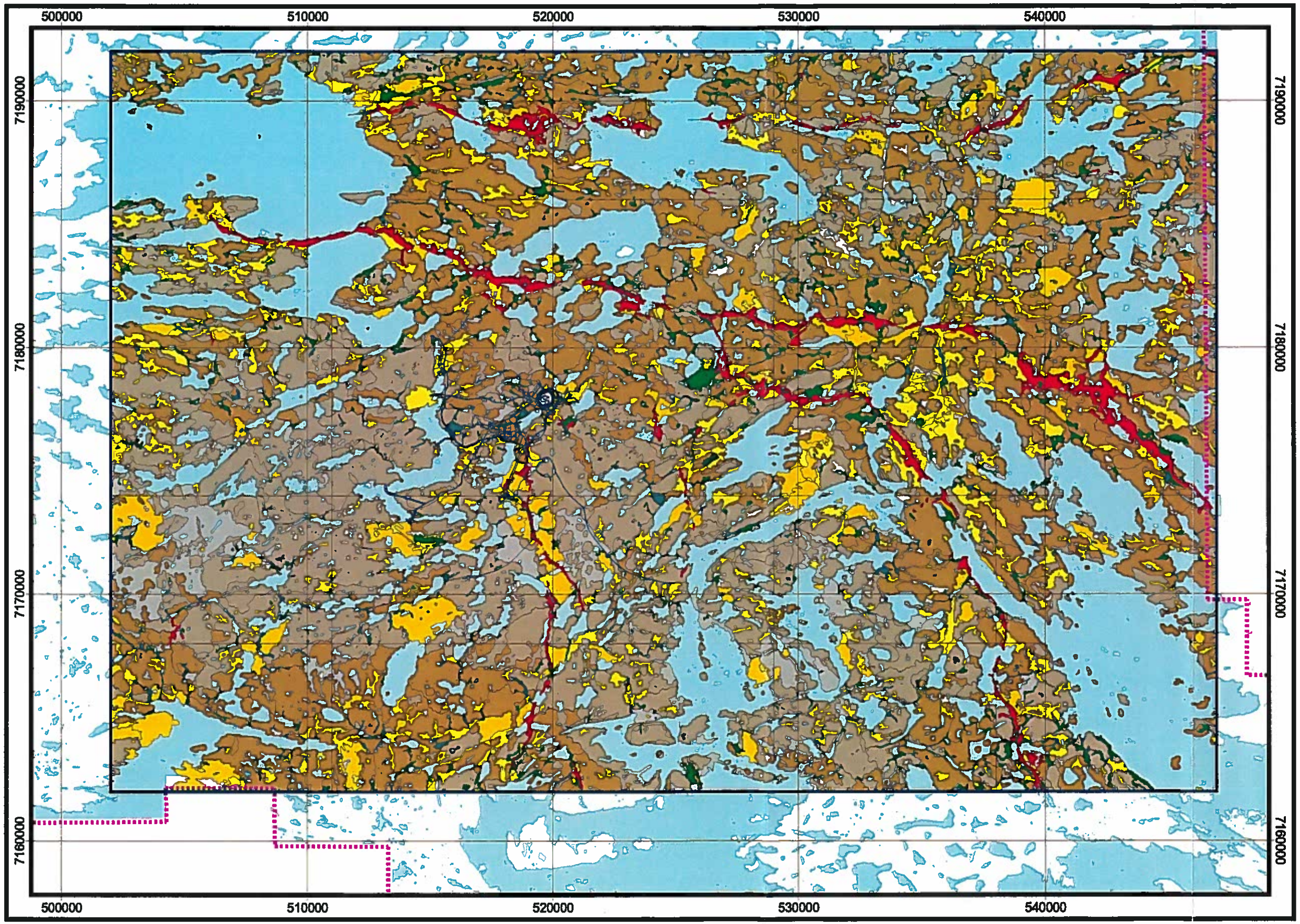
Table 3.6-1
Terrain Mapping Themes used to Colour-Code Recurring Landform Units on Terrain Maps

Terrain Map Unit	Description
Bedrock Controlled	Bedrock controlled terrain including exposed bedrock (Ru) and morainal veneers over bedrock (Mv/Ru).
Bouldery Types	Bouldery morainal blankets (bMb), bouldery wavy moraines over bedrock (bMw/Ru) and glaciofluvial veneers over bouldery morainal blankets (FGv/bMb).
Morainal Blankets	Thick (>1 m) mantles of unsorted morainal till (Mb).
Eskers	All esker landforms (sgkFGrb).
Other Glaciofluvial Deposits	Outwash plains and other non-esker glaciofluvial deposits (FGb).
Lacustrine Deposits	Glacial (LGb) and postglacial (Lb) pond and lake bottom sediments.
Fluvial Deposits	Holocene stream channels where fluvial veneers have been deposited over a variety of underlying substrates (Fv/various).
Organic Deposits	Organic veneers have accumulated in depressions and on low flat plains over a variety of substrates (Ov/various).

Table 3.6-2
Habitat Classification in the EKATI™ Diamond Mine Study Area Lac de Gras, NT

Ecosystem Unit	Formal Name	Common Name	Map Code
01	*Betula-Ledum*	Heath Mat Tundra	BL
02	*Saxifraga-Silene*	Xerophytic Herb Tundra	SS
03	*Betula-Empetrum*	Heath-Lichen Tundra	BE
04	*Betula-Rubus chamaemorus*	Birch Hummock	BR
05	*Betula-Calamagrostis*	Birch Seep	BC
06	*Eriophorum vaginatum-Andromeda*	Cotton-grass Tussock	EA
07	*Carex chordorrhiza-Eriophorum russeolum*	Sedge Meadow	CE
08	*Salix-Rubus arcticus*	Riparian Tall Shrub	SR
09	*Carex aquatilis-Eriophorum angustifolium*	Sedge Fen	CA
10	*Arctophila-Ranunculus*	Emergent Marsh	AR
11	*Umbilicaria*	Lichen-Boulder Field	BF
12	*Exposed Bedrock*	Exposed Bedrock	RB
Modifiers:			
b	30% or more of the surface cover is boulders		
r	30% or more of the surface cover is bedrock		
s	slope is 15% or greater		
e	unit occurs on an esker		
g	unit has more than 30% cover of shrubs more than 50 cm high		

Source: BHP, 1995a.



GENERAL LEGEND

- Ecosystem and Terrain Mapping of Claim Block Area (BHP 1995a)
- BHP Claim Block
- Infrastructure 1999
- Lakes
- Land

TERRAIN LEGEND

- No Data or Doesn't Fit
- Bedrock Controlled
- Bouldery
- Morainal Blankets
- Eskers
- Other Glacio-Fluvial Deposits
- Lacustrine Deposits
- Active Fluvial
- Organics

Datum: NAD83
Scale: 1:160,000
Date: January 27, 2000
Drawn By: LLL
Checked By: SM

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W E
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2000 0 2000 4000

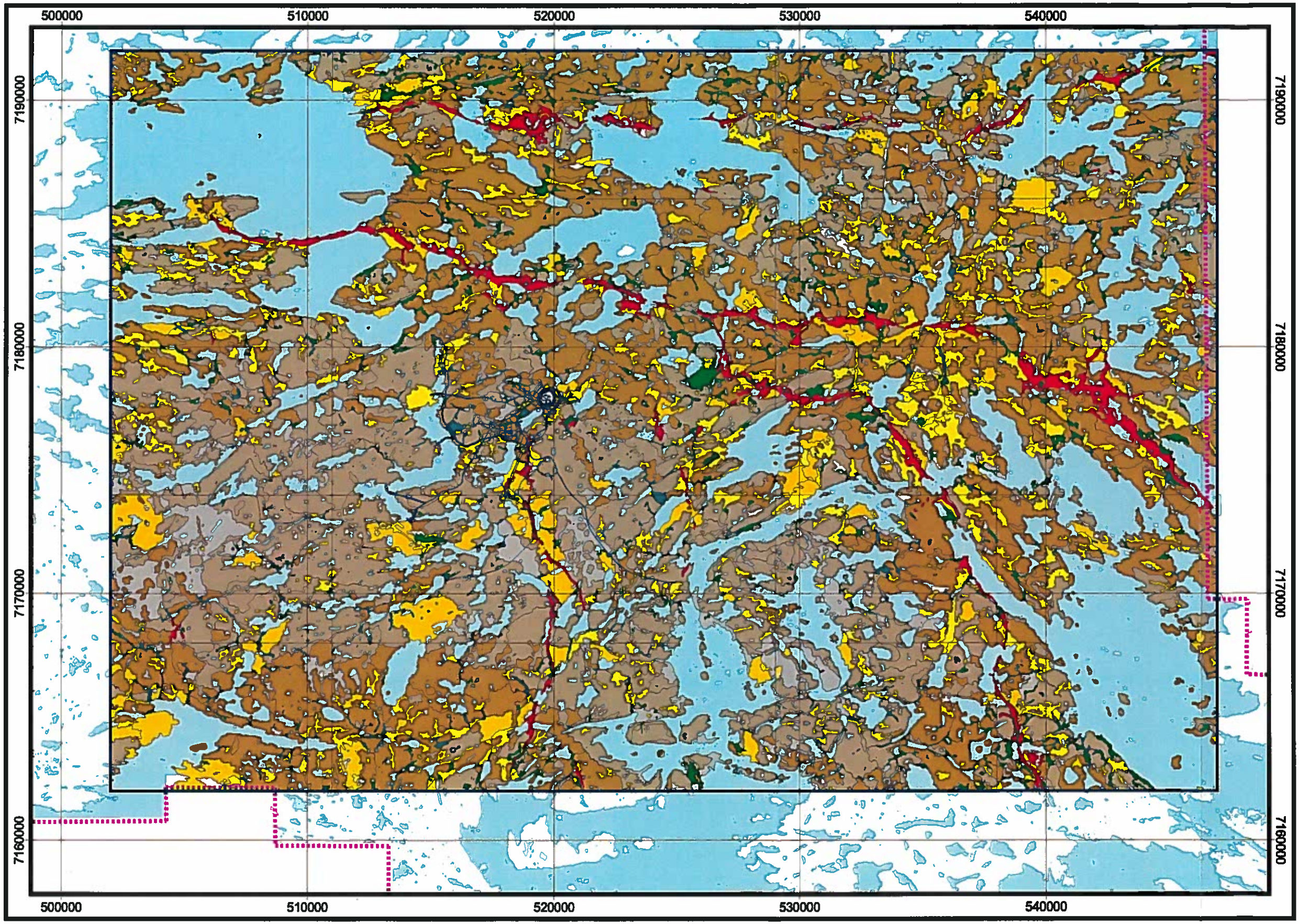
Metres

Terrain of the EKATI™ Project Area, Lac de Gras, NWT

FIGURE 3.6-2

BHP

Ekati diamond mine



GENERAL LEGEND

- Ecosystem and Terrain Mapping of Claim Block Area (BHP 1995a)
- BHP Claim Block
- Infrastructure 1999
- Lakes
- Land

ECOSYSTEM LEGEND

- Bedrock and Boulder Fields (RB, BF)
- Open Mat Tundra (BLb, BLr, Ble)
- Esker Complex (SSe,BEe, BLe)
- Closed Mat Tundra (BL)
- Tundra / Wetland Complexes (BL+BR, EA)
- Birch Hummock (BR)
- Cotton-grass Tussock (EA)
- Wetland complexes (BR, EA, CE, CA)
- Birch Seep (BC)
- Willow Riparian (SR)
- No Data / Doesn't Fit

Datum: NAD83
Scale: 1:160,000
Date: January 27, 2000
Drawn By: LJL
Checked By: SM

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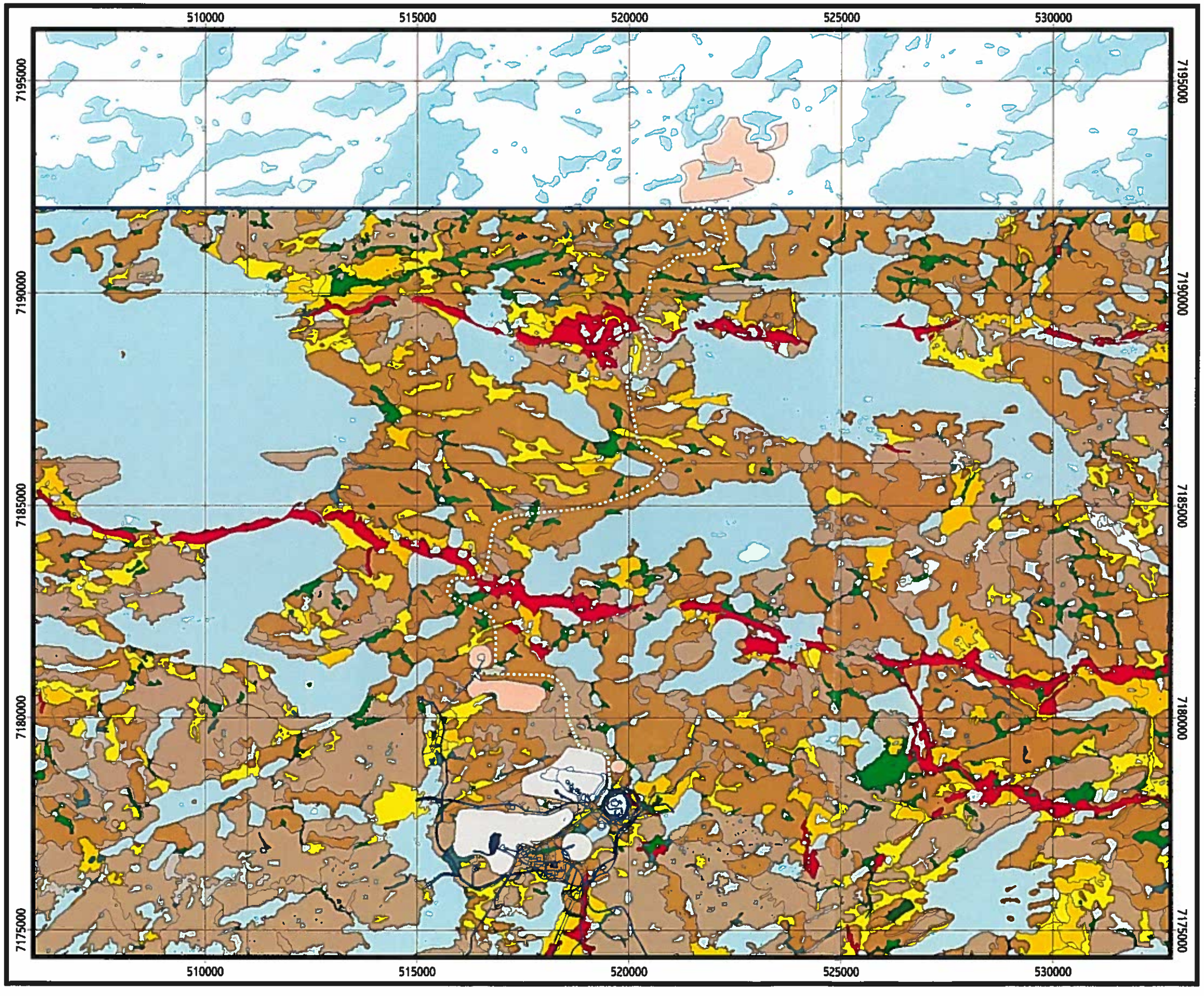
Metres

Ecosystems of the EKATI™ Project Area, Lac de Gras, NWT

Figure 3.6-5

BHP

Ekati diamond mine



GENERAL LEGEND

- BHP Claim Block
- Ecosystem and Terain Mapping of Claim Block Area (BHP 1995a)
- Proposed Development
- Existing Development
- Permitted Development
- Proposed Sable Road
- Existing Infrastructure
- Lakes
- Land

ECO SYSTEM LEGEND

- Bedrock and Boulder Fields (RB, BF)
- Open Mat Tundra (BLb, BLr, Ble)
- Esker Complex (SSe,BEe, BLe)
- Closed Mat Tundra (BL)
- Tundra / Wetland Complexes (BL+BR, EA)
- Birch Hummock (BR)
- Cotton-grass Tussock (EA)
- Wetland complexes (BR, EA, CE, CA)
- Birch Seep (BC)
- Willow Riparian (SR)
- No Data / Doesn't Fit

Datum: NAD83
Scale: 1:100,000
Date: January 27, 2000
Drawn By: LLL
Checked By: SM

N
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5000 0 5000 10000

Metres

Ecosystems of the EKATI™
Project Area, Lac de Gras, NWT

FIGURE 3.6-6

BHP

Ekati diamond mine

Ecosystem units were defined by unique combinations of distinguishing species and, as such, were intended to represent ecologically significant and distinct components of the regional gradient of soil moisture and soil nutrients. The range of relative soil moisture and soil units occupied by a particular ecosystem unit is considered to be the edatope of that unit, and inter-relationships between edatopes of ecosystem units in an area can be expressed on an edatopic grid (Figure 3.6-4).

The zonal ecosystem represents average soil conditions for a given climatic region and describes a site that is intermediate in the availability of soil moisture nutrients, *e.g.*, intermediate in soil moisture between a dry rock knoll with thin soils and a semi-aquatic wetland. All other ecosystem units are considered to be wetter, drier, richer or poorer than the zonal site for the region. In more broad-scale studies, vegetation on zonal ecosystems is used to distinguish biologically-significant segments of regional climatic gradients, *i.e.*, to distinguish biogeoclimatic zones.

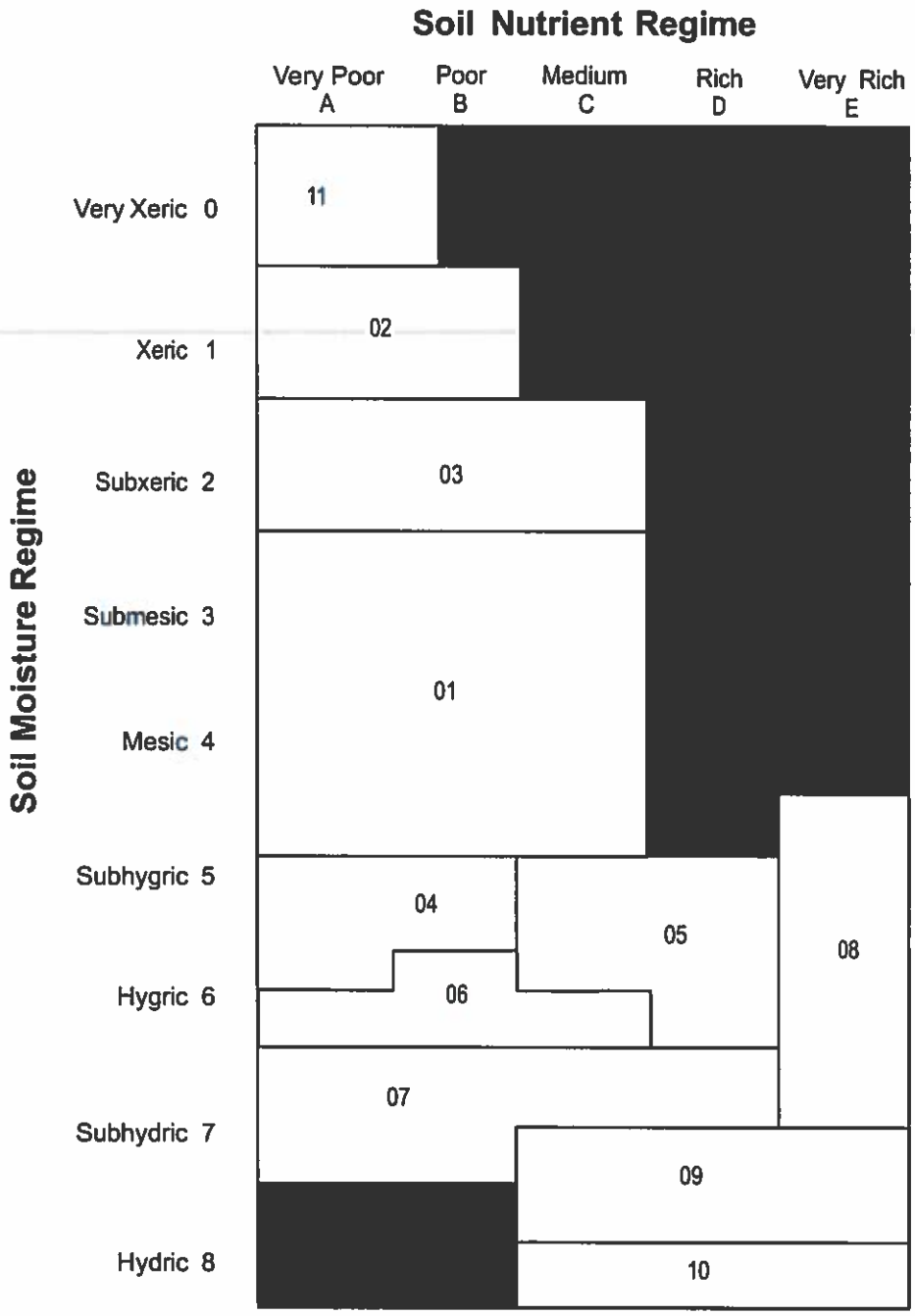
Many map polygons are complex, and this created a problem in developing connotative colour-theming presentations for the ecosystem maps. Across the landscape, some ecosystem units consistently occur together, and these were combined into ecosystem map units (Table 3.6-3). As much as possible, the ecosystem map units were created to group ecosystem units that commonly occur together and for which general management approaches can be developed. The approach taken was to provide a label in all polygons that described ecosystem percentiles and to use the colour theme to present the ecosystem map units as illustrated in the maps provided.

3.6.2.1 Description of Vegetation-Ecosystem Units

The following description of the vegetation-ecosystem units in the original 1,900 km^2 study area is adapted from BHP (1995a). Figure 3.6-5 presents a map of the vegetation-ecosystem units for the complete study area, while Figure 3.6-6 provides more detailed information for the areas in the vicinity of the proposed Pigeon and Beartooth pits and the haul road to the proposed Sable Pit.

Betula-Ledum [BL], Heath Mat Tundra

The heath mat or mesic tundra ecosystem (BL) is the "zonal" ecosystem unit in the study area. It typically occurs on well- to moderately well-drained upland sites and comprises 72% of the land area. Vegetation is typically a well-developed mat of low shrubs including dwarf birch (*Betula glandulosa*), diamond-leaved willow (*Salix planifolia*), Arctic willow (*Salix arctica*), Northern Labrador tea (*Ledum decumbens*), crowberry (*Empetrum nigrum*), black and red bearberry (*Arctostaphyllus alpina, A. rubra*), lingonberry (*Vaccinium vitis-idaea*) and bog bilberry (*Vaccinium uliginosum*).



01 Betula - Ledum
02 Saxifraga - Silene
03 Betula - Empetrum
04 Betula - Rubus chamaemorus
05 Betula - Calamagrestis
06 Eriophorum vaginatum - Andromeda
07 Carex chordorrhiza - Eriophorum russeolum
08 Salix - Rubus arcticus
09 Carex aquatilis - Eriophorum angustifolium
10 Arctophila - Ranunculus
11 Umbicullaria

An Edatopic Grid Showing Ecosystem Units in the EKATI™ Diamond Mine Study Area

FIGURE 3.6-4

Source: BHP, 1995a

Table 3.6-3
Descriptions of Ecosystem Map Units in the EKATI™ Diamond Mine Study Area

Ecosystem Map Unit	Description
Bedrock and Boulder Fields	This includes exposed bedrock (RB), which is relatively rare, and boulder fields (BF), which are more common. Both support very little vegetation other than rock lichens and have generally low capability for wildlife. As they have different interpretations for road building and development, they are distinguished on the terrain map.
Open Mat Tundra	This landscape unit includes bouldery tundra (BLb), rocky tundra (BLr) and non-esker *Betula-Empetrum* (BE) ecosystems. All have a typically open mat of dwarf birch and prostrate shrub vegetation.
Esker Complex	Esker complexes include all ecosystem units occurring on esker landforms. These include *Silene-Saxifraga* (Sse) on esker tops, *Betula-Empetrum* (esker type, BEe) on side slopes and *Betula-Ledum* (BLe) and occasionally *Betula-Rubus Chamaemorus* (BRe) at the base of eskers
Closed Mat Tundra	This includes typic *Betula-Ledum* ecosystem units (BL).
Tundra/Wetland Complexes	This includes complexes of tundra (BL) or bouldery tundra (BLb) with birch hummock (BR) and/or cotton-grass tussock tundra (EA).
Birch Hummock	This category includes all polygons typed as *Betula-Rubus chamaemorus* (BR).
Tussock Tundra	This category includes all polygons typed as *Eriophorum vaginatum-Andromeda* (EA).
Wetland Complexes	A complex of birch hummock (BR), cotton-grass tussock tundra (EA), sedge meadow (CE) and occasionally sedge fens (CA) and emergents (AR).
Birch Seep	All polygons typed as *Betula-Calamagrostis* (BC).
Willow Riparian	All polygons typed as *Salix-Rubus arcticus* (SR).

Source: BHP, 1995a.

The herb layer is sparse with alpine sweetgrass (*Hierochloe alpina*) and Bigelow's sedge (*Carex Bigelowii*) being the most common species.

The moss layer is not well developed and includes species of turf moss (*Polytrichum juniperinum*) and crane's bill moss (*Dicranum acutifolium*). Sphagnum mosses may occur on moister sites. Lichens include several species of *Cetraria, Cladina, Cladonia* and other species.

The Betula-Ledum ecosystem unit occurs on morainal blankets, bouldery morainal blankets, morainal veneers over bedrock and at the base of eskers. Soils are typically Orthic Turbic Cryosols with silt loam to sand loam texture and about 25% coarse fragments. Humus forms have F horizons with generally massive structure, firm to friable character and gritty textures. Humus forms average 7 cm in depth within the unit, and active layers are in excess of 150 cm. In frost boil areas, humus forms are either absent or

composed of a shallow litter layer only. At the moister end of the moisture gradient the *Betula-Ledum* unit grades, sometimes gradually, into the *Betula-Rubus chamaemorus* (BR) unit. Bouldery, rocky, slope, esker and shrubby types are all recognized. In sheltered slope breaks where snow accumulates, a taller shrub layer up to 50 cm in height may develop.

Saxifraga-Silene [SS], Xerophytic Herb Tundra

Xerophylic herb tundra (SS) occurs almost entirely on top of eskers. Alpine sweet grass, three-toothed saxifrage (*Saxifraga tricuspidata*), moss-campion (*Silene acaulis*), glaucous bluegrass (*Poa glauca*) and *Antennaria angustifolia* are common, with scattered crowberry and bearberry. In some areas, lichen growth is abundant and luxurious, with *Alectoira nigricans, Cetraria cucullata, C. nivalis* and *Thamnolia vermicularis* the most common. Wind ablation effects are common on many of these sites. The most critical ecological factor influencing these ecosystems is their coarse soils and exposure to strong winter winds, which limit both the availability of soil moisture and the capacity of plants to become established. Eskers are generally medium to coarse textured (sandy loams, loamy sands, sands and fine gravel) and rapidly drained. Soils are typically Orthic Regosols and Orthic Dystric Brunisols. Humus forms are thin to non-existent and average 3 cm in depth. Active layers are typically between 150 and 200 cm on esker sites. Mapped eskers and kames comprise less than 1% of the BHP study area.

Betula-Empetrum [BE], Heath Lichen Tundra

The *Betula-Empetrum* (BE) ecosystem unit occupies esker side slopes and morainal veneers on slope crests. Vegetation is typically an open mat of dwarf birch, crowberry and bearberry with significant lichen cover (*Alectoria nigricans, Cetraria cucullata, C. nivalis, Alectoria ochroleuca*). Herb and moss layers are not well developed. Morainal humus forms are thin, discontinuous and average only 4 cm. Soils are in many cases shallow to bedrock, with Orthic Turbic Cryosols most common. Active layer depths are in excess of 150 cm on BE sites. Orthic Dystric Brunisols, Cumulic Regosols and Brunisolic Turbic Cryosols are also found in this unit. Soil texture ranges from sandy loam to loamy sand with relatively high coarse-fragment content (45%). A shrubby type occurs on leeward slopes where dwarf birch may reach heights of about 1 m. The BE ecosystem unit covers about 2.5% of the BHP study area.

Betula Rubus Chamaemorus [BR], Birch Hummock

Birch hummock (BR) habitats comprise the typical hummocky terrain of the tundra and represent the second most common ecosystem unit (9.1%) of the BHP study area. Dwarf birch is abundant on the hummocks along with Labrador tea and other low shrubs, and a well-developed moss layer composed of sphagnums and glow moss (*Aulacomnium turgidum*). Cloudberry (*Rubus chamaemorus*) and Labrador lousewort (*Pedicularis labradorica*) are also common. The depressions between hummocks often support vegetation typical of the *Eriophorum vaginatum-Andromeda* ecosystem unit. Map units are typically complexes of BR, EA and CE. These occur on organic veneers overlying fluvial or lacustrine sediments of relatively fine texture (silts, silt loams and fine sandy loams). Soils are typically Gleyed Turbic Cryosols and Orthic Turbic Cryosols with an active layer depth of 44 cm.

Many sites in this ecosystem unit have shock-sensitive (or thixotropic) soils. When disturbed, for example, by shifting weight quickly from one foot to the other, they turn to "jelly." Millar and Bradley (1976) suggest that when the soil matrix water freezes, the structure of the generally fine and even-textured soil matrix is expanded. When disturbed the structure breaks down and the soil becomes super-saturated and will flow if not held in place by the humus layer and permafrost beneath (generally less than 50 cm from the surface). This kind of soil phenomenon is most common in the EA and CE ecosystem units and has important implications for engineering activities within these areas.

Betula-Calamgrostis [BC], Birch Seep

The birch seep (BC) ecosystem unit occurs in areas of active seepage passes through boulder lag deposits. Typical vegetation is dominated by dwarf birch that often achieves heights of 1 m and grows with low amounts of diamond-leaved willow. Crowberry and Labrador tea are scattered under the tall shrub layer, with a herb layer of bluejoint (*Calamagrostis canadensis*) and water sedge (*Carex aquatilis*). Scattered mosses and lichens occur on suitable substrates within the sites. A range of soil types is observed, most commonly Gleyed Dystric Brunisols and Orthic Gleysols. Soils have very high coarse-fragment contents with textures of the soil matrix silt loam, silt and sandy loams. Humus forms are relatively thick, averaging 9 cm. Active layers are in excess of 150 cm on these sites. Infrequent Mormoders reflect the increased nutrient status of these sites, compared to BR ecosystems.

Eriophorum Vaginatum-Andromeda [EA], Cotton-grass Tussock

On gentle lower slopes and depressions in morainal blankets, communities consist predominantly of tussock-forming sheathed cotton-grass (*Eriophorum vaginatum*). A well-developed sphagnum moss layer is also typical. Other common species include sedges (*Carex chordorrhiza, C. rotundata*), Russet cotton-grass (*Eriophorum russeolum*), bog-rosemary (*Andromeda polifolia*) and scattered shrubs such as dwarf birch and Labrador tea. This ecosystem unit typically forms complexes with BR, BC, EA and CE in low landscape areas, and with zonal tundra sites, where it occurs in depressions in the till. Soils are predominantly Gleyed Turbic and Static Cryosols, with common soil textures of silt and silt loam. Organic layers at the soil surface average 23 cm, which provides an insulating cover so that active layer depths average 36 cm.

Carex Chordorrhiza-Eriophorum Russeolum [CE], Sedge Meadow

The sedge meadow (CE) ecosystem unit typically occurs in complexes with the BR, BC and EA units where the *Carex chordorrhiza-Eriophorum russeolum* occupies the lowest depressions in the complex. Vegetation is predominantly cordroot sedge (*Carex chordorrhiza*), *Carex rotundata*, Russet cotton-grass, water sedge, and tufted clubrush (*Scripus caespitosus*). Diamond-leaved willow, Labrador tea and *Salix polaris* are scattered in the sites. Sphagnum mosses, *Drepanocladus uncinatus* and *Aulacomnion turgidum* are present and often have significant coverage. Compared to the hummocky appearance of the BR and EA units with which it is often complexed, the microtopography of the *Carex chordorrhiza-Eriophorum russeolumn* unit is quite flat, giving it a grassy,

meadow look. Mean active layer depth in these sites in 41 cm. Soils are most commonly Gleyed Static Cryosols with a mean surface organic layer depth of 19 cm.

Salix Rubus Arcticus [SR], Riparian Tall Shrub

The *Salix-Rubus arcticus* (SR) habitats occur along actively flooding stream channels where relatively thick veneers of fine-textured materials (silts, silt loams and silt clay loams) have been deposited. The productive soil medium and constant availability of flowing water support a tall shrub community (up to 4 m) of diamond-leaved willow (*Salix planifolia*), dwarf birch, green alder (*Alnus crispa*) and some white spruce (*Picea glauca*) in the southern portion of the study area. The herb layer is also well developed, with dwarf raspberry (*Rubus arcitcus*), dwarf marsh violet (*Viola epipsila*), common horsetail (*Esquisetum arvense*) and bluejoint common. Soils are typically Gleyed Dystric Brunisols and Gleyed Static Cryosols with active layers in excess of 150 cm. Humus forms are single-grained to massive and friable and have the characteristics of moders. This ecosystem is the most productive of any sampled in the study area. However, in terms of area, it only occupies about 0.5% of the mapped land area.

Carex Aquatilis-Eriophorum Angustifolium (CA), Sedge Fen

Sedge fens (CA) area are mostly restricted to lake and stream margins where the water table is above or near the surface during the growing season. The vegetation is predominately water sedge (*Carex aquatilis*) with smaller amounts of *Carex rotundata*, tall cotton-grass (*Eriophorum angustifolium*), marsh cinquefoil (*Potentilla palustris*) and sphagnum mosses. Sedge peat may form a thin organic veneer over fluvially derived silts and silty loams. Soils are typically Gleyed Static Cryosols. The surface organic layer averages 11 cm in depth and the active layer 54 cm.

Arctophila-Ranunculus (AR), Emergent Marsh

Emergent marsh (AR), with a characteristically red colour, occurs in shallow lakes and lake shallows and is predominately composed of pendant grass (*Arctophila fulva*), often with significant coverage of water sedge, and an emergent buttercup (*Ranunculus Pallasii*). Soils are composed of lake bottom silts and silt loams. The units are fairly limited in distribution except for a few shallow lakes where coverage is extensive, over several tens of hectares. In total, the less common wetland habitats CE, CA and AR occupy about 1% of the BHP study area.

Umbilicaria (RB), Lichen Boulder Field

A significant portion of the study area is covered in boulders. The boulders support a community of rock lichens such as rock tripes (*Umbilicaria* spp.), green map lichen (*Rizcarpon geographicum*), rock orange lichen (*Xanthoria elegans*), green starburst lichen (*Parmeliopsis ambigua*) and others not identified. Some vascular plants (scrub birch, diamond-leaved willow and bearberry) occur where thin organic layers have developed in crevasses among boulders. Although not sampled intensively, large areas can be dominated by these ecosystems.

3.6.2.2 Distribution of Vegetation

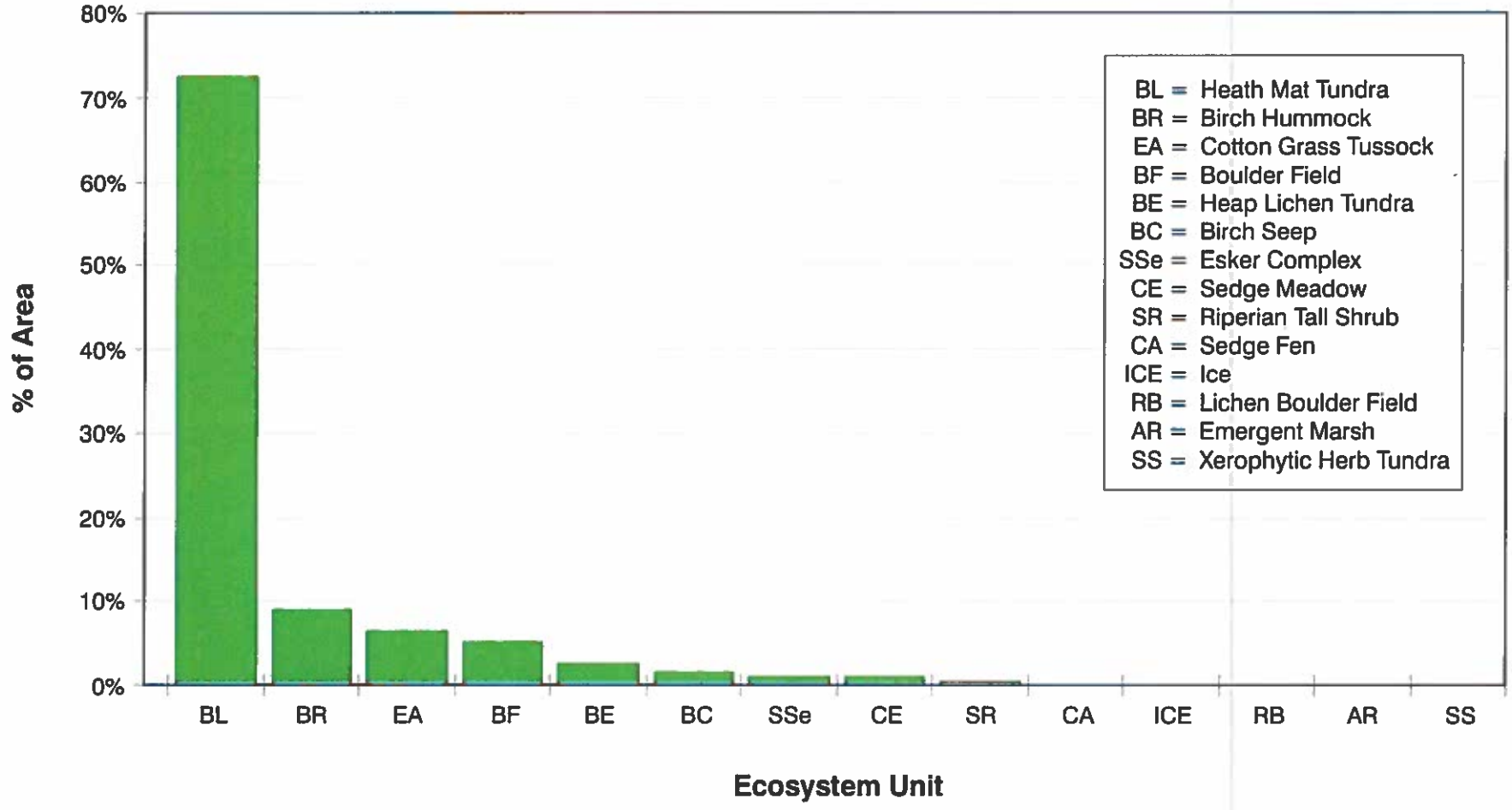
Figure 3.6-7 (Banci and Moore, 1997) summarizes the percentage distribution of vegetation-ecosystem units recorded in the BHP study area as a result of the work done for the 1995 EIS. As illustrated, approximately 72% of the terrain in the 1,900 km^2 study area comprises the heath mat "zonal" ecosystem (BL), which typically occurs on well- to moderately well-drained upland sites. The other more common vegetation-ecosystem units recorded include birch hummock (BR), comprising approximately 9% of the study area, and cotton-grass tussock (EA), comprising 6% of the study area.

As a relative comparison, Table 3.6-4 summarizes the results of the more recent ecological land classification mapping of BHP's 1,600 km^2 wildlife study area by RWED (Golder, 1999). This work estimated that 67% of the terrain in the BHP wildlife study area is occupied by "zonal" heath-type vegetation, often in combination with boulder fields or bedrock. Deep and shallow water habitats comprised 33.5% of the wildlife study area.

Table 3.6-4
Vegetation Units within the BHP Wildlife Study Area

Vegetation Unit	Number of Hectares	% of BHP Study Area
Aquatic Habitat		
Deep Water	31,347.87	19.71
Shallow Water	21,978.56	13.82
Terrestrial Habitat		
Heath Tundra	28,403.25	17.85
Heath/Boulder	22,622.75	14.22
Heath/Bedrock	15,360.81	9.66
Tussock/Hummock	14,853.56	9.34
Tall Shrub	5,224.50	3.28
Bedrock Complex	4,091.56	2.57
Esker Complex	3,195.75	2.01
Wetland (sedge meadow)	3,100.19	1.95
Birch Seep	2,971.44	1.87
Boulder Complex	2,272.75	1.43
Lichen Veneer	2,059.38	1.29
Spruce Forest	970.31	0.61
Unclassified	628.56	0.40
Total	159,081.25(1,590 km^2)	100

Source: Golder (1999) using RWED (1998) data.



Percentage Distribution of Vegetation-Ecosystem Units in the BHP Study Area

FIGURE 3.6-7

Source: Banci[illegible] Moore (1997)

3.7 Wildlife

The low to gently rolling landscape of EKATI™ is characterized by a mosaic of different vegetation and landform types interspersed with many lakes. As indicated in Section 3.6, heath tundra, in combination with boulders and bedrock outcrops, dominate the terrestrial landscape. Cottongrass tussock and hummock vegetation are also common. Eskers, which provide suitable material for constructing dens and travel routes for many animals, make up a relatively small but very important proportion of the landscape in the project area.

Despite the long, harsh winters a number of wildlife species occur in the region. The Bathurst caribou herd migrates through the area during spring and fall. Grizzly bears, wolves, wolverines and foxes forage and den in the area. Small mammals such as hares and ground squirrels are important sources of food for the larger carnivores. Many species of birds also inhabit the region on a seasonal and/or year-round basis. The year-round residents include Ptarmigans and Ravens. Raptors such as Peregrine Falcons, Gyrfalcons and Rough-legged Hawks migrate into the region and nest on cliffs and rock outcrops. Two species of owls, and Bald and Golden eagles have also been recorded. Waterfowl and songbirds migrate to the tundra every spring to breed.

The Aboriginal people of the area have been closely linked to the land and wildlife of the barrenlands for thousands of years. Caribou in particular are critically important to the people of this region. The native people have built up a wealth of traditional knowledge concerning caribou and other wildlife. When possible, BHP has used traditional knowledge to design mitigation measures to protect caribou and other species.

The wildlife of the EKATI™ Diamond Mine and surrounding area has been previously described in detail in the Environmental Impact Statement for the EKATI™ Diamond Mine (BHP, 1995) and more recently in Diavik's Environmental Assessment Report (Diavik, 1998b). The following is a brief review of some of the more important information on the wildlife of the project area as drawn from these earlier major submissions and other supporting sources.

3.7.1 Barren-Ground Caribou

Barren-ground caribou are considered to be the single most important Valued Ecosystem Component (VEC) that frequents the proposed development area, due to the pivotal role that they play in the lives of the Aboriginal people and other residents of the Northwest Territories. The Bathurst Caribou herd is the largest of the major barren-ground caribou herds found on the mainland of the Northwest Territories. Each year in both the northern and southern migrations (Plate 3.7-1), at least part of this herd passes across the EKATI™ Diamond Mine claim block. In 1996, the population was estimated at approximately 349,000 ± 95,000 (Gunn *et al.*, 1997). In the past, the herd has ranged in size from an estimated 174,000 caribou in 1982 to 486,000 caribou in 1986 (Case *et al.*, 1996).

Plate 3.7-1 Caribou beside Long Lake Road at the EKATI™ Mine.

The herd's range is approximately 250,000 km^2 with calving grounds near Bathurst Inlet and wintering habitat below the treeline (Figure 3.7-1). The annual range of the Bathurst herd overlaps with three adjacent caribou herds, primarily during the winter. Overlap occurs with the Bluenose East Caribou herd to the west in the vicinity of Great Bear Lake; Queen Maud Gulf Caribou herd (Gunn and Fournier, 2000), to the northeast, primarily during the winter; and with the Beverly herd in the area south of Great Slave Lake and extending to the Saskatchewan border (Figure 3.7-1).

The EKATI™ Diamond Mine and the entire Lac de Gras area are located within the broad spring and fall movement corridors of the Bathurst Caribou herd (Plate 3.7-2). Since 1997 RWED has been using satellite collars on caribou to track their yearly movements.

A comparison of the 1997, 1998 and 1999 satellite collar data shows the variation in the time of migration and travel routes selected by the herd between years (Figures 3.7-2, 3.7-3 and 3.7-4) (RWED, 1999). Caribou distribution and dispersion in 1999 was markedly different from that in 1998, but very similar to 1997, except for October and November which was similar to 1998.

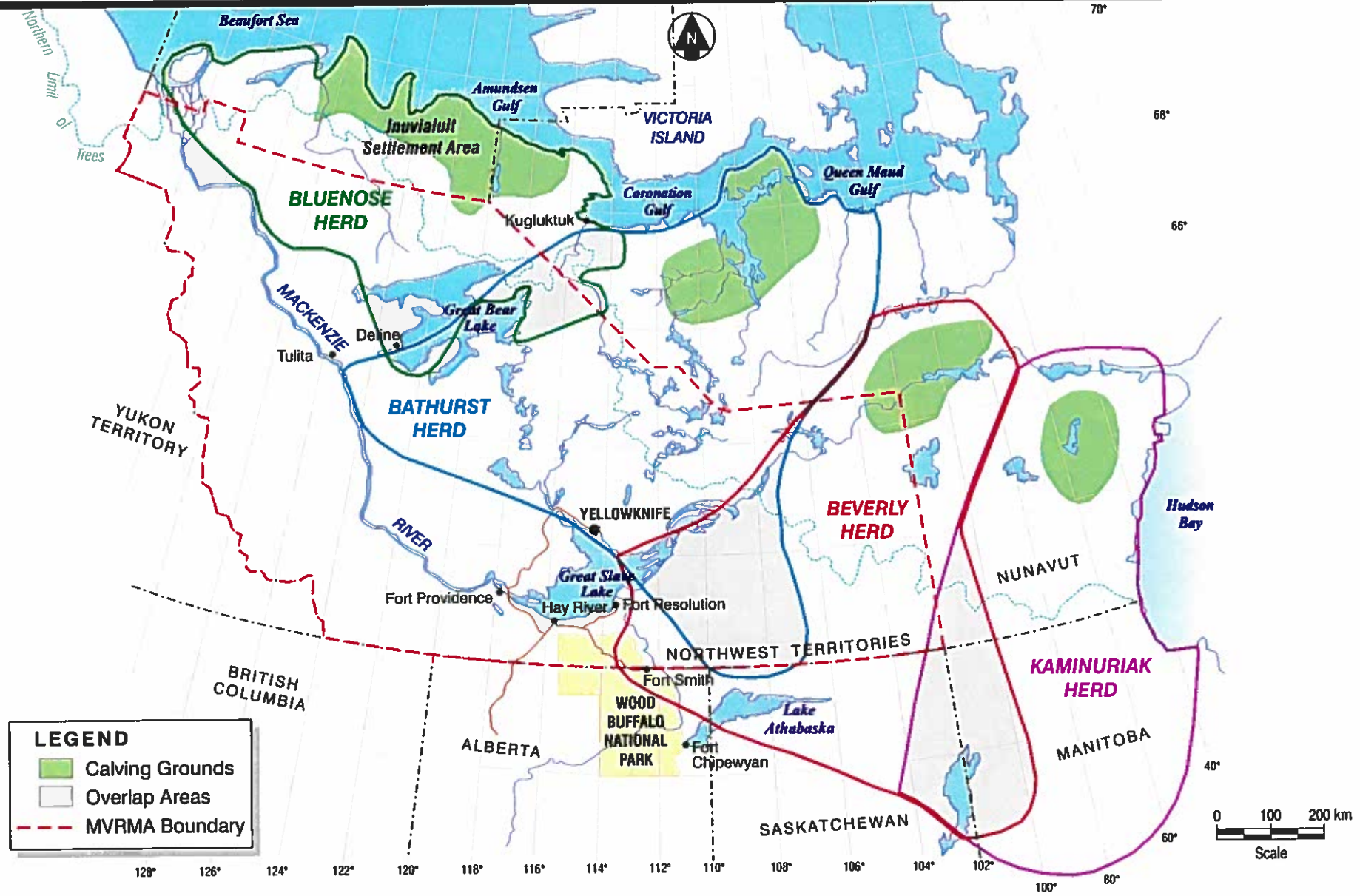


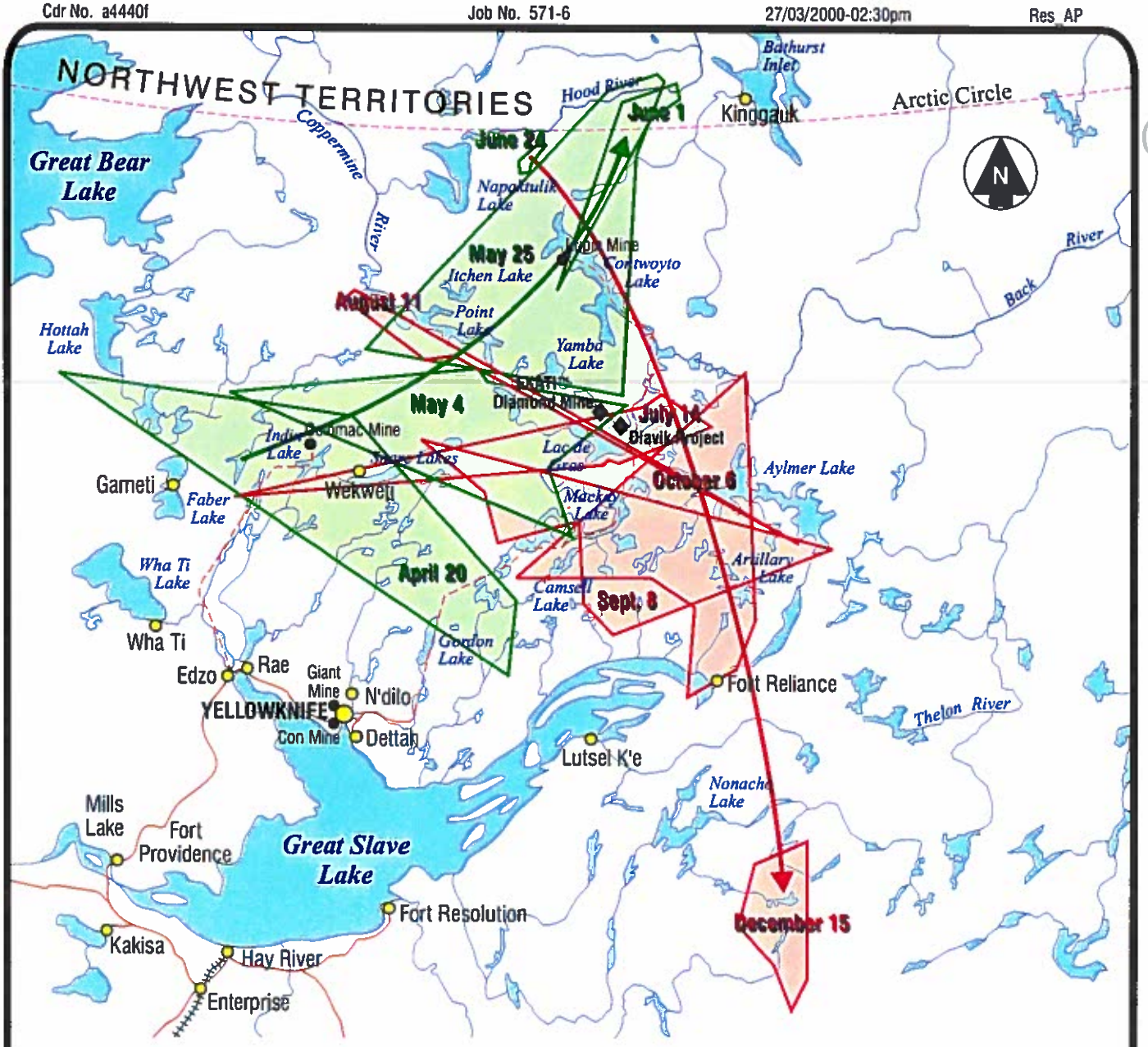
FIGURE 3.7-1

Annual Ranges, Calving Grounds, and Areas of Overlap between Four Barren-Ground Caribou Herds Residing Mainly in the Northwest Territories

BHP

Ekati diamond mine

Source: Diavik, 1998 b, *Environmental Assessment Submission*



LEGEND

- All-Weather Highways
- Winter Roads
- Railway
- Community
- Diamond Mine/Exploration
- Producing Mine
- Distribution of Herd Based on Satellite-Collared Caribou
- General Direction of Travel- - Northern Migration
- General Direction of Travel- - Southern Migration

0 100 200 km

Scale

REFERENCE

Selected Mineral Deposits of the Northwest Territories, Department of Energy, Mines and Resources, Mineral Initiatives 1991 to 1996 Revised October, 1996
Satellite data provided by RWED 1998

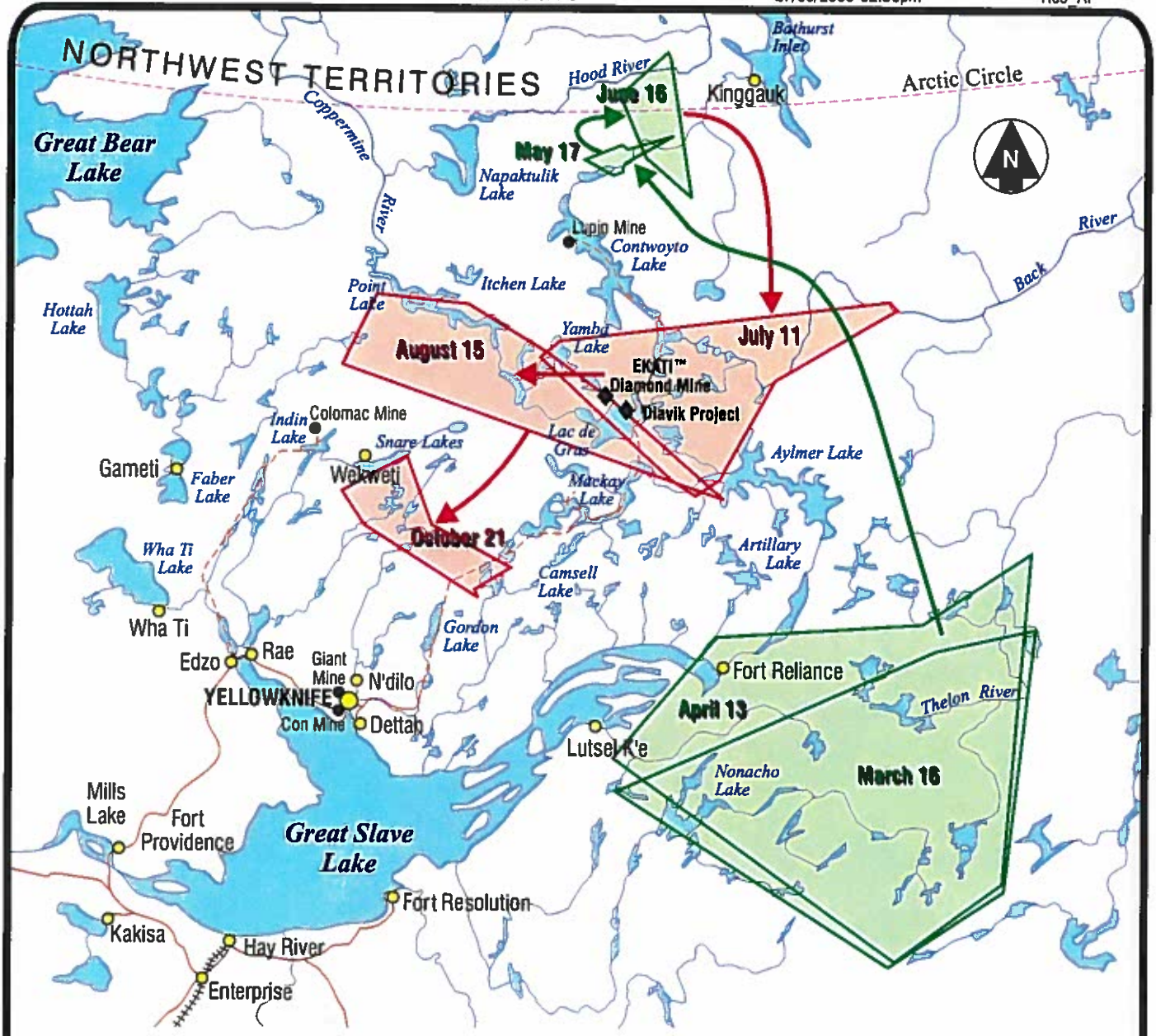
Distribution of Satellite-Collared Caribou During the Northern and Southern Migrations, 1997

FIGURE 3.7-2

BHP

Ekati diamond mine

Source: Golder, 1999, *1998 Wildlife Effects Monitoring Program*



LEGEND

- All-Weather Highways
- Winter Roads
- Railway
- Community
- Diamond Mine/Exploration
- Producing Mine
- Distribution of Herd Based on Satellite-Collared Caribou
- General Direction of Travel- - Northern Migration
- General Direction of Travel- - Southern Migration

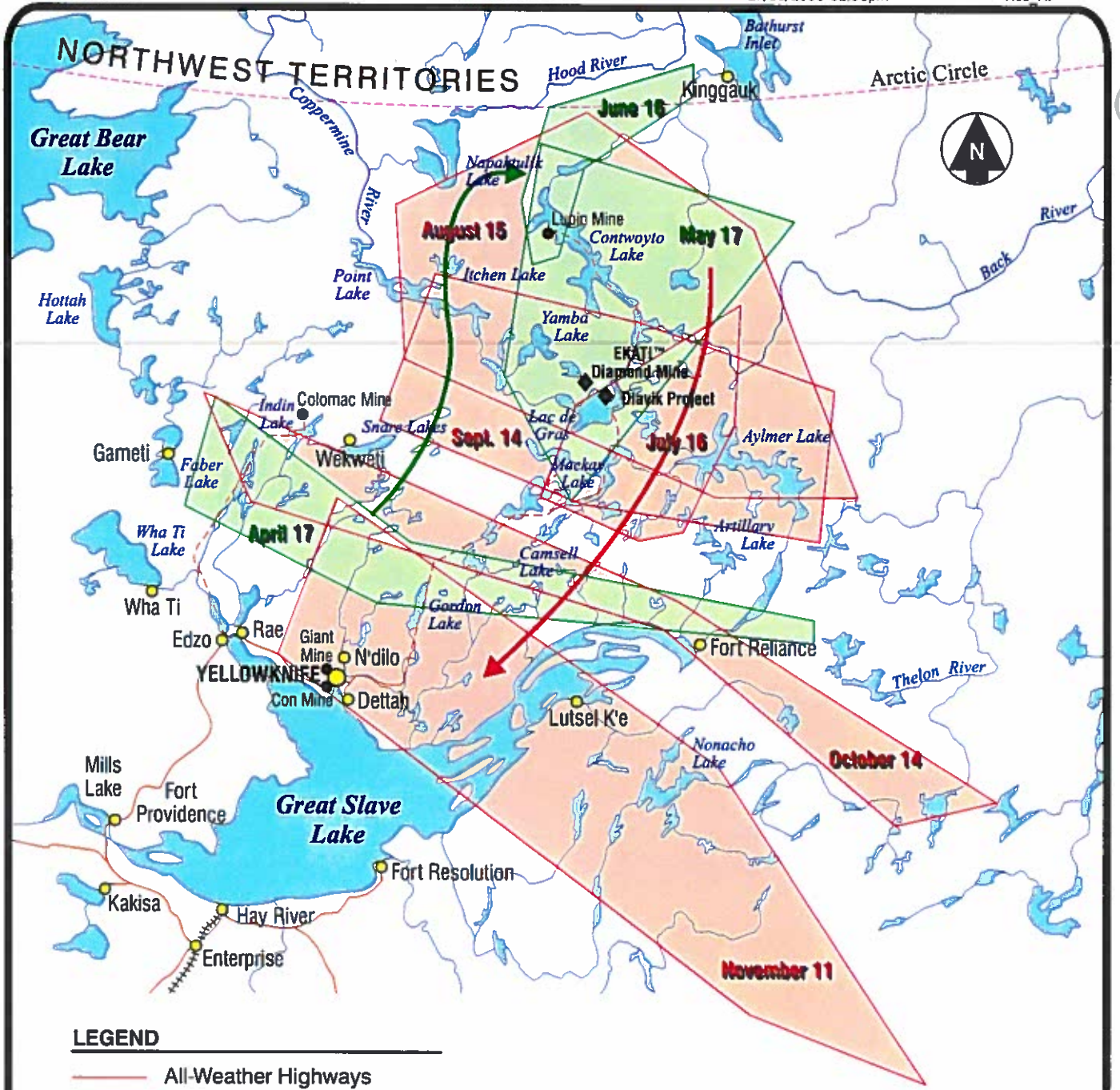
REFERENCE

Selected Mineral Deposits of the Northwest Territories, Department of Energy, Mines and Resources, Mineral Initiatives 1991 to 1996 Revised October, 1996
Satellite data provided by RWED 1998

Distribution of Satellite-Collared Caribou During the Northern and Southern Migrations, 1998

FIGURE 3.7-3

Source: Golder, 1999, *1998 Wildlife Effects Monitoring Program*



REFERENCE

Selected Mineral Deposits of the Northwest Territories, Department of Energy, Mines and Resources, Mineral Initiatives 1991 to 1996
Revised October, 1996
Satellite data provided by RWED 1998

Distribution of Satellite-Collared Caribou During the Northern and Southern Migrations, 1999

FIGURE 3.7-4

Source: RWED, 1999; Rescan, 1999c

Plate 3.7-2 Caribou trails near the Misery Road.

For example, during the 1997 northern migration, the distribution of satellite-collared animals indicated that most of the Bathurst Caribou herd moved west of the mine site and were on the calving grounds during the last week of May (Figure 3.7-2). By mid-July, most of the collared animals were located south and east of Lac de Gras, which corresponded with a large movement of caribou through the EKATI™ Diamond Mine wildlife study area. Although there appeared to be some north and south movements during the late summer, by September 8 all of the collared cows were located south of Lac de Gras (Figure 3.7-2). This was consistent with fall aerial surveys that recorded few caribou in the study area from mid-September through mid-October 1997, when survey flights ended. During the winter, these animals were located east of Great Slave Lake, which is considerably east of their traditional winter range north of Great Slave Lake.

In contrast to 1997, results from the 1998 satellite collar locations reveal a markedly different spatial and temporal distribution for the Bathurst caribou herd. Figure 3.7-3 shows that during March and April of 1998, caribou were dispersed to the east and south of Great Slave Lake, just north of the Saskatchewan border. By May 17, these caribou had migrated north and were on the calving grounds near the Hood River, approximately two weeks earlier than in 1997 (RWED, 1999). The northern migration corridor used in 1998 was approximately 130 km east of BHP's claim block, east of Lac de Gras and Contwoyto Lake, which was reflected by the low number of animals observed in the study area during spring aerial surveys.

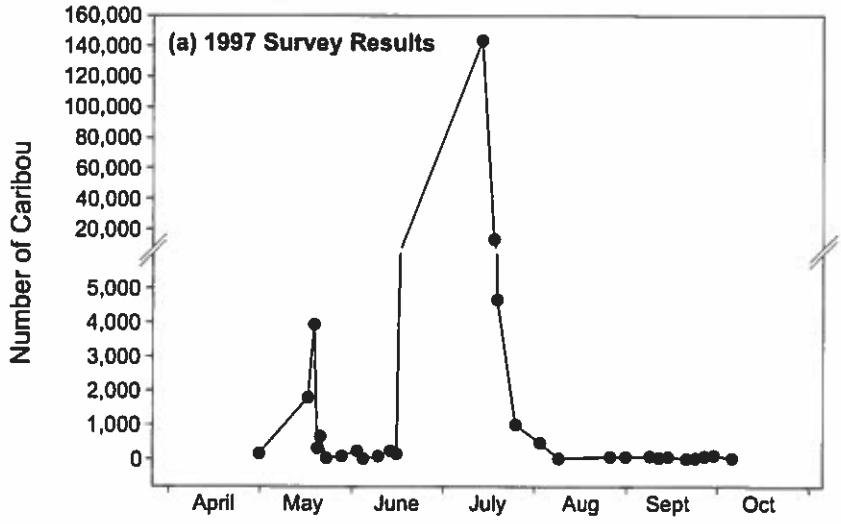
During 1998 the collared animals began migrating south between June 16 and July 11, and by mid-July caribou were dispersed around Yamba Lake, Lac de Gras and to the east. This corresponded with the largest number of caribou observed in the study area during the year. One month later, the caribou herd had moved into an area west of Lac de Gras and Point Lake. By October 21, the collared caribou had moved south of the treeline between Gordon Lake and Snare Lake.

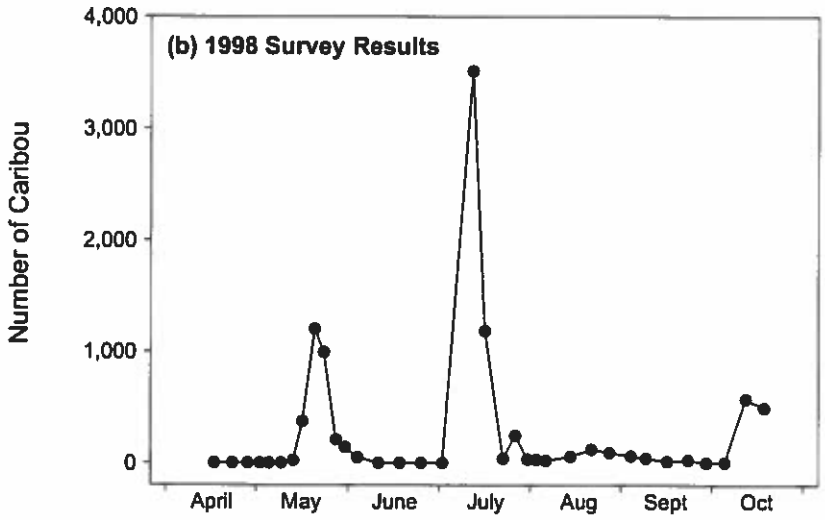
In comparison, the 1999 satellite data (RWED, 1999) show a similar distribution and dispersion to that of 1997 (Figure 3.7-4). Based on the collared caribou, most of the Bathurst caribou were below the treeline, southwest of Point Lake in mid- April. By mid-May they had moved to the east, above the treeline, around the western end of Lac de Gras, indicating that spring migration was underway. By June 10 the pregnant cows were on the calving grounds adjacent to the Burnside River. After calving, the post-calving migration headed southward towards Lac de Gras. By mid-July they were dispersed about 100 km south of Lac de Gras. By mid-August they had continued to disperse and were spread out between Aylmer Lake, Lac de Gras, Contwoyto Lake and Great Bear Lake, an area of roughly 90,000 km^2. By mid-September the dispersion had tightened: those caribou distributed to the north had moved southwest. By mid-October the caribou were distributed along the treeline between Great Bear Lake and southeast of Great Slave Lake. Caribou continued to move below the treeline in a southwesterly direction and were on their typical wintering grounds by mid-November (Heard, 1989). Within BHP's claim block, these movements are consistent with the aerial surveys flown.

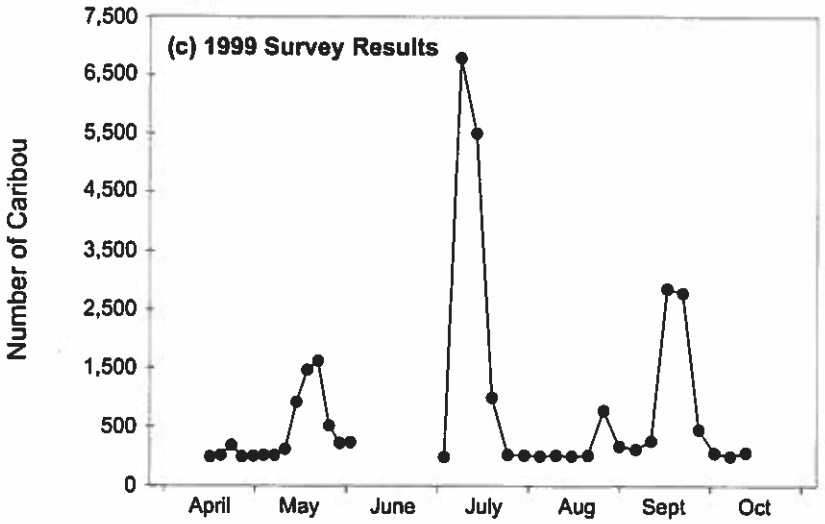
Systematic aerial caribou surveys have been flown across the wildlife study area since 1997. Figure 3.7-5 shows a comparison of the number of caribou observed during aerial surveys over the last three years. For each year there are typically three spikes representing northern, southern and post-migration movements. These spikes correspond to the migration patterns of the herd as indicated by satellite-collared caribou for each year. The greatest number of caribou occurring on the claim block was in 1997, followed by 1999 and 1998.

For 1999, the estimated number of caribou travelling across the claim block during all surveys was approximately 53,000 animals, of which 20,700, (39%), were within 14 km of the EKATI™ mine (Rescan, 1999c). The total number of caribou observed along the proposed Sable Road corridor during 1999 was 226 (0.06% of the Bathurst Herd) individuals for the northern migration, 84 (0.02% of the Bathurst Herd) individuals during the southern migration, and 1447 (0.4% of the Bathurst Herd) throughout the post-migration period (Rescan, 1999c).

For 1999, there was no detectable relationship between relative abundance of caribou and distance from the mine site during the northern and southern migrations, as well as during the post migratory period. The mine site did not appear to have an effect on the relative abundance of caribou during 1997, 1998 and 1999.







Note: No surveys were flown during June, 1999

Number of Caribou Observed During Each Aerial Survey in 1997 (a), 1998 (b) and 1999 (c)

FIGURE 3.7-5

Source: Rescan, 1999c

3.7.2 Muskoxen

Muskoxen are uncommon at Lac de Gras. It is highly probable that their historical range included the Lac de Gras region. The majority of the muskoxen in the world are found in the Northwest Territories (Graves and Hall, 1988). These animals occur on most Arctic islands, along the coast and in some areas as far south as the treeline. Historic numbers and distribution were greatly reduced across the barrenlands during the last century through a probable combination of over-hunting and unfavourable weather conditions (Graf and Shank, 1989). Over the last few decades the population in the central mainland of the Northwest Territories has been steadily growing (Graves and Hall, 1988). More recently, the muskoxen have been expanding their distribution to the south, including into BHP's claim block.

Their numbers and distribution across the property have varied from year to year. In 1994 there was only one sighting of six muskoxen. In 1995 there were 12 sightings of herds ranging in size from 4 to 28 individuals. These observations were distributed fairly evenly throughout the study area. In 1996 one herd of 13 individuals was frequently sighted in the area between Exeter and Ursula Lakes. In 1997 there was one unconfirmed sighting of a herd of 15 muskoxen, which occurred just outside the study area to the northeast. In 1998 there were two observations of muskoxen. A herd of 25 were observed on May 28 in the area between Exeter and Ursula lakes. Nineteen of these muskoxen were observed again on June 2 in the same area. In 1999 there were two observations of muskoxen documented within the wildlife study area. One was observed on July 8 north of Ursula Lake at the northern boundary of the study area. A second sighting was of one individual on August 25 on Ursula West Esker, between Osprey and Eagle Lake. There was an additional second-hand observation reported of a small herd northwest of Yamba Lake. Unfortunately the report could not be followed up. Being outside the wildlife study area it was not investigated.

Table 3.7-1 summarizes muskoxen observed within the wildlife study area from 1994 to 1999.

3.7.3 Grizzly Bear

Barren-ground grizzly bears range throughout much of the mainland Northwest Territories including the EKATI™ Diamond Mine claim block and the surrounding barrenlands (Plate 3.7-3). The grizzly bear has been given the status of vulnerable by COSEWIC (1997) due to its low resiliency to human-caused impacts, which is largely a function of its characteristic low population densities, low reproductive capacity and sensitivity to human activity (Diavik, 1998b). Due to potential impacts related to habitat displacement and possibly mortality, grizzly bears are considered by biologists to be the most sensitive species inhabiting the BHP study area and the region. Thus they are considered a Valued Ecosystem Component (VEC).

Table 3.7-1
Summary of Muskoxen Observed On and Near the BHP Wildlife Study Area, 1994 to 1999

Year	Date	Total Number Muskoxen	Location and Comments
1994[1]	Summer	6	Herd of 6 near Lac de Gras.
1995[2]	May 27	4	Herd of 4 observed 15 to 29 km N of exploration camp.
	June 5	4	Same herd observed 2 km NW of Hawk Lake.
	June 16	4	Same herd observed 2 km S of Ursula Lake.
	June 19	4	Same herd observed on SW tip of Hawk Lake.
	June 28	4	Same herd observed on W shore of Hawk Lake.
	July 14	4	Outside claim block near T-Lake.
	July 15	9	Outside claim block near T-Lake.
	July 28	9	E of Exeter Lake.
	July 29	9	Same herd observed 4 km N of EKATI™ Camp.
	August 1	9	Same herd observed 6 km N of EKATI™ Camp.
	August 14	28	24 adults and 4 calves N of study area.
	August 31	1	N side of Ursula Lake.
1996[3]	Multiple dates	13	Multiple sightings of herd of 13 between Exeter and Ursula lakes. 9 adults and 4 calves.
1997[4]	June 21	15	Herd of 15 muskoxen reported 15 km N of Duchess Lake, by EKATI™ camp personnel; unconfirmed sighting. Outside of study area.
1998[5]	May 28	25	Herd of 25 muskoxen reported 8 km north of Urusla and Exeter lakes (unconfirmed sighting).
	June 2	19	Herd of 19 muskoxen reported 8 km north of Ursula and Exeter lakes. This is part of the same herd seen on May 28.
1999[6]	July 8	1	One individual was seen north of Ursula Lake along the northern boundary of the wildlife study area.
	July 22	1	One individual was seen between Exeter and Ursula lakes.
	July 25	?[7]	A herd was spotted northwest of Yamba Lake near the northwest corner of BHP's claim block.

1: BHP, 1995
2: Rescan, 1995c
3: Steve Moore (*pers. comm.*).
4: Golder, 1998
5: Golder, 1999
6: Steve Moore (*pers. comm.*).
7: Muskox sighting was reported by a helicopter pilot passing through the region. He did not report the size of the herd.

Plate 3.7-3 Grizzly bear.

Little substantive information exists on the size and density of the grizzly bear population inhabiting the Lac de Gras area and the Slave Geological Province. However, but two locally derived population estimates are currently available for the Slave Geological Province. Based on telemetry data and visual sightings of radio-collared and uncollared bears, 30 adult and subadult grizzly bears (12 males, 18 females) were estimated to occur within the Diavik Regional Study Area which encompassed all of BHP's area of interest (1 bear/455 km^2) (Penner and Associates, 1998, in Diavik, 1998a). Including cubs and other young dependent bears, 49 bears (1 bear/286 km^2) were estimated to reside in Diavik's Regional Study Area. Extrapolation of this regional population estimate suggests that an estimated 407 adult and subadult grizzly bears reside in the Slave Geological Province (665 grizzly bears, including cubs and other dependants). A second estimate, based on the assumption that all human-caused grizzly bear mortalities to date have occurred within sustainable levels, suggest a population of 750-800 adult and subadult grizzly bears inhabiting the Slave Geological Province, and a population of 90 grizzly bears in Diavik's Regional Study Area (D. Cluff, *pers. comm.* in Diavik, 1998b).

Within the EKATI™ Diamond Mine study area, during 1995 and 1996, BHP participated in an integrated grizzly bear research program with the West Kitikmeot/Slave Study (WKSS) bear studies that included the radio collaring and tracking of 43 bears in the Slave Geological Province. Eight of these bears were monitored within the BHP claim block on a regular basis.

Barren-ground grizzly bears use widely distributed seasonal habitats within very large ranges. The home ranges of several male and female grizzly bears overlap the EKATI™ Diamond Mine claim block area (BHP, 1995). Adult grizzly bears typically remain within relatively defined home ranges, and annual home ranges of adult male bears (*ca.* 6685 km^2) typically exceed those of adult female bears (*ca.* 2074 km^2) (McLoughlin *et al.*, 1998, in Diavik, 1998b). Seasonal movement rates are also higher for males than for females. In general, adult male bears exhibit high initial movement rates during the breeding season, eventually decreasing distances travelled during the summer and fall seasons. Female movement rates are highest during summer and decrease during fall. Subadult females are known to utilize homes ranges that are similar in size and that are in proximity to or overlapping that of their mother's. Conversely, subadult male bears travel over extensive distances and often far exceed home range sizes of adult male grizzly bears (Diavik, 1998b).

During their travels, grizzly bears use a wide variety of habitats and show seasonal habitat preferences that are related to food availability, thermal shelter and hunting and escape cover. Snow-free areas on the tundra are preferentially used in spring, and tall shrub habitat is important during the summer months. Some bears are effective and frequent predators of caribou as well as scavengers of wolf-killed caribou. Caribou are very important in the diet of grizzly bears during spring, mid-summer and fall. During spring and early summer, bears forage primarily on green vegetation such as sedges and horsetails and a variety of other foods including fish and waterfowl eggs. Berries increase in dietary importance in mid-summer and bears begin intensive feeding in late summer, feeding on blueberries and other berries which commonly occur (BHP, 1995).

Grizzly bear den sites are widely distributed throughout the Slave Geological Province and the EKATI™ Diamond Mine/Lac de Gras region (Banci and Moore, 1997; McLoughlin *et al.*, 1997; Penner and Associates, 1998a). Grizzly bears typically enter their dens in mid-September to early-November and emerge in mid-April to mid-May (McLoughlin *et al.*, 1997). Dens are commonly constructed in glaciofluvial deposits where moderate slopes and fine soils allow easy excavation and provide good drainage. Figure 3.7-6 identifies the grizzly bear dens found in the BHP Wildlife Monitoring Program study area in 1997, 1998 and 1999 (Rescan, 1999c) and Plate 3.7-4 shows the single grizzly bear den that was found in the study area during 1998. In 1999 a new den was found along the north shore of Ulu Lake in the vicinity of the proposed Sable development.

In 1999, grizzly bear observations habitat usage were collected during spring and summer. During the spring, the majority of bear sign found was in wetland habitats, where bears fed on new sedges and grasses, on lemmings and last year's cranberries in closed mat tundra and birch hummock ecosystem units, and on ground squirrels on esker ecosystems. Digs for ground squirrels were found on esker habitats. The portions of eskers surveyed were typically adjacent to wetlands, and still had much snow cover on the leeward slopes.

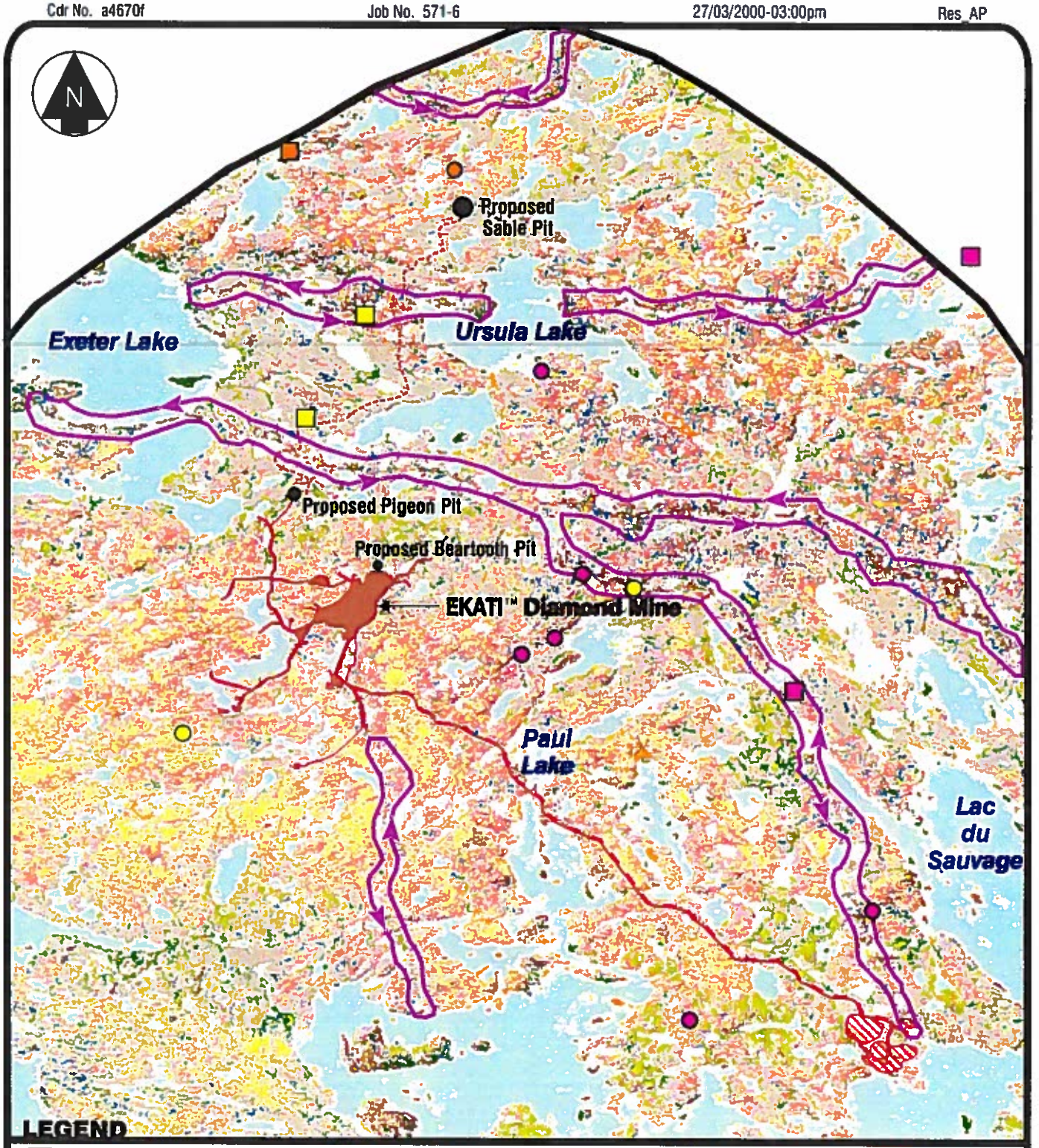


FIGURE 3.7-6

Esker Search Routes and Location of Grizzly Bear and Wolf Dens

Source: Golder 1999, Rescan 1999c

Plate 3.7-4 Grizzly bear den.

During the summer, the majority of bear sign was found in willow riparian habitats. Trails within the willow riparian habitats used by bears were distinct and well worn indicating extensive use over time. Bears used birch and willows within the riparian habitat for rubbing, typically leaving clumps of shed hair behind.

Much of the travel behaviour during summer was likely associated with hunting in willow riparian habitats, as caribou also frequented those habitats used by bears. Within these habitats, trails were littered with hair shed by caribou. Many of the streams flowing through the riparian habitats contained grayling and were likely fished by bears. Observations of bear behaviour were consistent with those described for collared bears in previous years.

3.7.4 Furbearers

The furbearers found in the wildlife study area are red foxes, Arctic foxes, wolves, wolverine and ermine. Foxes and wolves belong to the canid family and wolverine and ermine to the mustelid family. All four species are carnivores. The canids are hunters, taking prey ranging in size from shrews to caribou. Among this family, the wolf is the primary predator of barren-ground caribou. Both fox species feed primarily on small mammals and birds. Wolverine are also carnivores but are primarily scavengers. They rely on the kills of more successful hunters, such as wolves. Ermine are small predators that concentrate on small mammals such as mice and voles.

The term "furbearer" is a legal description, meaning that these animals may be trapped for their pelts. Foxes, wolves and wolverine are important species in the fur harvest, especially above the treeline because of the lack of other furbearers such as marten, beaver, mink and lynx. Ermine pelts are low in value compared to other species and do not figure prominently in the harvest.

The Lac de Gras area is remote, above the treeline and has a low diversity and abundance of furbearers. Foxes and wolverine are present year-round while wolves are present only when caribou are in the area. Ermine are also found year-round but are difficult to see and inventory without intrusive methods, *i.e.* trapping. Trapping of any of these species does not take place currently in the Lac de Gras area. It is unlikely that furbearers living at Lac de Gras are trapped by other communities, with the possible exception of wolves and perhaps wolverines. Only these two species have extensive movements that could bring them into contact with trappers and hunters.

Furbearers, especially wolves and wolverines, are considered a Valued Ecosystem Component because of their role in the food chain, their importance in the fur market and their high public profile. The national designation of wolverine as vulnerable (COSEWIC, 1997) also makes it a species of concern.

3.7.4.1 Foxes

Arctic fox and red fox are year-round residents in the BHP Wildlife Study area. The southern distribution limit of the arctic fox is generally described as the northern edge of the treeline. Arctic fox populations are known to fluctuate widely from year to year following changes in lemming populations, which is their primary food source (MacPherson, 1969; Garrott and Eberhardt, 1987). Red foxes, which are larger, have been reported to out-compete arctic foxes by usurping their dens and other limited habitat resources and food supplies (Rudzinski *et al.*, 1982; Bailey, 1992).

Foxes are solitary but form temporary social groups during the breeding season. The basic social unit is an adult male and female and their pups. One or two additional adults may be associated with the family group. Pairs seek den sites beginning in February and March and most pairs are established at dens no later than early May (Garrott and Eberhardt, 1987). Family groups focus much of their activity around dens until midsummer when the pups begin to wander extensively. The juvenile foxes disperse in the fall.

During the summer, foxes prey primarily on birds and small mammals. Lemmings are the predominant small mammal eaten by arctic foxes, and voles may also be consumed where and when they are numerous (Garrott and Eberhardt, 1987). Other fox prey includes ground squirrels, insects, arctic hares, fish, caribou and berries.

Foxes require suitable substrate to establish their dens. In the BHP Wildlife study area fox dens are commonly found on eskers and other accumulations of glacio-fluvial materials. According to Dogrib elders, a high concentration of fox denning sites are found on glacial features between the north end of MacKay Lake and the southeast end of Lac de Gras (BHP, 1995). Plate 3.7-5 illustrates one of the active fox dens located in the vicinity of the old Koala camp.

Plate 3.7-5 Assessment of fox den site near Old Koala camp.

Foxes can occupy dens for many years and are likely to return to the same ones because of previous successes in rearing offspring. MacPherson (1969) calculated that dens in the Canadian Arctic could be used for several centuries before the burrow system collapsed. As a result of many years of occupancy and gradual expansion, a den can evolve into a large complex system covering several hundred square metres and containing 20 to 80 burrow entrances (MacPherson, 1969). Thus, the complexity of the burrow can be an indication of its length of occupancy. Foxes can use more than one den during a season. Family groups may abandon a den site and move to another several kilometres away or may simultaneously occupy several dens.

3.7.4.2 Wolves

Wolves are found throughout the Slave Geological Province and are closely associated with caribou. Although there are no detailed census data on the number of wolves in the NWT, RWED estimated that there are between 1,400 and 3,000 wolves on the Bathurst Caribou range (Diavik, 1998b). Most wolves in the central arctic are not territorial and follow the caribou herd for most of the year except when they den to raise young.

Wolves are the predominant predators of barren-ground caribou and as such they play a pivotal role in all levels of the Arctic ecosystem. They are also hunted and trapped and

play an important role in local and regional economies. Like most large carnivores, wolves can be sensitive to disturbance, especially during their reproductive period (Chapman, 1977). Nevertheless, they possess demographic characteristics, especially high productivity and dispersal capabilities, that provide them with resiliency to modest levels of human disturbance of their habitat and populations (Weaver *et al.*, 1996). The population resiliency of wolves is a function of many environmental factors, and can either increase or decrease, given the right circumstances. For these reasons, wolves were selected for monitoring within the wildlife study area.

Wolves show a strong affinity to eskers and other glacial deposits for den sites and travel routes, and these features have been identified as Valued Ecosystem Components for the EKATI™ Environmental Impact Statement (BHP, 1995). Wolves are only present on the tundra during summer, and their dens are focal points of activity during this time. Wolf dens are traditional and may have been used over many years.

Wolves are habitat generalists, and their strongest affinity is for habitats occupied by their prey. However, they have very specific requirements for denning habitat. In the Slave Geological Province, nearly all den sites have been found on eskers or in other glacial deposits (Mueller 1995; Rescan 1996c, Golder 1998; D. Cluff, RWED, pers. commun.). Use of other habitats by wolves on the barrens to date has not been documented.

Surveys for wolf dens have been conducted in the EKATI™ Diamond Mine claim block since 1994 (BHP, 1995; Golder, 1999; Rescan, 1999c). Eskers are an important habitat for wolves. They den almost exclusively in eskers and other glaciofluvial deposits, and also use them for travelling (RWED, 1997c in Golder, 1999). Wolf dens located in the BHP wildlife study area during 1997, 1998 and 1999 esker searches are presented in Figure 3.7-6. In 1997 one occupied wolf den was found on the Lac du Sauvage esker east of Paul Lake, and in 1998 two wolf dens were located in the vicinity of the proposed Sable Road. In 1999, a previously inactive den located approximately 8 km northwest of the Sable development area was reoccupied (Rescan, 1999c). Plate 3.7-6 shows one of the active wolf dens observed in 1998.

Wolf pups are born in dens in late May and early June and do not move with the pack until late August. Treeline dens may persist longer and be reused more frequently than tundra dens (Heard and Williams, 1992). Of 63 wolf dens found on the Bathurst caribou range, 26 were on tundra, 28 in the treeline transition area and nine in the forest (Heard and Williams, 1992).

Dogrib elder knowledge indicates a high concentration of wolf denning sites north of Lac de Gras (BHP, 1995). However, traditional Dene use of this area for wolf hunting does not appear to be any more or less intensive than anywhere else on the barrenlands. Inuit traditionally hunted wolf north of Lac de Gras, especially when they wintered at Contwoyto Lake.

Based on work done in the Slave Geological Province by RWED (1997c), by mid-summer the average number of pups per pack is 4.6, with counts ranging from three to eight pups. Other preliminary work completed as a WKSS study by Cluff and Walton (1999), calculated an average of 3.7 pups/den based on counts for 6 active dens.

Plate 3.7-6 Active wolf den.

To monitor the movement of wolves during their denning period, in June 1997 and 1998 the WKSS wolf study (Cluff and Walton, 1999) fitted a number of wolves with satellite radio-collars. Figure 3.7-7 presents some of the preliminary data from this program, showing the movement of wolves tracked by satellite during the period June 15 to August 31, 1998.

During 1998 only one wolf den was located within BHP's wildlife study area; while in 1999 one wolf den was documented along the northern edge of the wildlife study area.

3.7.4.3 Wolverine

Although wolverine range throughout most of northern and western Canada including the BHP Wildlife Study area, much more needs to be learned about this elusive species. Wolverines are difficult to locate during snow-free periods, lead a solitary lifestyle and have a lower population density than wolves or foxes. Wolverine live at low densities

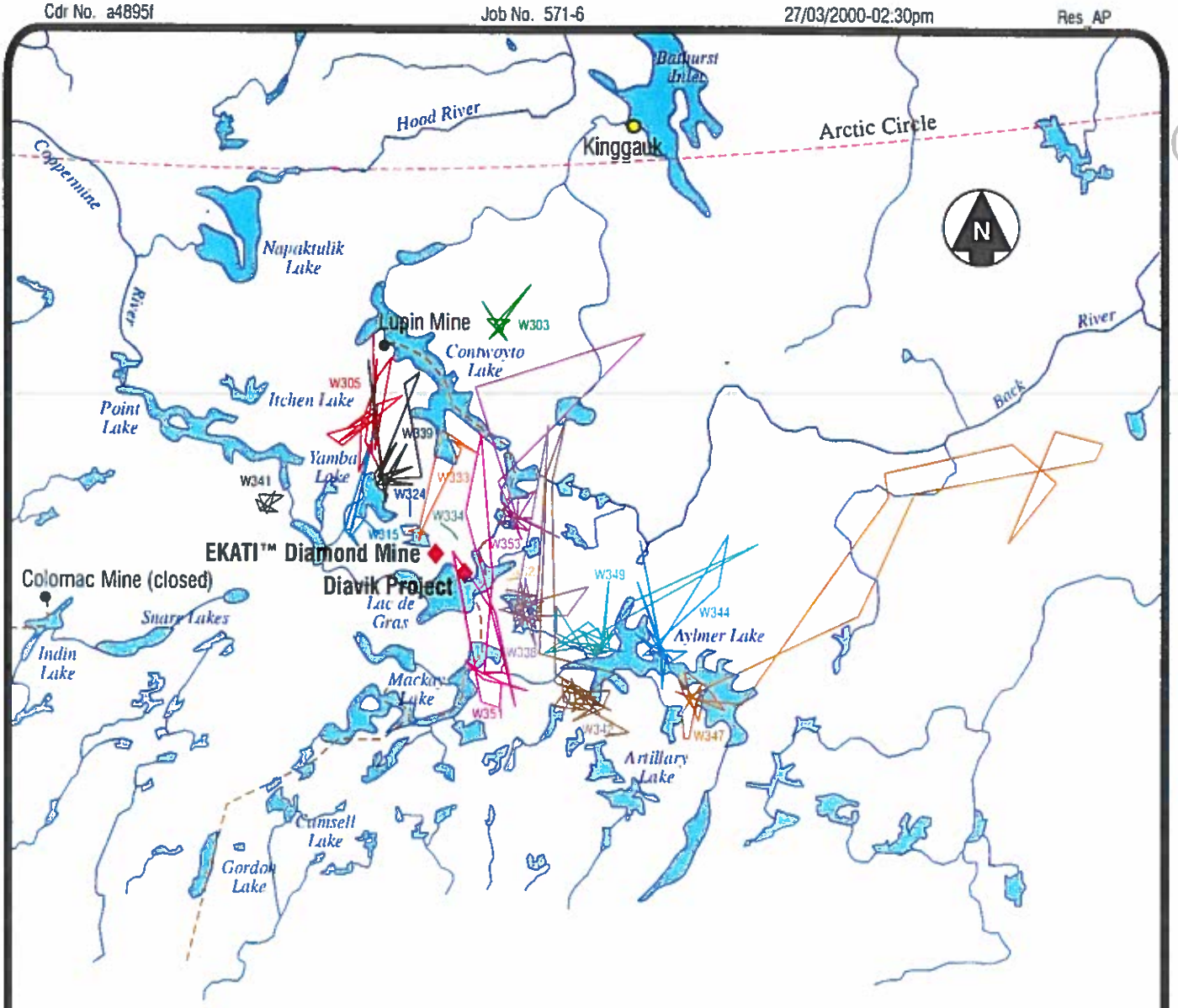


FIGURE 3.7-7

Summer Wolf Movements, 1998

Source: Cluff and Walton, 1999

even under optimal conditions (Banci, 1994). Reproductive rates are low and sexual maturity delayed, in comparison with other mammalian carnivores. Wolverine are scavengers and hunters of birds and small mammals, relying on a diversity of foods to offset the uncertainty of availability in the harsh northern environment. There appears to be a correlation between wolverine, ungulate populations and the presence of more successful hunter-carnivores such as wolves.

Within its geographic range, wolverine occupy a variety of habitats. However, a general trait of areas occupied by wolverine is their remoteness from humans and intensive development. Within wilderness areas, some wolverines have learned to take advantage of human foods. This behaviour was experienced directly by BHP during mid-winter (February and March 1998) when two wolverines had to be live-trapped and relocated to the treeline south of the mine site because of their continued attraction to the landfill site at the mine, despite the strategies being employed to minimize the availability of attractants at this location.

Recent wolverine studies sponsored by RWED with strong support from local hunters and trappers, are beginning to generate important baseline ecological information on wolverines living on the barrens. The three year study, begun in early 1996, was carried out to the west of the EKATI™ Diamond Mine in the vicinity of Yamba Lake, (Figure 3.7-8) (RWED, 1997a, 1997b). The project involved the capture and release of wolverines, radio-collaring of seven wolverines (six males, one female) and the collection of hunter harvest information.

Preliminary data from the radio-collaring component of the study (Figure 3.7-8) indicated home range sizes for adult females of 59 km^2, and for adult males of 137 km^2. Yearlings were estimated to have larger home ranges, ranging from 1,905 km^2 for yearling females, to 1,418 km^2 for yearling males. However, the researchers stressed that these calculations were to be treated as an approximate and tentative estimate because of various confounding factors such as the tendency of some collared animals, primarily juveniles, to emigrate from their study area (RWED, 1997b).

Wolverine are an important furbearer for the local communities and throughout the Northwest Territories. The WKSS studies (RWED, 1997a, 1997b) reported that during the 1996/97 hunting season, hunters from Kugluktuk and Umingmaktok brought in 137 wolverine carcasses, of which 37% (51) were females. For the 1997/98 season, 139 wolverine carcasses were brought in and females again made up 37 % of the harvest. These results were comparable to previous recorded harvests in the Kitikmeot (RWED, 1997b).

The presence of wolverine natal dens were monitored in past years. During 1995, 1996 and 1998 two natal dens were documented each year. Wolverine natal dens were not searched for in 1997. No wolverine natal dens were documented during 1999. Detecting dens is difficult even under ideal conditions since burrow openings are small and difficult

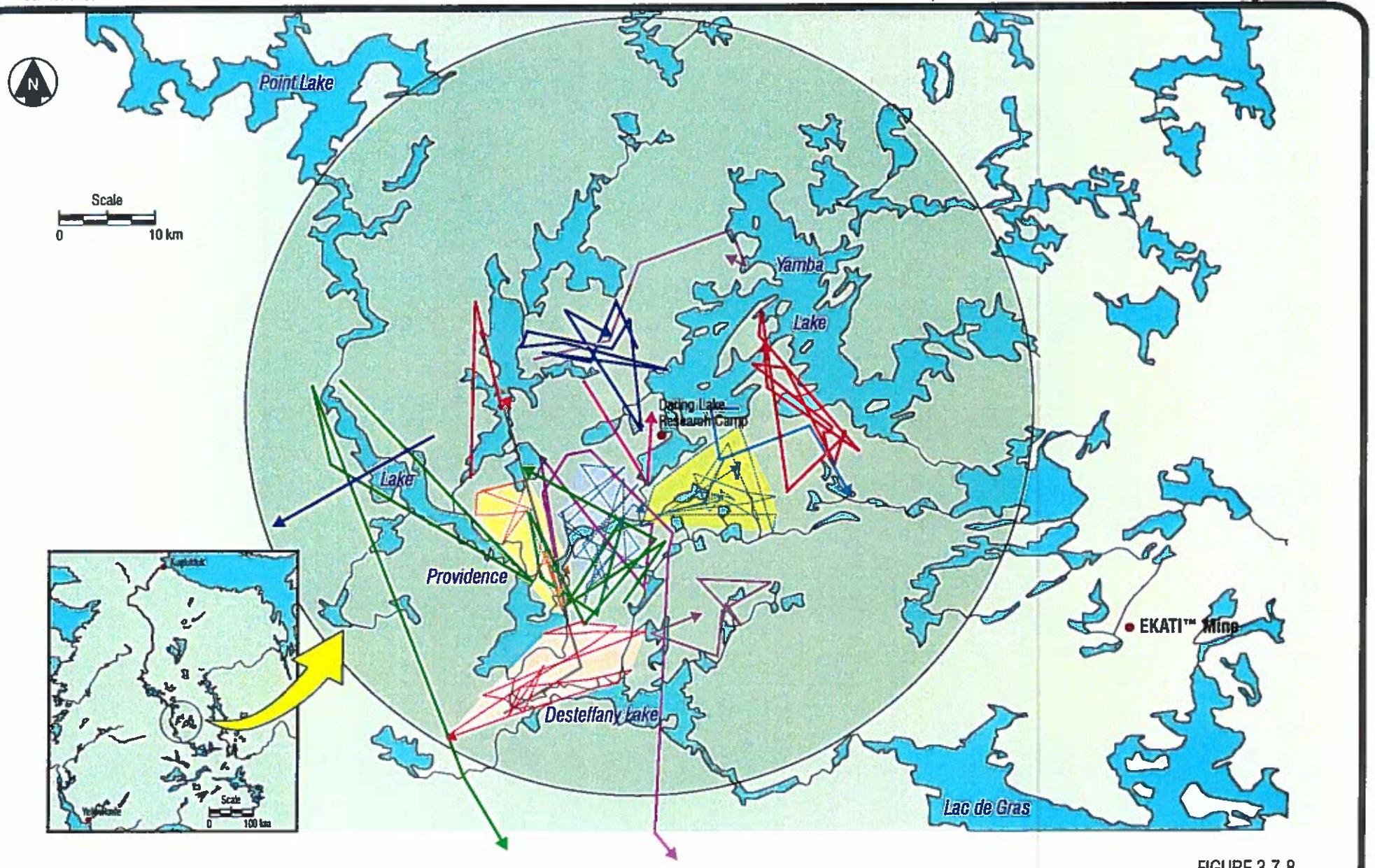


FIGURE 3.7-8

Wolverine Home Ranges and Movements in 1997 in the Wolverine Study Area

BHP

Ekati diamond mine

Source: RWED 97b

to detect, and the dens themselves are ephemeral. Surveyors rely on the presence and extent of animal sign for detecting and classifying dens. During April, repeated snowfalls accompanied with strong winds created poor conditions for detecting natal dens.

The inability to detect confirmed natal dens does not indicate that wolverines no longer den in the area. Individual wolverines were observed on a regular basis during the field season, as in past years. One female with two kits was observed at a rendezvous site near Pointe de Misere and would have had a natal den in the vicinity.

3.7.5 Small Mammals and Hares

Small mammals and hares are an important component of the biodiversity in the project area and throughout the Arctic.

Small mammals found in the EKATI™ Diamond Mine area include voles, mice, lemmings and shrews. Voles and mice at Lac de Gras include the northern red-backed vole (*Clethrionomys rutilus*), meadow vole (*Microtis pennsylvanicus*), chestnut-cheeked vole (*Microtis xanthognathus*) and white-footed deer mouse (*Peromyscus maniculatus*) (Shank, 1993). Lemmings species recorded have been brown lemmings (*Lemmus sibiricus*) and collared lemmings (*Dicrostonyx torquatus*). Little information is available on the occurrence and distribution of shrew species (*Sorex* spp.) in this area. For this brief discussion, the term "small mammals" also includes arctic ground squirrels and arctic hare.

Small mammals are important prey for carnivores such as arctic and red foxes and for avian predators. These prey are not migratory and are available all winter, if foxes and wolverine can access them. Ground squirrels are an important food for many carnivorous species, including grizzly bears. They establish their burrows in glaciofluvial deposits, using eskers to a large extent. Ground squirrels hibernate but wolverine have been known to dig them out of their hibernacula (Gardner, 1985). Lemmings and voles remain active under the snow and hares are active above ground.

In the Northwest Territories, small mammals tend to be cyclic, with tremendous fluctuations in populations sizes. These fluctuations are often regular (every three to four years) and large in magnitude with populations at the peak varying from ten to 50 times populations at the low (BHP, 1995). The abundance of small mammals affects the behaviour, use of habitats and population dynamics of the species that prey on them. Rough-legged Hawks and Snowy Owls choose areas of high microtine and lemming numbers in which to breed (Galushin, 1974; Pitelka *et al.*, 1955). Grizzly bears concentrate on habitats with ground squirrel burrows in the fall.

Fluctuations in small mammal populations can affect species other than carnivores. When small mammals numbers are low, prey switching by generalized predators such as arctic fox, wolves and wolverine can affect waterfowl breeding success (Sutherland, 1988). When numbers are high, the vegetation can be significantly reduced, affecting the

availability of food for other herbivores. For example, during a peak year at Baker Lake in the Northwest Territories, lemmings utilized about 15% of the vegetative standing crop (Krebs, 1964).

3.7.6 Birds

The Northwest Territories is home to few year-round bird residents but hosts immense numbers of migratory species during the brief snow-free period. The importance of the NWT for nesting and brood-rearing is evident in its 16 migratory bird sanctuaries covering 11 million hectares of arctic coastal habitat (Graves and Hall, 1988). Most of these sanctuaries are for the protection of waterfowl. One-fifth of the North American population of all ducks, geese and swans nest in the NWT (Graves and Hall, 1988).

Birds in the project area and the region are considered a Valued Ecosystem Component because of their sensitivity to development and species diversity in each habitat type. Some species, in particular waterfowl and ptarmigan, are important to Aboriginal and non-Aboriginal residents for food. The presence of bird species has been used as an ecological indicator to monitor environmental health. For example, waterfowl species are associated with wetlands, a relatively rare habitat type in the central arctic. Wetlands are not only used by birds but also by grizzly bears in the spring and barren-ground caribou in the fall (BHP, 1995).

Some passerine species nest in tall shrubs, another relatively rare vegetation community found in riparian habitats which are also used by grizzlies. Continued use of these important habitats by birds may be viewed as evidence that the overall integrity of these ecosystems is being maintained. Birds have also been used as ecological indicators because of their role in the ecosystem. Species feeding on fish, such as loons and colonial waterbirds, and birds of prey are at the top of their food chains. A shift in prey abundance as a result of human-caused disturbance will affect bird populations at the local level.

Although many migratory species use arctic habitats for only a few months of the year, these areas are important because birds are dependent on them for breeding and nesting. The EKATI™ Diamond Mine project area is small compared to the length and breadth of bird migratory pathways. However, assessing relative abundance and distribution of species has been useful since birds are sensitive to changes in habitat quality and quantity that result from development.

Bird studies and monitoring programs in the BHP project area have been carried out for the past five years. During that time over 70 species of birds have been identified in the wildlife study area (Table 3.7-2), including 43 confirmed breeders.

These species included breeders, migrants, molt-migrants, summer transients and unexpected visitors. Complementary work done for Diavik's Environmental Assessment submission during the period 1995 to 1997 confirmed the presence of 84 bird species within their larger and more varied regional study area (Diavik, 1998b).

Table 3.7-2
Birds Found in the BHP Wildlife Study Area, 1994 - 1999

Birds		Birds	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Common Loon	*Gavia immer*	Long-billed Dowitcher	*Limnodromus scolopaceus*
Pacific Loon	*Gavia pacifica*	Pectoral Sandpiper	*Calidris melanotos*
Yellow-billed Loon	*Gavia adamsii*	Red-necked Phalarope	*Phalaropus lobatus*
Red-Throated Loon	*Gavia stellata*	Ruddy Turnstone	*Arenaria interpres*
Horned Grebe	*Podiceps auritus*	Semi-palmated Sandpiper	*Calidris pusilla*
Canada Goose	*Branta canadensis*	Stilt Sandpiper	*Calidris himantopus*
Brant	*Branta bernicia*	White-rumped Sandpiper	*Calidris fuscicollis*
Greater white-footed Goose	*Anser albifrons*	Willow Ptarmigan	*Lagopus lagopus*
Tundra Swan	*Cygnus columbianus*	Rock Ptarmigan	*Lagopus mutus*
Snow Goose	*Chen caerulescens*	Bald Eagle	*Haliaeetus leucocephalus*
Mallard	*Anas platyrhynchos*	Golden Eagle	*Aquila chrysaetos*
Northern Pintail	*Anas acuta*	Gyrfalcon	*Falco rusticolus*
Green-winged Teal	*Anas crecca*	Merlin	*Falco columbarius*
American Widgeon	*Anas americana*	Northern Harrier	*Circus cyaneus*
Northern Shoveler	*Anas clypeata*	Peregrine Falcon	*Falco Peregrinus tundrius*
Greater Scaup	*Aythya marila*	Rough-legged Hawk	*Buteo lagopus*
Red-breasted Merganser	*Mergus serrator*	Snowy Owl	*Nyctea scandiaca*
Common Merganser	*Mergus Merganser*	Short-eared Owl	*Asio flammeus*
Surf Scoter	*Melanitta perspicillata*	Eastern Kingbird	*Tyrannus tyrannus*
Oldsquaw	*Clangula hyemalis*	Horned Lark	*Eremophila alpestris*
American Coot	*Fulica americana*	American Pipit	*Anthus rubescens*
Herring Gull	*Larus argentatus*	Common Raven	*Corvus corax*
Thayer's Gull	*Larus thayeri*	American Robin	*Turdus migratorius*
Glaucous Gull	*Larus hyperboreus*	Gray-cheeked Thrush	*Catharus minimus*
Arctic Tern	*Sterna paradisaea*	Yellow Warbler	*Dendroica petechia*
Long-tailed Jaeger	*Stercorarius longicaudus*	Blackpoll Warbler	*Dendroica striata*
Parasitic Jaegers	*Stercorarius parasiticus*	Rusty Blackbird	*Euphagus carolinus*
Sandhill Crane	*Grus canadensis*	Savannah Sparrow	*Passerculus sandwichensis*
Semi-palmated Plover	*Charadrius semipalmatus*	American Tree Sparrow	*Spizella arborea*
Lesser golden Plover	*Pluvialis dominica*	Harris' Sparrow	*Zonotrichia querula*
Black-bellied Plover	*Pluvialis squatarola*	White-crowned Sparrow	*Zonotrichia leucophrys*
Baird's Sandpiper	*Calidris bairdii*	Dark-eyed Junco	*Junco hyemalis*
Common Snipe	*Capella gallinago*	Snow Bunting	*Plectrophenax nivalis*
Dunlin	*Calidris alpina*	Lapland Longspur	*Calcarius lapponicus*
Least Sandpiper	*Calidris minutilla*	Hoary Redpoll	*Carduelis homemanni*
Lesser Yellowlegs	*Tringa flavipes*	Common Redpoll	*Carduelis flammea*
Long-billed Dowitcher	*Limnodromus scolopaceus*		

For purposes of long-term monitoring, BHP and the various stakeholders participating in the annual wildlife monitoring workshops agreed to concentrate on three main categories of birds, namely breeding birds, raptors and loons. The following are the highlighted results of the past three years of bird monitoring in the BHP Wildlife Study area. Further baseline information on these and other bird species frequenting the BHP study area and the larger regional study area investigated by Diavik is provided in BHP (1995) and Diavik (1998b).

3.7.6.1 Breeding Birds

For the BHP bird monitoring program breeding birds have been defined to include passerines, shorebirds and ptarmigan.

Spring bird migration begins in early May and peaks around mid to late May. The breeding season for passerines starts during the first week of June and continues until approximately the third week of June. Fall migration begins in mid-August and continues through to mid-September. Passeriformes are the most common breeders within the study area and include the Lapland Longspur, Lesser Golden Plover (Plate 3.7-7), Horned Lark and Harris Sparrow among others. The least common species breeding in the study area include the Blackpoll Warbler, Common Snipe, White-crowned Sparrow and Long-tailed Jaeger. Based on species richness, the three most important breeding habitats in the study area are riparian tall shrub, birch hummock and heath mat tundra.

Plate 3.7-7 Lesser Golden Plover.

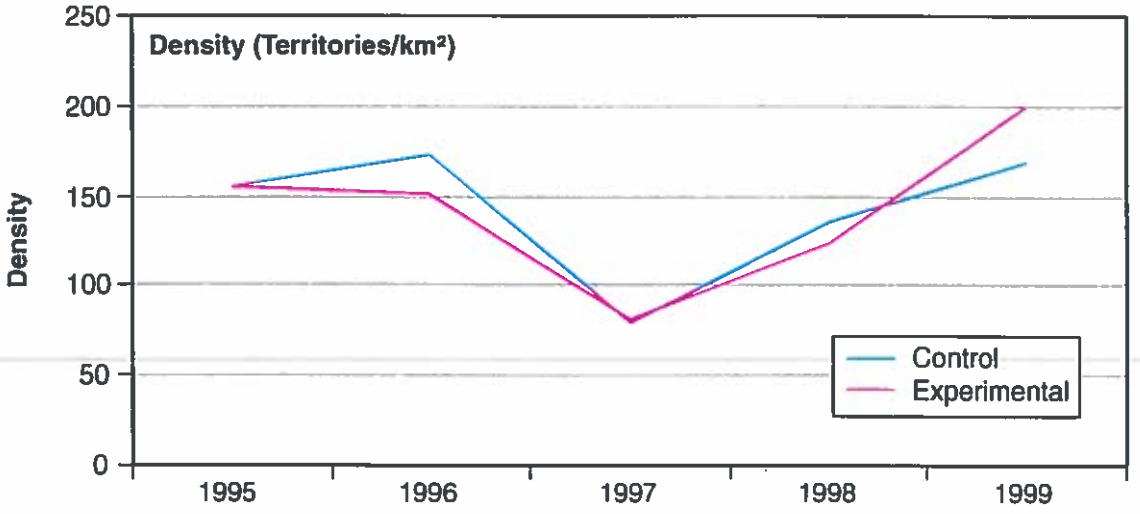
Since 1995 breeding bird surveys have been conducted on a number of experimental (<2 km from the mine site) and control sites (>10 km from the mine site) (Plate 3.7-8). In 1998, 21 permanent 0.25 km^2 plots were surveyed, of which 12 were control and nine were experimental sites. In 1999, ten permanent 0.25 km^2 plots were surveyed, of which six were control and four were experimental sites.

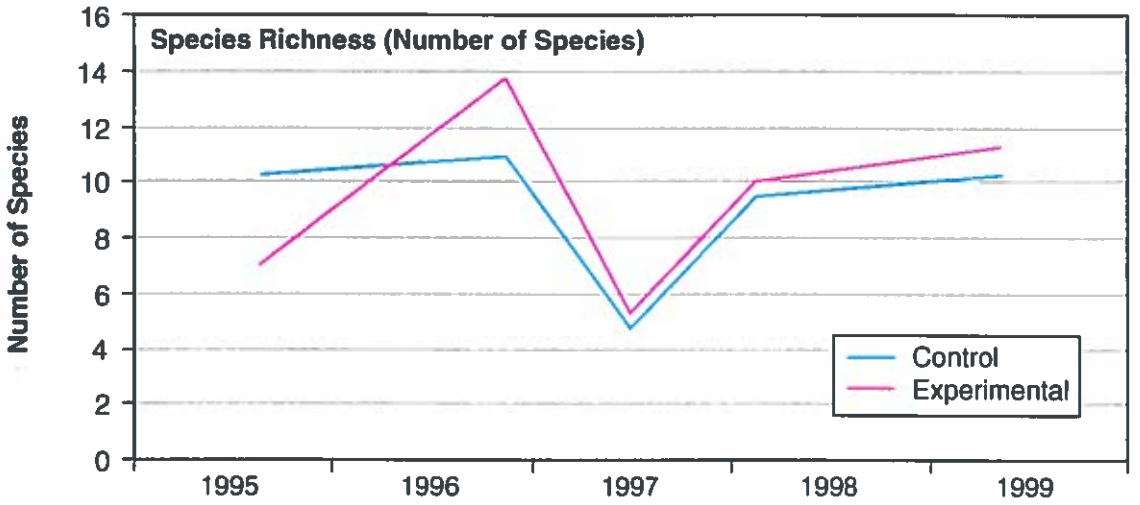
Plate 3.7-8 Experimental breeding bird plot, A/N site, beside mine infrastructure.

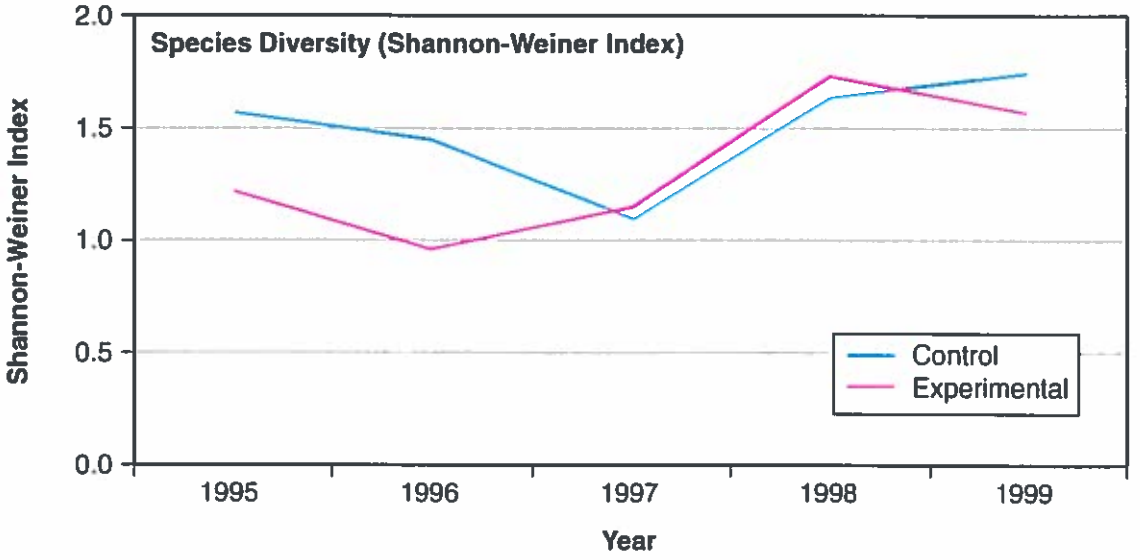
The survey methods used were consistent with those used in the earlier baseline studies and the more recent monitoring program (Golder 1998, 1999; Rescan, 1999c).

In 1999, over 2000 birds were documented on the breeding bird plots, representing 50 different species, of which 26 were confirmed breeders. Twenty-one species were common to mine and control sites, while four were unique to mine sites and 11 were unique to control sites (Rescan, 1999c).

For 1999, the results indicate that there was no statistical difference between sites for territorial density, richness and diversity (Rescan, 1999c). For territorial density, richness and diversity, there were no significant year and mine interactions (Figure 3.7-9). The data suggest that the annual changes in breeding bird territories appear to have been associated primarily with natural changes in breeding bird densities rather than possible effects of the current mining activities. In general the presence of the mine and its associated activities does not appear to be adversely affecting breeding bird densities.







Density (Territories/km²), Species Richness and Species Diversity (Shannon-Weiner Index) of Breeding Birds on Control and Experimental Sites, 1995 - 1999

FIGURE 3.7-9

Source: Rescan, 1999c

3.7.6.2 Raptors

In Canada and elsewhere raptors are viewed as indicators of a healthy environment (Furness and Greenwood, 1993). Their position as one of the top carnivores makes them, in part, inherently vulnerable to the effects of some human activity. Their low population densities and reproductive rates also makes them susceptible to population decline (Newton, 1979). Both symbolically and scientifically, raptors have come to represent a healthy or pristine landscape. Thus, raptors were identified as a VEC for BHP's Wildlife Effects Monitoring Program. In addition, the *tundrius* subspecies of Peregrine Falcon that breeds in the study area is listed as "vulnerable" by the Committee of the Status of Endangered Wildlife in Canada (COSEWIC, 1997).

Densities of raptors in the study area are low (BHP, 1995), but the following nine species have been documented:

- Bald Eagle;
- Golden Eagle;
- Northern Harrier;
- Rough-legged Hawk;
- Peregrine Falcon;
- Gyrfalcon;
- Merlin;
- Snowy Owl; and
- Short-eared Owl.

Of these species, only the Rough-legged Hawk, Peregrine Falcon, Gyrfalcon and the Short-eared Owl are confirmed breeders within the BHP study area. It is believed that the Bald Eagle may also breed in the area. A single Merlin was observed at the EKATI™ Diamond Mine. It has been classified as an "accidental visitor" as it was well outside its known breeding range. All raptors except the Gyrfalcon are summer residents, returning to the barrenlands in the spring to breed.

The survey methodology employed for BHP raptor monitoring has involved locating active nests in the spring during aerial caribou surveys and visiting known nesting sites in the early summer (late June) and in August, following RWED guidelines to avoid disturbance during courtship, egg laying or early incubation (Golder, 1999).

Figure 3.7-10 shows the location of occupied raptor nest sites during the period 1997 to 1999. To date none have been located in the vicinity of the proposed EKATI™ Diamond Mine expansion activities, due largely to the absence of suitable (cliff) habitat in this area.

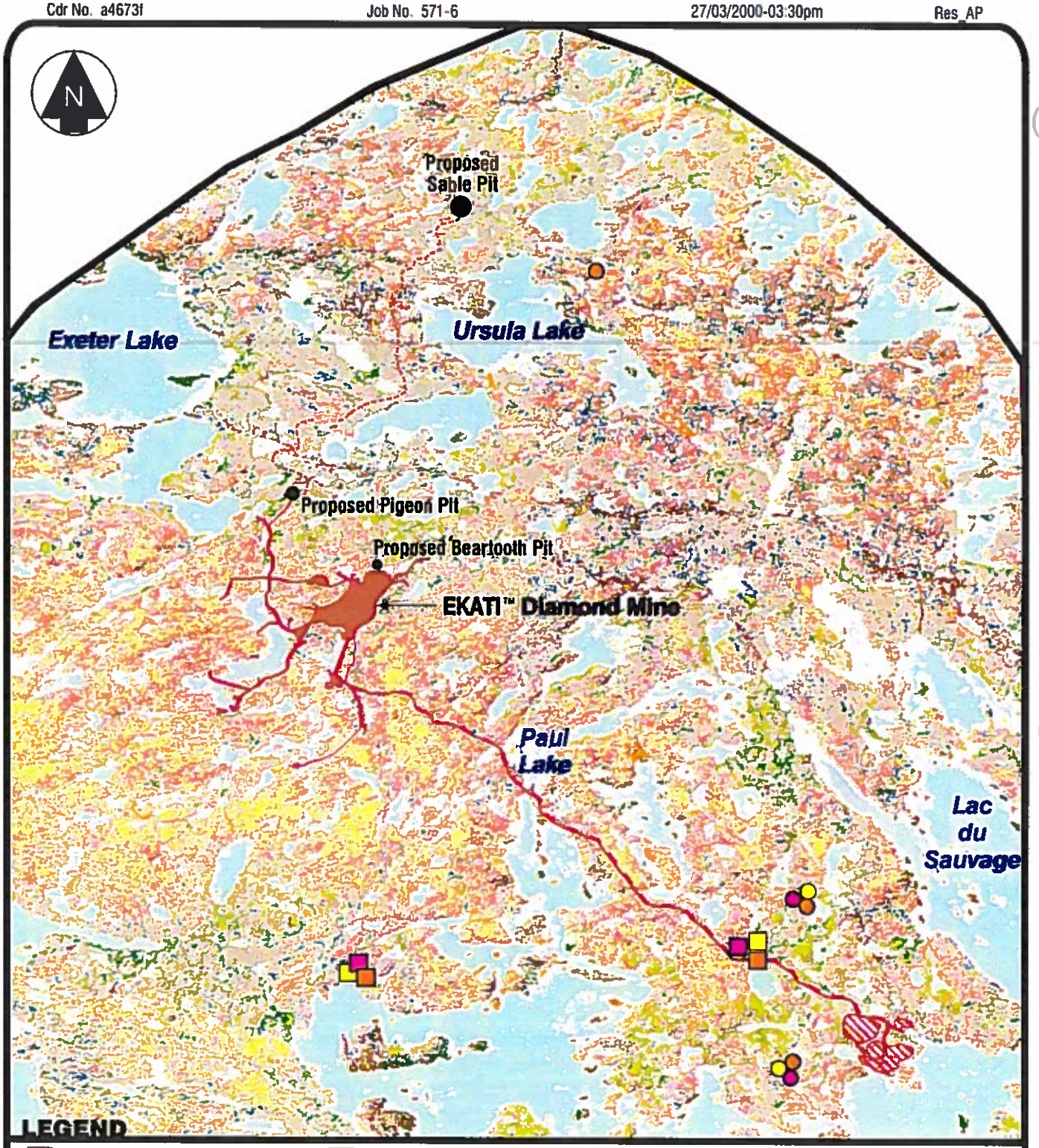


FIGURE 3.7-10

Location of Occupied Raptor Nest Sites, 1997 - 1999

Source: Golder 1999, Rescan 1999c

Six occupied nests were documented in 1998; four within the study area and two just outside the northern boundary. Three nests were occupied by Peregrine Falcons and three were occupied by Gyrfalcons. No Short-eared Owl or Rough-legged Hawk nests were recorded in the study area during 1998 (Golder, 1999) or 1999 (Rescan, 1999c).

Four nests were occupied by the same species in both 1997, 1998 and 1999. Two sites unknown from previous years were found also in 1998; a Gyrfalcon nest at North Esker and a Peregrine nest at Nanook Lake (Golder, 1999). Another raptor site was discovered in 1999, 76 km northeast of EKATI™ Diamond Mine, and was occupied by a pair of gyrfalcons.

A principal factor that limits the density of raptors within the BHP study area is the availability of suitable nesting habitat. Cliff habitat is found in only a few areas located at the extremities of BHP's claim block. Some historical nesting areas for raptors are located at the Lac de Gras outflow, the northern tip of North Esker, an area north of Misery Lake (Plate 3.7-9) and along the north shore of Lac de Gras near Fish Esker and the adjacent island to the south (BHP, 1995; Rescan, 1996). Only a few nest locations have been documented in the study area for the Short-eared Owl. This owl species nests on the ground in valleys, in dense mats of birch, making it difficult to locate nest sites. The density of raptor nests within the study area is low when compared to other nearby regions such as the area southeast of Lac de Gras and the western shore of Contwoyto Lake. Both these areas contain greater amounts of topographic relief, more cliffs and, consequently, greater densities of nesting raptors.

Plate 3.7-9 Suitable raptor nesting habitat is found in cliff areas located at the extremities of the claim block such as this site, north of Misery Lake.

3.7.6.3 Loons

Loons are relatively sensitive to human disturbance, particularly during the breeding period (Ehrlich *et al.*, 1988). Thus, similar to wolverines, loons can be thought of as indicators of pristine environments. Because loons exhibit a high degree of site fidelity (Strong, 1990; Strong *et al.*, 1987), the presence or absence of breeding territories from year to year has been used in the BHP Wildlife Study area to measure the potential long-term impacts of mining activities on the overall health of the environment immediately surrounding the mine site.

Loon surveys in the BHP study area were conducted on many lakes across the claim block beginning in 1994 and 1995. Incidental information continued to be collected across the claim block in 1996. Four species of loons have been observed in the BHP study area: the Yellow-billed, Red-throated, Pacific and Common Loon. The most common species are the Yellow-billed and Red-throated Loon, while the Pacific and Common Loon are only occasionally seen. All four species are known to breed in the study area. The common loon was confirmed to be breeding in the study area for the first time during 1998 (Golder, 1999).

Due to changes in protocol and emphasis on different species in BHP's wildlife studies, the 1998 and 1999 results are not directly comparable to results from previous years. Different lakes were surveyed during 1994 and 1995, and loon surveys were not conducted in 1996 or 1997. In 1998 only a few select lakes were monitored, while in 1999 the loon survey included lakes that had been surveyed in previous years.

Over the years many lake sites have been surveyed for breeding pairs and individuals, comprising of experimental lakes (within the core mine area), and control lakes (>10 km away) (Figure 3.7-11). Coincidentally, two of the current control sites are located in the vicinity of the proposed Sable Road, thus in the future they will become additional experimental sites.

In 1998 a total of 24 individual loons, comprising four different species, were observed. These species, from most to least common, included the Yellow-billed, Red-throated, Common and Pacific Loons. Red-throated Loons were associated with shallow lakes containing abundant aquatic vegetation, while the other three species showed a preference for large to medium sized lakes.

Of the nine lakes surveyed within the core mining area in 1998, only one had an occupied territory. In contrast, three occupied territories were recorded for the seven control lakes. However, it is important to note that many loons were observed feeding on the numerous lakes within the core mine area over the course of the summer. Thus, the observed difference in the number of breeding pairs between lakes outside and within the core mine area may be related to differences in the suitability of nesting habitat associated with these lakes. For example, lakes within the core mine area are typically deep and surrounded by bedrock and glaciofluvial deposits. Such features are associated with relatively poor shoreline vegetation, resulting in lower quality nesting, lower amounts of aquatic

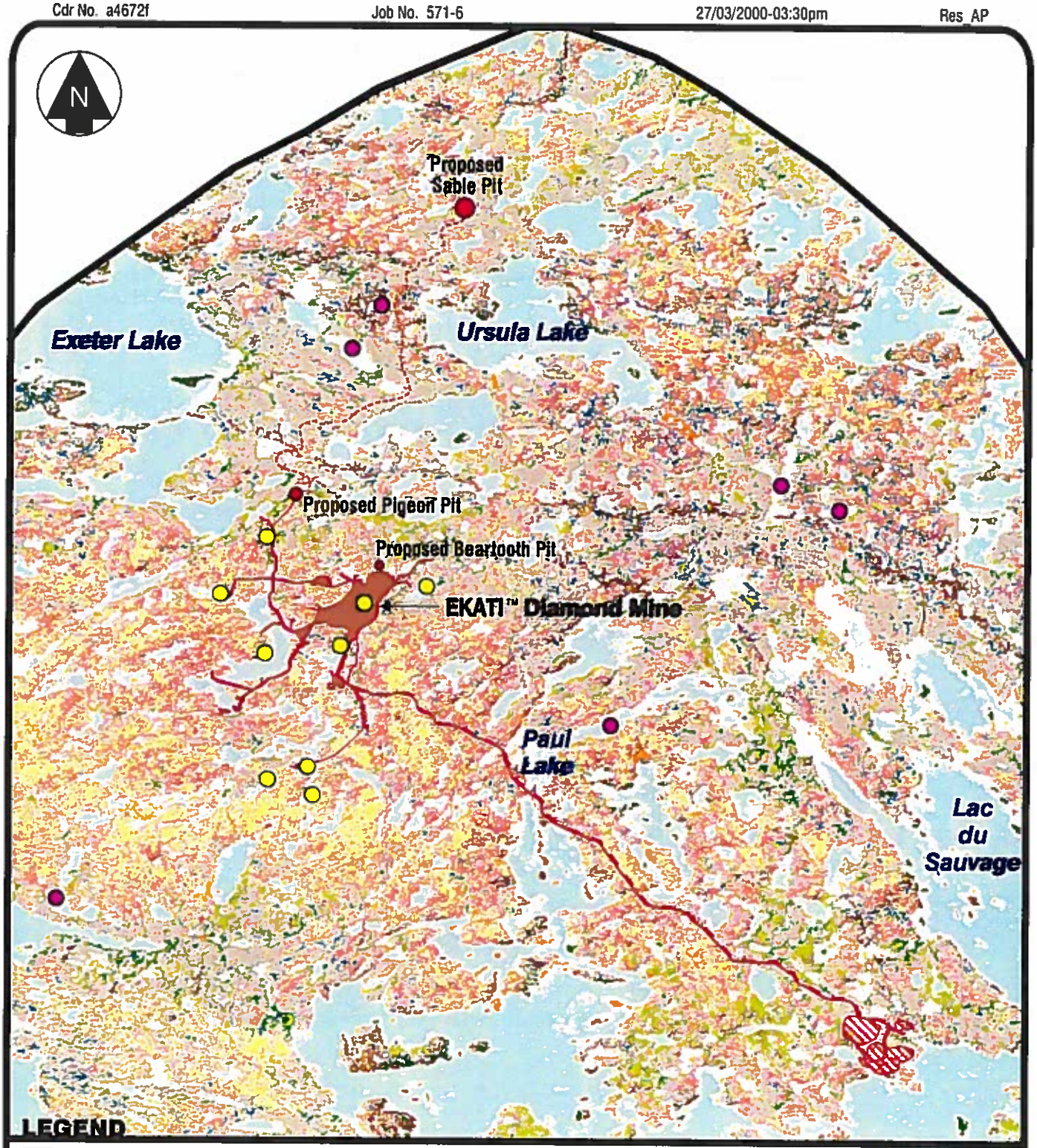


FIGURE 3.7-11

Loon Survey Locations, 1998/1999

BHP

Ekati diamond mine

Source: Golder, 1999

vegetation to provide hiding cover for loons and lower lake productivity. In contrast, many of the lakes outside the core area are comprised of lacustrine and organic deposits. These lakes have greater amounts of shallow water and shoreline and emergent vegetation, potentially containing more suitable nesting habitat for loons and higher lake productivity.

In 1999 a total of 166 loon observations were recorded representing four different species. These species, listed in order from most common to least common, include Yellow-billed, Pacific, Red-throated and Common Loon. The majority of these observations represent single sightings.

The 1999 loon surveys documented 19 territories occurring on 13 different lakes. Of the 19 territories occurring within the survey proper, 16 occurred on control lakes while three were found on experimental lakes.

Individual loons are seen on a regular basis across the experimental area. They do not represent occupied territories, but rather individuals feeding in lakes close to EKATI™ camp. Loons continue to maintain territories on a number of lakes close to the mine: Kodiak Lake, a waterbody adjacent to the airstrip; and Long Lake, a waterbody near the mine which has been altered through the construction of dykes and the addition of processed kimberlite material.

Results from long-term monitoring suggest that the distribution and number of loon territories across the experimental area are remaining stable. For the experimental and control sites, the percentage of occupied lakes vs. non-occupied remains moderately consistent. For example, the results for control sites show that for 1995, 1996, 1998 and 1999, 63.6%, 54.5%, 22.2% and 61.1%, respectively, of those lakes surveyed contained territories; (1998 values are depressed due to survey methodology). The experimental sites show that for 1995, 1996, 1998 and 1999, 15.4%, 21.4%, 15.4% and 13.3%, respectively, of those lakes surveyed contained territories.

After five years of monitoring, the data suggests that the mine, and its associated activities, does not appear to be adversely affecting the number of loons, nor the number of loon territories.

3.8 Archaeological Resources and Aboriginal Land Use

The conservation and protection of archaeological resources in the BHP claim block is recognized as an important priority in the region. As a result, archaeological investigations have been carried out in areas proposed for development in the claim block for the past six years by Points West Heritage Consulting Ltd. The Points West archaeological work has been greatly assisted by contributions from many people representing the communities of Dettah, N'dilo, Wekweti, Rae-Edzo, Wah Ti, Rae Lakes, Lutsel k'e and Kugluktuk, as well as the Prince of Wales Northern Heritage Centre, other archaeologists and BHP personnel.

A comprehensive review of the first five years of archaeological research (1994-1998) in the claim block area is provided in Bussey (1999b). The following description of the archaeological history and resources of the BHP claim block area has been extracted from Bussey (1999b), supplemented as necessary by the most recent information collected by Bussey in 1999 for the proposed new development area.

In addition, a brief description of available traditional land use information for the claim block area is provided in Section 3.8.8.

3.8.1 Ethnographic Background

The ethnographic records indicate that the barrenlands of the central Arctic were utilized seasonally by Aboriginal groups for a variety of purposes associated with hunting and trapping. Caribou was the most important game animal, but muskoxen and hare were also hunted for food. Fish was the mainstay when game was not available. Wolves, foxes and wolverine were hunted for their fur. The hunting of muskox for their robes and white fox for pelts for trade were important in the late 19th and early 20th centuries. Although muskoxen are not common in the Lac de Gras area today, their numbers were higher in the past. While hare were not a major food resource, they were utilized when necessary along with many other animals and birds. Caribou were the very major food source and their hides were important for clothing and shelter.

Several groups have traditionally used the Lac de Gras vicinity. They include the Copper Inuit, the Yellowknives, the Dogrib Dene and the Chipewyan. The major ethnographic sources are provided in the references. For the Inuit these are Birket-Smith (1959), Boas (1964), Jenness (1922), Mathiessen (1927), Rasmussen (1932) and Stefansson (1914), with a more recent summary by Damas (1984). References for the Yellowknives, Dogrib and Chipewyan are Birket-Smith (1930), Mason (1946) and Vanstone (1965), with more recent summaries by Gillespie (1981), Helm (1981) and Smith (1981). Fur trade records are housed in the collections of the Hudson's Bay Company.

The Copper Inuit occupy the Arctic coast north of Lac de Gras. Their traditional range is generally considered to be from Wise Point to Perry River, north to the southern shore of Banks Island, including most of Victoria Island, and south almost to Back River and Contwoyto Lake (Damas, 1984). According to Riewe (1992) Inuit activity has extended

to the Lac de Gras area. Medium-intensity activity is identified for the Yamba Lake and Achilles-Exeter Lake areas. High-intensity use is identified for an area north of Lac de Gras heading northeast to Contwoyto. Riewe (1992) indicated that the Yamba Lake area is part of an occasionally used travel route that links the Great Slave and Contwoyto lakes areas, but with improved air travel has not been used as much in recent years.

The Exeter Lake area has been used occasionally for trapping Arctic fox in winter or for hunting barren-ground caribou. The activities conducted in this area are subsidiary to those in the vicinity of Contwoyto Lake (Riewe, 1992). Riewe also notes that the Coppermine Inuit based at Contwoyto or Pellatt lakes hunt or trap in the Lac de Gras area. The intended game consists of barren ground caribou, wolf, wolverine and Arctic fox. A number of recent camps have been identified within or near the BHP study area, including those near Point de Misere and Paul Lake, southwest of Exeter Lake and on Lac de Gras, Exeter, Yamba and Ursula lakes. An archaeological site was also identified on the Coppermine River downstream from Lac de Gras (Riewe, 1992).

Traditional Copper Inuit subsistence was based on seasonal movements to harvest specific resources. From December to May, coastal groups aggregated into winter snowhouse villages on the ice. In May, they dispersed to hunt and fish on the land. Beginning about August and continuing through to November, caribou hunting was of prime importance. At this time of year, the animals were in good condition and their hides were best. The majority of the material culture was composed of bone and antler implements, but some arrows and fish hooks were made of copper or iron. Wood and soapstone were also utilized. Such specimens are found in archaeological context, although stone features tend to be more visible. Stones were used to hold down the hides used as shelter coverings, and the distinctive "rings of stone" or tent rings (considered a stone feature) are archaeologically evident. Drying skins were often held in place by smaller rings of stone - another type of stone feature. Large and small arrangements of rock were constructed to assist in hunting (blinds, caribou drives, traps), as signals or markers (including gravel markers) and for storage (caches). These represent stone features that can be readily identified.

The major use of the barrenlands by the Chipewyan, Dogrib and Yellowknives was for subsistence - hunting, trapping and fishing, with emphasis on hunting and trapping. Gathering was not a major economic activity, but berries would be harvested as they became available. The major game was caribou. Helm (1981) indicated that the majority of the Dogrib were located in the western part of their territory (between Great Slave and Great Bear lakes), but they ranged as far as Point Lake and Contwoyto Lake for caribou hunting. In preparation for the caribou hunt, Dogrib groups would often converge on Wekweti (Snare Lake), now a centrally located Dogrib community. Gillespie (1981) indicated that the Yellowknives were located in the forests and barrenlands adjacent to the eastern end of Great Slave Lake, while Smith (1981) defined Chipewyan territory generally as east and south of Great Slave Lake. The subsistence strategy and use of the barrenlands of all three groups are similar.

Bow and arrow, spears, deadfalls, snares and clubs were used to hunt a variety of animals. Travel during the snow-free months was by canoe; canoes were constructed of birch bark obtained south of the treeline. The canoe and all the supplies it carried had to

be transported overland at the portages along canoe routes. Snowshoes, sleds and dogs facilitated travel in winter. Throughout the year, camps had to shift in response to the availability of the subsistence resources. Easily transported shelters were required, and lengths of wood would often be packed into the barrenlands by the Dene for heating water and cooking food. Typically, several families would travel together to the barrens. Women and children would often stay at the treeline to fish and gather while the hunters proceeded into the barrenlands (Birket-Smith, 1930; Gillespie, 1981; Helm, 1981; Mason, 1946; Smith, 1981).

Mason (1946) refers to the Dogrib as "edge of woods" people and indicated that they often hunted caribou in the barrenlands during the summer. Winter was a preferred time for hunting muskoxen on the barrenlands because the hides were prime. Parties of men and dogs would travel into the barrenlands for these hunts.

Mason (1946) suggests that Yellowknife traditions relate to the Coppermine River. He uses as examples the manufacture of items from pounded native copper and the history of considering the Inuit as the enemy. The Yellowknives also travelled into the barrenlands to hunt caribou and muskoxen. Mason indicates that they would surround muskoxen and set snares or drive them into the water and shoot them. Bears were hunted using the bow and arrow, rifles, snares or log-falls. He describes the barrenland tipi as consisting of a dozen poles, shorter and smaller than those used on the plains. The covering was made of as many as 40 caribou skins. Brush and snow would be used for extra insulation in winter, and the hearth was centrally situated (Mason, 1946).

Helm (1981) briefly summarized the post-contact Dogrib annual cycle starting with their arrival at posts in late June or early July, when the objective was to trade the furs trapped in early spring. The Dogrib would camp at Fish Lake during the summer to catch and dry fish. The men would return to the barrenlands in late July and early August to hunt when the caribou were returning south. Fishing would continue though September and October with a brief hiatus for ice to form on the lakes. November and December were identified as the best times to hunt and trap for furs. It is noted that caribou are present in the woods in relatively large herds at this time. Subsistence in January and February generally depended on stored foods. March saw a return to caribou hunting before the animals returned to the barrens. Trapping and fishing was also important during this period. The winter furs were then taken to posts in April or May, and the rest of the spring was spent hunting, trapping and fishing (Helm, 1981). The annual rounds for Yellowknives and Chipewyan were similar.

A number of Dogrib and Yellowknife individuals have worked with the archaeological crews at EKATI™. In addition, a number of elders, including Inuit and Dogrib elders, have visited the BHP property and examined various archaeological sites. Several factors of importance that have been shared with the archaeologists:

- Eskers are important for burials because the soil is loose enough that it is possible to excavate a grave.
- The leeward side of an esker is a good location for a camp during cold, wet weather.

- The tops of eskers are important for viewing game and avoiding the bugs.
- Eskers are important because animals travel, forage and den on them.
- A camp would not be placed too close to an esker if trapping fox because doing so would scare the game.
- Islands are a good place for camps because it is harder for bears to get to them.
- The narrows of Lac de Gras is important for caribou hunting. (Note that ethnographic and historic accounts indicate that locations suitable for caribou to cross a large lake or river during their migrations are important places that are revisited; archaeological research has confirmed this.)
- March is a good time for fox trapping and fall is good for caribou hunting.

Traditional camps have been identified by elders and land users on the north shore of Lac de Gras and at the northwest end of a medium-sized lake between Lac de Gras and Yamba Lake. That traditional knowledge contributes substantially to an archaeological study is evidenced by work such as that conducted by Andrews and Zoe (1997). Ongoing traditional research is expected to contribute further to the archaeological database for the BHP study area. A brief description of traditional land use of the claim block in the 20th century is provided in Section 3.8.7.

3.8.2 Summary of Cultural History

R.S. MacNeish initiated archaeological research in the western part of the Northwest Territories with surveys in the Upper Mackenzie drainage-Great Slave Lake area (1951, 1953). Based on this work, MacNeish formed a tentative cultural sequence, which has since been modified. Noble (1971) conducted a reconnaissance program in the Great Slave Lake area and adjacent vicinities, the results of which provided for the elaboration of the regional cultural sequence and the identification of the Taltheilei tradition. Cinq-Mars (1973) and Clark (1975) investigated the western Great Bear Lake area and portions of the Mackenzie River. McGhee (1970) excavated a series of sites in the Coppermine River area. Cinq-Mars and Martijn (1981) provide a summary of these early investigations. Even more archaeological investigation was undertaken in the Mackenzie River area as a result of the NOGAP (Northern Gas and Oil Action Plan). For an overview of this detailed and varied work, refer to Cinq-Mars and Pilon (1991) and Pilon (1994). Early archaeological investigations conducted in the Arctic north of Lac de Gras include work by McGhee (1970, 1972, 1978), Taylor (1967, 1972) and Morrison (1978). Although sites on the coast and those located inland have differences, some similarities are evident, at least with regard to selected samples, including the above and Damkjar (1994), Bussey (1995b), Prager and Bussey (1997) and Prager (1998). These later studies, and others undertaken in the vicinity of the BHP property in recent years, were development-driven impact assessments, a new direction in archaeological investigations in this region.

Because little work has been conducted in the central barrenlands where the BHP claim block is situated, it has been necessary to review data from investigations undertaken to the west (Mackenzie Valley), east (Keewatin District) and north (Arctic) in order to summarize the background archaeological information. Until more work is undertaken, it must be assumed that environmental conditions and general archaeological traditions represented in adjacent areas likely occurred in the central interior as well. Only those that might be applicable at present are reviewed herein, although other cultural traditions may be identified in surrounding regions in the future.

Archaeological investigations suggest that occupation of the Northwest Territories extends to approximately 8000 years B.P. (before present). The earliest cultural period is typified by lanceolate (long, narrow or "lance-shaped") spear-points of stone. This is commonly referred to as the Northern Plano tradition and is believed to have spread into the area from the south. It is postulated that populations moved north as the climate improved after deglaciation. In Noble's (1971) early summary, he noted that sites associated with this tradition were commonly found on sand eskers and in blowouts, and that quartzite was commonly used for stone tools. There are few Plano sites identified in the Northwest Territories, but the better known sites include those near Grant Lake (Wright, 1976), on the Thelon River (Harp, 1961) and at Acasta Lake (Noble, 1971). Stewart (1991) has suggested that the low frequency of Plano sites could be the result of smaller populations, different hunting emphases and patterns (caribou may not have had the same economic significance) and/or that such sites have not been identified because they share attributes with more recent cultural periods.

The period between approximately 6500 and 3500 B.P. is relatively poorly represented in the archaeological record. It has been referred to by a variety of names, including the Shield Archaic. Wright (1972, 1981) has suggested that the Shield Archaic developed from local Paleo-Indian complexes present in the region; others, such as Gordon (1996) support this contention. This tradition is believed to be associated with a warming trend that may have prompted changes in animal and subsistence behaviour (expansion of forests north). Characteristic stone tools include corner-notched projectile points, wedges and a variety of knives and scrapers. The known site distribution is broader than evidenced in the Northern Plano tradition (Gordon, 1996).

Around 3500 B.P., a cooler climatic period (associated with a retreat of the treeline) is postulated. At this time the Pre-Dorset or Arctic Small Tool tradition appears (also referred to in the interior Northwest Territories as the Canadian Tundra tradition - Wright, 1981). This archaeological tradition, unlike the two earlier ones, is identified as a Paleo-eskimo people that moved in from the north in response to changing climatic conditions. It is postulated to represent a distinctive caribou-adapted lifestyle. The stone tools associated with this tradition are noticeably smaller, thinner and better fashioned. Fine-grained chert appears to be the preferred material for a number of tool types. Point characteristics include concave bases, triangular outlines and side-notches. Other tool types include wedges, scrapers, burins and knives (Clark, 1975; Gordon, 1975, 1996; McGhee, 1970; Noble, 1971; Wright, 1981). In Noble's (1971) early summary, he noted that sites associated with this tradition were located on sand exposures, in protected bays, on sheltered points, on eskers and on islands. Variations of this tradition have been found throughout much of the subarctic during this period (Gordon, 1996).

Around 2500 to 2600 B.P. the Arctic Small Tool tradition is replaced by the Taltheilei tradition associated with the Athapaskan occupation of the Northwest Territories. Tools are commonly made of a grey siliceous shale or quartzite; specimens of chert, basalt, red slate and other materials have also been recovered. The use of native copper has been associated with this period. The Taltheilei tradition is typified by a variety of point styles, including lanceolate and side- and corner-notched specimens. It is associated with barrenlands and forest environments and, as with the Arctic Small Tool tradition, involves heavy dependence on caribou hunting (Clark, 1977; Gordon, 1975, 1996; Noble, 1971; Wright, 1981).

3.8.3 Archaeological Investigations in the BHP Claim Block

Archaeological investigations in the vicinity of the BHP claim block, prior to those initiated by Points West in 1994, have been limited in scope. MacNeish (1951) recorded a single site near the outlet of Lac de Gras while conducting reconnaissance of selected areas in the Northwest Territories. In the late 1970s, Frank Metcalf recorded numerous sites on the Coppermine River (downstream from the Lac de Gras outlet), including four that are within the BHP claim block (Metcalf and Kobelka, 1978). The growth of diamond exploration in this vicinity has recently prompted a number of detailed archaeological assessments, including those conducted in the BHP claim block by Points West.

The archaeological surveys conducted by Points West on the claim block have focused on areas that are or were potentially affected by development. In 1994, field reconnaissance concentrated on five prospective kimberlite mining areas and their associated infrastructure sites. All were within a few kilometres of EKATI™. A proposed road route to Misery Lake was also examined. This road involved use of the large Lac du Sauvage Esker (Figure 3.8-1) and was abandoned for environmental and archaeological reasons. The 1994 investigations also included work on the Exeter Esker where an exploration camp was situated. The abandonment of the Lac du Sauvage Esker road route and the selection of an alternate route necessitated additional surveys southeast of EKATI™ to Misery Lake via the Paul Lake Narrows. This archaeological survey was undertaken in 1995.

In 1996, the study area was expanded to include locations to the north (portions of the Ursula West Esker and an unnamed esker north of Ursula Lake) and east (portions of the Duchess East and West eskers and Caribou Esker), as well as several sites near the EKATI™ camp. The area of investigation expanded further in 1997 to include localities well to the northwest toward Yamba Lake and an esker southwest of Exeter Lake. In 1998, investigations were conducted in the vicinity of several previously examined survey areas. The 1999 archaeological survey concentrated on areas potentially associated with the Sable, Pigeon and Beartooth developments and exploration localities elsewhere on the claim block.

DATUM : NAD 83.

480,000m E
500,000m E
520,000m E
540,000m E
7,200,000m N
7,180,000m N
7,160,00m N

YAMBA LAKE
EXETER LAKE
Whale
Falcon
Horseshoe
Otu
Mink
Reynolds
Vulture
Upper Panda
Grizzly
Koala
Kodiak
White
Long
Leslie
Nema
Fox
Nora
Slipper
Paul
Cavis
Misery
LAC DE GRAS
LAC DU SAUVAGE
DUCHESS EAST
MINERAL CLAIM BOUNDARY

FUTURE SABLE PIT
FUTURE PIGEON PIT
FUTURE BEARTOOTH PIT
PANDA PIT
EKATI™ MINE CAMP
OLD CAMP
CENTRAL SOUTH
EXETER
URSULA
URSULA WEST
URSULA EAST
VULTURE
DUCHESS WEST
CARIBOU
LAC DU SAUVAGE

LfNw-1, LfNw-2, LfNw-3
LfNv-1, LfNv-2, LfNv-3, LfNv-4, LfNv-5, LfNv-6, LfNv-7, LfNv-8, LfNv-9, LfNv-10, LfNv-11, LfNv-12
LfNt-1, LfNt-2, LfNt-3, LfNt-4
LeNv-1
LeNu-1, LeNu-2, LeNu-3, LeNu-4, LeNu-5, LeNu-6, LeNu-7, LeNu-8, LeNu-9, LeNu-10, LeNu-11, LeNu-12, LeNu-13, LeNu-14, LeNu-15, LeNu-16, LeNu-17, LeNu-18, LeNu-19, LeNu-20, LeNu-21, LeNu-22, LeNu-23, LeNu-24, LeNu-25, LeNu-26, LeNu-27
LeNt-1, LeNt-2, LeNt-3, LeNt-4, LeNt-5, LeNt-6, LeNt-7, LeNt-8, LeNt-9, LeNt-10, LeNt-11, LeNt-12, LeNt-13, LeNt-14, LeNt-15, LeNt-16, LeNt-17, LeNt-18, LeNt-19, LeNt-20, LeNt-21, LeNt-22, LeNt-23, LeNt-24, LeNt-25, LeNt-26, LeNt-27, LeNt-28
LeNa-1, LeNa-2, LeNa-3, LeNa-4, LeNa-5, LeNa-6, LeNa-7, LeNa-8, LeNa-9, LeNa-10, LeNa-11, LeNa-12, LeNa-13, LeNa-14, LeNa-15, LeNa-16, LeNa-17, LeNa-18, LeNa-19, LeNa-20, LeNa-21, LeNa-22, LeNa-23, LeNa-24, LeNa-25, LeNa-26, LeNa-27, LeNa-28, LeNa-29, LeNa-30
TK-1, TK-2, TK-3, TK-4
LdNv-1, LdNv-2, LdNv-3, LdNv-4, LdNv-5, LdNv-6, LdNv-10, LdNv-11, LdNv-12, LdNv-13
LdNt-1, LdNt-2, LdNt-3, LdNt-4, LdNt-5, LdNt-6, LdNt-7, LdNt-8, LdNt-9, LdNt-10, LdNt-11, LdNt-18, LdNt-37, LdNt-38
LdNa-1, LdNa-2, LdNa-3, LdNa-4, LdNa-5, LdNa-6, LdNa-7, LdNa-8, LdNa-9, LdNa-10, LdNa-11, LdNa-12, LdNa-13, LdNa-14, LdNa-15, LdNa-16, LdNa-17, LdNa-18, LdNa-19, LdNa-20, LdNa-21, LdNa-22, LdNa-23, LdNa-24, LdNa-25, LdNa-26, LdNa-27, LdNa-28, LdNa-29

LEGEND :
- ESKER
- TRADITIONAL SITE
- RECORDED ARCHAEOLOGICAL SITE

0 5 10 15 km
Scale 1 : 200 000

Figure 3.8-1
Distribution of Archaeological and Traditional Sites

BHP
Ekati diamond mine

Since the beginning of the archaeological investigations in 1994 Points West has recorded a total of 144 archaeological sites in the BHP study area. All of these sites are identified in Figure 3.8-1. Eighteen new sites were discovered in 1999 and a number of sites that were previously recorded by other researchers were revisited. It has been determined that these six sites are within the boundaries of the BHP study area, bringing the total number of recorded archaeological sites in the claim block to 150. Four traditional sites have also been identified (Figure 3.8-1).

Two of the 150 recorded archaeological sites likely represent ethnographic or traditional use. One site near Ursula Lake (LeNt-13) contained a chunk of firewood in addition to a sparse prehistoric component, and one site (LeNs-3) east of Paul Lake contained an almost complete birch bark basket. The four identified traditional sites contained cut wood, evidence of wood cutting, rocks forming a marker, or rifle cartridges and broken rock from a small fire. One of the archaeological sites (LdNs-8) consists of four rings of stone or "tent rings;" one previously recorded site (LdNv-2) has two such rings in addition to stone artifacts. The remaining 146 archaeological sites consist of lithic scatters – archaeological sites containing stone tools and/or pieces of stone (called flakes or debitage) removed in the process of manufacturing stone tools. The following discussion emphasizes the archaeological sites found in the vicinity of the proposed BHP expansion program. Further information on other recorded sites in the BHP study area is provided in Bussey (1999b) and the annual archaeological investigations reports (Bussey, 1994, 1995a, 1997a, 1998, 1999a).

The identification of the proposed expansion area north of EKATI™ prompted more intensive archaeological investigation at some localities in 1999. An earlier assessment of the Sable Lake area, including the road route south to EKATI™, had been carried out in 1996. In 1997 ground reconnaissance was undertaken in the vicinity of Beartooth Lake, and in 1998 inventory work was conducted near Pigeon as well as some site testing near Beartooth Lake. In 1999 a combination of aerial reconnaissance, ground reconnaissance and systematic data recovery work was done to ensure areas with archaeological potential within the sphere of influence of these potential mines had been assessed.

The objectives and methodologies employed for the archaeological investigations have been relatively constant throughout the six years of field work. Aerial reconnaissance is undertaken in advance of any proposed exploration activities. If there are landforms with sufficient archaeological potential near an exploration area, detailed ground reconnaissance is undertaken. If more extensive development is later proposed in the same area, a wider radius is examined through aerial reconnaissance and ground truthing. Although the emphasis in ground reconnaissance is landforms with moderate or greater archaeological potential, it should be acknowledged that areas with lower potential are often traversed. Once archaeological sites are located, they are photographed, described and plotted on 1:50,000 scale maps. In addition, since 1997 BHP has ensured that survey-grade GPS coordinates are obtained for each archaeological site to assist in protecting the resources, especially in the winter when they may be covered by snow and would be difficult to locate.

Once the archaeological sites within a specific development area have been identified, the feasibility of protecting and avoiding the resources is assessed. If avoidance does not

appear to be a viable option, mitigation measures are proposed to the Prince of Wales Northern Heritage Centre. To date, mitigation has consisted of excavation and/or systematic surface collection; combined, they are referred to as systematic data recovery.

In response to the proposed Sable, Pigeon and Beartooth pit developments, additional archaeological inventory was undertaken in 1999 to identify possible sites in the vicinity of each mine. In addition, it was necessary to test a number of sites near the Sable road; two of the latter sites were later subjected to systematic surface collection. Testing involves the excavation of shovel test. Systematic surface collection involves collecting all visible artifacts and recording the location of each in relation to a baseline or grid system. All field work was directed by Jean Bussey of Points West Heritage Consulting Ltd. For a more detailed discussion of methodology, refer to Section 4.1.

3.8.4 Archaeological Investigations for the Sable Pit

In 1996, the immediate vicinity of Sable Lake and a significant portion of the road route south to EKATI™ was traversed on foot. In the process, two discontinuous east-west eskers were crossed. Parts of these eskers lying beyond the road route were also examined and a number of archaeological sites were discovered; no sites were found within the proposed road route or near the mine. The parts of the road not traversed on foot were examined during two separate helicopter overflights to confirm that archaeological potential was low.

The Exeter Esker extends east to the Vulture Esker. It will be crossed by the proposed Sable Road in an area with sparse natural esker deposits. Three archaeological sites were found west of the road route in 1996 (Figure 3.8-2). LeNu-13 and LeNu-14 are lithic scatters that are well removed from the proposed road; they are on well-defined esker deposits overlooking a small lake. These sites are not threatened by development associated with the Sable mine and are easily avoided. At the east end of this lake is a slightly elevated landform containing a number of quartz chunks that were originally identified as a possible cache of raw material for stone tools. In 1998, a number of shovel tests were excavated at LeNt-14. It was determined that the quartz raw material was a result of natural boulder deterioration and did not represent stored or cached material. This location is no longer considered an archaeological site and no further investigation is recommended.

In response to the proposed Pigeon mine, additional archaeological investigation was undertaken in the vicinity of the above sites and included foot reconnaissance on the Exeter Esker east of the proposed Sable Road. Although two of the newly discovered sites appear to be close to the Sable Road, LeNt-24 and LeNt-28 are actually separated from it by an elevated rocky ridge. They are sufficiently distant that they should not be affected. The results of these 1999 Pigeon area investigations are discussed subsequently.

The Ursula West Esker is also in the path of the proposed Sable Road. The road will cross a natural break in the esker. Archaeological reconnaissance resulted in the discovery of three archaeological sites in 1996 (Figure 3.8-2). Two are located well east of the proposed

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Cad No. C1098 Sht. 2 View C1 Job No. 571-6 BHP 1999 EA Report 04/20/2000- 8:55am EKATI_BP

N

0 1 2 3 km

Scale 1 : 50 000

DATUM : NAD 83.

LEGEND :

LeNt-21 ● 1999 SITE

LdNs-16 ▲ PREVIOUSLY RECORDED SITE

ESKER

EXISTING ROAD

PROPOSED ROADS

515 000m E

520 000m E

7 195 000m N

7 190 000m N

7 185 000m N

7 180 000m N

North Sable Dump

2 Rock

South Sable Dump

FUTURE SABLE PIT

LeNu-15 LeNu-16 LeNu-17 LeNu-18 LeNu-19 LfNu-1

URSULA WEST ESKER

LeNt-12 LeNt-13 LeNt-23 LeNt-11 LeNt-10 LeNt-22 LeNt-21

EXETER LAKE

URSULA LAKE

LeNu-10 LeNu-11 LeNu-20 LeNu-21 LeNu-22 LeNu-23 LeNu-24 LeNu-25 LeNu-26 LeNu-27 LeNu-14 LeNu-13

EXETER ESKER

LeNt-14 LeNt-24 LeNt-28 LeNt-26 LeNt-18 LeNt-19 LeNt-25 LeNt-27

FALCON LAKE

VULTURE ESKER

LeNt-4 LeNt-6 LeNt-5 LeNt-7 LeNt-8

FUTURE PIGEON PIT

Pigeon

Pigeon Waste Dump

FUTURE ROAD

Nancy

Little Reynolds P.

LeNt-17

Vulture

Bearclaw

Beartooth

FUTURE BEARTOOTH PIT

Polar

Upper Panda

Pander/Beartooth Waste Dump

PANDA PIT

Koala Waste Dump

Grizzly

LeNt-15

Archaeological Sites Associated with the Exeter and Ursula West Eskers and BHP Proposed Development

Figure 3.8-2

BHP

Ekati diamond mine

road route (LeNt-10 and LeNt-11) and one is to the west (LeNt-13). In 1999, additional archaeological inventory was undertaken in response to the potential need for a gravel source near the north end of the Sable Road. Because the best source would be one of the well-defined sections of the esker near Ursula Lake, additional areas were examined on the east and west sides of the proposed road. Archaeological survey was undertaken to the west, resulted in the discovery of one new site (LeNt-23) (Figure 3.8-2). Subsequently, a better gravel source was identified on an esker point extending into Ursula Lake; archaeological inventory was therefore undertaken to the east as well. Two new sites (LeNt-21 and LeNt-22) were discovered (Figure 3.8-2). The four sites nearest to the most suitable gravel sources were subsequently tested to assess the level of mitigation that would be required in the event that avoidance of the archaeological sites was not feasible. LeNt-23, LeNt-10 (LeNt-10W) and LeNt-22 were subsequently tested and/or systematically surface collected after it was determined that drilling the gravel deposits could affect these archaeological resources.

LeNt-10 consists of two localities adjacent to Ursula Lake. In the western locality (LeNt 10W) the esker is approximately 8 m higher than the lake and is characterized by exposed or deflated rock and gravel and a relatively light scatter of unworked quartz flakes. Subsurface tests excavated in 1999 indicated that no buried cultural materials are associated with this locality – all artifacts are exposed on the surface. In late July, systematic surface collection was undertaken at LeNt-10W to salvage all surface specimens in advance of geotechnical testing. The Prince of Wales Northern Heritage Centre was consulted before the systematic data recovery was initiated. This work was approved under the 1999 Northwest Territories Archaeologists permit held by Jean Bussey of Points West Heritage Consulting Ltd. Approximately 170 flakes were collected; each artifact has coordinates that relate to an east-west site baseline that has been mapped by Sub-Arctic Surveys Ltd. The artifacts will be analyzed as part of the 1999 permit report. Once analysis is completed, the artifacts will be submitted to the Prince of Wales Northern Heritage Centre.

The eastern locality at LeNt-10 (LeNt-10E) is on a low, sandy point of land that extends into Ursula Lake. The site is at the western end of this landform in a partially vegetated area. The northern half of the site contains a number of relatively dense concentrations of unworked quartz flakes and also yielded two worked specimens, one shale and one quartz. Subsurface tests excavated in 1999 indicated that portions of this site contain high quantity of quartz artifacts beneath the surface; two of the eight shovel tests yielded cultural material. Only the archaeological material encountered during the subsurface testing was collected; all other specimens were left *in situ* (in place). BHP was informed that this site was a significant archaeological resource and that more extensive mitigation would be required if the site can not be avoided. Because this locality is separate from the western locality at LeNt-10, avoidance and protection is feasible even if the remainder of the esker is utilized as a gravel borrow.

LeNt-11 is located on a low esker remnant adjacent to an arm of Ursula Lake. It consists of a light scatter of quartz flakes in an area with sandy exposures and dense vegetal cover. Six subsurface tests were excavated at LeNt-11. None contained buried artifacts

and all surface specimens were left *in situ*. No geotechnical or other testing was proposed for this location since the deposits are insufficient for use as a gravel borrow.

LeNt-13 is located west of the road route, near the south end of a broad dispersed section of the Ursula West Esker. Two unworked flakes of quartz were discovered near one edge, and a piece of cut firewood (possible traditional artifact) was located near the height of land. The subsurface is exposed as a result of wind action and caribou, consequently there is limited potential for buried cultural material. No testing was undertaken in 1999 because this site is well removed from the proposed activity associated with the Sable Road and gravel sources.

LeNt-21 is a small site near the north edge of the Ursula West Esker east of the proposed Sable road. The site overlooks a seasonal creek that drains an interior pond. A retouched flake and a small number of unworked quartz flakes were noted on the surface. The artifacts are located on exposed eroding sand and gravel deposits. Dense vegetal cover is evident to the south and east. Six subsurface tests were excavated in this vicinity. No cultural material was encountered during testing, but it is possible that there are scattered, buried artifacts associated with the adjacent vegetated areas.

LeNt-22 is located across a bay from the eastern locality of LeNt-10, on a section of the Ursula West Esker that has been isolated by Ursula Lake (Figure 3.8-2). The cultural material was relatively sparse and was scattered over an exposed, sandy hill. Seven subsurface tests were excavated; no cultural material was recovered. The sand and gravel deposits were relatively thick in this portion of the esker. BHP has identified it as a suitable location for test drilling to determine if deposits were sufficient for road construction. Since geotechnical testing was to proceed, it was necessary to systematically collect the surface artifacts at LeNt-22. Approximately 23 flakes were recovered and the location of each was identified in relation to an east-west baseline mapped by Sub-Arctic Surveys. Once the analysis has been completed, the artifacts will be submitted to the Prince of Wales Northern Heritage Centre.

LeNt-23 is located on the edge of a series of landforms associated with the Ursula West Esker. It is west of the proposed Sable Road on a broad rocky stretch of esker overlooking the east end of a small lake. The site is lightly vegetated and consists of one cluster of three unworked quartz flakes. Three tests were excavated in the vicinity; one unworked quartz flake was recovered. The surface artifacts were left *in situ*. No further work was required at LeNt-23 because the surface deposits were too insubstantial for borrow use.

3.8.5 Archaeological Investigations for the Pigeon Pit

In 1998, exploration in the vicinity of Pigeon Pond prompted archaeological investigations in the area. Although no terrain in the immediate vicinity had good archaeological potential, it was decided to examine a number of low and moderately sensitive areas. The road to Pigeon Pond was constructed prior to being examined by Jean Bussey, Points West, but BHP conducted a ground survey of the route and identified

low archaeological potential. Points West confirmed this assessment by means of a helicopter overflight, no ground reconnaissance of the road was undertaken in 1999.

Initial field reconnaissance conducted in 1998 involved a number of small, scattered and slightly elevated landforms north of Pigeon Pond and the shore of the Fay Lake into which Pigeon Pond flows. This lake drains into a large lake referred to locally as Upper Exeter Lake. No archaeological sites were discovered in these areas. Additional work was then undertaken on limited areas of the Exeter Esker near Pigeon Pond to determine if use of the eskers extended eastward. Two new archaeological sites were found. A ground traverse was conducted for a distance of about 1 km along the southern edge of the Exeter Esker in the vicinity of LeNt-19 (Figure 3.8-2) as well as a slightly smaller part of the esker in the vicinity of LeNt-18. LeNt-18 is a large site on the west end of Falcon Lake that contains substantial cultural materials, which include a number of different lithic materials and some tools. There is potential for additional buried artifacts at this site. LeNt-19 is also a large site, but the cultural material is considerably sparser. No tools were noted and the lithic material is limited to quartz. Some vegetated areas are evident at LeNt-19 and buried cultural material could be present. Site assessment would be required to confirm the archaeological potential, but testing is generally conducted only at sites that are threatened.

In 1999, the possibility of a developing mine at Pigeon Pond prompted some additional ground reconnaissance. All parts of the Exeter Esker north of Pigeon Pond, east of the Sable Road and west of Falcon Lake that had not been examined previously were traversed on foot. Five new sites were discovered: LeNt-24, LeNt-25, LeNt-26, LeNt-27 and LeNt-28 (Figure 3.8-2). LeNt-24 is a small site on the edge of a poorly defined section of esker. It is north of a small lake and overlooks the east end. The exposed deposits are gravel, and approximately 10 unworked flakes were visible on the surface. There is some potential for buried cultural material since there is vegetal cover. Below, on a sloping and exposed sandy landform, is a larger site. LeNt-28 overlooks two ponds and contains a slightly greater variety of lithic material. Approximately 25 specimens were scattered across the site area. Although extensive portions of this sloping landform are eroding and exposed, there is some patchy vegetal cover and thus some potential for buried archaeological material. LeNt-25 is located to the southeast of LeNt-24 and LeNt-28 and east of LeNt-19, found in 1998. LeNt-25 is a large and generally sparse archaeological site on an elevated, well-defined section of esker consisting primarily of sand. Cultural material is slightly more frequent at the western end, but is lightly scattered across a large area. Most of the site area is exposed and deflated, but some areas are vegetated and could contain buried archaeological material. Both white and grey quartz are present and one worked artifact was noted; an estimated 35 to 50 specimens were observed on the surface at LeNt-25.

LeNt-26 is short distance north of LeNt-18, on a low, broad esker remnant along the shore of Falcon Lake. Around 20 to 25 flakes were encountered along the edge of vegetation near the northwest corner of LeNt-26; a few flakes were scattered elsewhere within the site. Most of this site is exposed and deflated, but there is vegetal cover around the boundaries indicating potential for additional archaeological material. The final site found in this area during 1999 was LeNt-27. It is located at the south end of a section of esker. LeNt-27 is another relatively large site characterized by a sparse scatter

of cultural material; however, a concentration of flakes is evident along the western edge of this elevated landform. The flakes are white quartz, with between 50 and 100 visible on the exposed surface. There is patchy vegetal cover on a portion of this site and thus some potential for buried archaeological material.

Additional inventory was conducted on the Exeter Esker in 1999, partially as a result of the proposed activity associated with the Pigeon Pit and partly to complete the inventory of this section of this landform. The full length of the Exeter Esker between Exeter and Falcon lakes has now been examined in detail. A total of 17 archaeological sites are located on this section of esker. All are sufficiently distant from the proposed Pigeon Pit that avoidance is feasible. Avoidance during construction of the Sable Road is also feasible. There is high potential for additional archaeological sites to the east, but that part of the Exeter Esker is well removed from any proposed development activity. Twelve sites have been recorded on the section of this esker south of Exeter Lake, and they are also well removed from the proposed development.

3.8.6 Archaeological Investigations for the Beartooth Pit

In response to the identification of exploration activity in the vicinity of Beartooth Lake, archaeological investigations were undertaken in 1997. The initial investigations involved a helicopter overflight of a broad area north of Panda Pit and ground reconnaissance at two locations. These localities were near the south end of Beartooth Lake on esker-like remnants along the west side of the valley. Boulders and exposed areas of bedrock at this northern locality were also examined. One new archaeological site, LeNt-17, was discovered. In 1997 LeNt-17 was noted to consist of four unworked flakes on the end of one of a series of small, scattered esker remnants. The subsurface deposits consisted of gravel, rock and sand with limited vegetal cover. Two of the flakes were grey quartz and two were white quartz; all specimens were left *in situ* in 1997.

As a result of the increased activity in the vicinity, some additional ground reconnaissance was conducted on the east side of the valley north of Beartooth Lake in 1998; no new archaeological sites were found. In addition, three shovel tests were excavated at LeNt-17. The tests were very shallow because the rock and gravel were highly consolidated, and no cultural material was recovered. Thorough examination of the surface yielded one additional flake; this flake and the four noted in 1997 were collected and submitted to the Prince of Wales Northern Heritage Centre.

In 1999, additional archaeological work was done near Beartooth. Emphasis was placed on two localities. The first area was around Beartooth Lake. All landforms near the lake were traversed on foot, and an extensive area to the west characterized by bedrock outcrops and boulders was examined in detail. No new archaeological resources were encountered. The second locality was an extension of the esker-like landform north of LeNt-17. A series of foot traverses permitted examination of a relatively broad area characterized by esker deposits interspersed with bedrock outcrops. Ground reconnaissance extended north and north-west until the esker-like deposits terminated near Pigeon Pond. No new archaeological sites were discovered.

Archaeological deposits have proved to be relatively sparse in the EKATI™ development area of the BHP claim block. Site frequencies increase in proximity to eskers; it is postulated that these landforms served as travel routes. Peripheral remnants of eskers, such as found near LeNt-17, have potential for archaeological sites, but the sites are not as large or as frequent. There are no other archaeological sites sufficiently near the proposed Beartooth Pit to be threatened. The proposed footprint of the mine has been adequately examined. Little new ancillary development is required for this proposed mine since the existing Panda Pit and its associated infrastructure are nearby.

3.8.7 Modern Aboriginal Land Use

Three of the potentially affected Aboriginal groups have provided BHP with information on traditional use of the BHP claim block in the 20th century. These include the Copper Inuit from Pellatt Lake who now live in Kugluktuk; the Dogrib from the Treaty 11 communities of Rae/Edzo, Wekweti and Gameti, who travelled through the Lac de Gras region on their way to Contwoyto Lake; and the Yellowknives Dene of Treaty 8 from N'dilo and Dettah, who hunt north through Lac de Gras from MacKay and Courageous lakes to Lac de Gras.

All three groups use the Lac de Gras region for the general pursuit of barrenland caribou, Arctic fox, Arctic wolf and wolverine. Fisheries on Lac de Gras and on the large inland lakes support these land use activities. There are major traditional fisheries at the Lac du Savage narrows and at the outlet of Lac de Gras. Long Lake was formerly used as a fishery by Dogrib and Yellowknives parties travelling by canoe to Yamba Lake via Exeter River.

Land use identified on the claim block can be summarized as winter and summer travel routes, short-term traditional camps, general hunting and trapping areas, fisheries, barrenland and caribou water crossings, graves, place names and knowledge of wildlife denning. The information presented in Figure 3.8-3 is not intended to be a complete record of Aboriginal use of the entire claim block area. It does not for instance include all of the Dogrib information, or material from the Metis or Chipewyan. It is sufficient, however, to determine that the proposed addition of the Sable, Pigeon and Beartooth pipes to the EKATI™ mine plan is not expected to have an adverse effect on traditional land use of the Lac de Gras region.

3.8.8 Commercial Outfitting at Lac de Gras

Courageous Lake Caribou Camps holds three land leases for outfitting barrenland caribou hunting. Two of the leases have tent camps. Their main base camp is at the outlet of Lac de Gras with a satellite on Lac de Gras south of the Lac du Sauvage Narrows. The third lease on the south side of Lac de Gras does not have a camp outfit at this time. Given that the camps are within the claim block, BHP has a contractual arrangement with Qaivuik Ltd. now owned by Courageous Lake Caribou Camps, which was established in 1996. Quaivuik has not brought hunters to Lac de Gras from its lodge at Courageous Lakes since the early 1990s, however, and the outfit was sold in February of 1999. The

new owners, Courageous Lake Caribou Camps, are considering the possibility of conducting hunting expeditions at Lac de Gras again in the future. They told BHP in January 2000 they did not feel the BHP mine would affect their business.

The Aurora Caribou Camp on Desteffany Lake below Lac de Gras and Arctic Safaris at Obstruction Rapids below Lake Providence on the Coppermine River are outside of the EKATI™ zone of influence.

3.8.9 Echo Bay Winter Road Land Use

With respect to items *ix* and *x* of 3.1.7 "Land Use" in the Terms of Reference, BHP proposes to deal with the Echo Bay winter road and its winter road camps only in the context of the cumulative effects that this development may have with relation to the road. Accordingly, BHP proposes not to describe the winter road or its operations, except in the context of cumulative effects.

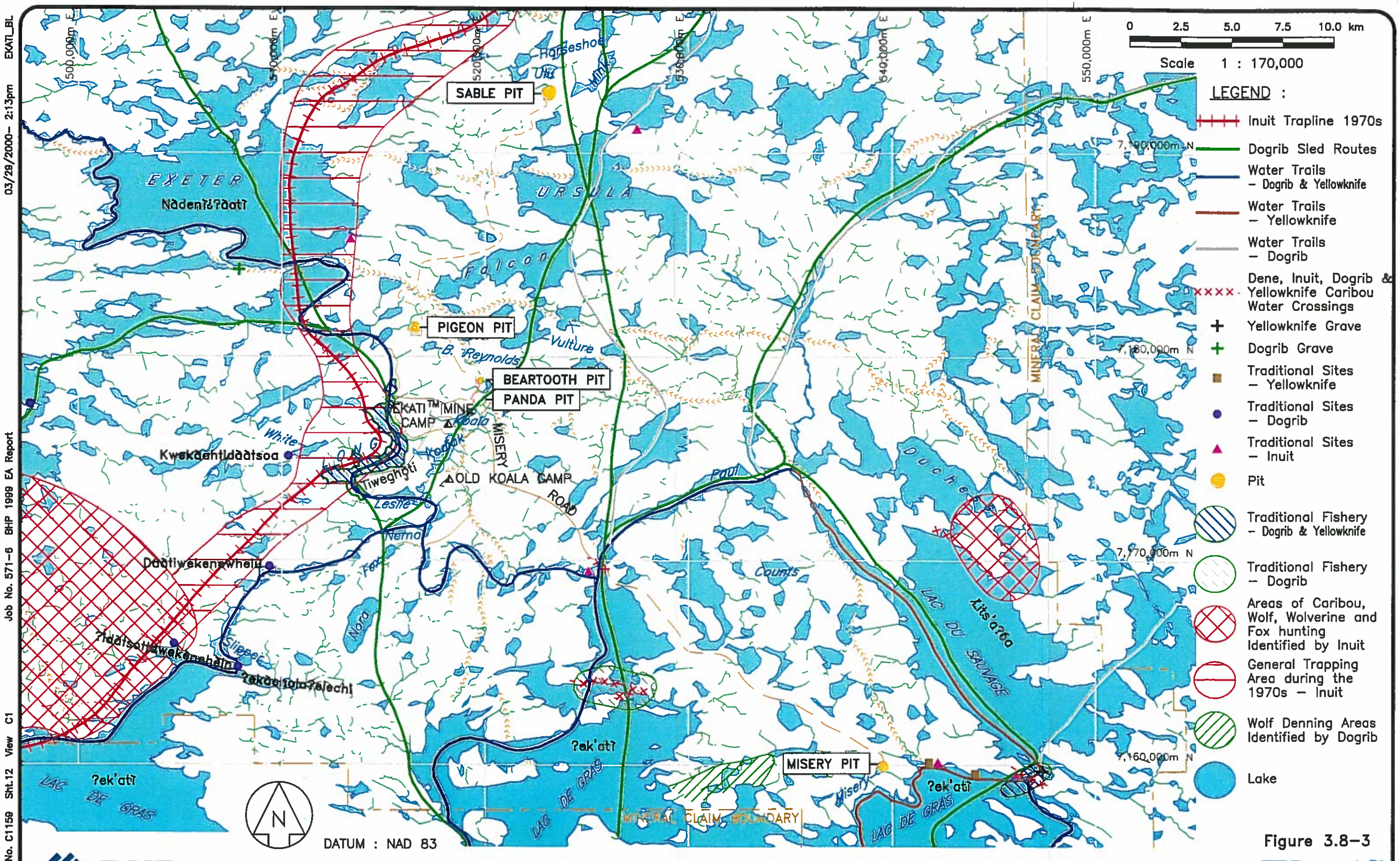

Figure 3.8–3

EKATI™ Mine and Future Developments

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3.9 The Social, Cultural and Economic Environment

The 1995 Environmental Impact Statement (EIS) established baseline data to describe the human environment for the EKATI™ Diamond Mine (EIS Volume II, Section 4). On April 1, 1999, the former Northwest Territories was divided into two separate jurisdictions, the Nunavut Territory and the Northwest Territories (NWT).

Jurisdictional change has altered the 1995 baseline data in describing the social, cultural and economic environment for the proposed Sable, Pigeon and Beartooth and kimberlite pit development. In this section a description of the social, cultural and economic environment for the EKATI™ Diamond Mine including the proposed Sable, Pigeon and Beartooth kimberlite pit development is provided. This description does not change the original baseline for the EKATI™ Diamond Mine.

The EKATI™ Diamond Mine including the proposed, Sable, Pigeon and Beartooth kimberlite pit development, is located in the NWT. This section of the report provides a description of the social, cultural and economic environment in the NWT, in those Aboriginal communities in the NWT directly impacted by EKATI™ and in the capital of the NWT, Yellowknife. A description of the social, cultural and economic environment is also provided for the west Kitikmeot region of Nunavut including the community of Kugluktuk which was identified in the EIS as directly impacted by EKATI™.

3.9.1 The Social, Cultural and Economic Environment of the NWT

3.9.1.1 Demographic Profile

In 1991, the NWT had 64,000 residents the majority of which (61%) were of Aboriginal ancestry (EIS Volume II, Section 4.1.7). In 1996, the Canada Census counted 39,672 people in the NWT alone. After April 1, 1999 persons of Aboriginal ancestry no longer made up the majority of the population in the NWT. Almost 52% of the NWT population were identified as being of non-Aboriginal ancestry. Among the population of Aboriginal ancestry (48%), Dene or Metis peoples are the largest group (37%) (Figure 3.9-1). While almost half of the NWT population are of Aboriginal ancestry, only 8% use an Aboriginal language in the home. Between 1986 and 1996, the use of an Aboriginal language in the home has declined.

Males make-up over half (52%) of the NWT's population. In 1996, about 44% of the population were 24 years of age or younger and almost 3.5% were 65 or more years of age (Figure 3.9-2). While the NWT has a young population compared to Canada as a whole, the territorial population is ageing. The fastest growing segment of the territorial population is persons who are 50 years of age and older (Bureau of Statistics, 1999).

Each year between 1991 and 1996, the population of the NWT grew by 1.8%, almost double the national rate. In the future it is expected that population increases will be smaller.

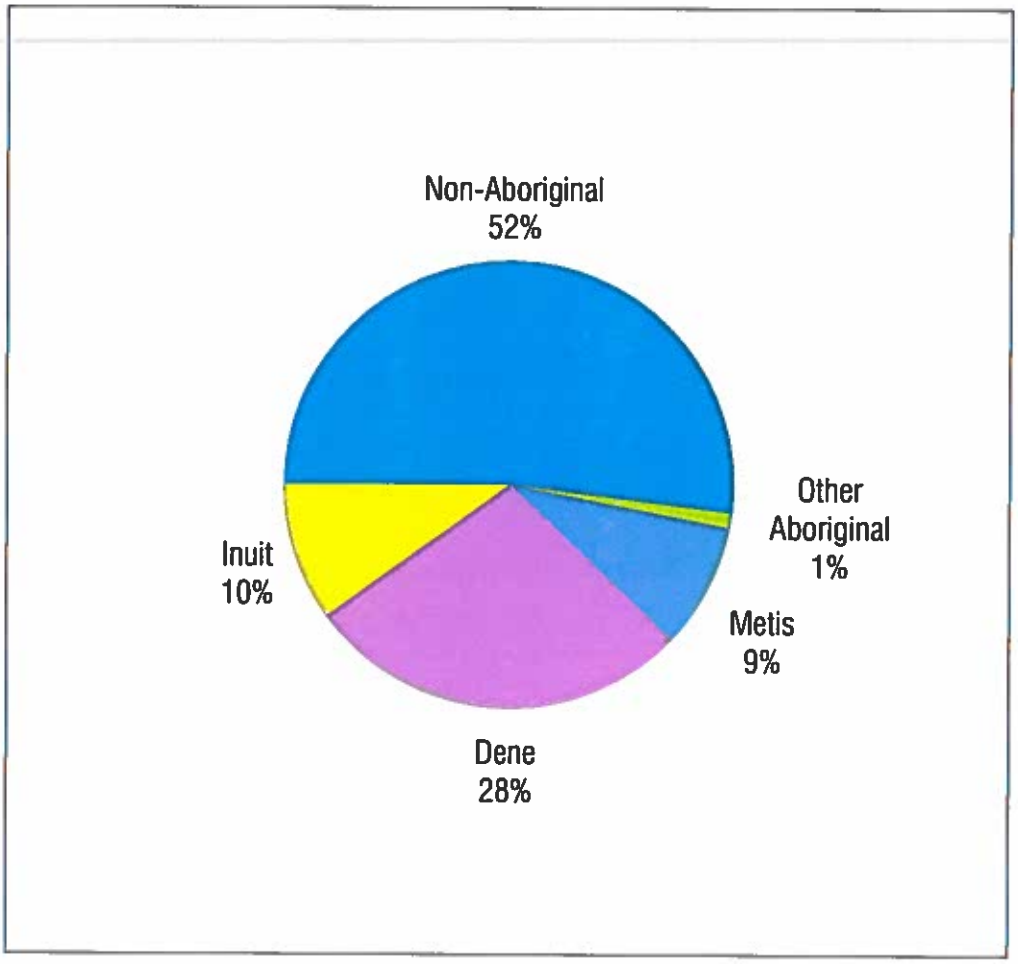


FIGURE 3.9-1

NWT Population by Ethnicity, 1996

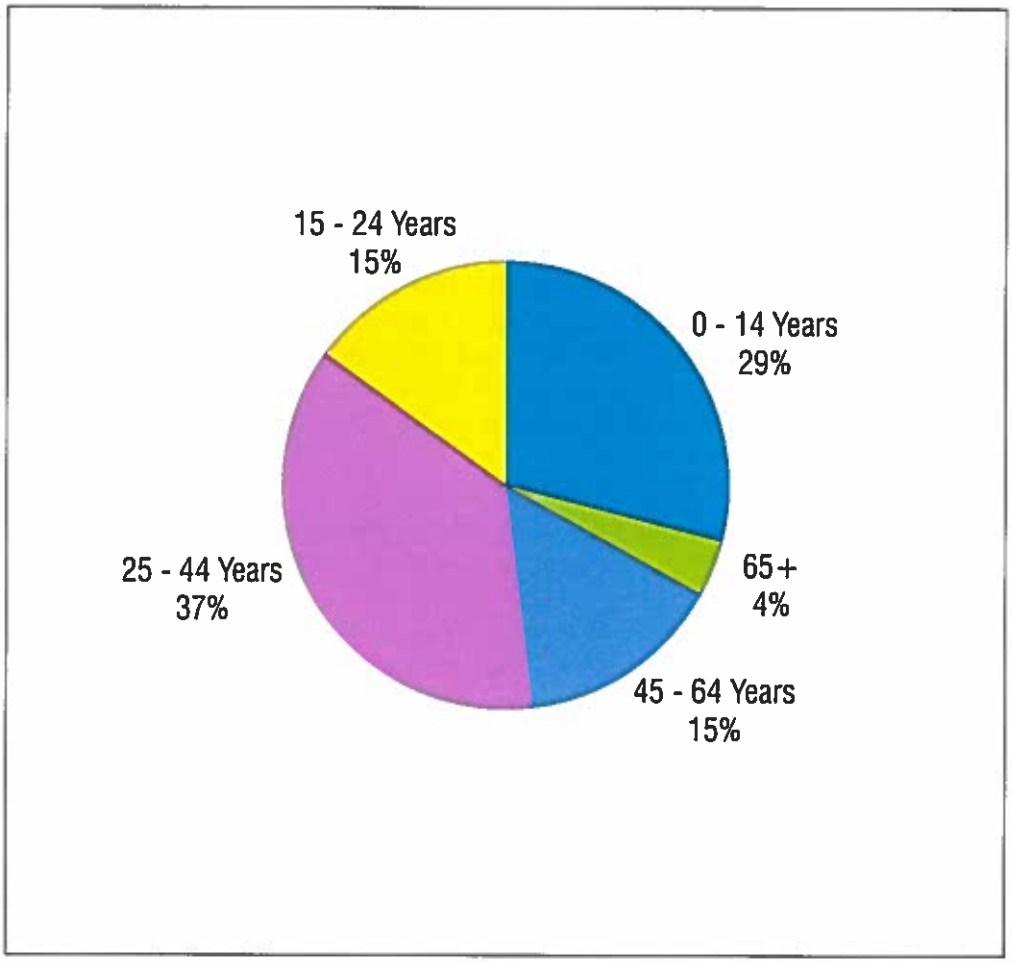


FIGURE 3.9-2

NWT Population by Age, 1996

Between 1998 and 2008, population growth is expected to decline marginally, fluctuating between 1.5% and to 1.7% annually. High birth and low death rates influence population growth in the NWT. While the NWT's birth rate is declining, it was 66% higher than the national rate in 1996 and about 58% higher in 1998. Since 1995, the NWT's death rate has been less than half the national rate (Figure 3.9-3).

3.9.1.2 Human Health and Well-Being

Human health and well-being are influenced by a wide range of socio-economic and personal factors. There are many indicators of health and well-being and some of these are identified in the 1996 Socio-Economic Agreement between BHP Diamonds and the GNWT.

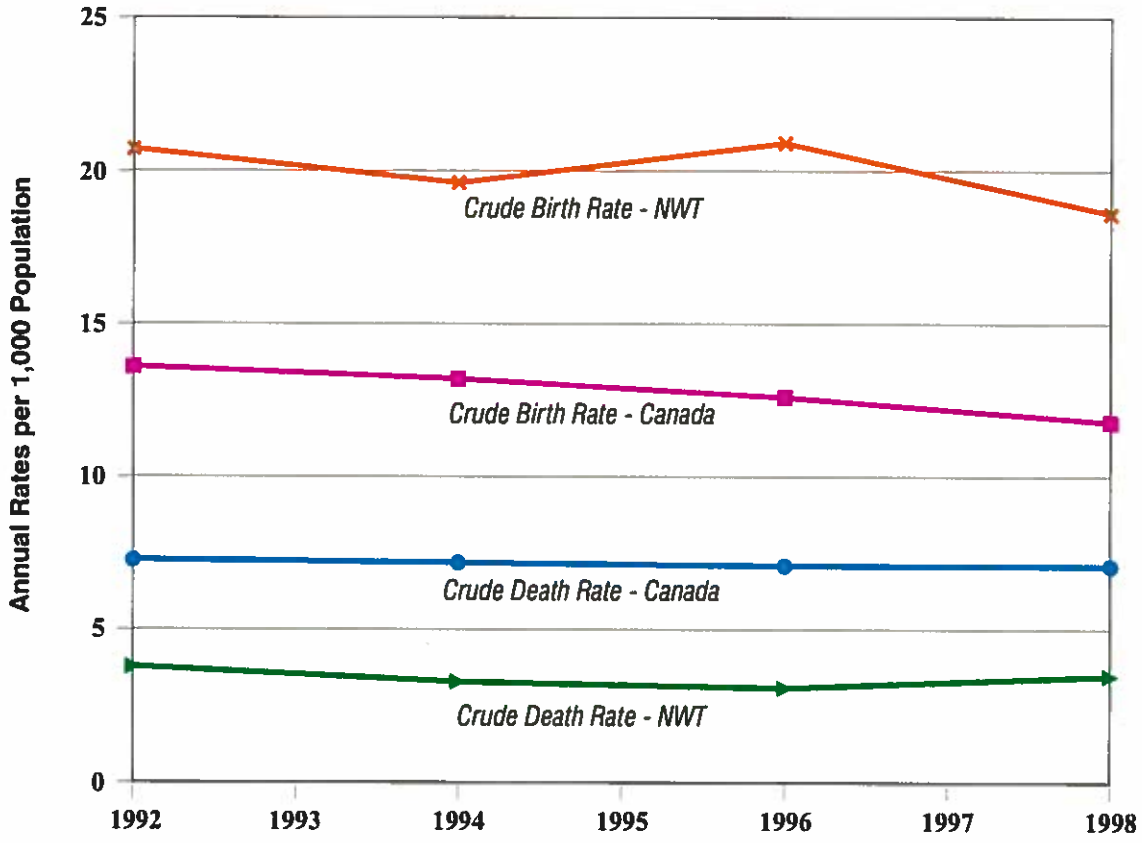
Crowded and unsuitable housing have been identified as key factors in human health and well-being. In the decade ending in 1996, the average number of persons per NWT dwelling declined slightly from 3.3 to 3.1 persons. Over the four year period between the NWT Housing Corporation's 1992 and 1996 housing surveys, an increase from 17% to 20% was recorded in the number of NWT houses in "core need" (households facing suitability, adequacy, affordability or multiple housing problems, and income below the community income threshold).

Members of single parent families have historically experienced more serious human health and well-being issues than those who are part of two parent families.

The reasons for this relate in large part to poorer economic circumstances of single parent families. Families headed by a lone female parent earn significantly less than those headed by a lone male parent or two parents. Lone parents head almost 16% of families in the NWT and this number is increasing. In fact, there were 22% more lone parent families in the NWT in 1996 than in 1991.

Violent and high risk behaviours put human health and well-being at risk. For much of the past decade, the rate of violent crime in the NWT has continued to increase (Figure 3.9-4). Crime rates in the NWT are about three times the national rate (Bureau of Statistics, 1999). The use of alcohol and/or other drugs are contributing factors to high crime rates in the North. The use of these substances among NWT residents is as much as twice the national average (Health and Social Services, 1999).

Between 1991/92 and 1997/98, the number of children in the NWT who were brought into care increased by 60% (Health and Social Services, 1999). The number of children in care peaked in 1995/96 and has declined slightly since that time (Figure 3.9-5). The reasons that children are brought into care vary widely and include neglect, special needs such as developmental delay and other family issues. The reasons for the dramatic increase in children in care also vary. Increases may be as a result for example, of changes in the economy, in apprehension efforts or greater awareness of children's needs



Canadian and NWT Birth and Death Rates, 1992 to 1998

FIGURE 3.9-3

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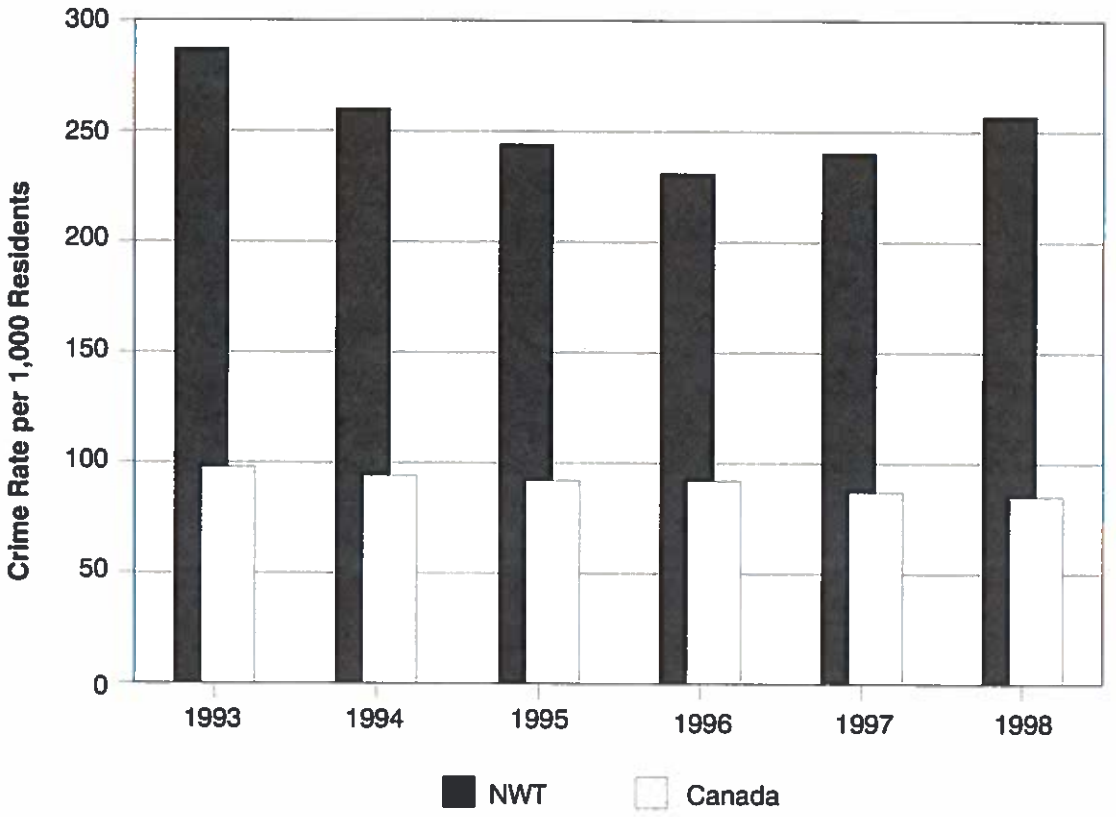

Source: Statistics Canada and GNWT, Bureau of Statistics

Canadian and NWT Crime Rates, 1993 to 1998 (per 1,000 population)

FIGURE 3.9-4

BHP

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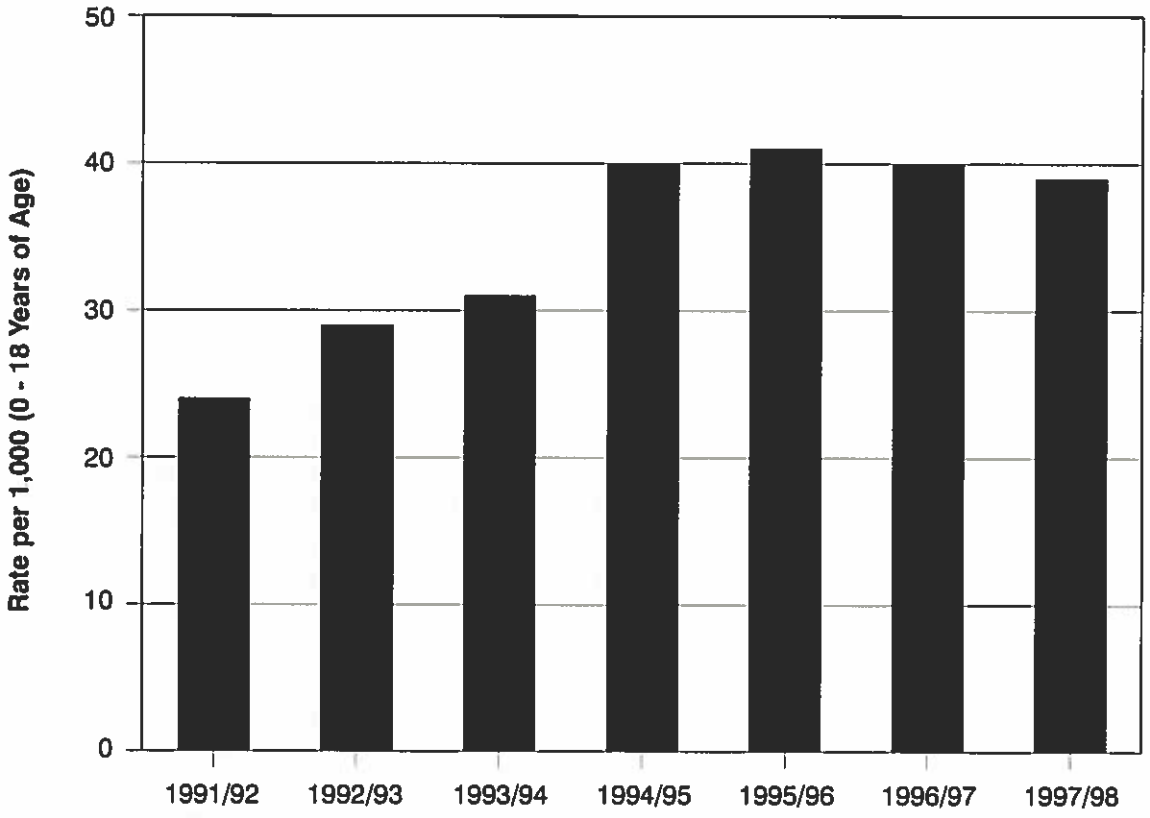

Source: GNWT, Bureau of Statistics and Department of Health and Social Services

Note: Rates include children who may be in care for as short a time as 48 hours to as long as 365 days during the year.

Children in Care in the NWT 1991/92 to 1997/98

FIGURE 3.9-5

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or rights (Health and Social Services, 1999). Reasons may also relate to the increasing rates of reported incidents of child sexual abuse and child physical abuse in the NWT. High rates of family violence and spousal assault in the NWT may also contribute to the number of children being brought into care.

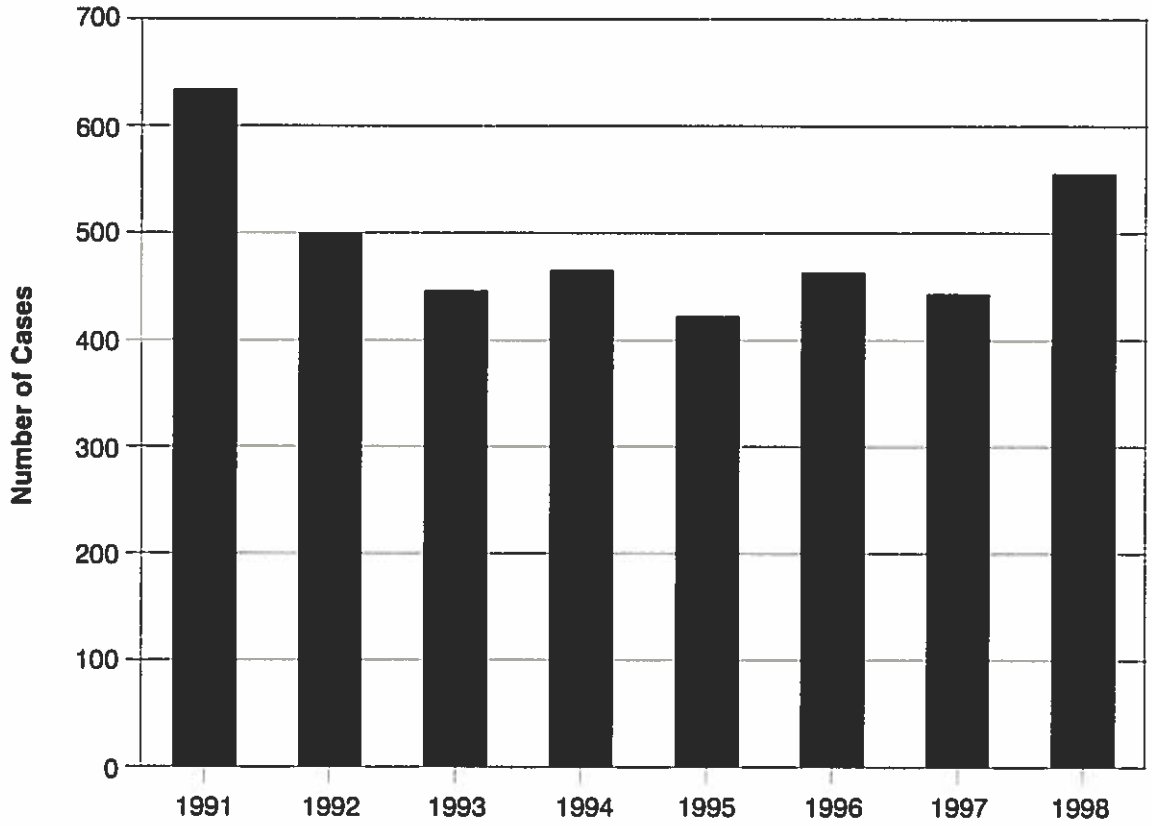
The NWT Health Status Report (Health and Social Services, 1999) states that the overall physical health of NWT residents is similar to that of other Canadians. The exception to this is seniors/elders in the NWT who have considerably poorer health compared to their peers elsewhere in Canada. Only 15% of NWT seniors/elders report excellent or very good health compared to 40% nationally. This same report describes the health of NWT residents by the main reasons that people are admitted to hospital. Other than childbirth, the main reason for hospital visits were mental disorders, respiratory diseases, injuries and disorders of the digestive system. Territorial residents primarily visit community health centres because of respiratory diseases, injuries, and diseases of the nervous system and sense organs. Smoking and alcohol use, respectively, contribute to high rates of respiratory diseases and injuries.

The NWT continues to face higher rates of tuberculosis than elsewhere in Canada. Between 1990-1998, the rates of tuberculosis were almost eight times the national rate. Tuberculosis is generally associated with over-crowded housing, smoking, malnutrition, infestations and chronic disease. The NWT also has higher than average rates of sexually transmitted diseases compared to the rest of the country. Between 1996 and 1998, the number of chlamydia, gonorrhea and hepatitis B cases rose from 472 to 559. Between 1989 and 1998, the average rate of infection was 542 per 50,000 people for reported cases of chlamydia compared to 77 per 50,000 population nationally. In the same period, the NWT had gonococcal infection rates of 104 per 50,000 population compared to 12 per 50,000 nationally (Figure 3.9-6) (Health and Social Services. 1999).

The GNWT-BHP Socio-Economic Agreement (1996) identified premature mortality as an indicator of health and well-being. Premature mortality is calculated as potential years of life lost due to death prior to 70 years of age (the normal life expectancy). In the NWT, 14,165 potential years of life were lost between 1991 and 1996 (621 years per 10,000 population). The leading causes of death are cancers (25%), injuries and poisoning (23%) and circulatory diseases (23%). NWT mortality rates due to injuries are more than twice the national rate. (Health and Social Services, 1999). In the decade ending in 1997, the rate of suicide in the NWT was 18 per 100,000 population. This compares to a national rate of 13 per 100,000 population.

3.9.1.3 Education

Education levels are improving for both Aboriginal and non-Aboriginal people in the NWT. Between 1991 and 1996, the percentage of working age people (15 or more years of age) with a grade nine or higher education increased from 81% to 85%. In this same period, more people gained trade certification or a university degree. Information collected in the 1994 and the 1999 NWT Labour Force Survey show that education levels



Source: GNWT, Health and Social Services Sexually Transmitted Diseases - Chlamydia and Gonococcal Infection

Reported Cases of Chlamydia and Gonorrhea in the NWT, 1991 to 1998

FIGURE 3.9-6

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among the working age population of Aboriginal ancestry continue to be lower than those of non-Aboriginal people (Figure 3.9-7). In 1994, 32% of Aboriginal and 3% of non-Aboriginal people of working age had not completed grade nine. In 1999, the percentage of Aboriginal and non-Aboriginal people of working age who had not achieved a grade nine education fell to 26% and 2% respectively. While the number of working age people with a university degree did not increase between 1994 and 1999, more people, particularly Aboriginal people, achieved a high school diploma or another certificate/diploma.

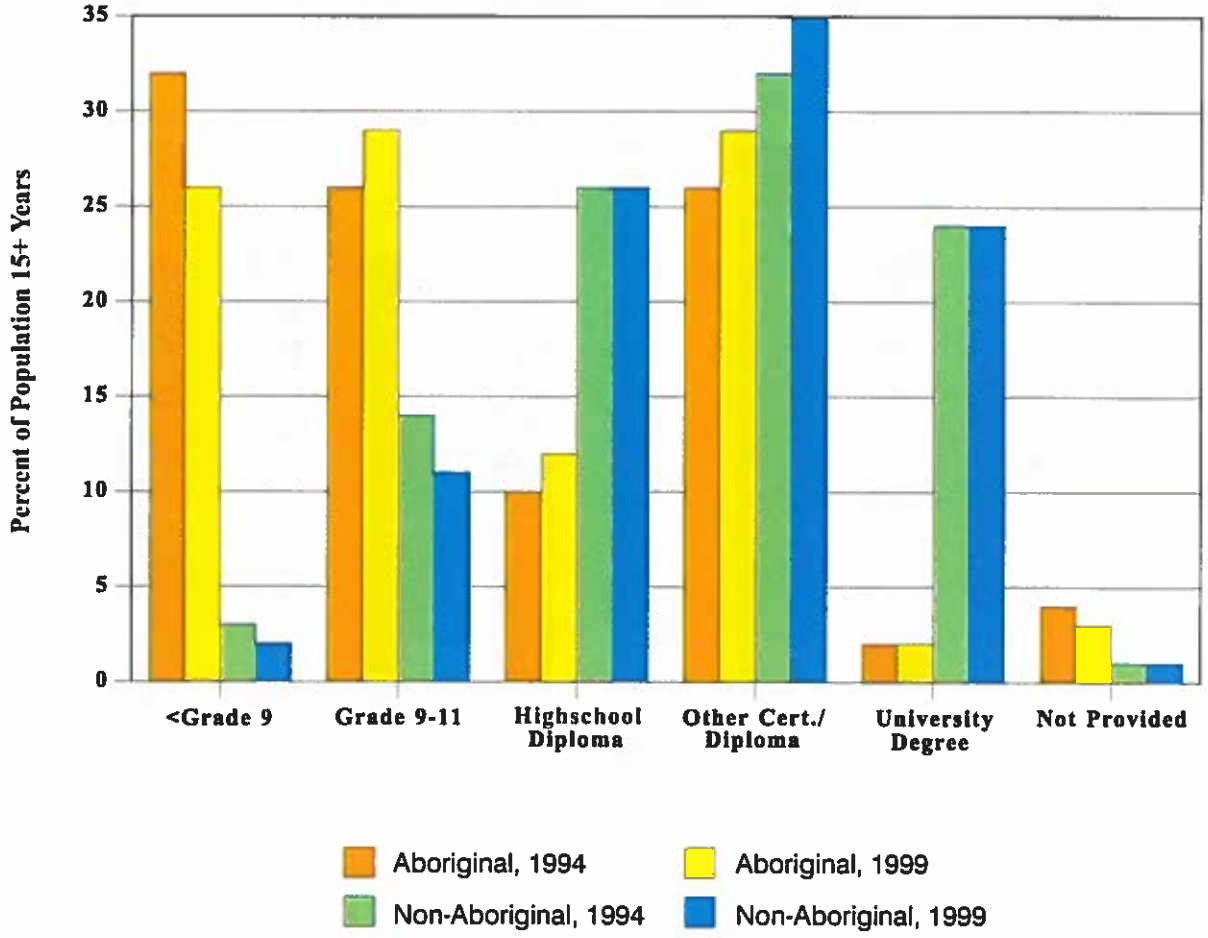
A Ministerial Forum on Education in the NWT (1999) reported that school enrolment, participation, retention and graduation continue to increase in the NWT. In 1998/99, over 9,000 students were enrolled in NWT schools. Each year between 1995 and 1999, enrolment increased by an average of 3% in senior high-school grades. Stay-in-school initiatives, the availability of higher levels of education in more NWT communities and greater understanding of the importance of formal education are factors contributing to increased student success.

More students (200 in 1995/96 and 276 in 1998/99) are graduating annually from schools in the NWT. Between 1995 and 1998, the NWT high-school graduation rate increased from 35% to 45% (Graduation rates are calculated by dividing the total number of graduates by the number of 18 year olds.) (Bureau of Statistics, 1999). Over this same period, graduation rates among Aboriginal students in the NWT increased from 12% to 22% while rates among non-Aboriginal students rose from 67% to 81%. While NWT graduation rates are increasing, the percentage of Aboriginal students completing high school continues to be significantly lower than the Canadian average (Bureau of Statistics, 1999).

Participation in post-secondary school has also increased in the NWT. In 1991/92, 828 students were enrolled at Aurora College and in 1998/99, the enrolment rose to 1074 (Figure 3.9-8). Between 1993-1995, enrolment at the college peaked at an average of 1434 students in each of these years. The number of NWT students receiving financial assistance to pursue post-secondary education also increased from 1009 in 1992/93 to 1543 in 1998/99, peaking in 1996/97 at 1643 students.

3.9.1.4 Labour Force Activity

Participation in the labour force is defined as those persons 15 years of age or older who are employed or unemployed. Of the 29,506 people of working age in the NWT in 1999, 78% participated in the labour force. Non-Aboriginal people participate in the labour force at a greater rate than Aboriginal residents, 89% compared to 65% (Figures 3.9-9, 3.9-10, 3.9-11). Labour force participation and employment rates increased in the NWT between 1994 and 1999, mainly due to changes in the Aboriginal work force. Participation rates rose from 77.2% to 78.3% of the population 15 years or older, and employment rates rose from 65.7% to 67.5% (Figure 3.9-9). A growing labour force, higher education levels and changing employment circumstances in various economic sectors may account for greater employment and labour force participation rates.



Highest Level of Educations of the NWT Working Age Population by Ethnicity, 1994 and 1999

FIGURE 3.9-7

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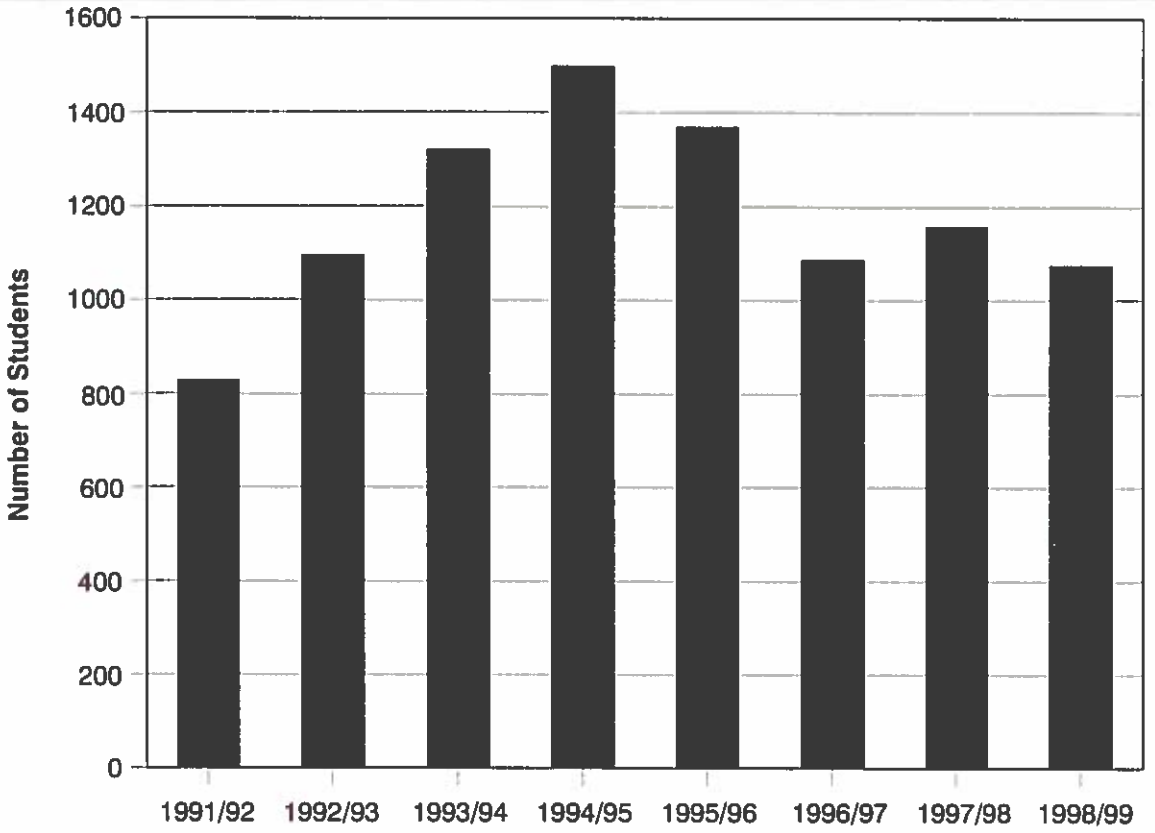

Source: Bureau of Statistics
Note: Enrolments reported as a full-time equivalents (1 person taking 10 courses)

Aurora College Enrolment, 1991/92 to 1998/99

FIGURE 3.9-8

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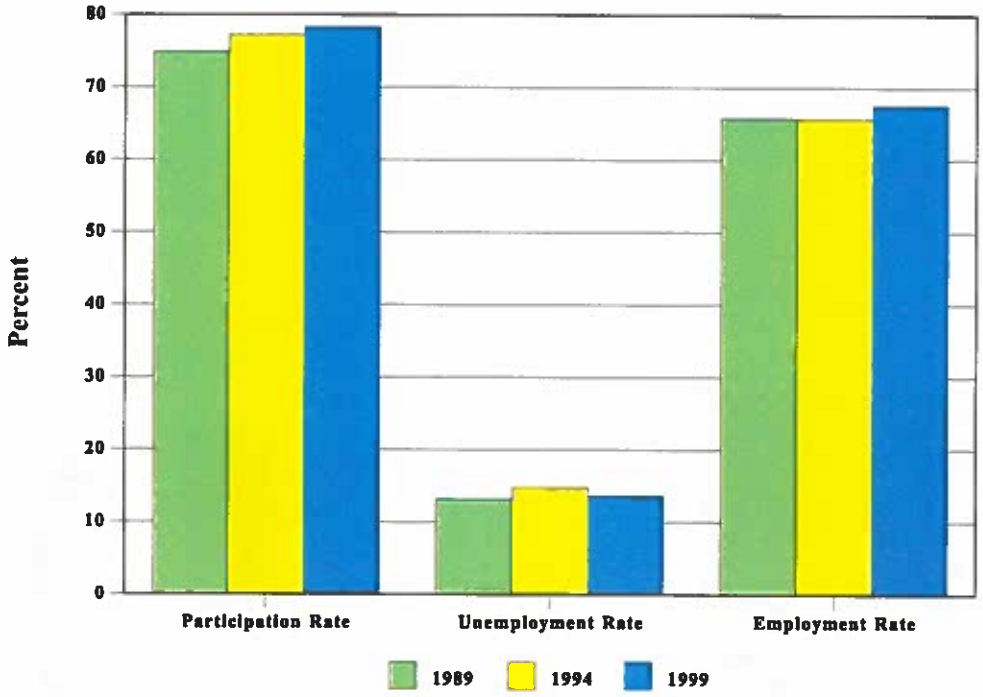


FIGURE 3.9-9

NWT Labour Force Activity, 1989, 1994 and 1999

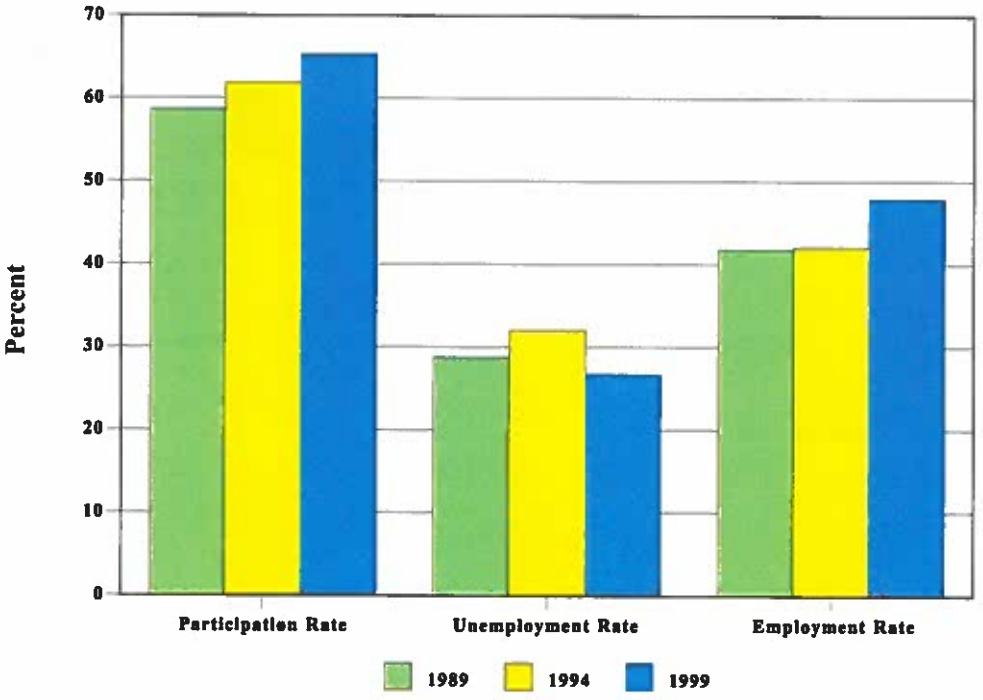
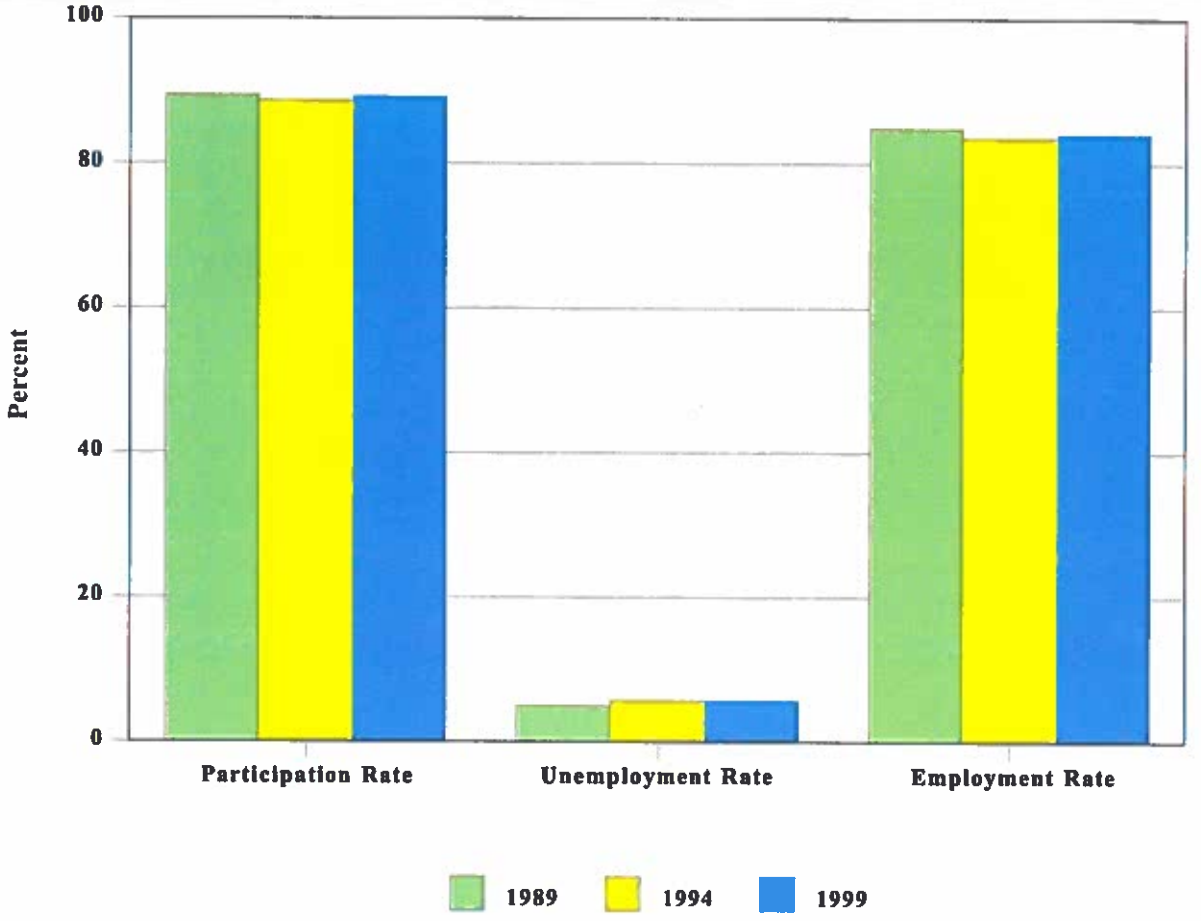


FIGURE 3.9-10

NWT Aboriginal Labour Force Activity, 1989, 1994 and 1999



Source: GNWT, Bureau of Statistics

NWT Non-Aboriginal Labour Force Activity, 1989, 1994 and 1999

FIGURE 3.9-11

Northerners with higher levels of education are more likely to be employed compared to those with lower levels of education. In 1996, only 32% of working age individuals with a grade nine or less education were employed compared to 78% of those with trade certification or other post-secondary education, and 92% of those with a university degree (Figure 3.9-12).

In 1996, the greatest number of employed NWT residents (40%) worked in government services including education and health services (Figure 3.9-13). Among the 3,485 workers employed with the GNWT in 1997, 31% were of Aboriginal ancestry. Other services contribute another 32% of NWT jobs while primary industries including construction, make-up about 16% of available jobs. The retail and wholesale trade account for 12% of jobs in the NWT.

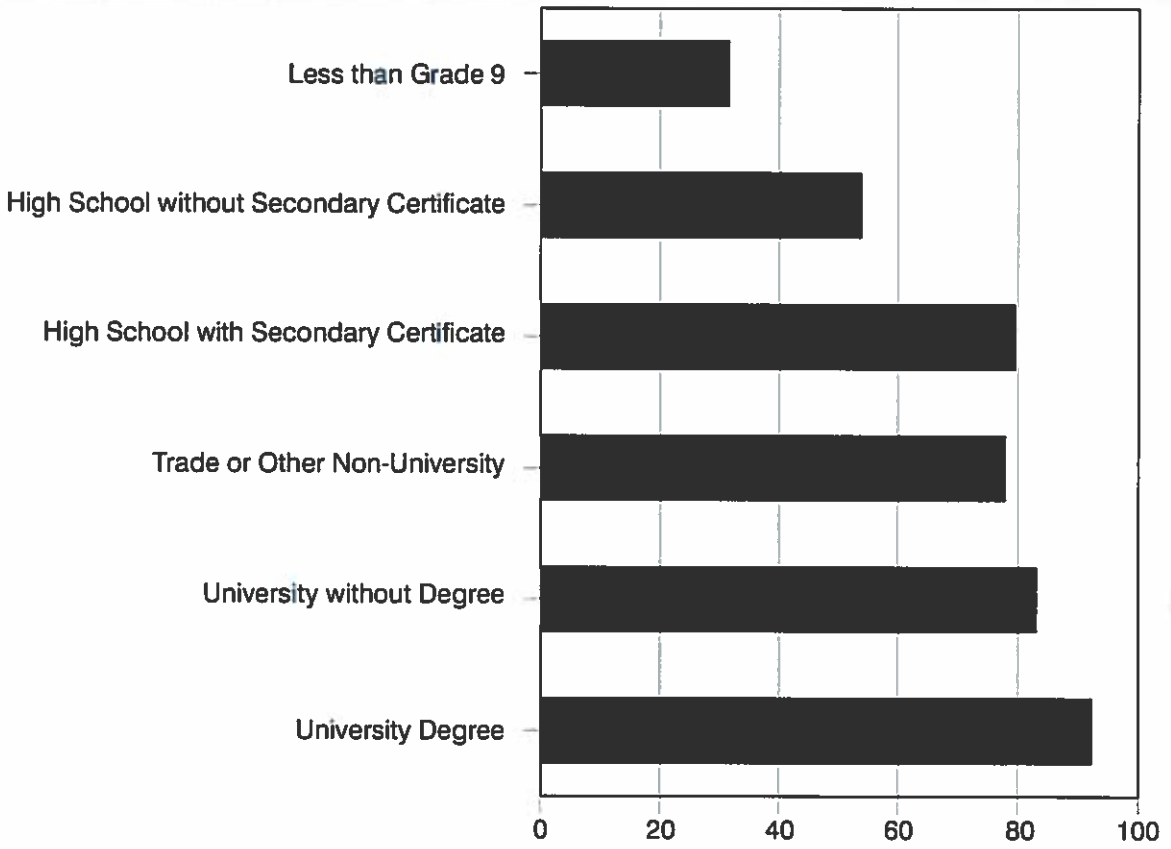
The 1994 and 1999 NWT Labour Force Surveys provide an occupational profile of the experienced labour force. The greatest number of workers have experience in management, business and administrative occupations, in sales and service occupations, and in trades, transport and primary industry occupations. The two surveys identified fewer NWT workers with experience in management, business and administrative occupations, 34% compared to 31%, and more cited experience in trades, transport and primary industry occupations, 18% compared to 20%.

The 1994 and 1999 NWT Labour Force Surveys also reported on working age people not working but wanting a job. Between the two survey periods, the number of people willing to do rotational work increased from 66% to 68% and the number needing training decreased from 69% to 68%.

3.9.1.5 Income

The average income in the NWT continues to be higher than the national average, but the gap is narrowing. Further, changes in average incomes in the NWT between 1991 and 1996 did not keep pace with the average increase in inflation. By 1996, the average income in the NWT had increased to $33,794, representing a 1% per annum increase compared to an average inflation rate of 1.8%. In 1997 personal disposable income in the NWT was 18% higher than in 1992.

Annual income support payments and the number of NWT recipients and dependants increased between 1993 and 1995. In 1996/97, the NWT Income Support Program was altered and subsequent increases in payments and recipients have been less dramatic (Figure 3.9-14). In 1998, $13,002,000 in income support payments were distributed to 3,922 recipients and their dependants in the NWT, compared to $14,294,000 to 4,260 recipients and their dependants in 1995. Recipients and their dependants received an average of 17% more in income support benefits in 1998 than in 1993.



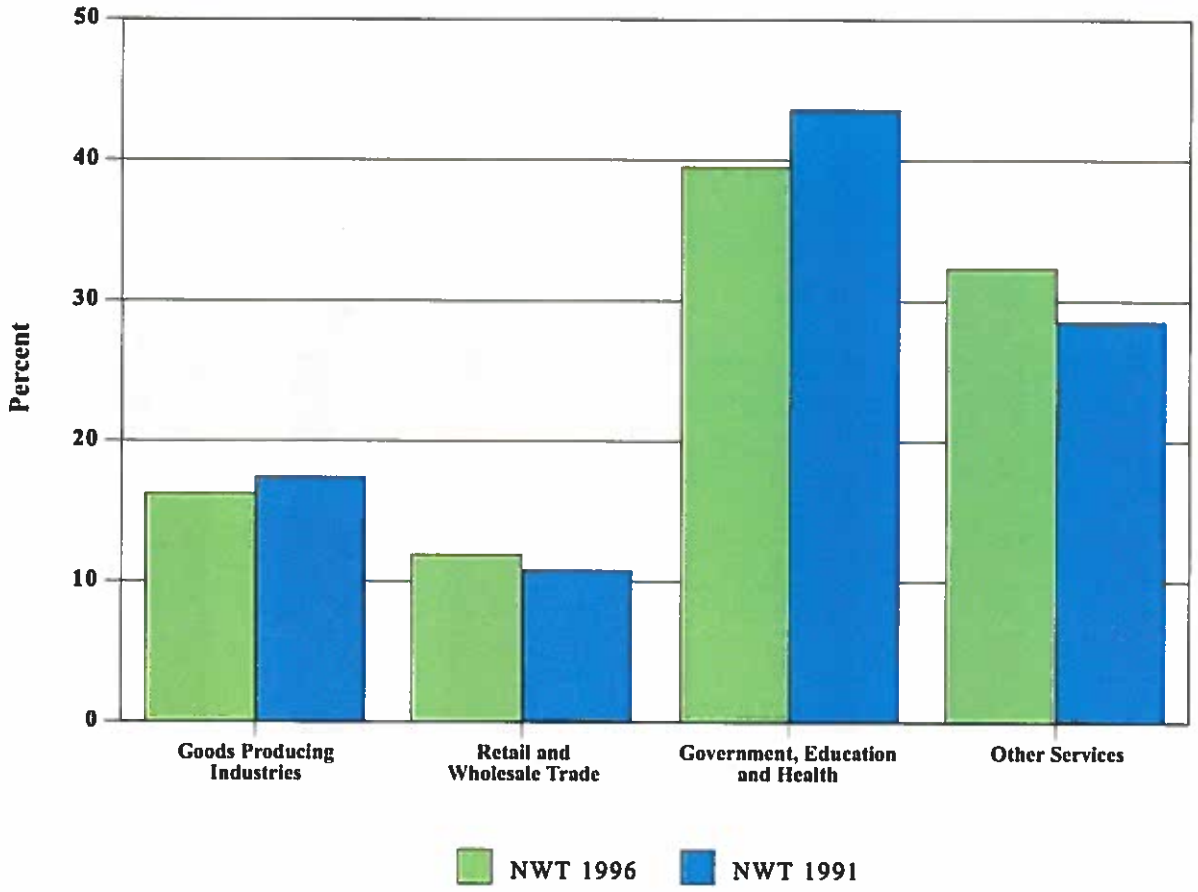
Source: 1996 Census of Canada

NWT Employment Rate by Highest Level of Schooling, 1996

FIGURE 3.9-12

BHP

Ekati diamond mine



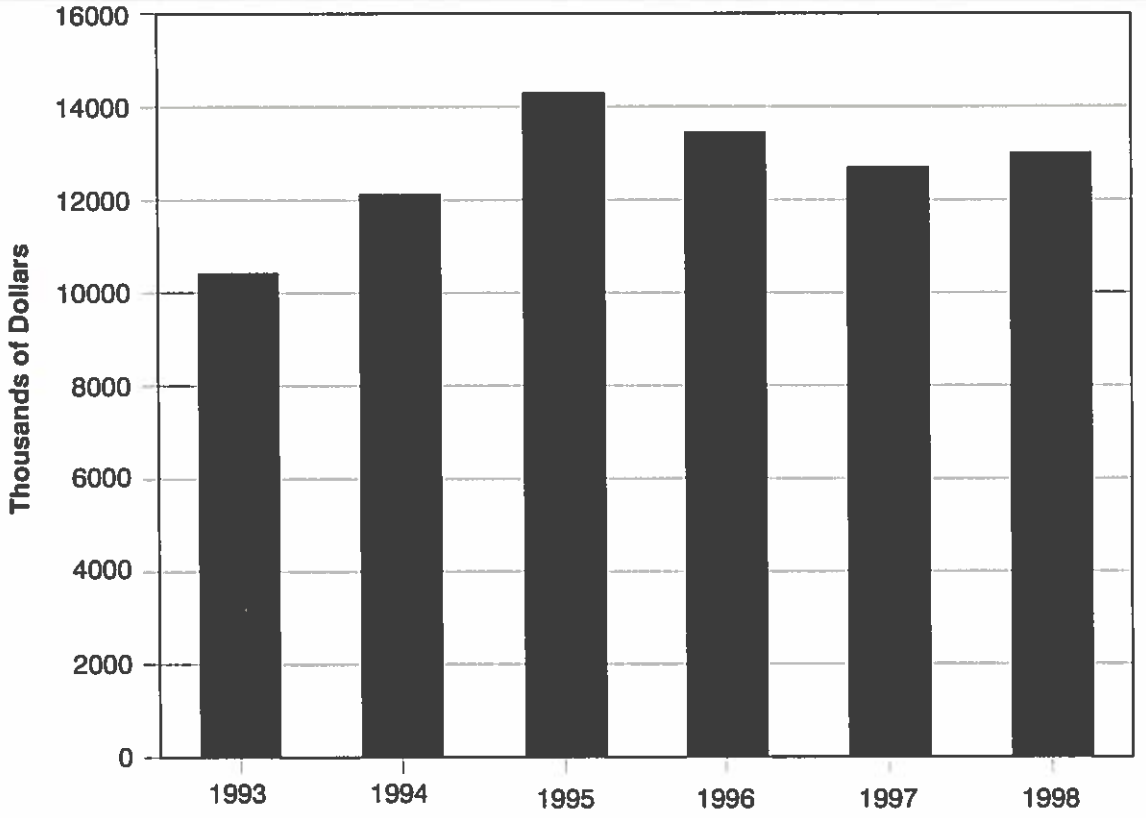
Source: 1996 Census of Canada, 1991 Census of Canada

NWT Employment by Industry Sector

FIGURE 3.9-13

BHP

Ekati diamond mine



Source: GNWT, Bureau of Statistics

Annual Social Assistance Payment in the NWT, 1993 to 1998

FIGURE 3.9-14

BHP

Ekati diamond mine

3.9.1.6 The NWT Economy

The Government of Canada and the Government of the NWT (GNWT) are the two senior levels of public government acquiring and expending funds in the Northwest Territories. Over the years through the process of "devolution" the GNWT has taken on "provincial type" responsibilities and currently operates with most of the powers and responsibilities of a provincial government. One major exception is the GNWT, unlike the provinces, does not yet have the right to collect resource revenues (such as mining royalties).

Since the creation of the Nunavut Territory on April 1, 1999, little detailed analysis has been undertaken of either the NWT or the Nunavut economy. The economies of the two jurisdictions are still considered as one by the Northwest Territories Bureau of Statistics and Statistics Canada.

In 1997 (last date of published information) public governments revenues (net transfers) amounted to $629 million and expenditures with $1,763 million for a net loss of $1,134 million.

In 1997, the Government of Canada had total revenues of $409 million in the NWT derived primarily from taxation (69%); contributions to social insurance plans (25%) and investment income (5.6%). In the same year the GNWT had total revenues of $1.17 billion dollars. GNWT revenues were primarily derived from transfers from the Government of Canada (81.2%); taxation (13.4%); contributions to social insurance plans (2%) and investment income (3.2%).

In 1997, the Government of Canada spent $1.44 billion in the NWT. Expenditures were primarily on transfers to the GNWT and local governments (66.2%); expenditures on goods and services (13.8%); transfers to persons and business (13.1%); and interest on public debt (6.9%). GNWT spent $1.27 billion in the NWT in 1997. Most of the expenditures were for goods and services (81.5%); transfers to persons and business (10.4%); transfers to local governments (9.1%); and interest on public debt (0.6%).

Political division of the NWT in 1999 changes the level but not the structure of public government revenue and expenditures in the NWT. For example transfers from Canada to the GNWT will decline from over $900 million in 1997 to an estimated $572 million in 1999/2000. GNWT expenditures will also decline from over $1.2 billion in 1997 to an estimated $723 million in 1999/2000. The basic structure of the new budget of the NWT will remain almost identical to pre-division as federal grants and transfers will continue to account for over 0% of all revenues.

The final domestic demand in the NWT and Nunavut economy increased by 14% from $2.9 billion in 1992 to $3.3 billion in 1997. This marked a reversal in the declining trend of the late 1980s and early 1990s. The government component of final demand declined while there was a significant increase in personal expenditures on goods and services and business fixed capital investment. Public sector investment in the NWT and Nunavut was 10% lower in 1997 than in 1992, however business fixed capital investment doubled

during the same period. Business expanded for the $700 million construction of the EKATI™ mine in 1997 and 1998.

The increase in exports continued to keep pace with the growth in imports between 1992 and 1997. In 1997, imports were valued at $1.4 billion and imports at $1.0 billion (Bureau of Statistics, 1999). For every dollar earned through exports from the NWT and Nunavut, $1.44 and $1.45 was spent on importing in 1992 and 1997.

The retail and wholesale trade sectors have significantly strengthened the economies of the NWT and Nunavut. In 1991, the combined wholesale and retail trade amounted to less than $547 million. In 1998, the value of this trade exceeded $857 million. Manufacturing has declined since 1993 and in 1998 amounted to $22 million.

The NWT's non-renewable resource sector has been challenged by low prices, labour disputes and more competitive global production and markets. In 1998, the value of gold production dropped to $54 million from $200 million in 1997. Diamond production in late 1998 was valued at about $53 million for the year (Bureau of Statistics, 1999). Oil and gas production also declined in 1998 to $172 million compared to $246 million in the previous year.

The NWT's fur production and harvest values have fluctuated throughout the 1990s. In 1991, 35,520 pelts were harvested for a value of $1,832,579. In 1996, the value of 39,934 pelts was $1,037,297. The value of pelts in 1997 was lower, with 42,856 pelts harvested for a value of $751,324.

3.9.1.7 Infrastructure

Due to the strong influence of government spending on all aspects of the NWT economy, fiscal restraint in the public sector for much of the 1990s has limited capital spending and infrastructure development. As discussed in subsequent sections and in the EIS Volume II, Section 4, the extent of physical and organizational infrastructure is directly related to the size and economy of the community. In small, communities, physical, human and organizational infrastructure is available for governance, health, education, protection, safety, housing, recreation and to meet basic day to day living needs. In the larger NWT communities, more complex physical, human and organizational infrastructure is available to meet a wider range of needs and to provide residents with a greater variety of service and program options.

3.9.2 The Social, Cultural and Economic Environment of First Nation Impact Communities in the NWT

BHP has special arrangements for impacted communities in the NWT. First Nation impact communities are Rae Edzo, Rae Lakes, Snare Lake and Wha Ti in the Dogrib Treaty 11 region and Lutsel K'e, N'dilo and Dettah in the Treaty 8 region. Baseline information was provided for impacted First Nation communities in the EIS, Volume II, Section 4.2. This

section draws on this baseline and provides additional detail to describe the social, cultural and economic environment of First Nation impact communities in the NWT.

3.9.2.1 Demographic Profile

In 1996, the ethnic mix of the population in NWT First Nation impact communities had not significantly changed since 1991. Those of Aboriginal ancestry, primarily Dene, represented 92% and 94% of total community populations in 1996 and 1991 (Table 3.9-1).

Table 3.9-1
First Nation Impact Community Populations by Ethnicity, 1996

Community	Total	Non-Aboriginal	Inuit	Dene	Metis	Other Aboriginal
Lutsel K'e	305	25	10	270	--	--
Dettah	190	--	--	190	--	--
N'dilo*	209	--	--	209	--	--
Rae-Edzo	1655	155	10	1440	50	10
Wha Ti	415	25	--	385	--	--
Rae Lakes	260	10	--	240	--	--
Snare Lake	135	15	--	120	--	--

Source: GNWT Bureau of Statistics, NWT Community Profiles derived from 1991 Canada Census
Note: *based on 1996 NWT Housing Corporation and assuming the same ethnic distribution as Dettah

The population of First Nation impact communities grew by 9.3% between 1991 and 1996, increasing the population from 2,903 to 3,174. The annual population increase in these First Nation communities was similar to that of the NWT as a whole, 1.8%. Population growth in N'dilo and Dettah were two communities that did not mirror the territorial rates. In the five years ending in 1996, the rate of population growth in these two communities was almost double the territorial rate. Forecasts to 2008 indicate that each year First Nation impact community populations will grow faster (by 1%) than the territorial population. Higher growth rates are influenced by the number of births in First Nation communities (Table 3.9-2).

Table 3.9-2
Historic and Projected First Nation Impact Community Populations, 1981 - 2008

					Estimated		
Community	1981	1986	1991	1996	1998	2003	2008
Dettah	143	131	150	190	208	226	241
Lutsel K'e	253	273	286	304	360	395	417
Rae-Edzo	1378	1378	1521	1662	1835	1914	2035
Rae Lakes	200	183	252	256	280	309	331
Snare Lake	69	119	127	135	140	164	182
Wha Ti	268	345	392	418	458	493	523

Note: Information on N'dilo is unavailable.
Sources: Government of the Northwest Territories, Bureau of Statistics.

The populations in NWT First Nation impact communities are young, with 47% - 55% of residents under 24 years of age. Birth rates well above Canadian and NWT levels, account for the youthfulness of these populations. In 1996, the average birth rate (number of births per 1,000 population) in WT First Nation impact communities ranged from 30.8 in Rae Edzo to 11.6 in Dettah (Table 3.9-3). With the exception of Snare Lake, the fertility rate (number of births per 1,000 teens) for teen girls, age 15-19, was well above the territorial rate. Almost one in four births in Rae Edzo was a teen birth between 1991 and 1996.

Table 3.9-3
Average 5 Year Births 1982 to 1996 and Birth Rates, 1986 to 1996

Community	Average Birth Rates					
	1982-86	1987-91	1992-96	1986	1991	1996
Dettah	1	2	2	7.6	12	11.6
Lutsel K'e	7	9	7	26.4	32.9	21.7
Rae-Edzo	36	48	51	25.8	31.8	30.8
Rae Lakes	3	6	7	16.4	22.2	28.9
Snare Lake	3	2	2	23.5	14.2	14.8
Wha Ti	10	12	9	27.8	31.1	22.5
NWT	**838**	**860**	**836**	**24.8**	**23.6**	**21.1**

Sources: Bureau of Statistics
Note: N'dilo data are included with Yellowknife
Birth rates represent the number of births per 1000 population. For communities with small populations these rates should be used with caution.

The average mortality rate (number of deaths per 1000 population) in the NWT in 1996 was 3.1. In First Nation impact communities, the average mortality rate was about 4.7. Higher mortality may be due to the higher proportion of seniors/elders in these communities. Persons 65 years of age or more make up about 7% of the population in First Nation impact communities and 3.5% of the NWT population.

3.9.2.2 Human Health and Well-Being

The physical health of residents of First Nation impact communities is similar to that of people throughout the NWT. Conditions related to the respiratory system, injury and poisoning, nervous system and sense organs, digestive system, and skin/subcutaneous bring residents to community health centres. Similar to NWT residents in general, the main reasons that people from these communities are admitted to hospitals are diseases related to the respiratory system, complications related to pregnancy/childbirth, diseases of the digestive system and mental disorders. The leading causes of deaths in First Nation impact communities are injuries/accidents, neoplasms and circulatory and respiratory diseases. Tuberculosis continues to be an issue for these First Nation communities. In 1997 nine cases were reported in Lutsel K'e and four cases in Rae-Edzo. Overcrowded housing and poor sanitation are among the conditions that contribute to the tuberculosis infections.

The level of sexually transmitted diseases is directly related to personal health practices. The incidence of sexually transmitted disease in First Nation impact communities remains many times higher than in the rest of Canada and higher than in the NWT as a whole. In 1991, 107 cases of chlamydia and gonorrhoea were reported in these First Nation communities, falling to 103 cases in 1996. In 1998, 121 cases of chlamydia, gonorrhea and hepatitis B were reported in these communities.

Housing conditions in First Nation impact communities are generally poorer than those in the NWT as a whole. While households in these communities were smaller in 1996 than in 1986, they have an average of 4 persons compared to the NWT average of 3.1 persons. Households in Rae-Edzo for example, had 4.5 persons in 1996 and in Wha Ti, households had 4.7 people (Table 3.9-4). Many households in these First Nation communities are also in "core need" (facing suitability, adequacy, affordability or multiple housing problems and income below the community income threshold). In Wha Ti and Snare Lake, 82.1% and 86.2% respectively, were identified as having a core need.

Table 3.9-4
Profile of Households and Families, 1986 and 1996

	Dettah		Lutsel K'e		Rae-Edzo		Snare Lake		Wha Ti	
	1986	1996	1986	1996	1986	1996	1986	1996	1986	1996
Private Households	30	60	50	85	250	370	15	35	55	90
Persons per Household	4.3	3.2	5.0	3.6	5.4	4.5	6.5	3.9	6.6	4.7
Husband-Wife Families	20	40	35	50	185	275	15	25	50	60
Lone Parent Families	5	10	15	15	55	60	--	10	10	15
Avg. # of Children per Family	2.4	1.8	2.7	2.1	3.2	2.5	3.7	2.3	3.5	2.8

Source 1996, 1991 and 1986 Census of Canada

The percentage of lone parent families largely remained unchanged in these First Nation communities between 1991 and 1996, making up 18% of all families. Relative to the number of households, there is a greater proportion of lone parent families in First Nation impact communities than in the NWT as a whole.

Family violence remains an important issue in the NWT and in First Nation impact communities. Family violence is defined as "physical, sexual, or mental abuse of one person by another, who is a member of the family or with whom the abused person has an intimate relationship" (Status of Women Council of the NWT, 1992). Reporting of family violence may not indicate the full extent of this crime as many incidents go unreported. Available data indicate that the extent of some violent acts within the family may be declining. Between 1991 and 1994, the average annual number of reported spousal assaults to the Rae-Edzo police detachment was 57. In 1995 and 1996, the average annual reported assaults to this detachment had declined to 44.

The *Child Welfare Act* provides protection of children 18 years of age and younger. The reasons that children come into care vary widely but neglect, abuse and other inappropriate behaviours within the family are known factors. As many as 50 children were brought into care in Rae-Edzo in 1996. By 1998, this number had dropped to 35. Both Rae Lakes and Wha Ti have had an increasingly higher incidence of children brought into care between 1996 and 1998 (Table 3.9-5).

Table 3.9-5
Children in Care in First Nation Impact Communities, 1995 to 1998

	Number of Children			
	1995	1996	1997	1998
Lutsel K'e	9	6	4	4
Rae Lakes	5	5	9	8
Rae-Edzo	65	50	27	35
Snare Lake	7	7	8	7
Wha Ti	7	7	5	12
Total	**93**	**75**	**53**	**66**

Source: Department of Health and Social Services. 1999. Community Health and Well Being 1998.
Note: A child is defined as a person under the age of eighteen. Data are unavailable for Dettah and N'dilo. Children included in the count were counted only once in the year, regardless of how many times he or she might be taken into care throughout the year.

The use of alcohol and drugs is wide spread in the northern population. While liquor is prohibited in Lutsel K'e, Snare Lake, Wha Ti and Rae Lake and is restricted in Rae-Edzo, alcohol and/or other drugs were contributing factors in 40% of the unlawful activity in the First Nations impact communities in 1995 and 36% of illegal activity in 1996 (Table 3.9-6). *Liquor Act* offences in First Nation impact communities consistently represented between one-quarter and one-third of all unlawful offences in 1995 and 1996. The remaining portion of unlawful activities are assaults, theft, property damage, and break and enter. As shown in Table 3.9-6, crime in these First Nation impact communities is declining. For example, the Rae police detachment reported 57% fewer crimes in 1996 than in 1993 and between 1995 and 1996, the incidence of crime in the region fell by 32% (Table 3.9-6).

3.9.2.3 Education

In 1998/99, school enrolment in First Nations impact communities (excluding N'dilo and Lutsel K'e students not attending school in their own community) was 858. Enrolment has declined by 3% since 1995/96. A declining school enrolment is contrary to overall trends in the NWT and may be attributed to more students attending school outside their home community. While enrolment is falling, high school graduation rates appear to be increasing. Between 1993/94 and 1995/96, Rae-Edzo graduated 24 students compared to nine graduates in the previous three-year period. Increasing graduation rates are consistent with higher levels of education being reported for the working age population in First Nation impact communities.

Table 3.9-6
Total Offences and Number of Crimes Where Alcohol and/or Other Drugs Was a Contributing Factor, 1995 and 1996

	Total 1995	A & D Related 1995	Total 1996	A & D Related 1996
Dettah	52	35	43	38
Lutsel K'e	195	33	148	6
N'dilo	100	72	84	50
Rae Lakes	15	2	18	2
Rae-Edzo	958	417	709	278
Snare Lake	2	0	3	0
Wha Ti	126	26	94	21
Rae Detachment	1127	452	858	306
Total	**2575**	**1037**	**1957**	**701**

Source: RCMP
Note: Includes crimes where alcohol or drugs were a contributing factor in the crime but does not include persons arrested for intoxication, drugs or charged with an offence under the Liquor Act and Regulations.

3.9.2.4 Labour Force Activity

Over half of the working age population in each First Nation impact community work at jobs and one-third or more pursue hunting, fishing and/or trapping activities. More than 80% of employed people in First Nation impact communities work in four occupational groups - sales/service (36%); trades/transport (16%); business and administration (12%); and trades/transport (16%). While lower than territorial levels, participation in the labour force in each of the First Nation impact communities increased substantially between 1989 and 1999 (Table 3.9-7). For example, labour force participation in Rae Lakes grew from 29.1% of the working age population in 1989 to 54.5% in 1999. In other communities, labour force participation has grown more steadily for instance, in Rae-Edzo participation rates were 53.3% in 1989 and 55.1% in 1999 (Table 3.9-7). Increasing participation rates may be attributed to greater access to, interest in and/or availability of wage employment activities.

Employment rates in First Nation impact communities were consistently below the NWT rate in 1994 and in some communities less than half the territorial rate. In all impact communities, employment rates remained the same or improved between 1994 and 1996. This trend has not continued into 1999. Between 1996 and 1999, the employment rate declined in Rae Lakes, Rae-Edzo, Snare Lake and Wha Ti. Over the past ten years, unemployment rates have declined in all First Nation impact communities except Rae-Edzo. The reasons for increasing levels of unemployment may be related to greater employment expectations, the requirement for higher levels of skills, or the availability of employment.

Table 3.9-7
Labour Force Activity in First Nation Impact Communities, 1989 to 1999

	1989	1991	1994	1996	1999
			Participation Rate		
Dettah	41.6	55.0	48.0	58.3	63.8
Lutsel K'e	44.6	62.2	62.3	54.8	66.4
Rae Lakes	29.1	56.3	37.4	54.5	54.5
Rae-Edzo	53.3	55.4	52.0	50.5	55.1
Snare Lake	43.6	56.3	31.5	61.1	65.8
Wha Ti	48.5	61.7	60.5	62.5	54.5
NWT	**74.9**	**78.2**	**77.2**	**77.2**	**78.3**
			Unemployment Rate		
Dettah	50.0	36.4	29.6	21.4	24.7
Lutsel K'e	39.1	26.1	31.7	13.0	28.4
Rae Lakes	56.4	22.2	10.8	38.9	42.7
Rae-Edzo	42.4	35.2	41.7	32.4	46.5
Snare Lake	52.9	22.2	17.2	27.3	35.6
Wha Ti	53.0	37.9	50.0	28.6	32.9
NWT	**13.2**	**11.3**	**14.8**	**11.7**	**13.7**
			Employment Rate		
Dettah	20.8	40.0	33.8	45.8	48.0
Lutsel K'e	27.2	43.2	42.6	45.2	47.5
Rae Lakes	12.7	43.8	33.3	33.3	31.2
Rae-Edzo	30.7	35.9	30.3	34.1	29.5
Snare Lake	20.5	50.0	26.1	44.4	42.3
Wha Ti	22.8	38.3	30.3	46.4	36.8
NWT	**65.0**	**69.3**	**65.7**	**68.2**	**67.5**

Source: Bureau of Statistics. 1999. 1999 NWT Labour Force Survey - Overall Results and Community Detail.

3.9.2.5 Income

The average income in selected First Nations impact communities (Lutsel K'e, Rae Lakes, Rae-Edzo, Snare Lake, and Wha Ti) in 1996 was $17,763, slightly more than half (53%) the NWT average. Incomes are increasing in these impact communities, rising by 3% in Lutsel K'e and Rae-Edzo and 14% in Snare Lake between 1991 and 1996. In 1991, the average annual income in these impact communities was 42% of the NWT annual average.

Prior to 1995 and changes in the NWT Income Support Program, annual income support expenditures to First Nations impact communities were increasing annually. Since 1995, expenditures and the number of income support cases have fallen to about 25% of the 1993 level. In 1998, $1,845,000 was paid to an average of 285 recipients and 695 beneficiaries in these impact communities. Reductions in income support are attributed mainly to changes in the Program.

3.9.2.6 Economy

The EIS Volume II, Section 4.2, describes the economy of the First Nation impact communities. As described in the EIS, the economy of these communities is mixed. Working age people residing in First Nation impact communities support themselves and their families through wage employment in public and Aboriginal government services including health and education and private businesses mainly in the retail, trade and transportation sectors. Most families pursue hunting and fishing activities which are important to offset the high cost of living in these communities. The cost of living in First Nation impact communities can be up to 35% higher than Yellowknife and 65% to 70% higher than Edmonton. Transfer payments in the form of income support round off the economy in these communities.

3.9.2.7 Infrastructure

The infrastructure for First Nation impact communities is described in the EIS Volume II, Section 4.2. Since 1995, the infrastructure in these communities has not changed substantially. Most smaller First Nation impact communities have the organizational, human and physical infrastructure to provide governance, health, education, recreation, protection, safety and basic daily living needs to community residents. Smaller communities have a school, community government administration facility, a recreation facility, health centre and one or two commercial establishments such as a general store, tourism outfitter and/or coffeeshop/arcade. In the larger communities of Rae-Edzo and to a lesser degree, Wha Ti, the infrastructure is more complex including a wider range of community facilities, administrative offices and commercial operations. Residents of First Nation impact communities continue to access services unavailable in their own communities in Yellowknife.

Governance structures in First Nation communities are based on a Chief and Council as described in the *Indian Act*. Public governance structures established by the Government of the NWT may also exist. In Rae-Edzo, the Hamlet of Rae-Edzo and the Rae Band First Nation Council function as two separate governing organizations. In Lutsel K'e, public and First Nation governance structures have been combined under one structure.

3.9.3 The Social, Cultural and Economic Environment of Yellowknife, NWT

The EIS identifies Yellowknife, the capital of the NWT, as a community directly impacted by the EKATI™ Diamond Mine.

3.9.3.1 Demographic Profile

Yellowknife has the largest population (17,275 in 1996) in the NWT, making up 43.5% of the total population of the territory. The capital city has been growing faster than the NWT, with the population increasing by 13.8% between 1991 and 1996. The population

in Yellowknife is expected to grow by another 10% by the year 2003 and a further 10% by 2008 (Table 3.9-8).

Table 3.9-8
Historic and Projected Yellowknife Population, 1981 to 2018

	Actual			Estimated			Projections		
Community	1981	1986	1991	1996	1998	2003	2008	2013	2018
Yellowknife	9,483	11,753	15,179	17,275	17,477	18,999	20,941	23,171	25,499

Source: Government of the Northwest Territories, Bureau of Statistics. 1999. Community Population Projections Northwest Territories, 1998 - 2018.

Yellowknife has the largest and fastest growing urban Aboriginal population in the NWT. Between 1986 and 1996, the Aboriginal population in the city grew from 16% to 20% of the total population. The 1996 Canada Census described the ethnicity of the Yellowknife population as 80.1% non-Aboriginal, 9.1% Dene, 7.1% Metis, 3.2% Inuit and .5% other Aboriginal. The city is a multi-cultural community with residents from virtually every country in the world.

Yellowknife's population is young, about 41% are persons 24 years of age and younger and 1.6% are persons 65 years of age or older. The Yellowknife birth rate in 1996 was lower than the territorial average, 18.7 per 1000 population as compared to 21.1. Teen births in the city are well below the territorial average, an average of 21 annually between 1991-1996 compared to 100 throughout the NWT). The city has a lower mortality rate than the NWT as a whole, 2.1 per 1,000 population in 1996 as compared to 3.6.

3.9.3.2 Human Health and Well-Being

Yellowknife is a magnet community for individuals and families from throughout the NWT and the Kitikmeot Region of Nunavut who are seeking social, health and education services and supports which are unavailable in their own community. The city is also a destination for northern and southern Canadian transients seeking work and other opportunities in the NWT. To some extent, the following description of human health and well-being is influenced by itinerant and transient residents.

Compared to other NWT communities, people in Yellowknife have access to a greater variety of housing, have fewer housing problems and are less subject to health and safety risks associated with inadequate housing. Housing surveys completed in 1992 and 1996 show that the percentage of households in Yellowknife with some type of core need (suitability, adequacy, affordability or multiple problems) declined from 5.5% in 1992 to 4.7% in 1996. These rates are well below the territorial average. Good housing conditions in Yellowknife may contribute to lower rates of tuberculosis in the city than elsewhere in the NWT. Between 1996 and 1998, 16 cases of tuberculosis were diagnosed in the city.

The structure of Yellowknife households differs from that in smaller NWT communities. In 1996, 23% were non-family (*e.g.* individuals and persons unrelated) households and 13.7% were lone parent households. The remaining households were headed by a husband and wife. Since 1991, the percentage of lone parent households has increased and the number of non-family households has declined. Yellowknife households are slightly smaller than the territorial average.

The family structure provides for the safety and security of its members, particularly more vulnerable members. An average of 197 children in Yellowknife were taken into the care of the government each year between 1996 and 1998. The reasons for children coming into care varies widely although neglect and poor parenting are factors. Spousal assaults are also an indicator of the health and well-being of families. Between 1991 and 1994, the number of reported spousal assaults in Yellowknife rose from 61 to 90. By 1996, the number of reported spousal assaults fell to 77. The number of women and children entering family violence shelters has remained stable for much of the decade. In 1997, 294 women (134) and children (160) sought shelter at the Alison MacAteer House in Yellowknife.

Crime rates in Yellowknife have remained stable. The number of offences related to theft (*e.g.* motor vehicle theft, theft over 5000), property damage and disturbing the peace have declined while the number of offences related to drugs and the *Liquor Act* have increased. Alcohol and/or other drugs were a contributing factor in approximately 10% of crimes in Yellowknife in both 1995 and 1996, a rate lower than that experienced in other NWT communities.

The physical health of Yellowknife residents is similar that of the NWT population as a whole. Yellowknife residents are less likely to die prematurely (*e.g.* before the age of 70 years) than residents of other communities in the NWT. The main cause of death in Yellowknife between 1986 and 1995 was injury and poisoning which accounted for one-third of the 317 deaths in the city over this period. Neoplasms accounted for one-quarter of deaths and suicides accounted for about 9% of deaths in the city in the same period.

The incidence of sexually transmitted disease in Yellowknife has fluctuated between 1991 and 1998. Between 1991 and 1996, an average of 111 cases of chlamydia and gonorrhea were diagnosed each year. In 1996, five cases of hepatitis C were diagnosed in the city. In 1998, 152 cases of chlamydia, gonorrhea and hepatitis C were recorded in Yellowknife. Overall, the rate of sexually transmitted disease in Yellowknife is lower than the rate recorded for the NWT as a whole.

3.9.3.3 Education

Yellowknife has 10 elementary and secondary schools. In 1996/97, the estimated capacity of the schools was 4,250 students and in the same year, student enrolment was 3,823. Between the 1990 and 1996 school years, enrolment in Yellowknife schools increased at an average of 2.5% per year. While Yellowknife's population has continued to grow, school enrolment has declined since 1995/96. In 1998/99, 3,665 students were

enrolled in city schools. Lower enrolment may be attributed to the changing age distribution of city residents.

Yellowknife students are more likely to graduate from high school than other students in the NWT. Each year between 1990 and 1996, Yellowknife schools graduated an average of 117 city residents. Educational achievement is also a characteristic of Yellowknife's working aged population. Educational levels are generally higher among city residents than among the NWT population as a whole. Among Yellowknife's working age population, only 4% have not achieved Grade 9. Over half of working age adults have achieved a university degree or other post-secondary certificate or diploma (Table 3.9-9).

Table 3.9-9
Highest Level of Education of NWT and Yellowknife Working Aged Adults, 1989, 1994 and 1999

	Yellowknife			NWT
	1989	1994	1999	1999
Population 15+ Years (N=)	9,193 (100%)	12,519 (100%)	13,139 (100%)	29,506 (100%)
< Grade 9	6%	5%	4%	13%
Grade 9 - 11	16%	16%	15%	19%
High School Diploma	28%	26%	28%	20%
Other Certificate/Diploma	30%	30%	33%	32%
University Degree	20%	23%	20%	14%
Not Provided	--	1%	1%	2%

Source: Government of the Northwest Territories, Bureau of Statistics. 1989 NWT Labour Force Survey and 1994 NWT Labour Force Survey.

3.9.3.4 Labour Force Activity

Yellowknife has the most active labour force in the NWT. In the decade between 1989 and 1999, labour force participation has consistently been higher than the overall NWT rate. Labour force activity has however, slowed in recent years. Participation of the Yellowknife labour force in 1996 and 1999, at 85.4% and 86.2% respectively, is slightly lower than rates recorded earlier in the decade, 87.3% in 1991 and 87.1% in 1989 (Table 3.9-10). Over this ten year period, the employment rate of the Yellowknife labour force also declined. In 1999, the employment rate of the Yellowknife labour force was 79.5% compared to 83.3% in 1989. The unemployment rate has risen over the ten year, from 4.4% in 1989 to 7.9% in 1999. Changes in labour force activity may be attributed to fiscal restraint and downsizing in the public sector, a major component of the Yellowknife economy.

Table 3.9-10
Yellowknife and NWT Labour Force Activity, 1989 to 1999

	1999	1996	1994	1991	1989
			Participation Rate		
Yellowknife	86.2	85.4	87.5	87.3	87.1
NWT	**78.3**	**77.2**	**77.2**	**78.2**	**74.9**
			Unemployment Rate		
Yellowknife	7.9	6.4	6.8	5.1	4.4
NWT	**13.7**	**11.7**	**14.8**	**11.3**	**13.2**
			Employment Rate		
Yellowknife	79.5	80.0	81.5	82.9	83.3
NWT	**67.5**	**68.2**	**65.7**	**69.3**	**65.0**

Source: Bureau of Statistics. 1999. 1999 NWT Labour Force Survey - Overall Results and Community Detail.

Working age people in Yellowknife are employed in a broader range of occupations than elsewhere in the NWT. The occupational distribution of employed Yellowknifers did not change significantly between 1994 and 1999. The greatest number of employed persons (35%) worked in management, business and administrative occupations. Sales and service occupations take up about 20% of the employed labour force and health, social science and education occupations another 15%. Between 1994 and 1999, the number of employed persons working in trades, transport and primary industries rose from 16% to 19% and the number employed in natural and applied science occupations fell from 10% to 5%. About 40% of Yellowknife adults hunt for recreational and/or domestic purposes and 7% are involved in craft activities.

Surveys conducted in 1989, 1994 and 1999 show changing characteristics of the Yellowknife labour force. Over the past decade, the percentage of working age people not working and wanting a job willing to take rotational employment has increased from 35% to 47%. At the same time, the percentage needing training has fallen from 55% to 48%.

3.9.3.5 Income

The average income of Yellowknifers is $41,482 (1996), about 23% higher than the territorial average. A pattern of higher than average income has been consistent for much of the last decade. Wage employment is the main source of income in Yellowknife.

In 1995/96, 671 Yellowknife residents received income support. The value of income support provided in the city was $3,789,000. Students, single parents, the unemployed and the working poor/inadequate income are the main users of income support. Among those receiving income support with a work history, the greatest number (37%) cited had experience working in the service sector. The greatest portion of income recipients in Yellowknife (39%) were between 25 and 34 years of age. More than half (53%) of those receiving income support in Yellowknife in 1995/96, had Grade 10 or more education.

Since 1995, income support use and benefits have declined. The value of payments issued in 1998 was $3,365,000.

3.9.3.6 Economy

The public sector is a dominant force in Yellowknife's economy. The three levels of government (municipal, territorial and federal) including health, education and social services contribute the greatest number of jobs, approximately 40%. The service sector is the second largest employer in the city, contributing about 15% of the jobs in Yellowknife. Yellowknife's service sector is the most diverse in the NWT, offering a range of personal, professional and business services. Transportation, communications and primary industries continue to make a substantial contribution to the Yellowknife economy. Like the service sector, these industries in Yellowknife are among the most diverse in the north. The economy of Yellowknife is changing as a result of downsizing and fiscal restraint in the public sector. Growth in the service and the non-profit sectors have been a consequence of less activity in the public sector.

The cost of living in Yellowknife is lower than that of many communities in the NWT. Still, costs in the city are 35% to 40% higher than in Edmonton.

3.9.3.7 Infrastructure

Yellowknife has the most developed infrastructure in the NWT. As the capital of the NWT and the only city in the territory, Yellowknife has a broad range of public and private infrastructure, and a sophisticated human and organizational infrastructure. The city boasts a variety of recreation facilities including two arenas, nine gymnasiums, indoor swimming pool, eight sheet curling rink, community library, 18 hole golf course, 350 seat performing arts centre and a host of other indoor and outdoor recreation spaces. The 84 bed Stanton Regional Hospital, Public Health Unit, variety of medical and dental clinics, group homes and seniors facilities add to the social infrastructure in the city. A new Aurora College Campus and a broad range of businesses in each economic sector are also features of the local infrastructure.

Yellowknife is served by an all-weather highway, two heliports, a variety of fixed wharfs and an airport with 7500' and 5000' asphalt runways. The city is the headquarters for northern operations of the federal government, such as the RCMP and the Department of National Defence. The city is also the headquarters for the Government of the NWT.

Yellowknife is governed by a city council with an administration of over 160 employees. A wide variety of Aboriginal and non-profit organizations serving the local and territorial populations are also based in the city. In 1999, an estimated 330 non-profit agencies were operating in Yellowknife.

3.9.4 The Social, Cultural and Economic Environment of West Kitikmeot Region of Nunavut Including Kugluktuk

The west Kitikmeot Region of Nunavut includes four communities - the regional centre of Cambridge Bay on Victoria Island, the mainland community of Kugluktuk, and the two small traditional communities of Bathurst Inlet and Umingmaktok. Kugluktuk, at the mouth of the Coppermine River, is considered an impacted community, and information provided in this section focuses on this community within its regional context. Baseline data for Kugluktuk (formerly known as Coppermine) is presented in the EIS Volume II, Section 4.3.

3.9.4.1 Demographic Profile

The majority of people (82%) in the west Kitikmeot Region of Nunavut have Inuit ancestry. Individuals of Inuit ancestry comprised 88.8% of Kugluktuk's population and virtually all of the small populations of Bathurst Inlet and Umingmaktok . (Table 3.9-11) Inuktitut or Innuinaqtun are spoken and/or understood by the vast majority of residents in these communities although English is increasing in use in the larger communities.

Table 3.9-11
Population Change in the West Kitikmeot Region, 1991 and 1996

	1991	1996	Change	Percent Change
Kugluktuk	1,059	1,201	142	13.4
Cambridge Bay	1,116	1,351	235	21.1
Bathurst Inlet	18	18	0	--
Umingmaktok	53	51	-2	-3.8
Total	**2,246**	**2,621**	**375**	**16.7**

Source: Statistics Canada, 1996 Census of Canada and 1991 Census of Canada.

In the five year period between 1991 and 1996, the population of the west Kitikmeot Region grew by 16.7%. Cambridge Bay saw the biggest increase in population over this period, growing by 21.1%.

The population in the west Kitikmeot Region is young mainly due to birth rates (26.2 per 1000 population) which are more than twice the national rate. About one-quarter of the births in the region are to teenage mothers. Over half (53%) of the region's population are 24 years of age or younger and 38% of these individuals are 14 years of age or younger. Almost 3% of the region's population is 65 years of age or more. Over the decade ending in 1996, death rates in the region have fallen from 5.6 (per 1000 population) to 3.8.

3.9.4.2 Human Health and Well-Being

The health and well-being of residents in the west Kitikmeot region compares with other northerners. Improvements are being recorded in some areas, leading to better health circumstances. Housing circumstances are improving. In 1996, fewer people were residing in Kugluktuk households (3.8 persons) compared to 4.6 in 1986. Further, the percentage of households in the region in 'core need' (households facing suitability, adequacy, affordability, or multiple housing problems and income below the community income threshold) fell from 40.7% in 1992 to 25% in 1996. While housing circumstances improved in the region overall, those in Umingmaktok worsened with all households reporting core need in 1996. Poor housing contributes to health and social issues.

The structure of families residing in west Kitikmeot households has not changed significantly in the last decade. Most households are headed by husband and wife families although the number of non-family and single parent households has increased slightly in both Kugluktuk and Cambridge Bay. Compared to the NWT and First Nation impact communities in the NWT, the needs of children appear to be met by the family. In the four years between 1995 and 1998, an average of 11 children came into care in Kugluktuk each year. Crime statistics for Kugluktuk show a decline in offences under the Child Welfare Act while Cambridge Bay has seen an increase in offences under the Act.

A significant number of families in Cambridge Bay and Kugluktuk experience violence. This does not seem to be the case for the smaller communities of Umingmaktok and Bathurst Inlet. One of every 15 adults (15+ years of age) in each of Cambridge Bay and Kugluktuk was affected by spousal assault in 1996.

The level of personal safety of residents of the west Kitikmeot is evidenced in part, by the number and type of offences recorded by the police. Between 1993-1996, two homicides (attempted murder and manslaughter) were recorded in each of Cambridge Bay and Kugluktuk. The incidence of sexual assault, other sexual offences, and other assaults has also remained high in these communities over this period. Alcohol or drugs were a contributing factor in about 33% of offences in Kugluktuk and Cambridge Bay in 1996.

The physical health of residents in the west Kitikmeot is similar to that of other northerners. Conditions related to the respiratory and nervous systems, sense organs, injury and poisoning, digestive system and skin/subcutaneous tissue are the main reasons for visits to health centres in Kugluktuk and Cambridge Bay. High risk behaviours including the use of cigarettes contribute to these conditions. High risk behaviours contributed to the incidence of sexually transmitted disease in the region. One in 23 adults (15+ years of age) in Cambridge Bay and Kugluktuk may be infected by chlamydia or gonorrhea.

In the first half of the 1990s, an average of 5.2 individuals in the west Kitikmeot were diagnosed with cancer. Neoplasms account for about 23% of the deaths in the region. Other main causes of death are injury and poisoning, diseases of the circulatory and the respiratory system. Of the 16 suicides that occurred in the region between 1986-1995,

81% took place in Kugluktuk. The issue of suicide particularly among young men, is a main concern of Kugluktuk residents.

3.9.4.3 Education

Enrolment in the three schools in the west Kitikmeot region continues to increase. The enrolment of 788 students in 1996-97 is 53% higher than in 1990-91. High school graduates from the two larger communities in the regions are also increasing, averaging about five students each year.

Greater use of student financial assistance and enrolments at Nunavut Arctic College program indicate that adults in the region are furthering their education. More adults are achieving some high school education and post-secondary certification/diploma. Labour force surveys show that about 35% of the working age population in the larger communities have post-secondary education either in the form of a university degree or other certificate/diploma. Education does remain a challenge for a significant portion of the working age population. Over one-third of the working age population have not achieved a basic level of literacy (*e.g.* Grade 9).

3.9.4.4 Labour Force Activity

The working age population (15+ years of age) in the west Kitikmeot region is relatively small, numbering less than 1500 people. Almost three-quarters of working aged people in Cambridge Bay participate in the labour force compared to 58% in Kugluktuk. Of the 34 working age people in Umingmaktok, 44% participate in the labour force. More than half of working age people in Kugluktuk and Umingmaktok hunt and fish, and one-third or more participate in craft activities.

In the last half decade, Kugluktuk's labour force participation rates increased from 54% (1994) to 58% (1999) of persons 15 or more years of age. Over this same period, employment increased from 69% to 72% and unemployment fell from 31% to 28% (Table 3.9-12). Among persons not working and wanting a job in Kugluktuk, fewer are willing to do rotational work and to feel that they need training. Interest in doing rotational work has dropped from 78% of those not working and wanting a job in 1989 to 58% in 1999.

3.9.4.5 Income

The average income (1996) in the large communities of the west Kitikmeot is $22,739 in Kugluktuk and $32,143 in Cambridge Bay. Between 1992 and 1996 incomes have increased by about 12% for people in Kugluktuk and fallen by 7% for income earners in Cambridge Bay. The reasons for declining income in Cambridge Bay are unknown.

Table 3.9-12
A Profile of Working Aged Adults, Kugluktuk, 1994 and 1999

	Kugluktuk	
	1999	1994
Pop. 15+ Yrs.	**821 (100%)**	**710 (100%)**
15-24 Years	25%	28%
25-64 Years	67%	66%
65+ Years	7%	8%
Aboriginal	87%	86%
Non-Aboriginal	13%	14%
Pop. 15+ Yrs	**821 (100%)**	**710 (100%)**
Worked at Job	58%	58%*
Trapped	10%	7%
Hunt/Fish	58%	56%
Crafts	43%	31%
Pop. 15+ Yrs.	**821 (100%)**	**710 (100%)**
Participation Rate	58%	54%
Labour Force	476 (100%)	383 (100%)
Employed	72%	69%
Unemployed	28%	31%
Employed	**345 (100%)**	**263 (100%)**
Aboriginal	70%	71%
Non-Aboriginal	30%	30%
Number Not Working and Wanting a Job	**476 (100%)**	**292 (100%)**
Do Rotational Work	58%	71%
Need Training	62%	83%

Source: NWT Bureau of Statistics, 1999 NWT Labour Force and 1994 NWT Labour Force Survey

*** Does not total 100% due to multiple activities. 1999 hunting data includes recreational hunters.**

Income support is an important part of the local economy in most west Kitikmeot communities. Income support may be sought by as many as 30% of the community population at various times throughout the year. In 1998, the value of income support payments in Kugluktuk was $872,000 to an average of 123 recipients and 312 beneficiaries. The main reasons people in the region seek income support is lack of other income options or as an income supplement.

3.9.4.6 Economy

The economy of the west Kitikmeot is a mix of wage earning and harvesting activities, and transfer payments. The public sector (government, health and education services) contributes the largest number of jobs in the region. In 1997, the GNWT employed 78 people in Kugluktuk and 42% of these employees had Aboriginal ancestry. The service, transportation, construction and primary industry sectors contribute the remaining jobs. The mineral sector employs people in most west Kitikmeot communities.

The cost of living in the west Kitikmeot region is high. In Kugluktuk, the cost of living is estimated at 85%-90% higher than Edmonton.

3.9.4.7 Infrastructure

The human, physical and organizational infrastructure varies widely among the communities in the west Kitikmeot region. Bathurst Inlet has no public infrastructure. Private infrastructure is limited to a seasonal naturalist lodge. Umingmaktok has a school, airstrip, and store and receives itinerant services from Cambridge Bay. Both Kugluktuk and Cambridge Bay have a range of private and public infrastructure. Both communities are governed by a hamlet council and residents have access to a variety of other organizations designed to respond to specific human, economic, and land and resource issues.

4. ENVIRONMENTAL EFFECTS ASSESSMENT

4.1 General Scope of Assessment

4.1.1 Scope of the Proposed Development

The Project Description Report provided by BHP in November 1999 was used by the Mackenzie Valley Environmental Impact Review Board (MVEIRB) to develop Terms of Reference for the Environmental Assessment for the proposal to add the Sable, Pigeon and Beartooth kimberlite pipes to the EKATI™ Mine Plan (MVEIRB, 1999).

The scope of the EKATI™ Diamond Mine development includes:

- mining of Sable, Pigeon and Beartooth pipes;
- waste rock, overburden and lake bottom sediment management;
- water management structures (retention/diversion dams, semi-pervious dyke, stream diversion and pipelines);
- lake dewatering and pit water management;
- road construction and operation; and
- borrow pits and quarry sites.

The MVEIRB has also requested information on aspects of the proposed development that will integrate with existing infrastructure, facilities and operating procedures at the EKATI™ Mine. These include:

- processed kimberlite management;
- sewage and waste management;
- use of existing roads and transportation infrastructure; and
- existing environmental effects monitoring programs.

4.1.2 Scope of Assessment

The Environmental Assessment has been prepared in general accordance with the Terms of Reference of the MVEIRB, to assist the MVEIRB, regulatory agencies, Aboriginal organizations and other interested parties in understanding the anticipated environmental and socio-economic consequences of the proposed development. As a result, the Environmental Assessment Report (EAR) examines the predicted effects, including possible cumulative effects, of the proposed development on the physical, biological, socio-economic and cultural components of the environment in the development area and the region.

4.2 Assessment Methodology for New Pipes

The assessment methodology for the new pipes is divided into two sections:

- biophysical; and
- social, cultural and economic.

The key components that could potentially affect the natural environment are presented and used to establish a ranking system for the assessment of environmental effects. To facilitate this evaluation, the ecological parameters of the VECs were reviewed and the attribute tables developed to provide a transparent process for the effects assessment. The assessment methodology for the social/cultural/economic environment is discussed in Section 4.7.

4.2.1 Background and General Methodology

The current proposed development represents an addition to the existing EKATI™ Diamond Mine, which was subjected to comprehensive environmental assessment and review under the Federal Environmental Assessment and Review Process in 1995/96. The recommendations arising from that assessment have led to the establishment of a world-class effects and compliance monitoring program at EKATI™.

As part of the NWT Diamonds Project approval, a number of binding agreements were negotiated, including an Environmental Agreement, a Socio-Economic Agreement and a series of Impact and Benefits Agreements. The Socio-Economic Agreement provides for the monitoring of key economic indicators, employee attitudes and community wellness. The responsibility for the activities are split between BHP and the GNWT.

In addition to annual reports, the Agreement requires BHP to produce an environmental impact report every three years "*on the longer term effects of the Project*[1] *and the results of environmental monitoring programs and the actual performance of the Project in comparison to the results in the Impact Statement*[2]" (Article V.2.a). The document must also evaluate how BHP's adaptive management has performed to date. BHP has consulted the Agency and regulatory agencies on the framework for the first Environmental Impact Report referred to as the Impact 2000 Report, which is due April 30, 2000. Compliance monitoring at EKATI™ is based on the criteria of EKATI™'s existing Type A Water Licence.

Recognizing these earlier and continuing initiatives, the environmental assessment methodology employed in this EAR has been adapted from and is intended to complement the methods used in these other monitoring efforts.

[1] Project refers to EKATI™ Diamond Mine.

[2] Impact Statement refers to the 1995 EIS.

4.2.1.1 Valued Ecosystem Components

The resulting environmental assessment methodology uses Valued Ecosystem Components (VECs) as the primary focus for evaluating the possible effects of the proposed development. VECs have been identified and refined over the past five years, as a result of the continuing compliance and effects monitoring and the effective dialogue that has taken place amongst the various stakeholders.

As a result, the original list of VECs used for the 1995 EIS has been reduced from 16 to 10 for both the current EAR and the Impact 2000 Report. A summary of these changes is provided in Table 4.2-1 below.

Table 4.2-1
Comparison of VECs Used for the 1995 EIS, the 2000 EAR and the Impact 2000 Report

1995 EIS[1]	2000 EAR[2]	IMPACT 2000[3]
Air Quality	Air Quality	Air Quality
Permafrost	Permafrost	Permafrost
Eskers	--	--
Water Quality	Surface Water Quality and Quantity	Surface Water Quality and Quantity
Hydrology	--	--
Fish/Aquatic Habitat	Fish/Aquatic Habitat	Fish/Aquatic Habitat
Vegetation	Physical/Terrestrial Environment	Physical/Terrestrial Environment
Wildlife/Wildlife Habitat	--	--
Caribou	Caribou/Habitats	Caribou/Habitats
Grizzly Bears	--	--
Wilderness	--	--
Carnivores/Habitats	Carnivores/Habitats	Carnivores/Habitats
Breeding Birds/Habitats	Breeding Birds/Habitats	Breeding Birds/Habitats
Biodiversity	--	--
Climate	--	--
Groundwater	Groundwater	Groundwater
--	Heritage Sites	Heritage Sites

1: Environmental Impact Statement (BHP 1995).
2: Environmental Assessment Report for Sable, Pigeon and Beartooth pipes (this document).
3: Three year Environmental Impact Report.

The rationale for the changes that were made to the VECs employed in this assessment follows:

- *Eskers (deleted/incorporated)* – Eskers *per se* are not a VEC. Eskers are a component of the VECs: wildlife habitat (carnivore, caribou and breeding birds),

Physical/Terrestrial environment and heritage sites. Changes to eskers have the potential to affect these VECs. Hence eskers were incorporated with these VECs.

- *Hydrology (incorporated with water quality)* – Hydrology was incorporated with water quality. Hydrology and water quality compliment each other and need not be treated separately.
- *"Wildlife"* – The VECs related to "wildlife" were changed to be more consistent with the aquatic community. The VEC for the aquatic community is "Fish/Aquatic Habitat". The wildlife VECs were revised to Caribou/Habitats, Carnivores/Habitats and Breeding Birds/Habitats.
- *Vegetation, Wilderness (incorporated)* – A more applicable VEC called "Physical and Terrestrial Environment" was developed to incorporate changes to the local landscape. This category facilitates discussion on the project footprint and its effect on physical losses (area, physical and biological diversity).
- *Biodiversity (deleted)* – This VEC was considered to be too general to allow effective measurement. Biodiversity can be argued to be a component of other VECs, *e.g.*, an effect on water quality (VEC) may affect the diversity of the fish population (fish is a VEC).
- *Climate (incorporated)* – Climate was combined into air quality.
- *Valued Cultural Components, Heritage Sites (added)* – An importance is put on archaeological and contemporary and traditional land use sites and graves. It is a goal of EKATI™ economic management programs not to have effects on significant heritage sites. Archaeological and traditional sites, however, are not part of the "ecosystem." A new category was added to allow the inclusion of heritage sites in the assessment of potential environmental effects.

Using the VECs as the primary focus for the analysis, the assessment of potential effects is based on a review of the main proposed development activities that could cause environmental consequences. The analysis examines all phases of the proposed development including: construction, operation, decomissioning and post-decomissioning. The likely interactions, both direct and indirect, between mine activities and environmental components are described.

4.2.1.2 Utilization of Experience and Monitoring Data

The assessment draws heavily on the past three years of direct construction, development, operations and environmental management experience gained at the EKATI™ Diamond Mine. This has been complemented with the comprehensive results obtained through the various ongoing environmental monitoring programs.

Environmental management at EKATI™ utilizes both compliance and effects monitoring. Compliance monitoring is primarily associated with compliance to regulated levels of discharge as specified in EKATI™'s Type A Water Licence. Effects monitoring is tied to the Environmental Agreement and Water Licence. Environmental monitoring under the Environmental Agreement is addressed in detail in BHP's

Operating Environmental Management Plan (OEMP). That umbrella plan includes but is not limited to; the Aquatic Effects Monitoring Program (AEMP), the Wildlife Effects Monitoring Program (WEMP), Air Quality, Materials Management, Spill and General Contingency, Waste Management, Traffic Management, Quarry Management and Archaeological Site Management plans.

The existing monitoring plans will be appropriately modified based on any criteria imposed by the new Type B Water Licence for dewatering Sable, Pigeon and Beartooth lakes, stipulations of the new Fisheries Authorization and recommendations for monitoring that arise from the current assessment. The modification of the monitoring plans will occur following the environmental assessment phase of the permitting process when all new requirements associated with the addition of the three new pipes to the EKATI™ mine plan are known.

4.2.1.3 Spatial Boundaries

Based upon the experience of three and a half years of original baseline studies (1993 to 1996), three years of effects and compliance monitoring for EKATI™ (1997 to 1999) and three and a half years of baseline studies for Sable, Pigeon and Beartooth (1996 to 1999), it was determined that the spatial boundaries, which define the geographic extent within which mine-related activities may affect a VEC should be revised from those used in BHP's 1995 EIS. This change is being made both for this EAR and the Impact 2000 report. The optimized boundaries more realistically define the bounds of local and theoretical boundaries of potential cumulative effects.

The spatial boundaries incorporated into the original impact definitions pertaining to physical and biological components were based on "Terrestrial Ecozones and Ecoregions of Canada," a map developed by Environment Canada and Agriculture Canada (Ecological Stratification Working Group, 1995). The application of this approach resulted in the definition of geographic extents wherein possible effects could be predicted, including:

- Local - Ecosection 168, which is large enough to contain all of the Lac de Gras Watershed and the Yamba/Exeter Lake Watershed and covers approximately 50,000 km^2;
- Regional - Takijuk Lake Upland Ecoregion, which contains the Coppermine River Drainage Basin and covers approximately 116,600 km^2; and
- Greater than Regional - Southern Arctic Ecozone.

Although the use of these definitions served their purpose for the 1995 EIS, it was determined that they were not well suited for continued use at this time. In particular, actual operating experience and the results of the comprehensive monitoring programs carried out over the past three years have confirmed that the spatial limits of any measurable effects observed for the VECs being monitored have generally been very localized.

As a result, for the current EAR assessment, as well as for the Impact 2000 Report, a decision was made to redefine the local, regional and broader spatial boundaries into smaller, more appropriate units.

In addition it was also recognized that different boundaries were needed, depending on the VEC that was being assessed. In particular, it was necessary to define more relevant boundaries for addressing water-related VECs compared to terrestrial VECs.

Notwithstanding the substantial changes that have been made to the spatial boundaries, based on the best professional judgement of the assessment team, the basic predictions of environmental effects made in BHP's 1995 EIS are still appropriate today, using these new much smaller boundaries for assessment. The details of the boundary areas defined for each VEC are presented in the following sections.

4.2.2 Specific Assessment Methodology

The following sections describe in detail the methodology used to assess the significance of any residual effects associated with each VEC. Residual effects refer to those effects that are predicted to remain after the application of mitigation measures. Methodologies in general were similar to those utilized in the 1995 EIS. Improvements were made where it was appropriate. Assessment of the VECs was grouped into more all-inclusive sections entitled air, land, water and wildlife. VECs addressed in each section of this chapter are presented in Table 4.2-2.

Table 4.2-2
VECs assessed within each General Section of the EAR

General Section	Section Number	VECs Included
Air	4.3	Air Quality
Land	4.4	Permafrost
		Physical/Terrestrial Environment
		Groundwater
		Heritage Sites
Water	4.5	Surface Water Quality and Quantity
		Fish/Aquatic Habitat
Wildlife	4.6	Caribou/Habitats
		Carnivores/Habitats
		Breeding Birds/Habitats

For each VEC, potential effects as a result of specific mine-related activities are identified and described. After each description of a potential effect, a discussion is provided on the mitigation measures that have been developed and successfully applied at the existing EKATI™ Diamond Mine. Where appropriate, innovative or new approaches which may be used at the proposed Sable, Pigeon and Beartooth sites to minimize/mitigate environmental effects are discussed. Specific operating policies and

environmental management procedures that either will or may be employed to minimize effects are discussed as appropriate.

The significance of any residual effects are classified as being negligible, minor, moderate, or major. To assign a significance classification to a residual effect several different attributes were considered, including:

1. geographic extent – the geographic extent to which a development activity may affect the VEC;
2. duration – the length of time that a development activity has the potential to affect the VEC;
3. frequency – the rate of reoccurrence of a development activity over the duration of potential effect;
4. reversibility – the degree (or length of time) to which the environment will recover after the mine-related activity having the potential to affect the VEC has ceased;
5. probability – how likely an effect is to occur;
6. capacity of renewable resources to meet the needs of the present and future (sustainable development);
7. ecological context – the qualitative consideration of ecological interactions based on best professional judgement; and
8. magnitude – the degree of deviation from the current conditions or accepted guidelines, and/or the number of individuals affected.

The attributes considered were generally consistent for each VEC. However, the attribute definitions vary depending on the characteristics of the VEC. Attribute definitions used for the assessment are provided in Tables 4.2-3 through 4.2-6.

Depending on the VEC being considered, some attributes are more important than others. In general, geographic extent and duration were often considered to be of greatest importance when assigning the significance rating to a residual effect. However, best professional judgement was also utilized in drawing the final conclusion about the overall significance of a residual effect.

4.2.2.1 Air Quality

The methodology in Section 4.2.2 was used to assess all residual effects related to air quality resulting from development of the three kimberlite pipes. The assessment was conducted by an air quality specialist who drew upon experience gained from previous air quality modelling information. The attributes in Table 4.2-3 were applied to all

Table 4.2-3
Impact Attribute Definitions for Air Quality

Geographic Extent	Duration	Frequency	Reversibility[1]	Probability	Future Capacity of Renewable Resources (sustainability)	Magnitude[2]	Increasing Potential Effect
Portion of Local Area Within 100 m of emission source	Very Short Term[2] <1 hour	Rare <1 time per year	IS Reversible <3 years	VERY UNLIKELY to occur	The impact on the VEC would not reduce capacity of the resources to meet needs	CAAQO maximum	↓
Local Area Within claim boundary	Short Term <24 hours	Regularly 1 time per month	IS Reversible 3 to 5 years	UNLIKELY to occur	The impact on the VEC MAY reduce capacity of the resources to meet needs	>CAAQO maximum	
Regional Area Region within 100 km radius	Moderate Term >1 year	Regularly 1 time per day	MAY be Reversible 5 to 10 years	MAY occur	The impact on the VEC would LIKELY reduce capacity of the resources to meet needs	>>CAAQO maximum	
Global Area Hemispheric or global scale related to climate change	Moderate to Long Term >5 years		UNLIKELY Reversible (includes NOT reversible)[3] > 10 years	LIKELY to occur			

1. **The EIS had NOT reversible as a separate rating identified as "nil".**
2. **Candian Ambient Air Quality Objectives air pollutant levels recommended by Environment Canada.**

Table 4.2-4
Impact Attribute Definitions for Permafrost, Groundwater, Physical/Terrestrial Environment and Heritage Sites

Geographic Extent[1]	Duration	Frequency[3]	Reversibility[4]	Probability	Future Capacity of Renewable Resources (sustainability)	Increasing Potential Effect
Portion of Local Area Very small geographic extent; portion of WEMP Boundary	Very Short Term[2] < 3 years	Rare <1 time per year	IS Reversible < 3 years	UNLIKELY to occur	The impact on the VEC would not reduce capacity of the resources to meet needs	↓
Local Area WEMP Boundary	Short Term < 10 years	Regularly 1 time per week up to 1 time per year (1 wk < regular < 1 yr)	MAY be Reversible < 10 years	MAY occur	The impact on the VEC MAY reduce capacity of the resources to meet needs	
Portion of Regional Area Portion of BHP Claim Block Boundary	Moderate Term > 10 years	Often More than once per day (includes continuous)	UNLIKELY Reversible (includes NOT reversible)[5] > 10 years	LIKELY to occur	The impact on the VEC would LIKELY reduce capacity of the resources to meet needs	
Most of Regional Area BHP Claim Block Boundary	Moderate to Long Term Several decades					

1. **Geographic extent (spatial boundaries) for assessment have been redefined from the 1995 EIS for land related VECs.**
2. **Short Term was not defined in the 1995 EIS.**
3. **Frequency was not defined in the 1995 EIS in absolute terms.**
4. **EIS did not place time scale on reversibility. Time scale was imposed to place reversibility into reasonable perspective.**
5. **The EIS had NOT reversible as a separate rating identified as "nil".**

Table 4.2-5
Impact Attribute Definitions for Water Quality, Quantity and Fish/Aquatic Habitat

Geographic Extent[1]	Duration	Frequency[3]	Reversibility[4]	Probability	Future Capacity of Renewable Resources (sustainability)	Increasing Potential Effect
Portion of Local Area Very small geographic extent; small area within Koala or Yamba/Exeter watersheds	Very Short Term[2] < 3 years	Rare <1 time per year	IS Reversible < 3 years	UNLIKELY to occur	The impact on the VEC would not reduce capacity of the resources to meet needs	↓
Local Area Koala Watershed and/or specific subdrainages of Yamba/Exeter Lake watershed as defined	Short Term < 10 years	Regularly 1 time per week up to 1 time per year (1 wk < regular < 1 yr)	MAY be Reversible < 10 years	MAY occur	The impact on the VEC MAY reduce capacity of the resources to meet needs	
Portion of Regional Area Lac de Gras and Yamba/Exeter Lake watersheds and the downstream area to Lake Providence on the Coppermine River	Moderate Term > 10 years	Often More than once per day (includes continuous)	UNLIKELY Reversible (includes NOT reversible)[5] > 10 years	LIKELY to occur	The impact on the VEC would LIKELY reduce capacity of the resources to meet needs	
Most of Regional Area Coppermine River Drainage Basin downstream of Lake Providence	Moderate to Long Term Several decades					

1. **Geographic extent (spatial boundaries) for assessment have been redefined from the 1995 EIS for aquatic VECs.**
2. **Short Term was not defined in the 1995 EIS.**
3. **Frequency was not defined in the 1995 EIS in absolute terms.**
4. **EIS did not place time scale on reversibility. Time scale was imposed to place reversibility into reasonable perspective.**
5. **The EIS had NOT reversible as a separate rating identified as "nil".**

Table 4.2-6
Impact Attribute Definitions for Wildlife and Wildlife Habitat

Geographic Extent[1]	Duration	Frequency[2]	Reversibility[3]	Future Capacity of Renewable Resources (sustainability)[5]	Increasing Potential Effect
Local Study Area WEMP study area; approx. 1,600 km².	**Long Term** > 10 years (disturbance/displacement effects)	Exposure to individuals is predictable, periodic, and in total is a few days per year	IS Reversible < 10 years post-operation	Effects on VEC will not reduce population size or ecosystem function	↓
Regional Study Area BHP Claim Block; approx. 3,500 km²	**Very Long Term** Several decades (habitat loss)	Exposure to individuals is unpredictable, episodic, and in total is a few days per year	MAY be Reversible < 10 years post-operation	VEC effects MAY SLIGHTLY reduce population size or ecosystem function	
Greater than Regional Area (varies with VEC)		Exposure to individuals is unpredictable, episodic, and in total is several to many days per year	UNLIKELY Reversible (includes NOT reversible)[4] > 10 years post-operation	VEC effects MAY MODERATELY reduce population size or ecosystem function	
		Continuous exposure during the portion of the year that individuals are present		VEC effects WILL LIKELY reduce population size or ecosystem function	

1. Geographic extent (spatial boundaries) for assessment have been redefined from the 1995 EIS for wildlife VECs.
2. Frequency was not defined in the 1995 EIS in absolute terms. The frequency of habitat disruption and disturbance stimuli is continuous, but the effect on wildlife is intermittent and based on the frequency of exposure resulting from wildlife movements.
3. EIS did not place time scale on reversibility. Time scale was imposed to place reversibility into reasonable perspective.
4. The EIS had NOT reversible as a separate rating identified as "nil".
5. Considers the ecological context of the effect, a qualitative attribute based on Best Professional Judgement where the residual effects are discussed in context of the population and the ecosystem.

residual effects to assign a significance rating. The sub-categories of geographic extent were generally based on distance from point source and not fixed boundaries since air quality issues are most severe at the point source. However, the regional spatial boundary for air quality was defined as the BHP claim block and is illustrated in Figure 4.2-1.

The magnitude of a residual effect was also considered. Federal guidelines set forth by Environment Canada were utilized to aid in the determination of the significance of any potential residual effects.

4.2.2.2 Permafrost

The methodology used to assess the significance of predicted residual effects with regards to permafrost drew upon the expertise of professionals who specialize in civil/geotechnical engineering in an arctic environment. These professionals are familiar with not only site specific conditions at EKATI™ but are also well-versed in surficial geology and the geomorphology of glacial landforms. Sound engineering judgement was utilized when concluding the significance of any potential residual effect. The assessment is qualitative, as there are no quantitative adherence parameters set forth by governing regulatory agencies. The significance of any predicted residual effects on permafrost were assessed using the impact attributes listed in Section 4.2.2. The impact attributes and their sub-categories utilized for the assessment of permafrost related residual effects are presented in Table 4.2-4. The spatial boundaries used for the assessment are indicated in Figure 4.2-1.

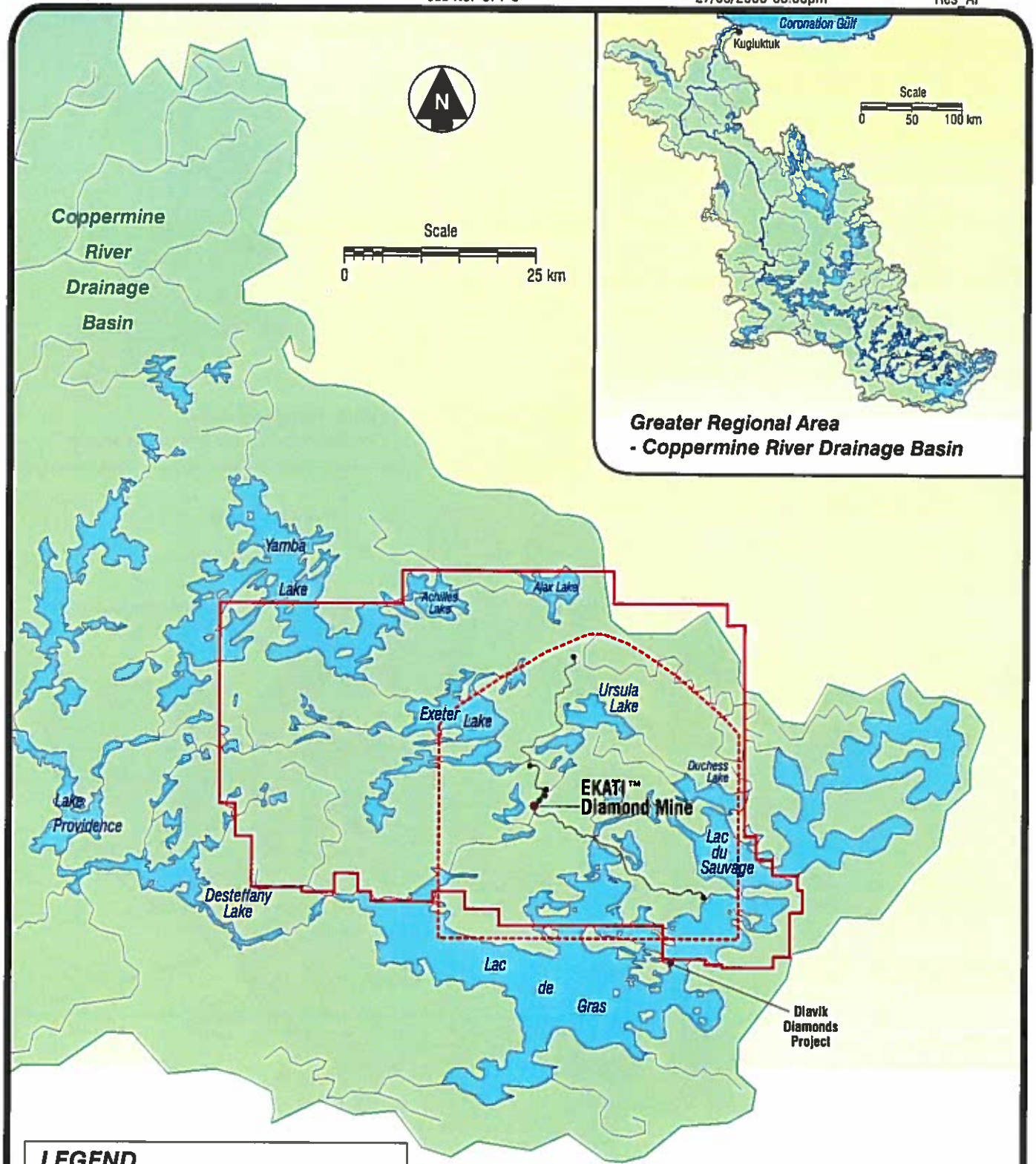
4.2.2.3 Physical/Terrestrial Environment

This VEC incorporates both ecosystem components as well as landscape related issues that need to be discussed when considering future development. The ecosystem components include vegetation, biodiversity, and productivity. The landscape related issues include frost heave, earthquake hazard, and pit slope stability. The ecosystem components were assessed based on the general methodology presented in Section 4.2.2.

The impact attributes and their definitions utilized for the assessment of the vegetation, biodiversity, and productivity related residual effects are presented in Table 4.2-4. The spatial boundaries used for the assessment are indicated in Figure 4.2-1.

4.2.2.4 Groundwater

The methodology used to assess the significance of predicted residual effects with regards to groundwater utilized sound engineering judgement when concluding the significance of any potential residual effect.



LEGEND

Terrestrial Assessment Boundaries

------ Local Study Area (WEMP Boundary)

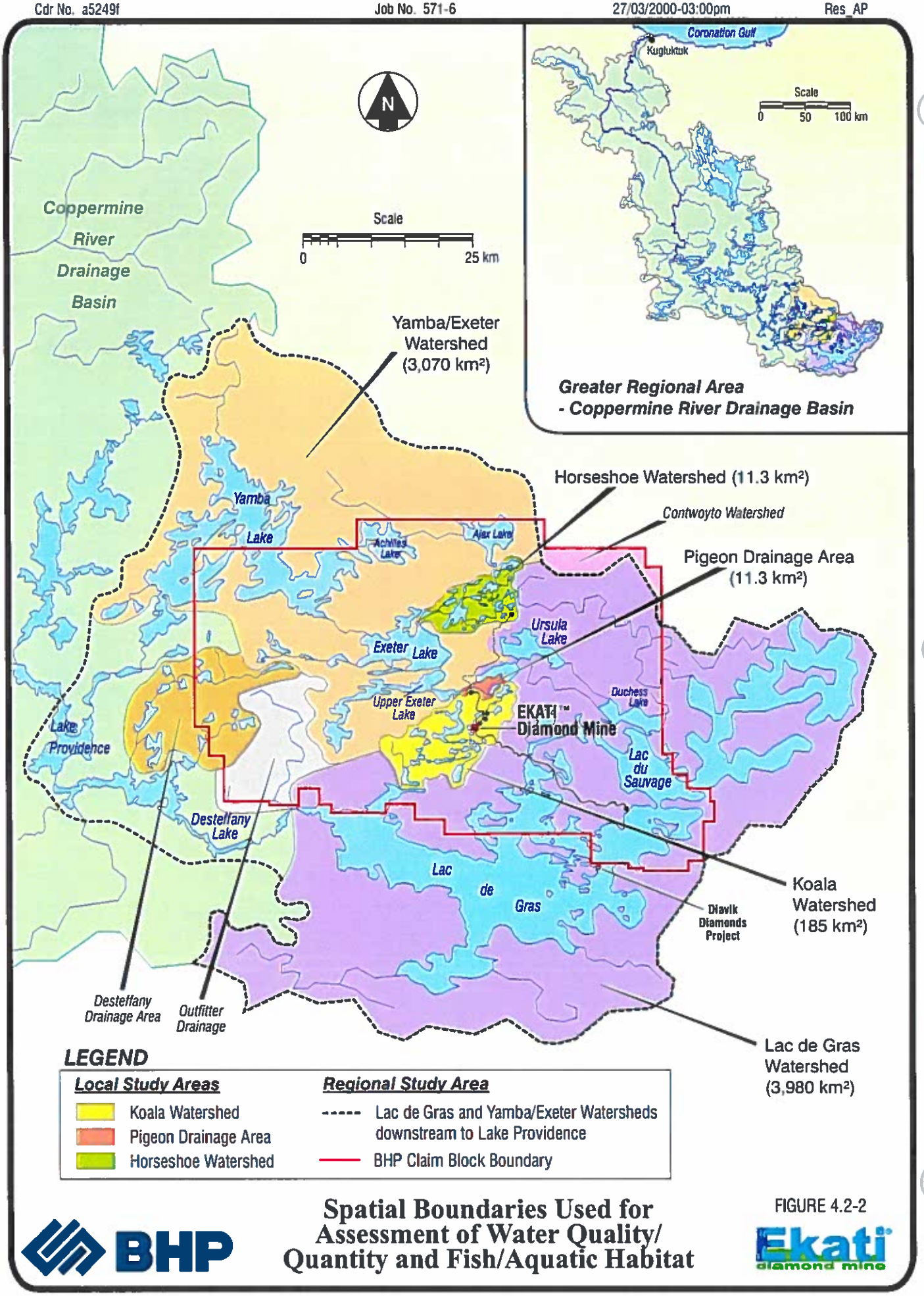
—— Regional Study Area
(BHP Claim Block Boundary)

Spatial Boundaries Used for Assessment of Air and Land-Related VECs

FIGURE 4.2-1

BHP

Ekati diamond mine



Spatial Boundaries Used for Assessment of Water Quality/ Quantity and Fish/Aquatic Habitat

FIGURE 4.2-2

The results from the groundwater modelling conducted in 1995 and 1996 have been used to assess the significance of any predicted residual effects on groundwater.

The significance of any predicted residual effects on groundwater were assessed using the impact attributes listed in Section 4.2.2. The impact attributes and their definitions utilized for the assessment of groundwater related residual effects are presented in Table 4.2-4. The spatial boundaries used for the assessment are indicated in Figure 4.2-2.

4.2.2.5 Heritage Sites

The methodology in Section 4.2.2 was used to assess all residual effects relating to heritage sites that result from the development of the three kimberlite pipes. The assessment was conducted by a professional archaeologist with over six years of archaeological experience within the BHP claim block. The attributes in Table 4.2-4, with the exception of future capacity of renewable resources, were applied to all residual effects to assign a significance rating. The future capacity of heritage sites as a renewable resource was not considered because heritage sites are not renewable resources. The sub-categories of geographic extent used for the assessment of residual effects relating to heritage sites are illustrated in Figure 4.2-1.

4.2.2.6 Surface Water Quality and Quantity

The significance of any predicted residual effects on water quality and water quantity were assessed using the impact attributes listed in Section 4.2.2.

The magnitude of a residual effect was also considered. For water quality, federal guidelines for the protection of aquatic life and BHP's Water Licence discharge criteria were utilized to aid in the determination of the significance of any potential residual effects. For water quantity, deviation from the natural regional and watershed hydrological regimes was considered, as well as major changes to water flows.

The quantifiable impact attributes utilized for the assessment of water quality and water quantity residual effects are presented in Table 4.2-5. For the impact attribute of geographic extent, local and regional areas were defined and are presented in Figure 4.2-2. The local area for water quality and quantity was defined as the Koala Watershed and or specific subdrainages within the Yamba/Exeter watersheds (*e.g.*, Pigeon Drainage Area, Horseshoe Watershed). The regional area was defined as the Lac de Gras and Yamba/Exeter watersheds including the downstream area to their confluence at Lake Providence.

4.2.2.7 Fish/Aquatic Habitat

The significance of any predicted residual effects on fish/aquatic habitat were assessed using the same attributes and levels utilized for water quality and quantity (Table 4.2-5). In addition, the attribute ecological context, which provides a qualitative consideration of

ecological interactions based on best professional judgement, was also considered. The predicted residual effects were discussed on a broader scale.

The attribute magnitude was considered in the form of the number of individual fish potentially affected. For example, a residual effect could affect a specific group of individuals, a population, or an entire stock of fish.

The same geographic areas were used in the assessment of fish/aquatic habitat as were used for water quality and quantity (Figure 4.2-2).

4.2.2.8 Caribou, Carnivore and Breeding Birds Habitat Assessment Methodology

The Assessment Methodology presented here applies to three VECs: Caribou/Habitat, Carnivores/Habitat, and Breeding Birds/Habitat. For the purpose of simplicity, these three VECs will be herein referred to as Wildlife and Wildlife Habitat. The significance of any predicted residual effects on wildlife and wildlife habitat was assessed using the impact attributes listed in Section 4.2.2. The impact attributes and their definitions utilized for the assessment of wildlife and wildlife habitat related residual effects are presented in Table 4.2-6. Prediction confidence, based on a subjective evaluation of the adequacy of site-specific information and the understanding of effects, methods, and efficacy of mitigation was also considered.

For the impact attribute of geographic extent, local and regional areas were defined and are presented in Figure 4.2-3. The local area for wildlife and wildlife habitat was defined as the Wildlife Environmental Monitoring Program (WEMP) Boundary (1,600 km^2). The regional area was defined as the BHP claim block boundary (3,400 km^2). An area greater than the regional area (CEA Study Area) was also defined, 31, 222 km^2.

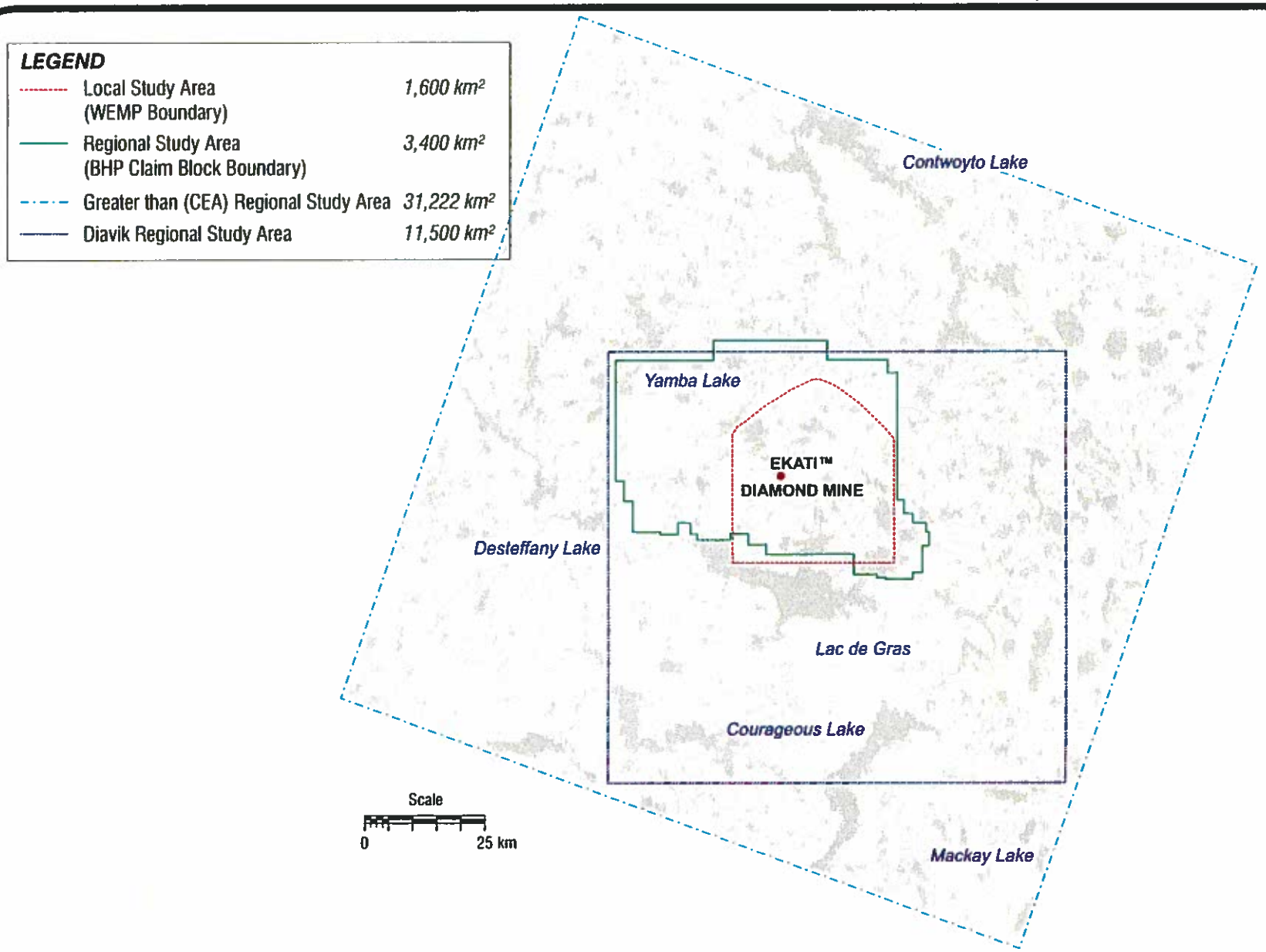


FIGURE 4.2-3

Spatial Boundaries Used for Assessment of Wildlife VECs

4.3 Air Quality and Noise

4.3.1 Air Quality

Air quality is considered a Valued Ecosystem Component because of its importance to worker health and safety, vegetation, wildlife and water quality. Air quality also has aesthetic value in terms of visibility and odour.

The primary concerns from an air quality perspective are associated with the following types of emissions:

- gaseous;
- particulate; and
- fugitive dust.

As predicted in the 1995 Environmental Impact Statement (EIS), airborne emissions of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), total suspended particulate (TSP) and greenhouse gases (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) have been relatively low and well within Environment Canada Canadian Ambient Air Quality Objectives (CAAQO) recommended levels. The low pollutant emission rates are largely attributable to effective management procedures. For example, the use of low sulphur diesel fuel at EKATI™ has resulted in SO_2 emissions of 40 tonnes in 1999 (BHP, 2000). In 1999, BHP consumed approximately 39.5 million litres of diesel fuel. The 1995 EIS predicted that the SO_2 emission rate would be in the range of 70 tonnes annually, based on an annual diesel fuel consumption of 70,000 tonnes (83 million litres).

The potential effects of the EKATI™ Diamond Mine on air quality have been assessed in a number of reports. Sources of air emissions may be classified as continuous or event type. Examples of a continuous source would be regular traffic along a haul road or operation of the crusher, while blasting would be considered an event source. Based on the 1995 EIS, activities that can potentially affect air quality include:

- diesel-fired power generation (gaseous and particulate emissions);
- diesel-fired boilers (gaseous and particulate emissions);
- ore processing in the primary crusher (particulate emissions);
- operation of the Process Plant (particulate emissions);
- vehicle traffic, including trucks, aircraft and other mobile equipment (gaseous and particulate emissions);
- mining operations, including blasting and waste rock and ore handling (gaseous and particulate emissions); and
- waste management, including solid waste and waste petroleum incineration (gaseous and particulate emissions).

The integration of the Sable, Pigeon, Beartooth pipes into the mine plan does not alter the air quality effects predicted in the 1995 EIS, as the overall air containment emission rates are essentially unchanged. The most salient point of previous air dispersion modelling results is the prediction that the overall, long-term air quality effects on areas at or beyond the BHP mineral claims boundary will be negligible. These results were based on a worst-case scenario air modelling assessment that included the Leslie pipe. The removal of Leslie pipe and the addition of Sable, Pigeon, Beartooth results in no net change to the inputs for the worst-case scenario; the overall operations of EKATI™ will remain nearly constant. The equipment fleet, main facilities and ore production rates have also remained constant since the EIS was prepared. The only notable change is that the main power plant has one less generator than the 1995 predicted requirement. Otherwise, there have not been significant changes in equipment or technology since modelling was last carried out.

4.3.1.1 Existing Air Quality Monitoring Program at EKATI™

BHP has adopted *in situ* monitoring over numerical modelling, which is dependent on a suite of input assumptions. The 1995 EIS used air dispersion modelling to predict the effects of mine-related air emissions. The Air Quality Monitoring Program (AQMP) for EKATI™ has adopted the use of snow and vegetation monitoring studies which have been used to monitor the actual spatial extent and any potential residual effects of particulate and gaseous emissions. BHP established an air quality management and monitoring program at the EKATI™ Diamond Mine in 1997. The operational monitoring plan is part of the EKATI™ Mine Operating Environmental Management Plan (OEMP; BHP 1999a) for effectively managing the site and minimizing any residual effects. Monitoring is performed at least every three years, with the flexibility to increase the frequency should development activities require additional monitoring.

This description of the air quality monitoring program is mainly to outline steps being taken to ensure that EKATI™ operations are carried out in an environmentally responsible manner. Accurate predictions of pollutant loading rates are not possible based on the results of the monitoring program thus far. Data from the 1998 operational monitoring program constitute the baseline for comparison with future studies; it is really the first step of a long-term effort. However, general inferences have been made based on the available 1998 study results. As the monitoring program matures, more data will become available to improve future evaluations of effects. Prior to the addition of new kimberlite pipes to the mine plan, monitoring studies (*e.g.*, snow surveys and vegetation studies, see below) will be performed to gather new baseline data for the potentially affected areas.

The objectives of the monitoring program are:

- to monitor emission sources at the mine; and
- to measure potential direct and indirect effects of mine emissions on air quality (BHP, 1998).

To achieve these objectives, the monitoring program has five main elements:

- dispersion modelling;
- high volume (HV) air sampling at selected sites;
- mass-balance emissions calculations;
- snow surveys; and
- vegetation studies.

To monitor total suspended particles, HV air samplers have been installed at two locations at the mine: the accommodations building (1996) and the Grizzly Lake pumphouse (1998). Short-term, local increases in ambient dust concentrations have been measured. Specifically, at the accommodations complex station, the 24-hour average TSP concentrations exceeded the CAAQO level of 120 $\mu g/m^3$ on two occasions in the summer of 1998. However, annual mean TSP concentrations at the station (11.4 $\mu g/m^3$ in 1997, 28.1 $\mu g/m^3$ in 1998, and 21.9 $\mu g/m^3$ in 1999) were well below the CAAQO recommended maximum annual mean concentration (60 $\mu g/m^3$). Hence, as predicted in the 1995 EIS, no residual effects are expected at any of the proposed pit locations. Measured TSP concentrations at the Grizzly Lake pumphouse station have been very low and are close to undisturbed baseline levels. It should be noted that natural events can also significantly affect TSP concentrations. For example, there were four occasions that the CAAQO criterion was exceeded during baseline studies in 1994, likely due to smoke from a forest fire.

Gaseous pollutants from EKATI™ have a relatively minor influence on ambient air quality compared to fugitive dust. In the 1995 EIS, contoured model results for gaseous emissions concentrations show predicted short- to long-term concentrations far below the most stringent CAAQO recommended levels for the pollutants modelled (SO_x, NO_x and CO). Although the effects of gaseous emissions were predicted to be negligible to minor, emission quantities from EKATI™ are nonetheless estimated for monitoring purposes. BHP uses empirical mass-balance emissions calculations for the pollutants of primary concern to ambient air quality (NO_x and SO_x) and global climate (CO_2, CH_4 and N_2O).

Emissions of NO_x and SO_x are calculated using the following equations:

$$M_{NOx} = V_d \times 0.84 \times 0.07 + M_{NOx,\ ANFO} \qquad (1)$$

$$M_{SOx} = V_d \times 0.84 \times 0.02 \times 0.05 + M_{SOx,\ ANFO} \qquad (2), \text{ where:}$$

- M_{NOx} and M_{SOx} are masses in tonnes of NO_x and SO_x released;
- V_d is the volume in m^3 of diesel fuel;
- $M_{NOx,\ ANFO}$ and $M_{SOx,\ ANFO}$ are the masses in tonnes of NO_x and SO_x released by the use of ammonium nitrate-fuel oil explosives (ANFO);
- 0.84 is the density of diesel fuel in tonnes/m^3;

- 0.07 is the NO_x conversion factor;
- 0.02 is the SO_x conversion factor; and
- diesel fuel sulphur content is assumed to be 0.05% by mass.

Blasting operations are estimated to produce 0.008 tonnes of NO_x and 0.001 tonnes of SO_x per tonne of ANFO consumed; these emission rates were recommended by the United States Environmental Protection Agency (U.S. EPA) and are widely accepted.

Greenhouse gas emissions are calculated using the equation:

$$M_{gh} = V_d \times f_c \quad (3)$$

where the conversion factors (f_c) for CO_2, CH_4 and N_2O are 2.73 kg/L, 0.00016 kg/L and 0.0004 kg/L, respectively.

The mass of pollutants emitted from EKATI™ for 1999, calculated using Equations (1), (2) and (3), is summarized in Table 4.3-1. The total consumption of diesel fuel during 1999 was 39,505,375 litres and the total use of ANFO was 7,310 tonnes.

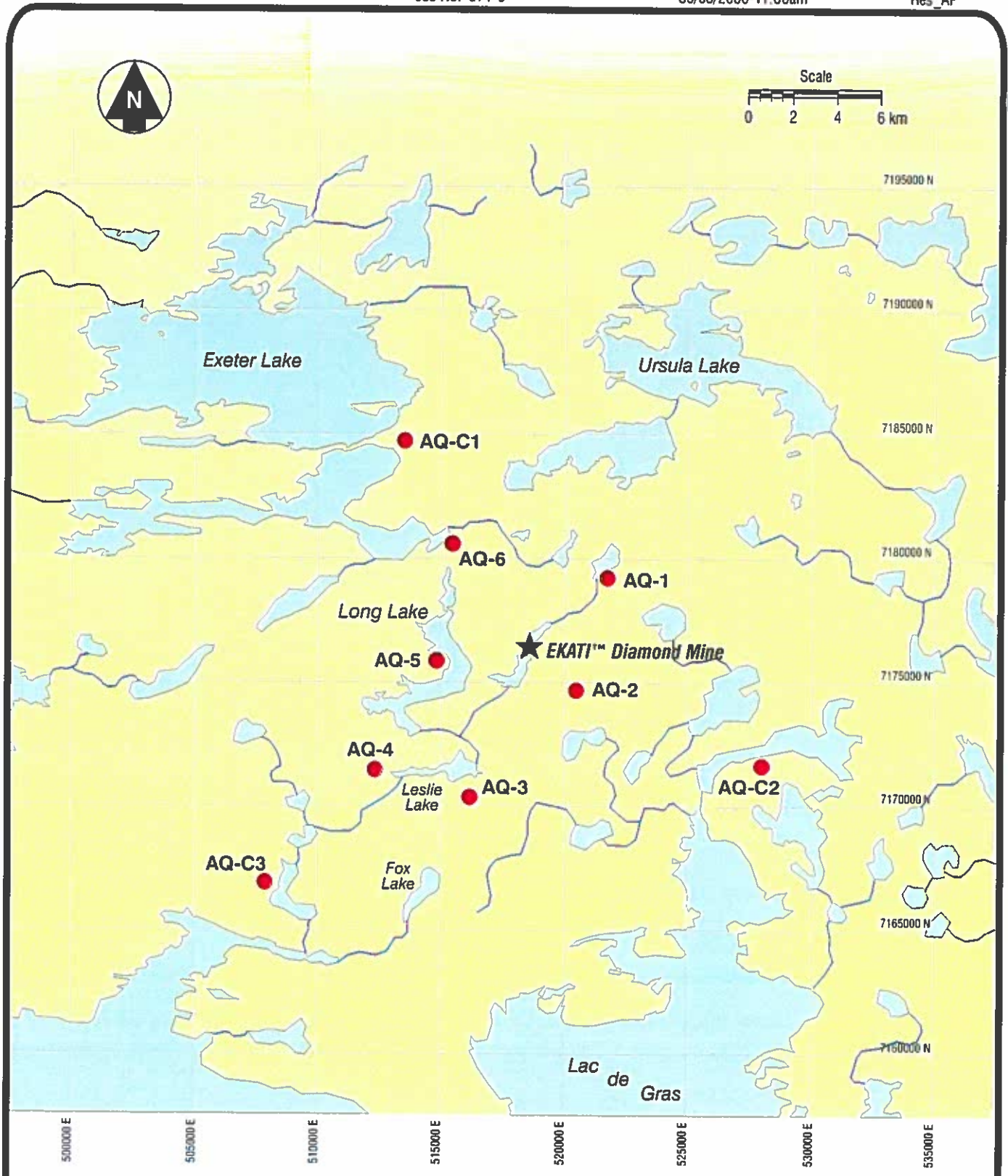
Table 4.3-1
1999 ANFO and Diesel Emissions

Pollutant	Emissions from:		Total Emissions in 1999 (tonnes)
	ANFO (tonnes)	Diesel (tonnes)	
NO_x	58.5	2,322.9	2,381.4
SO_x	7.3	33.2	40.5
CO_2	n/a	107,850	107,850
CH_4	n/a	6.3	6.3
N_2O	n/a	15.8	15.8

Source: BHP, 2000.

Of the greenhouse gases emitted by EKATI™, the most important is CO_2. Emissions of CO_2 from the EKATI™ mine for 1999 have been calculated at nearly 108,000 tonnes. For 1996, the year of the most recent available information, Environment Canada estimated that the total emissions of CO_2 for Yukon-Northwest Territories were around 2.7 million tonnes (Environment Canada, 1999). Total CO_2 emissions in Canada for 2000 are expected to be around 498 million tonnes (Environment Canada, 2000). Based on these values, the EKATI™ CO_2 emissions represent about 4% of the Yukon-Northwest Territories total and 0.02% of the Canadian total. Greenhouse gas emissions will be continually monitored through the total annual diesel fuel consumption.

Snow surveys are another component of the monitoring program used to evaluate the effect of dust and gaseous emissions generated from mine operations. Snow surveys were first conducted in spring 1998. Nine sampling sites were selected based on terrain



Snow, Vegetation and Lichen Monitoring Stations for Air Quality Studies

FIGURE 4.3-1

Source: ABR, 1999

type, such that various terrain units are represented, and proximity to mine/construction sites. Six of these sites are within the Koala Watershed (4 to 6 km from the main camp) and three are control sites (10 to 12 km from the main camp) selected to represent background conditions. The Koala Watershed and snow sample locations are indicated on Figures 4.2-2 and 4.3-1, respectively. Two control sites were selected above and below the Koala Watershed and the other was selected outside the Misery Watershed.

Samples were collected using a snow corer and measurements of snow-water equivalent and snow chemistry were performed for each sample. The data were analyzed to determine significant differences between physical and chemical parameters between sampling locations. Snow samples were collected from the crest, middle and toe of the slope at each respective location.

The analyses indicated that ammonia, antimony, manganese, uranium and vanadium were higher in the snow samples taken within the Koala Watershed (site group) than in samples taken from the control sites (control group). However, results for antimony and uranium are questionable due to proximity to detection limits and contamination. Comparison of results from different parts of the slope (crest, middle, toe), indicate that sulphate was the only parameter which differed significantly with regard to topographic gradient. The level of sulphate was found to be lower in samples taken from the crest of the slope than from the middle or toe of the slope.

Although results of the statistical analysis indicate significant differences for only a few parameters, other parameters such as total suspended sediment, turbidity, aluminum and iron are on average higher in the site group. These differences are not considered statistically significant because of the high degree of variability within the site group. Whether aluminum and iron were deposited from fugitive dust is unknown, but will be investigated. Overall, the comparison of samples taken at site group and control group locations suggests that effects are negligible.

Emissions of SO_x at EKATI™ (Table 4.3-1) are relatively low compared to totals for the Yukon-Northwest Territories and Canada, likely due to the use of low sulphur diesel. Although ammonia is elevated at Koala Watershed sites relative to the control sites, NO_x levels are not. Because of low emissions of SO_x and NO_x, acid deposition is not predicted to occur.

Vegetation studies are also used to assess the effects of air emissions. Changes to air quality can be indicated by the following changes to vegetation (specifically lichens and mosses):

- changes that occur in plant community composition; and
- changes that occur in chemical concentrations in plant tissues.

Vegetation surveys are an effective alternative for assessing long-term air quality in remote locations, such as EKATI™, where the use of sophisticated electronic equipment is not feasible.

The vegetation monitoring program was initiated in summer 1998 (ABR, 1999). Vegetation monitoring stations were established at six locations within the Koala Watershed (mine area) and at three reference locations. The reference sites represent each of the three basic morphological types, and are located above and below the Koala Watershed and outside the Misery Watershed. Vegetation monitoring stations are indicated on Figure 4.3-1. At each location, a permanent transect is in place at the top of a slope, mid-slope, and lower slope (comparable to the snow sample stations) to measure vegetation cover. The three transects are 50 m long and extend parallel to the face of the slope.

Vegetation cover is measured along each transect using the point-intercept method: plant species are recorded that intersect points at 0.5 m intervals delineated on a plastic metre tape along the 50 m transect (100 points per transect). When multiple layers (canopies) are present in the vegetation at a sampling point, the plant species in each layer are recorded. Total cover of each species is calculated as the sum of all the "hits" of that species at all 100 points. Because multiple canopies of species can occur at each point along a transect, total plant cover can exceed 100%. Species occurring in the area immediately surrounding the transects are recorded as traces.

The vegetation cover estimates and list of species compiled for each monitoring station serve as baseline data for assessing changes in plant community composition in response to air-quality effects from mine activities over the life of the mine. Both the mine area and reference area have similar vegetation types, which will allow for comparison between the areas in future monitoring efforts.

The diversity of vegetation types and taxonomic richness in both monitoring areas allows for a comprehensive air quality-vegetation response evaluation, ensuring that a variety of wildlife habitats are being monitored for any changes in plant community that may result from mine air emissions. Despite the presence of significant differences in pH and certain metals between the mine area and reference area, the higher levels measured in the mine area are not of concern. The pH of lichen tissue in the mine area is well within the normal range for soils in the region and none of the measured trace metal levels are unusually high (Adriano, 1986). Nevertheless, the elevated levels of some metals at certain monitoring stations within the mine area suggest mine activities may be responsible for the higher concentrations. Future monitoring efforts will allow for a comparison with these baseline data to determine if any measurable changes have taken place.

To better assess the significance of location on the concentrations of trace metals and other air quality indicators, replicate sampling of lichens within each topographic gradient is recommended (ABR, 1999). The comprehensive list of trace metals that were analyzed for in this initial monitoring effort has established an important baseline, but it is believed that the list can be reduced without compromising the goals of the air quality monitoring program. For example, many of the metals analyzed were at or below detection limits in both mine area and reference area samples (*e.g.*, Ag, Be, Hg, Sb, Se, Tl, and Ur) and are unlikely to be by-products of emissions generated by the mine's power plant or other combustion sources. Even levels of some of the metals that were significantly higher in the mine area (*e.g.*, Mo and Sr) probably are not biologically

relevant. Moreover, the vegetation surveys did not record any effects of nitrous or sulphur oxides.

The results of the vegetation surveys were not very comparable to the snow survey results, but this difference is to be expected because plants can accumulate trace metals and other analytes at much higher concentrations. However, vegetation studies have found negligible differences between vegetation in the mine and reference areas, indicating no effects due to mine-related activities. The two data sets will allow a comprehensive measure of cumulative effects of mine air emissions on aquatic and terrestrial receptors in the area.

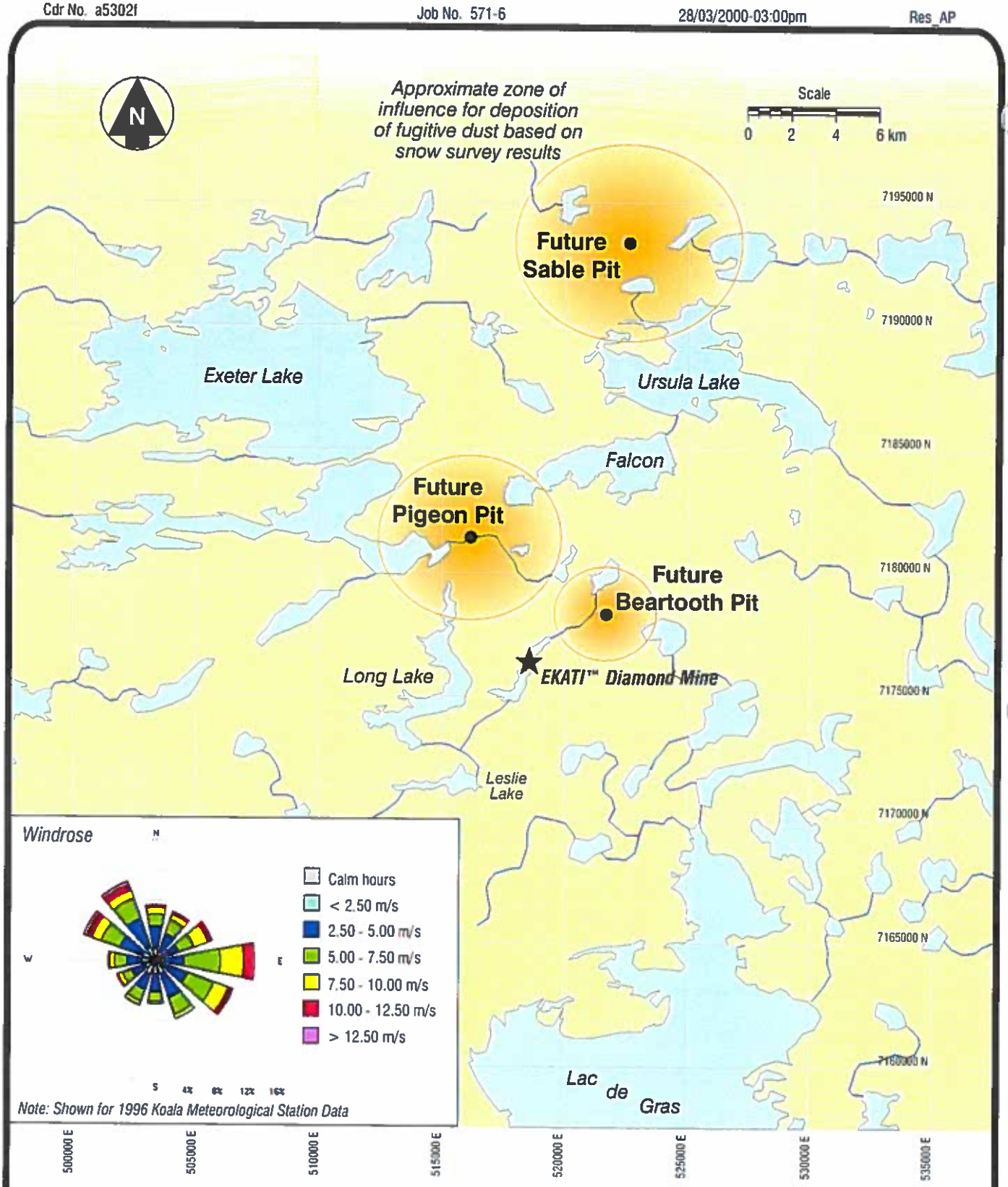
Monitoring of fugitive dust is of particular importance because, as predicted in the 1995 EIS, fugitive dust is the primary parameter of concern with respect to air quality. Fugitive dust is any uncontrolled particulate matter generated from open sources; it is called *fugitive* because it is not discharged to the atmosphere in a confined flow stream. There are mine-related activities at EKATI™ which release fugitive dust into the air. The main dust emitting activities are:

- mineral processing;
- ore handling and crushing;
- operation of conveyors;
- blasting; and
- wind blowing across waste rock storage piles and roads.

The 1995 EIS predicted that the highest fugitive dust emissions would coincide with the peak in hauling activity for each pit during the summer months. The amount of fugitive dust created by road traffic (*i.e.* ore and waste hauling) depends on a suite of parameters, including:

- moisture content of the surface materials;
- silt content (silt are those particles with diametres of less than 75μm);
- gross vehicle weight;
- number of wheels;
- velocity of the vehicle; and
- wind speed.

The model results from the 1995 EIS indicated that the worst-case annual TSP concentrations from ore and waste hauling would be around 50 $\mu g/Nm^3$. The CAAQO recommends that the annual TSP concentration should be less than 70 $\mu g/Nm^3$. The concentration of TSP along the haul roads for the development of the Sable, Pigeon and Beartooth pipes is expected to be very similar to that estimated for the existing EKATI™ operation.



Sable, Pigeon and Beartooth Pits Mine Development - Estimated Zone of Particulate Deposition

FIGURE 4.3-2

The effect of fugitive dust on air quality depends on its quantity and drift potential in the atmosphere. Larger dust particles settle out near their source; smaller particles can remain in the atmosphere for longer periods of time and travel relatively far from the source. Of the small particles, PM_{10} represents a relatively fine size range not overly susceptible to gravitational settling. The potential drift distance for a particle is a function of the initial release height, the terminal settling velocity of the particle, and the degree of atmospheric turbulence (*i.e.* wind). Theoretically, for a typical wind speed of 4.4 m/s (16 km/hr), particles larger than 100 µm are likely to settle out within 6 to 9 m. Particles with diameters between 30 and 100 µm are likely to settle within 60 m from the source. Smaller particles, particularly PM_{10}, have a much slower gravitational settling velocity and will travel farther from the source, but mostly settle within 2 to 3 km of the source (U.S. EPA, 1995).

4.3.1.2 Mining Operations at Sable, Pigeon and Beartooth Pipes

Air quality effects from the proposed development of the Sable, Pigeon and Beartooth pipes will result mostly from particulate and fugitive dust emissions. Air emissions similar to the three pipes are also expected from the development of the Ursula Esker granular quarry. The incremental effect from gaseous pollutants is not expected to be significant since there will be no incremental increase in air emissions from the major stationary sources, namely the diesel power plant and boilers which are currently in operation at EKATI™. Past experience at EKATI™ and other northern mining operations in the region, namely Diavik, has shown that the air quality effects from the activities have been negligible. Based on this past experience and ongoing monitoring, predictions can be made regarding the potential effects from the development of the Sable, Pigeon, and Beartooth pipes at EKATI™.

The primary activities at the Sable, Pigeon and Beartooth pipes that could affect ambient air quality are:

- movement of heavy equipment along unpaved haul roads generating fugitive dust;
- blasting in the open pits;
- exhaust emissions from internal combustion engines; and
- wind erosion of the waste rock storage piles.

The support facilities at the Sable Pit will consist of a small, independently powered warehouse and field office complex. A two-bay truck shop will be constructed. A stand-alone diesel power plant will provide power to the warehouse, office complex and truck shop. The Sable diesel power plant will be a minor source of air emissions.

The activities involved with extraction of quarry materials from the Ursula Esker granular quarry will also be a source of gaseous and fugitive dust air emissions. The majority of the construction fill required to support the development of the Sable, Pigeon and Beartooth pipes will be obtained from waste rock from mining operations. Select

material will be required for haul road surfacing and laydown pads and berms for the Sable and Pigeon pits.

The mass of air pollutants emitted from EKATI™ for the Sable, Pigeon and Beartooth development were calculated using the mass balance method previously described. The mass balance calculations for air pollutants are used on an annual basis as part of the AQMP. The diesel fuel consumption for the proposed development was estimated from the total tonnage of waste and ore. The total tonnage of waste and ore for the development are summarized in Table 4.3-2. The total projected volume of diesel fuel required to excavate 208.4 million tonnes of material is 188 million litres. This is not an annual diesel fuel consumption, rather it is an estimate of the entire diesel fuel required for the Sable, Pigeon and Beartooth development.

Table 4.3-2
Waste Rock and Ore Tonnage

Pit	Waste (millions of tonnes)	Ore (millions of tonnes)	Total (millions of tonnes)
Sable	120.8	12.9	133.7
Pigeon	51.2	5.3	56.5
Beartooth	16.8	1.4	18.2
Total	188.8	19.6	208.4

The total mass of explosives required for the proposed development was estimated from the total tonnage of material moved. Past experience and best professional judgement have been used to estimate the mass of ANFO required for each tonne of waste and ore that will be blasted. Table 4.3-3 summarizes the projected total mass of ANFO required for the development.

Table 4.3-3
ANFO Requirements for Development

Pit	Waste (tonnes)	Ore (tonnes)	Total (tonnes)
Sable	16,308	890	17,198
Pigeon	6,912	366	7,278
Beartooth	2,268	97	2,365
Total	25,488	1,353	26,841

The mass balance equations presented earlier may now be applied to the entire diesel fuel consumption and ANFO requirements for the devleopment to estimate the pollutants of primary concern to ambient air quality (NO_x and SO_x) and global climate (CO_2, CH_4 and N_2O). The results are presented in Table 4.3-4.

Table 4.3-4
Sable, Pigeon and Beartooth Gaseous Emissions

Pollutant	Emissions from ANFO (tonnes)	Emissions from Diesel (tonnes)	Total Emissions (tonnes)	Estimated Annual Emissions[1] (tonnes)
NO_x	215	11,031	11,246	1,250
SO_x	27	158	185	21
CO_2	n/a	512,148	512,148	56,905
CH_4	n/a	30	30	3.3
N_2O	n/a	75	75	8.3

1: Assuming a nine-year operating period for Sable, Pigeon and Beartooth pits.

For 1999 Environment Canada estimated that the total CO_2 emissions for Yukon-Northwest Territories were 2.74 million tonnes (Environment Canada, 1999). Total CO_2 emissions in Canada for 2000 are expected to be around 498 million tonnes (Environment Canada, 2000). Based on these values, and considering the production schedule for the proposed development is roughly nine years, the estimated average annual CO_2 emissions from the Sable, Pigeon and Beartooth development are about 2.1% of the Yukon-Northwest Territories total and 0.011% of the Canadian total.

4.3.1.3 Haul Roads

Air emissions from haul road traffic will be minimal at Beartooth compared to Pigeon and Sable because of the length of the respective haul roads. The lengths of the Sable, Pigeon and Beartooth road segments are approximately 18.4 km, 4.3 km and 0.7 km, respectively. The majority of the traffic using the road system will be the haul trucks required to transport kimberlite ore to the Process Plant. The traffic volumes using the Sable Road during mining operations have been determined using Cat 777 haul trucks operating 24 hours per day, 365 days per year. The estimated haul truck traffic volumes are summarized in Table 4.3-5. Other traffic on the Sable Road will be comprised of trucks to deliver explosives, maintenance and support equipment and light service vehicles (BHP, 1999c). There will also be additional requirements for the transportation of employees.

Table 4.3-5
Sable Road: Estimated Traffic Volumes

Year	Projected Loads/Day
2005	15
2006	15
2007	30
2008	35
2009	63
2010	99
2011	85
2012	28

The concentration of TSP that will be generated along the Sable Road is expected to be similar to that estimated by fugitive dust modelling in the 1995 EIS for the existing EKATI™ operation. The worst-case annual TSP concentrations would be around 50 µg/Nm^3; the CAAQO recommended annual average TSP concentration is 70 µg/Nm^3.

The development of the Pigeon Pipe will have similar air quality effects to haul road traffic since it is located approximately 4.5 km (*i.e.* 4.5 km in a straight line) northwest of the existing Panda Pit. There will also be blasting and waste rock handling operations which are sources of particulate and gaseous emissions. Blasting in open pits will cause short-term increases in particulate concentrations in the vicinity of the pit. Although the dust cloud created by a blast is quite impressive, the particulate settle out of the ambient air quickly and in the immediate vicinity of the open pit.

The Echo Bay Winter Road, used to move bulk commodities between Yellowknife and EKATI™ to support the mining operations, is not a source of fugitive dust because of its snow and ice cover. As a result, the addition of the three kimberlite pipes to the EKATI™ mine plan will not cause an increase in fugitive dust due to traffic along the Echo Bay Winter Road.

The primary concern of fugitive dust along the haul roads is its effect on visibility and local vegetation. Vegetation growing near the development areas might be slightly affected by deposition of dust, though wind and rain will likely remove most accumulations. Further discussion on this topic is provided in Section 4.4.1.3.4. Fugitive dust emissions will cause short-term local increases in TSP concentrations. The dust plume will be quickly transported and dispersed by the prevailing winds.

Based on the 1998 snow survey results and available information (U.S. EPA, 1995), zones of particulate deposition in the vicinities of the Sable, Pigeon and Beartooth pits have been predicted, as indicated on Figure 4.3-2. These zones of influence are predicted to extend not more than 3 km from the pits and associated waste rock storage piles. The distribution patterns of gaseous emissions are less easily predicted, though the results of the 1995 EIS air dispersion modelling and the 1998 snow and vegetation studies indicate the impacts will be negligible.

4.3.1.4 Thermal Inversions

Mining of the Sable Pit is planned to reach a depth of approximately 360 m (el. 135 m) below grade. Mining of the Pigeon and Beartooth pipes is expected to reach a depth of approximately 155 m and 200 m below grade, respectively (BHP, 1999f). The trapping of diesel emissions in deep open pits was a concern that was addressed in the 1995 EIS. At that time, it was thought that a thermal inversion in a deep open pit during the cold winter might cause a trapping layer at the crest of the pit and there could be a corresponding buildup of air contaminants within the open pit. A thermal inversion exhibits an atmospheric temperature profile that warms with increasing distance from the ground. Because the cooler (more dense) air lies beneath the warmer (more buoyant) air, the condition is extremely stable. Thermal inversions tend to form during night hours under light wind and clear sky conditions. Diamond mines in Russia have experienced

air quality problems in deep open pits during inversion conditions. The formation of ice fog in the deep open pits might also be a concern as it may cause a visibility problem.

The frequency of stable atmospheric conditions was calculated in the 1995 EIS and used to determine the potential for air contaminants to build up in a deep open pit. The methodology used to estimate the probability of the stable atmospheric conditions is beyond the scope of this document (interested readers are directed to the 1995 EIS report). The probability of the occurrence of the meteorological conditions that would allow a thermal inversion lasting longer than 20 hours was calculated to be 0.29%. The deepest pit at the current EKATI™ mine is approximately 95 m deep and no air quality problems have been noted, however, there have been temporary visibility problems caused by fugitive dust during the summer (Butler pers. comm., 1999).

4.3.1.5 Wind Erosion

Wind erosion of the waste rock storage piles depends on many factors, such as wind speed and particle size distribution of the waste rock. The entrainment of dust particles by the action of turbulent air currents (*i.e.*, wind erosion of an exposed surface) requires a wind speed of over 19 km/hr (5.3 m/s, U.S. EPA, 1995). Most waste rock from the Sable Pit will be either two-mica granite or biotite granite similar to that found at the Panda Pit. Some low grade and crater phase kimberlite will be mixed within the waste rock storage piles. Till and lake sediment materials will also be stored within a select waste rock storage pile (BHP, 1999c). Wind erosion of the granite portion of the waste rock pile is not likely to cause fugitive dust, however, the till and lake sediment materials will have a much smaller particle size and are more likely to cause fugitive dust during strong wind events.

Approximately 51.2 million tonnes of waste rock will be removed from the Pigeon Pit and placed in a waste dump situated south of the pit. The majority of waste rock from Pigeon Pit will be biotite granite which does not normally produce large quantities of fugitive dust during periods of high winds.

Waste rock from Beartooth Pit is classified the same as Panda Pit waste rock. The Beartooth waste rock will be stored in the existing Panda Waste Rock Storage Pile area. Hence, the footprint of the Panda Waste Rock Storage Pile will increase and there will be more surface area for the wind to contact. However, similar to the Sable and Pigeon waste rock piles, the Panda waste rock storage pile will not produce a large quantity of fugitive dust from wind erosion since the primary mineral in the waste rock is granite. Lake bottom sediments from Beartooth will be stored within the Lake Bottom Sediments Storage area.

4.3.1.6 Mitigation Measures

BHP's air quality management plan identifies appropriate measures to ensure that fugitive dust and gaseous emissions are minimized as much as possible. Gaseous emissions will be reduced at source by:

- using low sulphur fuels; and
- preventive maintenance programs for the equipment to ensure optimum operation of all combustion sources.

Higher levels of fugitive dust from haul roads will occur in the summer when the activities are intensified and there is no snow cover on the roads. Extended periods with no precipitation will also contribute to increased fugitive dust emissions. Fugitive dust from haul roads will be minimized by:

- grading and watering of roads;
- application of approved dust suppressants;
- controlling vehicle speeds; and
- scheduling and routing programs to reduce trips.

Road watering will be used to control fugitive dust if there is an extended period of dry weather and fugitive dust is creating a visibility problem. EKATI™ currently uses several Caterpillar 777 water trucks to control road dust, especially during summer months when the dust has been found to create a visibility problem (Butler pers. comm., 1999). A speed limit is enforced at EKATI™ and will also apply on the haul roads to the Sable, Pigeon and Beartooth pits. The haul roads are constructed primarily of granitic waste rock material produced during mining activities capped off with select aggregates.

Blasting in the open pits creates short-term releases of fugitive dust. Fugitive dust emissions related to blasting will be controlled by blasting techniques, limiting blast sites, hole-firing sequences and stemming blastholes. Beartooth, Pigeon and Sable pits will be developed in a manner similar to the Panda Pit. Blasting will occur once or twice per day. Controlled blasting techniques will decrease fugitive dust emissions, particularly as a result of less fly rock. Pre-stripping and production blasting will take place at different times for each pit. Based on experience at the Panda Pit, ambient dust concentrations diminish rapidly.

Control techniques for fugitive dust sources generally involve watering, chemical stabilization, or reduction of surface wind speed with wind breaks or source enclosures. Watering is the least costly and most common mitigation measure employed but only provides temporary dust control. The use of chemicals to treat exposed surfaces provides longer dust suppression, but is more costly and may have adverse effects on plant and animal life. Windbreaks and source enclosures are often impractical because of the size of the fugitive dust sources (U.S. EPA, 1995).

To date, a number of trials have been implemented to determine the most effective dust suppressant for the EKATI™ haul roads. The most promising product is Tembind, a wood industry by-product derived from wood lignin. This product has been approved by GNWT as a dust control agent and has been used by the Department of Transportation and Arctic Airports on many highways and airstrips. Tembind is more commonly known as sodium lignosulphonate and the manufacturer considers it a low toxicity substance.

Two applications are made per year and the manufacturer's recommended application rate is strictly followed (Butler pers. comm., 1999).

EKATI™ experienced poor visibility conditions due to fugitive dust at Panda Pit in 1999. Production was not interrupted, though equipment speeds were reduced to compensate for the reduced visibility. On one occasion it was deemed necessary to test the air quality at Panda Pit. The air quality was found to be acceptable (Skeeles pers. comm., 2000).

If a thermal inversion causes the air quality in one of the open pits to exceed industrial hygiene levels, employees will be reassigned to different elevations and/or other pits to work (essentially shutting down the operation for that one pit). In addition, support equipment not essential to maintain production will be limited or removed from the pit.

Whenever inversion conditions exist at EKATI™, the Mine Operations Team Leader will notify the Safety Department. Prior to the start of the shift, the Safety Department representative along with the Team Leader will proceed to the bottom of the pit to inspect the situation and obtain air quality measurements. Air quality measurements will include CO, NO_X and oxygen. If the measurements are out of compliance with the Mine Regulations, work in the pit will be halted until two consecutive measurements comply with acceptable levels as detailed in the Mine Regulations. The Mine Operations Team will be notified of the results and will resume work when air quality is acceptable. If ice fog creates a visibility problem in the open pits, traffic speeds will be reduced until visibility improves.

The Sable Pit power plant will be operated and maintained on a regular basis. Regularly scheduled maintenance and the use of low sulphur diesel fuel will minimize air emissions. The dispersion of air emissions from internal combustion sources is enhanced by the temperature difference between the ambient air and the gaseous emissions. Persistent wind also assists in dispersing the emissions. Based on past studies, wind speeds of less than 1 m/s occur approximately 4 to 11% of the time. The buoyancy of the stack emissions and turbulent mixing ensure that the air contaminants are quickly dispersed and carried away from the source.

4.3.1.7 Assessment of Residual Effects

Long-term residual effects on ambient air quality will be negligible, based on 1995 EIS air emissions model results and *in-situ* snow and vegetation monitoring. Therefore, the future capacity of renewable resources should not be affected by air emissions from the development of the Sable, Pigeon and Beartooth pipes.

The residual effects of fugitive dust on vegetation will be negligible, as precipitation will remove any deposited dust from the surrounding vegetation. The haul roads will be constructed of on-site materials, therefore fugitive dust from the haul roads will contain the same materials as the present surface soils, and thus should have a negligible effect. Fugitive dust will not significantly affect wildlife near the open pits or waste dumps.

The residual effects from blasting activities will be negligible. The gaseous emissions will be sufficiently diluted by the ambient air. There will be deposition of particulate around the open pits following a blast. The deposition of particulate will not adversely affect the vegetation or wildlife in the area. Precipitation and wind will naturally remove most of the accumulated particulate from the vegetation. Sections 4.4.1.3 and 4.6 present more detailed discussion of the effects of air emissions on vegetation and wildlife, respectively.

The residual effects on air quality from open pit activities, especially concerning the health of equipment operators, will be short-term due to the natural environmental processes that will dissipate a thermal inversion. The future capacity of renewable resources will not be affected by air emissions from heavy equipment operating in the open pits, and the long term residual effects will be negligible.

The main concerns with respect to air quality during decommissioning of the Sable, Pigeon and Beartooth development areas will be fugitive dust emissions from heavy equipment travelling along unpaved roads during mine reclamation and exhaust emissions. A concern for air quality during post-decommissioning will be wind erosion of the reclaimed waste dumps. The extent of concern will depend on a number of environmental factors such as soil moisture and wind speed.

4.3.2 Noise

Noise levels that result from EKATI™ were predicted in the 1995 EIS in order to identify and assess any adverse noise effect on the workers, other individuals and wildlife. Baseline levels of noise on the arctic tundra are very low (*i.e.*, roughly 30 dBA) due to the absence of human activity. The primary sources of noise at the EKATI™ mine include:

- aircraft;
- mobile and stationary mining equipment; and
- blasting.

The spatial boundaries for noise coincide with the boundary for air quality (*i.e.*, the claim block). The integration of the Sable, Pigeon and Beartooth pipes into the mine plan does not alter the noise effects presented in the 1995 EIS. To assess the effect of noise, several scenarios were considered in the 1995 EIS which were representative of the levels of activity that were expected. The scenarios included:

- operation of B727 and B737 aircraft;
- mining operations in the vicinity of Panda, Koala and Misery pits;
- haul trucks travelling between Misery Pit and the Process Plant; and
- blasting within any of the proposed pits during operations.

The EIS contains a detailed description of acoustical concepts and terminology; only the most important terms are included in this assessment. The unit most often used to describe noise levels for mobile and stationary mining equipment is the Equivalent Sound Level (L_{eq}) which is defined as the steady sound level that would contain the same amount of sound energy as the actual time varying sound level. An L_{eq} is calculated for any receptor by combining the predicted sound energy from all significant noise sources and averaging over the time period of interest, for example one year. To describe aircraft noise, a slightly different unit was used, the Noise Exposure Forecast (NEF). The NEF is commonly used by agencies such as Transport Canada and Canada Mortgage and Housing Corporation. Airport noise was also predicted in terms of L_{eq} to allow comparison with the predictions for the stationary and mobile mining equipment.

4.3.2.1 Aircraft

Aircraft noise is a concern for the mine employees living and working in the immediate vicinity of the airstrip. Aircraft operating beyond the immediate vicinity of the EKATI™ airstrip are more likely to affect wildlife and people engaged in wilderness tourism activities. For the purposes of the 1995 EIS, maximum daily flights were used to conservatively estimate noise effects. During operations, the EKATI™ airport was expected to receive up to eight flights per day and an average of three flights per day (BHP, 1995). An average of 25 passenger and cargo flights (*e.g.* fixed wing aircraft) per week are commonplace during April through January. During operation of the winter haul road (*i.e.*, February and March), EKATI™ nominally receives 12 flights per week (Perry, pers. comm., 2000).

The effects of aircraft noise were considered in the 1995 EIS with a predictive model, the U.S. Federal Aviation Administration Integrated Noise Model (INM). The results are presented in the 1995 EIS. It was concluded that there would be no risk of hearing damage for the occupants of either the Koala exploration camp or the EKATI™ accommodations building. Interference with communication would likely occur at the exploration camp during aircraft noise events since the exploration camp is situated at the southwest end of the airstrip (BHP, 1995). Currently, the exploration camp is not in continuous use. The sound exposure levels predicted for the EKATI™ main accommodation complex from the different types of aircraft are summarized in Table 4.3-6.

Table 4.3-6
Sound Exposure Levels at Camp Due to Aircraft

Aircraft Type	Arrivals on Runway	Departures on Runway
B727	<80 dBA	100 dBA
B737	<80 dBA	93 dBA
DC3	<80 dBA	80 dBA
Twin Otter	<80 dBA	< 80 dBA
Gulfstream	<80 dBA	97 dBA

Source: BHP, 1995.

Noise from helicopter operations occurs almost entirely within the claim block; at most locations it occurs infrequently and irregularly. The predicted levels are unlikely to be considered objectionable to most humans.

4.3.2.2 Mining Operations at Sable, Pigeon and Beartooth Pipes

Noise from mining activity is ongoing for the areas adjacent to the pits and Process Plant. The day-to-day noise levels produced vary, depending on the extent and the location of the heavy equipment. Four scenarios were developed in the 1995 EIS to assess the noise produced by EKATI™. The worst-case scenario was based on the following assumptions:

- the maximum noise during pit development is in the initial stages when the equipment is working at ground level and there are no pit walls to attenuate the noise levels;
- the early stages of pit development involve the most equipment;
- infrastructure noise (*i.e.*, Power Plant and Process Plant) will be relatively constant throughout the life of the mine; and
- the propagation of noise will vary on a seasonal basis due to the variation in atmospheric thermal gradient (BHP, 1995).

Computer modelling was used to develop noise level contours. The contours for Panda/Koala covered a larger area than Misery because of the presence of the Process Plant and Power Plant and use of larger equipment at Panda/Koala. The noise contours for Sable and Pigeon pits covered a smaller area than Panda/Koala because the power and process plants are not in the immediate vicinity of either Sable or Pigeon. The proposed Sable and Pigeon pits are located approximately 15 and 4.5 km away from the existing Panda Pit, respectively. The noise contours for Beartooth Pit will be very similar to Panda/Koala since Beartooth is located only 1 km north of the existing Panda Pit. The noise contours predicted for winter covered a larger area than summer due to the presence of thermal inversions that promote propagation of sound. The zone of influence for a significant noise level (*i.e.*, 35 dBA) generally extended less than a few kilometres from the actual mining activity and was well inside the claim block. Therefore, it is unlikely that any non-mine personnel would be within the areas near Sable, Pigeon and Beartooth pits and no adverse noise effect on humans is anticipated.

4.3.2.3 Haul Roads

The noise produced by trucks travelling along Misery Road was also estimated in the 1995 EIS. These noise levels are relevant because there will be similar activity between the Sable Pit and the Process Plant. Different types of haul trucks will be used on the Misery and Sable roads. The Misery Road will typically use a highway haul truck, whereas Caterpillar 777 mine haul trucks will be used on the Sable Road. The length of the haul road between Sable Pit and the Process Plant is approximately 18 km. The Caterpillar 777 mine haul trucks will comply with Transport Canada noise limits for new

heavy-duty trucks. Maximum noise levels may persist for only a few seconds close to the haul road or perhaps as long as a minute at a lower intensity farther away. Long-term average noise levels along the Sable Pit haul road will be extremely low due to the brief duration of each noise event.

4.3.2.4 Blasting

Blasting will occur at the three pits. The blasting method used for the pits will be similar to that which is currently used at the Panda Pit. Blasts will typically take place once or twice per day and use sequential delay systems. The overall duration of a blast is typically in the 1 to 2 second range. Noise from a blast is usually assessed on the basis of single noise events rather than long-term averages, since blast noise is typically of short duration, but with relatively high peak levels. Blast noise is predominantly low frequency sound and for that reason it is quite omni-directional. Therefore, predicted noise levels from a blast were computed in terms of peak noise levels at various distances from the source.

The peak noise levels from a blast have been calculated empirically. The results are similar to noise levels recorded by BHP at the Island Copper Mine near Port Hardy, BC The "worst-case" scenario for the propagation of blast noise is when the receiver is located directly down wind of the blast or when a temperature inversion occurs. The predicted peak levels from blasting are all well below 115 dB, except in the immediate vicinity of the active pits. As noted in the 1995 EIS, a conservative criterion for avoidance of complaints from blast noise is 115 dB. Nonetheless, individuals involved in wilderness tourism activities might object to the mere audibility of the blast noise.

Based on the predicted peak levels and the expected background levels of 25 to 40 dB at locations remote from the mine activity, the extent of blast noise audibility was estimated to be on the order of 8 km during normal atmospheric conditions and 30 km during temperature inversions and downwind conditions. Once several benches have been established in the open pits, the audibility of a blast is reduced to as little as 4 km for "normal" atmospheric conditions and 10 km during temperature inversions and downwind conditions (BHP, 1995).

4.3.2.5 Mitigation Measures

The scope of development for the Sable, Pigeon and Beartooth development Environmental Assessment Report does not include the existing EKATI™ camp facilities. However, several noise mitigation measures were suggested in the 1995 EIS. The noise mitigation measures were implemented and they are summarized here for information only. At the EKATI™ facilities, noise from jet aircraft departures could result in sleep disturbance. Therefore, the buildings were designed to mitigate and attenuate aircraft noise. Noise mitigation for mining operations and along haul roads is not necessary. As for the pits, as they become deeper the walls of the pit will attenuate the blast noise.

4.3.2.6 Assessment of Residual Effects

Residual effects of noise on ambient air quality will be negligible. Mitigation measures have already been implemented in the form of designing site buildings to attenuate noise, thereby preventing noise from affecting workers located in the accommodations complex. There will be negligible residual effects from noise created by mining operations and haul road traffic. With respect to blasting, noise may be an issue when a pit is first being developed, but once pits are deep enough, the pit walls will attenuate blast noise. Effects of noise on wildlife are discussed in Section 4.6.

4.3.3 Summary of Predicted Effects on Air Quality

Table 4.3-7 provides a summary of the predicted air quality and noise effects from development of the Sable, Pigeon and Beartooth pipes. The potential effects are listed for air quality and noise in the absence of mitigation. The table also summarizes the mitigation measures that will be undertaken by BHP to minimize effects and the significance of any residual effects after mitigation measures have been taken into account. The concluding significance ratings were based on the impact attributes presented in Section 4.2.2, Table 4.2-3 of this report and on best professional judgement.

Table 4.3-7
Summary of Residual Effects on Air Quality and Noise Due to Development of Sable, Pigeon and Beartooth Pipes

Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Traffic along haul roads, especially Sable	Fugitive dust along haul roads	Road watering, natural precipitation and wind	Negligible
Blasting in open pits	Fugitive dust, release of CO, NO_x and SO_2	Limit the number of blast sites, hole firing sequences, sufficiently stemming blastholes	Negligible
Blasting in open pits	Blasting noise	Longer detonator delay period, lower explosive weight per delay (control blasting techniques)	Negligible
Waste rock storage piles	Wind erosion causing fugitive dust	No lake sediments to be placed on surface of waste rock pile	Negligible
Waste rock storage piles	Wind regime modification	Limit height of waste rock storage piles to 60 m	Negligible
Operation of heavy equipment including power plant at Sable Pit	Release of CO_2, NO_x, SO_x, particulate from internal combustion engines burning diesel fuel	Routine maintenance of engines, buoyancy of air emissions, wind, use of low sulphur diesel fuel	Negligible

(continued)

Table 4.3-7
Summary of Residual Effects on Air Quality and Noise Due to Development of Sable, Pigeon and Beartooth Pipes (completed)

Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Operation of heavy equipment in deep open pit (*e.g.* Sable, 360 m below grade)	Thermal inversion causing buildup of air emissions from heavy equipment, a cloud of air emissions causing a visibility problem	Move equipment to different bench, natural environmental processes, use of low sulphur diesel fuel	Negligible
Operation of diesel generators	Heat island effect	None	Negligible
Fuel combustion	Climate change	Minimize fuel consumption, regular engine maintenance, adequately insulated buildings	Negligible
Fuel combustion	Acidic deposition	Use of low sulphur diesel fuel, scheduled maintenance of diesel powered equipment	Negligible
Operation of aircraft	Noise from arrivals/departures of fixed-wing aircraft and helicopters	Limit flight schedules to non-sleeping hours for day-shift workers; buildings designed to attenuate aircraft noise	Negligible
Mining operations	Noise from heavy equipment and project activities	Regular maintenance for heavy equipment	Negligible

4.4 Land

All development activities to date at the EKATI™ Diamond Mine have taken place within the spatial boundary of the Wildlife Environmental Monitoring Program (WEMP). The Sable, Pigeon and Beartooth pipes are also within the boundary.

The approach used in the following assessment of possible effects resulting from the new development on the land environment examined the following Valued Ecosystem Components (VECs):

- permafrost;
- groundwater;
- physical/terrestrial environment; and
- heritage sites.

The second component of the assessment examined the potential effects that the environment of EKATI™ could have on the proposed development. Those land-related effects include:

- ground movement attributed to frost action;
- earthquake hazard;
- climatic trends and permafrost; and
- pit wall stability.

The land section of the environmental effects chapter is organized so that each VEC or landscape related issue is discussed separately. Within each section, the effect(s) on the VEC or landscape related issue are examined. Mitigation measures are described, and the significance of the residual effects is evaluated.

4.4.1 Effects of Proposed Development on Environment

4.4.1.1 Permafrost

Permafrost, or perennially frozen ground, has been identified as a VEC due to the possibility of disturbance. The physical effects related to permafrost as the result of development were presented in the EIS (BHP, 1995).

EKATI™ is well within the region of continuous permafrost, as described in Section 3.2.3. Permafrost at EKATI™ has been estimated to extend to a depth of about 320 m. This information was obtained from the geothermal gradient measured in a deep (approximately 280 m) geotechnical borehole adjacent to Panda Pit. The measured

ground temperatures at depth suggest that the permafrost is in long-term equilibrium with the prevailing climate. To a large extent, this equilibrium is controlled by:

- conditions in the near surface soils; and
- vegetation at the ground surface.

There is some potential for permafrost to be affected during all phases of the proposed development as a result of activities such as road building, construction of site facilities, dam construction, stream diversion, open pit mining and waste rock deposition.

Permafrost soils are susceptible to erosion and subsidence to varying degrees if they thaw. The susceptibility to disturbance upon thaw has been related to terrain units identified from surficial geological mapping. With few exceptions, the active layer soils within the region of the proposed development are granular, well drained and stable. There are no:

- natural landslides;
- significant surface erosion areas; or
- large-scale thaw-induced (thermokarst) depressions.

The terrain unit that is most susceptible to thaw subsidence if disturbed by construction activities is peat-covered lacustrine lowlands. These soils have excess ground ice that is protected from thaw by a thin vegetation cover.

Construction and mining will change the local ground surface-air interface, resulting in changes to the permafrost regime. Those changes could initiate either cooling or warming of permafrost. Initiation of a warming trend within the underlying permafrost will result in localized deepening of the surface active layer. Effective design procedures must be used to both predict and mitigate any changes in the ground thermal regime that could result in instability due to thaw or possibly freezing. Analyses of earth structures on permafrost include an assessment of the effect of climatic variability, including potential long-term trends such as global warming. The methodology for inclusion of global warming as a design criterion for permafrost-sensitive structures is described in Section 4.4.2.1.

The potential effects of the development on permafrost are normally limited to the immediate base area, or footprint, of the structures on or in permafrost terrain. The following subsections describe the potential effects and their mitigation.

4.4.1.1.1 Pit Development in Permafrost

Freeze-thaw effects of seeping groundwater and changing permafrost conditions could decrease the geotechnical stability of the pit walls. Geotechnical studies based on drill core data are incorporated into pit design to ensure pit wall stability. Thus, sound engineering design, established mining practice and site observations will mitigate the

potential for pit wall instability. The engineered pit safety berms are designed to capture any localized rockfall.

Exposed overburden soils along the pit perimeters will be cut to a shallow slope and, if required, will be covered with a stabilizing layer of granular fill to prevent thawing and degradation of the permafrost.

The pit walls that were initially in a permafrost state will develop a new surface active layer, or zone of seasonal thaw. The behaviour of the pit walls has been observed during development of the Panda Pit, in order to fully characterize the nature of the rock and its response to thaw. These observations have been supplemented by installation of ground temperature cables in the pit walls.

The strength of the granite walls has been shown not to depend on maintaining permafrost conditions. Permafrost is maintained within the rock face beyond the active layer of 4 m to 6 m. These observations are believed to be entirely applicable to conditions at the three proposed pits. Techniques have been developed to scale the walls to remove potentially hazardous loose rock.

Once mining has ceased, the mined-out pits will be filled and become lakes. The thawed zone adjacent to the walls and the floor of the pits will enlarge somewhat in response to the new thermal boundary. Because affected areas will be submerged and essentially no different from the lake margins typical of the area, the residual effects are considered to be negligible.

4.4.1.1.2 Site Infrastructure

Construction of site infrastructure will affect the ground thermal regime and cause the permafrost to degrade or aggrade (extend upwards). These thermal changes do not constitute an environmental impact on their own; however, degradation of permafrost as a direct result of thermal changes could cause instability of the active layer. The greatest risk is the formation of shallow surface ponds adjacent to the toe of the fill sideslopes such as road embankments, laydown pads, waste rock storage piles and dams on permafrost foundations. These ponds would generally be very small and present no risk for contained suspended solids or turbidity that could be released into streams. The degree to which the area will be affected varies with terrain type and will be most prevalent in peat-covered lacustrine lowlands.

Temperature changes that may occur in the permafrost foundation soils can be predicted using common geothermal analysis techniques for the design of facilities on permafrost. The analysis will predict future ground temperatures and thaw depths for the purpose of evaluating the interaction between the structure and the permafrost. The results are used to guide the design so that permafrost conditions are preserved or enhanced where potential adverse impacts are identified. The retention/diversion dams, stream diversion, waste rock storage piles and road construction designs described in this document will be confirmed by geothermal analysis once more detailed site data have been collected and evaluated.

Construction over the permafrost must recognize conditions that are particularly sensitive to disturbance. The localized fine-grained soils with excess ground ice are must susceptible to thaw-settlement. The characteristic behaviour of these permafrost-sensitive soils has been determined from previous geotechnical evaluations and post construction experience at the mine site. The designs that have been developed, such as those described in the report "Preliminary Design of Water Control Structures for Sable, Pigeon and Beartooth Developments" (EBA, 2000), take into account the ice-rich nature of certain terrain units. Road and dam designs provide sufficient stable fill over ice-rich permafrost, where encountered, to preserve the frozen conditions. The minimum fill thickness requirements will be determined by geothermal modelling during the final design stage. Where it is not practical to entirely preserve the permafrost, the potentially unstable frozen materials will be excavated and replaced with stable, erosion-resistant materials.

The use of design measures to preserve or enhance the permafrost have successfully mitigated potential terrain effects on thaw-sensitive soils. Construction equipment traffic between facilities will be restricted to fill surfaces consistent with accepted practice for permafrost terrain. A permafrost ground temperature monitoring program, initiated for the design of various existing facilities, will be continued. This program has verified that the potential effects on permafrost are consistent with the analyses previously conducted.

The Two Rock Lake and Bearclaw Lake retention/diversion dams and the Pigeon Stream Diversion will be constructed during winter months to minimize potential disturbance to permafrost. The stream diversion will be constructed by over-excavating into the permafrost soil and replacing it with stable fill materials. Therefore, the erosion potential along the stream diversion will be low. The stream diversion will be constructed using suitably sized streambed material. Additional bank and bed protection will be applied during the operational period if localized areas experience settlement or erosion. The natural flow from Bearclaw Lake will be diverted by means of a temporary pipeline seated on timber cribbing, placed directly on the tundra. This minimizes the surface disturbance to the maximum extent possible. The diversion pipeline will be installed and ultimately removed, at the time of decommissioning, during the winter months.

All engineering design and construction practices will adhere to sound engineering principles for arctic regions to eliminate adverse effects. Examples of large-scale mining operations engineered to eliminate environmental effects on continuous permafrost terrain include not only development to date at EKATI™ but also the Polaris Mine, in Nunavut, and the Red Dog Mine, in Alaska (Giegerich, 1988; Giegerich, 1992). The Lupin Mine, in Nunavut, (Dufour and Holubec, 1988) is an example of a smaller-scale mining operation on terrain similar to EKATI™.

The potential severity of effects is related to the prevailing surficial soils, permafrost conditions and topography. The significance of residual effects on permafrost are considered negligible due to the low topographic relief, extremely local effects and the single-event nature of construction.

4.4.1.2 Groundwater

Groundwater has been identified as a VEC because changes in subsurface flow could result in the potential drawdown of lakes and streams adjacent to the areas where the groundwater is affected. Activities that could have a potential effect on groundwater movement include:

- lake dewatering;
- mining of kimberlite pipes where permafrost does not currently exist because of the presence of a lake (sometimes referred to as a talik); and
- re-establishment of lakes within the exhausted pits.

These activities will take place during the construction, operation and decommissioning periods, respectively. Development of a deep open pit will result in some flow to the pit walls and bottom for the duration of pit development. This effect will be reversible, however, as steady-state conditions will prevail once the pit is refilled.

4.4.1.2.1 Potential Sources of Pit Inflow

Water will accumulate in the pits during mine operations. The principal sources of pit water inflow are:

- surface runoff from the local catchment area adjacent to the pit;
- subsurface seepage through the active layer (once it has developed) in soils exposed around the pit perimeter; and
- subsurface seepage from any non-permafrost rock exposed at depth on the pit floor or lower pit walls.

Observations from Panda Pit have shown that it is not possible to distinguish the inflow volumes from each of these three sources. However, surface and subsurface active layer water enter the pits only during the summer, when the greatest amount of water is observed. Overall water accumulations have been small and reasonably within pre-mining predictions.

4.4.1.2.2 Groundwater Modelling Analyses

Physical effects related to groundwater as a result of open pit mining were initially documented using a two-dimensional groundwater model in the EIS (BHP, 1995). A more rigorous three-dimensional analysis (Robertson GeoConsultants Inc., 1996) was conducted as an extension to the groundwater model presented in the 1995 EIS. The influence of pit development on the groundwater system and, hence, on nearby lakes was further addressed in this evaluation.

The three-dimensional groundwater model was developed to assess the potential effect of a fully developed pit on groundwater flow in the vicinity of several nearby lakes (Robertson GeoConsultants Inc., 1996). Modelling of the groundwater regime surrounding a typical open pit shows that the inflows are small. This is primarily due to two factors:

- the pit walls are invariably within the zone of permafrost bedrock (all non-permafrost rock is removed); and
- unfrozen bedrock below the permafrost has a very low hydraulic conductivity.

The hydraulic conductivity values for the granitic rock mass used to conduct the three-dimensional groundwater analyses, ranged from $K=10^{-8}$ m/s for shallow bedrock (0-150 m depth) to $K=10^{-10}$ m/s at depth (>150 m). The hydraulic gradients between lakes under existing (pre-mining) conditions are small and, as a result, the groundwater flow velocities in the rock mass are extremely slow. Therefore, a steady-state flow regime will never develop around the pit, and the amount of groundwater flowing into the pit will be minimal.

The previous groundwater modelling assumed that the permafrost extended to 250 m below land surface. However, it has now been estimated that permafrost extends to a depth of about 320 m adjacent to Panda Pit. Permafrost within the rock sideslopes provides an effective natural barrier against the inflow of groundwater. The modelling analysis shows that the effects of pit development will be negligible due to the strictly local area, short-term period and reversibility upon flooding.

4.4.1.2.3 Operational Phase

Pigeon Pit will be mined entirely within permafrost. Pigeon Pond is both too shallow and of insignificant size to have created an underlying mass of unfrozen ground below the seasonally frozen layer. Beartooth Pit will be developed to a depth of 155 m, and, as such, the unfrozen zone that might extend to the bottom of permafrost is anticipated to be small. A layer or body of unfrozen ground below the seasonally frozen layer and above or within permafrost is often referred to as a talik. The thickness of a possible unfrozen zone (*i.e.*, talik) below a lake is a direct function of:

- water depth;
- dimensions of the lake (*i.e.*, width and length); and
- water temperature.

Accordingly, the potential effects related to subsurface groundwater inflows during the construction and operational stages are not present in either the Pigeon or Beartooth pits.

With a planned depth of 360 m, Sable will be the only pit to be mined below the anticipated depth of permafrost (320 m). Due to the projected depth and size of Sable Pit, the groundwater regime below the maximum depth of permafrost could be affected during dewatering and mining. These changes are not expected to measurably affect the water level in adjacent lakes because of the very low hydraulic conductivity of the granite

rock and very long seepage paths below the permafrost zone (as discussed above). Furthermore, this effect will be reversible, once the pit is refilled. As the result of the short time frame, the reversibility and restricted geographic extent, the effect has been assessed as negligible.

Near-surface groundwater flow adjacent to each pit will be disturbed during the summer season for the duration of dewatering activities. These changes in the groundwater flow will hardly be measurable. It is anticipated that groundwater movement below the maximum depth of permafrost will be affected during construction and operational phases only at the Sable Pit. This change is not expected to measurably affect the water level in the adjacent lakes. Equilibrium conditions will return once the pit is refilled. Water level observations made to date at North Panda Lake have not indicated any drawdown while mining in the immediately adjacent Panda Pit.

4.4.1.2.4 Decommissioning Phase

Sable and Pigeon pits will be filled by pumping water from nearby large lakes. The exhausted Beartooth Pit will be partially filled with processed kimberlite and covered with a surface layer of fresh water.

As the exhausted pits gradually fill with water, the permafrost boundary will shift as the thawed zone adjacent to the walls and the floor of the pits enlarges. A talik will eventually form under the reclaimed Pigeon Pit Lake. Pit flooding is anticipated to be complete before the talik develops. A talik will also form, or enlarge if one currently exists, under the newly created Beartooth Pit Lake. In both instances this will have no effect on the groundwater regime, as equilibrium conditions will exist before the talik develops.

Groundwater movement below the maximum depth of permafrost will be affected during decommissioning at the Sable Pit and for a number of years while the pit is being refilled. This could have an effect on the groundwater flow regime, which will seek to achieve a steady state. Water from within the adjacent rock strata will continue to flow slowly into the pit. The previous analyses have shown that there will be no measurable effect on the surrounding lakes or the overall groundwater regime. Therefore, the overall significance of any possible effects on the groundwater regime is considered negligible. The results of the previous groundwater modelling are considered applicable for the purpose of this evaluation. The actual depth of permafrost in the vicinity of the proposed Sable Pit will be determined before mining begins to verify this conclusion.

The residual effect on the groundwater regime associated with development of the Sable Pit will be continuous for a moderate to long-term, as the estimated period of time required to refill the pit with water is 15 to 25 years. However, this effect will be reversible, as equilibrium conditions will prevail once the pit is refilled. The effect will be restricted to a portion of the local area and as such is rated as negligible.

4.4.1.3 Vegetation

Vegetation will be affected during all stages of the proposed development and can be divided into two types of disturbance by area:

- areas where existing vegetation will be completely lost due to excavation and burial; and
- areas where vegetation may be degraded due to different levels and kinds of disturbance.

Local terrestrial ecosystems, comprising areas of distinct plant communities and their associated soils, occur in a relatively predictable manner across the BHP claim block. As described in Section 3.6.2, the ecosystem mosaic in the area changes in response to environmental factors, including:

- local climatic effects (snow accumulation areas);
- soil physical properties (soil texture, coarse fragment content and composition, drainage); and
- physiographic factors (slope position, slope angle and slope aspect).

Ecosystem mapping has been conducted over the BHP claim block to identify local ecosystems and provide an inventory of plant and soil components. This inventory and classification provides the ecological framework for assessing effects and mitigating vegetation loss or damage resulting from development.

4.4.1.3.1 Rare or Endangered Species

Vegetation surveys have been conducted within the BHP claim block (BHP, 1995a) and Diavik's Regional Study Area (Diavik, 1998c). No rare or endangered plants were identified within the areas surveyed.

4.4.1.3.2 Vegetation Loss

Vegetation currently occupying proposed development areas such as pits, waste rock storage piles, site infrastructure pads and roads will be lost during construction and operations. The extent of existing vegetation habitat found within the proposed development areas was quantified by overlaying a map of the footprint of each feature on the applicable ecosystem map(s). GIS software was used to perform the area calculation (Table 4.4-1). Section 3.6.2 provides descriptive information on each ecosystem unit.

The locations of the pipes are fixed and so there are no options to development in their immediate areas. However, some adjustments can be made to the locations of associated infrastructure to limit habitat loss. The primary mitigation measure for minimizing

Table 4.4-1
Habitat Lost to Point and Linear Features

	All Units are in Hectares										
	BF, RB: Bedrock and Boulder Fields	BLb, BLr, BLe: Open Mat Tundra	SSe, BEe, BLe: Esker Complex	BL: Closed Mat Tundra	BL + BR, EA: Tundra/Wetland Complex	BR: Birch Hummock	EA: Cotton Grass Tussock	BR, EA, CE, CA: Wetland Complex	BC: Birch Seep	SR: Willow Riparian	Total
Point Features											
Sable Pit	0.7	0.7	0.0	253.9	0.0	0.7	0.0	0.0	0.0	0.0	256.0
Pigeon Pit	5.5	15.5	0.0	90.0	0.0	2.1	0.0	16.9	0.0	0.0	130.0
Beartooth Pit	0.0	0.5	0.0	7.6	2.2	0.0	0.0	0.1	0.6	0.0	11.0
Total Losses Due to Point Features	6.2	16.7	0.0	351.5	2.2	2.8	0.0	17.0	0.6	0.0	397.0
Linear Features											
Sable Road	0.0	8.3	0.2	25.1	0.0	0.7	0.2	0.3	0.0	0.0	34.8
Pigeon Road	0.0	4.5	4.9	38.2	8.1	1.4	0.0	0.0	0.2	0.0	57.3
Beartooth Road	0.0	0.0	0.4	3.7	0.5	0.3	0.0	0.0	0.0	0.0	4.9
Total Losses Due to Linear Features	0.0	12.8	5.5	67.0	8.6	2.4	0.2	0.3	0.2	0.0	97.0
Total Direct Habitat Loss Due to All Proposed Development	6.2	29.5	5.5	418.5	10.8	5.2	0.2	17.3	0.8	0.0	494.0
Percent	1.3	6.0	1.1	84.7	2.2	1.1	0.0	3.5	0.2	0.0	100.0

impacts on important terrestrial vegetation ecosystems, such as wetlands and tall shrub communities, is careful route selection for Sable Road. Other mitigation will be achieved by revegetation and encouraging natural recovery, as suitable. Reclamation plans are summarized and described in BHP's 1995 Environmental Impact Assessment (BHP, 1995) and Interim Abandonment and Reclamation Plan (BHP, 1999a).

The principal means of restoring vegetation in the three pit development areas will be natural colonization. At present, no revegetation efforts are planned for the waste rock storage areas, gravel roads, site infrastructure pads or dykes. Mining equipment will be used to alter the surface topography in these areas to create conditions more favourable for natural colonization. Other areas of minor disturbance with physical characteristics suitable for the establishment and support of vegetation will be scarified and seeded. Leaving some units to recover naturally while establishing vegetation in others will allow the limited available resources in terms of materials and soil amendments to be used where they are likely to be most effective. Revegetation research was initiated at EKATI™ in 1994 and is on-going. Findings from the revegetation research (Section 5.5.2) will be incorporated into the reclamation plan to refine techniques and amend current approaches where appropriate.

Even with on-going reclamation efforts in select areas, it is unlikely that the 494 ha of vegetation units lost as a result of the proposed development will return completely to

their original condition. Re-establishment of vegetation is characteristically slow in naturally granular upland areas such as boulder fields and eskers. However, it is important to realize that the proposed development footprint represents:

- 0.31% of the local study area;
- 0.15% of the BHP claim block; and
- 0.04 % of the wildlife regional study area.

The residual effect of development will therefore be continuous for the medium to long-term. The effect may be considered reversible, however, because vegetation that does eventually recolonize the area will be characteristic of the local study area. Because the area of impact is so small, the effect is rated as negligible.

4.4.1.3.3 Reduction of Productivity

In some cases, development activities may lead to degradation of vegetation and ultimately result in reduced productivity or changes in species composition over a given area. The principal effects on vegetation are related to air quality issues arising from dust and gaseous emissions, primarily NO_x and SO_2. Air quality modelling for the assessment of the EKATI™ mine and the Diavik Diamonds Project showed that concentrations of CO_2, NO_x and SO_2 were below threshold levels for effects on vegetation. Therefore, dust will be the important factor.

Many mining activities, including blasting, quarrying, heavy equipment operations, surface traffic and aircraft landings and take-offs, generate dust. The Arctic tundra is relatively free of natural dust, so the consequences of anthropogenic sources can be important. Fugitive dust emissions can have both direct and indirect effects on vegetation; these effects can be negative or positive, depending on plant species.

Dust effects on vegetation may arise from physical accumulation on plants and soil or from chemical properties of the suspended material. Documented impacts of dust on plants include:

- reduced water content and increased moisture wicking;
- reduced chlorophyll content;
- reduced carbon uptake rates; and
- alterations to plant chemical composition (Spatt and Miller, 1981; Meininger and Spatt, 1988).

Patterns of dust deposition on vegetation are a function of various factors, including particle size, wind, ambient moisture, and vehicle and traffic characteristics. Small particles travel farther, especially if borne by strong winds. Dust effects from roads are documentable up to 100 m from the source and can alter the abundance and distribution of plant species (Table 4.4-2). Heavy dust blankets may eliminate lichens and mosses,

Table 4.4-2
Plants of the Lac de Gras Area Reported to be Affected by Dust Deposition

Species Reported to be Adversely Affected by Dust Deposition		Species Reported to be Positively Affected by Dust Deposition	
Latin Name	**Common Name**	**Latin Name**	**Common Name**
Ledum decumbens	Labrador tea	*Calamagrostis spp.*	Reed bent grass
Lycopodium annotinum	Stiff club moss	*Eriophorum angustifolium*	Cottongrass
Pedicularis lapponica	Lapland lousewort	*Eriophorum vaginatum*	Cottongrass
Rubus chamaemorus	Cloudberry	*Rubus chamaemorus*	Cloudberry
Vaccinium uliginosum	Arctic blueberry	*Salix spp.*	Willow
Vaccinium vitis-idaea	Lingonberry		

Source: Golder, 1998.

but lighter dust loads may enhance moss growth (Walker and Everett, 1987). Some plants, including willows and grasses, may thrive in light to moderate dust deposition areas, while some berry-producing plants may be inhibited.

Indirect effects of dust include changes in snowmelt patterns. The darkened surface of snow within the dustfall area absorbs solar radiation and accelerates snowmelt. Consequently, areas within the dustfall zone will lose their snow cover earlier and more often than similar areas that are free of dust. Snowmelt within 30 to 100 m of the Dalton Highway in Alaska was advanced by 10 to 14 days over areas unaffected by dust (Walker and Everett, 1987). As an additional consequence, depth of thaw may also be greater in these areas. Where snowmelt is advanced, phenology will be accelerated and vegetation may be more productive. Snowmelt and rainfall help to mitigate dust layering on vegetation.

Diavik conducted an investigation of dust deposition patterns during the construction phase at EKATI™ (Cirrus Consultants, 1998). Dust was observed to travel up to 150 m from the source, but concentrations on vegetation were greatest at distances less than 30 m from source. Given the coarse nature of material used to construct the roadbed, the proportion of fine-textured particles will be low, and thus dust production is expected to be comparable to that measured by Diavik. Dust was recorded to have travelled up to 200 m downwind of Panda Pit (Cirrus Consultants, 1998) with no visible detection of dust within 20 minutes of blasting. Additionally, both the distance of travel and amount of time visible are expected to decrease as the pit deepens. A complete discussion of air quality related effects from the proposed development is provided in Section 4.3.

To assist in determining the possible effects on local vegetation associated with airborne particulate and gaseous emissions generated by the existing mining operation at EKATI™, a series of vegetation monitoring stations were established in 1998 (ABR, 1999) (Figure 4.3-1). A more complete discussion of this program is provided in Section 4.3; thus, only the most important results are presented herein. Lichens were selected for the accumulation of trace elements because they were commonly available in the mine area and at the reference sites selected. In addition, they tend to accumulate trace

elements almost entirely from atmospheric deposition (as opposed to uptake from roots), exhibit slow growth, have a long life span and are particularly sensitive to SO_2 contamination.

The results from the preliminary sampling and analysis in 1998 showed that levels of cobalt, chromium, copper, lithium, molybdenum, strontium and titanium were slightly higher ($P \leq 0.05$) in the existing EKATI™ area than in the reference area. However, the levels were well below those that would be considered toxic to plants or hazardous to wildlife (ABR, 1999). Figure 4.4-1 presents the key analytical results for metals from the lichen monitoring program. In addition, the pH of lichen tissue was determined to be somewhat higher in the mine area than at the reference sites. All values recorded were within the normal range of soils in the region, and none of the trace metal levels were considered abnormally high (ABR, 1999).

The primary mitigation measures to be employed in the proposed development areas includes BHP's practice of applying water as a dust suppressant as needed, and BHP's policy of regularly scheduled maintenance of vehicles and mining equipment.

Even with the diligent application of these mitigation measures, vegetation adjacent to areas of development activity will be exposed to dust and intermittent low levels of gaseous emissions (see Section 4.3) similar to those observed in the ABR (1999) study. This effect will be continuous for the duration of operations, will be limited to a small part of the local study area and will not affect the future capacity of the ecosystem. The effect is reversible once dust and gaseous emissions cease. Consequently, the effect is rated as negligible.

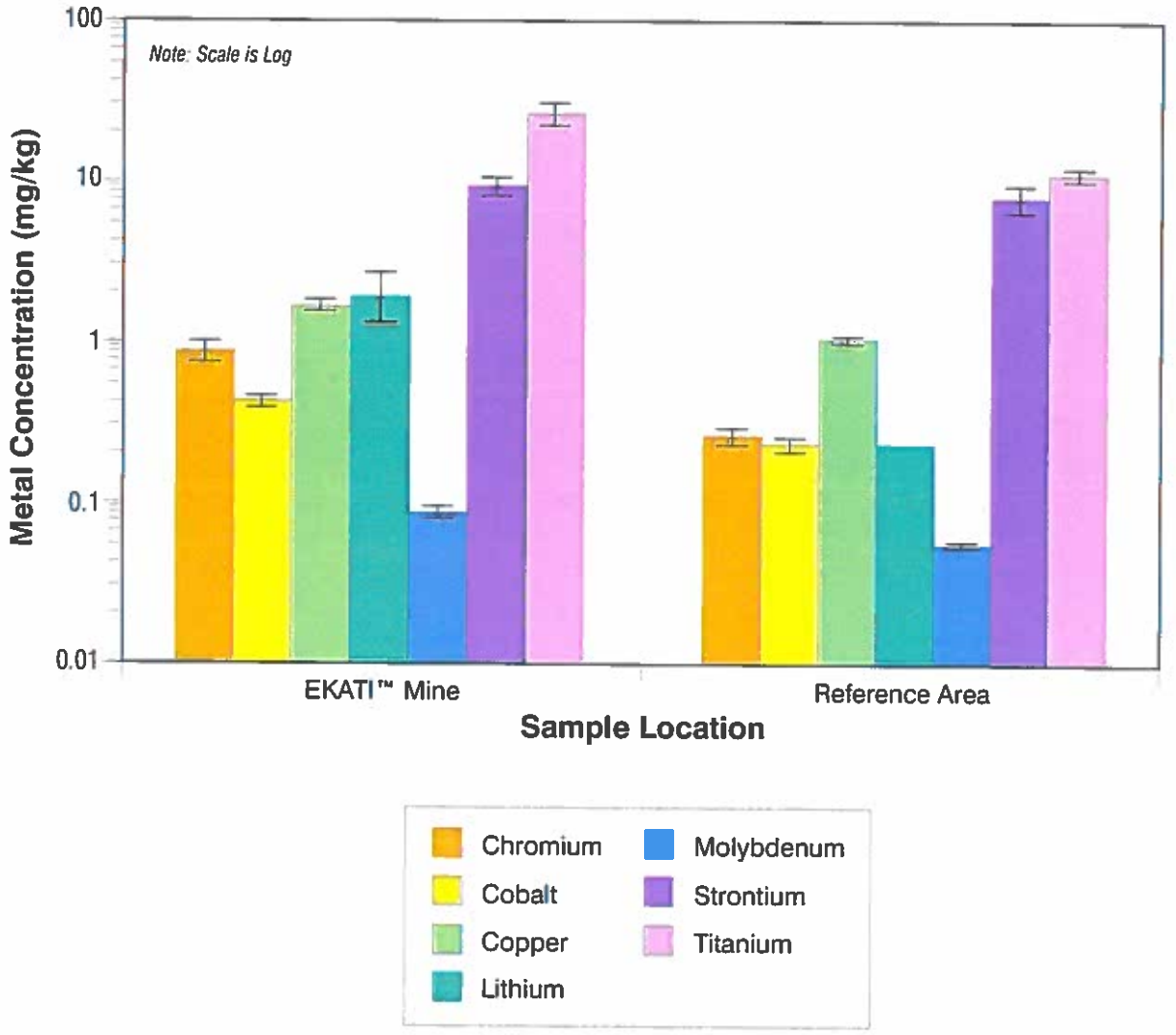
4.4.1.3.4 Biodiversity

A number of activities associated with the development of Sable, Pigeon and Beartooth pipes could potentially alter vegetative biodiversity:

- pit excavation;
- waste storage area development; and
- road construction and subsequent use.

As shown in Table 4.4-1, approximately 84.7% (418.6 ha) of the total area lost is represented by the heath tundra (BL) ecosystem unit. Heath tundra is the most common unit found in the BHP claim block, representing 72% of the land area within the block. A further 1.3% (6.2 ha) of the directly affected area is characterized by boulder field (BF) and exposed bedrock (RB). These percentages within the directly affected area are representative of the overall ecosystem unit presence within the claim block.

Pit excavation, road construction and subsequent use of the Sable Road will all contribute to dust and gaseous emissions. This may result in a vegetation species shift within 50 m



Comparison of Trace Metal Concentrations in Lichens at EKATI™, 1998

FIGURE 4.4-1

Source: ABR, 1999

of directly affected areas. Mitigation measures include careful route selection, BHP's practice of applying water as a dust suppressant as needed, and BHP's policy of regularly scheduled maintenance of vehicles and mining equipment.

In the unlikely event of a residual effect after BHP implements mitigation measures, it is likely reversible. The effect will last continuously for a short to moderate term, but would not reduce the biodiversity of the claim block. For these reasons, as well as the small portion of the local study area that may be affected, the effect is rated as negligible.

4.4.1.3.5 Wetlands

Wetlands will be affected through all stages of development of Sable, Pigeon and Beartooth pipes. These effects can be divided into two classes:

- loss of wetlands due to excavation and burial; and
- alteration of wetland areas due to operations associated with the pipes.

The wetland ecosystem units present within the BHP claim block were identified from the ecosystem mapping. These wetland complexes consist of birch hummock (BR), cotton-grass tussock tundra (EA), sedge meadow (CE) and occasionally sedge fens (CA) and emergents (AR).

4.4.1.3.5.1 Wetland Loss

All types of vegetation, including wetlands, currently occupying proposed areas of development (pits, waste rock storage piles, site infrastructure pads, roads) will be lost. The area of the wetland ecosystem units found within each proposed development area was calculated by overlaying a map of the proposed footprint and the applicable ecosystem maps.

The primary mitigation measure for minimizing impacts on wetland areas is careful route selection for Sable Road. Wetland ecosystem units – birch hummock (BR), cotton-grass tussock tundra (EA), sedge meadow (CE), and sedge fens (CA) – total 16.5% of the BHP claim block area. Approximately 4.1% of this habitat will be lost to the proposed development footprint, mostly (3.2%) through the development of Pigeon Pit. Impacts in the Pigeon development area will be partially mitigated by diverting Pigeon Stream (Section 4.5.4.1.2). The diversion will be designed and implemented so that he resulting stream mimics present conditions as closely as possible; this includes allowing for overflow during freshet to create wetland areas.

Other mitigation measures for reducing direct effects on wetlands in the development areas include revegetation techniques and natural recovery.

The residual effect of the loss of wetland habitat will likely be continuous for a moderate to long-term. The effect is unlikely to be reversible but is confined to a small percentage of the local study area. Consequently, the effect is rated as negligible.

4.4.1.3.5.2 Wetland Alteration

The proposed development presents some potential for wetland areas to be altered. As discussed above, the main issue related to mine activities is air quality, specifically the generation and deposition of dust.

Mitigation measures include careful route selection for the Sable Road. Approximately 3.0 ha, or approximately 3%, of the area directly affected by the road is wetland. Wetland adjacent to the road will potentially be affected by dust deposition. This effect will be localized (within 100 m of the road), of low magnitude and short-term (<2 years). Further mitigation measures include BHP's practice of applying water as a dust suppressant as needed, and BHP's policy of regularly scheduled maintenance of vehicles and mining equipment.

As with vegetation in general, even with the effective application of mitigation measures, wetlands adjacent to development activities will be exposed to conditions similar to those observed in the ABR (1999) study. The effect will be continuous for a short length of time, limited to a small portion of the study area and reversible once dust and gaseous emissions cease. Consequently, the effect is rated as negligible.

4.4.1.4 Heritage Sites

4.4.1.4.1 Effects on Heritage Sites

Most of the archaeological sites in the vicinity of the proposed Sable, Pigeon and Beartooth pits are sufficiently distant that no effect will be realized from development. The Sable Pit waste rock storage sites and the Beartooth/Pigeon section of the Sable Road have not yet been adequately surveyed with regard to archaeological resources. The need for these investigations is discussed below. With the exception of human activity and roads, which are also assessed below, no other activities associated with the Sable Pit will affect archaeological resources. This includes all aspects of construction, except roads, and all activities required for maintenance and decommissioning.

No archaeological sites are located within the development footprints of the Pigeon or Beartooth pits, although one site has been identified north of Beartooth. With the exception of the road and human activity, none of the development activities associated with construction, operation or decommissioning of these pits is expected to affect archaeological resources.

4.4.1.4.1.1 Road Construction

Development of borrow sources and construction of the road from Sable to Pigeon could potentially disturb or destroy archaeological sites on the Ursula West and Exeter eskers. To mitigate destruction or disturbance of any sites near the road itself during construction, the archaeological resources will be identified on maps and plans as areas to avoid and will be monitored by an archaeologist familiar with the site boundaries. Since

the sites would be protected and remain in context, there would be no direct residual archaeological effect from road construction.

Four archaeological sites (LeNt 10,11,21,22) are located near two proposed sources of gravel for Sable Road construction. It was determined in July 1999 that two of these sites could have been disturbed by a planned test program to assess the suitability of the gravel deposits for construction use. As a result, systematic surface collection of artifacts and detailed recording and mapping were done at the western locality of LeNt-10 and along the full length of LeNt-22. The residual effect is that the artifacts are no longer in their original context, but they are available at the Prince of Wales Northern Heritage Centre. Since no buried deposits were found at either site, the sampling probably recovered nearly 100% of the archaeological resources. The possibility that any artifacts were missed could be mitigated by having a qualified archaeologist re-examine the site prior to use as a quarry. In addition, monitoring during future gravel testing or borrow operations would permit the collection of any other artifacts exposed during these activities.

The residual archaeological effect of gravel testing near these two sites is of local geographic extent but long-term duration. The effect represents a one-time event and is basically irreversible, although the distribution of artifacts can be recreated because detailed notes were recorded. The magnitude of the effect is judged to be low because the sites were systematically collected, and so the general significance of the disturbance is negligible.

Protection of other identified sites (LeNt 24 and 28) near the proposed Sable Road will be provided through identification and construction monitoring - *i.e.*, avoidance. Intensive archaeological survey has been conducted in these vicinities, and there is very little potential for finding additional archaeological resources. Since the archaeological sites near the gravel sources can be avoided and protected, there is no residual effect.

The Sable haul road between the Beartooth and Pigeon pits has not been subject to an archaeological assessment through ground reconnaissance. Based on a preliminary interpretation of landforms, the potential for archaeological resources is tentatively assessed as low to moderate. Any sites encountered could be mitigated though systematic data recovery or avoidance; no large or intensively utilized sites are predicted in areas without eskers or large lakes, and small sites will be avoided or protected. Any sites within the road route would be disturbed or destroyed if avoidance was not feasible. Therefore they will be mitigated prior to construction.

Archaeological effects in this area would be localized, irreversible and long-term but unlikely to occur. Because mitigation can be carried out, the magnitude is judged to be low and the general significance to be negligible.

4.4.1.4.1.2 Waste Rock Storage Piles

The waste rock storage sites associated with Pigeon and Beartooth pits have been examined previously for archaeological resources, with negative results, or are located in areas with low archaeological potential and do not require ground reconnaissance. The rock storage areas associated with Sable Pit have not been assessed; aerial examination

and possibly ground reconnaissance would be required in these areas. The potential for archaeology sites is not high, however, and it is expected that any sites encountered could be mitigated through systematic data recovery. While the sites would likely be small and primarily on the surface (thus easy to mitigate through surface collection), avoidance during waste rock pile construction is not likely to be feasible. Sites within or near such storage piles would be destroyed or extensively disturbed; salvaging artifacts and related information for future study would lessen the impact.

Archaeological effects associated with the Sable waste rock storage piles would be localized, irreversible and long-term. If a site were to be encountered it would be mitigated before waste rock dumping was initiated, thus the magnitude would be low and the general significance of effects would be negligible.

4.4.1.4.1.3 Human Activity

Human undertakings, during both work and non-work related activities, could potentially affect archaeological sites during construction, operation or decommissioning of the Sable, Pigeon or Beartooth pits. There is only one archaeological site near Beartooth but numerous sites on the Ursula West and Exeter eskers between the Pigeon and Sable pits. These sites will not be affected directly by the developments as proposed, but could be subject to indirect impacts resulting from increased human presence in the study area. Impacts could include the trampling of artifacts by field crews walking along the eskers or the collection of artifacts by unauthorized individuals.

Impacts resulting from human activity can be mitigated by limiting access to areas outside the development footprints to individuals who are educated concerning the value of archaeological resources, and by prohibiting the use of any vehicles, including snow-mobiles, on eskers and elevated landforms adjacent to lakes. Steps to ensure such archaeological protection are an essential part of the ongoing management of the BHP claim block. The effective implementation of these steps will ensure that there will be minimal residual effects on archaeological resources from human activity.

The one archaeological site (LeNt 17) near the Beartooth pit was mitigated because of the threat of impact as a result of its proximity to the proposed development. Although development would be unlikely to extend as far north as the actual site, human activity could have disturbed the surface of the site or resulted in the removal or relocation of specific artifacts. Therefore, the surface artifacts were collected; there are no buried deposits at this location. As a result, the artifacts are no longer in their original context. The possibility exists that some may have been missed and left behind. Although the latter is unlikely, repeated site revisits will be made by qualified archaeologists to ensure that any additional artifacts are identified, recorded and collected.

As with the other mitigated sites, the residual archaeological effect for this site is of local geographic extent but long-term duration. The effect is unlikely to be reversible, although the artifacts could possibly be replaced because detailed notes were recorded. The magnitude of this effect is judged to be low because the surface artifacts were systematically collected and there is low potential for the presence of any additional

surface or buried archaeological deposits. The general significance of this archaeological effect is negligible.

In general, human activities could affect the archaeological resources within most of the regional area, but not all will necessarily be the result of BHP's operations. Although only a part of a site is usually disturbed, it is possible that the context of highly significant artifacts could be lost because they are the most visible. Since human activity is more dispersed in the BHP claim area than at most development-specific projects, where mitigation and/or protection can be ensured, the effects could be greater. For this reason, the general significance of archaeological effects due to human activities would be assessed as minor if no mitigation measures are taken. With BHP's mitigation plans, however, the effect is rated as negligible.

4.4.1.4.1.4 Conclusions

BHP will conduct additional studies in the proposed development areas to ensure that effects on archaeological resources remain negligible. The waste rock storage sites for the proposed Sable Pit and the road route between the Pigeon and Beartooth pits will be examined from the air, and areas with good archaeological potential will be traversed on foot.

BHP will ensure that monitoring is undertaken in the vicinity of the Ursula and Exeter eskers during construction of the Sable Road. Monitoring will also be conducted during borrow excavation activities at either of the possible gravel sources on the Ursula West Esker. In accordance with the NWT Land Use Regulations and the NWT Archaeological Site Regulations, monitoring will be conducted by a qualified archaeologist who holds a valid permit and is familiar with the characteristics and boundaries of the recorded archaeological sites.

The archaeological effects from the proposed development are assessed as being negligible, primarily because mitigation has already been undertaken and/or because of the low probability of impacts. The low probability of impacts is a factor of low site density in the development areas. Residual effects are expected to remain negligible with rigorous application of the proposed protection measures at archaeological sites, especially those some distance away from development areas.

4.4.1.5 Visual and Aesthetic Resources

The EIS (BHP, 1995) predicted that EKATI™'s effects on vegetation and habitat would be negligible. That document acknowledged, however, that reclamation, refilling the pits with water to re-establish lakes, revegetating the access roads and weathering of waste rock piles after decommissioning would be a lengthy process due to the arctic conditions. This could have a long-lasting aesthetic effect on future users of the immediate mine area of the claim block (EIS, Volume IV, Section 3.2). The June 1996 report by the EARP panel addressed visual and aesthetics within the broader framework of wilderness. While acknowledging there would be a loss of "wilderness experience," EARP accepted BHP's conclusion that "... the long-term residual effects would be negligible if reclamation were successful" (CEAA, 1996).

Given the conclusions of EARP, this assessment will focus on whether or not the proposed three-pipe development will change the original EARP prediction on visual and aesthetic effects.

The addition of Sable, Pigeon and Beartooth to the EKATI™ mine plan will result in the loss of some vegetation and wildlife habitat through the construction of roads, waste rock storage piles and infrastructure. Habitat effectiveness in areas immediately adjacent to the developments will also decrease somewhat during the years of operation. The reclamation plans for Beartooth, Sable and Pigeon are consistent with those for the existing EKATI™ Diamond Mine; the process will be similarly protracted because of the harsh arctic conditions.

BHP investigated four factors to determine the potential for significant additional visual and aesthetic effects as a result of the three-pipe development:

- Is BHP managing EKATI™'s footprint to limit visual effects?
- Will reclamation of EKATI™ address potential visual effects?
- Will the proposed development visually or aesthetically affect known patterns of wilderness use?
- Will the landscape created by the mine pose aesthetic issues for casual observers or recreational users of the barrenlands?

These issues are discussed below.

First, the EKATI™ mine footprint is carefully managed by allowing new land disturbance only after all options for using the existing infrastructure have been reviewed. EKATI™'s land-use planning objectives are to minimize disturbance and maintain pristine tundra to the edge of the development. Any encroachment outside of existing development areas is strictly controlled, and vehicles must remain on roadways.

The 1:50,000 scale, 15-m satellite image in Figure 4.4-2 demonstrates the continued presence of undisturbed tundra around the infrastructure of the EKATI™ mine. BHP is investigating the potential use of satellite imagery as a mechanism to monitor changes to mine-related structures (*i.e.*, roads and waste rock storage piles) and the status of reclamation measures. EKATI™ has been false-coloured red to make it stand out. Bedrock, boulders and heath are purple, and heath and tussock tundra with little surface rock are light green. The faint red blushes are cloud shadows. It is evident in this image that the EKATI™ footprint is defined and contained.

Second, progressive reclamation at EKATI™ has now commenced after the first full year of production. Experimental revegetation programs undertaken to date suggest that reclamation should be successful in the long term. Conceptual engineering and environmental designs for re-establishing lakes in the mined-out pits will be finalized when the pits are ready for decommissioning. Appropriate reclamation will reduce residual visual and aesthetic effects.

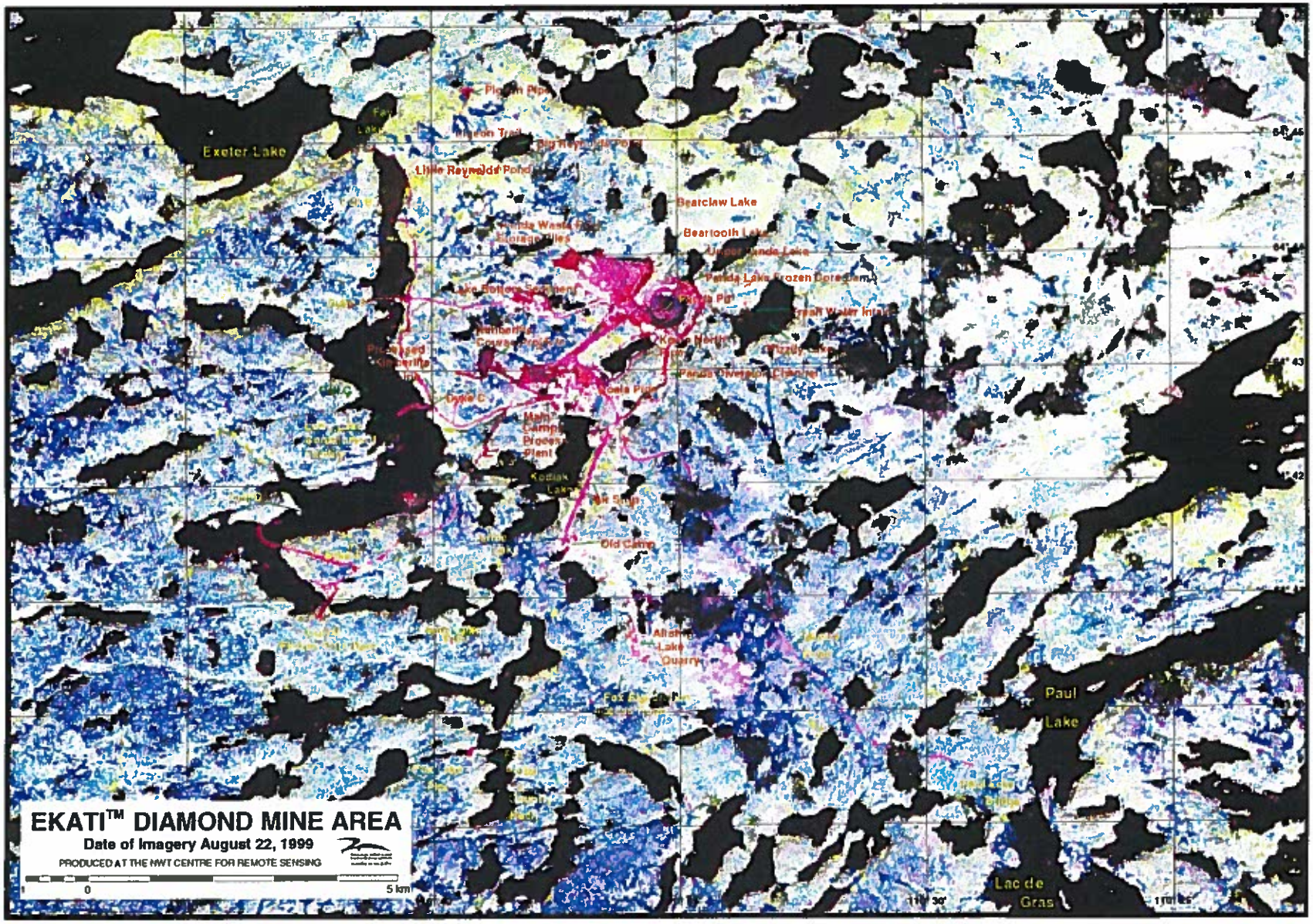


FIGURE 4.4-2

The EKATI™ Mine Footprint

With regard to EKATI™'s impact on wilderness use, BHP has identified three current wilderness activities in the Lac de Gras region that could potentially be affected by visual and aesthetic issues:

- traditional transportation, hunting and fishing;
- recreational canoeing; and
- commercial sport hunting.

BHP has been able to determine only limited use of the EKATI™ site by Aboriginal people over the last 50 years. It is evident that the Lac de Gras area was more intensively used before the second world war. Winter dogsled routes pass to the west across Exeter Lake and just east of Sable (see Figure 3.8-3), but no intensive traditional use of the proposed Sable, Pigeon and Beartooth development areas has been identified to date by the local Aboriginal groups. Therefore, the potential for visual and aesthetic effects on Aboriginal land users is negligible.

A guide published by the Canadian Recreational Canoeing Association recommends the outlet of Lac de Gras as the headwater starting point for parties travelling the Coppermine River (McCredie, 1995). According to local outfitters and airline companies, many trips start further downstream in the Coppermine River system. The proposed Sable, Pigeon and Beartooth development is not visible from Lac de Gras or any point downstream on the Coppermine River. The proposed development will therefore have negligible visual and aesthetic effects on recreational canoeing on the river.

Courageous Lakes Caribou Camps has commercial sport hunting camps at the outlet of Lac de Gras and on Lac de Gras south of the Lac du Sauvage narrows. These camps, formerly operated by Qaivik Ltd., are currently closed. The new owner plans to resume hunting and re-open the camps within the next few years. The outfitter does not anticipate that proximity to mining will affect his business. The outfitter does not plan to take hunters north of Lac du Sauvage and so they would never see the three pits. The proposed development will therefore have a negligible aesthetic effect on sport hunting in the Lac de Gras area.

The issue of the mine's general visual and aesthetic quality within the overall landscape and its effect on casual observers, such as airline passengers en route across the North, is nebulous. Some people prefer to see large expanses of natural, undeveloped wilderness with no human intervention, while others consider features such as the mine to be points of interest in the scenery.

To determine the actual visibility of the mine at 30,000 feet, BHP contracted the NWT Sensing Centre to create a 1:250,000 scale image of the EKATI™ mine site (Figure 4.4-3). In this image, the central EKATI™ development is about the size of a nickel, and outlying features such as the Misery Road are visible but not distinct. On Figure 4.4-3, the mine site has been false coloured red to make it stand out from the surrounding tundra. As on Figure 4.4-2, bedrock, boulders and heath are purple, and the tussock tundra is light green.

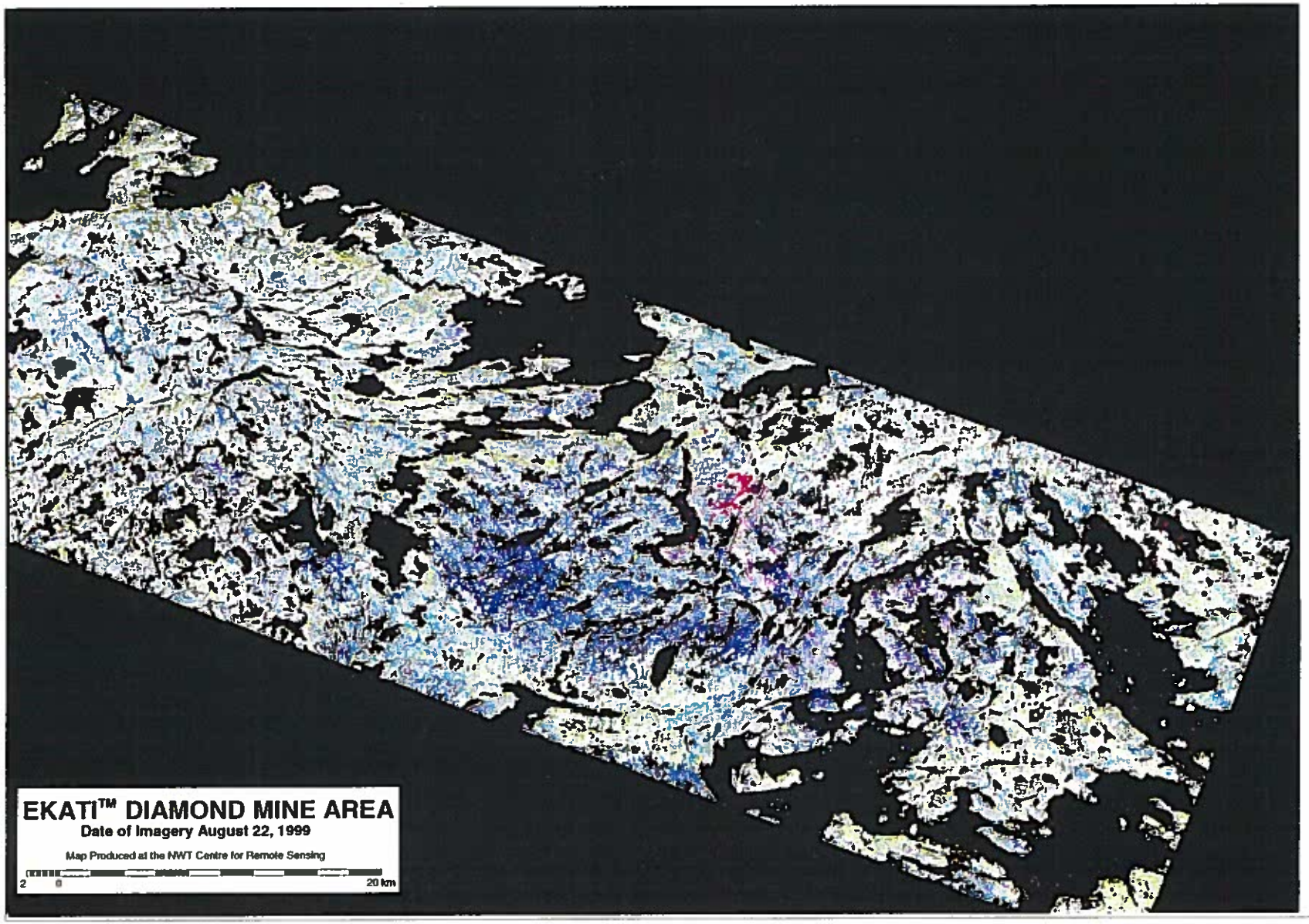


FIGURE 4.4-3

EKATI™ from 30,000 Feet

Figure 4.4-4 is a satellite image of Yellowknife at 30,000 feet. The same colour scheme has been used to show the Con and Giant mines (red), surrounding rock (purple) and vegetation (green). The older sections of the city are orange, yellow and white. Over time, the waste rock storage piles and other features at EKATI™ are expected to weather and blend into the landscape in the same way as the older parts of Yellowknife. The current EKATI™ footprint fits within the outline of the Giant Mine site north of the city.

For the purpose of this EAR, visual and aesthetic effects on any casual observers or future visitors to the mine area, such as tours conducted by tourism operators, are considered negligible.

4.4.2 Assessment of Environment on Development

4.4.2.1 Climatic Trends and Permafrost

There are currently two frozen core dams functioning as water containment structures at the EKATI™ site. The proposed development plan includes the construction of two more dams. The preliminary design of those dams, described in the report "Preliminary Design of Water Control Structures for Sable, Pigeon and Beartooth Developments" (EBA, 2000), has identified that they will also be frozen core structures. Frozen core dams rely on sustaining permafrost within the dam foundation and internal core to eliminate seepage losses. Embankment stability does not require that the core remain frozen. This section examines potential impacts that climatic variability or a climatic warming trend could have on the design and performance of permafrost-sensitive structures and the tools that have been used to assess the risks associated with a potential warming trend.

It is generally accepted that climatic warming has occurred and is continuing in the region of the Mackenzie Valley. Climate trends have also shown a cooling trend in Canada's Eastern Arctic. The interior of the NWT has not shown definitive warming or cooling trends. The Environmental Adaptation Research Group, within Environment Canada, sponsored a project with the objective of identifying "Climate Change Impacts on Permafrost Engineering Design". The final report with the same title was released in March 1998 (Environment Canada, 1998). That study examined the relationship between global climate change and the long-term performance of engineered structures built on permafrost. A risk-based project screening process was developed that relates sensitivity to climate change and possible failure consequences. The purpose of project screening is to identify those structures on permafrost soils where the risk of failure due to permafrost thaw could be significant and to recommend the level of analysis that is appropriate to assess the effects of possible climate change.

The existing EKATI™ Long Lake Containment Facility outlet dam was adopted as a case example during the Environment Canada study. It was ranked as a structure with a high potential failure consequence, although the sensitivity to climate change was considered only moderate because of the cold natural permafrost conditions. The screening process

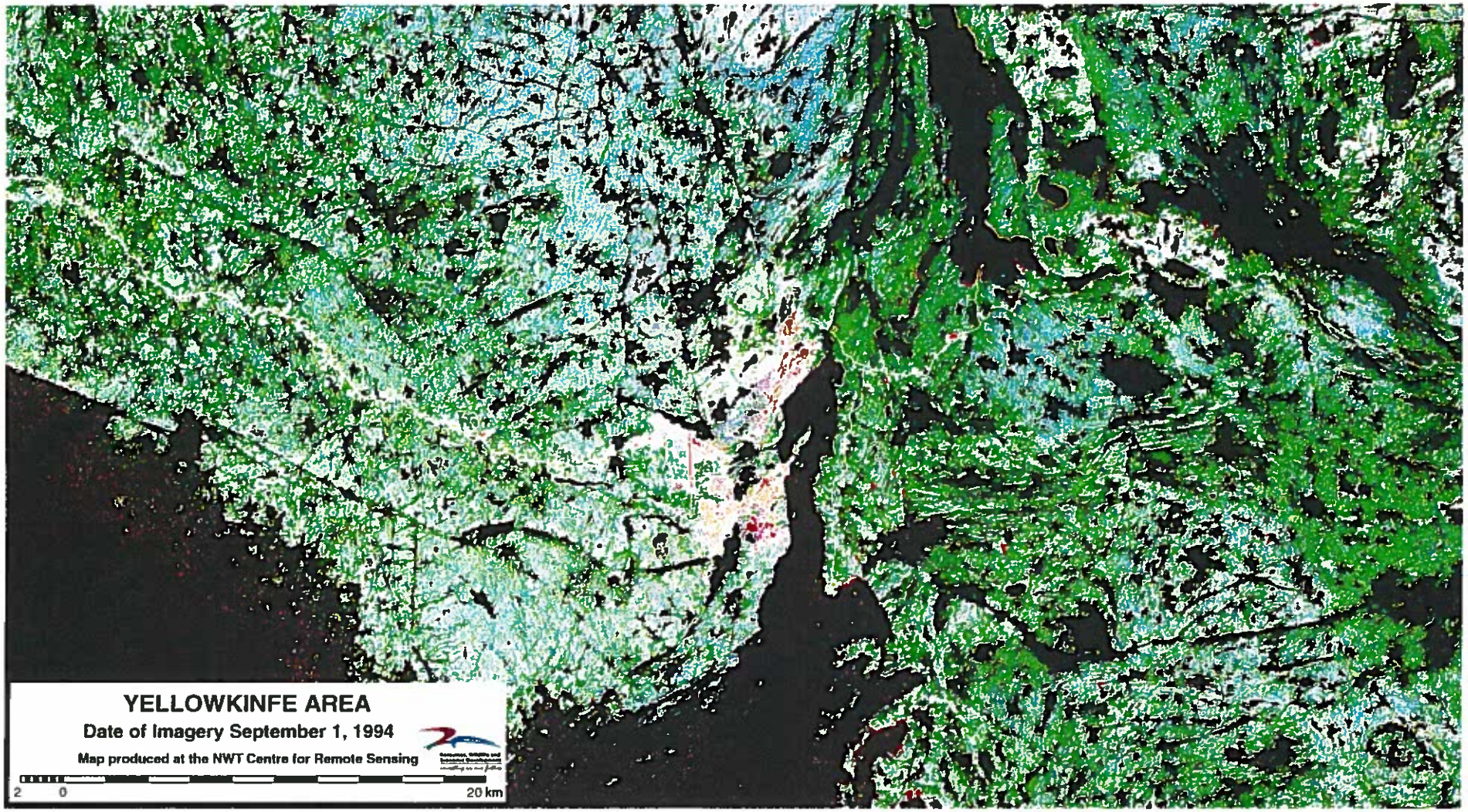


FIGURE 4.4-4

Yellowknife from 30,000 Feet

concluded that detailed quantitative analyses were required to evaluate the impacts of climate change on the structure. That analysis was completed and the results provided guidance for final design of the structure (EBA, 1995). The results of the screening process can be applied to all water-retaining structures at the EKATI™ mine site. Structures that are sensitive to possible changes in permafrost condition require quantitative analyses of the effects of climate change. Other structures, such as roads and building foundations, require only qualitative assessments during the design process.

The water-retaining structures described in this report have been developed to a preliminary design stage, based on experience with design and performance of other similar structures at the mine site. The preliminary designs do not include thermal and stability analyses, as these will be undertaken at the final design stage. The methodology for thermal design of frozen core dams that has been adopted for all permafrost-sensitive structures on the site is described in the report "Tailings Management Plan and Preliminary Design of Retention Structures" (EBA, 1995). That methodology includes detailed two-dimensional geothermal modelling to predict the time-temperature relationship within the dam and its foundation. These analyses include the following:

- a base case analysis that uses long-term mean annual air temperatures;
- the base case with a climatic warming trend taken from scientific studies published by Environment Canada; and
- analyses that include the effect of unusually warm years, such as experienced on site during the winter of 1998-99.

These analyses have shown that structures with a short operational life are not particularly sensitive to climate change because of the substantial time lag between an observed trend in air temperature warming and a corresponding response in the ground temperature.

The two operating frozen core dams have been instrumented with ground temperature cables and settlement monuments. These instruments are monitored to collect performance data that can be compared with analytical predictions. The data and interpretation are reported annually to the Water Board in compliance with the Water Licence. The records have confirmed the applicability of the design tools and their input parameters for the EKATI™ site. The monitoring program can also be used for early detection of temperature irregularities in the dam core or foundation that could be an early indicator of a warming trend. All frozen core dams constructed at the site will include a similar monitoring program. The results will be used to detect and mitigate permafrost warming that could result in adverse performance of the structure.

4.4.2.2 Frost Action and Ground Movements

Under certain conditions, frost heave during refreezing of the active layer each fall could be damaging to structures. Incremental small freezing displacements can result in frost-shattered bedrock surfaces and heave of bedrock slabs over geological time. These processes have been observed on-site at locations where exposed bedrock topography is in contact with wet fenlands. Abundant surface water is present to fill the voids in the

rock each summer, resulting in freeze-expansion the following winter. Where such conditions are identified in a sensitive foundation, the frost-shattered material will be excavated and replaced with well-graded compacted fill. The fill is designed to remain frozen, and is not normally subjected to substantial freeze-thaw cycles. Where instability concerns remain, a monitoring program will be implemented and mitigation measured adopted as required.

Some local effects may occur on the surface; however, design and construction practice will ensure there is no risk to structures. The physical effects associated with the proposed development will be negligible.

4.4.2.3 Earthquake Hazard

The project area is geologically stable, of low seismic risk and with no natural landslides suggestive of earthquake hazard. Potential for ground instability related to seismic activity was documented in the EIS (BHP, 1995). No earthquake of Richter Magnitude M6 or greater has occurred within 1,000 km of EKATI™ in recorded history.

An earthquake risk evaluation for the site was obtained from the Pacific Geoscience Centre, Geological Survey of Canada, as presented in the EIS (BHP, 1995). Predicted ground velocities for the 10% and 5% probability of exceedance in 50 years (475 and 1,000 year events, respectively) are presented in Table 4.4-3.

Table 4.4-3
Peak Ground Velocities Probability of Exceedance in 50 Years

		Probability of Exceedance
Peak Ground Acceleration, gravity units	0.013	0.016
Peak Ground Velocity, m/s	0.039	0.046

Acceleration of 0.01 to 0.02 gravity units is very small and would not cause damage to earth or other structures. The peak velocities of 0.04 to 0.05 m/s are high relative to the acceleration values and indicate that the risk is coming from a distant earthquake rather than a small local earthquake. Velocities in this range would not cause damage to earth or other structures.

The risk of damage to water-retaining structures in the event of an earthquake will be assessed and included as part of the final design analyses in accordance with the "Dam Safety Guidelines" published by the Canadian Dam Association (January 1999). Those guidelines classify structures in accordance with their consequences of failure. Structures with a high consequence ranking, such as the diversion dam at the pit crests (Panda, Beartooth), have been designed for an earthquake with very low annual exceedance probability (1/1,000 to 1/10,000). The region is not considered seismically active, therefore, earthquake analysis has not been a significant design factor on previous structures and the overall effect is considered to be negligible.

4.4.2.4 Pit Wall Stability

The conceptual pit configurations for the Sable, Pigeon and Beartooth pipes (Section 2.2.2, Figures 2.2-3, 2.2-4 and 2.2-5) represent approximations of the ultimate pit footprints and volumes that will be mined. Their slope angles are best estimates based on geotechnical data available at this time and current operational experience gained from the active Panda Pit.

Final slope stability evaluations will be undertaken for each pipe to define stable slope angles for each pit. The evaluations consist of detailed fault and structure mapping and modelling from regional geology as well as resource and geotechnical drill hole data. Freeze-thaw effects of seeping groundwater and changing permafrost conditions could decrease the stability of the pit walls. The data will be used by and/or under the direction of a licensed professional engineer experienced in ground stability design to define a geotechnical pit design in compliance with Northwest Territories Mine Heath and Safety Regulation 1.04. The geotechnical pit slope parameters and guidelines will then be used to design the final economic pit and produce the pipe's overall mine plan. The final pit designs and mine plans for each pipe will then be summarized and compiled into a Notice of Intention to Commence Work as required by Section 17 of the Mine and Safety Regulations. Thus, sound engineering design and construction practice will mitigate pit wall stability, and the pit bench configurations will contain any localized rockfall. Techniques have been developed to effectively scale the walls to remove potentially hazardous rock. This practice will continue for the three pipe development. Although ice forms on the pit walls, it has not presented an operational issue; generally the ice sublimates in the spring and poses no hazard.

4.4.3 Summary of Land VECs and Landscape-Related Issues

There are three activities associated with the proposed development that may affect the land environment:

- development and operations of the pits,
- construction and use of Sable Road, and
- infrastructure required for the proposed development.

All effects on the VECs are predicted to be negligible (Table 4.4-4). Although some effects may be long-term or frequent in nature, the portion of the local study area affected is very small.

Table 4.4-4
Summary of Predicted Effects on Land-Related VECs due to Proposed Development of Sable, Pigeon and Beartooth Pipes

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Permafrost	Pit Development	Instability of active layer causing soil erosion and subsidence due to thaw.	Engineering design of pit walls and pit bench configurations.	Negligible
	Construction and use of Sable Road	Instability of active layer causing soil erosion and subsidence due to thaw.	Careful route selection. Engineering design to preserve frozen conditions.	Negligible
	Infrastructure (including waste rock storage piles)	Instability of active layer causing soil erosion and subsidence due to thaw.	Engineering design to preserve frozen conditions.	Negligible
Groundwater	Pit Development	Draw-down of lakes and streams adjacent to pits.	None needed as steady state conditions will prevail once pits are refilled.	Negligible
	Construction and use of Sable Road	none		n/a
	Infrastructure (including waste rock storage piles)	none		n/a
Physical/ Terrestrial Environment	Pit Development	Loss of vegetation Species shift Wetland Loss	Natural revegetation Application of water as a dust suppressant. Pigeon Stream Diversion engineered to create wetlands.	Negligible Negligible
	Construction and use of Sable Road	Loss of vegetation Species shift Wetland Loss Wetland Alteration	Natural revegetation Application of water as a dust suppressant. Careful route selection.	Negligible Negligible
	Infrastructure (including waste rock storage piles)	Loss of vegetation Species shift	Natural revegetation	Negligible Negligible
Heritage Sites	Road Construction	Destruction or disturbance of sites.	Identification on maps and avoidance of sites.	Negligible
	Waste Rock Storage Piles	Destruction or disturbance of sites.	Systematic Data Recovery.	Negligible
	Human Activity	Indirect impacts from increased human presence in the study area.	Prohibit the use of vehicles on eskers. Education about the value of archaeological resources.	Negligible

4.5 Water

To date, development activities at the EKATI™ Diamond Mine have been limited to the Lac de Gras Watershed (3,980 km^2) and the Koala Watershed subdrainage (185 km^2). The proposed development of the Sable and Pigeon pipes and their associated infrastructure will begin to impinge upon two small headwater drainages of the Yamba/Exeter Watershed (3,070 km^2). These are the Horseshoe Watershed (88.9 km^2) and the Pigeon Drainage Area (11.3 km^2). These watersheds and drainage areas are depicted in Figure 4.2-2 in the assessment methodology section (Section 4.2).

The following assessment of the possible effects of the proposed new development on the water environment has used an ecosystem approach involving the integrated examination of the two primary Valued Ecosystem Components (VECs) which define the aquatic environment, namely 1) water quality and quantity, and 2) fish/aquatic habitat. The maintenance of adequate water flows and acceptable water quality in fish-bearing lakes and streams is critical for the continued protection of fish and aquatic habitat in the development area.

The water section of this environmental effects chapter is organized as follows:

1. A general section, which addresses mine-related activities and issues which are common to all three pipe developments;
2. A section on the Sable Pipe development, in which mine-related activities, effects, mitigation measures and an assessment of residual effects are presented for the VECs water quantity, water quality, and fish/aquatic habitat;
3. A section on the Sable Road, again assessing the magnitude of any predicted residual effects;
4. A section on the Pigeon Pipe development, organized in the same manner as the Sable Pipe section;
5. A section on the Beartooth Pipe development, again organized similarly to the other pipe sections; and
6. A summary section, which provides a synopsis of the residual effects on water-related VECs common to all pipe developments.

4.5.1 General

Fish habitat is defined in the *Canada Fisheries Act* as, "...spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." This definition therefore includes primary and secondary producers and macroinvertebrates within food webs utilized by fish. Discussions of fish habitat in this section of the report therefore include consideration of effects on fish food organisms as well as effects on the physical environment. Fish and

the organisms they depend upon constitute the aquatic life of the waterbodies that will be affected by the three pipe development. For this reason, the term "aquatic life" will be used interchangeably with "fish and aquatic habitat" in this report.

Based upon existing biological and ecological site characteristics and previous experience from mining operations at other lakes in the BHP claim block, predictions can be made regarding the potential effects on aquatic life from the development of the Sable, Pigeon and Beartooth pits. Some effects are obvious and immediate. For example, lake dewatering will result in the loss of all remaining fish (those that have not been fished-out), fish habitat and invertebrate species until the pits have been restored to productive lake status. Less apparent are potential effects on fish production potential associated, for example, with stream diversions, changes in water flow and water quality, water containment structures and waste rock storage.

Within the three proposed pit development areas, the fish communities in Sable Lake, Two Rock Lake (Sable Pit development), Big Reynolds Pond (Pigeon Pit development), Beartooth Lake, and Bearclaw Lake (Beartooth Pit development) can be considered to be isolated and self-sustaining. Fish migration into or out of these lakes is severely restricted by poor quality migration habitat, very low flows and the ephemeral nature of their inflow and outflow streams.

Isolated lakes represent autonomous ecosystems, a condition that is ecologically rare worldwide but still relatively common in the Canadian Arctic (Vanriel and Johnson, 1995). It is likely that fish initially entered these lakes through interconnecting stream channels that provided unimpeded fish access at some time in the past. These connecting streams became unusable as migratory pathways, probably through the gradual deposition of substrate materials combined with reduced flows, thereby isolating fish within the lakes.

Vanriel and Johnson (1995) provide a description of autonomous ecosystem lakes in the Canadian Arctic. These lakes eventually reach a stationary state. In energetic terms, energy is acquired and conserved in the biomass of these lakes for long periods of time, until conditions change sufficiently either to permit significant population exchanges among adjacent water bodies or population extinction.

Because of the virtual isolation of fish stocks in Sable and Two Rock lakes, Big Reynolds Pond and Beartooth and Bearclaw lakes, it is probable that their fish populations do not contribute significantly to the fish gene pool of any other lakes in the Lac de Gras or Yamba/Exeter watersheds. As well, there is no evidence to suggest that these waterbodies could be used for sustained food, recreational or commercial fishing. This is the case because of their remote location, small fish populations and poor productivity.

The development of the Sable, Pigeon and Beartooth pits will involve a range of mining-related activities similar to those already employed successfully at the existing EKATI™ mine along with several innovations to further minimize potential effects on the aquatic environment. All sewage as well as other wastes generated by the operational infrastructure in the Sable, Pigeon and Beartooth areas will be transported to the existing

EKATI™ mine facilities. It will be handled in accordance with established waste management procedures. As such, the potential effects of sewage and other wastes on water were not addressed.

The common activities that will occur at some or all three of the pipe developments that could potentially affect water include the following:

- lake dewatering;
- pit water discharge;
- flow diversion;
- in-stream/lake construction;
- waste rock storage/drainage;
- pit restoration to productive lake status at the end of the mining cycle;
- operational activities (blasting/fugitive dust); and
- all weather road construction.

The following sections present general discussions on all of the common activities.

4.5.1.1 Lake Dewatering

Lake and pond dewatering will affect fish and aquatic habitat, but is expected to have negligible effects on water quality and quantity.

Sable Lake will be dewatered during the late fall through a combination of the Two Rock Lake Outflow Stream and Two Rock Lake, which will have been developed into a two-stage sedimentation and polishing pond prior to the dewatering of Sable Lake. Clean water from Sable Lake will be discharged directly to the Two Rock Lake Outflow Stream leading to Horseshoe Lake. As the water is lowered in Sable Lake and total suspended solids (TSS) begin to approach the Licence criteria, the remaining water will be discharged to the sedimentation pond at the east end of Two Rock Lake. This will allow settling of solids and filtration of the water as it moves through the engineered semi-pervious dyke that will be constructed in Two Rock Lake.

For Beartooth Lake and Pigeon Pond, all water will be directed to the Koala Watershed during the dewatering process. At Beartooth Lake all clean water will be pumped in a controlled manner during late fall into North Panda Lake which flows into the Panda Diversion Channel (PDC). As the water in Beartooth Lake is lowered and begins to approach Water Licence criteria, the remaining water will be redirected to the Process Plant prior to discharge to the Long Lake Containment Facility. At Pigeon Pond, all of the water will be pumped during the late fall either to Little Reynolds Stream which flows into the Long Lake Containment Facility. Discharges from the Long Lake Containment Facility to the downstream Koala Watershed are regulated and controlled by the existing Type A Water Licence.

Prior to dewatering, the fish in each of Sable Lake, Two Rock Lake (sedimentation pond), Pigeon Pond, Big Reynolds Pond (the location of the Pigeon Waste Rock Storage Area), and Beartooth Lake will be harvested in accordance with the requirements of the anticipated Fisheries Authorization to be issued by the DFO. Indigenous harvesting techniques will be utilized along with methods developed in previous fish-out programs. As with the existing Fisheries Authorization, no net loss and compensation provisions will be specified in the new Authorization by DFO.

4.5.1.2 Pit Water Discharge

It is expected that the discharge of pit water will have a minor effect on water quality, and a negligible effect on water quantity. It is not expected that the minor effect on water quality will result in a change to the biology of aquatic ecosystems.

In Sable pit, mine water collected in sumps will be used for road watering, drilling and other pit operations. Any excess water will be pumped to the Two Rock Lake sedimentation pond for retention and eventual filtration through the semi-pervious dyke into the polishing pond prior to release in accordance with Licence criteria to the downstream Horseshoe Watershed (via Horseshoe Lake). At Pigeon and Beartooth pits the small quantities of mine water collected in the pit sumps will be pumped to either the existing EKATI™ Process Plant or the Long Lake Containment Facility. Either way, pit water from Pigeon and Beartooth pipes will be introduced to the Long Lake Containment Facility.

It is expected that the quality of pit water from Sable, Pigeon, and Beartooth pits will be similar to the water quality that has been observed in the existing Panda Pit. Elevated concentrations of most materials in pit water (*e.g.* total suspended solids) can be mitigated by settling and filtration. This has been previously demonstrated in the Long Lake Containment Facility where Panda pit water is discharged. Potentially poor quality pit water from Sable will be mitigated by retention and filtration through the semi-pervious dyke in Two Rock Lake. Pit water from Pigeon and Beartooth will be discharged to the Long Lake Containment Facility via the Process Plant.

Elevated concentrations of nitrogen compounds will likely remain in pit water after the previously discussed mitigation measures have been employed (filtration dykes in Two Rock Lake and the Long Lake Containment Facility). As such, it is possible that elevated concentrations of nitrogen will be introduced to waterbodies downstream of Two Rock Lake and the Long Lake Containment Facility.

Nitrogen compounds are introduced into surface waters by the use of ammonium-nitrate based explosives (ANFO) in normal mining operations. Nitrogen compounds can reach surface waters from blasting activities, waste rock storage, mine water, and the use of waste rock in construction. Nitrogen is a required nutrient for plant and algae life, along with other nutrients such as phosphorus and carbon.

The most common form of dissolved nitrogen found in surface waters around EKATI™ is nitrate. Nitrate serves as a nutrient for primary producers, and is not known to be toxic to aquatic organisms. Nitrite and ammonium are other nitrogenous compounds which

can be toxic to aquatic life in high concentrations (0.06 and 2.2 mg/L, respectively). The primary nitrogenous compound that has been present in the Long Lake Containment Facility and downstream waterbodies is nitrate; concentrations of both nitrite and ammonium have been low and well below the criteria for the protection of aquatic life (Rescan, 1999).

Monitoring programs to date have shown that elevated nitrogen concentrations that exit the Long Lake Containment Facility have not caused a change to the biology of aquatic ecosystems downstream. This is probably because phosphorus, not nitrogen, is the limiting nutrient in this system, as it is in most fresh water systems. Phosphorus concentrations exiting the Long Lake Containment Facility are currently at baseline concentrations, which support background concentrations of phytoplankton biomass found in lakes in the area (typically less than 1 µg/L chlorophyll *a*).

In addition to sediment-associated parameters and nitrogen compounds, mine water may contain varying concentrations of particulate kimberlite. However, the Long Lake Containment Facility is designed to retain any particulate matter, and discharge water is monitored and must contain total suspended solid concentrations of 25 mg/L or less in accordance with the Water Licence.

The potential for exposure of aquatic life to processed kimberlite downstream of the Long Lake Containment Facility is low, given the Water Licence specifications (TSS < 25 mg/L). However, concerns over the potential toxicity of kimberlite to aquatic life led to the design and conduct of a study to "...obtain information on the associated toxicity and sub-lethal effects of kimberlite solutions to aquatic organisms (Enviro-Test Laboratories, 1998)".

Experimentation was carried out using kimberlite from the Fox and Panda pipes. The Panda kimberlite was not toxic to the fish, zooplankton and phytoplankton species used in this study, and only slightly toxic to bacteria at a concentration of 200 mg/L. The suspensions prepared from Fox kimberlite were acutely toxic to all species tested, but toxicity was related to suspended solid concentrations that would never occur in fish-bearing waters. The 96 hour LC50 (the concentration of kimberlite at which 50 percent of the organisms die within 96 hours) for rainbow trout was 667 mg/L and 7305 mg/L for *Daphnia magna*. These concentrations were greater than 25 times the allowable discharge concentration of total suspended solids from the Long Lake Containment Facility. Sub-lethal effects on fish of the Fox kimberlite suspension also occurred, however, and appeared as gill lesions and accumulations of aluminum and nickel in their gills. . Aluminum and nickel are metals normally associated with kimberlite. As well, high concentrations of particulates commonly result in physical damage to fish gills. However, as stated previously, total suspended solid concentrations of 25 mg/L or less must be met before any water from the Long Lake Containment Facility is discharged to downstream waterbodies.

While it is apparent that very high concentrations of particulate kimberlite can result in both lethal and sub-lethal effects on fish and other aquatic organisms, water discharged into the receiving environment is required to meet discharge criteria stipulated in the Water Licence. The Water Licence limits TSS discharges to 25 mg/L, a concentration that will not result in adverse effects on fish or their food supply, according to the Enviro-

Test Laboratories (1998) study. Both the Long Lake Containment Facility and the Two Rock sedimentation pond have been designed to clarify water to levels equal to or less than the 25 mg/L level.

4.5.1.3 Flow Diversion and Water Containment

A number of water containment and diversion structures will be constructed to provide effective drainage management in relation to the development of the three pits. The diversion of water flow will have an effect on fish and aquatic habitat, and potential negligible to minor effects on water quality and quantity. The diversion structure associated with effects on water VECs is the Pigeon Stream Diversion structure.

As part of the Sable Pit development, a dam will be constructed at the outlet of Two Rock Lake. The effect on water quantity will be minimized by discharging water as it naturally accumulates, consistent with best management practices. The effects on water quality and fish/aquatic habitat are expected to be negligible.

The development of Pigeon Pit will eliminate Pigeon Pond and approximately 520 m of Pigeon Stream. A short (440 m) stream diversion will be constructed to permanently realign Pigeon Stream. It will maintain the drainage in a manner that maintains flow and mimics current stream conditions. The design and construction plan for this stream realignment will allow seasonal fish passage and will be used to re-establish viable fisheries habitat as has been done with the Panda Diversion Channel. In addition, after mining is completed, the Pigeon Pit Lake will be reconnected to the downstream end of the original Pigeon Stream, resulting in the restoration of an additional 220 m of streambed. Pigeon Pond has an upstream catchment area of approximately 900 ha. Flows expected through the Pigeon Stream Diversion are approximately 1.8 to 2.5 million m^3/y based upon an average and high annual runoff depths of 224 and 350 mm, respectively. The diversion channel itself will have negligible effects on water quantity. Water quality could be affected during the construction and possibly during the initial operation of the channel. Section 4.5.4.3 summarizes the likely effects of this stream diversion on fish and fish habitat.

For Beartooth Pit development, the present flow from Bearclaw Lake into Beartooth Lake will be diverted for approximately ten years by means of a pipeline from Bearclaw Lake to the upper reach of Beartooth-North Panda Stream. The diversion of the flow into the stream rather than directly to North Panda Lake will assist in preserving the limited aquatic habitat in this area. A small dam structure will be constructed at the outlet of Bearclaw Lake. This structure has been sized to provide sufficient storage capacity within Bearclaw Lake to handle the entire spring freshet. Pumping from Bearclaw Lake to Beartooth-North Panda Stream will be conducted at varying rates in response to natural hydrological conditions in order to maintain a stable water elevation within Bearclaw Lake and appropriate natural flow volumes within downstream watercourses. Hence, the effect on water quantity is expected to be negligible, and the effects on water quality and fish/aquatic habitat are also expected to be negligible.

4.5.1.4 In-Stream/Lake Construction

It is expected that the effect on water quantity of in-stream/lake construction work will be negligible. This activity does have the potential to affect water quality and fish/aquatic habitat. Applying appropriate mitigation measures (*e.g.* seasonality of construction activities) is expected to reduce the significance of residual effects on water quality and fish/aquatic life to negligible.

In-stream/lake construction activities will take place as part of the Sable, Pigeon and Beartooth pipe developments. For the Sable area, a semi-pervious dyke will be constructed in Two Rock Lake, along with a dam at the outlet of Two Rock Lake. For the Pigeon area, a diversion structure will be constructed to relocate Pigeon Stream around Pigeon Pit. For the Beartooth area, a dam will be constructed at the outlet of Bearclaw Lake.

All of these construction activities have the potential to affect the surface water quality of waters in direct contact or immediately downstream of the construction activities. Water quality could be affected by the introduction of sediment-associated parameters[3], or by the leaching of ammonium nitrate residues associated with waste rock. All construction activities will be scheduled during winter when there is no stream flow. This schedule will substantially limit the risk of adverse effects on the streambed.

4.5.1.5 Waste Rock Storage/Drainage

Waste rock generated from the mining operations at Sable, Pigeon and Beartooth pits will be stored in designated areas near each pit. This is described in the Project Description Report (BHP, 1999c). The potential exists for waste rock runoff to affect water quality and possibly fish and aquatic habitat. However, due to the use of perimeter berm structures described in Chapter 2, the volume of runoff is expected to be minimal, thus the potential effect on water quality and fish habitat is expected to be negligible.

At the Sable Pit, approximately 120.8 million tonnes of waste rock and small amounts of overburden will be generated. Most waste rock will be a two-mica granite similar to that found at the Panda Pit. This granite has been shown to be inert with respect to runoff quality. However, lesser quantities of biotite schist, migmetite and diabase will also be extracted. The results of recent acid base accounting (ABA) testing on these rock types indicate a slightly greater range of sulphide content (0.1% S as sulphide) and neutralization potential than do the Pigeon or Beartooth sample results, although the sulphide content is consistently low as is the neutralization potential. While the testwork to date indicates there is no potential for acid generation and acid rock drainage, the potential for metal leaching will be addressed further, particularly in relation to the Sable location.

[3] **Sediment-associated parameters include TSS, turbidity, total phosphorous, total aluminum, *etc.***

At Pigeon Pit, approximately 51.2 million tonnes of waste rock will be generated. The waste rock storage area for Pigeon Pit has been located entirely within the Koala Watershed in order to ensure that runoff from the waste rock storage stockpile site will migrate to the existing Long Lake Containment Facility. The majority of waste rock from Pigeon Pit will be biotite granite, similar to that found at the Panda Pit. This granite has been shown to be benign with respect to runoff quality. Lesser quantities of biotite schist and diabase will also be extracted. These subordinate waste rock types may have the potential to generate poor quality runoff due to the potential for acid production. However, the results of recent ABA testing of these rock types indicate that net acid generation is not expected from the Pigeon waste rock and in the absence of net acid generation, potential metal leaching is not expected to occur.

Waste rock from the Beartooth Pit is classified the same as Panda Pit waste rock (two-mica granite), which has shown to be inert with respect to runoff quality. The waste rock will be stored within the existing Panda Waste Rock Storage Pile area. All lake bottom sediments from Beartooth will be stored within the existing Lake Bottom Sediments Storage Pile area. Approximately 16.8 million tonnes of waste rock will be generated from the mining of Beartooth Pit. The size of the original Panda Waste Rock Storage Pile will increase slightly (404,000 m^2) to accommodate material from Beartooth.

BHP's Waste Rock Runoff Management Plan for each of the waste rock storage areas is directed at minimizing the risk of potentially adverse effects on nearby waterbodies. This will be achieved at Pigeon and Beartooth pits by directing the runoff draining from the waste rock piles to the Long Lake Containment Facility.

In addition, the plan adopts a strategy that encourages permafrost formation in the waste rock storage piles such that infiltration water will not drain freely from the piles but will be trapped in the voids of the rock and freeze. The concept, described in Section 2.2.3 involves the construction of perimeter berms consisting of an insulating rockfill cover filled with well graded frozen rockfill, and a rockfill blanket to be placed on the tundra. Waste rock will be placed over the blanket, and water draining through the waste rock will be contained within the blanket long enough to freeze, gradually filling the voids with ice.

BHP plans to test this containment concept at the existing Panda waste rock storage area. The results will be used to refine the concept as necessary for application at the Sable location. In addition, at Sable the perimeter berms to be employed will be located a minimum distance of 100 m from potentially affected waterbodies such as Ulu and Horseshoe lakes in order to maintain a further protective buffer zone for these lakes.

4.5.1.6 Pit Restoration: Reclamation to Lake Status

When mining has been completed, all three pits will be reclaimed as lakes that will include features to permit the re-establishment of viable lake ecosystems. Options for the reclamation of mined-out pits at the EKATI™ Diamond Mine have been previously investigated by the company and a number of strategies have been developed (BHP, 1999b). Generally, mined-out pits will be reclaimed such that normal hydrological regimes will be established for the location of the pits within their respective watersheds. Reclaimed pits will also be modified such that viable lake ecosystems will be created.

Reclamation plans involving the creation of habitat and the restoration of fish populations in pit lakes will be developed in consultation with the Department of Fisheries and Oceans.

A brief discussion of the basic sequence of steps follows. After mining has been completed in the pit, all structures and equipment will be removed. Next, the near-surface pit access ramp and upper bench will be modified to provide a littoral zone (Figure 4.5-1). Additional littoral areas will be created by constructing bays around the periphery of the pit. Graded shorelines can be created by drill and blast of the high wall onto the upper benches. Once the critical habitat components have been constructed, the pit can be allowed to fill naturally or be fill-assisted by drawing water from a large, nearby lake. Using lake water to fill the pits will ensure that the lake is seeded with the necessary primary and secondary producers of a lake ecosystem. Filling would be conducted over a number of years to minimize effects on the source lake and the prevailing hydrological conditions. If necessary, fish stocks can be introduced into the lake once acceptable water quality conditions have been achieved. A monitoring program will be initiated during the refill stage and would be continued until there was clear evidence that a viable fish community has been re-established.

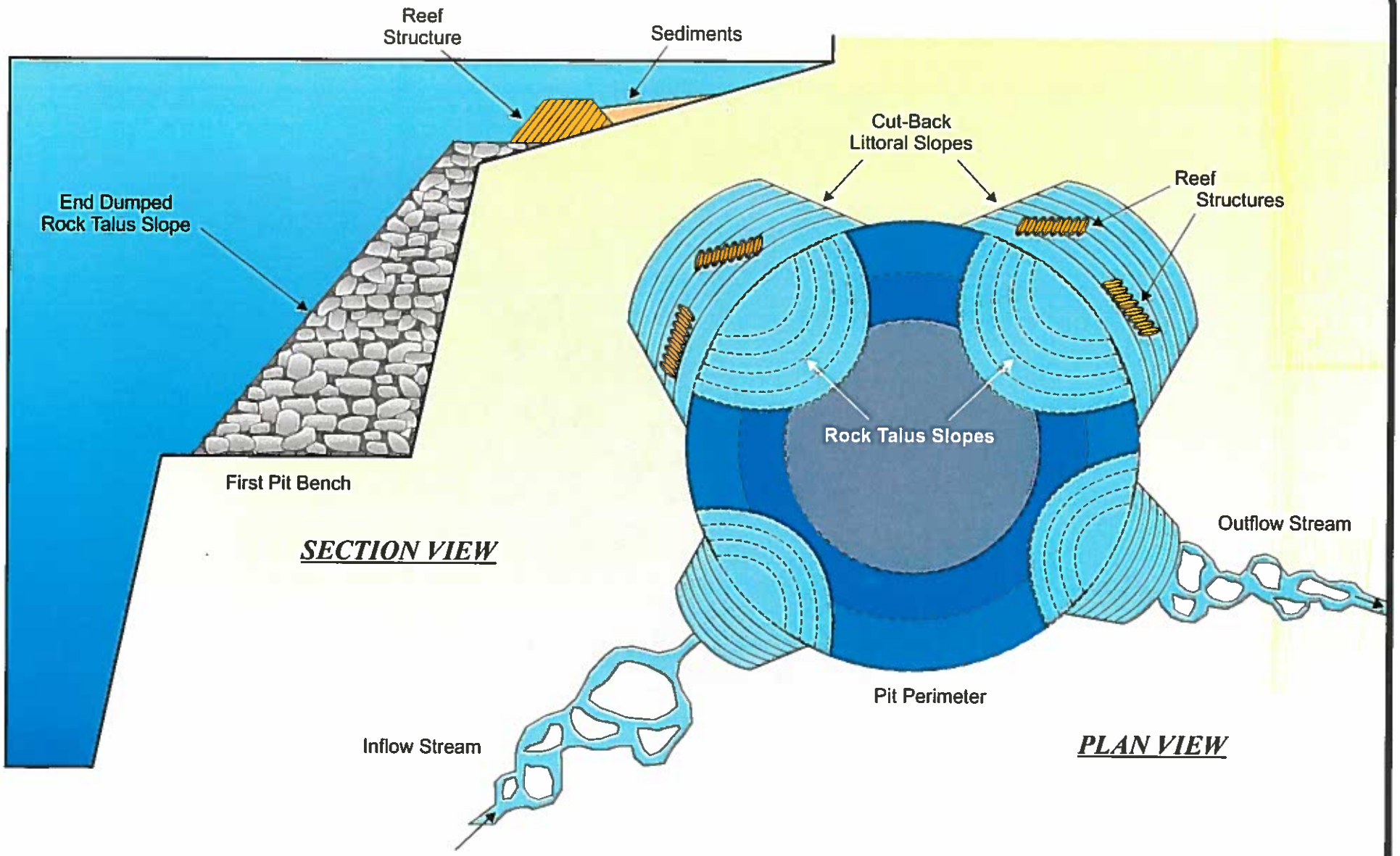
The refilling of Sable Pit has been estimated to take from 15 to 25 years (Subsection 4.5.2.1.4.1). However, for assessment purposes the upper bound estimate of 25 years has been adopted. On this basis water will be pumped from Ursula Lake, located in the Lac de Gras Watershed, at a rate of 0.2 to 0.3 m^3/s during the open water months for a period of approximately 25 years. Ursula Lake is believed to be large enough (~ 25 km^2) to accommodate water removal with minimal effects on this lake. Options that would reduce the filling period without adversely affecting local hydrological conditions will be reviewed once sufficient streamflow data have been collected and evaluated.

The refilling of Pigeon Pit will be accomplished by the pumping of water from nearby Upper Exeter Lake over a period of approximately five years. Upper Exeter Lake has a surface area of approximately and is large enough to accommodate water removal with minimal effects on the lake. In addition, for both of these pit refilling operations, DFO approved fish screens would be installed on pump intakes to prevent entrainment of fish during pumping.

Beartooth Pit will be infilled with processed kimberlite over a period of two years. Once Beartooth Pit is filled to a predetermined elevation with processed kimberlite and/or water (Figure 4.5-2) and the water quality has been determined to be acceptable for aquatic life, these life forms would be reintroduced. Reclamation of Beartooth Pit will precede reclamation of any other pits in BHP's current mine plan. As such, the results obtained from habitat restoration efforts at Beartooth Pit will influence habitat restoration plans and methodologies used at other pits.

4.5.1.7 Operational Activities (Blasting/Fugitive Dust)

Other common operational issues related to each of the three pits to be developed that may affect the aquatic environment include sewage and fugitive dust. The expected effects on water quality and quantity and fish/aquatic habitat are negligible.



BHP

Conceptual Fish Habitat in Rehabilitated Pit Lake

FIGURE 4.5-1

Ekati diamond mine

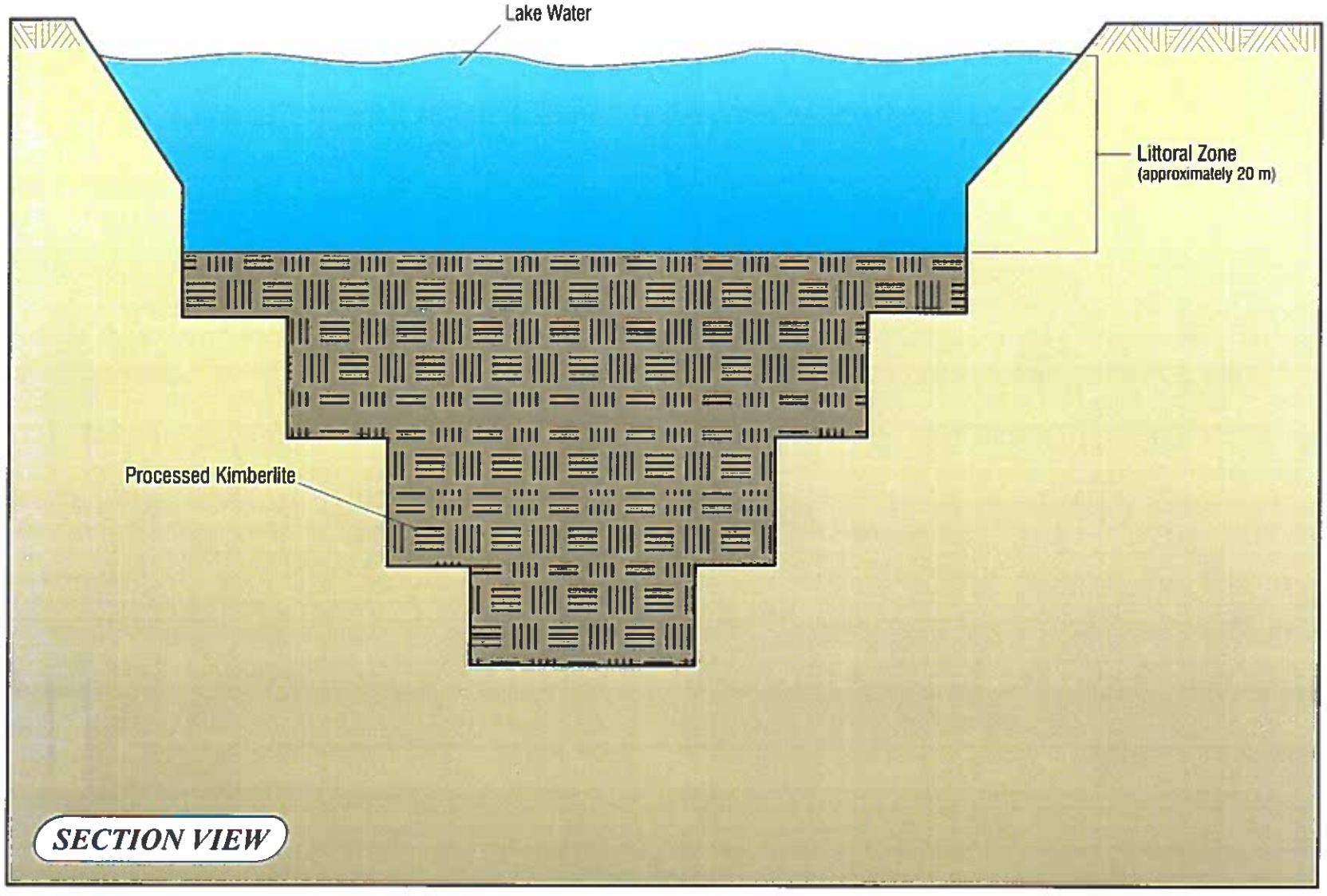


FIGURE 4.5-2

Conceptual Pit Lake: Processed Kimberlite Fill

All sewage and grey water at all three pit sites will be collected and backhauled to the main EKATI™ camp for treatment.

Fugitive dust will be generated as a result of blasting and mine operations in the pits and vehicular traffic. At the existing EKATI™ mine airborne particulates have been transported to nearby waterbodies but the effects on water quality have been localized and minimal, with no resulting changes to the biology of aquatic ecosystems.

4.5.1.8 All Weather Road Construction

The proposed Sable, Pigeon and Beartooth Roads (Figure 4.5-3) will be constructed to provide all-weather access between the existing EKATI™ facilities and the Sable, Pigeon and Beartooth Pits, respectively. The proposed overall alignment has been selected as the main roadway from which only a short spur will be required to access local site infrastructure and development at the Sable, Pigeon and Beartooth sites. The lengths of the Sable, Pigeon and Beartooth Road segments are approximately 18.4 km, 4.3 km and 0.7 km, respectively.

The majority of the traffic using the road system will be the haul trucks required to transport kimberlite ore to the Process Plant. Design standards and criteria have been established based on operational requirements in conjunction with regulatory compliance (*i.e.,* Northwest Territories Mine Health and Safety Act and Regulations). The road will be a continuous fill structure placed on the existing tundra surface with the necessary precautions taken to ensure the underlying permafrost remains undisturbed.

Environmental factors were incorporated into the route alignment selection process to minimize effects on area streams, the Ursula Esker, terrestrial vegetation, wildlife habitat, and heritage resources. The proposed Sable Road crosses seven stream channels. Seasonal fish populations have been recorded for Pigeon Stream and two other area streams may support seasonal populations of fish (Figure 4.5-3). To maintain existing flows, appropriately sized culverts will be installed at all streams identified as possessing fish populations for at least part of the year.

4.5.2 Sable Pipe

The following sections present the mine-related activities resulting from the development of Sable Pipe that could affect water-related VECs, mitigation measures that will be implemented, and an assessment of any residual effects. The assessment methodology for residual effects evaluations is presented in Section 4.2. The Sable Pipe discussion is divided into the VECs water quantity, water quality, and fish/aquatic habitat. Section 4.5.2.4 considers the interrelationships of water quantity, water quality and fish/aquatic habitat to provide an ecological perspective in evaluating the overall residual effects on these VECs of development of the Sable Pipe. An overview map of the Sable Pipe development area showing the major directions of surface water flow is provided in Figure 4.5-4.

4.5.2.1 Water Quantity (Hydrology)

4.5.2.1.1 Lake Dewatering (Sable Lake)

4.5.2.1.1.1 Lake Dewatering via Two Rock Outflow Stream and Two Rock Lake

Clean water from Sable Lake (393,000 m^3) will be pumped directly into Two Rock Lake outflow stream. As the water level in Sable Lake drops and water quality begins to approach Licence criteria, the remaining water will be pumped into the sedimentation pond (east portion) of Two Rock Lake for settling and filtration through the semi-pervious dam prior to release to the Two Rock Lake Outflow Stream. The rate of release into Two Rock-Horseshoe Stream either directly or from the dam will be guided by best management practices that mitigate the possible effects of dewatering Sable Lake. The seasonal variation in water flows in the area are as follows:

- a high peak or freshet flow occurring in late May to early June, when approximately 60% of the total water volume passes through the streams,
- a low-flow period in the summer, when water levels become very low in some streams, and
- increased flows in the fall, when water levels are higher than in the summer, but still lower than during the spring.

In general, streams are most sensitive to elevated high flows during the low-flow summer period, when habitat is more susceptible to erosion. As well, water flow is required during the entire open water season (unless the stream naturally dries up) to allow for fish passage, so water flows should not be eliminated due to containment structures (dams) if viable fish habitat is present immediately downstream. However, Two Rock-Horseshoe Stream is normally dry for at least part of the summer months, and does not support fish populations.

Possible effects on Two Rock-Horseshoe Stream hydrology will be minimized by employing a low discharge rate. For example, a discharge rate of 0.2 m^3/s should be sufficient to drain the lake within one month. In addition, flows entering Horseshoe Lake via Two Rock-Horseshoe Stream will dampen naturally before discharging further downstream and thus further dampening the effect.

Water from Sable Lake will be pumped into Two Rock Lake Outlet Stream and/or Two Rock Lake during the fall (October/November). Pumping during the fall will ensure that a large portion of the dewatering volume is sent downstream before winter freeze up. As a result, peak (freshet) and minimum flows in the following year will not be artificially altered. The experience BHP has gained through the dewatering of Panda and Koala lakes has indicated that the effects of pumping are minimized by fall dewatering.

N

DATUM : NAD 83

Date of Photography :
August, 1993 unless otherwise shown

0 0.5 1.0 2.0 3.0 km

Approx. 1 : 46,000

TWO ROCK L.

Sable Pit

525 000m E

7 190 000m N

515 000m E

EAGLE L.

SR7

URSULA L.

Ursula Esker

SR6

BIG POND
Shallow

SR5

URSULA L.

Sable Road

7 185 000m N

SR4

FALCON L.

Exeter Esker

SR3

SR2

SR1

Pigeon Pit

Fay L.

Pigeon

Big Reynolds

Date of Photography :
September 3, 1999

Little Reynolds

Road

Beartooth Road

Beartooth Pit

Panda Pit

Koala North Test Pit

Koala Pit

Date of Photography: September 3, 1999

7 180 000m N

Vulture L.

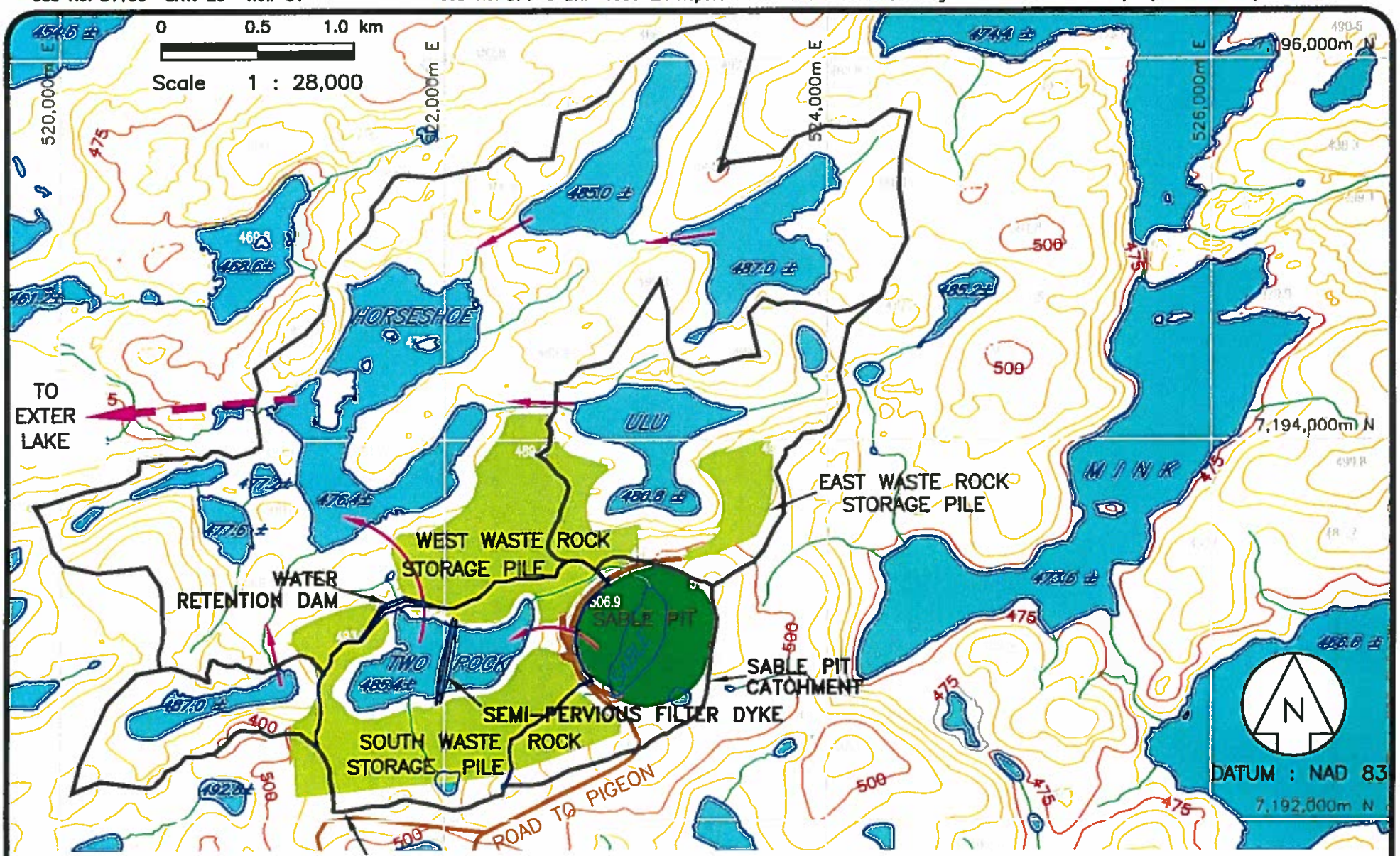
Source : BHP, 1999C

Figure 4.5-3

Sable, Pigeon and Beartooth Road Alignments Showing Stream Crossings

BHP

Ekati diamond mine



Source : EBA, 2000

Figure 4.5-4

Surface Water Drainage for the Sable Pipe Development Area

BHP

Ekati diamond mine

4.5.2.1.1.2 Lake Storage Capacity

The dewatering of Sable Lake will cause a very small reduction in the lake storage capacity of the Yamba/Exeter Watershed until mine reclamation is complete. The principal role of lake storage is to attenuate extreme flow events. The potential effects of the loss of lake storage is decreased as flows will be dampened in Two Rock Lake by the dam. The dam allows BHP to attenuate flows by gradually discharging downstream.

The loss of lake storage caused by the dewatering of Sable Lake will persist until the pit has been reclaimed to lake status. The effect will be highly localized as flows will be attenuated by the dam at the outlet of Two Rock Lake. Because flows will be dampened in Two Rock Lake, the significance of the residual effect of the loss of lake storage capacity is expected to be negligible.

4.5.2.1.2 Flow Diversion: Two Rock Dam and Water Discharge from Two Rock Lake

A dam will be constructed at the outlet of Two Rock Lake. The possible hydrologic effect of the dam is the prevention of natural drainage from Two Rock Lake, and the altered discharge to receiving waters from water pumping. To mitigate this possible effect, discharge from Two Rock Lake will be determined by two factors: natural accumulation behind the dam (which will reflect the natural seasonal pattern in stream flows due to precipitation), and water quality guidelines. After the added volume from Sable Lake dewatering has been pumped downstream (approximately one to two months), the dam is not expected to significantly alter the natural downstream hydrology because the quantity of water pumped from Two Rock Lake will reflect natural accumulation resulting from runoff and/or snowmelt. Flow volumes into Horseshoe Lake are therefore not expected to deviate from pre-development conditions since discharge from Two Rock Lake will only occur as necessary to alleviate the accumulation from runoff and/or snowmelt.

The residual effect from flow diversion will only be evident locally. The future capacity of the concerned streams is not expected to be affected. The duration of the effect is greater than ten years and continuous. However, once the dam is breached and the lake is reclaimed flows will revert to original conditions. The significance of the residual effect of flow diversion on water quantity is expected to be negligible.

4.5.2.1.3 Waste Rock Storage/Drainage

Waste rock from the development of Sable Pit will be stored in waste rock storage areas located around Two Rock and Ulu lakes as described in the Project Description Report (BHP, 1999c). In order to mitigate potential effects on water quality, perimeter berms will be constructed to minimize discharge from the waste rock storage piles in the Sable Area. The containment of runoff water originating from precipitation will cause a small reduction in the effective surface drainage area. The reduction in drainage area (residual effect) represents approximately 0.01% of the Yamba/Exeter Watershed and thus will not cause any measurable effects on downstream hydrology. The reduction in effective drainage area does not require any mitigation strategy.

The small reduction in the effective drainage area is very localized, and after an extended period of time (greater than 20 years), precipitation falling on the surface area of the waste rock area is expected to flow over the berm structures (at which point poor water quality will not be an issue). Hence, the small reduction in the effective drainage area is not permanent. As it is unlikely that the small reduction in effective drainage area will cause any measurable change in downstream hydrology, the capacity of any resources in the area will not be affected. It is expected that the small reduction in the effective drainage area will have a negligible effect on water quantity.

4.5.2.1.4 Sable Pit Reclamation

4.5.2.1.4.1 Source Water for Filling

Sable Pit will be filled with water during the reclamation phase and returned to the drainage basin as a lake. Pit filling by natural runoff and groundwater accumulation would take a very long time; several hundred years. The reclamation phase will be accelerated by pumping fresh water from Ursula Lake. The accelerated filling will substantially shorten the duration of the environmental effects by returning the lake to a productive environment at the earliest feasible time. Pit filling by extracting water from a nearby large lake will be managed to minimize effects on the existing hydrological regime.

The Sable Pit Volume has been estimated to be 50.6 million m^3. A mean pumping rate of 0.2 to 0.3 m^3/s for a four-month summer season would result in pit filling durations of 25 and 15 years, respectively. These flow volumes would remove a portion of the mean annual net accumulation of water in the Ursula basin ranging from approximately 16 to 22 percent. The refill time of 15 years, corresponding to 22 percent of the runoff, is believed to be a realistic estimate however the upper bound estimate of 25 years is possible, depending on the nature of the outflow from Ursula Lake. Additional information must be collected to characterize the outflow channel and its hydrograph in order to determine the pumping rate that will have negligible effect on fish habitat in the channel and downstream.

The requirement for streamflow data with the Ursula Basin and uncertainties in the hydrological parameters necessitate a conservative approach to evaluation of the environmental effects of this phase of the development. Therefore, a filling duration of 25 years has been adopted for the environmental assessment, recognizing there are positive benefits to substantially shortening the duration by varying the pumping rates and by careful assessment of the potential effects that reduced could have on downstream aquatic habitat.

BHP will conduct baseline monitoring at Ursula Outflow so that site specific data can be used to directly quantify the absolute discharge from the lake. In addition, BHP will alter its pumping rate as conditions of the year vary. That is, during 'dry' years the pumping rate will be reduced to ensure that the rate of withdrawal will not result in any impacts. BHP will control the pumping rates to mimic the general shape of the hydrograph and the

magnitude of change to peak and minimum flows, in order to ensure that there is no adverse effect on fish habitat and fish movement.

Changes to the hydrological regime of Ursula Outflow by extracting water from Ursula Lake will persist for twenty-five consecutive years (long-term) throughout the open water season. The hydrological effect will be reversible once Sable Pit has been filled. The geographic extent will be local as the contribution from Ursula Lake to downstream flow decreases proportionately. BHP will be able to control the pumping rate and mimic natural seasonal conditions based on baseline monitoring results. It is expected that the effect on water quantity from the pumping of water from Ursula Lake will be negligible.

4.5.2.1.4.2 Lake Storage Changes

The reclaimed Sable Pit will have a greater surface area compared to the existing Sable Lake. A greater surface area will result in an increased ability to dampen flows, due to the increase in surface area. This factor will attenuate downstream discharges during the open water season. Although no hydrologic monitoring from the original Sable Lake has been preformed to date, discharge from the reclaimed pit is still expected to reflect predevelopment conditions since the pit will be completely filled during reclamation. Therefore, evaporation and runoff volumes should not change, assuming similar climatic conditions.

The reclaimed pit will have a heightened ability to dampen flows which could result in a lengthened freshet period. The likely effects could be significant locally along the connecting stream between Sable and Two Rock lakes; far reaching effects at Exeter Lake are not expected since the area of interest represents less than 1% of the total drainage area. The heightened ability to dampen flows would persist continuously on a long-term basis. The geographic extent is very local. An effect on the future capacity of the downstream channel is unlikely since only a small change to the hydrograph is possible. The effect would likely not be reversible. However, because the effect will only be evident very locally, it is expected that the significance of the residual effect will be negligible.

4.5.2.2 Water Quality

4.5.2.2.1 Lake Dewatering (Sable Lake)

Sable Lake will initially be dewatered by pumping clean water from Sable Lake into Two Rock Lake Outlet Stream. As the water level in Sable Lake drops, water quality will deteriorate due to the introduction of suspended solids and sediment-associated parameters. When this occurs, water will be pumped into the eastern portion of Two Rock Lake, upstream of the semi-pervious dyke. This will allow for the treatment of any sediment-laden water. Water will not be pumped out of Two Rock Lake unless it meets BHP's Water Licence discharge criteria.

Poor water quality during dewatering is only a concern during the later stages of dewatering. To minimize effects, lake dewatering will occur in the fall, after complete ice cover has formed. The ice will prevent sediment suspension by wind mixing, thereby reducing suspended solids and associated parameters in the lake water. By transferring water from waterbodies during the fall, effects on receiving water quality can be minimized.

In addition, the following actions will also be undertaken to minimize effects on water quality:

1. Gradual Dewatering. By dewatering slowly, exposed lake bottom sediments will have more time to drain, thereby increasing their physical stability;
2. Dewatering During Optimum Season. By starting the dewatering process during periods of low precipitation, the exposed lake bottom sediments are less susceptible to erosion. If dewatering is timed properly, sediments will be covered with lake ice and will experience immediate freezing as the water is removed; and
3. Monitoring. To ensure that poor quality water is not discharged, the water in the lake being dewatered will be regularly sampled and monitored for regulated parameters.

The residual effect being assessed is the effect on water quality from Sable Lake dewatering. The geographic extent to which the dewatering of Sable Lake could affect water quality is very localized, affecting a very small area within the Horseshoe Watershed. The duration of effect is very short-term (<3 yrs), as all dewatering would occur within one season. The frequency of the effect is once, and the effect on water quality will be reversible as time passes and sediment-associated parameters settle out. Based on the impact attributes presented in Section 4.2, it is expected that the effect on water quality from the dewatering of Sable Lake will be negligible.

4.5.2.2.2 Pit Water Discharge (Sable Pit via Two Rock Lake)

Sable Pit water is expected to contain elevated concentrations of nitrogen and sediment-associated parameters. Sable Pit water will be pumped into the eastern portion of Two Rock Lake upstream of the semi-pervious dyke. Based on similar structures within the Long Lake Containment Facility, it is expected that the semi-pervious dyke in Two Rock Lake will be effective. However, elevated nitrogen concentrations are expected to persist in the western portion of Two Rock Lake, and will be discharged into downstream waterbodies (*e.g.*, Horseshoe Lake).

Lakes and streams in the area are likely phosphorus-limited (based on published papers and monitoring results). This means that it is the concentration/availability of phosphorus in waters that limits and therefore controls primary producer biomass. Hence, the addition of slightly elevated levels of nitrogen is not expected to result in a change to aquatic ecosystems in downstream waterbodies. Phosphorus associated with pit water is expected to remain in the upstream portion of Two Rock Lake, as phosphorus is particle reactive and will likely be effectively mitigated by the semi-pervious dyke.

To minimize concentrations of nitrogen in pit water, proper handling and storage of ANFO will be conducted at all times. The semi-pervious dyke within Two Rock Lake is not expected to reduce the concentration of nitrogen in water within the polishing pond.

The residual effect of elevated nitrogen levels in Two Rock Lake from the introduction of Sable Pit water has the potential to affect the water quality of waterbodies immediately downstream of Two Rock Lake (Horseshoe Lake). However, a biological effect is not expected. The geographic extent of the effect is expected to be local, as it may be observed in more than one waterbody downstream of discharge. However, it is expected that detectable elevated nitrogen concentrations will remain within the Horseshoe Watershed, and not be detectable in Exeter Lake. The duration of the effect would be for the length of time that mine water from Sable Pit is introduced into Two Rock Lake (approximately six years), and for as long as water is pumped or discharged from Two Rock Lake into downstream waterbodies. The frequency of the effect will be semi-continuous during the open water seasons (whenever water is pumped from Two Rock Lake). Water quality will slowly revert back to background levels by dilution (from precipitation and runoff of low nitrogen water). Elevated nitrogen levels are likely to occur, but they will not reduce the future capacity of renewable resources to meet needs. The overall significance of the residual effect (elevated nitrogen concentrations) to downstream water quality caused by the discharge of Sable Pit water is expected to be minor.

4.5.2.2.3 In-Stream/Lake Construction: Construction of Two Rock Frozen Core Dam

The construction of the dam at the outlet of Two Rock Lake will result in the introduction of sediments and sediment-associated parameters to downstream waterbodies (Two Rock-Horseshoe Stream, Horseshoe Lake) during the initial stages of dam construction. In addition, use of blasted waste rock could result in the temporary elevation of nitrogenous compounds in downstream waterbodies.

Dam construction will occur during the winter season, when no water is flowing through Two Rock-Horseshoe Stream. This will effectively limit exposure of fresh quarry rock to running waters. The only other possible mechanism for introducing parameters to surface water is via the accumulation of particulate matter on snow and ice. The snow and ice would melt during spring freshet of the following open water season and possibly introduce particulate matter to surface waters. This brief flushing would occur only once and would be introduced into Horseshoe Lake at a time when elevated levels of many parameters are naturally occurring in local lakes. Elevated levels of TSS, nitrogen, and possibly total aluminum may be measurable in Two Rock-Horseshoe Stream during the one-time freshet event. Water quality is not likely to be affected from this activity after freshet or in waterbodies downstream of Horseshoe Lake.

The geographic extent of the possible effect would be highly localized (Two Rock-Horseshoe Stream only). The duration of the residual effect would be very short-term, lasting only during freshet of one season. The frequency of this effect will be extremely rare, as it will only occur once. The effect is reversible, in that any slightly elevated levels will drop back to baseline levels it a matter of weeks. This effect is unlikely to

occur and will not reduce the future capacity of renewable resources to meet needs. Federal criteria for the protection of fresh water aquatic life would likely not be exceeded. It is expected that the residual effects on water quality as a result of dam construction will be negligible.

4.5.2.2.4 Waste Rock Storage/Drainage

Waste rock from the Sable Pit will be placed on the tundra adjacent to the pit. A west waste rock storage pile is planned which would lie between Ulu Lake, Horseshoe Lake, and Two Rock Lake; an east waste rock pile would be located immediately east of Ulu Lake; and a south waste rock pile would be located around the southern extent of Two Rock Lake. Drainage from the Sable Pit waste rock piles could potentially affect the water quality of these lakes because the waste rock has some potential to be acid-generating (see Section 2.2.3). However, poor quality water could also result from the percolation of precipitation through fresh waste rock.

To mitigate potential effects on water quality, all waste rock piles will remain a minimum distance of 100 m from lake shores. As well, perimeter berms will be constructed within the toe of the waste rock piles where drainage is expected, as described in Section 2.2.3. Precipitation that infiltrates the piles will be retained to the maximum practical extent. The quantity of runoff escaping to adjacent lakes is anticipated to be minimal. Eventually precipitation will run off the waste rock area as in other topographically similar areas (decades after reclamation).

In summary, runoff from Sable Pit waste rock piles could affect the water quality of nearby waterbodies. However, the pile construction system is expected to minimize or eliminate runoff of poor quality from entering any waterbodies. As such, residual effects of waste rock drainage on water quality are expected to be negligible.

4.5.2.2.5 Pit Reclamation: Sable Pit

Sable Pit will be filled with clean water from Ursula Lake over a period of 25 years or less. As water is added to the pit each open water season, it may become elevated in suspended solids due to the suspension of sediment during filling. However, after each open water season the newly placed water will have a winter season in which particulate material can settle out. As such, there is really only the potential to affect the water quality of downstream waterbodies during and after the final year of water filling.

The water level during the final year of filling will be kept low enough to ensure that water will not flow out of the lake until it has had a full winter season in which to settle. In addition, only pristine water from Ursula lake will be introduced to Sable Pit. It is therefore expected that the water quality of Sable Pit Lake will be representative of undisturbed lakes in the area after lake reclamation. Hence the potential effect of Sable Pit Lake water on downstream water quality is expected to be negligible.

4.5.2.2.6 Blasting Activities and Fugitive Dust from Pit Operations, Vehicular Traffic, and Waste Rock Dumping

Blasting activities and fugitive dust could result in slight increases in TSS, total aluminum, total nickel and nitrogenous compounds in waterbodies within a one to three kilometre radius of dust-generating activities (*e.g.*, Ulu, Two Rock, Horseshoe lakes). Data obtained during exploration activities indicated that fugitive dust could cause a slight increase in TSS over background concentrations (approximately 4 mg/L compared to < 3 mg/L), total aluminum concentrations slightly above background concentrations (0.080 mg/L compared to 0.020 mg/L) and total nickel concentrations slightly above background concentrations (0.002 mg/L compared to 0.001 mg/L; Rescan, 1995; Rescan, 1999b). Results from a snow survey in 1998 also indicated that fugitive dust could contribute to elevated concentrations of manganese, vanadium and iron (BHP, 1998). Slightly elevated concentrations (approximately two times greater than background concentrations) of nitrogen are also possible (*e.g.*, Grizzly Lake, Rescan, 1999b).

Hence, monitoring data indicate that there could be possible slight effects on water quality, but exact concentrations will depend on a number of factors, including the proximity of waterbodies to dust-generating activities, wind direction, *etc*. Resulting concentrations are expected to be low and below criteria for the protection of aquatic life.

To minimize the generation of fugitive dust, road surfaces will be sprayed with water during the open water season. This has worked well for the existing roads at EKATI™. Dust generation from other activities will be difficult to mitigate; however, the potential effects on water quality will likely be very localized and minimal..

The effect on water quality from blasting/fugitive dust is expected to be very localized, possibly affecting waterbodies which lie primarily within the Horseshoe Watershed, although waterbodies in the adjacent Ursula Watershed could also be affected. The duration of the effect will be for as long as blasting and dust-generating activities occur in the area (less than ten years) and the frequency would be regular. Reversibility of this effect is high, as the detectable effects on water quality would be very slight, and once the activities stop effects on water quality would most likely not be detectable (because of dilution from lake mixing, *etc*.). Slight changes to water quality will not reduce the future capacity of renewable resources to meet needs. It is expected that the residual effects of blasting and fugitive dust deposition on water quality will be negligible.

4.5.2.2.7 Construction of Surface Facilities

Surface facilities proposed to be constructed in the Sable Pipe area include a warehouse, a field office, a truck shop, a fuel storage facility and two explosives magazines. Site preparation for surface facilities will involve covering vegetation and surficial materials with borrow material. These activities could results in fugitive dust emissions and intermittent sediment loading to nearby streams and lakes. Sediment loading to waterways could result in increased levels of TSS and associated parameters. Effects on water quality as a result of the construction of surface facilities are expected to be very short-term and minimal.

Locating facilities away from waterbodies and controlling drainage will prevent the introduction of any soil/sediments into nearby waterbodies. As a result of these mitigation measures, residual effects of surface facility construction on water quality will be negligible.

4.5.2.3 Fish/Aquatic Habitat

4.5.2.3.1 Potential Effects and Mitigation for Sable Pipe Development

The following summarizes the waterbodies and fish habitats that will potentially be affected by development of the Sable Pit:

- *Sable Lake*: to be dewatered;
- *Sable Lake inflow and outflow streams*: to be lost due to Sable Lake dewatering, pit development and waste rock deposition;
- *Two Rock Lake*: to be fished-out due to its intended use for pit water discharge;
- *Two Rock Lake inflow stream*: to be lost due to waste rock deposition;
- *Two Rock Lake outflow stream*: to be affected by changing water discharge patterns from Two Rock Lake, by the construction of a dam just below Two Rock Lake and by the loss of the Two Rock lake fish population; and
- *Ulu Lake*: potentially affected by runoff from waste rock piles.

During the life of the Sable Pit and until pit flooding and habitat replacement are completed, all fish populations and fish habitat in the above waterbodies, with the exception of the Two Rock Lake outflow stream and Ulu Lake, will be lost.

The population of lake trout in Sable Lake was estimated in 1997 to be about 100 fish (Rescan, 1998). In addition, sampling in Two Rock Lake in 1999 resulted in a catch of 77 round whitefish and 54 lake trout. In the case of the latter lake, population estimates cannot be calculated with available data since a mark-recapture program was not conducted. No fish were found during sampling of the Sable Lake and Two Rock Lake inflow and outflow streams. Habitat quality in these streams was determined to be very poor. Further, fish migration into and out of both these lakes is unlikely due to their ephemeral nature, bouldergardens and low, occasionally subterranean flow.

Because fish migration into or out of Sable and Two Rock lakes is unlikely except under extreme water flow conditions, both of these lakes appear to be ecologically autonomous, as discussed in the beginning of Section 4.5. It is therefore probable that these lakes do not contribute to each other's fish gene pool or to that of downstream lakes in the Yamba/Exeter Watershed.

Fish habitat reclamation plans for the Sable Pit will generally follow the methodology outlined in Section 4.5.1.6. Following habitat restoration, pit flooding will commence. To fill Sable pit, water will be pumped from Ursula Lake, which is located in the Lac de Gras Watershed. At a removal rate of 0.2 m^3/s, approximately 2.1 million m^3 of water would be pumped annually from Ursula Lake, resulting in complete filling of Sable Pit Lake in 25 years. This water extraction is anticipated to reduce downstream discharge from Ursula Lake by about 16% (average annual flow). While it is not anticipated that this flow reduction will affect fish or aquatic habitat, baseline information will be collected and a monitoring program put in place to ensure that the proposed level of water extraction does not result in adverse effects on the VEC fish/aquatic habitat.

Once flooding is completed, a program will be required to stock the lake with appropriate fish species. It is anticipated that invertebrates will naturally recolonize the lake rapidly as a result of larval drift and aerial insect dispersal.

Two Rock Lake will be fished-out because it is to be used as a sediment pond to receive Sable Lake water during dewatering and mine water during operations. The subsequent restoration of fish habitat in Two Rock Lake will include breaching of the pervious filter dyke and removal of the control structure at the outlet of the lake. While only natural sediments from Sable Lake will be discharged into Two Rock Lake, the accumulation of this material over the life of the pit might temporarily render unusable potential fish rearing and spawning grounds. Settled sediments will gradually wash into the deep basin of the lake. This process could be accelerated by power washing selected habitats in the littoral zone, if necessary. Fish stocking within Sable Pit Lake could commence once suitable habitat conditions have been restored. It is probable that the benthic invertebrate community will revert to pre-development conditions through natural colonization and community adaptation to the reintroduction of predatory fish species.

Fish habitat and fish stocking programs will be planned in consultation with the Department of Fisheries and Oceans and will be carried out in accordance with agreements reached with regulatory agencies.

4.5.2.3.2 Assessment of Effects on Fish/Aquatic Habitat – Sable Pit

The fish communities of Sable Lake and Two Rock Lake will be lost, at least for the duration of mining activities and until habitat restoration and pit filling are completed. The potential exists to replace and possibly supplement existing production capacity in these lakes in the future. This will require the creation of suitable habitats and adaptive management based on regular monitoring of water quality, food availability and fish survival.

At a local scale (Horseshoe Watershed), the loss of fish populations and production from Sable Lake is predicted to have a negligible effect. Sable Lake is a very small headwater lake in a watershed containing hundreds of lakes, most of which possess populations of fish. In itself, this is not reason enough to suggest that the loss of fish production from Sable Lake would have a negligible effect on local and regional fish stocks. However, Sable Lake is ecologically isolated (see beginning of Section 4.5) due to poor or non-existent migration habitat in its outflow channel. As a result, genetic exchange among

fish in Sable Lake and any other lakes in the Yamba/Exeter Watershed is unlikely. For the same reason, Sable Lake is not available as a habitat for fish from other waterbodies.

In addition, the remote location, small size and very limited fish production potential of Sable Lake obviates its use for sustained commercial, food or recreational fishing. It is unlikely that human exploitation of the fish in this lake has been, in the past, anything other than highly intermittent.

The inflow and outflow streams of Sable and Two Rock lakes were not found to possess suitable spawning, nursery, rearing or migration habitats. As such, the loss of these streams due to Sable Pit development is considered to have negligible effect on the overall fish habitat productive capacity of the Yamba/Exeter Lake system.

The potential for adverse effects on the fish populations of other lakes, particularly Ulu and Horseshoe lakes, in the vicinity of the Sable Pit development has been mitigated by the inclusion of engineered structures intended to prevent waste rock drainage from reaching fish bearing lakes (see Section 4.5.1.5). Other mitigation measures include the containment of turbid water on site and the disposal of sewage and grey water at an approved sewage system at the main EKATI™ site.

4.5.2.4 Water Summary for Sable Pipe

Each of the above sections pertaining to the effects of the Sable development have concluded that the significance of these effects individually on water quantity, water quality and fish/aquatic habitat will be negligible to minor. It is also important to examine the interactions among these VECs to assess the medium and longer term ecological consequences of this development.

The conversion of Two Rock Lake into a settling and storage basin will cause a deterioration in Two Rock Lake water quality. Discharges to Horseshoe Lake will be controlled to ensure that Water Licence criteria are met.

Increases in levels of nitrogen and suspended solids are the most likely changes that will occur in the quality of water discharged to Horseshoe Lake from the control structure at Two Rock Lake. Phosphorus levels may rise in the Two Rock sedimentation pond as a result of the accumulated pit water. However, experience at the Long Lake Containment Facility suggests that this nutrient will likely not become elevated in water discharged below the Two Rock Dam, probably because most of it will bind to particulates which will be contained behind the semi-pervious dyke. Increased levels of nitrogen have the potential to increase primary producer biomass, but only in systems where nitrogen is the limiting nutrient. In most fresh water systems, phosphorus, not nitrogen, limits phytoplankton biomass. This is almost certainly the case at Horseshoe Lake. Water sampling conducted one time in Leslie Lake (late summer, 1998) below the Long Lake Containment Facility revealed elevated levels of nitrogen compounds but background concentrations of phosphorus, with no measurable increase in the biomass of primary producers relative to concentrations in undisturbed lakes in the area (Rescan, 1998).

There is the potential (although not expected) for suspended solids to be introduced to Horseshoe Lake via Two Rock Lake if operational conditions are not effective. The concentration of suspended solids in water released from Two Rock Lake will depend on the effectiveness of the Two Rock semi-pervious dam. In addition, particulates will settle out in the Two Rock-Horseshoe Stream and in Horseshoe Lake. Two Rock-Horseshoe Stream does not support fish life and Horseshoe Lake is predicted to have only limited fish production potential due to its shallow depth (mean depth is 2.0 m) and poor quality lake trout spawning habitat (Rescan, 2000).

It is therefore unlikely that water quality changes will adversely affect aquatic life in Horseshoe Lake. It is even less likely that any change in water quality will be detectable at Exeter Lake, particularly because Sable and Two Rock lakes only represent one percent of the total Exeter Lake drainage area.

The potential exists for intermittent reductions in flow from Two Rock Lake to Horseshoe Lake. This could occur if, for example, it was necessary to store water longer to ensure that Water Licence criteria were met. Such flow reductions would not affect aquatic life in the Two Rock-Horseshoe Stream, which does not support fish populations and is normally dry for at least part of the summer months. Flow reductions in summer would also not affect fish life in Horseshoe Lake since the Two Rock-Sable drainage is only part of the Horseshoe Lake drainage area and because summer flows from Two Rock Lake are normally very low.

The loss of fish in Sable and Two Rock lakes are the most significant effects of the Sable development on the aquatic ecosystem. Changes in hydrology and water quality can be expected but are likely to be restricted to the immediate area of the development and downstream to Horseshoe Lake. Adverse effects below Horseshoe Lake will likely not be detectable. In addition, the present isolation of fish populations in Sable and Two Rock lakes restricts genetic exchange so that fish in these lakes do not contribute to the gene pool elsewhere in the Yamba/Exeter Watershed.

The effects of the Sable development will be restricted to a limited portion of the Yamba/Exeter Watershed, will be reversible and will not affect the future sustainability of the system. It is therefore anticipated that the overall effects of the Sable development on the aquatic environment will be negligible. An overall summary of predicted effects of the Sable development on water quantity, water quality and fish/aquatic habitat is provided in Table 4.5-1.

4.5.3 Sable Road and Other All Weather Roads

4.5.3.1 Water Quantity

The development of the three kimberlite pipes will require the construction of an access road that is expected to cross a total of seven streams within the Sable, Pigeon, and Beartooth areas. Culverts will be constructed on three of the seven streams to ensure water flow and accessibility by fish. The other four streams that will be crossed are

Table 4.5-1
Summary of Predicted Effects on Water-Related VECs due to Sable Pipe Development

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Water Quantity	Lake Dewatering: Sable Lake	Altered flows and attenuating capacity	Dewater at low rate and at least sensitive time of year; control pumping	Negligible
	Flow Diversion: Two Rock Dam and Discharge Water	Altered discharge to receiving waters	Discharge from Two Rock Lake as natural accumulation forms and as required to maintain aquatic habitat	Negligible
	Waste Rock Storage/Drainage	Runoff routing	None required	Negligible
	Pit Reclamation: Sable Pit	Reduced discharge from source lake	Use reduced pumping rate; conduct baseline monitoring; and pump during 'wet' years	Negligible
Water Quality	Lake Dewatering: Sable Lake	Introduction of high turbidity water and sediment-associated parameters into Two Rock Lake and Stream	Gradual dewatering; dewatering during optimum season (fall); monitoring	Negligible
	Pit Water Discharge: Sable Pit via Two Rock Lake	Introduction of water with elevated suspended solids, sediment-associated parameters and nitrogenous compounds into downstream waterbodies	Dyke in Two Rock Lake; control of Two Rock Lake discharge; ANFO and waste rock handling procedures	Minor
	In Stream/Lake Construction: Construction of Two Rock Lake Dam	Introduction of sediments/particulate matter into downstream waterbodies; introduction of nitrogenous compounds due to ANFO use and waste rock use	Construction will occur during winter (no water flow)	Negligible
	Waste Rock Storage/Drainage	Possibility of high ammonium, nitrate, TSS, in drainage	Construction of perimeter berms to minimize off-site drainage	Negligible
	Pit Reclamation: Sable Pit	Elevated sediment-associated parameters to Sable Pit Lake and possibly downstream waterbodies	Seasonal settling of suspended solids prior to discharge; pristine water from Ursula Lake used to fill pit	Negligible

(continued)

Table 4.5-1
Summary of Predicted Effects on Water-Related VECs due to Sable Pipe Development (continued)

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
	Blasting and Fugitive Dust	Introduction of TSS, TAI and nitrogen compounds to Two Rock, Ulu and other waterbodies	Road surfaces sprayed with water during open water season	Negligible
	Construction of surface facilities	Introduction of sediments/particulate matter into waterbodies; possible increase in TSS and associated parameters	Control of drainage; facilities will be located away from waterbodies	Negligible
Fish/Aquatic Habitat	Lake Dewatering: Sable Lake	Loss of aquatic life including fish, fish production and fish habitat	Fish-out of lake: restoration of suitable habitats and stocking of fish following mine closure and pit filling	Negligible
	Lake Dewatering: Loss of flow in Sable Lake inflow and outflow streams	None, these streams do not support fish habitat	None	Negligible
	Pit Water Discharge: discharge of Sable Lake and Sable Pit water to Two Rock Lake	Degradation of habitat for aquatic life, including fish	Fish-out of lake; breaching of dams and restoration of habitats following Sable Pit closure	Negligible
	In-Stream/Lake Construction: Construction of a dam and filter dyke in Two Rock Lake	Degradation of habitat for aquatic life, including fish	Breaching of dams and restoration of habitats following Sable Pit closure	Negligible
	Flow Diversion: Flow changes in the Two Rock Lake outflow stream	None, this stream does not support fish habitat	None	Negligible
	Waste Rock Storage/Drainage	Deterioration of habitats for aquatic life including fish, due to poor quality runoff	Maintenance of a 100 m setback from lakes; construction of frozen core berms along the face of waste rock areas bordering on waterbodies	Negligible

ephemeral and are not fish-bearing. Streams supporting properly designed culverts will have unaltered hydrological regimes. A properly designed culvert is one that does not cause upstream flooding during high flows. BHP has experience in culvert design coupled with six years of hydrological monitoring that will ensure that the culverts will not cause any effect to hydrology.

In the unlikely event that the culverts alter the hydrological conditions, the geographic extent would be localized. The duration would be short-term since BHP would reconstruct the culverts if they were adversely affecting flows. The frequency would be every year during freshet. Since the effect is highly unlikely and if it was to occur it would quickly be alleviated, the residual effect of the use of culverts on water quantity is rated as negligible.

4.5.3.2 Water Quality

Road development to the Sable Pipe area and between the road and Sable, Pigeon and Beartooth pits may affect water quality through erosion and in-stream construction work (*e.g.* installation of culverts), both of which could introduce sediments and sediment-associated parameters into downstream waterbodies (*e.g.* Pigeon Stream, other streams).

The road route has been selected to minimize stream crossings and maximize distances from waterbodies. The route selected for the proposed Sable Road is presently located between two watersheds which will result in the fewest stream crossings possible. Where culverts are necessary, they will be installed following sound engineering practices to minimize stream disturbance. After road construction is complete, grading and compacting of all roads will occur in order to reduce the risk of erosion.

Road construction activities have the potential to affect water quality only in localized areas. Any effects would be very short-term in duration, occurring only during construction activities. The frequency of this effect will be rare, as road construction will occur only once and be completed prior to development of the three pits. Residual effects are unlikely to occur and this will not reduce the future capacity of renewable resources to meet needs. Federal criteria for the protection of aquatic life will probably not be exceeded. It is expected that the residual effects of road construction activities on water quality will be negligible.

4.5.3.3 Fish/Aquatic Habitat

The alignment of the Sable, Pigeon, and Beartooth roads along with stream crossings is presented in Figure 4.5-3 of Section 4.5.1.8. A detailed assessment of the habitat at each of the streams to be crossed by the proposed all-weather haul road to the Sable pit is provided in Chapter 3. This 18 km section of road will cross seven streams, only three of which, at crossings SR1, SR3 and SR6, are likely to support seasonal fish populations and migration.

Road construction and operation will have the potential to affect fish and fish habitat directly in the following ways:

- *obstruction to fish migration.* Culverts will be installed in streams that are inhabited by fish populations for at least part of the year. If improperly sized and installed, culverts can obstruct fish passage due to insufficient water depth in the culvert, excessive water velocities and drops at the downstream end of the culvert.

Appropriate culvert sizing, based upon hydrological conditions in a stream, is crucial to ensure that water depth is sufficient to permit fish passage and that water velocities are not excessive for the migratory species. Culverts will be positioned part way into the substrate to avoid stream bottom erosion and drops at the downstream end.

- *erosion at culvert sites.* Erosion can occur around a culvert if it is not properly installed or sized. In addition, culverts can cause substantial downstream bed and bank erosion particularly if a culvert is installed upstream of a channel bend. Under such circumstances the confined flow at the culvert exit could be directed toward the stream bank resulting in scour and sediment releases. Excessive erosion can cause a culvert to collapse resulting in an obstruction to fish migration. Erosion also results in the release of soil particles that can degrade habitats for fish and invertebrates. Appropriate erosion control measures both at the site of the culvert and downstream will be based on site-specific conditions. In general, road slopes at the culvert installation will be armored to prevent erosion around the culvert. If possible, stream crossings will be selected to avoid culvert installations just upstream of channel meanders; straight sections of channel are preferred. Streambanks downstream of culverts will be armoured if they are susceptible to erosion from culvert discharges.

- *erosion due to road construction.* Road construction can result in the release of particulates into downstream waters, particularly from the operation of heavy machinery in the flowing water, dredging of a flowing stream and backfilling using soil having a high proportion of fines. Excessive sediment in a watercourse can alter or destroy spawning, nursery and rearing habitats for fish and adversely affect habitats for fish food organisms. Road construction can result in the release of particulates into downstream waters. Mitigation measures that are available to minimize such impacts include: appropriate timing (to avoid spawning periods and high runoff periods), the use of construction materials that have been processed to meet specific particle gradation specifications, avoiding the operation of heavy machinery in streams, and the placement of sediment control barriers (*e.g.*, filter fabrics) where soil exposure or sediment releases can not be avoided.

- *loss of critical fish habitat due to culvert installation.* In some cases the road alignment could cross directly over critical aquatic habitat resulting in adverse impacts to local populations of fish. This could occur, for example, where a culvert is installed over a spawning bed in a small stream where spawning habitat is very limited. Potential direct losses of critical fish habitat will be avoided through adjustments in road alignment based on site specific advice provided by aquatic biologists.

The assessment of effects on aquatic life due to the construction of the Sable Pit haul road assumes that site specific culvert installation mitigation measures are employed and that critical habitats are avoided. Under such conditions, there will be no disruption in fish migration, nor will critical fish habitat be lost. It is therefore anticipated that the effects on fish and fish habitat of the Sable Pit haul road will be negligible.

The operation of the Sable Road has the potential to affect fish and aquatic habitat in three ways: fugitive dust falling on aquatic habitats, collapse of culverts, and accidental spills of fuel, lubricants and other materials.

As indicated in Section 4.5.4.2.6, fugitive dust from vehicular traffic is not likely to adversely affect aquatic life. Mitigation measures used elsewhere at the EKATI™ mine site have been effective in controlling dust from access roads and will be employed for the Sable Road.

Culverts designed for fish passage must be engineered for the specific load conditions. BHP has considerable experience designing and constructing access roads used by heavy equipment. This engineering experience and knowledge will help to ensure that stream crossings do not fail.

Fuel and lubricants can be harmful to aquatic life. While there can be no absolute assurance that accidental spills will not occur, a spill management contingency plan has been produced and implemented by BHP for the EKATI™ mine site to deal with such events and to minimize environmental damage.

4.5.3.4 Water Summary for Sable Road

In general, road construction and stream crossings have the potential to alter stream flow patterns, channel hydraulics, water quality and consequently, adversely affect fish and aquatic habitat. In most cases, these impacts occur due to inappropriately sized and installed culverts, the exposure of soils to flowing water, the operation of heavy machinery in stream channels, and the siting of the road alignment in unsuitable locations.

Three of the seven streams that will be crossed by the Sable Haul Road probably possess runs of fish for at least part of the open water season. In addition, water bodies (ponds and lakes) immediately downstream of the other road crossings likely support aquatic life, possibly including fish. While culverts will only be necessary in streams confirmed to provide fish passage, environmentally sound road and stream crossing techniques will be used at all channel crossings to mitigate water quality deterioration.

Prior to road construction, during freshet, a ground-level assessment will be made at all streams to be crossed by the Sable road to confirm the presence or absence of fish. This final stream assessment will also include an evaluation of habitat at the proposed crossing location to determine whether these locations include critical habitat features. Under such circumstances, it may be necessary to shift the road alignment.

Mitigation measures to be employed at stream crossing sites include the appropriate sizing of culverts (where needed) based on background hydrological information, installation of major culverts during winter to eliminate erosion during construction, road siting to avoid critical habitats and the use of sediment control devices and measures. In

addition, monitoring at all stream crossing sites will identify altered water flow and water quality conditions so that remedial measures can be initiated quickly.

It is anticipated that the significance of the residual effects on the aquatic VECs due to construction of the Sable Road will be negligible. However, failure of any of these measures will result in highly localized effects that are likely to occur during only one summer season. Unexpected adverse effects include possible downstream sedimentation, culvert failure or blockage, culvert-induced changes in stream hydraulics, and fish migration obstruction. All these problems can be quickly identified and resolved.

Table 4.5-2 summarizes the effects on aquatic VECs of the Sable Road construction, mitigation measures to be employed and the likely significance of any residual effects.

Table 4.5-2
Summary of Predicted Effects on Water-Related VECs due to Sable Road Construction

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Water Quantity	Installation of culverts	Upstream flooding	Proper design through experience and hydrological data	Negligible
Water Quality	Road construction	Introduction of sediments into waterways during construction	Grading and compacting to prevent erosion; route located away from waterbodies; minimize stream crossings	Negligible
Fish/Aquatic Habitat	Culvert installation and obstruction to fish migration	Restriction of fish passage; loss of suitable habitats for spawning	Appropriate culvert sizing; positioning in the stream; and winter installation of major culverts	Negligible
	Erosion at culvert sites	Adverse sedimentation impacts on spawning, nursery and rearing habitats	Armouring of road slopes and susceptible stream banks	Negligible
	Erosion due to road construction	Sedimentation impacts on fish habitat	Timing; use of screened material for backfilling; avoidance of heavy machinery in streams; filter fabrics	Negligible
	Loss of critical habitat due to culvert installation	Direct habitat loss	Shift in road alignment	Negligible

4.5.4 Pigeon Pipe

The following sections present the project activities resulting from the development of Pigeon Pipe that could impact water-related VECs, mitigation measures that will be

implemented, and an assessment of any residual effects. The assessment methodology for residual effects evaluations is presented in Section 4.2. The Pigeon Pipe discussion is divided into the VECs water quantity, water quality, and fish/aquatic habitat. An overall summary of the residual effects on all water related VECs associated with the development of the Pigeon Pipe is provided at the end of the section. An overview map of the Pigeon Pipe development area showing the major directions of surface water flow is provided in Figure 4.5-5.

4.5.4.1 Water Quantity (Hydrology)

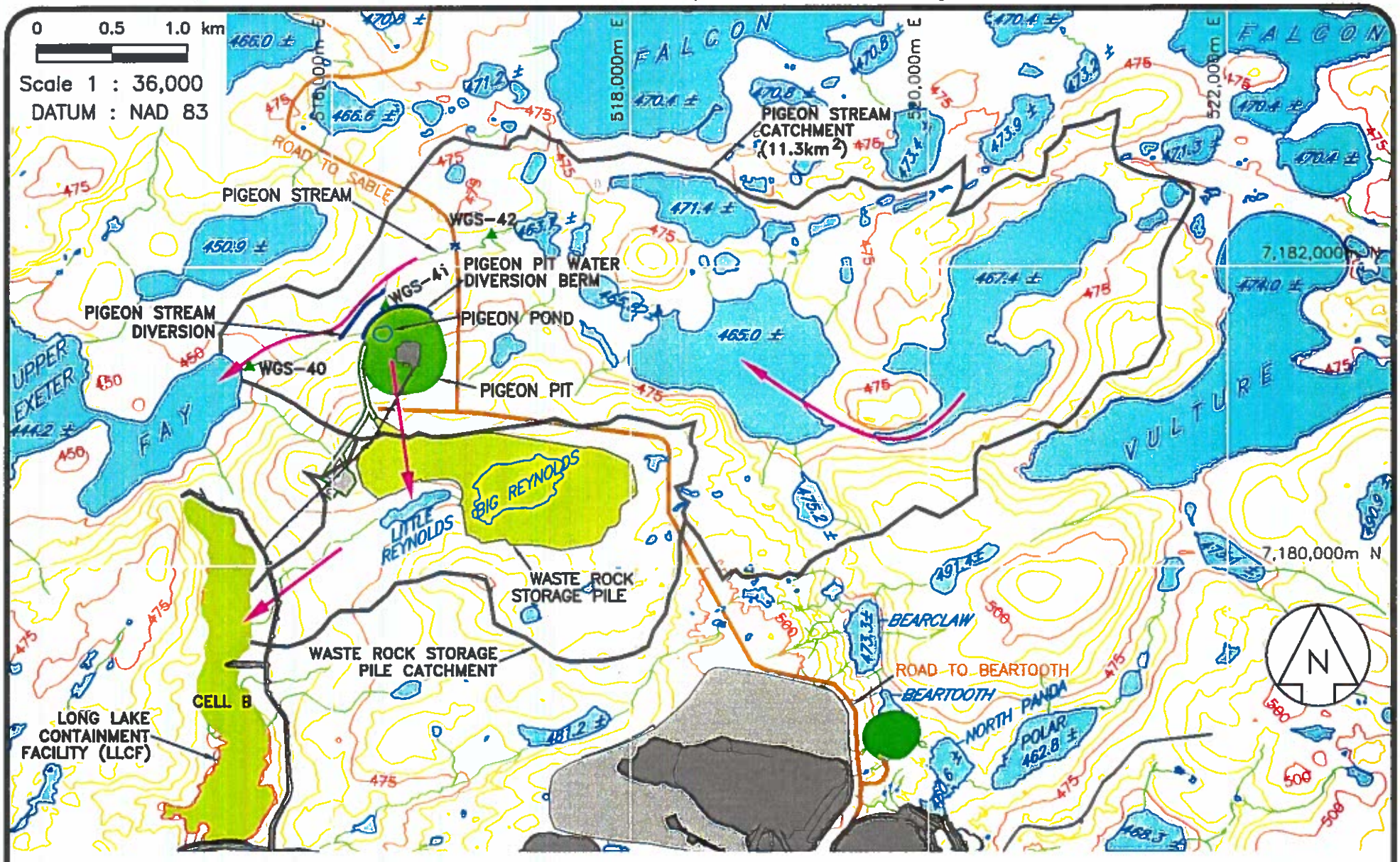
4.5.4.1.1 Lake Dewatering (Pigeon Pond)

The development of Pigeon Pit requires the dewatering of Pigeon Pond, which is a small waterbody. Formal bathymetry of Pigeon Pond was not undertaken due to its relatively small size. The volume was estimated to be 18,500 m^3, based on the surface area and an estimate of the mean depth. The relatively small quantity of water within Pigeon Pond will be pumped into Little Reynolds Pond, which flows into the Long Lake Containment Facility. The effect of the dewatering of Pigeon Pond will be a minor increase to the input volume to the Long Lake Containment Facility.

The volume of water to be removed from Pigeon Pond is small and will contribute only 0.2% to the annual water discharge from the Long Lake Containment Facility. As well, BHP controls the discharge of the Long Lake Containment Facility. As a result, there will be no measurable effect on water quantity downstream of Long Lake from the dewatering of Pigeon Pond, and the effects are expected to be negligible. In addition, the surface area of Pigeon Pond is so small (~100 m^2) that there will be no detectable changes in water quantity from changes in the lake storage capacity by dewatering the lake.

4.5.4.1.2 Flow Diversion: Pigeon Stream Diversion

The development of Pigeon Pit will result in the loss of Pigeon Pond. Pigeon Pond receives flow from headwater lakes of the Yamba/Exeter Watershed and discharges into Fay Lake. The Pigeon Stream Diversion (PSD) will be constructed to allow flows from the headwater reaches of the Yamba/Exeter Watershed to enter Fay Lake unaltered, circumventing Pigeon Pit. The PSD will be built to mimic current hydrological conditions. That is, it will permit flooding of freshet flows into the surrounding wetlands in the vicinity of the former Pigeon Pond. BHP will utilize the experience gained from the construction and maintenance of the Panda Diversion Channel to improve upon the planned stream diversion. The PSD will be 80 m shorter in total length as compared to the sections of Pigeon Stream which it is replacing. However, with the reconnection of Pigeon Pit Lake to the original Pigeon Stream, an additional 220 m of stream will be available to fish. Flow conditions are not expected to deviate from current conditions. The length of the PSD will be approximately 440 m. Assuming an average annual runoff of 224 mm over the entire catchment area upstream of Pigeon Pond (10.3 km^2), an average annual flow expected through the PSD is approximately 2.31 million m^3/y.



Source : EBA, 2000

Surface Water Drainage for the Pigeon Pipe Development Area

Figure 4.5-5

BHP

Ekati diamond mine

The unlikely residual effect of the PSD (altered hydrological regime) will be local and it will persist continuously and permanently. Once mining is complete, the PSD will remain as an independent, functional structure. No change in the capacity of the aquatic resources is expected. The effect on water quantity from this flow diversion is expected to be negligible.

4.5.4.1.3 Waste Rock Storage/Drainage

The waste rock storage area will fill and surround Big Reynolds Pond, and will be located entirely within the Koala Watershed. The hydrological effect of the waste rock storage pile will be an altered runoff pattern as described previously in the Sable Pipe section. In addition, the removal of Big Reynolds Pond (183,623 m^3) will decrease the storage capacity and flow dampening capacity of the Koala Watershed.

The footprint of the area affected by the waste rock storage pile represents less than 1% of the Koala Watershed, and therefore is not expected to cause a detectable alteration in runoff patterns due to the presence of the waste rock. As well, the removal of Big Reynolds Pond, which flows directly into the Long Lake Containment Facility, will not cause a detectable change in water quantity to any waterbody other than the outflow stream of Big Reynolds Pond.

The geographic extent of the effects on water quantity from waste rock storage is highly localized, with effects terminating in the Long Lake Containment Facility (will not be observed further downstream). The effects will persist indefinitely throughout the year and they are not reversible. The future resource capacity of Big Reynolds Pond will be eliminated. However, the residual effect is rated as negligible because it is highly localized and will not impact flows downstream of the Long Lake Containment Facility.

4.5.4.1.4 Pit Reclamation: Pigeon Pit

After mining activities have ceased in Pigeon Pit, it would take approximately 20 years for the pit to be filled with water from natural runoff from upstream sources (*e.g.*, if Pigeon Stream were allowed to flow into the pit). However, Pigeon Stream and downstream waterbodies would incur a significant reduction in flow. Extracting water from a nearby source lake would reduce the time required to reclaim the pit to lake status, and would avoid effects on Pigeon Stream and downstream waterbodies.

The mitigation plan for the filling of Pigeon Pit is to extract water from Upper Exeter Lake. Filling Pigeon Pit with water from Upper Exeter Lake would require five years as opposed to 20 years if the pit were allowed to naturally refill. Upper Exeter Lake is relatively close to Pigeon Pit and is large enough (28 km^2) that a withdrawal rate of 0.5 m^3/s is not expected to impact downstream hydrologic conditions. Pumping will occur during the open water season and will vary according to the yearly hydrological conditions.

The final volume of Pigeon Pit is estimated to be 22,000,000 m^3. Based on a maximum pumping rate of 0.5 m^3/s and a pumping period of four months, the total volume extracted from Upper Exeter Lake per year for the purpose of filling Pigeon Pit will be 5,200,000 m^3. To determine the effect that water extraction will have on flows downstream of Exeter Lake an estimate of the total runoff volume for the watershed is required. Based on an annual average precipitation of 345 mm, the total volume added to the drainage area (233 km^2) is 80,385,000 m^3. Since approximately 25% of the drainage basin is lake surface, 25% of the total volume from precipitation can be added directly to the available discharge volume. The other 75% of the drainage basin is terrestrial. Therefore the estimated runoff coefficient of 0.65 must be applied to the remaining volume from precipitation. The total volume entering Upper Exeter Lake is 59,283,938 m^3. The rate of evaporation and number of evaporation days were averaged from six years of data to be 2.5 mm per day and 128 days, respectively. The total water volume lost to evaporation is estimated to be 18,640,000 m^3 for the entire watershed (25% of the drainage area was estimated to be lake surface). The net runoff volume for the Upper Exeter Lake Drainage Area is estimated to be 40,643,938 m^3. Therefore the extraction of 5,200,000 m^3 from Exeter Lake would reduce the downstream discharge to 35,443,938 m^3, this equates to a 13% reduction in discharge from Upper Exeter Lake. A 13% reduction in the overall discharge will alter the hydrological conditions, but is not expected to adversely affect fish and fish habitat.

BHP will conduct baseline work at Upper Exeter Lake prior to pit decommissioning so that site specific data can be used to directly quantify the absolute discharge from the lake. In addition, BHP will alter its pumping rate as conditions during the year vary. That is, during 'dry' years the pumping rate will be reduced to ensure that the rate of withdrawal does not result in a change to the general shape of the hydrograph, the magnitude of change to peak and minimum flows, and how these changes relate to fish habitat.

The residual effect of extracting water from Upper Exeter Lake will persist for five consecutive years throughout the open water season. The hydrological effect is reversible once Pigeon Pit has been filled. The geographic extent will be local as the contribution from Upper Exeter Lake to the discharge from Exeter Lake is supplemented by 332 km^2 of drainage area within the overall Exeter Watershed. Therefore, the overall reduction in discharge from Exeter Lake is estimated to be 5%. A 5% reduction is not expected to alter the hydrology of receiving waters. In addition, since the pumping rate from Upper Exeter Lake will be reduced as required to maintain an acceptable discharge to Exeter Lake, the residual effect is rated as negligible.

4.5.4.2 Water Quality

4.5.4.2.1 Lake Dewatering (Pigeon Pond)

Pigeon Pond will be dewatered by pumping water directly into Little Reynolds Pond which flows into the Long Lake Containment Facility. The only natural waterbody that could potentially be affected is Little Reynolds Pond, which is not fish-bearing.

As described in the Sable Pipe section, water quality is expected to be poor during the final stages of dewatering. The dewatering process will be carried out as described previously.

Dewatering of Pigeon Pond could affect water quality of Little Reynolds Pond only, which is a very localized area within the Koala Watershed. The duration of the effect would be very short-term, as all dewatering will occur within one season. The frequency of this effect will be rare as the activity will only take place once and it is reversible. This effect may occur, but it will not reduce the future capacity of renewable resources to meet needs (there are no fish in the waterbody affected). It is expected that the residual effects of Pigeon Pond dewatering on water quality will be negligible.

4.5.4.2.2 Pit Water Discharge: Pigeon Pit

Water that collects in Pigeon Pit can be expected to be similar to Panda Pit mine water, which contains elevated concentrations of suspended solids, sediment-associated parameters and nitrogen. Water from Pigeon Pit will be pumped into the drainage basin of Little Reynolds Pond and allowed to flow down the existing streambed to the Long Lake Containment Facility. The only natural waterbodies that may be affected are Little Reynolds Pond and its outflow.

The discharge of Pigeon Pit water will affect Little Reynolds Pond, which is not a fish-bearing waterbody. Effects of pit water will be very localized in nature. Pigeon Pit water will contribute to the nitrogen loading of the Long Lake Containment Facility, which discharges water into downstream waterbodies within the Koala Watershed. The duration of the effect will be for as long as Pigeon Pit water is discharged (approximately four years). The frequency of the effect will be continuous during the open water season. The effect will be eliminated when the discharge of Pigeon Pit water stops. The overall significance of residual effects to water quality from the discharge of Pigeon Pit water via Little Reynolds pond and the Long Lake Containment Facility to the downstream Koala Watershed is expected to be minor.

4.5.4.2.3 Flow Diversion: Construction and Operation of Pigeon Stream

A surface water diversion structure will be constructed to realign Pigeon Stream around the proposed Pigeon Pit. Construction of the Pigeon Stream Diversion (PSD) could introduce sediments and associated parameters into downstream waterbodies, including Pigeon Stream and Fay Lake. Waste rock will be used during construction, which will cause the introduction of nitrogenous compounds into surface waters.

Measurements made within the Panda Diversion Channel (PDC) immediately after opening indicated that nitrogen and total phosphorus concentrations were all elevated over background levels (Rescan 2000-Kodiak Lake report).

Based on measurements made in Kodiak Lake (the receiving waterbody of the PDC) during in-stream construction activities in the Panda Diversion Channel, current

mitigation measures and methodologies employed have been effective and have contributed to the development of productive new fisheries habitat. However, monitoring in Kodiak Lake has indicated that the use of waste rock (generated from the use of ammonium nitrate-based explosives) in stream construction within the Panda Diversion Channel can result in elevated concentrations of nitrogen for one to three years.

The Pigeon Stream Diversion will be designed using field-proven engineering and construction practices to reduce slope erosion and other problems associated with slope stability. The design of the PSD will employ lessons learned from construction and operation of the Panda Diversion Channel. If necessary, silt curtains will be installed downstream to minimize the introduction of sediment-associated parameters to downstream waterbodies (Pigeon Stream, Fay Lake).

The main identifiable residual effects on water quality that may occur after mitigation measures are employed is the introduction of nitrogen and possibly sediment-associated compounds (including phosphorus) to downstream waterbodies. Measurements made in Kodiak Lake during and after the construction of the Panda Diversion Channel indicate that leaching of nitrogen from waste rock could occur for up to three years or longer. Phosphorus associated with sediment material could potentially be introduced into downstream waterbodies for a short period of time during the initial flushing of the channel, but is not expected to persist for more than two seasons. As well, the placement of silt curtains aid in reducing the transport of sediments. However, the potential exists for primary producer biomass to be slightly enhanced by the introduction of phosphorus. The effect on aquatic life is expected to be temporary and localized to Fay Lake if an effect is even detected.

The geographic extent of the effect would be limited to a small portion of the Pigeon drainage area, (Pigeon Stream and Fay Lake) and would most likely not be observable in Upper Exeter Lake. The duration of potential effects would be during construction activities and for likely no more than three years after construction has been completed. The frequency of this effect would be continuous during the open water season for an estimated three years after construction was completed. This effect is reversible because water quality will not be affected by the PSD after approximately three years. It is likely that elevated concentrations of nitrogen may persist in Pigeon Stream water for a period of approximately three years. Phosphorus may potentially be introduced into the water by sediment suspension during the early life of the channel, although phosphorus may be mitigated by standard sediment control measures. However, the potential exists for primary producer biomass to be elevated in Fay Lake, but no further downstream. The effect on aquatic life will be temporary if an effect is even detected. Federal criteria for the protection of aquatic life are not expected to be exceeded in any downstream waterbodies. The residual effects on water quality from the construction and operation of the Pigeon Stream Diversion are expected to be minor.

4.5.4.2.4 Waste Rock Storage/Drainage

The location of the proposed waste rock storage pile at Pigeon will result in the burial of Big Reynolds Pond. Runoff from the Pigeon Pit waste rock storage area will remain in

the Koala Watershed and drain into either Little Reynolds Pond or the Long Lake Containment Facility. Little Reynolds Pond (which is not fish-bearing) and outflow are the only natural waterbodies that could be affected by runoff from Pigeon Pit waste rock.

Assuming that runoff is of similar quality to runoff from Panda Pit waste rock, Little Reynolds Pond and outflow could be exposed to elevated concentrations of sediment-associated parameters, ammonia and nitrate. Federal guidelines for the protection of aquatic life may be exceeded in Little Reynolds Pond for several parameters; however Little Reynolds Pond is a shallow slough and not necessarily subjected to freshwater guidelines.

The waste rock storage pile will eliminate Big Reynolds Pond. The pile has been located to ensure that water percolating through the waste rock will drain into the Long Lake Containment Facility and remain entirely within the Koala Watershed.

The geographic extent of potential effects would be localized in area, with Little Reynolds Pond and outflow being the only natural waterbodies that could potentially be affected. The duration of effect would be for as long as runoff drains to Long Lake, which could be in excess of a decade. The frequency of the effect will be continuous during the open water season. Once runoff stops, the concentrations of the various parameters mentioned above could return to normal in Little Reynolds Pond, thus the effect is reversible. This effect may occur, but it is unlikely that it will reduce the future capacity of renewable resources to meet needs as Little Reynolds Pond is not fish-bearing. Mainly due to very localized effects, it is expected that the overall residual effects of Pigeon Pit waste rock drainage on downstream water quality will be negligible.

4.5.4.2.5 Pit Reclamation: Pigeon Pit

Pigeon Pit will be filled with clean water from Upper Exeter Lake over a period of five years. As water fills the pit each open water season, it may become elevated in suspended solids due to the suspension of sediment during filling. However, after each open water season the newly placed water will have a winter season in which particulate material can settle out. As such, there is really only the potential to affect the water quality of downstream waterbodies during and after the final year of water filling.

The water level during the final year of filling will be kept low enough to ensure that water will not flow out of the lake until it has had a full winter season in which to settle. In addition, only pristine water from Upper Exeter Lake will be introduced to Pigeon Pit. It is therefore expected that the water quality of Pigeon Pit Lake will be representative of undisturbed lakes in the area after lake reclamation. Hence the potential effect of Pigeon Pit Lake water on downstream water quality is expected to be negligible.

4.5.4.2.6 Blasting and Fugitive Dust from Pit Operations, Vehicular Traffic, and Waste Rock Dumping

The deposition of fugitive dust could result in slight increases in TSS, total aluminum, total nickel and nitrogen in nearby waterbodies. Blasting activities may result in the

introduction of nitrogen to nearby waterbodies (*e.g.*, Pigeon Stream) and to pit water. The waterbodies most likely to be affected are Pigeon Stream and Little Reynolds Pond, although other waterbodies within a one to three kilometre radius of the dust-generating activities may also be influenced (*e.g.*, Fay Lake). Resulting concentrations of these parameters are not expected to exceed federal criteria for the protection of aquatic life, and are not expected to cause a change in the biology of aquatic ecosystems (based on Grizzly Lake monitoring; Rescan, 1999b).

The mitigation measures and the assessment of residual effects for the Pigeon pipe area are the same as those presented previously for the Sable pipe area. The expected effect on water quality from blasting and dust generating activities is negligible.

4.5.4.2.7 Construction of Surface Facilities

Surface facilities proposed to be constructed in the Pigeon Pipe area include a field office, a truck line up area and a fuel storage facility. Site preparation for surface facilities will involve covering vegetation and surficial materials with rockfill. These activities could result in fugitive dust emissions and intermittent sediment loading to nearby waterbodies, although the proposed construction area drains towards Long Lake. As such, the construction of surface facilities is not a concern for natural waterbodies in the area. Effects on water quality as a result of the construction of surface facilities are expected to be very short-term and minimal.

The mitigation measures and the assessment of residual effects for the Pigeon pipe area are the same as those presented previously for the Sable pipe area. The expected effect on water quality from the construction of surface facilities is negligible.

4.5.4.3 Fish/Aquatic Habitat

4.5.4.3.1 Potential Effects and Mitigation for Pigeon Pipe Development

The following summarizes the waterbodies and fish habitats that will be affected by development of the Pigeon Pit:

- *Pigeon Stream*: to be diverted around the Pigeon Pit through an engineered channel;
- *Pigeon Pond*: to be dewatered;
- *Big Reynolds Pond*: to be completely filled in with waste rock;
- *Little Reynolds Pond*: to receive residual pit water; and
- *Big Reynolds-Little Reynolds Stream*: to be partially filled by waste rock. Water flow will be effectively eliminated by the loss of Big Reynolds Pond.

4.5.4.3.1.1 *Pigeon Stream and Pigeon Pond*

Pigeon Stream, which drains to Exeter Lake via Fay Lake and Upper Exeter Lake, provides suitable migration, spawning and summer rearing habitat for Arctic grayling. Grayling represented over 80% of the 93 fish caught during sampling in this stream[4]. Pigeon Pond is used primarily by grayling as a holding pool during both upstream and downstream migration. Overwintering by these fish in Pigeon Stream is unlikely because it freezes to the bottom in winter over most of its length.

The potential loss of fish habitat in Pigeon Stream due to Pigeon Pit development is restricted to a 520 m length of channel, including Pigeon Pond. No fish mortalities due to the diversion are anticipated since dewatering of the pond is to occur after the beginning of freeze-up, when juvenile fish migrate into larger adjacent lakes such as Exeter Lake to overwinter.

A 440 m diversion channel will be constructed to carry Pigeon Stream water around the Pigeon Pit development. This channel will incorporate characteristics and structures intended to replace the grayling habitat that is being lost due to the stream diversion. The following channel design features have been proposed to achieve no net loss of productive capacity of habitat, as required by the DFO Policy for the Management of Fish Habitat:

- *Substrate*: The channel bottom will consist of a mixture of cobbles and gravel, interspersed with boulders to provide varied habitat for spawning, nursery and rearing habitat. In addition, it is anticipated that natural bed and bank scour will contribute smaller particles to the streambed in depositional zones. Boulder placement is important in producing microhabitats that are generally important for young of the year and juvenile fish. The natural streambed has a high proportion of sand in the section of the channel that is to be diverted. Every attempt will be made to replicate this condition. It is assumed that natural erosion of upstream eskers will continue to contribute significant inputs of sand and gravel to the stream;
- *Habitat structures*: A variety of structures are being contemplated in the design of the channel to create suitable habitat conditions for grayling. These include vortex weirs, rock vanes, boulder clusters and wing deflectors. In most cases, these structures cause changes in flow direction and water velocity, which in turn create scour and depositional zones, leading to a variety of habitats and microhabitats, similar to that found in natural stream systems; and
- *Pool creation*: A pool is to be created at the downstream end of the diversion channel. This will partially compensate for the loss of Pigeon Pond habitat, reduce water velocities where the diversion channel connects with the natural channel, and provide a rest area for migrating fish.

[4] **Other species captured were slimy sculpin, burbot and lake trout.**

In addition, when Pigeon Pit is reclaimed to lake status, flow from the lake will be restored to the downstream portion of the original Pigeon Stream. This will result in the restoration of approximately 220 m of streambed.

4.5.4.3.1.2 *Pigeon Pit Reclamation*

After about three years of mining, Pigeon Pit will be reclaimed as a viable fish bearing lake through the creation of suitable spawning, nursery and rearing habitats. The methods used to create these habitats will be similar to those described in Section 4.5.1.6.

Following habitat restoration, the pit will be flooded, by pumping water directly from Upper Exeter Lake. The use of Upper Exeter Lake water to fill the Pigeon Pit will preclude the need to redirect a portion of Pigeon Stream to Pigeon Pit. Therefore there will be no effect on water quantity in Pigeon Stream. The downstream end of the new pit lake will be reconnected to the original Pigeon Stream Channel and the pit lake will be monitored to determine whether fish stocking is needed. It is probable that the lake will first be colonized by Arctic grayling, since this species regularly uses Pigeon Stream for migration, spawning, nursery and rearing. It is expected that primary and secondary producers and macroinvertebrates will naturally colonize the pit lake. These organisms will be contained in water pumped from Upper Exeter Lake or will arrive in the form of aerial drift.

4.5.4.3.1.3 *Big Reynolds Pond*

Only Arctic grayling were found during gill net sampling in Big Reynolds Pond. It is apparent that the small population of grayling in this pond is isolated and therefore, self-sustaining. Big Reynolds Pond is connected through Little Reynolds Pond to Cell B of the Long Lake Containment Facility. There is very little likelihood of fish passage into or out of Big Reynolds Pond due to the very poor migration habitat available in the Big Reynolds-Little Reynolds Stream and because neither Little Reynolds Pond nor the Long Lake Containment Facility offer suitable habitat conditions.

The population of grayling in Big Reynolds Pond is likely limited by the availability of overwintering habitat. This pond has a maximum depth of 3.2 m and a mean depth of 1.1 m. Therefore, only a very small area of the pond is available for overwintering; the rest of the pond would freeze to the bottom.

4.5.4.3.1.4 *Little Reynolds Pond*

Little Reynolds Pond will not be directly affected by the placement of waste rock. However, water from Pigeon Pond will be pumped to Little Reynolds Pond during dewatering. As well, residual Pigeon Pit water will be pumped to Little Reynolds Pond en route to the Long Lake Containment Facility. During the winter months no pit water is expected to be generated because Pigeon Pit is shallow and entirely location within permafrost.

There are no persistent populations of fish in Little Reynolds Pond. This pond is very shallow (generally less than one metre) and has a substrate consisting of organic matter and silt. Fish migration during spring and summer from downstream areas has been

precluded by fish-out efforts in the Long Lake system and by the deposition of processed kimberlite in Cell B of the Long Lake Containment Facility.

4.5.4.3.1.5 Big Reynolds-Little Reynolds Stream

The Big Reynolds-Little Reynolds Stream is made up of sections of indistinct bouldergarden channel, and runs and cascades over boulders. Streamflow is ephemeral. Fish population sampling was not conducted in the stream since all streams flowing into Long Lake were included as part of the original EKATI™ Diamond Mine Habitat Compensation Agreement and Fisheries Authorization with DFO. However, because suitable habitats for spawning, rearing and migration are lacking in the Big Reynolds-Little Reynolds Stream, it is unlikely that it supports populations of fish, even seasonally.

4.5.4.3.1.6 Drainage from Waste Rock Piles

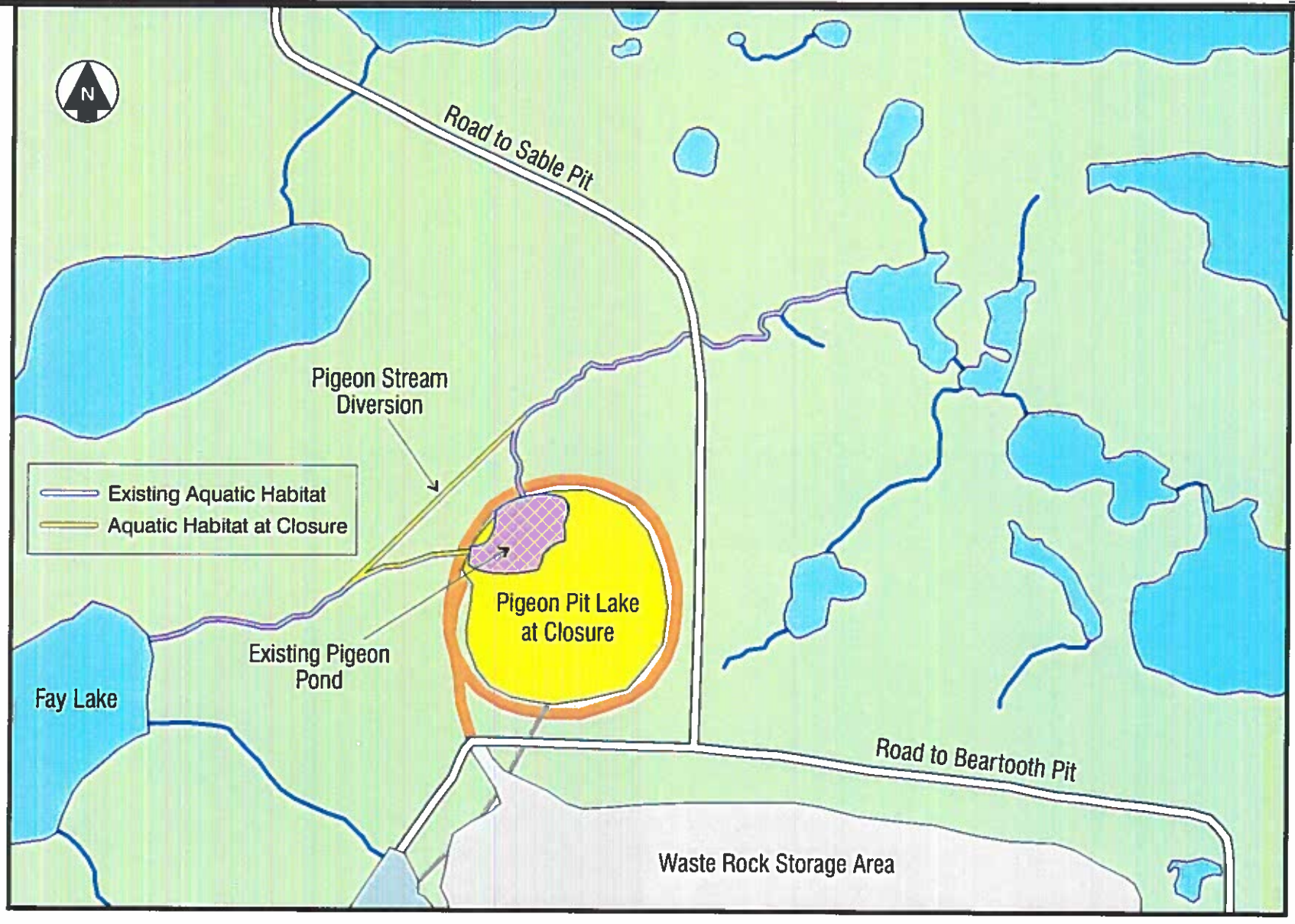
It is anticipated that the waste rock deposited in Big Reynolds Pond may have some potential to generate poor quality runoff. However, runoff from the waste rock pile will eventually collect in the Long Lake Containment Facility, which has been designed to contain and mitigate poor quality runoff water prior to discharge to downstream waterbodies.

4.5.4.3.2 Assessment of Effects on Fish/Aquatic Habitat for Pigeon Pit

Figure 4.5-6 depicts the fish habitat changes that will occur from the evolution of Pigeon Pond to the restoration of Pigeon Pit Lake. Fish habitat will be temporarily lost in the section of Pigeon Stream that will be diverted due to Pigeon Pit development. It is anticipated, though, that the diversion channel will be created with sufficient habitat features and characteristics to achieve no net loss of productive capacity of habitat. In addition, after the pit has been restored to lake status, the downstream end of the original Pigeon Stream will be reconnected to the new pit lake through the original streambed to provide suitable migration and rearing habitat, particularly for Arctic grayling. Arctic grayling produced in Pigeon Stream make up a portion of the grayling population of Fay Lake and Exeter Lake. Since the productive capacity of habitat in this stream should not change appreciably, it is not anticipated that the grayling population of Fay Lake and Exeter Lake will be adversely affected by the Pigeon Pit development.

Future fish production in Big Reynolds Pond will be lost. This pond presently possesses a very small, isolated population of Arctic grayling whose production potential is severely restricted by the lack of overwintering habitat. Fish in such lakes do not contribute to the gene pool within the larger watershed nor are they available as habitats for fish migrating from downstream areas. This is particularly true for Big Reynolds Pond since it drains to Little Reynolds Pond and the Long Lake Containment Facility, neither of which possess fish populations.

Arctic grayling production in Big Reynolds Pond is very limited and does not contribute significantly to the overall production of grayling in the Lac de Gras system. Further, there is no genetic exchange between fish in Big Reynolds Pond and fish in any other downstream waterbodies nor is there any human exploitation of fish in this pond.



Schematic of Fish Habitat Changes for the Development of Pigeon Pipe

FIGURE 4.5-6

BHP

Ekati diamond mine

Following pit reclamation, successful fish production in Pigeon Pit Lake will have a moderate, positive effect on fish and fish habitat capacity within the Pigeon Stream and Fay Lake systems since no lake exists presently over the site of the Pigeon Pit development. The overall increase in available habitat and fish production from Pigeon Pit Lake will more than compensate for the loss of habitat and fish production from Big Reynolds Pond.

The proposed Pigeon and Sable developments both lie within the Yamba/Exeter Watershed. It is anticipated that there is unlikely to be a measurable effect on aquatic life in Exeter Lake (including Fay Lake) from either of these developments. It can therefore also be concluded that the cumulative effect of both developments on the aquatic life of Exeter Lake and downstream waterbodies will be negligible.

4.5.4.4 Water Summary for Pigeon Pipe

Each of the above sections pertaining to the effects of the Pigeon development have concluded that the significance of these effects individually on water quantity, water quality and fish and aquatic habitat will be negligible to minor. It is also important to examine the interactions among these VECs to assess the medium and longer term ecological consequences of this development.

Changes in water quantity and water quality from development of the Pigeon Pit will mainly occur within Big Reynolds and Little Reynolds ponds and consequently, the Long Lake Containment Facility all of which are located within the mine's water management system. The overall effect of the development activities on fish and aquatic habitat will be restricted to the loss of the small, isolated fish population in Big Reynolds Pond. Little Reynolds Pond does not support fish nor do the inflow and outflow streams of both Big and Little Reynolds ponds.

Pigeon Pond is a widening in Pigeon Stream and serves mainly as a rest area for migrating adult Arctic grayling during their upstream spawning migration. The loss of this pond will not likely affect the Fay Lake grayling population due to the inclusion of suitable migration, spawning and rearing habitat in the design of the Pigeon Stream Diversion.

Pigeon Pit will be filled by pumping water from Upper Exeter Lake for a period of five years. The anticipated pumping rate of water from Upper Exeter Lake will reduce overall water discharged from Exeter Lake by five percent. This slight decrease in flows is not anticipated to have any adverse effects on fish or aquatic habitat in the Exeter Lake outflow stream.

Since all water from the Pigeon Pit will be directed toward Little Reynolds Pond and the Long Lake Containment Facility, only the construction of the Pigeon Stream Diversion has the potential to affect water quality in Pigeon Stream and Fay Lake. Upon opening of the diversion channel, it is anticipated that there will be a brief increase in suspended sediments due to the fine materials washed from the rock to construct the channel. This impact will be mitigated using standard sediment control measures. These measures will also likely reduce the introduction of particle-associated phosphorus into downstream

waterbodies. In addition, the channel will be opened under high flow conditions to maximize the dilution of particulates.

It is likely that elevated concentrations of nitrogen may persist in Pigeon Stream water for a period of approximately three years. Phosphorus may potentially be introduced into the water by sediment suspension during the early life of the channel, although phosphorus may be mitigated by standard sediment control measures. However, the potential exists for primary producer biomass to be elevated in Fay Lake, but no further downstream. The effect on aquatic life will be temporary if an effect is even detected.

Residual effects on the aquatic environment due to development of the Pigeon Pipe will likely be restricted to small portions of the Yamba/Exeter and Lac de Gras watersheds. The effects will generally be reversible, and will not affect the future capacity of renewable resources in either watershed. In addition, the creation of habitat and the proposed stocking of fish in Pigeon Pit Lake will result in fish production where none exists presently. It is therefore anticipated that the overall significance of the effects of the Pigeon Pipe development on water quantity, water quality and fish and aquatic habitat will be negligible to minor. Table 4.5-3 provides a summary of the activities associated with the Pigeon Pipe development and the significance of their residual effects on aquatic VECs.

Table 4.5-3
Summary of Predicted Effects on Water-Related VECs due to Pigeon Pipe Development

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Water Quantity	Lake Dewatering: Pigeon Pond	Minor increase in water volume at Long Lake Containment Facility and elevated peak flows; Reduction in storage capacity of Yamba/Exeter Watershed	Controlled release from Long Lake Containment Facility. Construction of stream diversion that allows for dampening of peak flows	Negligible
	Flow Diversion: Pigeon Stream Diversion	Altered discharge to receiving waters	PSD designed to mimic the current conditions associated with Pigeon Stream	Negligible
	Waste Rock Storage/Drainage	Altered runoff generation time; Loss of lake storage	None required	Negligible
	Pit Reclamation: Pigeon Pit	Reduced discharge from source lake	Use reduced pumping rate and only pump during 'wet' years	Negligible
Water Quality	Lake Dewatering: Pigeon Pond	Introduction of high turbidity water and associated parameters into Little Reynolds Pond and outlet	Gradual dewatering; dewatering during optimum season; monitoring; final discharge into Long Lake	Negligible
	Pit Water Discharge: Pigeon Pit	Pit water: introduction of high turbidity water, sediment-associated parameters, and nitrogenous compounds into Little Reynolds Pond and Long Lake	ANFO handling and storage procedures; retention in Long Lake prior to discharge downstream	Minor

(continued)

Table 4.5-3
Summary of Predicted Effects on Water-Related VECs due to Pigeon Pipe Development (completed)

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
	Flow Diversion: Construction and operation of Pigeon Stream Diversion	Sediment transport; introduction of sediment and associated water quality parameters to down stream waterbodies (Pigeon Stream, Fay Lake); introduction of nitrogenous compounds due to ANFO and use of waste rock	Winter construction; design to reduce erosion; placement of stabilization structures; use of silt curtains; monitoring	Minor
	Waste Rock Storage/Drainage	Elimination of Big Reynolds Pond; introduction of leachate to Little Reynolds Pond	Engineer waste rock pile to drain into Long Lake and to minimize runoff	Negligible
	Pit Reclamation: Pigeon Pit	Elevated sediment-associated parameters in Pigeon Pit Lake and possibly downstream waterbodies	Seasonal settling of suspended solids prior to discharge: pristine water from Exeter Lake used to fill up pit	Negligible
	Blasting/Fugitive dust	Introduction of TSS, nitrogenous compounds to Pigeon Stream and other waterbodies	Road surfaces sprayed with water during open water season	Negligible
	Construction of surface facilities	Introduction of sediments into waterbodies	Winter construction; locate facilities away from waterbodies	Negligible
Fish/Aquatic Habitat	Flow Diversion: Diversion of Pigeon Stream	Fish mortality; loss of fish habitat productive capacity	Dewatering of Pigeon Pond after freeze-up commences; design of diversion channel to include habitat features	Negligible
	Flow Diversion: Loss of flow to Big Reynolds-Little Reynolds Stream	None; does not contain fish habitat	None	Negligible
	Pit Water Discharge: Discharge of Pigeon Pond water and Pigeon Pit water to Little Reynolds Pond	None; does not support fish community	None	Negligible
	Waste Rock Storage/Drainage: Waster rock storage in Big Reynolds Pond	Complete loss of fish habitat and fish production	None at site; fish habitat creation at Pigeon Pit Lake following the completion of mining; restoration of downstream portion of Pigeon Stream.	Negligible

4.5.5 Beartooth Pipe

The following sections present the project activities resulting from the development of Beartooth Pipe that could affect water-related VECs, mitigation measures that will be implemented, and an assessment of any residual effects. The assessment methodology of residual effects utilized is presented in Section 4.2 of this report. The Beartooth Pipe discussion is divided into the VECs water quantity, water quality, and fish/aquatic

habitat. An overall summary of the residual effects on all water related VECs associated with the development of the Beartooth Pipe is provided at the end of the section. An overview map of the Beartooth Pipe development area in provided in Figure 4.5-7. The major directions of surface water flow are indicated on the map.

4.5.5.1 Water Quantity

4.5.5.1.1 Lake Dewatering: Beartooth Lake

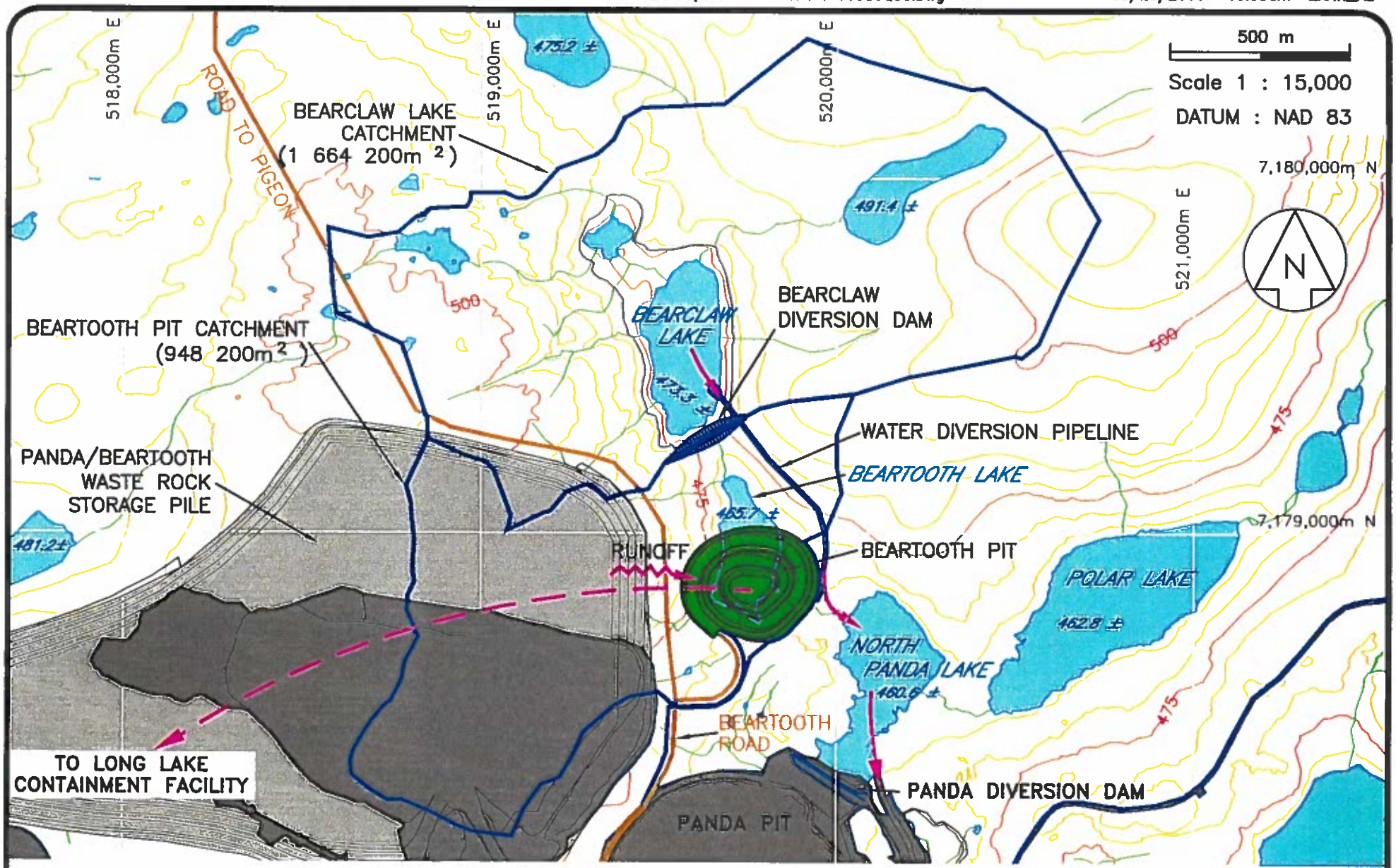
Water contained within Beartooth Lake (145,000 m^3) will be pumped downstream into North Panda Lake. The dewatering process including mitigation measures will be carried out as described previously (see Sable Pipe section).

Flows downstream of North Panda Lake within the Koala Watershed will experience changes during the dewatering process. Based upon knowledge obtained from the aquatic effects monitoring program (AEMP) within the Koala Watershed, the changes are not expected to deviate significantly from natural yearly fluctuations. The AEMP has monitored the hydrology of the area for over six years. Minimum flows are typically reached in early August before the onset of late summer rain events. Flows increase steadily as precipitation dictates until winter freeze up. Dewatering of lakes during this period will elevate the flows to some degree. The change caused by lake dewatering on Beartooth-North Panda Stream can not be quantified at this time since no baseline monitoring has occurred at this location. However, the dewatering rate will be governed by requirements of aquatic life and thus should remain within the natural range of flow for the given time period.

To ensure the effects of dewatering are minimized, a low rate of discharge from Beartooth Lake over a long period of time, coupled with the appropriate timing of dewatering, will be used. The maximum rate of withdrawal in BHP's Water Licence is 0.5 m^3/s. BHP plans to use a reduced pumping rate to mitigate the effect incurred from dewatering.

The dewatering of Beartooth Lake during the fall will alter the latter portion of the hydrograph to some degree. This effect will likely occur but will not persist in subsequent years and will only occur during the dewatering period. Flows during the following freshet period will not be affected. Residual effects from slightly higher flows during the end of the open water season are considered negligible both locally at the Panda Diversion Channel (PDC) and further downstream within the Koala Watershed.

The dewatering of Beartooth Lake and hence removal of this waterbody from the surface water system will cause a small reduction in the lake storage capacity of the Koala Watershed until mine reclamation is complete. The principal role of lake storage is to attenuate extreme flow events. The reduced lake storage capacity caused by the dewatering of Beartooth Lake could potentially contribute to higher peak flows on a



Source : EBA, 2000

BHP

Surface Water Drainage for the Beartooth Pipe Development Area

Figure 4.5-7

Ekati diamond mine

small section of Beartooth-North Panda Stream. The duration of the potential effect is long-term (until Bearclaw Pit Lake is reclaimed) and the frequency is continuous. Once the pit is reclaimed to lake status, the effect will be reversible. The geographic extent of the effect is very localized and within a portion of the local drainage area; as such, the small effect from the removal of Beartooth Lake on lake storage capacity (water quantity) is expected to be negligible.

4.5.5.1.2 Flow Diversion: Bearclaw Dam and Water Discharge from Bearclaw Lake

A dam will be constructed at the outlet of Bearclaw Lake in order to prevent water from flowing into the active Beartooth Pit. The possible hydrologic effect of the Bearclaw dam is altered discharge to receiving waters. However, water from Bearclaw Lake will be pumped into Beartooth-North Panda Stream in order to maintain normal hydrological conditions downstream. Water pumping rates will be determined by the natural accumulation of water behind the dam (which will reflect precipitation and runoff), and fish habitat requirements downstream. As such, the diversion of water from Bearclaw Lake to North Panda Lake is not expected to significantly alter the natural downstream hydrology.

As BHP can control the discharge of water from Bearclaw Lake into downstream waterbodies, residual effects of flow diversion on water quantity are not anticipated. Once flow diversion has been eliminated and Beartooth Pit Lake is reclaimed and re-connected with the surface water system, flows would once again revert to predevelopment conditions. No change in the future capacity of resources in Beartooth-North Panda Stream is expected. The overall effect of flow diversion on water quantity is expected to be negligible.

4.5.5.1.3 Waste Rock Storage/Drainage

Waste rock generated from the mining of Beartooth Pipe will be stored in the existing Panda waste rock area, and will result in an increase in the size of the existing storage pile. Direct precipitation upon the areal surface of the pile will not yield a natural runoff pattern, as described previously. Precipitation will infiltrate the waste rock increasing the time required to generate runoff.

Similar to what has been described for Sable and Pigeon pipes, the effects of the waste rock storage pile on water quantity are an increased runoff generation time and routing of runoff. A mitigation strategy for the increased runoff generation time is not necessary since the area affected by the waste rock storage pile represents less than 1% of the Koala Watershed and therefore is not expected to cause a change in hydrologic conditions greater than what is observed with natural variability. As well, runoff water will remain within the Koala Watershed. The duration of the slightly altered runoff pattern would be continuous and persist for several decades. Reversing the effect would be unlikely. No change to the future capacity of the watershed is expected. Due to the small area affected and the unlikelihood of detecting changes above natural variability, it is expected that the effect of waste rock storage on water quantity will be negligible.

4.5.5.1.4 Pit Reclamation: Beartooth Pit

The exhausted Beartooth Pit will be filled by directing the processed kimberlite slurry stream into the pit. Filling the pit with processed kimberlite and water is expected to take two years compared to 20 years if allowed to fill with natural runoff. Once the pit is filled and water quality guidelines are met, the newly formed lake will be reconnected to the drainage basin. As the pit will be filled with processed kimberlite the only hydrological effect will be a reduction in the annual discharge at the Long Lake Containment facility control structure. The discharge will be reduced to about two thirds of the discharge during a typical year.

The reclaimed Beartooth Pit will have a greater surface area compared to the existing Beartooth Lake. A greater surface area will result in an increased ability to dampen flows, due to the increase in surface area. This factor will attenuate downstream discharges during the open water season. Although no hydrologic monitoring for the original Beartooth Lake has been performed to date, discharge from the reclaimed pit is still expected to reflect predevelopment conditions since the pit will be completely filled during reclamation. Therefore, evaporation and runoff volumes should not change, assuming similar climatic conditions.

The reclaimed pit will have a heightened ability to dampen flows which could result in a lengthened freshet period. The likely effects could be significant locally along the connecting stream between Beartooth and North Panda lakes, but detectable effects downstream within the Koala Watershed are not expected. The heightened ability to dampen flows will persist continuously on a long-term basis. The geographic extent is very local. An effect on the future capacity of the downstream channel is unlikely since only a small change to the hydrograph is possible. The effect would likely not be reversible. However, because the effect will only be evident very locally, the significance of the residual effect is expected to be negligible.

4.5.5.2 Water Quality

4.5.5.2.1 Lake Dewatering: Beartooth Lake

Water from Beartooth Lake will be pumped into North Panda Lake during dewatering as long as discharge water meets the Water Licence criteria. The discharge point in North Panda Lake will be a floating pipe in order to minimize erosion and to maintain acceptable water quality. When Water Licence criteria are approached, Beartooth Lake water will be pumped to the Process Plant and eventually be discharged to the Long Lake Containment Facility.

As described previously in the Sable Pipe section, water quality is expected to be poor during the final stages of dewatering. The dewatering process will be carried out as described previously.

Dewatering of Beartooth Lake could potentially affect water quality in North Panda Lake and possibly other downstream waterbodies. This is not expected to occur, as water

quality will be monitored and water diverted into the Long Lake Containment Facility if necessary. Even if water was not diverted, the effect would be localized and would only occur at the end of dewatering when there is the potential for sediment-laden water to be transferred to North Panda Lake. This event will only occur once. The effect is reversible and will not reduce the future capacity of renewable resources to meet needs. Based on the impact attributes, it is expected that the residual effects of dewatering on water quality will be negligible.

4.5.5.2.2 Pit Water Discharge: Beartooth Pit

Water that collects in Beartooth Pit can be expected to be similar to Panda Pit mine water, which contains elevated concentrations of suspended solids, sediment-associated parameters and nitrogen. In addition, runoff from the Panda/Beartooth waste rock pile will also contribute to Beartooth Pit water. Water from Beartooth Pit will be directed to the Long Lake Containment Facility.

As Beartooth Pit water will be pumped directly to the Process Plant and then to the Long Lake Containment Facility, there is no potential for mine water to affect natural waterbodies in the upper portion of the Koala Watershed. However, Beartooth Pit water will likely contribute to the nitrogen loading of the Long Lake Containment Facility, which discharges water into downstream waterbodies within the Koala Watershed. Effects on water quality caused by elevated concentrations of nitrogen would likely remain within the Koala Watershed and would therefore be local in geographic extent. The duration of the effect will be for as long as Beartooth Pit water is discharged (approximately three years). The frequency of the effect will be continuous during the open water season. Slightly elevated nitrogen concentrations are not expected to reduce the future capacity of renewable resources. It is unlikely that federal criteria for the protection of aquatic life will be exceeded. The overall significance of residual effects on water quality from the discharge of Beartooth Pit water downstream via the Long Lake Containment Facility is expected to be minor.

4.5.5.2.3 In-Stream/Lake Construction: Bearclaw Dam

The construction of a dam at the Bearclaw Lake Outlet will essentially eliminate any natural water flow from the lake. Water will be pumped from Bearclaw Lake into North Panda Lake. The water quality of Bearclaw Lake itself could be affected by the construction of the dam, possibly resulting in elevated concentrations of sediment-associated parameters and nitrogen from waste rock leaching. There is therefore the potential for Bearclaw Lake water to affect the water quality of downstream waterbodies such as North Panda Lake and the PDC.

Similar to the Two Rock Lake dam, construction will occur during the winter season, which will minimize the introduction of sediments and associated parameters to open water. Sediments/associated parameters and nitrogen could be introduced to Bearclaw Lake during the short period of freshet the following season. However, sediment-associated parameters would likely settle onto the lake bottom with time.

The possible residual effects on water quality (from dam construction) are expected to be very local in geographic extent (remain within Bearclaw Lake, possibly slightly elevated concentrations of nitrogen in North Panda Lake and downstream). As described previously, leaching of nitrogen from waste rock would likely cease within three years time, and probably sooner. The frequency of this effect would be continuous during the open water season, until leaching is no longer occurring. Once leaching stops, this effect will be reversed. Slightly elevated nitrogen concentrations will not reduce the future capacity of renewable resources to meet needs. Federal criteria for the protection of fresh water aquatic life would likely not be exceeded. It is expected that the residual effect on water quality as a result of dam construction will be negligible.

4.5.5.2.4 Waste Rock Storage/Drainage

Waste rock from the Beartooth Pit will be stored in the existing Panda waste rock storage area. Runoff from the existing Panda Waste Rock Storage Pile currently flows over the tundra in several directions, as well as flowing into Beartooth Lake. Once Beartooth Pit is present, very low volumes of surface water runoff will drain into Beartooth pit, and will subsequently be pumped to the Long Lake Containment Facility along with the pit water. Hence, runoff from Beartooth waste rock will likely contribute to increased concentrations of suspended solids (and associated metals) and nitrogen to Beartooth Pit water. Beartooth waste rock is not expected to be acid-generating.

Waste rock placement and associated mitigation measures have been designed to minimize the potential for runoff to enter Bearclaw Lake. Runoff that does exit the pile would percolate over the tundra prior to entering Beartooth Pit.

The potential effect on water quality would be contained within the Koala Watershed and therefore local in geographic extent. The potential effect would be continuous during the open water season for as long as Beartooth waste rock is being added to the waste rock storage pile and for up to three years afterwards (until all blasting residue has been washed off of the waste rock). The effect is not expected to reduce the capacity of resources to meet needs. The significance of Beartooth waste rock runoff on water quality is expected to be negligible.

4.5.5.2.5 Pit Reclamation: Beartooth Pit

Beartooth Pit will be filled with processed kimberlite over two summer seasons. When the pit is capped with water, the resulting lake depth will be approximately 20 m. There is the potential that water in the newly formed pit lake could be high in suspended solids and other parameters due to the slow settling rate of processed kimberlite and the possibility of sediment (processed kimberlite) suspension. Poor water quality could potentially be introduced to downstream waterbodies (*e.g.*, North Panda Lake).

Processed kimberlite/water will be allowed to settle within the pit for one winter season. The following spring, the water quality of the newly formed lake will be tested. If water is of poor quality, it will not be allowed to flow out of the pit lake but instead will be pumped into the Long Lake Containment Facility. Clean water from Bearclaw Lake will

then be pumped into Beartooth Pit Lake. Water will not be allowed to flow out of Beartooth Pit Lake into North Panda Lake until it meets BHP's Water Licence criteria.

The discharge of water from the reclaimed Beartooth Pit Lake has the potential to affect water quality in downstream waterbodies within the upper portion of the Koala Watershed. Water in the newly formed pit lake could have elevated concentrations of suspended solids and other parameters associated with processed kimberlite. However, the mitigation measures that will be employed will prevent any possible impacts on downstream water quality, as water will not be discharged from the lake to the downstream watershed unless Water Licence criteria are met. Based on the ability to retain the Beartooth Pit Lake water and control it if necessary, it is expected that the effects on downstream water quality will be negligible.

4.5.5.2.6 Blasting and Fugitive Dust from Pit Operations, Vehicular Traffic, and Waste Rock Dumping

Blasting could result in fugitive dust entering waterbodies within a one to three kilometre radius of dust-generating activities (*e.g.*, North Panda Lake, Bearclaw Lake, Polar Lake).

The mitigation measures and the assessment of residual effects for the Beartooth pipe area are the same as those presented previously for the Sable pipe area. The expected effect on water quality from blasting and dust generating activities is negligible.

4.5.5.3 Fish/Aquatic Habitat

4.5.5.3.1 Potential Effects and Mitigation for Beartooth Pipe Development

The following summarizes the waterbodies and fish habitats that will be affected by development of the Beartooth Pit:

- *Beartooth Lake*: to be dewatered;
- *Bearclaw Lake*: a small storage dam is to be constructed at the mouth of this lake;
- *Bearclaw-Beartooth Stream*: temporary elimination during mine operations due to diversion of flows to Beartooth-Panda Stream;
- *Beartooth-Panda Stream*: will receive water discharged via pipeline from Bearclaw Lake; and
- *North Panda Lake*: will receive water from Beartooth Lake during dewatering.

4.5.5.3.1.1 Beartooth Lake

Four species of fish were found in Beartooth Lake: Arctic grayling, lake trout, burbot and slimy sculpin. Population estimates for grayling and lake trout[5] ranged from 98-138

[5] Cacheable by 3.8 cm stretched mesh gillnets.

and 42-46, respectively. The other two fish species were found in only very small numbers. The fish in this lake will be fished-out prior to dewatering. However, fish production potential will be lost at least until the completion of mining, habitat replacement and pit flooding.

As discussed in Section 3.5.3, the migration of fish into or out of Beartooth Lake is unlikely due to the poor quality migration habitat available in Bearclaw-Beartooth Stream and Beartooth-Panda Stream. While fish movements in these streams may occasionally occur at times of freshet, such events would likely be rare. For this reason, the fish community in Beartooth Lake can be considered to be isolated and self-sustaining, as discussed in Section 4.5.1.

Beartooth Lake is to be dewatered within a two-month period in October and November. This timing will help minimize the effects of runoff back into Beartooth Lake and will reduce bank erosion through freezing.

The conceptual fish habitat reclamation plan for the Beartooth Pit includes the creation of suitable rearing and spawning areas as described in Section 4.5.1. Following habitat restoration, pit flooding will commence. As indicated in Section 4.5.1 it is proposed that processed kimberlite be backfilled into the Beartooth Pit, provided that testing shows that this material will not cause deterioration in water quality. This will effectively shorten the period required to fill the pit to two summer seasons. Once flooding is completed, it will be necessary to carry out a program to assess water quality and potential food availability for fish. It may take a period of a few years for the processed kimberlite to settle sufficiently to serve as a useful habitat for macroinvertebrates. Further, if most of the water in the new pit lake is derived from the discharge of an aqueous suspension of processed kimberlite, primary and secondary producers may be absent from the water column. This potential problem will be mitigated through the discharge of water from Bearclaw Lake over the summer period. This will serve to seed the new lake with phytoplankton, zooplankton and both larval and adult macroinvertebrates. It is anticipated that recolonization by macroinvertebrates will also occur in the form of aerial drift. Fish stocking will be feasible once it has been determined that Beartooth Pit Lake is capable of supporting self-sustaining populations of fish food organisms. Fish stocking programs will be planned in consultation with the DFO and will be carried out in accordance with agreements reached with regulatory agencies.

The filling of pit lakes with processed kimberlite is experimental. For this reason, the length of time that will be required to reach conditions suitable for fish cannot be predicted with certainty. However, this technique has the potential to reduce pit filling time in Beartooth Pit Lake to only about two years. It is therefore anticipated that fish stocking could commence 10 to 12 years following the initial dewatering of Beartooth Lake.

Fish and fish habitat reclamation in Beartooth Pit will precede that in any of the other pits in the BHP Diamonds claim block. As such, the results obtained from habitat restoration efforts at Beartooth Pit Lake will influence habitat restoration plans and methodologies used at other pits.

4.5.5.3.1.2 *Bearclaw Lake*

Although fish sampling studies have not been carried out on Bearclaw Lake, it is assumed from bathymetric, hydrologic, water chemistry and secondary production investigations (Bryant, 1996), that this lake likely supports a self-sustaining fish community. The dewatering of Beartooth Lake should not adversely affect the fish community upstream in Bearclaw Lake due to the lack of fish migration between these two lakes.

The construction of the small water control dam at the outlet of Bearclaw Lake will have no effect on fish migration patterns or spawning potential since the Bearclaw Lake outflow stream does not possess suitable migration, spawning or rearing habitat. While the dam will be sized and operated to minimize storage within Bearclaw Lake (BHP, 1999c), small increases in depth might actually provide additional spawning and rearing habitat for lake trout (assuming that this species exists in Bearclaw Lake). Optimal spawning habitat is often in short supply in small arctic lakes since much of the potential spawning habitat is located in shallow areas subject to freezing to the bottom. Increases in depth could therefore make more habitat available that does not freeze in winter. In this regard it will be important to ensure that water levels in the lake are not artificially elevated in the lake during lake trout spawning season, only to be allowed to fall during the winter. Such a scenario could result in spawning in areas that later freeze to the bottom, thereby resulting in egg mortality.

Appropriate fish screens will be installed on pump intakes to prevent entrainment of fish during pumping from Bearclaw Lake.

4.5.5.3.1.3 *Bearclaw-Beartooth Stream*

The Bearclaw-Beartooth Stream will lose all flow for the duration of the dewatering, mining and Beartooth Pit flooding stages, a period of about 10 years (assuming that Beartooth Pit is backfilled with processed kimberlite). However, because this stream does not possess fish habitat for any life stage of grayling or lake trout, dewatering will not result in a loss of productive capacity.

4.5.5.3.1.4 *Beartooth-Panda Stream*

Waterflow from Bearclaw Lake will be diverted via pipeline to the upper reach of Beartooth-Panda Stream. The discharge will be regulated to match, as closely as is practical, seasonal flows in this stream. This flow regime has been developed to avoid the loss of habitat that might be present in Beartooth-Panda Stream. As indicated above, habitat surveys of this stream have revealed very little, poor quality fish habitat. However, it is possible that some fish from North Panda Lake might occasionally inhabit certain portions of the channel.

Water pumped to Beartooth-Panda Stream will discharge into a stilling pool lined with natural boulders to preclude erosion of the stream bed and banks.

4.5.5.3.1.5 *North Panda Lake*

Water will be discharged into North Panda Lake during the two month period in which dewatering of Beartooth Lake is to occur. This discharge water will be sampled and tested in order to ensure compliance with the Water Licence criteria. If these criteria are not met, water will be diverted to the Long Lake Containment Facility via the Process Plant (BHP, 1999c).

Water will be discharged into North Panda Lake during Beartooth Lake dewatering through a floating pipe to minimize erosion. Flow rates into North Panda Lake will not exceed 0.5 m^3/s, a rate that should not adversely affect fish or fish habitat in North Panda Lake or in the Panda Diversion Channel. Since dewatering is to occur during freeze-up, it is possible that a portion of this water will be stored in North Panda Lake over winter as ice. This may result in somewhat higher than normal volumes of water being released to the Panda Diversion Channel and Kodiak Lake during freshet the following spring. These volumes will not be in excess of the diversion channel capacity nor are they likely to be sufficient to affect upstream grayling migration.

4.5.5.3.1.6 *Drainage from Waste Rock Piles*

Due to the nature of the host rock for the Beartooth Pipe, waste rock at this site is not anticipated to be acid producing (BHP, 1999c). Waste rock from the Beartooth Pipe will be stored in the Panda Waste Rock Storage Pile area. Run-off from this area leads primarily to the Long Lake Containment Facility. Similarly, all Beartooth Lake bottom sediments will be stored within the existing Panda Pit Lake Bottom Sediments Storage pile. Therefore, no adverse effects on fish or fish habitat are anticipated from Beartooth Pit waste rock drainage.

4.5.5.3.2 Assessment of Effects on Fish/Aquatic Habitat for Beartooth Pit

Residual effects of the Beartooth Pit development on fish and aquatic habitat are restricted to the fish community and habitat of Beartooth Lake, which will be lost due to dewatering. It is anticipated that this fish community will be restored upon completion of mining and subsequent pit flooding. Due to the isolation of fish populations in Beartooth Lake, there is little or no genetic exchange with fish populations elsewhere in the Lac de Gras Watershed.

The inflow and outflow streams from Beartooth Lake have minimal fish habitat and are poor migratory pathways for fish. While Bearclaw-Beartooth Stream will not carry water until after mining is completed, water will continue to flow in Beartooth-Panda Stream due to pumping from Bearclaw Lake to the upstream section of this channel. As such, it will be possible for fish from North Panda Lake to access this stream, although it is likely that this occurs only rarely at present.

No effects from waste rock storage are anticipated due to the nature of the host rock underlying Beartooth Lake and because waste rock is to be stored in existing waste rock piles which drain primarily to the Long Lake Containment Facility.

It is therefore anticipated that the effects on fish and aquatic habitat of the Beartooth Pit development will be negligible at the local (Koala Watershed) level. It is also expected that there will not be any cumulative effects on the fish and aquatic habitat of the Koala Watershed from the Beartooth and Pigeon mining activities. This is because the effects on aquatic life from these mining activities will be restricted to the immediate area of these developments. As indicated in the above water quality sections, Pigeon Pit water, water pumped from Pigeon Pond and any drainage from Pigeon waste rock will all be directed through the Long Lake Containment Facility, which has been designed to mitigate potential downstream effects on water quality and habitat from all of the pit developments within the Koala Watershed.

4.5.5.4 Water Summary for Beartooth Pipe

As the first of the pits in the BHP claim block to be restored to lake status, the Beartooth Pit will be used to evaluate the feasibility/success of backfilling with processed kimberlite, habitat restoration techniques, and the biological response to mining activities and restoration efforts. Activities at other pits will therefore be modified as necessary based on the lessons learned at Beartooth.

Aside from the direct loss of the fish population of Beartooth Lake due to dewatering, all other activities related to the Beartooth Pipe development can be mitigated to prevent the potential for adverse environmental effects. The possible exception to this forecast is that elevated levels of nitrogen from pit water storage and waste rock drainage will add to the nitrogen loading of the Long Lake Containment Facility. Phosphorus rather than nitrogen likely limits primary producers in these waters. Monitoring at the outlet of the Long Lake Containment Facility has revealed background concentrations of phosphorus, indicating that mitigation measures employed by BHP are effective in maintaining low water concentrations of phosphorus in Cell E of the Long Lake Containment Facility. Hence, it is expected that elevated concentrations of nitrogen will continue to exit the Long Lake Containment Facility, but phosphorus concentrations are expected to remain low and therefore Long Lake water is not expected to affect aquatic life from a nutrient standpoint.

Although the Bearclaw outflow stream will be cut off until water levels in Beartooth Pit Lake are restored, this stream does not support fish populations due to poor quality habitat conditions. As such, the diversion of flow from Bearclaw Lake to the upstream end of the Beartooth-Panda Stream will not result in any loss of habitat or fish production. This redirection of flow will preserve the limited fish habitat in the Beartooth-Panda Stream.

Changes in flow patterns and water quality will be reversed within about 6-8 years following initial development of the Beartooth Pit due to the anticipated rapid reclamation of the Beartooth Pit to lake status. Backfilling with processed kimberlite will greatly reduce pit flooding duration. However, it is uncertain how long it will take following pit flooding for water quality conditions to become suitable for fish and other aquatic life. BHP will take the opportunity at Beartooth to monitor water quality issues, and use these actual results to improve upon future plans for other pit reclamation activities.

With the exception of a contribution to elevated levels of nitrogenous compounds in and downstream of the Long Lake Containment Facility, the effects on the aquatic environment of the Beartooth Pipe development are likely to be confined to the area of Bearclaw, Beartooth and North Panda lakes, a small portion of the Koala Watershed. These effects will be reversible once mining is completed and the pit has been re-filled. As a result, there should be no reduction in the future capacity of renewable resources within the Beartooth Lake system.

It is therefore predicted that the residual effects of Beartooth development on water-related VECs will be negligible to minor. Table 4.5-4 summarizes the activities, potential impacts, mitigation measures and the significance of residual effects of Beartooth development.

Table 4.5-4
Summary of Predicted Effects on Water-Related VECs due to Beartooth Pipe Development

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Water Quantity	Lake Dewatering: Beartooth Lake	Elevated flows and altered flow attenuating capacity	Dewater at low rate and at least sensitive time of year	Negligible
	Flow Diversion: Bearclaw Dam & Water Pumping	Altered discharge to receiving waters	Discharge from Bearclaw Lake as natural accumulation forms and as required to maintain aquatic habitat	Negligible
	Waste Rock Storage/Drainage	Runoff routing	None required	Negligible
	Pit Reclamation: Beartooth Pit	Heightened ability to attenuate flows	Fill pit with processed kimberlite; reconnection of drainage area; no donor lake	Negligible
Water Quality	Lake Dewatering: Beartooth Lake	Introduction of high turbidity water and associated parameters into North Panda Lake	Gradual dewatering; dewatering during optimum season; monitoring; discharge into Long Lake if poor water quality	Negligible
	Pit Water Discharge: Beartooth Pit	Introduction of nitrogenous compounds downstream of Long Lake	Pump discharge water to Long Lake; minimize affecting new waterbodies	Minor
	In Stream/Lake Construction: Dam construction at Bearclaw Lake outlet	Introduction of sediment and associated parameters to Bearclaw Lake; introduction of nitrogenous compounds due to use of waste rock	Winter construction	Negligible
	Waste Rock Storage/Drainage	Introduction of leachate to Long Lake	Engineer waste rock pile to minimize runoff; pump runoff to Long Lake	Negligible
	Pit Reclamation: Beartooth Pit	Introduction of TSS to North Panda Lake	No discharge will be allowed unless water is of acceptable quality; poor quality water will be pumped to Long Lake and replaced with clean water	Negligible
	Blasting/Fugitive Dust	Introduction of TSS, nitrogenous compounds to North Panda Lake, Bearclaw Lake, Polar Lake	Road surfaces sprayed with water during open water season	Negligible

(continued)

Table 4.5-4
Summary of Predicted Effects on Water-Related VECs due to Beartooth Pipe Development

VEC	Activity	Potential Effects in the Absence of Mitigation	Mitigation Measures	Significance of Residual Effects
Fish/Aquatic Habitat	Lake Dewatering: Dewatering of Beartooth Lake	Loss of fish, fish production and fish habitat	Fish to be fished-out; habitat to be restored and fish to be stocked as part of pit lake reclamation	Negligible
	Flow Diversion: Diversion of flows from Bearclaw Lake	Loss of habitat in Bearclaw-Beartooth Stream; entrainment of fish in water pipeline	Bearclaw-Beartooth Lake does not possess fish habitat; pipeline entrance to be screened	Negligible
	Flow Diversion: Flow changes in Beartooth-Panda Stream	Loss of flow due to dewatering of Beartooth Lake; streambank and bed erosion at pipeline discharge point	Flow to be restored by pumping water from Bearclaw Lake to the upper reaches of the Beartooth-Panda Stream; erosion to be prevented by discharging into concrete baffle boxes or rock structures	Negligible
	Flow Diversion & In-Stream/Lake Construction: Dam Construction in Bearclaw Lake	Excessive water fluctuations in North Panda Lake; inducement of spawning in habitats that would later freeze; disturbance of bottom sediments	Water levels behind the dam will be managed to simulate natural water elevation patterns; water levels will not be held artificially high during spawning season; appropriate construction techniques will be used to minimize sediment disturbance	Negligible
	Flow Diversion: Discharge of water to North Panda Lake	Water elevation changes; shoreline erosion; water quality deterioration	Beartooth Lake will be dewatered slowly; water will be discharged from an offshore floating pipeline; water will be discharged to North Panda Lake only if it meets regulatory standards	Negligible
	Waste Rock Storage/Drainage	Poor quality runoff to adjacent lakes and streams	All waste rock is to be stored in the existing, approved Panda waste rock storage area which drains to the Long Lake Containment Facility	Negligible

4.5.6 Summary of Sable, Pigeon and Beartooth Pipe Development on Water VECs

Table 4.5-5 summarizes the overall residual effects on aquatic VECs of the major activities associated with development of the Sable, Pigeon and Beartooth pipes. Only mine water discharge from the three pits and the construction and operation of the Pigeon diversion channel may result in residual effects on water quality that can be of minor significance; the significance of residual effects associated with all other activities is anticipated to be negligible.

Potential minor residual effects due to mine water discharge and the Pigeon diversion channel may occur due to the potential release of nitrogen. Nitrogen could be introduced into surface waters as a result of the use of ANFO in blasting operations. Waste rock and mine water may therefore contain variable amounts of nitrogen which could be flushed or discharged into receiving waters.

Table 4.5-5
Overall Residual Effects of the Sable, Pigeon and Beartooth Pit Developments on Aquatic VECs

Mine-Related Activities	Water VECs	Significance of Residual Effects[1]
1. Lake Dewatering	Water Quality & Quantity:	Negligible
	Fish/Aquatic Habitat:	Negligible
2. Pit Water Discharge	Water Quality & Quantity:	Minor
	Fish/Aquatic Habitat:	Negligible
3. Flow Diversion (Pigeon Stream Diversion)	Water Quality & Quantity:	Minor
	Fish/Aquatic Habitat:	Negligible
4. In-Stream/Lake Construction	Water Quality & Quantity:	Negligible
	Fish/Aquatic Habitat:	Negligible
5. Waste Rock Storage/Drainage	Water Quality & Quantity:	Negligible
	Fish/Aquatic Habitat:	Negligible
6. Pit Restoration	Water Quality & Quantity:	Negligible
	Fish/Aquatic Habitat:	Negligible
7. Blasting/Fugitive Dust	Water Quality & Quantity:	Negligible
	Fish/Aquatic Habitat:	Negligible
8. All Weather Roads	Water Quality & Quantity:	Negligible
	Fish/Aquatic Habitat:	Negligible

1: Significance of residual effects, after the application of mitigation measures.

While every attempt will be made to limit the release of nitrogen to pit water and to use uncontaminated waste rock in the construction of the Pigeon Stream Diversion, experience at the Long Lake Containment Facility has shown that it will be a challenge to prevent an increase in the concentrations of nitrogen above background levels in the downstream receiving environment.

Nitrogen can be associated with rapid increases in primary producer biomass, in extreme cases leading to increased turbidity and oxygen depletion. However, within the Lac de Gras and Yamba/Exeter watersheds, as in most fresh water systems, it is phosphorus that limits the biomass of primary producers, not nitrogen. Since it is unlikely that the Sable, Pigeon and Beartooth developments will lead to significantly increased levels of phosphorus in receiving waters, phytoplankton blooms in Horseshoe Lake or Fay Lake are not expected to occur. The exception is potential phosphorus loading from the Pigeon Stream Diversion into Fay Lake, where slightly elevated concentrations of phytoplankton biomass are possible but not likely.

Proposed habitat restoration and fish stocking at Pigeon Pit will take place upon completion of mining activities and pit flooding. It is anticipated that this will result in a new productive lake where none exists presently. Assuming that the outlet channel from Pigeon Pit Lake will be accessible to migrating fish, this lake should provide suitable spawning and rearing habitat for Arctic grayling and possibly lake trout from Fay Lake, Upper Exeter Lake and Exeter Lake. While the steady-state size of the fish population in the new pit lake cannot be accurately predicted, a self-sustaining fish community in this new waterbody would represent a net gain of productive capacity of habitat, as promoted by the DFO Policy for the Management of Fish Habitat.

4.6 Wildlife and Habitat

4.6.1 General

Effects on wildlife and wildlife habitat associated with development activities may take place throughout all phases, from development through post-decommissioning:

- Wildlife effects - physical and behavioural disturbance, including displacement and habituation.
- Habitat effects - loss and degradation of habitat, including losses due to roads and construction.

Habitat loss results primarily during the development phase. Degradation of habitat is a secondary effect of habitat loss during develop and operation and results in reduced habitat effectiveness.

Potential effects of the proposed development of the Sable, Pigeon and Beartooth kimberlite pipes (the pipes) on wildlife and wildlife habitat can be predicted and evaluated based on experience and empirical knowledge gained through previous and current operations at EKATI™, as well as inferences drawn from published literature.

The proposed development was evaluated by development type (pits *vs.* roads), and by effect type (physical effects on habitat resulting from construction *vs.* disturbance and other effects as a consequence of operational activities). Potential effects were assessed for the following VECs:

- caribou,
- carnivores (especially grizzly bears), and
- breeding birds,

as well as their habitats. The carnivore VEC was further divided into grizzly bears and furbearers (Arctic and red foxes, wolves, and wolverines), to reflect:

- the relative abundance of ecological data on grizzly bears in the study area, especially for habitat use,
- the relatively high global conservation concern for grizzly bears,
- the grizzly bear's relatively low ecological resilience (Weaver *et al.*, 1996), and
- the concept that an assessment of potential effects, including cumulative effects, on grizzly bears would serve as a broad umbrella for assessment of effects on other carnivore species.

4.6.1.1 Pits

4.6.1.1.1 Potential Effects

The direct effects of the development of pipes include the loss of existing habitat that accompanies the excavation of the pits, accumulation of waste rock piles and the development of affiliated infrastructure. Indirect effects may be associated with disturbance resulting from blasting, power plant noise, human presence and the operation of heavy equipment.

4.6.1.1.1.1 Physical

The establishment of waste rock storage piles and facility pads will bury vegetation, thus eliminating existing wildlife habitat within the development footprint. If gravel is required for surfacing, the source will be the Ursula Esker. Eskers are important to wildlife, and their use as quarries can result in the loss of habitat for wildlife.

Elevated structures including truck shops, office facilities, explosives magazines and fuel storage tanks can have both negative and positive effects on wildlife because few of these features occur naturally in the tundra landscape. These structures can act as barriers to movement or as sanctuaries from predators, pests or weather. Elevated structures can be used by birds as platforms for feeding, hunting, or nesting.

4.6.1.1.1.2 Operational Activities

A small risk to wildlife exists for injury or mortality due to development and operations activities, such as blasting and fly rock, and unpredictable incidents involving wildlife encounters in the active areas. Habituation of wildlife is a potential consequence of human activity at the proposed development sites. Habituation to non-natural foods constitutes a serious impact to wildlife, typically leading to conflict and the removal of the habituated individuals.

Disturbance related to industrial activity may affect wildlife beyond the immediate footprint as noise and other stimuli can degrade habitat effectiveness within a zone of influence surrounding the source. As point sources of disturbance, pit developments alone are unlikely to substantially interrupt movement corridors for wildlife—animals can simply divert around them.

Blasting, stripping, and all aspects of mining are potential sources of fugitive dust. Dust deposition on vegetation can influence plant phenology, productivity, abundance, and community composition (Section 4.6.1.2), with potential consequences for wildlife.

Caribou

Potential effects on caribou include:

- direct loss of habitat,
- displacement from preferred habitat,
- disruption from normal activities with energetic consequences,
- deflection of intended travel routes, and
- direct injury as a result of accidental contact between caribou and pit operations.

In addition, caribou may be attracted to development sites as refuge from predators and insects (Noel *et al.*, 1998) as was found with some of the disturbed sites at the EKATI™ mine site.

Dust deposition on vegetation near operations can affect availability and use of caribou forage. Changes in plant species composition may favour caribou, as grasses and sedges may respond positively to light dust loads. Caribou may be attracted to affected areas, especially in spring in response to accelerated snowmelt and subsequently advanced phenology.

Grizzly Bear

Grizzly bears are sensitive to human activity and are frequently displaced by industrial developments (McLellan, 1990). Research from other environments has enabled modelling of changes in grizzly bear habitat effectiveness as a result of disturbance. Such a model was developed for the proposed development (Section 4.6.1.2.3.3).

Fugitive dust from mining activities can alter vegetation communities. In areas of light-moderate dust deposition, some spring bear forage species such as grasses and sedges may be enhanced. Conversely, berry-producing species including lingonberry and blueberry may be adversely affected (Table 4.6-1), reducing bear foods that are important during late summer and fall.

Table 4.6-1
Plants of the Lac de Gras Area Reported to be Affected by Dust Deposition[1]

Species Reported to be Adversely Affected by Dust Deposition		Species Reported to be Positively Affected by Dust Deposition	
Latin Name	**Common Name**	**Latin Name**	**Common Name**
Ledum decumbens	Labrador tea	*Calamagrostis* spp.	Reed bent grass
Lycopodium annotinum	Stiff club moss	*Eriophorum angustifolium*	Cottongrass
Pedicularis lapponica	Lapland lousewort	*Eriophorum vaginatum*	Cottongrass
Rubus chamaemorus	Cloudberry	*Rubus chamaemorus*	Cloudberry
Vaccinium uliginosum	Arctic blueberry	*Salix* spp.	Willow
Vaccinium vitis-idaea	Lingonberry		

[1] **Source: Golder,1998.**

Birds

The development of the pipes may affect birds through habitat loss and displacement, and changes in behavioural patterns as a result of disturbance from blasting and heavy equipment operation. Critical disturbance periods for birds include migration, nesting and moulting. Disturbance can have negative consequences for birds through increased energy requirements by their exclusion from feeding habitats and the expenditure of energy to avoid noise.

Changes to vegetation resulting from dust deposition may affect birds by altering availability of nest sites or food. Of greater consequence, however, is the predicted pattern of snowmelt in the dustfall zone, which is expected to accelerate green-up by 10-14 days in affected areas. This could provide spring foraging opportunities for passerines, waterfowl, and raptors, and advanced nesting for passerines.

4.6.1.1.2 Mitigation Measures

4.6.1.1.2.1 Physical

The key to mitigating potential negative effects on wildlife is to identify potentially important habitats and to limit disturbance in those habitats. Avoidance, where possible, is the primary measure to protect important habitats. However, this is not possible with the pit locations.

Reclamation in conjunction with natural revegetation, will return altered habitats to a usable state for wildlife, although recolonization by productive vegetation will be slow. Research has shown that wildlife can respond quickly to attempts to rehabilitate habitats. For example, caribou in arctic Alaska fed preferentially on vegetation growing in some disturbed areas that were associated with oil development (Klein, 1980; Hanson, 1981).

All of the eskers within the proposed development area have been surveyed and existing bear and wolf dens identified (Section 3.7). Where possible, these den sites and potential denning areas will be protected.

4.6.1.1.2.2 Operational Activities

Caribou and other wildlife will be deterred from entering the pits by the construction of waste rock berms around the perimeters. A berm constructed around the existing Panda pit has been effective in deflecting caribou. All operators on site will continue to remain vigilant to nearby wildlife before conducting activities that could cause injuries. The generation of dust will be minimized by application of water or other dust suppressors to roadways within and adjacent to the pit developments.

Wildlife habituation to human foods near Sable, Pigeon and Beartooth infrastructure will be prevented:

- Food waste will be backhauled to EKATI™ and incinerated, and
- BHP policy prohibits feeding of wildlife.

Bear safety training programs for all staff and contractors will be continued.

4.6.1.1.3 Assessment of Effects and Residual Effects

4.6.1.1.3.1 General

Overall effects on wildlife and habitat of the proposed development of the Sable, Pigeon, and Beartooth kimberlite pipes will be small. A total of 397.1 ha of wildlife habitat will be eliminated as a result of development of pits, waste rock piles, and associated infrastructure (Table 4.6-2). Disturbance resulting from pit operations will cause wildlife displacement for some species. Some wildlife may be attracted to the activity and infrastructure, but conflicts have been and shall continue to be avoidable.

4.6.1.1.3.2 Caribou

Caribou will lose 397.0 ha of potential habitat as a direct result of development of the proposed pits, waste rock piles, and associated infrastructure (Table 4.6-2). In addition, there will be a reduction in habitat effectiveness as they avoid the disturbances associated with blasting and heavy equipment. The relative importance of different ecosystem types to migrating caribou is unknown, so it is not possible to assess the value of the lost habitat. However, 88 % of disturbed habitat is of the heath tundra (BL) ecosystem type, the most abundant habitat type in the local study area.

Based on observations from the Wildlife Effects Monitoring Program (WEMP), most displacement effects related to EKATI™ appear to operate at only a very localized scale. Analysis of caribou distribution throughout the local study area indicates that there was no significant relationship between caribou location or relative abundance and distance from the mine in 1997, 1998, or 1999 (Golder, 1998; 1999; Rescan, 1999c). The mine does not appear to influence overall caribou distribution within the local study area. However, nursery groups may be more sensitive to disturbance (see below).

Caribou behaviour, categorized as comfort (bedding, feeding, or standing) or movement (walking, trotting, or running) activity, was statistically unrelated to distance from the existing EKATI™ development in 1998 and 1999 (Golder, 1999; Rescan, 1999c). In 1997, however, caribou did increase movement behaviours as they approached the mine (Golder, 1998).

Table 4.6-2
Habitat Lost to Point Features and Linear Features

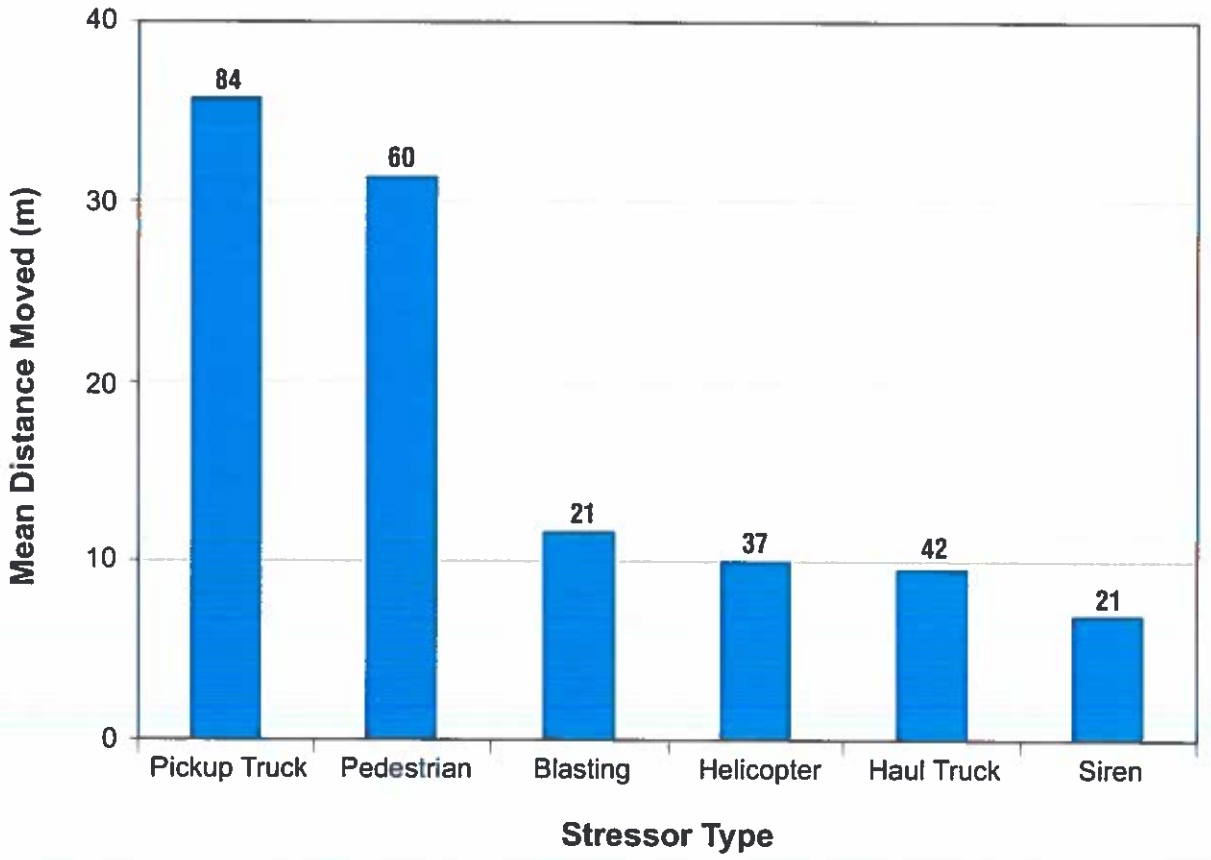
	All Units are in Hectares										
	BF, RB: Bedrock and Boulder Fields	BLb, BLr, BLe: Open Mat Tundra	SSe, BEe, BLe: Esker Complex	BL: Closed Mat Tundra	BL + BR, EA: Tundra/Wetland Complex	BR: Birch Hummock	EA: Cotton Grass Tussock	BR, EA, CE, CA: Wetland Complex	BC: Birch Seep	SR: Willow Riparian	Total
Point Features											
Sable Pit	0.7	0.7	0.0	253.9	0.0	0.7	0.0	0.0	0.0	0.0	256.0
Pigeon Pit	5.5	15.5	0.0	90.0	0.0	2.1	0.0	16.9	0.0	0.0	130.0
Beartooth Pit	0.0	0.5	0.0	7.6	2.2	0.0	0.0	0.1	0.6	0.0	11.0
Total Losses Due to Point Features	6.2	16.7	0.0	351.5	2.2	2.8	0.0	17.0	0.6	0.0	397.0
Linear Features											
Sable Road	0.0	8.3	0.2	25.1	0.0	0.7	0.2	0.3	0.0	0.0	34.8
Pigeon Road	0.0	4.5	4.9	38.2	8.1	1.4	0.0	0.0	0.2	0.0	57.3
Beartooth Road	0.0	0.0	0.4	3.7	0.5	0.3	0.0	0.0	0.0	0.0	4.9
Total Losses Due to Linear Features	0.0	12.8	5.5	67.0	8.6	2.4	0.2	0.3	0.2	0.0	97.0
Total Direct Habitat Loss Due to All Proposed Development	6.2	29.5	5.5	418.5	10.8	5.2	0.2	17.3	0.8	0.0	494.0
Percent	1.3	6.0	1.1	84.7	2.2	1.1	0.0	3.5	0.2	0.0	100.0

Behavioural responses of caribou to particular stressors were categorized from zero (no visible reaction) to three (intense reaction – animal trots or runs). Stressors that elicited the most vigorous reactions from caribou included:

- humans on foot,
- low-flying aircraft, and
- slow-moving trucks (Golder, 1998, 1999; Rescan, 1999c).

Displacement distances were greatest in response to pickup trucks and people on foot (Figure 4.6-1).

The pit-related stressors with the greatest potential for impacts on caribou are blasting, moving haul trucks, and heavy equipment. During 1997 through 1999, caribou responses to a total of 26 blasts and 64 haul trucks were observed (Table 4.6-3). The intensity of responses to these stressors varied but was generally low. Movement was elicited in only 34.6% of blast observations and 10.9% of haul truck observations. Intensity of response was probably related to distance to the stressor. In 1999, the mean distance from caribou to all blasts was 854.1 (± 203.4 [S.E.]) m, but the mean distance to blasts that elicited level 3 responses was only 255.0 (± 222.7) m (Rescan, unpublished data).



Note: Numbers above columns are sample sizes

Average Distance Moved by Caribou as a Result of Different Stressors at EKATI™, 1998 and 1999

FIGURE 4.6-1

BHP

Ekati diamond mine

Table 4.6-3
Behavioural Responses of Caribou at EKATI™

Year	Blasts					Haul Trucks				
	Intensity of Response[1]					Intensity of Response[1]				
	N	0	1	2	3	*n*	0	1	2	3
1997	5	3	1	1	0	21	18	1	2	0
1998	5	1	3	0	1	15	6	5	3	1
1999	16	3	6	4	3	28	18	9	0	1
Total	26	7	10	5	4	64	42	15	5	2
Percent	100	26.9	38.5	19.2	15.4	100	65.6	23.4	7.8	3.1

1: Behavioural responses of caribou to stressors were categorized from 0 (no visible reaction) to 3 (intense reaction – animal trots or runs). Level 0 and 1 responses are considered comfort; level 2 and 3 responses are considered movement.

Caribou that did react by moving typically did not go far. The average distance moved in response to blasts was 6 m in 1998, and 13 m in 1999 (Rescan, 1999c). The average distance moved by caribou in response to haul truck disturbance was 21 m in 1998 and 3 m in 1999 (Rescan, 1999c).

Caribou comfort activities were frequently observed near the mine in 1997, 1998, and 1999 (Plate 4.6-1). In addition, a high proportion of comfort-related activities was observed on disturbed habitat sites (Rescan, 1999c). During summer, these observations may have been related to relief from insect harassment (Plate 4.6-2).

Plate 4.6-1 Caribou in the vicinity of the emulsion plant.

Plate 4.6-2 Caribou seeking relief from insects on drill pad at Pigeon Drill Pad Site.

Potential influences of the mine on caribou group composition during southern migration are unclear. During 1999, more non-nursery groups than nursery groups were observed

Conversely, more nursery groups than non-nursery groups were observed further than 14 km from the mine. In 1998, there was no significant relationship between group composition and distance from the mine (Golder, 1999).

Most research on caribou response to industrial activity has been focused on calving grounds, especially in the vicinity of the Prudhoe Bay oilfields. Compared with other classes of caribou, cows with calves are reported to react relatively strongly to disturbance and to avoid roads for up to two to three weeks after birth (Dau and Cameron, 1986; Cameron *et al.*, 1992; review in Murphy and Lawhead, 2000). Some authors dispute the magnitude and significance of those responses (*e.g.*, Cronin *et al.*, 1998). By the peak of southern migration past EKATI™, calves are only three to five weeks old and cows may still be relatively sensitive.

Although caribou are clearly able to use the EKATI™ area, the *frequency* of comfort behaviours was lower on the mine site than on control sites in 1997 and 1998 (Golder, 1998, 1999). Both nursery and non-nursery groups spent 15% less time feeding at the mine site than on control sites (Golder, 1999). Observations in 1997 and 1998 indicated that the cumulative influence of all mine-related disturbances altered caribou behaviour and activity budgets; this relationship was statistically significant only in 1998 (Golder, 1999). The conclusion was that caribou responded negatively to mine disturbance in 1997 and 1998. This relationship was not demonstrated in 1999 (Rescan, 1999c).

The Bathurst caribou herd was estimated at 349,000 animals in 1996 (Gunn *et al.*, 1997). Although the EKATI™ site lies within the general migration route of this herd between their winter and calving ranges, relatively few caribou were exposed to the mine during 1997, 1998, or 1999 (Table 4.6-4). The maximum percentage of the herd that came within 14 km of the mine during 1997, 1998, and 1999 was 9.5%, 0.2%, and 1.9%, respectively (Rescan, 1999c). The estimated total number of caribou counted during all surveys in 1999 throughout the local study area was 53,000 (Rescan, 1999c).

Table 4.6-4
Mean Number of Caribou and Mean Percentage of the Bathurst Herd Potentially Exposed to Mining Activities at EKATI™

Year	Northern Migration[1]		Southern Migration[2]	
	Mean Number per Day	Mean Percentage of Herd per Day	Mean Number per Day	Mean Percentage of Herd per Day
1997	18	0.005	11,989	3.435
1998	88	0.025	77	0.022
1999	382	0.109	739	0.212

1: 1997: April 30 – June 1; 1998: April 16 – June 2; 1999: April 15 – June 1.
2: 1997: June 14 – July 31; 1998: June 16 – July 31; 1999: July 5 – August 6.
Note: Percentages based on 1996 estimate of Bathurst herd (349,000 animals; Gunn *et al.*, 1997).

Disruption to caribou behaviour and activity budgets can impose energetic costs. Diavik (1998b) modelled effects of their proposed development on caribou energetics. They predicted that during annual migration, energy expended by caribou would increase by 0.2 to 2.0 % as a result of cumulative land use activities in their Regional Study Area. Potential increases in energetic costs attributable to development in the regional study area during northern migration, when cows are pregnant, were estimated at less than 1%.

In summary, Diavik (1998b) predicted that energetic costs resulting from cumulative developments within their Regional Study Area would not measurably affect the:

- fitness,
- reproductive performance, or
- abundance of the Bathurst herd.

The proposed development of the Sable pipe extends marginally beyond Diavik's Regional Study Area and was not included in their cumulative effects assessment.

Few accidents involving caribou and pit activities are anticipated. No mining-related caribou injuries have occurred at EKATI™ since exploration and operations began.

Dust from mining activities will affect caribou forage availability in a small area within 100 m of sources. Predicted effects on vegetation community structure will be neutral or may favour caribou, as seasonally important species may be enhanced by light to moderate dust loads. Accelerated snowmelt in areas of dustfall will advance phenology

and render plants available to caribou during northern migration. It is difficult to predict the response of caribou to these changes. Caribou may be unable to exploit these foraging opportunities because the sites are close to the mine. Conversely they may be attracted to these sites and gain nutritional benefits but with an increased risk of accidental injury from mining operations. Additionally, there is a small risk that predators may be attracted to concentrations of caribou.

4.6.1.1.3.3 *Grizzly Bear*

The direct effects of development of the proposed pits on grizzly bears will be limited to a small area (397.1 ha) of physical habitat alteration. A larger area of potential grizzly bear habitat will be affected by disturbance associated with mining operations. The implications of this loss of habitat are discussed along with road-related habitat losses in Section 4.6.1.2. Conflicts between bears and humans will be prevented by:

- meticulous and thorough management of garbage and other potential attractants; and
- bear awareness training.

Fugitive dust from mining activities will likely alter the abundance and distribution of some bear foods. Spring forage may be enhanced if grasses and sedges respond positively to dust deposition, and early snowmelt makes vegetation available. Late summer-fall foods, especially berries, may be reduced in the narrow zone influenced by dust. Caribou and small mammals may be attracted to these zones, providing potential prey. However, it is doubtful that grizzly bears will be able to exploit these opportunities or will be otherwise substantially affected by dust, as their avoidance of disturbance will largely exclude them from these areas during periods of operations. Most vegetation effects occur within 100 m of dust sources, well within the zone of influence of disturbance associated with mining (Section 4.4.1). It is therefore likely that grizzly bears will be largely excluded from these areas during periods of operations and will not be directly affected by changes to vegetation.

4.6.1.1.3.4 *Furbearers*

The direct effects of development of the proposed pits on furbearers will include a small loss of habitat. Wildlife displacement as a result of disturbance, will apply particularly to wolves and wolverines. There will be some potential for the attraction of foxes and wolverines out of curiosity and to exploit prey which may colonize the mine site. Conflicts will be avoided by ensuring the application of BHP's policy of not feeding wildlife and the consistent application of BHP's waste management plan.

Dustfall may affect furbearers indirectly by changing habitat conditions within 100 m of active mine sites. Changes in vegetation communities may influence prey availability. Early snowmelt will create hunting opportunities for small mammals, birds, or caribou that may be attracted to these sites. Wolves and wolverines may avoid areas in such proximity to disturbance, but Arctic and red foxes may benefit.

4.6.1.1.3.5 Birds

In general, habitats lost due to the proposed development consist mostly of heath tundra habitat units, which are poor in quality and low in value for birds. Although individuals with territories adjacent to the pits will be displaced, birds are adaptable. Structures such as buildings and communication and weather towers can provide nesting opportunities for birds (Ritchie, 1991). Their use as nesting sites has been documented for ravens (Koala camp fuel tank for three years; Paul Lake bridge for two years; and a maintenance shed at the EKATI™ Mine).

In the short term, development of the three pits will eliminate nesting and feeding habitat for some birds such as Lapland longspurs, sparrows, horned larks and rock ptarmigan. However, based on recent breeding bird surveys, upland bird diversity around Pigeon Pond and Sable Lake is low compared to other breeding bird plots due to the prevalence of poor quality habitat. Loon territories have not been documented on Sable Lake from 1995 to 1999. Raptors are not known to nest near these proposed pits. Thus, bird habitat loss in association with the pits is negligible with respect to the surrounding habitat within the wildlife study area.

Birds will encounter noise within the development area during migration or during nesting. Based on bird surveys and other general observations collected on site between 1994 to 1999, data suggest that birds typically show no detectable responses to stressors and that effects from mining and associated activities are negligible (Rescan, 1999c).

Despite human disturbance associated with mining, waterfowl and shorebirds continue to utilize lakes adjacent to the Panda Pit, mine infrastructure and roads. One pond, only 225 m from Panda Pit and adjacent to an active road, is commonly used by greater scaup, old squaw and northern pintails for feeding and staging. Data from BHP's 1999 WEMP suggest that the distribution and number of loon territories adjacent to the mine site are remaining stable. Loons are regularly seen within the mine site area and continue to maintain territories on a number of lakes close to the mine including:

- Kodiak Lake, located adjacent to the airstrip and the main camp, and
- Long Lake, which has been altered through the development of intermediate dykes and the addition of processed kimberlite material in the upper cells.

Shorebirds such as red-necked phalaropes and least sandpipers also use ponds within the existing footprint. Several pairs of semi-palmated sandpipers have nested adjacent to developed areas over the last two years (S. Moore, Rescan Environmental Services, pers. comm).

Raptors, including peregrines, gyrfalcons and rough-legged hawks, are commonly recorded hunting along the eskers and ridges that traverse the mine area. Bald and golden eagles have been observed in the vicinity of EKATI™ and rough-legged hawks and short-eared owls have been documented hunting within the road system (Rescan, 1999c). Nesting habitat for birds of prey, primarily cliffs, does not exist within areas proposed for development. The nearest raptor territory is approximately 7 km to the southeast.

The density of breeding bird territories, species diversity, and species richness were monitored on permanent survey plots from 1995 to 1999 (see Figure 3.7-9). None of those parameters changed significantly over time or relative to distance from the mine (Rescan, 1999c).

The changes in vegetation associated with dustfall may improve small mammal habitat and increase the numbers that will be available as prey for the raptors. Additionally, the earlier green-up will make affected areas available for foraging and nesting by birds. However, alterations to plant communities resulting from dust deposition on vegetation may be negative to birds, in that berry-producing species may be reduced.

4.6.1.1.4 Summary of Predicted Effects Related to Pits Development

The development of the proposed pits will eliminate 397.1 ha of potential wildlife habitat. Aside from a few species that may forage within or colonize the footprint areas, this habitat loss will persist until the completion of site rehabilitation, which will be slow.

Fugitive dust resulting from mining operations will affect vegetation within about 100 m of mine sites thus modifying the plant communities, an effect that is expected to persist beyond closure. Dustfall on snow will accelerate melt and expose vegetation earlier in the spring. This may provide enhanced feeding opportunities for some species which are tolerant of disturbance, but may also introduce risk of accidental injury or predation. Mine-induced changes in snowmelt patterns will stop at closure.

Disturbance associated with blasting and heavy equipment operation will affect wildlife use of habitat outside of the direct development footprints. This displacement will reduce habitat effectiveness for all species, but the zone of influence will depend on the specific level of sensitivity of individuals and species. For small mammals and most passerine birds, loss of effective habitat will be minimal. For more sensitive species such as carnivores, a larger area will be affected. Reductions in habitat effectiveness resulting from disturbance are mitigated completely and immediately upon cessation of the disturbance.

4.6.1.2 Roads

4.6.1.2.1 Potential Effects

Roads can affect wildlife in several distinct ways (Jalkotzy *et al.*, 1997). Roads can be considered *habitat* when they provide wildlife with some requisites for survival such as food or shelter (*e.g.*, insect relief for caribou). A road is a *conduit* when wildlife moves along it (*e.g.*, a wolf traveling on a wind-swept road during winter). Roads may be *barriers* or *filters* if wildlife movements across them are blocked completely or selectively, respectively. Roads may act as *sources* if wildlife living in the corridor disperses into surrounding habitat (*e.g.*, small mammals), or they may act as *sinks* if wildlife is attracted and dies as a result (*e.g.*, collisions). Road structure, patterns and

intensity of use play a major role in determining the extent to which a road fulfills each of these functions.

4.6.1.2.1.1 *Physical*

Roads eliminate the habitat upon which they are constructed. Unless rock or gravel road fill is substantially altered, early succession plants recolonize the gravel's surface slowly (Cargill and Chapin, 1987). A second potential impact arises from the source of gravel fill. Although most of the material required for road construction will be waste rock generated by the mining operations, select aggregates (gravel) will be required for surfacing of the roads. This material will be sourced from a designated portion of the Ursula Esker. This will result in the loss of some habitat for wildlife.

The physical presence of roads does not generally appear to be a deterrent to caribou (*e.g.*, Dempster Highway; Miller, 1985), and experience to date at EKATI™ supports this. Roads that create a barrier to vision because of height have the potential to hide predators and can deter caribou (Surrendi and DeBock, 1976; Roby, 1978). Wolves may also learn to use such roads as vantage points in searching the landscape for prey and as a screen for stalking caribou close to the road (Roby, 1978). Steep, bouldery road embankments can be difficult or dangerous for some species to cross. Roads can also attract wildlife, providing travel routes, insect relief, prey, shelter, or other habitat features.

4.6.1.2.1.2 *Operational Activities*

The effect of roads can be much greater than simply the area lost. The physical structure of roads resembles that of natural features such as eskers, and most wildlife can likely readily adapt to their presence. However, traffic and the associated disturbance will affect wildlife mainly throughout the operational phase (Sable – 11 years (BHP, 1999c)). Displacement associated with disturbance may have physical and physiological effects that can act at the level of individuals, groups, or populations. Animals that are displaced from important habitats may sustain increased energetic costs that can directly influence health and survival of themselves, their offspring, and their population (Diavik, 1998b). They may also face reduced security and increased predation risk. Movement patterns can be disrupted by traffic-related disturbance. This can result in dissection of home ranges, and potentially populations.

Habitat alteration also results from the deposition of dust. Haul truck traffic is expected to be the greatest source of dust generation associated with the EKATI™ development. Dust deposition on vegetation can influence plant phenology, productivity, abundance, and community composition (Section 4.4.1), with consequences for wildlife.

Because of the high cultural and ecological importance of caribou and grizzly bears in the EKATI™ area, combined with the relative abundance of research literature, many of the comments below are specific to these species. However, the effects described pertain generally to all wildlife, to greater or lesser extents.

Caribou

Individual disruption of caribou may occur along roads. Horejsi (1981) documented behavioural responses of barren-ground caribou to a pick-up truck on the Dempster Highway. Forty-eight percent of animals reacted to the vehicle by running away, while another 38% trotted away. Fast-moving vehicles were particularly frightening to caribou. In Alaska, vehicular traffic disrupted feeding times and spatial distributions of caribou (Dean and Tracy, 1978). A follow-up study ten years later suggested that caribou appeared to be habituating to the road, but individual disruption still occurred (Singer and Beattie, 1986).

Few data exist on traffic thresholds tolerable by caribou before normal behaviour is changed. At the Kuparuk oilfield near Prudhoe Bay, traffic volumes in excess of 10 to 15 vehicles per hour reduced the ability of calving and post-calving caribou to cross roads (Curatolo and Murphy, 1986; R. Shideler, Alaska Dept. Fish and Game, pers. comm). Although most groups eventually crossed roads, the significance of additional energetic costs resulting from delayed movements was unknown. Projected peak haul truck volumes on the Sable Road are 99 loads/day (BHP, 1999c). This equates to 198 one-way trips per day, or 8.3 vehicles per hour, not including non-haul traffic.

Compared with other classes of caribou, cows with calves in the Prudhoe Bay area are known to react relatively strongly to disturbance and to avoid active roads for up to two to three weeks after birth (Dau and Cameron, 1986; Cameron *et al.*, 1992). During northern migration through the EKATI™ area, when calves are not present, caribou are generally less sensitive to anthropogenic disturbances, so it is not possible to predict traffic thresholds acceptable to migrating caribou encountering the proposed Sable road. By the peak of southern migration past EKATI™, calves are only three to five weeks old, cows are presumably still relatively sensitive, and traffic thresholds may be similar to those observed at Prudhoe Bay.

Avoidance of development corridors by migrating caribou has not been unequivocally documented. Bergerud *et al.* (1984), in their summary of various caribou herds across North America, believed that all documented changes in migration patterns could be attributed to changes in population size and concurrent shrinkage in range sizes. They cited numerous cases where migrating caribou cross highways in Alaska and elsewhere in spite of intensive hunting pressure along these development corridors. Data from the WEMP at EKATI™ indicated that caribou behaviour was statistically unrelated to distance from the existing EKATI™ mine in 1998 and 1999 (Golder, 1999; Rescan, 1999c).

As with the open pits, the deposition of dust on vegetation adjacent to roads can affect availability and use of caribou forage. Changes in plant species composition may favour caribou, as grasses, sedges and willows may respond positively to light dust loads. Caribou may be attracted to affected areas, especially in spring in response to accelerated snowmelt and subsequently advanced phenology.

Like all wildlife, caribou are vulnerable to collision mortality (Brown and Ross, 1994). If roads prove to be attractive to caribou for movement or insect relief, the risk of accidental injuries will increase. Injuries could also be sustained by caribou traversing rough, bouldery sections of roadsides, especially if they are startled by vehicles or predators.

Road developments could be beneficial to caribou. Their elevated structure will provide relief from insect harassment, and vantage points for predator detection. Roads are easier to walk on than most natural habitats, and their use as conduits may decrease energetic costs of migration. The proposed Sable road is essentially parallel to the general direction of caribou migration through the EKATI™ area. Existing roads at EKATI™ are preferred travel routes through the mine site for caribou (Rescan, 1999c), and the proposed Sable road may also prove attractive.

Grizzly Bears

The greatest potential for effects on grizzly bears arising from the proposed development is associated with traffic on the roads to Pigeon and Sable pits. The U.S. Fish and Wildlife Service (1993) believes that "roads probably pose the most imminent threat to grizzly habitat today", and that "the management of roads is the most powerful tool available to balance the needs of bears and all other wildlife with the activities of humans". Road-related impacts on grizzly bears are primarily associated with mortality resulting from increased access for people with firearms, but also include disturbance and wildlife displacement resulting from traffic.

Categories of effects of traffic on grizzly bears include:

- direct effects such as collisions, and
- loss of habitat effectiveness because of bears avoiding the disturbance associated with roads.

Many authors have reported collision mortality in grizzly bear populations (*e.g.*, LeFranc *et al.*, 1987; Gunson, 1995; Huber *et al.*, 1995; Gibeau and Heuer, 1996). In the Prudhoe Bay oilfield development, at least one grizzly bear was killed in a collision, and there have been several near misses (R. Shideler, Alaska Dept. Fish and Game, pers. comm). Bears that are attracted to roads as travel routes may be more likely to be struck by vehicles. Use of roads as travel routes may also lead bears into developed areas with increased risk of negative interactions with humans.

Greater potential effects of road developments on grizzly bears are related to bear avoidance of human activities that are concentrated on roads. Traffic can create barriers to grizzly bear movements, effectively bisecting home ranges and populations (Gibeau and Heuer, 1996). If movement patterns are inhibited, one potential result is a decline in population genetic variability.

Grizzly bears are known to be sensitive to disturbance, and displacement from habitat adjacent to roads has been widely reported (Tracy, 1977; McLellan and Mace, 1985; Archibald *et al.*, 1987; Mattson *et al.*, 1987; Purves *et al.*, 1992). Wildlife displacement

can reduce access to security and efficiency of foraging strategies, with possible population-level consequences.

Disturbance affects wildlife within a zone of influence (ZOI) around the source. However habitat within the ZOI is not lost, it is just reduced in effectiveness; wildlife can still use the area, but may not be able to do so as effectively as before disturbance. The reduction in effectiveness can be estimated by a coefficient that reflects the intensity of the particular disturbance. The degradation of habitat effectiveness can be quantified by the product of the ZOI and the coefficient of habitat effectiveness (CHE) for an activity. The ZOI is a horizontal measure of the area in which bears would be affected by the activity. The CHE reflects the degree of disturbance within the ZOI (Weaver *et al.*, 1986). A CHE is a value between 0 and 1 and estimates the remaining habitat capability. For example, a ZOI of 500 m and a CHE of 0.4 indicates that within the area of a buffer of 500 m around an activity, the ability to support bears is reduced to 40% of potential. Either 60% of the bears have been displaced, or all of the bears can use the area only 40% of the time, or some combination.

The availability of ecosystem mapping in the EKATI™ area, combined with detailed, site-specific grizzly bear habitat use data collected by BHP (Banci and Moore, 1997), permitted modelling of the predicted effects of disturbance associated with the proposed development on grizzly bear habitat. Values for ZOI and CHE for tundra environments are not available. Therefore, for this model, ZOI and CHE values determined from empirical data for grizzly bears in the contiguous United States were adopted.

Many factors affect estimates of ZOI and CHE. Both parameters are influenced by topography and by the presence of security cover, which is defined as vegetation adequate to hide 90% of a standing adult bear from human view at ≤60 m (Weaver *et al.*, 1986). Substantial topographic relief and security cover are relatively rare in the area, so "non-cover" ratings were used in the EKATI™ model. Environmental conditions such as wind and snow cover can also affect ZOI ratings.

Both parameters are also influenced by the degree of wariness or, conversely, habituation of the individual bears involved. Wary bears are displaced more by disturbance, so zones of influence are larger and coefficients of habitat effectiveness are lower. Habituation of grizzly bears to humans and non-natural food sources is undesirable as it frequently results in conflicts and bear mortality. However, habituation to traffic and industrial activity is beneficial, as it reduces the intensity of displacement from those disturbances. Grizzly bears may habituate fairly quickly to predictable disturbances, as long as they are not associated with strongly negative consequences such as shooting or direct harassment (Tracy, 1977; McLellan and Mace, 1985; Bader, 1989; McLellan and Shackleton, 1989*a*; R. Shideler, Alaska Dept. Fish and Game, pers. comm.). In the case of the proposed development, it is likely that bears will initially behave warily, but will habituate over time (perhaps two years). However, individuals can be expected to vary in their rate and degree of habituation, and some bears may not habituate to traffic (Archibald *et al.*, 1987).

Several additional assumptions remain. Some classes of grizzly bears, including sub-adult males and adult females with cubs, have relatively high security requirements (Mattson *et al.*, 1987; McLellan and Shackleton, 1989). This can mean they are more displaced by industrial activity (have a larger ZOI), or conversely that they will seek refuge within areas avoided by potentially predatory adult males (have a smaller ZOI). Zones of influence are also unique to each individual bear, and some bears can be expected to have a much higher tolerance of disturbance than others.

A major influence on the parameters is the type of disturbance. Primary categories include:

- motorized *vs.* non-motorized,
- linear *vs.* point *vs.* dispersed, and
- low-use *vs.* high-use *vs.* 24-hour (Mattson, 1998).

For the EKATI™ model, all disturbances were classed as motorized, pit developments were classed as points and 24-hour, and roads were classed as linear and high-use (>100 vehicles per month; Gibeau, 1998). Linear motorized high-use ZOI reported in the literature range from 500 m to 800 m (Mattson, 1998); 800 m was chosen for the EKATI™ model to reflect the fact that most traffic will be large haul trucks. Point, motorized, 24-hour ZOI for pit developments was 1,000 m. This ZOI was applied to the perimeter of the proposed development footprints.

These ZOI values should be considered minimum disturbance distances. They are based on research conducted in diverse but primarily mountainous landscapes, under a variety of land-use activities. Few studies have closely examined responses of grizzly bears to industrial activity in a tundra environment. Harding and Nagy (1980) reported that grizzly bears appeared to avoid drilling and staging camps by at least 1,000 m. However, Ballard *et al.* (1993) detected no avoidance by grizzly bears of the Red Dog mine during its construction. No study has investigated reactions to large volumes of heavy haul-truck traffic. Finally, responses to blasting may be more intense and more far-reaching than responses to the steady noise emanating from the types of point disturbances reported in the literature. For these reasons, habitat disruption using larger buffers of 3 km and 10 km around all motorized disturbances was also modeled for the cumulative effects assessment. Noise from blasts and other intensive industrial activities could be audible for out to 10 km (Diavik, 1998b) and thus potentially affect wildlife behaviour.

Buffers representing the ZOI were created around the proposed roads and pit developments in ArcView®, using the BHP ecosystem map as a base. The total area encompassed by the cumulative ZOI was calculated, and categorized by ecosystem type (Table 4.6-5). These results were compared to baseline conditions to quantify the habitat area affected by proposed activity. Waterbodies were excluded from buffer calculations, although these areas could potentially be used by bears prior to spring break-up.

Table 4.6-5
Reduction in Habitat and Habitat Effectiveness for Grizzly Bears

Development[1]	Footprint (ha)	Width of Disturbance buffer (m)	Zone of Influence (ha)	Coefficient of Habitat Effectiveness
Beartooth Pit	11.1	1,000	32	0.18
Beartooth Road	5.0	800	0[2]	0.21
Pigeon Pit	130.0	1,000	502	0.18
Pigeon Road	57.3	800	154	0.21
Sable Pit	256.0	1,000	1,085	0.18
Sable Road	34.8	800	1,492	0.21
Pit Total	397.1		1,619	
Road Total	97.1		1,647	
Total	**494.2**		**3,265**	

1. Pit developments include pits, waste rock piles, pads, and associated infrastructure.
2. The Beartooth Road buffer is encompassed in buffers for Pigeon Road and Beartooth Pit.

Reported CHE for linear motorized high-use and point motorized 24-hour activities are 0.21 and 0.18, respectively (Mattson, 1998). These values are an indicator of the resultant habitat capability within the zone of influence during operations. This result can be interpreted as a population effect or a habitat effect, but this requires several assumptions and an intermediate step—the quantification of the relative value of available habitat types, such as through Habitat Suitability Indices (HSI). More simply, CHE values can be viewed as indicators of the effectiveness of habitat relative to areas outside of the ZOI. Values for CHE have a temporal component, reflecting seasonal changes in relative importance of habitat types to bears. However, for simplicity a single model was generated to encompass annual habitat-use patterns.

In order to assess potential effect of the mine on grizzly bear habitat, grizzly bear radiotelemetry locations collected in the Lac de Gras area during 1995 and 1996 were used to develop a habitat suitability map of the area. The assessment focussed on female bears; females use much smaller home ranges than males (McLoughlin *et al.*, in press) and are therefore more susceptible to local effects of development.

Radiotelemetry fixes recorded by GPS were used. Due to the low number of radiolocations (112 within the BHP habitat-mapped area) only two seasons were differentiated. Season I covered den emergence to July 6, and Season II was July 7 to den entry.

Season I: Den Emergence to July 6

The 36 available locations were used to develop a habitat suitability index. Most locations (92%) were contributed by a single bear (out of three individuals). To account for the positional error (and error in the local vegetation) instead of using single "precise" (as described by their UTM coordinates) point locations, the 25 locations dispersed within a 50 m radius around the original point were used.

Small sample size precluded the application of standard methods of assessing habitat preference (*e.g.*, compositional analysis, analysis of ranks). Instead, the ecosite types used were cross-tabulated with the available ecosite types. As a measure of habitat selection, standardized residuals were used (the difference of the observed and expected count divided by an estimate of its standard error). By doing so it was possible to express the deviations in standard deviation units allowing direct comparison among them. The ability to detect selection of a given ecosite type using radiolocations is directly related to the average ecosite patch size. With the low number of radiolocations, we recognized a potential for the locations to be close to, but missing completely, some of the more fragmented and small ecosite types. To account for this possibility, the distance was calculated from each fix to each of the selected ecosite types closest to the given point. A set of random points was then generated within the local study area, and the procedure repeated (distance calculations). The two sets (Mann-Whitney test) were then compared to determine whether bear locations show a non-random distribution (affiliation with certain ecosite types, with a null hypothesis that the distribution of bear locations is random). The tests fully confirmed the cross-tabulation results (see Appendix D for the statistics).

This analysis suggests that female grizzly bears appeared to select (in order of preference) for the following ecosite types:

1. Willow Riparian (maximum standardized residual)
2. Wetland Complex (70% of the maximum standardized residual)
3. Open Mat Tundra (weak preference: 26% of the maximum standardized residual)

The shortcoming of a univariate method of habitat suitability assessment lies in it lacking the means of quantifying the relationship between the "selected" habitat types. No quantification is possible for those ecosite types that are used proportionally to their availability. Instead, a habitat ranking is usually produced. By using standardized residuals as a measure of selection it was possible to quantitatively relate ecosites being selected to the habitat type for which the strongest selection is detected. This is expressed as the percent of the maximum standardized residual (standardized residual of the most strongly selected for ecosite type). In other words, this method allows the measurement of habitat importance using the most preferred ecosite type as a yardstick. In the absence of an absolute measure of habitat importance (no such thing has ever been developed) this was found to be a useful method.

Season II: July 7 to den entry

The 76 available locations (three individual bears) were used to develop a habitat suitability index. The same methodology as described in the "Season I" section was used. See Appendix D for statistics.

With three individual bears contributing to the pool of radio-locations, both the cross-tabulation analysis (all bears pooled together) and the habitat selection analysis were run as described by Neu *et al.* (1974). The compositional analysis could not be run as it requires data from at least six animals.

The analysis on the pooled data suggests that female grizzly bears appeared to select (in order of preference) for the following ecosite types:

1. Esker Complex
2. Willow Riparian (75% of the maximum standardized residual)
3. Birch Seep (63% of the maximum standardized residual)
4. Birch Hummock (38% of the maximum standardized residual)

Individually, bears exhibit a significant variation in habitat selection (Appendix D). Most of the selection for the Esker complex, for example, is driven by a single bear. One bear totally "avoided" this ecosite. Similarly, just one individual drives the selection for the Willow Riparian complex; others totally "avoided" this ecosite type. However, recognizing that our ability to detect selection of a given ecosite type using radiolocations is directly related to the average ecosite patch size, the distance analysis was run on the selected ecosite types (see Season I section for details). The test fully confirmed ecosite preference inferred from the analysis of the pooled database. These results were interpreted as direct evidence of association of all three female bears with the above listed ecosite types.

The potential disturbance effects on grizzly bears apply to the road development phase as well. Development activities may in fact generate more intensive disturbance effects than routine haul traffic. Additionally, during winter there is a risk of disturbance of denning grizzly bears. From the last week of October to the last week of April, nearly all grizzly bears are in dens (McLoughlin *et al.*, in press). Bears may be displaced from their dens by intensive industrial activity (Harding and Nagy, 1980). Bears which flee their dens during winter will likely experience severe nutritional and physiological stress and may die, and abandoned cubs will not survive (Reynolds, 1981). However, bears may be relatively tolerant of disturbance when in their dens. Reynolds *et al.* (1986) found that no bears deserted their dens despite seismic activity within 800 m and, in one instance, the passage of a supply train within 100 m. The danger of winter industrial operations within grizzly bear denning areas is that precise locations of dens will not be known, and new road development or other activities may inadvertently approach them closely. This risk disappears when development is complete. Presumably, bears will not den within the ZOI of active roads.

Fugitive dust from haul truck traffic can alter vegetation communities. In areas of light-moderate dust deposition, some spring bear forage species such as grasses and sedges may be enhanced. Conversely, berry-producing species including lingonberry and blueberry may be adversely affected (Table 4.6-1), reducing bear foods available during late summer and fall. Most dust-related vegetation effects will occur within 100 m of roads and well within the zone of influence of traffic disturbance. It is therefore likely that grizzly bears will be largely excluded from these areas during periods of traffic and not directly affected by changes to vegetation.

Not all habitat alterations related to road development will necessarily *reduce* habitat quality for grizzly bears. Roads may serve as travel corridors for grizzlies (Smith, 1978; Zager, 1980). Within the Prudhoe Bay oilfield development, grizzly bears did not avoid roads, readily crossing and using them as travel conduits (R. Shideler, Alaska Dept. Fish and Game, pers. comm). One grizzly bear was observed to use the Fox Road at EKATI™ as a travel conduit on several occasions in 1998 (S. Moore, Rescan, pers. comm.) Use of roads by bears may increase during darkness (Aune and Stivers, 1985; McLellan and Shackleton, 1988), presumably because of reduced traffic volumes, increased security, or both. Elevated road surfaces may provide insect relief and thus be attractive to bears during summer. However, in the studies cited above, traffic volumes were relatively low and use was irregular and discontinuous. The volumes, frequency, regularity, and 24-hour pattern of traffic in an active haul program may preclude grizzly bear use of roads. Small mammals, which may colonize roadsides, may attract grizzly bears. However, any attraction of bears to roads will include an increased risk of collision.

Birds

The potential effects on birds from operational activities on the proposed Sable Road includes disturbance and collisions. The proposed Beartooth road is not applicable here since it will be built along the strip of land between the already existing Panda pit and Panda waste rock storage pile. Presumably, birds do not effectively utilize this narrow strip of tundra.

Birds utilizing habitat within the Pigeon and Sable Road corridors will be affected by disturbance. The effects of noise on birds include exclusion from feeding and nesting habitats and the expenditure of energy to avoid the noise. The periods during which disturbance may be critical include migration, nesting and moulting. Disturbance may cause nesting birds to abandon nest and clutch. The absence of the female from the nest also allows access to predators.

Changes to vegetation resulting from dust deposition along roads may affect birds. Of greater consequence, however, is the predicted pattern of snowmelt in the dustfall zone. This is expected to accelerate green-up by 10-14 days in affected areas. This could provide spring foraging opportunities for passerines, waterfowl, and raptors, and advanced nesting for passerines.

Some birds are at risk of collision with vehicles. In particular, raptors may hunt along roads and scavenge on animal remains on the road.

4.6.1.2.2 Mitigation Measures

4.6.1.2.2.1 Physical

The proposed route for the Pigeon and Sable roads avoids the off-esker glacio-fluvial deposits that occur between EKATI™ and Sable Lake. The route also avoids most

wetlands and other high-quality wildlife habitat. Roads will be of low profile (nominally 2 m) where possible, and ramps to facilitate crossing by caribou will be integrated at strategic points that have been identified as traditional travel routes. Additional ramps to accommodate caribou can be incorporated throughout the operational phase if it is determined that caribou crossing would be facilitated. If the Sable Road proves to be attractive to caribou as a travel corridor, access ramps may be required to facilitate concurrent use of the road by caribou and traffic. BHP proposes to establish a gravel quarry on the edge of the Ursula Esker but will be employing all measures necessary to ensure protection of important wildlife values.

Reclamation of the roads at closure will produce structures physically analogous to eskers. Road rehabilitation according to the Abandonment and Restoration Plan, will return altered habitats to a usable state for wildlife, although recolonization by productive vegetation is expected to be slow. Research has shown that wildlife can respond quickly to attempts to rehabilitate habitats. For example, caribou in arctic Alaska fed preferentially on vegetation growing in some disturbed areas that were associated with oil development (Klein, 1980; Hanson, 1981).

4.6.1.2.2.2 Operational Activities

Reductions in habitat effectiveness resulting from disturbance can be mitigated through habituation to the disturbance stimuli. Wildlife will habituate most quickly to traffic that follows predictable patterns. Mitigation of the potential effects of traffic on resident and migratory wildlife will be predicated upon environmental awareness training and the cooperation of drivers using the Sable Road.

BHP's policy specifies that at all times, wildlife on the road has the right-of-way; vehicles are required to stop to allow animals to cross. This applies to all members of a group of animals, to prevent division of groups. Drivers are instructed on specific protocols to apply when wildlife is observed in the vicinity of the road. The goal is to encourage wildlife habituation to traffic. Therefore, drivers are directed to slow down when wildlife is observed off-road, but *not to stop*. However, drivers must be vigilant for unanticipated flight reactions by wildlife that may suddenly decide to cross in front of trucks.

It is predicted that in some years, during migration large numbers of caribou will encounter the proposed Sable Road. During periods of heavy migration, hauling and other traffic may be suspended to facilitate caribou movement through the area (IEMA, 1999). This may become particularly important during periods of high traffic intensity, when projected traffic volumes approach values that may constitute a temporary barrier to caribou movement. Convoying may be used where regular spacing of haul traffic appears to be disruptive to wildlife movement.

Advisory "Wildlife Crossing" signs for drivers will be erected where the Sable Road intersects the Exeter and Ursula eskers, and in other locations determined through monitoring to be major travel routes for caribou and other wildlife.

Truck traffic on haul roads is likely to be the greatest potential source of dust at EKATI™. The generation of dust will be minimized by application of water or other dust suppressors to roadways as needed and restricting vehicle speeds.

The general increase in the footprint of the EKATI™ development will also increase the opportunity for direct interactions and conflicts between workers and wildlife, including bears. Environmental awareness training for all staff will continue to be an important part of the wildlife mitigation program.

Virtually all potential negative effects of the proposed roads on wildlife are related to disturbance arising from operational activities. As soon as mining is terminated and traffic ceases on the Pigeon and Sable roads, habitat effectiveness within the ZOI will return to pre-development values.

4.6.1.2.3 Assessment of Effect and Residual Effects

4.6.1.2.3.1 General

The development of Sable, Pigeon and Beartooth roads will bury 97.0 ha of habitat (Table 4.6-2), of which 69 % is closed mat tundra and 13 % is open mat tundra. The roads resemble eskers and most wildlife will readily adapt to their physical presence once operations are terminated and roads are abandoned.

Traffic will result in the most substantial potential effects on wildlife associated with the proposed development. The proposed Sable Road intersects the Exeter/Vulture and Ursula eskers, which are important movement corridors for many wildlife species. Two potential consequences are that wildlife movements may be interrupted by disturbance associated with traffic, and that a higher rate of collision mortality may occur at these sites.

Initially, wildlife flight reactions can be expected in response to moving vehicles. All such responses generate increases in energetic requirements, with a corresponding decline in fitness (Axys and Penner, 1997). As resident wildlife habituates to traffic, flight reactions will decline in frequency and intensity. Migratory wildlife, including caribou, will encounter the proposed development for only a few days per year and are likely to continue to perceive the mine as a novel feature. They, as well as particularly sensitive individuals and species with high security requirements, will not habituate and will continue to incur these costs. However, the field evaluations of caribou reactions to the presence of the EKATI™ mine (WEMP) indicate that caribou appear to be comfortable with roads, passing trucks and other general human activities. Depending upon the season and family grouping, caribou appear to habituate to the current levels of non-threatening human intervention.

Experience gained to date at EKATI™ suggests that most wildlife, including red and Arctic foxes, Arctic hares, small mammals, and most bird species, will readily habituate

to mine-related activities. Some of these will simply incorporate the proposed development into their home ranges, whereas others may exploit the new habitat features.

4.6.1.2.3.2 *Caribou*

The development of roads to Pigeon and Sable pits will eliminate 97.0 ha of caribou habitat. The relative importance of different ecosystem types to migrating caribou is unknown, so it is not possible to assess the value of the lost habitat.

Dust from haul truck traffic will affect caribou forage availability in a small area within 100 m of roads. Predicted effects on vegetation community structure will be neutral or may favour caribou, as seasonally important species may be enhanced by light to moderate dust loads. Accelerated snowmelt in areas of dustfall will advance phenology and render plants available to caribou during northern migration. It is difficult to predict the response of caribou to these changes. Caribou may be unable to exploit these foraging opportunities because of avoidance of disturbance stimuli so close to traffic. Conversely they may be attracted to these sites and gain nutritional benefits. Those benefits may be attended by increased risk of collision. Additionally, there is a small risk that predators may be attracted to concentrations of caribou along roads.

In addition, potential caribou habitat adjacent to the road corridors will be reduced in effectiveness. Caribou may avoid roadside habitat in response to traffic disturbance. Caribou responses to anthropogenic stressors observed at EKATI™ in 1997-1999 is reported above (Section 4.6.1.1.3). Generally, reactions were weak and flight distances short. However, most behavioural observations were conducted within the mine site, and because the Misery road did not exist in 1998 and was under construction during 1999, few opportunities existed to observe caribou reactions to traffic proceeding at speed on haul roads.

Caribou reactions to pickup traffic were observed 90 times in 1998 and 1999. Most of these observations involved vehicles travelling at 40 km/h or more. Caribou responses were classed as level 0 or 1 (comfort) in 64.4 % of observations, as level 2 in 18.9 % of observations, and as level 3 (trotting or running) in 16.7 % of observations. The mean distance moved for all responses to pickups was 35.8 m (Figure 4.6-1). Excluding aircraft and pedestrians, pickup traffic elicited the most vigorous reactions from caribou of all stressors monitored.

In order to evaluate the relative numbers of caribou that could potentially interact with the proposed road, specific aerial surveys were implemented in 1999 for the proposed Sable Road route. Fourteen surveys of the road route were conducted during northern migration, and eight surveys were conducted during southern migration.

During northern and southern migration, 226 (mean = 16.1) caribou, and 84 (mean = 10.5) caribou were observed on the Sable corridor surveys, respectively (Rescan, 1999). The average percentage of the Bathurst herd exposed to the Sable road corridor during northern and southern migration were 0.004 % and 0.003 % per day, respectively. Consequently, although it is probable that caribou will be disrupted to some degree by

traffic on the Pigeon and Sable roads, the number of animals affected will likely be small. Aerial surveys of the proposed Sable Road in 1999 indicated that caribou observations were broadly distributed along the length of the route (Figure 4.6-2).

The primary focus will involve accommodating caribou needs to cross roads. BHP's commitment to preventing disruption of caribou movements through the area, by construction design and adaptive traffic management, will facilitate uninterrupted migration through the EKATI™ area. Caribou are not likely to habituate to traffic, as most are present in the area for only a short time in the spring and again in the fall. However, the experience at the EKATI™ mine is that the reaction of caribou to current levels of activity is decreasing.

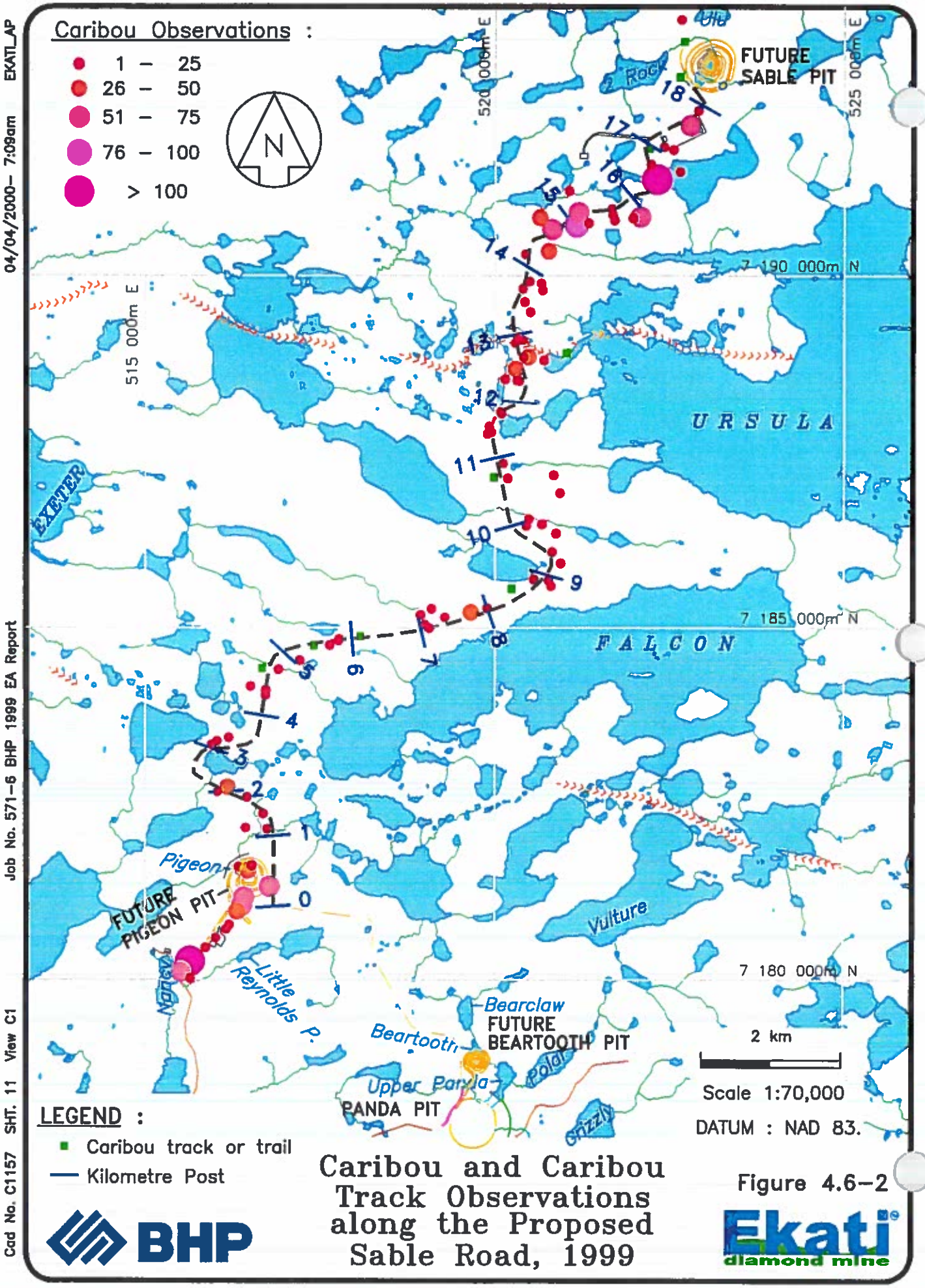
Despite proactive and adaptive efforts to reduce the risk, there remains the possibility that caribou will be struck by vehicles on the Pigeon and Sable haul roads. No caribou have been killed or injured as a result of mine-related activities to date at EKATI™, or at Diavik (Diavik, 1998b). After 17 years at the Lupin mine, three incidents in which caribou were killed or injured have been reported (Hohnstein, 1996). With the consistent application of BHP's Traffic Management Plan (OEMP) it is anticipated that the number of caribou involved in collisions at EKATI™ will remain very low.

The risk of collision injury may be increased due to the orientation of the Sable Road. Its general trend from south-southwest to north-northeast corresponds generally to the general direction of caribou migration through the area. As a result, caribou may attempt to move along the road surface, rather than simply cross it. This may lead to relatively frequent interactions between caribou and haul traffic. In such circumstances, it will be important to not force quick reactions from caribou, and to provide safe egress from the road surface. An adaptive approach to the construction of crossing ramps, as well as temporary suspension of haul traffic during periods of high caribou abundance, should reduce the risk of collisions with caribou.

The existence of roads may enhance caribou habitat at closure. Roads share physical similarities with eskers and, devoid of traffic, will likely be readily used for travel corridors, vantage points and insect relief (Plates 4.6-3 and 4.6-4).

4.6.1.2.3.3 Grizzly Bear

Total potential grizzly bear habitat lost to road development will be 97.0 ha. In addition, a larger area of bear habitat will be affected by traffic disturbance (Section 4.6.1.2). It is important to note that the habitat within the zone of influence is only reduced in effectiveness for bears, it is not eliminated. Bears can still use this area, but the likelihood of their doing so is reduced. Describing it in terms of "reduced in effectiveness" merely permits qualification of habitat effects.



Caribou and Caribou Track Observations along the Proposed Sable Road, 1999

Figure 4.6–2

BHP

Ekati diamond mine

Cad No. C1157 SHT. 11 View C1 Job No. 571–6 BHP 1999 EA Report 04/04/2000– 7:09am EKATI_AP

Plate 4.6-3 Caribou moving along an EKATI™ Mine haul road.

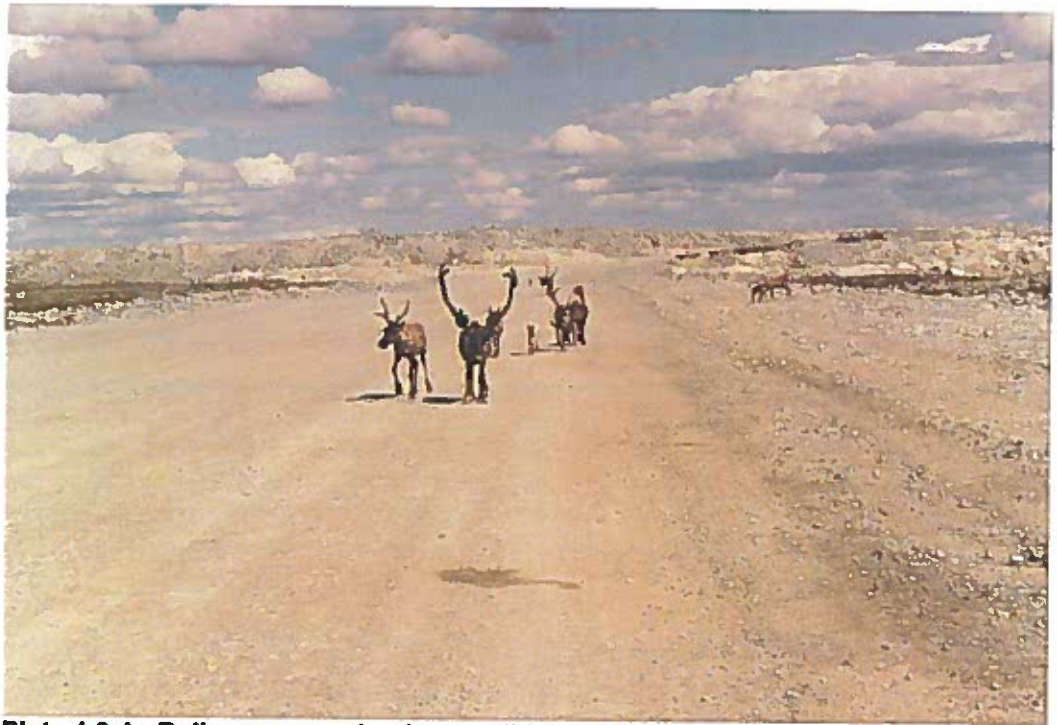


Plate 4.6-4 Bulls, cows and calves walking on the EKATI™ mine haul road near Panda Pit.

Individual grizzly bears do not use their home ranges exclusive of other bears. The location of the proposed development likely intersects the areas used by two to four adult females, one to three adult males, and several subadults.

Avoidance of disturbance related to traffic on the Sable Road has the potential to interrupt movements by resident bears and consequently force a reconfiguration of their home ranges. During periods of frequent haul traffic, individual bears which are sensitive to disturbance may not be able to move between portions of their home ranges which lie on opposite sides of the Sable Road route as efficiently as prior to development. Habituation may permit some bears to exploit habitats adjacent to roads and other developed corridors. However, it may also greatly increase the likelihood of collision and negative bear-human interactions, with the attendant risk of management action to remove problem bears.

Fugitive dust from haul truck traffic will likely alter the abundance and distribution of some bear foods:

- Spring forage may be enhanced if grasses and sedges respond positively to dust deposition;
- Early snowmelt makes vegetation available;
- Late summer-fall foods, especially berries, may be reduced in the narrow zone influenced by dust; and
- Caribou and small mammals may be attracted to these zones, providing potential prey.

However, it is doubtful that grizzly bears will be able to exploit these opportunities as their avoidance of disturbance will largely exclude them from areas affected by dust during periods of operations.

The proposed Pigeon and Sable road routes do not closely approach any known sites of former grizzly bear dens. However, a den occupied by a grizzly bear during winter 1998-99 was located on the north shore of Ulu Lake, within 1.0 km of the proposed Sable Pit. Grizzly bear den sites in the EKATI™ area are frequently found off-esker in glacio-fluvial or lacustrine sites that are difficult to predict (Banci and Moore, 1997).

The existence of roads may enhance bear habitat at closure. Roads share physical similarities with eskers and, devoid of traffic, will likely be readily used for travel corridors, vantage points, and insect relief. Ground squirrels and other small mammals may colonize these new habitats, in turn providing prey for bears. However, it is unknown whether potential den sites for bears can be created.

4.6.1.2.3.4 Furbearers

Under the proposed road development wolves, Arctic and red foxes, and wolverines will sustain the same loss of habitat (97.0 ha) as other species. In addition, it is anticipated that there will be a reduction in habitat effectiveness adjacent to roads and pit developments. This is expected to affect wolves and wolverines more than foxes but the

magnitude of habitat disruption is unknown. As with the other mammals, fugitive dust from haul truck traffic will likely alter the abundance and distribution of some foods.

Wolverines are classified by COSEWIC as vulnerable, and are also sensitive to human activity (Copeland, 1996). Arctic and red foxes are considerably more tolerant of such activities, although they are still vulnerable to collision mortality.

Roads can be a major threat to wolf populations because of barrier effects and vehicle collisions (Noss *et al.*, 1996). Canids frequently use roads as conduits. It is likely that the Sable Road will be attractive to foxes and wolves as a travel corridor. Active driver awareness will be required to minimize the risk of road kills.

The proposed Sable Road route does not approach any known wolverine or fox den sites. However, it passes within 500 m of a wolf den on the Ursula Esker. This den has been occupied in recent years, including during 1998. Wolves commonly rotate occupancy of den sites between and within years. This pack used a different den in 1999, but this does not indicate abandonment of the Ursula Esker den site. Wolves are sensitive to disturbance at their dens (Chapman, 1977), and it is possible that development of the Sable road will preclude further use of this den. Alternate den sites exist in the area.

The existence of roads may enhance carnivore habitat at closure. Roads share physical similarities with eskers and, devoid of traffic, will likely be readily used for travel corridors, vantage points, and insect relief. Ground squirrels and other small mammals may colonize these new habitats, in turn providing prey for carnivores. Foxes and wolverines may be able to establish dens on roadside banks, but it is unknown whether esker surrogates suitable for denning by wolves can be created.

4.6.1.2.3.5 Birds

The development of Sable, Pigeon and Beartooth roads will bury 97.0 ha of habitat. Birds will be displaced from this habitat.

Data collected during BHP's baseline program and WEMP reveal that the proposed Sable Road placement is not in proximity to any known raptor nests. The road corridor is designed to follow upland habitat in heath tundra that will mitigate effects on loon territories. The existence of roads may enhance bird habitat at closure. Ground squirrels and other small mammals may colonize these new habitats, in turn providing prey for raptors. Gravel-nesting birds such as plovers and jaegers may use abandoned road surfaces for nest sites.

Disturbance from operational activities will likely be insignificant. Based on BHP's WEMP, breeding bird density has not significantly changed in proximity to the mine site for those roads that already exist.

Advanced snowmelt resulting from dust deposition will expedite green-up adjacent to roads and make affected areas available for foraging and nesting by birds. However, increased bird activity along roadsides may be accompanied by higher rates of collision.

4.6.1.2.4 Summary of Predicted Effects of Roads

The development of the proposed roads to the Pigeon and Sable pits will bury 97.0 ha of potential wildlife habitat. Aside from a few species that may forage within or colonize the roadsides, this habitat loss will persist until reclamation efforts have been completed, and traffic has been eliminated. During development and operation, habitat adjacent to the roads will be reduced in effectiveness for wildlife, depending on each species' sensitivity to disturbance. Some risk of vehicle-wildlife collisions will exist, but intensive mitigation should result in low mortality rates.

Fugitive dust resulting from haul truck traffic will affect vegetation within about 100 m of roads. Some wildlife forage species will be enhanced and some will be reduced. Changes in plant community structure will persist beyond the operational life of the roads. Dustfall on snow will accelerate melt and expose vegetation earlier in the spring. This may provide enhanced feeding opportunities for some species which are tolerant of disturbance, but may also introduce risk of collision mortality or predation. Substantial changes in snowmelt patterns will cease with the decommissioning of pits and associated roads.

Until local wildlife populations habituate to traffic between EKATI™ and the Sable pit, some interruption of intended movement across the proposed road route can be expected. Accommodating this interruption (*i.e.*, turning back or going around the development) will invoke increased energetic costs. Quantification of these effects is not possible, but for large, mobile species they are likely minor. For smaller species with small home ranges and reduced mobility, home ranges could be bisected and dispersal compromised.

4.6.1.3 Summary of Predicted Effects of Pits and Roads on Wildlife

4.6.1.3.1 General

The proposed development of the open pits, waste rock storage piles and roads at Sable, Pigeon, and Beartooth will eliminate 494.0 ha of potential wildlife habitat. This habitat loss will persist until reclamation efforts have been completed, and natural and fostered vegetation has been re-established. However, the total area directly affected constitutes only 0.3 % of the Local Study Area. Therefore, all effects related to direct habitat loss are considered to be negligible.

Disturbance associated with:

- blasting,
- heavy equipment operation, and
- haul truck and other traffic

will affect wildlife use of habitat outside of the direct development and road footprints. This displacement will reduce habitat effectiveness for all species, but the zone of influence will depend on the specific level of sensitivity of individuals and species. For small mammals and many birds, loss of effective habitat will be negligible. For more

sensitive species such as carnivores, a larger area will be affected (Table 4.6-5). Reductions in habitat effectiveness resulting from disturbance are mitigated completely and immediately upon cessation of the disturbance.

Fugitive dust resulting from mining operations will affect vegetation within about 100 m of mine sites and roads. Changes to vegetation communities will be beneficial for some wildlife and detrimental to others, and a seasonal component to these effects exists. Changes in plant community structure will persist beyond the operational life of the mine. Dustfall on snow will accelerate snow melt and expose vegetation earlier in the spring. This may provide enhanced feeding opportunities for some species which are tolerant of disturbance, but may also introduce risk of accidental injury or predation. Changes in snowmelt patterns will cease with decommissioning of mines.

No Threatened or Endangered species of wildlife are known to occur in the Lac de Gras area (Table 4.6-6). Species listed as Vulnerable are defined by COSEWIC as "of special concern because of characteristics that make it particularly sensitive to human activities or natural events". The wildlife species which occur in the Lac de Gras area but which are not listed in Table 4.6-6 are designated either Not at Risk (a species that has been evaluated and found to be not at risk) or Indeterminate (a species for which there is insufficient scientific information to support status designation).

Table 4.6-6
Status of Birds and Mammals as Assigned COSEWIC

	Status category		
Taxonomic group	**Endangered**	**Threatened**	**Vulnerable**
Mammals	None	None	Grizzly bear Wolverine
Birds	None	None	Peregrine falcon (*tundrius* subspecies)

The physical structure of roads resembles that of natural features such as eskers, and most wildlife will readily adapt to their physical presence once operations are terminated and roads are abandoned.

4.6.1.3.2 Caribou

The total loss of summer habitat and habitat effectiveness for caribou will be minimal. Calving and winter range will be unaffected by the proposed development. Although mine-related activities may alter caribou behaviour and activity budgets, such effects will be minimal and will directly influence a very small fraction of the Bathurst herd in any year. The potential for disruption of caribou movement will be mitigated proactively by careful planning of road routes and construction design, and by an adaptive approach that regulates traffic while caribou are present.

Disturbance from industrial activity and traffic associated with the proposed Sable, Pigeon, and Beartooth development will be potentially audible by caribou out to 10 km from the source. However, caribou are unlikely to be restricted in their use of this area. A buffer of 3 km around proposed developments encompasses an area within which caribou may both see and hear industrial activities. Monitoring data from the WEMP during 1997-1999 suggest that caribou behaviour is not measurably affected within this area, and most caribou do not avoid this zone.

Effects will persist throughout the development and operation phases. However, because caribou use the EKATI™ area primarily during migration, the duration of effects is discontinuous within any particular year; for all but a few weeks per year, no caribou are affected. Because most predicted effects are related to disturbance, they will be virtually entirely reversible upon termination of operations.

In summary, effects on caribou of the proposed development of the Sable, Pigeon, and Beartooth kimberlite pipes are predicted to:

- apply to a portion of the regional population;
- persist over more than one decade;
- apply in a predictable, periodic manner for a few days per year;
- be reversible in less than 10 years post-operation;
- not reduce the population size or ecosystem function; and
- be of minor significance (Table 4.6-7).

Table 4.6-7
Summary of Predicted Effects of the Proposed Development on Caribou

Criteria	Comments
Geographic Extent	Effects from the proposed development on caribou will influence only individuals which encounter the development. Those individuals migrate beyond the local study area and regional study area boundaries. However, there is expected to be no measurable effect on the overall distribution of the Bathurst caribou herd.
Duration	Duration of effects will be long-term, equivalent to the operating life of the development (>11 years).
Frequency	Individual caribou will be exposed to disturbance periodically, during northern and southern migration and during post-migration. It is predictable that some caribou will be exposed during each period, but not predictable that the same individuals will be repeatedly exposed. Effects will reoccur on an annual basis.
Reversibility	Upon termination of mining activities, disturbance effects will cease. Negligible habitat alteration will persist. Site reclamation and natural revegetation will restore pads and roads to useable habitat.

(continued)

Table 4.6-7
Summary of Predicted Effects of the Proposed Development on Caribou (Completed)

Criteria	Comments
Ecological Context/Sustainability	The total area of the proposed development represents a very small fraction of the Bathurst herd's overall distribution. Consequently, development will not jeopardize the ecological integrity of the herd's annual range. The combined footprint is small relative to the width of the migration corridor and is not expected to significantly affect caribou migration. Caribou which migrate through the local study area are harvested within the regional and greater study areas, so minor population effects arising from the proposed development will be cumulative with those at greater scales.
General Significance Category	There is expected to be a negligible effect on the overall distribution and abundance of the Bathurst caribou herd; however low prediction confidence for some effects directs overall significance rating to **minor**. Predicted effects on caribou are not likely to reduce the capacity of the caribou population to sustain its ecological and economic role.

4.6.1.3.3 Grizzly Bears

Potential residual effects on grizzly bears include possible increased mine-related mortality, and habitat disruption. Diavik estimated that an average of 0.12 to 0.24 grizzly bears per year were killed for every industrial camp operating in their assessment area during 1986-1997 (Axys and Penner and Associates, 1998b). Applying this estimate to the proposed development of Sable, Pigeon, and Beartooth—as if it represented a unique industrial camp—it is estimated that one bear would be killed every 4.2 to 8.3 years. However, nearly all problem wildlife bear mortalities arise from access to human food or garbage. The proposed development is unlikely to produce any such attractants, and it is likely that no problem wildlife bear removals will result. However, there remains a small risk that a bear may be struck by a vehicle, particularly on the Sable Road.

The total area within an 800 m disturbance buffer around the proposed Sable, Pigeon, and Beartooth roads, plus a 1-km buffer around the three proposed pits, is 3,265 ha, or 32.7 km². Within this area, grizzly bear habitat effectiveness will be reduced. Average home range sizes for female and male grizzly bears in the central Canadian Arctic were 2,074 km² and 6,685 km², respectively (McLoughlin *et al.*, in press). Therefore, the total area of habitat loss, combined with reduced habitat effectiveness arising from the proposed EKATI™ development constitutes 1.8 % of a female's home range and 0.6 % of a male's home range.

Grizzly bear habitat use was intensively studied in the EKATI™ area during 1995 and 1996 (Banci and Moore, 1997). All study bears demonstrated statistically significant selection for riparian willow (SR), birch seep (BC), and sedge meadow (CE) habitats. These ecosystem units comprise 0.0 ha (0 %), 20.6 ha (4.0 %), and 16.8 ha (3.3 %), respectively, of the combined footprint of the roads plus the three proposed pits, waste

rock piles, and associated infrastructure (Table 4.6-2). All bears demonstrated statistically significant avoidance of heath mat tundra (BL), which constitutes 432.4 ha (84.5 %) of this combined footprint. Therefore, more than 92 % of the habitat lost to development is of relatively low importance to bears.

Within the combined zones of influence of the pit developments and the roads, the important bear habitats of riparian willow (SR), birch seep (BC), and wetland (BR, EA, CE, CA) habitats comprise 8 ha (0.3 %), 11 ha (0.4 %), and 142 ha (4.4 %), respectively (Table 4.6-2). Closed mat tundra (BL), the least important bear habitat type, comprises 2,400 ha (73.5 %) of the area within the disturbance buffer. More than 94 % of the grizzly bear habitat reduced in effectiveness by disturbance associated with the proposed development is of relatively low importance to bears.

Availability of habitat affects the population carrying capacity. Describing habitat loss in terms of population effects requires two further steps:

1. Habitat suitability indices (HIS), which assign a numeric value to the importance of different habitat types, must be calculated, based on empirical knowledge of habitat use.

2. The geographic scale at which these effects are to be evaluated needs to be determined.

It is tempting to apply HIS models in management decisions, but this should be avoided prior to model validation (Cole and Smith, 1983). For this reason, it was determined that disturbance effects of the proposed EKATI™ development would be described only in terms of habitat loss and disruption.

In summary, the effects of the development of the Sable, Pigeon, and Beartooth pipes and associated roads on grizzly bears are predicted to:

- apply to a portion of the regional population;
- persist over more than one decade;
- apply in an unpredictable, episodic manner for a few days per year;
- be reversible in less than 10 years post-operation;
- possibly reduce the population size or ecosystem function; and
- be of moderate significance (Table 4.6-8).

4.6.1.3.4 Furbearers

Arctic and red foxes are highly adaptable to human activities and are unlikely to sustain measurable disturbance or population effects. However, wolves and wolverines are generally more sensitive to disturbance and have population characteristics that make the consequences of even minor population effects of greater significance.

Table 4.6-8
Summary of Predicted Effects of the Proposed Development on Grizzly Bears

Criteria	Comments
Geographic Extent	Individual bears with home ranges intersecting the proposed development will experience habitat loss and disruption, and may be exposed to mine-related mortality risk. Because of their large home ranges and extensive movements, those bears comprise the regional population.
Duration	Effects from disturbance will be continuous during the bear-active season (May-October). Duration will be long-term at an estimated 11 years.
Frequency	Individual bears will be exposed to disturbance episodically, during the non-denning season. It is predictable that some bears will be exposed, and predictable that some resident bears will be exposed repeatedly during a year. Effects will reoccur on an annual basis.
Reversibility	Upon termination of mining activities, disturbance effects will cease. Negligible habitat alteration will persist. Site reclamation and natural revegetation will restore pads and roads to useable habitat.
Ecological Context/Sustainability	The total area of the proposed development represents a small portion of an individual bear's home range. The location of the proposed development likely intersects the areas used by 2-4 adult females, 1-3 adult males, and several subadults. Movements of adult and subadult males that encompass the EKATI™ area may also extend beyond the regional study area boundaries..
General Significance Category	Predicted effects on grizzly bears are likely to have a minor effect on the sustainability of the regional or greater-than-regional populations. However, poor predictive confidence for the significance of habitat disruption, and the consequences of even a very low number of mortalities, drive the overall significance rating to **moderate**.

The areal extent of direct habitat disruption can be measured. However, habitat avoidance can be assessed only through detailed study of the behaviour and movements of the affected individuals. Wolves are relatively sensitive to human activity (Weaver *et al.*, 1996) and display higher levels of avoidance than many other species, such as caribou. Wolves avoid human settlements and activity (Thurber *et al.*, 1994), and avoid hunting near sites of human habitation and development (Paquet, 1993). If wolves and grizzly bears are similarly sensitive to disturbance, and the zone of influence around the proposed developments is the same for wolves as it is for grizzly bears, then about 33 km² of potential habitat will be reduced in effectiveness for wolves. Wolves that den in the Lac de Gras area are migratory, and follow caribou to their wintering grounds. Annual ranges for radio-collared males averaged over 63,000 km² (Walton, 1999), so the loss of habitat from the proposed EKATI™ development is negligible on an annual basis. However, wolf home ranges during the summer (pup-rearing) were around 1,200 to 2,000 km² (Walton, 2000), so habitat disruption during summer has a larger relative effect. Thus, potential disruptions to den sites or foraging opportunities during pup-rearing could have greater consequences for the population.

Wolves possess demographic characteristics, especially their high productivity and dispersal capabilities, that provide them with resiliency to modest levels of human disturbance of their habitat and populations (Weaver *et al.*, 1996). However, there exists a threshold, and human activities and developments have been implicated in wolf declines and extirpations (Mech, 1995, Clark *et al.*, 1996). Wolf population sizes in the NWT are unknown, and variable and unpredictable mortality levels may act cumulatively with other perturbations to negatively affect populations.

Wolverines have relatively low demographic resilience and may be even more vulnerable to population perturbations than grizzly bears (Weaver *et al.*, 1996). Habitat loss and disruption related to the proposed development are unlikely to substantially affect regional wolverine populations, but even the low risk of development-related mortality warrants concern.

Overall, effects of the proposed development of the Sable, Pigeon, and Beartooth pipes and associated roads on Arctic and red foxes are predicted to:

- apply to a few individuals of the local population;
- persist over more than one decade;
- apply continuously to resident individuals;
- be reversible in less than 10 years post-operation;
- not reduce the population size or ecosystem function; and
- be of negligible significance (Table 4.6-9).

For wolves and wolverines, predicted effects will:

- apply to a portion of the regional population;
- persist over more than one decade;
- apply in an unpredictable, episodic manner for a few days per year;
- be reversible in less than 10 years post-operation;
- possibly reduce the population size or ecosystem function; and
- be of minor significance (Table 4.6-9).

4.6.1.3.5 Birds

Overall, effects of the proposed development of the Sable, Pigeon, and Beartooth pipes and associated roads on birds are predicted to:

Table 4.6-9
Summary of Predicted Effects of the Proposed Development on Furbearers

Criteria	Comments
Geographic Extent	**Foxes:** The overall effects on Arctic and red foxes from the proposed development are expected to be negligible at the local, regional, and greater levels. **Wolverines:** Individuals with home ranges intersecting the proposed development will experience habitat loss and disruption, and may be exposed to mine-related mortality risk. Because of their large home ranges and extensive movements, those wolverines comprise the regional population. **Wolves:** Individual wolves with home ranges intersecting the proposed development will experience habitat loss and disruption, and may be exposed to mine-related mortality risk. Because of their large annual home ranges and extensive movements, those wolves comprise the regional population.
Duration	For all species, the duration of disturbance effects will be long-term and will coincide with the operational life of the proposed development. Negligible habitat loss will persist until revegetation of pits and roads.
Frequency	Individual foxes may be exposed to disturbance continuously within their home ranges. Individual wolves, during spring-fall and potentially during winter. Wolverines will be exposed to disturbance episodically throughout the year. It is predictable that some individuals will be exposed, and predictable that some residents will be exposed repeatedly during a year. Effects will reoccur on an annual basis.
Reversibility	Upon termination of mining activities, disturbance effects will cease. Negligible habitat alteration will persist. Site reclamation and natural revegetation will restore pads and roads to useable habitat.
Ecological Context/Sustainability	**Foxes:** Negligible habitat and mortality effects will be felt within the immediate vicinity of the development. **Wolverines:** Minor effects will be felt within the immediate vicinity of the development. Movements through the EKATI™ area may also extend beyond the regional study area boundaries. Low population productivity requires that even a few mortalities be considered significant. **Wolves:** Minor effects will be felt within the immediate vicinity of the development. Wolves migrate well beyond the regional study area, so affected individuals are part of the greater-than-regional population.
General Significance Category	Predicted effects on Arctic and red foxes will be **negligible**. Effects on wolves, and wolverines are not likely to negatively affect the sustainability of the regional or greater-than-regional populations. The significance of habitat disruption, and the consequences of even a very low number of mortalities, drive the overall significance rating to **minor**.

- apply to a few individuals, of several species, of the local populations;
- persist over more than one decade;
- apply continuously to resident (including nesting) individuals;
- be reversible in less than 10 years post-operation;
- not reduce the population size or ecosystem function; and
- be of negligible significance (Table 4.6-10).

Table 4.6-10
Summary of Predicted Effects of the Proposed Development on Birds

Criteria	Comments
Geographic Extent	The effects of the proposed development will be local, and limited to those birds with territories adjacent to development.
Duration	Those effects that do manifest themselves will be seasonal, while birds are present during spring and summer. A few species are annual residents and would therefore potentially be exposed to activities year-round. Duration will be long-term, but will subside after human activity ceases.
Frequency	The frequency of effects will be continuous for individuals nesting adjacent to the proposed development, and will reoccur on an annual basis.
Reversibility	Upon termination of mining activities, disturbance effects will cease. Negligible habitat alteration will persist. Site reclamation and natural revegetation will restore pads and roads to useable habitat.
Ecological Context/Sustainability	Birds affected by the proposed development represent a very small fraction of the population at the local, regional, or greater-than-regional levels. Integrity of bird populations and habitats will not be affected at the local, regional and greater levels.
General Significance Category	The effects on birds from the proposed development are predicted to be **negligible**.

4.7 Effects on the Social, Cultural and Economic Environment

4.7.1 Approach

The addition of the Sable, Pigeon and Beartooth pipes to the EKATI™ mine plan will not change the pace or scale of the current or planned operations at the mine. Therefore, this Environmental Assessment Report (EAR) views the potential socio-economic effects of the proposed development on the northern economy as part of overall effects of EKATI™ operations.

The proposed development will allow the mine to continue operating at the 18,000 tonnes per day (t/d) production level for three years beyond the current life of the mine. The assessment methodology employed herein is intended to complement the methods used in the EIS (BHP, 1995) to analyze the socio-economic effects of mining operations at EKATI™. In general, the analysis and predictions outlined in the EIS are still valid and form a significant part of the current analysis. In this EAR, many of the economic impacts have been restated to reflect the effects of the three-pipe addition; the availability of more current BHP expenditure and employment data; and recent changes to the tax system and fiscal arrangements between the GNWT and the federal government.

The 1995 BHP Environmental Impact Statement (EIS) assessed the potential socio-economic effects of building and operating the EKATI™ Diamond Mine (formerly known as the NWT Diamonds Project) in the NWT. The EIS analysis was based on a review of two factors: supply and demand. The Northwest Territories – its peoples, businesses, infrastructure and resources – represented the supply side. BHP represented the demand side, with its need for staffing, goods and services and infrastructure.

In determining the potential socio-economic effects of EKATI™, the EIS developed a baseline against which change could be compared. Baseline data for economics, income, population, *etc.*, were analyzed extensively in that document. This information was also used to examine the potential effects of the construction and operational phases of the project. The operational analysis in the EIS was based on the mine operating at two benchmark stages of production: 9,000 t/d in 2000, expanding to 18,000 t/d by 2007.

The currently proposed development is expected to maintain the following socio-economic effects of the 18,000 t/d operation:

- the total EKATI™ mine employment and income benefits;
- the purchase of goods and services needed to supply the EKATI™ mine;
- the residual social effects on NWT and Nunavut communities related to EKATI™ employment and income; and
- the economic benefits to the NWT and Canada.

As stated above, the integration of the three pipes will not significantly alter the analyses and predictions documented in the 1995 EIS (BHP, 1995). As such, valid estimates and conclusions from the EIS will be repeated where appropriate. Changes in the context of the 1995 EIS or the Socio-Economic Agreement will be noted when applicable.

4.7.2 Classification of Effects

The magnitude of effects arising from the proposed development has been examined and classified according to the criteria outlined below.

4.7.2.1 Geographic Extent

Although the former Northwest Territories now constitutes two geo-political territories, the analysis of the potential effects of the Sable, Pigeon and Beartooth development will continue to focus on the Northwest Territories and the same communities where employment, income and biophysical change may be expected:

- Treaty 11 Dogrib communities of Rae-Edzo, Wha Ti, Rae Lakes (Gameti) and Snare Lakes (Wekweti);
- Treaty 8 Akaitcho communities of Dettah, N'dilo and Lutsel K'e;
- Kugluktuk; and
- Yellowknife.

An effect is considered to be local if it applies to the directly affected communities and their residents. If an effect extends beyond the directly affected communities but not outside the NWT, it is considered to be regional.

4.7.2.2 Duration

The assessment considers the duration of effects resulting from Sable, Pigeon and Beartooth pipe production. For consistency with the EIS, any change to mine closure and post-closure effects resulting from Sable, Pigeon and Beartooth production is taken into account. The duration of effects may be:

- Short-term: less than one generation (less than 30 years)
- Medium-term: one generation, people born to those alive today (30 to 60 years)
- Long-term: more than one generation (more than 60 years).

Effects are classified as minor, moderate and major if the effect duration is short-, medium- or long-term.

4.7.2.3 Frequency

Effects are classified as low, medium and high if the effect frequency is only once, occasionally or regularly.

4.7.2.4 Summary

In summary, the analysis of the potential effects of the proposed development builds on:

- the 1995 EIS and the impact and benefit predictions contained in that document when no change is anticipated to the pace or scale of development;
- BHP's internal policies, procedures and practices;
- the Socio-Economic Agreement, specifically with respect to the supply of people, business and resources in the NWT to meet the ongoing operational needs of EKATI™; and
- the IBAs. It should be noted that the IBAs will be referenced in general terms or used in aggregate statistics because of their confidentiality provisions.

4.7.3 BHP Operations in 1999

Wage and salary information from the first full year of operations indicates that direct benefits to Aboriginal and northern employees (in all skill categories) were consistent with, and in many cases higher than, those forecast in the EIS (BHP, 1995). Specifically:

- In 1999, the actual BHP and contractor hiring rates of northern resident and Aboriginal employees was 69.8% of the total EKATI™ workforce. Northern Aboriginal employment was 33.2% of total employment. These rates were higher than the Socio-Economic Agreement target levels (Socio-Economic 1999 Annual Report). This, combined with a 10% turnover rate during the first year of EKATI™ production, indicates that the employment benefit for Aboriginal and northern residents predicted in the EIS are being met.
- At 14%, the ratio of women in the EKATI™ workforce was three times higher in 1999 than the ratio of women employed in the mining industry reported in the EIS (BHP, 1995). Fifty percent of the women employed at EKATI™ are Aboriginal.
- The average direct income and benefits paid to northern residents and Aboriginal employees in the first year of production are slightly higher than the levels forecast in the EIS (BHP, 1995).

4.7.4 Predicted Effects on the Economy

BHP is committed to northern-preference hiring and purchasing policies and agreements, and hopes to contribute long-term socio-economic benefits to the NWT. The EIS determined that employment and income could potentially have the greatest socio-economic effects on the NWT economy over the life of EKATI™. The extent of these effects depends upon BHP's expenditures in the NWT. The level of expenditures, in turn, depends on the ability of the NWT labour force and business sector to fulfill the employment and goods and services requirements at the mine (BHP, 1995).

The impacts of the three-pipe addition were analyzed using four variables or areas: Gross Domestic Product, employment, labour income and government finances.

Estimates of these economic impacts were made from simulations based on the most recent project data on employment, income and production. The economic impact (input-output) model used for the NWT estimates was developed by Ellis Consulting Services. This model is almost identical to the one used by the Input-Output Division of Statistics Canada and is highly disaggregated, covering a potential of 162 industries and 485 commodities.

The simulations provide estimates of both the direct impacts associated with on-site production from the three pipes and the impacts generated by "spin-off" from this activity. The spin-off impacts are referred to as "indirect" and "induced" and are calculated as multipliers.

Direct impacts are derived from BHP employment and production at the mine site. Indirect impacts include economic activity associated with employees and contractors at the mine site and with firms in the production chain that supply goods and services to the mine.

Induced impacts result from the spending of wages (after withdrawing a portion for taxes and savings) earned by employees involved in direct and indirect production on consumer goods and services. This spending increases the demand for commodities and production in the NWT.

All dollar values presented in this analysis are measured in constant 1999 dollars. All employment or jobs are expressed in person-years.

4.7.4.1 GDP in the NWT

Continuation of production at the EKATI™ Diamond Mine through the addition of the Sable, Pigeon and Beartooth pipes is predicted to have a significant impact on the NWT Gross Domestic Product (GDP). As shown in Table 4.7-1, the three pipes are estimated to contribute $973 million ($324 million annually) to GDP in the NWT.

Table 4.7-1
Contribution of the Beartooth, Sable and Pigeon Pipes to NWT GDP

	Direct ($million)	Indirect ($million)	Induced ($million)	Total ($million)
Total	787	117	69	973
Annual Average	262	39	23	324

Source: Ellis Consulting Services.

One method of demonstrating this impact is to compare its relative significance to the total economy. For example, in 1998 total GDP for the NWT (including Nunavut) was $2.4 billion. The direct contribution to GDP from the addition of these three pipes therefore represents 11% of the total economy in 1998. If all impacts (including indirect and induced) are considered, the total contribution from the three pipes represents 14% of GDP in 1998.

4.7.4.2 Employment in the NWT

The Sable, Pigeon and Beartooth development is predicted to have a large impact on employment in the NWT. As shown in Table 4.7-2, an estimated 4,108 person-years of employment will be maintained for three years by the addition of these three pipes. This includes direct, indirect and induced employment.

Table 4.7-2
Contribution of the Sable, Pigeon and Beartooth Pipes to NWT Employment

	Direct (Person-Years)	Indirect (Person-Years)	Induced (Person-Years)	Total (Person-Years)
Total NWT	1,899	1,442	768	4,108
Non-Aboriginal	950	1,008	537	2,495
Aboriginal	950	432	231	1,613
Annual NWT	633	481	256	1,369
Non-Aboriginal	317	336	179	832
Aboriginal	317	144	77	538

Source: Ellis Consulting Services.

Aboriginal participation in the proposed development is expected to remain as predicted in the EIS (BHP, 1995), at 39% to 40% of the total direct, indirect and induced employment. It is expected that Aboriginal northerners would receive 950 (317 annually) of the direct BHP person-years of employment. As predicted in the EIS, the development would increase the number of women in mining. Women account for 4% of employees in the overall Canadian mining industry (Statistics Canada) but 14% of the EKATI™ workforce in 1999.

The EIS (BHP, 1995) prediction that unemployment in the NWT would decrease by at least 3% during the operations phase remains the same.

One method of demonstrating the significance of the employment impacts is to compare their relative significance to the total employment in the economy. For example, in 1999 total employment in the NWT (excluding Nunavut) was just under 19,000. The direct contribution to employment represented by the three pipes is 3%, or one job in thirty, in the NWT in 1999. If all impacts (including indirect and induced) are considered, total employment represented by the three pipes is 7%, or more than one job in fifteen in the NWT in 1999.

4.7.4.3 Labour Income in the NWT

The development is expected to contribute almost $250 million ($81.9 million annually) to NWT labour income and to increase NWT labour income by at least 5% per year during operations. This would include substantial wage income increases in Aboriginal communities, as predicted in the EIS. Table 4.7-3 shows the breakdown between direct, indirect and induced labour income.

Table 4.7-3
Contribution of the Beartooth, Sable and Pigeon Pipes to NWT Labour Income

	Direct ($000s)	Indirect ($000s)	Induced ($000s)	Total ($000s)
Total	131,196	81,259	33,271	245,726
Annual Average	43,732	27,086	11,090	81,909

Source: Ellis Consulting Services.

4.7.4.4 Government Finances

Table 4.7-4 summarizes total direct tax revenues accruing to the federal and territorial governments from the three-pipe development. Additional tax revenues would accrue to the federal and other provincial governments from taxes paid by workers at the BHP site who do not live in the NWT.

4.7.4.4.1 Federal Government Finances

4.7.4.4.1.1 Federal Government Revenues

As shown in Table 4.7-4, it is estimated that the federal government will receive an estimated $337 million ($112 million annually) in total tax revenues. The largest tax source would be corporate income tax, at $142 million ($47 million annually). Mining royalties would account for $91 million ($30 million annually) and personal income taxes $40 million ($13 million annually).

Table 4.7-4
Total Tax Revenues from Sable, Pigeon and Beartooth Pipes

Tax Category	NWT ($million)	Federal ($million)	Total ($million)
Fuel Tax	12.0	4.0	16.0
Property Tax	2.0	0	2.0
Surface Rights Fees	0	3.0	3.0
Corporate Income Tax	68.2	141.9	210.1
Mining Royalties	0	91.0	91.0
Dividend Withholding Tax	0	9.0	9.0
Tax on Can. Dividends	0	31.0	31.0
Personal Income Tax	17.3	39.6	56.9
NWT Payroll Tax (Net)	0.2	0	0.2
UI Premium	0	9.4	9.4
CPP Premium	0	7.9	7.9
Total	**99.8**	**336.8**	**436.6**

Source: Ellis Consulting Services

4.7.4.4.1.2 Federal Government Expenditures

The EIS (BHP, 1995) estimated that the EKATI™ Diamond Mine would add about $4.0 million each year to federal expenditures, based on average estimated per capita costs in 1991. This was based on data before the division of the NWT; without Nunavut, per capita costs are likely to be less. Also, with the addition of Diavik Diamonds Project, expenditures will be further reduced; nevertheless, the EIS predictions will be used. Thus, costs to the federal government of $4.0 million for each of three years would total of $12.0 million.

4.7.4.4.1.3 Federal Government Net Finances

The federal government would receive $337 million ($112 million annually) in revenues and at the same time incur increased expenditures of $12 million ($4 million annually), for a net positive change of $325 million ($108 million annually).

4.7.4.4.2 Territorial Government Finances

4.7.4.4.2.1 Territorial Government Revenues

The EIS (BHP, 1995) identified two potential effects on territorial government revenues. The first was the annual direct and indirect tax revenues that would accrue to the territorial government as a result of spending by BHP, its employees, suppliers and

supplier employees. The second was the Formula Finance Grant received by the territorial government from the federal government.

As shown in Table 4.7-4, the GNWT would receive $100 million ($33 million annually) in tax income from direct economic activity[6] related to the project. The largest tax sources would be corporate income tax of $68 million ($23 million annually), personal income taxes of $17 million ($6 million annually) and fuel taxes of $12 million ($4 million annually).

The Formula Finance Grant (FFG) provides an annual grant entitlement, which varies depending on incremental revenues received by the territorial government. The EIS estimated the impact on the FFG of increased revenues and population growth resulting from the EKATI™ Diamond Mine.

Since the EIS was prepared, a significant change has been made to the FFG structure. The "perversity" factor has been removed (or reduced), and now the NWT actually retains a portion (albeit a relatively small one) of new eligible revenues[7]. The new grant structure[8] would result in a claw-back of about 82% of GNWT tax revenues relating to the EKATI™ Diamond Mine. This means that although GNWT tax revenues would increase $100 million ($33 million annually), there would also be a drop in the FFG of $82 million ($27 million annually), leaving the GNWT with a net positive increase of $18 million ($6 million annually) in revenues.

4.7.4.4.2.2 *Territorial Government Expenditures*

The EIS (BHP, 1995) anticipated increased territorial government spending due to population growth relating to the NWT Diamonds Project. These were identified as the variable costs of government services associated with people moving to the NWT, including more schools, health services, regulatory personnel and funding for social agencies. The additional costs were estimated by first dividing the GNWT budget by the population to arrive at an average cost of $19,000 per person. It was then assumed that per capita costs were likely much higher in remote locations than in Yellowknife and Hay

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[6] There would also be tax revenues accruing to governments from income earning from indirect and induced economic activity related to the proposed project.

[7] It is expected that with the new FFG the GNWT would "retain" approximately 18% of tax revenues received from the project (based on work done by Ellis Consulting Services from data received from the GNWT Department of Finance). It should also be noted that changes to the grant have no net impact on overall government revenues from the national perspective. For example, a drop in the grant of $25 million reduces territorial revenues by that amount but at the same time reduces federal expenditures by the same amount.

[8] The NWT has received cash transfers from the federal government under a formula financing arrangement since 1985-86. The principle behind the Formula Financing Agreement is similar to the federal-provincial Equalization program: that less well off jurisdictions should receive funding to allow them to provide reasonably comparable levels of public services at reasonably comparable levels of taxation. The Grant represents the difference between the GNWT expenditure needs and its revenue-raising capacity. The formula used to determine the grant is the following: Grant = Gross Expenditure Base – Eligible Revenues. When the EIS was prepared, the formula in place reflected the lower "tax effort" of the NWT to the Canadian average, and the grant was actually reduced by more than new eligible revenues. For example, for every $1.00 in new income tax revenues collected by the territorial government, the grant was reduced by $1.30. In the EIS (BHP, 1995) it was therefore anticipated that the revenues accruing to the territorial government from the Grant would be eroded at a rate greater than the increase in project related tax revenues.

River, where the new project-related in-migration was predicted to occur. It also recognized that many of the GNWT expenditures were "fixed" and would not vary with a change in population. As a result of these considerations, an estimate of $10,000 was adopted as an additional cost to the territorial government for each new in-migrant to the NWT resulting from the NWT Diamonds Project. The EIS estimated that project-generated population growth would be 1,000 people, for a total of $10 million annually.

Based on the relatively strong economy in 1995, the EIS predicted that the EKATI™ mine would "drive" in-migration and lead to significant growth in the population of the NWT. Current population data for the NWT, given in Table 4.7-5, show that the predicted population growth did not occur; the population in June 1999 was almost identical to the population in June 1994. The positive net in-migration shown for 1999 may be attributable in part to the start-up of the EKATI™ Diamond Mine, but the minimal overall change to the population of the NWT has two important consequences:

- Since project-related in-migration has not led to strong population growth, GNWT expenditure demands have not increased.
- Without the EKATI™ mine, the population of the NWT might have continued to decline in 1999. Because the FFG is driven in large part by population growth, this would eventually lead to a reduction in the overall territorial government budget. In addition, because a significant portion of government expenditures are fixed, the per capita costs of government could actually rise, leaving the territorial government in a worse fiscal position.

Table 4.7-5
NWT Population (1992 to 1999)

Year	Population June 30th	Net Annual In-Migration
1992	39,400	-213
1993	39,900	41
1994	41,700	124
1995	41,500	-399
1996	41,829	-603
1997	41,814	-785
1998	41,015	-812
1999	41,270	*141

Source: Statistics Canada.
***Includes only January to September 1999.**

Therefore, it is unlikely that the territorial government has incurred or will experience the annual $10 million increase in expenditures predicted to result from the EKATI™ mine.

The EIS (BHP, 1995) further estimated that the EKATI™ mine, operating at 9,000 t/d, could result in the creation of 851 new jobs in the NWT in 2000. It was expected that more than 600 of these jobs would be filled by existing NWT residents, including 400

previously unemployed persons. The change in status of these people would lead to savings for the territorial government in three potential areas:

- Social Assistance Payments
  The EIS assumed that all 400 unemployed persons were on social assistance and used an average annual saving of $3,500 per person, to arrive at a total annual saving of $1.4 million.
- Social Housing Payments
  The EIS assumed that all 400 unemployed persons lived in public housing and would be paying minimum rent. It assumed that half would remain in public housing but pay an average $500 more rent per month, to arrive at an estimated annual saving of $1.2 million.
- Grants, Other Assistance
  The EIS estimated a saving of $0.4 million in grants and assistance programs for all sectors of the economy, reflecting a more buoyant economy.

In total, the EIS estimated annual savings to the territorial government of $3.0 million for the 9,000 t/d production cycle of EKATI™. By providing three more years of production at 18,000 t/d, the three new development pipes will result in even greater savings.

With the addition of the three pipes, the predicted employment level is 1,369 person-years, which is an increase of 61% over the 851 person-years predicted in the EIS at the 9,000 t/d level of operation. Therefore, if the same assumptions hold, the savings to the territorial government with the addition of the three new pipes will be $4.8 million per year.

4.7.4.4.2.3 Territorial Government Net Finances

The territorial government would receive $100 million ($33 million annually) in revenues and at the same time have a reduction in expenditures of $14 million ($5 million annually), for a net positive change of $114 million ($38 million annually). After the impact on the FFG is taken into account, the net positive change of $114 million ($38 million annually) would fall to $32 million ($11 million annually).

4.7.4.4.3 Municipal Government Finances

The EIS stated that public infrastructure and services in all local communities likely to be affected had sufficient capacity to absorb any anticipated project-related population increases. As shown in Table 4.7-5, the population of the NWT has remained stable; hence, there should be no new demands on public infrastructure and services. The impact of the EKATI™ Diamond Mine has been positive, however, as mine-related in-migration has helped to protect the tax base of local communities that would otherwise have been eroded.

4.7.4.5 Summary

In summary, the proposed development will not change the significance of residual annual employment, income and government finance effects on the northern economy predicted in the EIS. These effects will continue to be major and positive. The pace and scale of the development will have no additional effects other than those anticipated in the EIS.

4.7.5 Opportunities for Northern Businesses

The opportunities for local, regional and territorial businesses will be maintained for three more years as a result of the proposed development. An equivalent of $234.9 million (three years x $78.3 million annual purchasing rate at 18,000 t/d) in incremental purchases will be made through northern and Aboriginal businesses as a result of this development.

With the three-pipe addition, BHP will continue its northern purchasing objectives as outlined in the Socio-Economic Agreement as well as those agreed to in the IBAs. BHP has instituted preferential purchasing opportunities and a number of other business development initiatives that actively encourage the participation of local, Aboriginal, regional and territorial businesses. Under the Socio-Economic Agreement and BHP's internal policies, BHP commited to the following objectives to create opportunities for northern businesses:

- During construction, 28% of the total annual value of goods and services was to be supplied by local businesses.
- During operations, 70% of the total annual value of goods and services will be supplied by local businesses.
- The procurement offices for EKATI™ are in Yellowknife and at the mine site.
- Among other services, air charter, catering and janitorial services, are tendered in unbundled contracts, which promotes northern and Aboriginal business bids on EKATI™ contracts.
- BHP encourages southern suppliers to affiliate with local and Aboriginal business or, alternatively, for southern suppliers to establish a presence in the North.
- BHP purchasing agents inform IBA impact communities and local businesses of upcoming contracts and tenders.
- All contracts are reviewed monthly, and contractors are monitored for northern resident and Aboriginal hiring.

Additionally, IBA commitments give preferential considerations to local Aboriginal businesses or to joint ventures associated with Aboriginal local businesses.

The business opportunities for local, regional and territorial businesses will not change as a result of the three-pipe development.

4.7.5.1 Effects of Local Purchases on Northern Businesses

BHP's northern and Aboriginal purchasing policy will continue throughout the development and operation of the three pipes. Statistics from the construction phase and first year of production underscore the company's economic contributions to northern and Aboriginal businesses in the NWT. They also demonstrate the local/regional ability to meet the opportunities created by contractor and new employee spending:

- Construction phase (1997-1998) northern purchases totalled $321 million ($150 million in 1997 and $171 million and 1998), almost $145 million more than expected during mine construction (Table 4.7-6).
- Of the total northern purchases during construction, the average northern value is calculated at $64 million, almost $30 million more than was predicted in the EIS (BHP, 1995). Of the money earned from local purchases, 20% is re-invested in the North.
- During construction, benefits from local purchases flowed primarily to the larger centres of Yellowknife and Hay River. However, BHP purchased $103 million of goods and services from the Aboriginal business community – approximately 15% of the total company purchases.
- The Yellowknife business community alone supplied more than twice the value of purchases originally estimated for the construction phase in the EIS.
- Total BHP purchases during the construction phase exceeded the EIS prediction by $53 million (BHP, 1995).
- Cumulative totals of northern and Aboriginal purchases for the construction phase exceeded $600 million.

Table 4.7-6
EKATI™ Purchase of Goods and Services in the North – Construction Phase (1997-1998)

Location of Purchase	Value of Construction Purchases	Percentage of EKATI™ Total
NWT Businesses	$321,378,641	46.7%
Aboriginal Businesses	$102,821,402	14.9%
EKATI™ Total	$688,708,266	100%

Source: BHP Diamonds Inc.
***Northern purchases include purchases from Aboriginal businesses.**
†Aboriginal purchases are shown as a percent of total NWT purchases.

In the first year of operations (Table 4.7-7) local purchases totalled more than $280 million, representing 78.7% of all purchases. This exceeded EIS expectations (BHP, 1995) and the Socio-Economic Agreement objective of 70%.

Table 4.7-7
EKATI™ Purchase of Goods and Services in the North – Operations Phase (1999)

Location of Purchase	Value of Purchases	Percentage of EKATI™ Total
NWT Businesses	$280,329,483*	78.7%
Aboriginal Businesses	$51,833,130	14.6%†
EKATI™ Total	$356,072,300	100.0%

Source: BHP Diamonds Inc.
***Northern purchases include purchases from Aboriginal businesses.**
†Aboriginal purchases are shown as a percent of total NWT purchases.

The northern expenditures on goods and services in the "ramp-up"[9] year totalled 46.7%, which was higher than EIS predictions of 28% (Table 4.7-6). Local businesses successfully supplied EKATI™ with the needed goods and services during the construction phase and the first year of production at the 9000 t/d production level. This demonstrates the ability of local businesses to meet, and/or exceed, Socio-Economic Agreement operational target levels for supply of goods and services at 9000 t/d. Further, it shows that local businesses have already met supply levels for the predicted 18,000 t/d production levels.

4.7.5.2 Summary

It is predicted that opportunities for local, Aboriginal, regional and territorial businesses to meet the EKATI™ purchasing demands during the additional three years of operations created by the proposed development will continue. The pace and scale of the development will cause no additional effect on or disruption of the ability of local business to meet these demands.

The integration of the three pipes into the mine plan will maintain opportunities for the sale of goods and services for northern businesses. As such, the residual effect on the economy predicted in the EIS remains the same. The integration of the three pipes will maintain the moderate positive residual effect identified in the EIS.

4.7.6 Economic Diversification

Historically, economic development in the NWT has been largely dependent on gold mining, government and oil and gas developments. BHP's commitment to purchasing a significant percentage of goods and services in NWT communities promotes economic diversification on the local, regional and territorial level. These purchases provide

[9] **Ramp-up occurs in the early stages of production and lasts until mining systems are "fine tuned." Additional equipment, infrastructure and specialized labour may be required resulting in unusually higher production costs.**

opportunities for business expansion and the creation of new, specialized services related to EKATI™. These benefits will continue with the Sable, Pigeon and Beartooth development.

The EIS predicted that the main providers of goods and services would be in the larger centres of Yellowknife and Hay River, and that these communities would benefit most from EKATI™ activities (BHP, 1995). In 1999, BHP spent more than $271 million in Yellowknife and approximately $8.9 million in Hay River, for total northern spending in excess of $280 million.

Table 4.7-8 presents actual BHP spending for 1999. The level and distribution of these expenditures indicate the significance of BHP's role in diversifying and strengthening the NWT economy.

Table 4.7-8
Total 1999 EKATI™ Expenditures

Expenditures	Total Northern ($)	Other ($)	Total ($)
Air Support	6,980,000	69,000	7,050,000
Rent and Accommodations	452,000	39,000	491,000
Land Freight	3,413,000	0	3,413,000
Contractors	7,337,000	28,000	7,365,000
Northern Labour Service	8,428,000	305,000	8,733,000
Community Relations	234,000	0	234,000
Goods and Services	204,635,000	75,168,000	279,802,000
Capital Equipment	60,000,000	0	60,000,000
Contract Labour	10,507,000	10,227,000	20,734,000
Other Goods and Services	134,128,000	64,941,000	199,068,000
Fuel	31,732,000	0	31,732,000
Fees, Licences, Assessments	17,121,000	134,000	17,254,000
Total Purchases	**$280,329,000**	**$75,743,000**	**$356,072,000**

Source: BHP Diamonds Inc.

Diversification of the northern economic base occurred largely during construction and in 1999, when BHP was "ramping up" to full production at EKATI™. In the first year of operations (January to December 1999) BHP made 78.7% of all EKATI™ purchases locally. Seventy-three percent of that local purchase total was for goods and services, and 11% was for fuel.

Throughout construction and the first year of operations, the northern business community built significant capacity through joint ventures, alliances with distributors, expansion of existing northern businesses and establishment of new ones to meet the purchasing demands of the mine. As an example, the North Slave Metis has formed three joint ventures with companies based in the south and is looking at establishing another with a local company. Further opportunities for business development remain, especially in the area of steel fabrication and parts distribution for the Process Plant at EKATI™.

As indicated previously in Section 4.7.1.2, BHP encourages southern suppliers to affiliate with local and Aboriginal business or, alternatively, to establish a presence in the North.

Value-added activities have also been established as a result of the EKATI™ mine, including the BHP sorting and valuation facility and local diamond cutting and polishing firms. BHP has entered into arrangements to supply three Yellowknife-based companies with rough diamonds for cutting and polishing in the NWT. One facility is currently in operation (30 to 40 employees) and the other two under construction. Once fully operational, these local operations are expected to process about 10% of the value of total production from the EKATI™ mine. The three-pipe development will maintain a continuous supply of rough diamonds to these Yellowknife-based facilities. Cutting and polishing manufacturers, in partnership with Aboriginal development corporations and government, are making significant expenditures on infrastructure, equipment and specialized training to establish and expand this new value-added industry in the north.

Local manufacturing provides additional indirect and induced employment opportunities beyond the levels identified in the EIS. The BHP sorting and valuation facility provides employment related to security, administration, sorting, training and federal government valuation. The long-term viability of local value-added activities will be enhanced as a result of continued mine operation.

Another method of demonstrating the scale of impact BHP will have on diversifying the northern economy is to observe its effect on industries other than direct mining in the NWT. Table 4.7-9 presents estimates of the value of the spin-off (*i.e.*, indirect and induced) impacts from the direct mine activity.

It is estimated that the indirect and induced impact resulting from direct mine production would lead to a $61.9 million rise in GDP, $38.1 million in labour income and 736 person-years of employment in the NWT.

The predicted results on Table 4.7-9 show that the economic impacts would be distributed across a wide range of industries. For example, although about one-quarter of the contribution to total employment would be in the services incidental to the mining[10] industry group (24%), over three-quarters of the impacts would be generated in industries outside of mining. Transportation industries would provide 23% of the employment, while the community and business services industries and retail trade industries would provide 20% and 12%, respectively. This illustrates that the spin-off impacts would be dispersed across a range of industries and would help to diversify the economy by strengthening industrial sectors outside of mining.

[10] **Businesses in the "services incidental to mining" category include firms providing contract drilling, blasting and other specific services to the mining industry.**

4.7.6.1 Summary

The effect of the proposed development on opportunities for diversification will continue to be short-term, frequent and primarily local. The significance of the residual effect will not change, remaining moderate and positive as predicted in the EIS.

Table 4.7-9
Sable, Pigeon and Beartooth Pipes
Indirect and Induced Impact on the NWT Economy by Industry

	GDP at Factor Cost		Labour Income		Employment	
	($000s)	(%)	($000s)	(%)	(PYs)	(%)
Agricultural and Related Service Industries	39	0.1	17	0.0	0	0.0
Fishing and Trapping Industries	19	0.0	4	0.0	1	0.2
Logging and Forestry Industries	23	0.0	8	0.0	0	0.0
Mining, Quarrying and Oil Well Industries	16,113	26.0	13,328	34.9	178	24.2
Manufacturing Industries	410	0.7	264	0.7	9	1.2
Construction Industries	1,657	2.7	1,033	2.7	11	1.5
Transportation and Storage Industries	12,267	19.8	8,429	22.1	171	23.2
Communication Industries	2,770	4.5	1,289	3.4	17	2.3
Other Utility Industries	1,485	2.4	378	1.0	8	1.1
Wholesale Trade Industries	1,383	2.2	918	2.4	24	3.2
Retail Trade Industries	3,597	5.8	3,230	8.5	86	11.6
Finance, Insurance and Real Estate Industries	16,081	26.0	4,555	11.9	50	6.7
Community, Business, Personal Services	5,174	8.4	3,855	10.1	145	19.7
Households	902	1.5	868	2.3	37	5.0
Total	61,920	100.0	38,177	100.0	736	100.0

Source: Ellis Consulting Services.

4.7.7 Barriers to Employment

BHP has committed to removing or reducing barriers to employment through strategies outlined in the EIS, the Socio-economic Agreement and the IBAs. The company's success at reducing barriers to employment thus far is evidenced by the diversity (educational, ethnicity, gender) of the workforce currently employed at EKATI™. These policies will be in effect for the duration of the EKATI™ Diamond Mine.

At community meetings and other public consultations during the 1995 environmental assessment, NWT residents identified three main barriers to northern resident and Aboriginal employment in the mining industry: education, training and experience (BHP, 1995). The three employment barriers cited most often by mining companies were lack of experience, very few or no job applications from Aboriginals and an inadequate number of jobs.

BHP has implemented hiring, recruitment and training initiatives to reduce employment barriers for Aboriginal and northern residents (BHP, 1995). These initiatives include:

- northern and Aboriginal employment preference and specific IBA provisions regarding Aboriginal barriers;
- aggressive recruitment and advertising for job opportunities at EKATI™ in Aboriginal and northern communities;
- hiring employees who have varying levels of education, relevant experience and aptitude;
- requiring contractors to adhere to BHP's policy of northern and Aboriginal preferential hiring;
- Aboriginal consultations. Each IBA has a representative who monitors the IBA commitments and liaises with BHP's Aboriginal Affairs Senior Advisor and Aboriginal Employment Coordinator. Their duties include promoting and facilitating Aboriginal recruitment and employment;
- free transportation for employees coming from point-of-hire communities that are remote and could possibly be inaccessible to the wage economy;
- work place support systems such as Drug and Alcohol and Employment Assistance Programs, literacy classes and money management;
- training including employee trades certification and literacy;
- opportunities for job transfers and advancement at EKATI™; and
- employing women in non-traditional job positions.

BHP is committed to creating and maintaining a culturally diverse workforce at EKATI™ Diamond Mine. By implementing the following education and training programs, BHP is actively reducing barriers, retaining employees and promoting a stable workforce:

- All BHP employees are required to complete a full orientation program, including Cross Cultural Awareness training.
- A second level, Cross Cultural Awareness course is mandatory for all managers.
- Long-term contractors are required to complete the BHP Diamonds Inc. orientation program.
- Training Progression Plans are available for employees. All employees are eligible and considered part of the plan upon hire. The employee's motivation and ability to perform required tasks guides their progress through the plan and opportunities to gain certification and career development.
- BHP Diamonds Inc. supports certification of its workers and currently has 14 apprentices in the following areas: millwright, welder, heavy-duty mechanic, instrumentation, electrical and heavy equipment operations.
- All training at BHP Diamonds Inc. is competency based. Employees are required to learn the theory first, *i.e.*, safety procedures and associated hazards, and only then

may engage in hands-on training and procedures. The "buddy system" – matching a skilled and experienced worker with a trainee – is used in all instances when introducing an employee to a new area in the plant or a piece of equipment in the pit.

- Scholarship funds are established in each IBA group for eligible high school and post-secondary students. Scholarships have been provided since 1994, and scholarship recipients are given preference for summer employment.
- BHP participated in the development of Pre-Employment Mine Training at Aurora College. In 1998, BHP hired 11 of 14 graduates of the Trades Access Program.
- The optional Education Assistance Plan is a benefit available to BHP employees to enable further education.
- Youth and school programs to promote staying in school, healthy lifestyle choices and mining careers are used in Yellowknife, Fort Smith, Rae-Edzo, Rae Lakes, Wha Ti, Snare Lake, Lutsel K'e, Dettah, Ndilo, Kugluktuk and Fort Simpson.
- BHP's Human Resources staff regularly participate in career fairs to distribute career/job information and training requirements for positions. Audio-visual information is available in at least two Aboriginal languages.

The following factors were taken in consideration in assessing the potential effect of the proposed development:

- Employment demand will not change with the integration of the three kimberlite pipes into the EKATI™ mine plan.
- Of total BHP and contractor employment at EKATI™ in the first full year of production, 69.8% were northern residents and 33.3% of the total workforce was Aboriginal.
- Of EKATI™'s employees, 14% were women.
- BHP's employee turnover rate for the first year of operation is 10%.
- Thirty young people between the ages of 18 and 24 years were recruited into the EKATI™ workforce during the first production year.
- BHP has a substantial inventory of northern and Aboriginal applications to fill vacant positions.
- BHP is developing a culturally desirable workplace.

4.7.7.1 Summary

The effect of the proposed development on barriers to employment in the NWT will continue to be short-term, frequent and primarily local. The significance of the residual effect from the proposed development will remain moderate and positive as predicted in the EIS.

4.7.8 Workforce Availability

As stated throughout this analysis, the integration of Sable, Pigeon and Beartooth will create no additional demand for employment for EKATI™ at either the 9,000 t/d or 18,000 t/d production levels. Therefore, the three-pipe development will not alter the demand for wage and salary employment for EKATI™ predicted in the EIS (BHP, 1995). Based on BHP's hiring and retention achievements and labour force interest in EKATI™ in 1999 during the first year of production, the capacity of the NWT labour force to supply skilled Aboriginal and northern resident employees to EKATI™ for the development is considered to be positive. Further, BHP's implementation of workforce training initiatives and support for EKATI™ employees, such as trades certification and professional affiliation, will provide opportunities to enhance the NWT labour force in all skill categories (*i.e.*, professional, skilled, semi-skilled).

The development of the three pipes will not change the distribution of positions at EKATI™ or the expected percentage of northern labour force participation in each of the skill categories. Estimates of local and Aboriginal participation will follow EIS predictions and will approximate those objectives set out in the Socio-Economic Agreement. It is anticipated that as the mine life progresses, more Aboriginal and northern residents will be hired and promoted into higher skill levels. IBA hiring, recruitment, training and advancement provisions will also improve Aboriginal participation at all skill levels.

4.7.8.1 Employment by Skills Category

During the two levels of production, there will be two types of employment at the mine site: BHP direct employment and to a lesser extent, when operational needs arise, employment with major contractors. While BHP has provided for on-site training for its employees at all skill levels, contractors will also be needed from time to time to fulfill the need for skilled trades people. To enhance BHP's long-term goals, contractors who provide services for BHP are required to adhere to BHP's employment policies of northern and Aboriginal preferential hiring and training when applicable (see Socio-Economic Agreement for contractor policy).

The EIS stated that staffing requirements at the mine would evolve from year to year, reflecting the mix of surface and underground mining operations. However, the two levels of production selected for assessment in the EIS provide the minimum and maximum levels of EKATI™ employment. The EIS calculations factor in a gradual increase in total employment numbers to accompany the increase in production rates.

As seen in Table 4.7-10, BHP anticipated that overall proportionate levels of skill categories needed at EKATI™ in the year 2000 for the 9,000 t/d production level would favour skilled and professional people. The predictions have generally approximated the first year of operations.

At the 9,000 t/d level in year 2000, the EIS stated that 398 (62%) of the 638 NWT-based positions at EKATI™ could be filled by NWT residents, including 64% of the professional/management positions, 41% of the skilled positions and 91% of the semi-skilled/unskilled jobs (BHP, 1995).

Table 4.7-10
Direct BHP Employment Profile by Skills Category

Skill Category	EIS Prediction for Direct BHP Employment	Actual BHP Employment, 1999 (% of Total PYs)
Professional	9%	10%
Skilled	52%	46%
Semi-skilled and Unskilled	39%	44%

Source: BHP, 1999.

Northern and Aboriginal employees worked 79.4%, or 474.4 person-years, of the total 601.5 BHP person-years for the 1999 operational year. Table 4.7-11 identifies that northern and Aboriginal employees comprised 79% of the professional/management positions, 53% of the skilled and 89% of the semi-skilled/unskilled BHP person-years created by EKATI™ Diamond Mine operations. These figures do not include contractors so that a more accurate comparison can be made with the EIS and its predictions.

Table 4.7-11
BHP Direct Hires by Skill Category - Operations 1999

	EIS Prediction	1999 Operations
Skills Category	Northern and Aboriginal Positions (%)	Northern and Aboriginal (% Total PYs)
Professional	64	79
Skilled	41	53
Semi- Skilled/Unskilled	91	88
Total	**62.4**	**79.4**

Source: BHP, 1999.

The ability of BHP to hire qualified northern employees substantially beyond the EIS predictions may speak to several issues, including:

- availability of skilled workers due to layoffs and terminations of other employees in the NWT. For example, lay-off notices were issued to over 300 employees at the two Yellowknife gold mines between 1997 and 1999 and 590 GNWT employees in 1996 and 1997;
- free transportation from remote communities to the mine site and the interest of Aboriginal communities in participating in the wage economy.

For purposes of the Socio-Economic Agreement, BHP and contractor statistics are reported together for 1999 and demonstrate achievement of its objectives as well as percentages of Aboriginal and northern residents hired in each skill category.

In the first year of 1999 operations, 626 (70%) of the 898 person-years (including contractors) of NWT-based positions were filled by northerners. Aboriginal employees represented 33.2% of the northern employment (298 person-years). Not only were the EIS predictions exceeded, but the Socio-Economic Agreement objectives of 62% northern and 31% Aboriginal, respectively, were surpassed.

Further breakdown of data reported under the Socio-Economic Agreement presented in Table 4.7-12 shows the distribution of northern, Aboriginal and "Other" employees in each of the skill levels for the 1999 operational year. Northern and Aboriginal employees occupied 79% of the professional, 53% of the skilled and 86% of the semi-skilled/unskilled total number of positions created by EKATI™ mine operations.

It is anticipated that Aboriginal and northern participation estimates will approximate those predicted in the EIS and the Socio-Economic Agreement objectives over the life of the proposed development, considering:

- Northern participation has generally exceeded EIS and Socio-Economic Agreement objectives in the first year of operations and is predicted to be maintained over the life of the proposed development as well as the life of the mine.

Table 4.7-12
Distribution of Employees by Skill Category – Operations 1999

Skill Category	Aboriginal (% PYs)	Northern (% PYs)	Other (% PYs)
Professional	10	69	21
Skilled	16	37	47
Semi-Skilled/Unskilled	57	29	14

Note: Includes direct BHP and contract person-years.

- Aboriginal participation has exceeded EIS and Socio-Economic Agreement expectations in the first year of operations. Over one-third of BHP and BHP's contractors' employees at EKATI™ are Aboriginal. Estimates of Aboriginal participation will correspond to the goals set out in the EIS and Socio-Economic Agreement over the life of the proposed development as well as the life of the mine. As education, pre-employment training and on-site training opportunities are accessed by employees to enhance their skills, Aboriginal participation will increase from present levels in semi-skilled, skilled and professional categories. The IBAs also contain provisions ensuring preferential hiring, training and other mechanisms to create a skilled Aboriginal workforce.
- Participation by women at EKATI™ in the first year of operations was approximately 14%, of which 42% were northern and 51% were Aboriginal

employees. More than half of female employees worked in non-traditional jobs at the mine site (Socio-Economic Agreement 1999 Report).

The EIS predicted that in 2007 the EKATI™ demand for employment for 18,000 t/d and underground mining could generate another 256 direct jobs generally based in the NWT. The EIS assumed that the skill levels of the NWT labour force will have improved by the time the mine reaches the 18,000 t/d production level, and that NWT residents would be able to fill all new positions with no additional requirements for fly-in rotational employees from other parts of Canada.

The EIS predicted that 70% of the workforce in 2007 would be northern residents. In 1999, BHP reported that 80% of BHP employees and 70% of BHP and BHP's contractor employees were Aboriginal and northern residents, matching the EIS prediction for the year 2007. Given that the proposed development will not create any additional employment demand, it is expected that the NWT labour force will continue to have the capacity to meet EKATI™'s requirements at the 18,000 t/d production level. This conclusion is supported by the success of BHP's work training initiatives and the fact that targets are being met and turnover is low.

4.7.8.2 Future Availability of Skilled Workers

Difficulties in securing employment from the NWT in all skill categories have not materialized for BHP at this time. BHP directly hires full-time employees to satisfy longer-term operational requirements and relies more heavily on contractor employees to meet shorter-term and specialized operational needs.

The NWT labour force is benefiting now from long-term worker training and support initiatives to supply skilled northern and Aboriginal workers for the future employment demand of the proposed development. For example:

- Under the Socio-Economic Agreement, the GNWT agrees to commit resources to offer pre-employment training programs and mining-related education to increase the number of semi-skilled and skilled workers (Socio-Economic Agreement, Sec. 4.8.3).
- Aurora College has expanded its mining-related training programs to meet future mining industry requirements, which will result in additional skilled employees. Since 1998, 11 of 14 Trades Access Program graduates were hired by BHP.
- Student employment, IBA scholarships and "stay-in-school" programs can lead to the availability of more NWT young people for skilled and professional jobs. The number of young people entering the labour force will continue to increase substantially. More Aboriginal students are graduating from high school and pursuing post-secondary education.
- Unskilled labour and assistant positions provide entry into EKATI™ and the opportunity to gain experience and training, leading to promotions and entry into skilled areas of the mine. Progression to technical or more highly skilled operating positions is possible with additional on-site training, education and experience.

- Competitive wage levels and benefits provided by the mining industry will continue to attract and improve the level of skilled workers.

4.7.8.3 Summary

The ability of BHP to continue to secure northern and Aboriginal employment in all skill categories should continue unabated. No change in the major positive employment effects predicted in the EIS is expected as a result of the proposed development. It is further expected that the proposed development will sustain employment opportunities for skilled, educated and experienced northern and Aboriginal employees for another three years. At mine closure, skilled EKATI™ workers will be better equipped to make productive work choices in their home communities, the mining industry and other industries as well.

4.7.9 Traditional Economies, Harvesting, Tourism and Recreation

BHP's education and training initiatives, two-week-in/two-week-out rotational schedules and encouragement of Aboriginal hiring are improving the overall job readiness, literacy and work skills of many northerners. These opportunities are providing the means for Aboriginal men and women, particularly in the smaller communities, to participate and progress in the mixed economy, as outlined in the EIS (BHP, 1995).

A recent article in the Native Journal (Appendix E) interviewed Patrick Charlo, an EKATI™ employee, who commented on his participation in a mixed economy.

> *Working out of town on shift rotations can be challenging to families but Patrick sees the overall benefits of the employment and the quality time off to spend with his family. "It was quite a learning experience and difficult to adjust to being away from home but I talked with my wife and family and we worked it out. On my time off, I can spend time with my family and go on the land with my children to teach them traditional skills," states Patrick and continues, "Jobs in mining with companies like BHP's Ekati Diamond Mine are providing good opportunities for Northern people. It's a real benefit for Northern people. It's cheaper to fly people in from close communities. People in small communities are used to short-term jobs but eventually they get used to long-term jobs. I bought two new snowmobiles and I'm thinking of renovating my house. My daughters also understand the importance of having a good education. I teach them the importance of education and I tell them about my experiences at work and encourage them to finish school." Patrick Charlo is one Northerner who has demonstrated that he can gain meaningful employment in the mining industry and still maintain a quality life-style for his family and himself. Today Patrick continues to work at Ekati Diamond Mine and still keeps close ties to the land and his traditional cultural pursuits – maintaining a balance between traditional pursuits and modern wage employment.*

The EKATI™ employment and income benefits accommodate employee participation in both traditional lifestyles and the wage economy. The proposed three-pipe development will continue to offer Aboriginal and northern residents these opportunities. Work rotation allows hunting, trapping and fishing pursuits while income generates new purchases of recreation and hunting equipment such as boats, snowmobiles and rifles by family members in traditional subsistence activities.

The EIS considered the loss of income-in-kind to hunters who depend on the Bathurst Caribou herd in the event of any major disruption to the herd's migratory path (BHP, 1995). Caribou monitoring does not indicate that EKATI™ production is affecting caribou migration or the harvesting of country food. The Environmental Agreement ensures that BHP monitors how and if the Bathurst caribou herd is being affected by mining activities. These monitoring programs will continue throughout the life of mine to minimize effects on caribou migratory paths and the potential loss of country food due to migratory changes.

The EIS forecasted potential loss of income to sport hunting camps, hunting and fishing packages close to the mine (BHP, 1995). Although the outfitter at Lac de Gras has maintained active licences, sport hunting has not been conducted at these camps since 1996. With the recent sale of these sport hunting camps, BHP has initiated communication with the new owner/outfitter to mitigate effects so that outfitting activities and the wilderness experience can be sustained in adjacent areas. Monitoring of the Bathurst caribou herd is also central to BHP's mitigation of EKATI™ effects on outfitting.

4.7.9.1 Summary

The EIS prediction of negligible residual effects on the traditional economy from employment and income will remain the same. Likewise, the potential residual effects of future mines production on harvesting (sustenance hunting), tourism and recreation (sports hunting outfitters) resulting from the three pipe developments are expected to remain negligible, as predicted in the EIS.

4.7.10 Inflation and Cost of Living

The EIS (BHP, 1995) reviewed the potential for increased cost of living in Yellowknife. It stated that there was no firm evidence to support predictions of either an increase or a decrease in the cost of living as a result of the EKATI™ mine.

The EIS stated that, although there had been a general decrease in housing prices in Yellowknife over the past five years, the NWT Diamonds Project could increase housing prices if EKATI™-related migration led to demand outstripping the supply of houses. It also stated that increased sales volumes resulting from spending by BHP and its employees might help foster a more competitive market place and help to reduce prices. On the negative side, the EIS stated that a large number of highly paid workers at the mine could affect the cost of living and force other local employers to raise salaries to compete (BHP, 1995).

The evidence to date shows that, in spite of the construction and operation of the EKATI™ mine, there has been no significant increase in the cost of living in Yellowknife. The Consumer Price Index (CPI) for Yellowknife grew, on an annual basis, by only 0.9% in 1998. For the first eleven months of 1999, the year-over-year change in Yellowknife prices was 1.2%. This was significantly lower than the price rise of 2.2% in Canada and 2.6% in Edmonton during the same period.

4.7.10.1 Summary

There is no evidence to suggest that the proposed development would lead to any increases in the cost of living or inflation in Yellowknife or the NWT. The proposed development will continue, as predicted, to have no effect on inflation.

4.7.11 Human Health

Mining activities associated with the three-pipe development could potentially have an effect on the health of humans in the NWT, particularly those in the surrounding communities. Effects could include indirect changes to the biophysical environment, and/or direct changes to the socio-economic environment through employment at the mine and the associated income.

4.7.11.1 Human Health and the Biophysical Environment

The assessment of effects on human health and exposure to identified hazards depends on the degree to which the proposed development affects biophysical resources such as water, air, vegetation and wildlife, and the types and level of human use of those resources. The integration of the three kimberlite pipes into the EKATI™ mine plan builds on the experience of previous mining construction and operational activities at EKATI™.

Spatial boundaries for the types and level of human use of land and resources include:

- the BHP claim block;
- the Bathurst caribou range; and
- commercial outfitting areas adjacent to the claim block.

Current land use within the claim block is limited to:

- Two sport hunting camps on Lac de Gras adjacent to the claim block. Inactive since 1996, the sport hunting camps were recently sold and the new operator intends to commence sport hunting in year 2000.
- Kugluktuk trappers potentially use an area extending to a point north of Lac de Gras. Dene trapping historically concentrated south of the claim block.

- Residents and General Hunting Licence holders (GHL) hunt caribou throughout the range of the Bathurst herd during fall and spring migration and in wintering areas south of the claim block in or near the treeline. Hunter access during winter is aided by the Lupin winter road.
- Some hunting may be done on the claim block but is discouraged for safety reasons near mining operations, the accommodations complex and the Process Plant. Use of the area is infrequent and more typically in the winter, when hunters and trappers from Kugluktuk are able to access the claim block by snowmobile or winter road.
- BHP employees, contractors, suppliers and authorized mine visitors are the only regular and consistent land users of the claim block.

4.7.11.1.1 Air Quality

Air quality effects are addressed in the EIS (BHP, 1995) and Section 4.3 of this EAR. Primary concerns were localized gaseous, particulate and fugitive dust emissions during the operations phase. After mitigation (water spraying and natural dispersion) there would be negligible effects on wildlife, vegetation near open pits, waste dumps and access roads, and the future capacity of renewable resources. Changes in air quality at the bottom of open pits resulting from temperature inversions were predicted to have infrequent and short-term effects on the health of workers in the pits at the time of inversions.

Integrating the three pipes into the mine plan is not expected to change the air quality effects predicted in the EIS. BHP personnel and authorized visitors are subject to the company's Occupation Health and Safety Program, which includes procedures for emergency response preparedness to reduce the risk of employee injury. The company has fully trained personnel for medical intervention as required and takes a proactive approach to minimize the effects of accidental hazards on air and water quality.

4.7.11.1.2 Water Quality

Water quality effects are addressed in the EIS (BHP, 1995) and Section 4.5 of this EAR. The EIS predicted that potential effects associated with the operations phase were associated with possible contamination resulting from surficial disturbance and management of impounded processed kimberlite. Section 4.5 predicts that minor effects on water quality may result from the construction of the Pigeon Stream Diversion and from Sable Pit water discharges into the downstream Horseshoe Watershed.

The proposed development areas are likely to be used by non-mine workers only when the lakes and streams are frozen. Any solid contaminants affecting water quality during the construction of infrastructure would therefore be inaccessible. No other water quality results are expected to affect these users of the claim block as a result of the proposed development. Changes in water quality would present no health risks to people drinking water and consuming fish from lakes and streams on or downstream from the claim block. For mine workers, any drinking water for camp use is treated and routinely monitored subject to the Public Health Act. BHP's Aquatic Effects Monitoring Program (AEMP) will continue throughout the life of mine.

4.7.11.1.3 Vegetation

Vegetation effects identified in the EIS (BHP, 1995) and Section 4.4 of this EAR included either loss or degradation of vegetation. Both the EIS and this EAR predict that lost vegetation will have a negligible effect on the overall loss of wildlife habitat. Depending on mitigation, the residual effects of air quality on the degradation of vegetation were considered negligible.

Plant/berry picking is not a known contemporary use of the area identified for the proposed development.

With continued monitoring and mitigation, effects on vegetation, loss of habitat and subsequent effects on human health are expected to remain negligible with the Sable, Pigeon and Beartooth developments.

4.7.11.1.4 Wildlife

The EIS (BHP, 1995) and Section 4.6 of this EAR identified caribou as a central link in the food chain and a critical component of the arctic ecosystem. The EIS reported that at a local level, animals may become habituated to the development. Some wildlife displacement may occur, but monitoring and mitigation can avoid adverse environmental effects. In reference to wildlife harvesting, the GNWT agreed with Diavik Diamonds Project's evaluation that distribution of the Bathurst caribou, at the herd level, would not be affected by diamond mine development and operation adjacent to the claim block on nearby Lac de Gras (CEAA, 1999). Sport and subsistence hunting is also possible adjacent to and south of the claim block during the fall migration. The EIS predicted that hunting of caribou will not increase during mine operations. Potential for hunting is greatest during the winter road period. Few caribou are present at the mine site area during this period.

Employee restrictions on hunting and fishing in the claim block eliminate hazards or risks to human health associated with employee consumption of wildlife or fish. Water quality in the Long Lake Containment Facility is monitored within established guidelines throughout the life of the mine for the protection of livestock (CCME) and will have negligible effects on caribou. Effects on the health of consumers of caribou that have migrated through or close to the proposed development are expected to negligible. Any changes affecting caribou that could be potentially harmful to human health will be assessed and addressed in the context of the Wildlife Effects Monitoring Program (WEMP).

To minimize bear/worker conflicts, BHP will continue to incinerate all food wastes and garbage, deliver bear awareness programs and avoid critical bear habitat as necessary to minimize the mine's effects on bears. Bear/non-mine worker conflicts are unlikely because few non-mine workers use the area during the seasons when grizzly bear are most active.

4.7.11.2 Biophysical Effects on Human Health

Identified or accidental hazards could affect air and water quality, vegetation and wildlife in proximity to the Sable, Pigeon and Beartooth pipes or access roads. Higher concentrations of dust and loss of vegetation can be expected in the vicinity of access roads or pits. There could be some reduction in the use of habitat and displacement of caribou, bear and furbearers in the zone of influence around these pits. However, with the exception of EKATI™ workers, the timing and level of human use of the claim block suggests that effects on human health due to identified or accidental hazards affecting air and water quality, vegetation and wildlife would be negligible.

4.7.11.3 Socio-Economic Effects on Human Health

The EIS identified that EKATI™ employment, income and long distance commuting were potential causes of effects on the human health and well-being of local communities. BHP predicted that (BHP, 1995):

- unemployment rates in the NWT would decrease during operations;
- earned income and purchasing power would increase in many NWT communities; and
- a two-weeks-on/two-weeks-off rotational schedule would be best suited to the needs of EKATI™ and the workers.

Potential effects on human health resulting from identified causes included:

- a two-week rotational schedule enabling off-shift workers to enjoy larger blocks of uninterrupted quality time with family members; Aboriginal employees to pursue traditional subsistence harvesting activities; and on-shift workers to work safely and productively;
- the availability of supplementary income to enhance hunting and fishing activities and reinforce traditional connections to the land;
- the availability of employment and improved confidence, self-esteem, independence and personal stability;
- potential increases in marital pressures for families unfamiliar with separation and family disruption;
- increased income in the mixed economy potentially leading to alcohol and drug abuse, greater family violence and family breakdown, more gambling, family hardship and criminal activity; and
- an increase in social disruption with potential strain on policing and social services, and creating gaps in the socio-economic relationships between the industrial employees, employees in other sectors and the unemployed.

The EIS suggested that efforts to manage social problems are more successful when addressed by communities within the context of a buoyant economy. Further, new employment and other skills learned at the worksite through training can have a positive effect on communities and families. Regular incomes can improve the standard of living of individuals and communities (BHP, 1995).

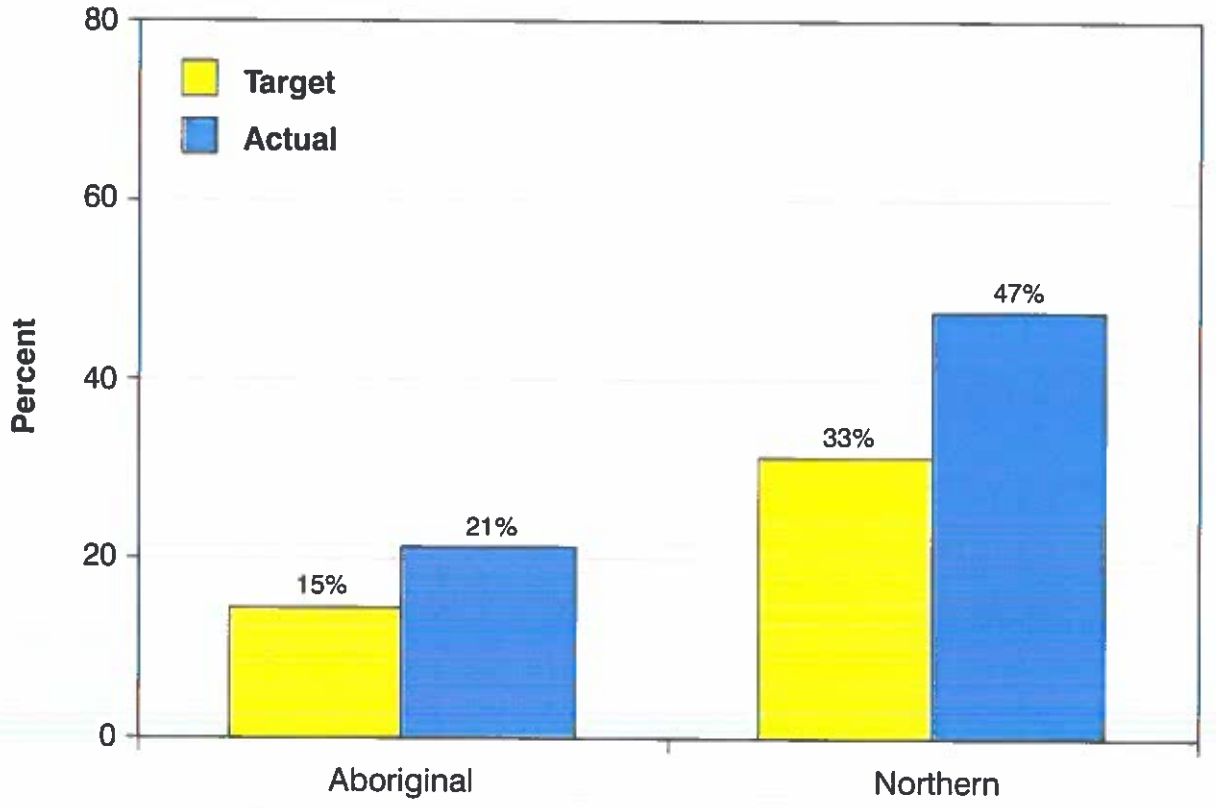
BHP proposed mitigation/enhancement to address these effects in the EIS (BHP, 1995) and has implemented the following:

- employment preference policies, which have been effective in meeting Aboriginal and northern resident employment targets for BHP and its contractors;
- support of community mobilization programming and the NWT Community Mobilization Partnership;
- permanent BHP positions such as the Aboriginal Employment Coordinator and Senior Aboriginal Affairs Advisor, which provide a direct link between the BHP corporate structure and Aboriginal communities;
- employment training programs to encourage increased Aboriginal participation in the project and higher level jobs in a wage economy;
- employment supports including Alcohol and Drug Counselling and Employee Assistance Programs, Family Day at EKATI™, which provides families with an appreciation of the environment in which a family member lives and works; and
- two-week work rotational schedule and regular income to enhance employee satisfaction.

Figures 4.7-1 and 4.7-2 compare the Socio-Economic Agreement hiring targets for the construction and operational phases for the NWT-based positions required for the 9,000 t/d production levels and the actual employment levels attained. Employment figures are based on person-years and combine BHP's employees and contractors' employees as outlined in the Agreement.

As summarized in Figure 4.7-1, the construction period objectives were exceeded, with northern resident employment reaching 46.78% (indicated as 47% in Figure 4.7-1) of the total employment compared to the target of 33%. Aboriginal employment was 20.64% (indicated as 21% in Figure 4.7-1) compared to the target of 14.52 % (indicated as 15% in Figure 4.7-1) of total employment.

Figure 4.7-2 illustrates that the operational phase objectives were exceeded, with northern resident employment reaching 69.8% (indicated as 70% in Figure 4.7-2) of the total employment compared to the target of 62%. Aboriginal employment was 33.2% (indicated as 33% in Figure 4.7-2) compared to the target of 31% of total employment.

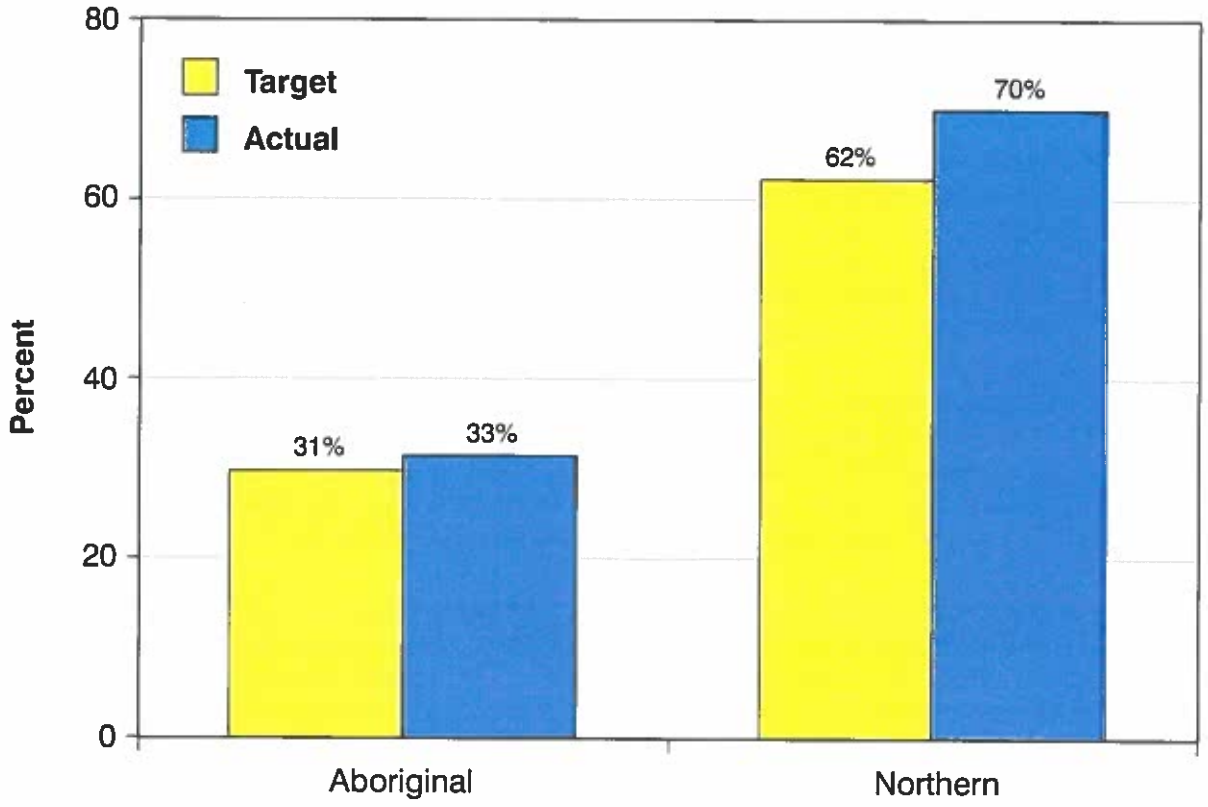


BHP Socio-Economic Agreement
BHP Employment Performance
Hiring Targets 1997/98
Construction Phase

FIGURE 4.7-1

BHP

Ekati diamond mine



BHP Socio-Economic Agreement
BHP Employment Performance
Hiring Targets 1999
Operational Phase

FIGURE 4.7-2

BHP

Ekati diamond mine

The BHP employee turnover rate of 10% in the first year of production compares favourably with the rate of 13% to 14% at Lupin Mine in its first year of production, suggesting that BHP is achieving stability in its EKATI™ workforce. BHP expects that maintenance of a stable workforce and availability of employment will contribute to meeting and exceeding employment objectives. This will further contribute to worker confidence, self-esteem, independence and personal stability.

Even though levels of employment will not increase with the integration of the new pipes, BHP has instituted additional measures to help ensure retention of a northern workforce.

The EIS (BHP, 1995) discussed the challenges associated with facilitating Aboriginal and northern resident employment in an isolated industrial work site. To help reduce effects on human health, especially in Aboriginal impact communities, BHP initiated the NWT Community Mobilization Partnership and Job Development Strategy in 1995. Some 450 partners from business, Aboriginal and community organizations, and government, representing a cross-section of mining and related industries, have collaborated to develop community capacity to benefit from the expanding resource sector in the NWT. BHP continues to support the NWT Community Mobilization Partnership.

Mitigation measures and BHP's adaptive management address potential negative effects of northern employment, income and work rotation on community wellness. The Socio-Economic Agreement states that if residual effects of EKATI™ activities on community wellness/human health are identified, there are provisions for BHP and the GNWT to collaborate in supporting communities in meeting their needs.

Monitoring of human health/community wellness indicators was undertaken by the GNWT in accordance with the Socio-Economic Agreement and results were reported in early 1999. In its first annual report (GNWT, 1999) there were no definitive trends that suggest residual effects on the wellness of communities resulting from EKATI™ construction and operational activities (Evan Walz, pers. comm.). A second monitoring tool, the Employee Attitudinal Survey, will be implemented in 2000 and can be expected to provide helpful information for communities to better understand and address their community wellness issues and needs.

Although it is too soon to measure trends regarding the effectiveness of BHP's employment enhancement measures, northern and Aboriginal residents are successfully being hired into and retained in new EKATI™ jobs. The EKATI™ contribution of new jobs has come at a time when other employment has been and may continue, in the short term, to be lost due to downsizing in NWT mining and public service sectors. The stability of the workforce should contribute to a buoyant economy and the context suggested in the EIS for communities to manage their own human health and community wellness issues.

The following employment benefits influence the assessment of the three-pipe development:

- Annual production rates will remain the same as forecast in the EIS (BHP, 1995).

- Rotational employment will continue.
- Employment targets are being achieved.
- Wage and benefit income levels are slightly higher than those forecast in the EIS (BHP, 1995).
- The capacity of northern and Aboriginal business to supply goods and services to EKATI™ exceeded EIS (BHP, 1995) expectations and Socio-Economic Agreement targets during construction and the first year of operations.

4.7.11.4 Summary

Changes in employment and income effects on human health and community wellness due to the three-pipe development are therefore expected to remain moderate and positive, as predicted in the EIS. The proposed development will maintain the benefits highlighted above for three additional years. GNWT monitoring of community wellness indicators throughout the life of mine will allow for identification of residual effects and create opportunities to maintain or increase mitigations if necessary.

4.7.12 Infrastructure

The EIS (BHP, 1995) described the EKATI™ mine use of public infrastructure in transporting supplies and people to the site. The rail system north from Alberta, NWT highways from Alberta to Yellowknife and on to the Lupin winter road and the Yellowknife airport were the main public infrastructure identified. Yellowknife is described as the centre for marshalling supplies to be moved on the winter road. The EIS indicated that at "benchmark" production cycles, there would be excess capacity in the public ground transportation systems for the re-supply of EKATI™.

Potential ground transportation effects were identified in the EIS (BHP, 1995):

- conflicts for current highway users;
- potential for more highway accidents;
- increased highway maintenance costs; and
- increased use of the rail link to the NWT.

The number of annual re-supply trips to EKATI™ by ground transportation is currently lower than predicted in the EIS (BHP, 1995). The predicted levels will not be exceeded with the three-pipe addition. Ground transportation infrastructure has steadily improved in the region with continued realignment and paving of NWT Highway 3 between Fort Providence and Yellowknife.

Yellowknife has been established as the main employment-staging centre for the mine. All air transport for incoming and outgoing personnel arrives or departs from the Yellowknife airport. Most personnel use the airport (Braden Burry Expediting Terminal) for scheduled

connector flights to and from home communities. Information from the first year of production indicates that the number of aircraft trips to the site is as predicted in the EIS, at approximately 500 to 600 per year (BHP, 1995). The EIS commented that the Yellowknife airport is under-utilized and has unused capacity on scheduled services to pick-up communities and Edmonton, and that potential congestion or disruption of service can be avoided. Recently completed renovations at the Yellowknife main terminal and the use of a private terminal for scheduled EKATI™ flights reduce the potential terminal congestion. The EIS (BHP, 1995) stated that apart from highways and airports, EKATI™ will have few direct requirements for use of NWT infrastructure.

The EIS (BHP, 1995) did, however, predict a potential population in-migration of up to 1,000, primarily to Yellowknife (800) and Hay River (200). The EIS (BHP, 1995) predicted that the existing and planned housing, serviced lots, school and power infrastructure in these communities would have the capacity to accommodate this in-migration. In-migration would not affect the provision of health services and infrastructure in the communities. Hospitals such as Stanton Regional and HH Williams typically have excess bed capacity. Employees can access health services, infrastructure and recreation infrastructure on-site. Drug and Alcohol counselling and EAP employment support is also available on-site or via telephone. The EIS (BHP, 1995) predicted that in-migration would have a positive impact on Yellowknife and Hay River.

Current population data for the NWT, shown in Table 4.7-5, indicate that the population has not been growing and that the EIS-anticipated net in-migration has not occurred. The population in June 1999 was almost identical to that in June 1994. Although recruitment and hiring for the existing EKATI™ production took place during the last half of 1998 and early 1999, downsizing of the GNWT and of two Yellowknife gold mines were probably factors in the no-net population growth scenario in the NWT. Higher-than-expected purchasing by local business during the construction of EKATI™ indicates that additional needs for capital and employees were met.

4.7.12.1 Summary

Effects of the proposed development on infrastructure are expected to remain negligible as predicted in the EIS.

4.7.13 Summary of Socio-Economic Effects from Sable, Pigeon and Beartooth Development

Table 4.7-13 summarizes the effects of the proposed development on the socio-economic environment. It includes mitigation/enhancement measures for each effort and indicates the significance of residual effects. The effects of the proposed development will remain as predicted in the EIS for EKATI™ production at 18,000 t/d.

Table 4.7-13
Socio-Economic Effects from Sable, Pigeon and Beartooth Development

	Probability of Occurrence	Mitigation/ Enhancement	Significance of Residual Effect Predicted in EIS	Change to Significance of Residual Effect
Employment/ Income	H	✓ Preferential recruitment ✓ Extensive training programs ✓ Transportation from selected communities to EKATI™ ✓ Rotational work schedule ✓ Equal opportunity employer ✓ Contractor and subcontractor policies ✓ Wage economy income enhances the traditional economy ✓ Money management counselling ✓ *Community mobilization/job partnership strategy*[1] ✓ *Waiver of strict educational requirements* ✓ *Comprehensive benefit plan* ✓ *Aggressive northern and Aboriginal recruitment* ✓ *Competitive wage package* ✓ *Employment support programs* ✓ *Career advancement opportunities*	Major Positive	No change
Traditional Economies, Culture (Aboriginal Lifestyle and Culture - EIS)	H	✓ Rotational work schedule ✓ Cross-cultural training ✓ Traditional knowledge studies ✓ Consultations/workshops ✓ Training and education ✓ Waiver of strict education requirements ✓ Community mobilization / Job Partnership programs ✓ Transportation from selected communities to mine site ✓ Employment income enhances traditional economy ✓ *Preferential Aboriginal and gender recruitment*	Minor Negative	No change
Harvesting (Sustenance Hunting - EIS)	L	✓ Traditional knowledge study ✓ Rotational work schedule ✓ Wage economy enhances traditional economy	Negligible	No change

Italics indicate new mitigation measures not mentioned in the original EIS but included herein as per discussions within text.

(continued)

Table 4.7-13
Socio-Economic Effects from Sable, Pigeon and Beartooth Development (Continued)

	Probability of Occurrence	Mitigation/ Enhancement	Significance of Residual Effect Predicted in EIS	Change to Significance of Residual Effect
Land-Use-Sustenance-Hunting - EIS	L	✓ Independent Monitoring Agency ✓ Biological wildlife studies ✓ No hunting policy at EKATI™ ✓ *Ongoing caribou monitoring*	Negligible	No change
Tourism and Recreation	L	✓ Re-route aircraft ✓ Outfitter communication, meetings ✓ *Transportation to EKATI™* ✓ *Community mobilization/job partnership*	Negligible	No change
Barriers to Employment	H	✓ Preferential recruitment ✓ Aggressive northern and Aboriginal recruitment	Moderate Positive	No change
(Job/Education Aspirations - EIS)	H	✓ Contractor and subcontractor policies ✓ Scholarship program ✓ Summer student employment ✓ Extensive training/education programs ✓ IBAs ✓ Certification programs ✓ Transportation to EKATI™ from selected communities ✓ Cross-cultural training ✓ Employee Assistance programs ✓ Career counselling ✓ *Waiver of education requirements* ✓ *Equal opportunity employer*		
Opportunities for Local, Regional and Territorial Business (Business Climate - EIS)	H	✓ Preferential local business opportunities ✓ Contractor and subcontractor policies ✓ Wage income will enhance NWT consumer spending ✓ IBA business opportunities ✓ EKATI™ will be one of the largest industrial operations in the NWT ✓ New export industry for Canada (value added industries) ✓ *Procurement offices at EKATI™ and Yellowknife* ✓ *Unbundling of contracts*	Moderate Positive	No change
Economic Diversification (Business Climate - EIS)		✓ *Employment income enhances NWT consumer spending* ✓ *Almost $1 billion NWT incremental economic benefit*		

Italicizing indicates new mitigation measures not mentioned in the original EIS but included herein as per discussions within text.

(continued)

Table 4.7-13
Socio-Economic Effects from Sable, Pigeon and Beartooth Development (Completed)

	Probability of Occurrence	Mitigation/ Enhancement	Significance of Residual Effect Predicted in EIS	Change to Significance of Residual Effect
Availability and Use of NWT Skilled Workers (Employment and Income- EIS)	H	✓ Preferential recruitment ✓ Aggressive northern recruitment ✓ Extensive training programs ✓ Transportation to EKATI™ ✓ Equal opportunity employer ✓ Contractor and subcontractor policies ✓ *Competitive wage levels* ✓ *Comprehensive benefit plan* ✓ *Flexible entry level for Aboriginal employees* ✓ *Career counselling* ✓ *Employment supports* ✓ *Certification programs*	Major Positive	No change
Government Expenses and Revenue	H	✓ *Over $1 billion NWT incremental economic benefit* ✓ *No additional costs to government*	Major Positive	No change
Inflation and Cost of Living (Business Climate - EIS)	L	✓ Preferential local business opportunities ✓ Employment income enhances NWT consumer spending ✓ *Competitive wage levels* ✓ *Comprehensive benefit plan*	No effect	No change
Human Health (Community well-being - EIS)	M	✓ Community mobilization ✓ Employee Assistance Program ✓ Drug and Alcohol free worksite ✓ Extensive training programs ✓ Rotation schedule ✓ Banking and financial supports ✓ *Aboriginal liaison staff* ✓ *IBAs - empowerment funding* ✓ *Drug and Alcohol counselling*	Moderate Positive	No Change
Human Health	L	✓ Bear awareness programs ✓ Occupation Health and Safety Program ✓ Aquatic Effects Monitoring Program ✓ Wildlife Effects Monitoring Program	Moderate Positive	Negligible
Infrastructure	L	✓ Non-applicable	Negligible	No Change

Italics indicate new mitigation measures not mentioned in the original EIS but included herein as per discussions within text.

4.8 Residual Effects

Earlier sections of Chapter 4 assessed the effects, including the residual effects, of development of the Sable, Pigeon and Beartooth pits on air quality (Section 4.3), the land environment (Section 4.4), the water environment (Section 4.5), wildlife and habitat (Section 4.6) and the social, cultural and economic environment (Section 4.7).

This section provides a summary of the predicted residual effects of the proposed development after the incorporation of the mitigation measures. These include the standard policies and operating procedures currently employed at the existing EKATI™ mine. Included are any modifications to the operating procedures developed as a result of experience gained, lessons learned and the application of adaptive management principles which have led to a process of continuous improvement at EKATI™.

Figure 4.8-1 summarizes the predicted significance of residual effects of the proposed development on the physical and biological environment of the development area. In general the residual effects for most Valued Ecosystem Components (VECs) evaluated are predicted to range from negligible to minor. A brief discussion of the residual effects follows.

4.8.1 Air Quality

The residual effects of the development of the Sable, Pigeon and Beartooth pits and associated infrastructure on the VEC air quality, which includes noise, are predicted to be negligible for all activities evaluated.

Dust generated by vehicles on the roads and mining activities represents the largest source of air emissions at the site. However, the results of modelling, air monitoring and snow surveys have confirmed that most dust particles will settle out within 100 m from the source with only the smallest (PM_{10}) particles travelling further.

Airborne emissions of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x) from mine equipment and power generation are expected to remain low for the new development and well within the Canadian Ambient Air Quality Objectives (CAAQO) recommended levels within the local study area (WEMP boundary).

Most sources of noise from project activities will be short-term and intermittent. The zone of influence of significant noise levels (35 dBA) are predicted to extend less than a few kilometres for most noise sources.

4.8.2 Land Environment

The land environment encompasses the VECs permafrost, groundwater, physical/terrestrial environment (vegetation) and heritage sites. The residual effects of the development of the Sable, Pigeon and Beartooth pits and associated infrastructure on

each of these VECs are predicted to be negligible for all activities evaluated. Brief discussions on each of the land environment VECs follow.

4.8.2.1 Permafrost

Permafrost will be affected during all phases of the proposed development due to activities such as road building, construction of site facilities, dam construction, stream diversion, open pit mining and waste rock deposition. However, with the application of sound engineering principles and practices for arctic regions and based on previous experience, all residual effects on permafrost will be limited to very localized areas and will result in negligible effects.

4.8.2.2 Groundwater

Activities that could have a potential effect on groundwater include lake dewatering, the mining of kimberlite where permafrost does not currently exist (*e.g.*, the talik zone below lakes) and the refilling of exhausted pits. The results of previous groundwater modelling and direct experience gained from operations and observations at the Panda Pit indicate that there will be no measurable effects on the surrounding lakes or the groundwater regime in relation to any of the proposed new pits. Any limited effects (*e.g.*, on equilibrium conditions at Sable Pit) will be negligible, restricted to an extremely localized area and will be reversible once the pit is refilled.

4.8.2.3 Vegetation

The development of the Sable, Pigeon and Beartooth pits and associated infrastructure will result in the direct loss of 494 ha of vegetation units. Eighty-four percent of this area is representative of heath mat tundra, which is the most common vegetation unit in the claim block. The proposed development footprint represents 0.31% of the local study area and 0.15% of the BHP claim block. Selective reclamation efforts and natural revegetation will eventually restore some of the footprint area to characteristics similar to those of the local study area.

The development activities will also generate dust and gaseous emissions that could result in changes to vegetation productivity or species composition in certain areas. However, based on the studies reviewed in this EAR, the effects can be either negative or positive. For example, heavy dust blankets may eliminate lichens and mosses, but lighter dust loads may enhance moss growth. Similarly, some plants, including willows and grasses, may thrive in light to moderate dust deposition areas, while some berry-producing plants may be inhibited. These indirect effects will be limited to small parts of the local study area and all effects will be reversible once dust and gaseous emissions cease.

4.8.2.4 Heritage Sites

Most of the archaeological sites in the vicinity of the proposed Sable, Pigeon and Beartooth pits are sufficiently distant that no effects will be realized from development. No archaeological sites are located within the development footprint of the Pigeon or Beartooth pits. Four archaeological sites are near two proposed sources of gravel for Sable Road construction and two other sites are near the proposed Sable Road have been identified for protection. With the application of protection measures, including mitigation (systematic collection, documentation, removal, *etc.*), the residual effect on heritage sites is expected to be negligible.

4.8.3 Water Environment

The water environment VECs are water quality and quantity and fish/aquatic habitat. The activities related to the development of the Sable, Pigeon and Beartooth pits and associated infrastructure that could affect the water environment include:

- lake dewatering;
- pit water discharge;
- flow diversion;
- in-stream/lake construction;
- waste rock storage/drainage;
- pit restoration to productive lake status at the end of the mining cycle;
- operational activities (blasting/fugitive dust); and
- all weather road construction.

With the application of sound engineering principles for arctic regions, and compliance with Water Licence criteria, most of the residual effects resulting from the proposed development on water VECs are predicted to be negligible (Figure 4.8-1). However, minor residual effects are predicted for water quality in relation to pit water discharges and the construction of the Pigeon Stream Diversion. Brief discussions on each of the water environment VECs follow.

4.8.3.1 Water Quantity

All effects on water quantity related to the development of the Sable, Pigeon and Beartooth pits are expected to be negligible after the application of mitigation measures. In particular, the timing of lake dewatering and the control of discharge rates during dewatering to comply with Licence criteria will minimize effects on local hydrological conditions.

Significance of Residual Effects	
Not applicable/None	
Negligible	○
Minor	●
Moderate	●
Major	●
Positive Effect	+

Valued Ecosystem Components (VECs)	DEVELOPMENT AND OPERATION																									DECOMMISSIONING										POST-DECOMMISSIONING			
	1 Process Plant Operation	Diesel Power Generation	Road Traffic	1 Processed Kimberlite Management	1 Freshwater Supply	Waste Rock Storage/Drainage	Excavation of Pits	1 Winter Roads	Human Activity	2 Flow and Stream Diversion (PSD)	Blasting	All-Weather Roads, Dams, Dykes, Berms, *etc.*	Lake Dewatering	Pit Water Discharge	Quarrying	Pre-Stripping	Presence of Roads	1 Sewage Management	1 Solid and Hazardous Waste Management	1 Air Traffic	Environmental Monitoring	Processed Kimberlite/Surface Reclamation	Re-establishment of Lakes (Pit Reclamation)	Waste Rock Storage Reclamation	Road Reclamation (culverts)	Diesel Power Generation	Human Activity	Flow and Stream Re-establishment	Recontouring, Revegetation	Environmental Monitoring	Wind Erosion/Dust Generation	Drainage from Waste Rock Dumps	Landscape Alteration	Environmental Monitoring
Air Quality	○	○		○	○			○	○			○			○	○	○						○	○		○					○				
Permafrost					○	○						○	○		○	○	○																		
Physical/Terrestrial Environment (Veg)	○	○			○	○		○		○	○	○			○	○	○					+							+		○		+		
Surface Water Quality and Quantity		○			○				●	○	○	○	○	●			○					+	○		○			○				○			
Fish/Aquatic Habitat		○			○			○	○		○	○	○								○	+	+		○			○				○			
Caribou/Habitats	○	●			○	○		●	○	●	●				○	○	○				○	+		+	+		+		+	○			+	○	
Carnivores/Habitats		●			○	○		○		●	●				●	○	●				○						●		+	○			+	○	
Breeding Birds/Habitats		○			○	○		○		○	●				○	○	○				○						○		+	○			+	○	
Groundwater					○	○			○				○	○	○								○								○				
Heritage Sites					○			○			○				○	○	○																		

1: Not in scope of development and therefore not assessed.
2: PSD = Pigeon Stream Diversion

BHP

Summary of Residual Effects
Sable, Pigeon and Beartooth Development

FIGURE 4.8-1

Ekati diamond mine

Significance of Residual Effects	
Not applicable/None	
Negligible	○
Minor	●
Moderate	●
Major	●
Positive Effect	+

Valued Ecosystem Components (VECs)	DEVELOPMENT AND OPERATION																									DECOMMISSIONING										POST-DECOMMISSIONING			
	1 Process Plant Operation	Diesel Power Generation	Road Traffic	1 Processed Kimberlite Management	1 Freshwater Supply	Waste Rock Storage/Drainage	Excavation of Pits	1 Winter Roads	Human Activity	2 Flow and Stream Diversion (PSD)	Blasting	All-Weather Roads, Dams, Dykes, Berms, *etc.*	Lake Dewatering	Pit Water Discharge	Quarrying	Pre-Stripping	Presence of Roads	1 Sewage Management	1 Solid and Hazardous Waste Management	1 Air Traffic	Environmental Monitoring	Processed Kimberlite/Surface Reclamation	Re-establishment of Lakes (Pit Reclamation)	Waste Rock Storage Reclamation	Road Reclamation (culverts)	Diesel Power Generation	Human Activity	Flow and Stream Re-establishment	Recontouring, Revegetation	Environmental Monitoring	Wind Erosion/Dust Generation	Drainage from Waste Rock Dumps	Landscape Alteration	Environmental Monitoring
Air Quality	○	○		○	○			○	○			○			○	○	○						○	○		○					○				
Permafrost					○	○						○	○		○	○	○																		
Physical/Terrestrial Environment (Veg)	○	○			○	○		○		○	○	○			○	○	○					+							+		○		+		
Surface Water Quality and Quantity		○			○				●	○	○	○	○	●			○					+	○		○			○				○			
Fish/Aquatic Habitat		○			○			○	○		○	○	○								○	+	+		○			○				○			
Caribou/Habitats	○	●			○	○		●	○	●	●				○	○	○				○	+		+	+		+		+	○			+	○	
Carnivores/Habitats		●			○	○		○		●	●				●	○	●				○						●		+	○			+	○	
Breeding Birds/Habitats		○			○	○		○		○	●				○	○	○				○						○		+	○			+	○	
Groundwater					○	○			○				○	○	○								○								○				
Heritage Sites					○			○			○				○	○	○																		

1: Not in scope of development and therefore not assessed.
2: PSD = Pigeon Stream Diversion

BHP

Summary of Residual Effects
Sable, Pigeon and Beartooth Development

FIGURE 4.8-1

Ekati diamond mine

Once the pits are exhausted, they will be restored to lake status by refilling with water from source lakes: Exeter Lake for Pigeon Pit; Ursula lake for Sable Pit. The current projected time frame for refilling of the lakes ranges from a maximum of 25 years for Sable Pit to 5 years for Pigeon Pit. Beartooth Pit will be partly in-filled with processed kimberlite to a predetermined elevation before restoration. In each case, the pumping rates and seasonal timing of water withdrawal will be controlled to achieve negligible residual effects on the source lakes and downstream hydrological conditions. The results of future hydrological monitoring will be used to refine the pumping rates and the timeframes for completion of the refilling phase of pit lake restoration.

4.8.3.2 Water Quality

4.8.3.2.1 Sable Pit Water

The discharge of pit water from the future Sable Pit via the Two Rock Lake sedimentation and polishing pond system into the downstream Horseshoe Watershed may result in a minor residual effect on downstream water quality. Increased levels of nitrogenous compounds in pit water, resulting from the use of ANFO for blasting will be discharged to the Two Rock Lake sedimentation pond for about six years.

All water discharged downstream from Two Rock Lake will comply with Water Licence criteria. Increased levels of nitrogen (nitrate will probably be the predominant form) have the potential to increase primary producer biomass in systems where nitrogen is the limiting nutrient. In most northern fresh water systems, phosphorus, not nitrogen, limits phytoplankton biomass. This is expected to be the case at Horseshoe Lake and thus elevated levels of nitrate, if they occur, are not likely to result in a measurable increase in the biomass of downstream primary producers.

Future aquatic monitoring to be conducted at this location will assist in determining if additional mitigation measures will be required to reduce nitrogen loading to the Horseshoe Watershed.

4.8.3.2.2 Pigeon/Beartooth Pit Water

Mine water from both the Pigeon and Beartooth pits will be redirected to the Long Lake Containment Facility. All water released from the Long Lake Containment Facility to the downstream Koala Watershed is discharged in compliance with Water Licence criteria.

The Pigeon and Beartooth pit operations are expected to contribute to the nitrogen content of the Long Lake Containment Facility. Nitrogen is monitored at EKATI™ as part of the Aquatic Effects Monitoring Program (AEMP) and the Surveillance Network Program (SNP). The introduction of nitrogen to surface waters is a result of normal, world-wide accepted mining practices involving ammonium-nitrate based explosives. BHP has taken the initiative to respond to nitrogen levels within the containment facility,

and has implemented improved management programs to reduce the amount of nitrogen that is introduced to surface waters.

4.8.3.2.3 Pigeon Stream Diversion

The construction of the Pigeon Stream Diversion to realign the existing stream around the Pigeon Pit could introduce sediments and associated parameters downstream, possibly into Fay Lake for a period of two to three years. The federal criteria for the protection of aquatic life are not expected to be exceeded in any downstream waterbodies. The effect is reversible and the residual effect from the construction and initial operation of the Pigeon Stream Diversion is rated as minor.

4.8.3.3 Fish/Aquatic Habitat

Lake and pond dewatering will affect fish and aquatic habitat for the duration of the mining operations and the completion of lake restoration.

Before dewatering, the fish in each of Sable Lake, Two Rock Lake (sedimentation pond), Pigeon Pond, Big Reynolds Pond (the location of the Pigeon Waste Rock Storage Area), and Beartooth Lake will be harvested in accordance with the requirements of the anticipated Fisheries Authorization to be issued by the DFO. As with the existing Fisheries Authorization, No Net Loss and compensation provisions will be specified in the new Authorization by DFO.

The fish communities in these lakes can be considered to be isolated and self-sustaining. Fish migration into or out of these lakes is severely restricted by poor quality migration habitat, very low flows and the ephemeral nature of their inflow and outflow streams. Therefore, their fish populations probably do not contribute significantly to the fish gene pool of any other lakes in the Lac de Gras or Yamba/Exeter watersheds. Due to the remote location, small fish populations and poor productivity, there is no evidence to suggest that these waterbodies could be used for sustained food, recreational or commercial fishing.

When mining has been completed, all three pits will be reclaimed as lakes that will include features to permit the re-establishment of viable lake ecosystems. Options for the reclamation of mined-out pits at EKATI™ have been previously investigated by the company and a number of strategies have been developed (BHP, 1999b). Generally, mined-out pits will be reclaimed such that normal hydrological regimes will be established for the pit lakes within their respective watersheds. Reclaimed pits will also be modified to re-establish viable lake ecosystems.

Once acceptable water quality conditions have been achieved, fish stocks will be re-introduced into each lake. Lake-specific monitoring programs will be carried out during the refill stage and would continue until there was clear evidence that viable fish communities had been re-established.

Within their respectice watersheds, the initial loss of the small fish populations and associated aquatic habitats from these isolated self-sustaining lakes is considered to represent a negligible effect. However, once the pit lakes have been restored to viable lake ecosystems in accordance with the DFO No Net Loss Policy, positive residual effects may result.

The construction of the Sable Road will involve the crossing of seven streams, of which three probably have seasonal fish runs for at least part of the open water system. Mitigation measures to be employed at stream crossing sites include:

- appropriate sizing of culverts (where needed) based on background hydrological information;
- construction of major crossings such as Pigeon Stream during winter to eliminate erosion during construction;
- road siting to avoid critical habitats; and
- use of sediment control devices and measures.

As a result, the significance of residual effects on the aquatic VECs due to construction of the Sable Road are expected to be negligible.

4.8.4 Wildlife and Habitat

The wildlife VECs selected for assessment include:

- caribou and their habitats;
- carnivores and their habitats; and
- birds and their habitats.

The carnivore VEC was further divided into grizzly bears and furbearers (arctic and red foxes, wolves and wolverines). Grizzly bears have been treated separately because of a number of factors including their relatively low ecological resilience, the relatively high global conservation concern for grizzly bears and the relative abundance of ecological data on grizzly bears in the study area, especially for habitat use.

Minor residual effects of the proposed development activities are predicted for caribou/habitats, as well as minor and one potentially moderate residual effect on carnivore/habitat (grizzly bears) (Figure 4.8-1). Only negligible residual effects are predicted for birds in relation to the proposed development. Brief discussions on each of the wildlife VECs examined follow.

4.8.4.1 Habitat – General

The proposed development of the open pits, waste rock storage piles and roads at Sable, Pigeon, and Beartooth will directly eliminate 494.2 ha of potential wildlife habitat. This habitat loss will persist until reclamation efforts have been completed, and natural and fostered vegetation has been re-established. Complete rehabilitation will be slow. The total area directly affected constitutes only 0.3 % of the local study area. Therefore, all effects related to direct habitat loss are considered to be negligible.

Disturbance associated with blasting, heavy equipment operation, and haul truck and other traffic will affect wildlife use of habitat outside of the direct development and road footprints. This displacement will reduce habitat effectiveness for all species, but the zone of influence (ZOI) will depend on the specific level of sensitivity of individuals and species. For small mammals and many birds, loss of effective habitat will be negligible. For more sensitive species such as carnivores, a larger area will be affected. Reductions in habitat effectiveness resulting from disturbance (rated as minor) are mitigated completely and immediately upon cessation of the disturbance.

Fugitive dust resulting from mining operations will affect vegetation within about 100 m of mine sites and roads. Changes to vegetation communities will be beneficial for some wildlife and detrimental to others. Dustfall on snow will accelerate snow melt and expose vegetation earlier in the spring. This may provide enhanced feeding opportunities for some species that are tolerant of disturbance, but may also introduce risk of accidental injury or predation. Changes in snowmelt patterns will cease with decommissioning of mines.

4.8.4.2 Caribou

The total loss of summer habitat and habitat effectiveness for caribou will be minimal. The calving ground and winter range will be unaffected by the proposed development. Although mine-related activities may alter caribou behaviour and activity budgets, such effects will be minimal and will directly influence a small fraction of the Bathurst herd in any year. The potential for disruption of caribou movement has been mitigated proactively through route selection, construction design, and the application of BHP's adaptive management approach that adjusts traffic while caribou are present.

Noise from mining and traffic associated with the proposed Sable, Pigeon, and Beartooth development will be potentially audible by caribou out to 10 km from the source. However, caribou are unlikely to be restricted in their use of this area. A buffer of 3 km around proposed developments encompasses an area within which caribou may both see and hear industrial activities. Monitoring data from the WEMP during 1997-1999 suggest that caribou behaviour is not measurably affected within this area.

Residual effects rated as minor (Figure 4.8-1) will persist throughout the development and operation phases. However, because caribou use the EKATI™ area primarily during migration, the period of effects is discontinuous within any particular year. Caribou are

only affected for a few weeks per year. Because most predicted effects are related to disturbance, they will be reversible upon termination of operations.

4.8.4.3 Grizzly Bears

Potentially minor to moderate residual effects of the proposed development on grizzly bears include:

- possible increased mine-related mortality; and
- habitat disruption.

BHP has experienced no grizzly bear mortalities to date at EKATI™, and the company's primary goal remains to achieve zero mortalities of any wildlife species. However, based on historical records, Diavik estimated that an average of 0.12 to 0.24 grizzly bears per year were killed for industrial camps operating in their assessment area during 1986-1997. Using this scenario, the proposed Sable, Pigeon, and Beartooth development could result in a bear being killed every 4.2 to 8.3 years. Nearly all problem wildlife bear deaths arise from access to human food or garbage. The proposed development is unlikely to produce any such attractants, and it is likely that no problem-bear removals will result. However, there remains a very small risk that a bear may be struck by vehicles, particularly on the Sable Road.

Associated with the development, there is a reduction in habitat effectiveness for grizzly bears. This has been estimated to be an 800 m ZOI around the proposed Sable, Pigeon, and Beartooth roads, plus a 1-km ZOI around the three proposed pits and covers an area of 3,265 ha, or 32.7 km^2. The total area of habitat loss, combined with reduced habitat effectiveness arising from the proposed Sable, Pigeon and Beartooth development represents 1.8 % of a female's home range and 0.6 % of a male's home range.

Within the combined ZOIs of the pit developments and the roads, the important bear habitats of riparian willow (SR), birch seep (BC), and wetland (BR, EA, CE, CA) habitats comprise 8 ha (0.3 %), 11 ha (0.4 %), and 142 ha (4.4 %), respectively. Closed mat tundra (BL), the least important bear habitat type, comprises 2,400 ha (73.5 %) of the area within the ZOI. More than 94 % of the grizzly bear habitat within the ZOI associated with the proposed development is of low importance to bears.

The potentially minor to moderate residual effects on grizzly bears as a result of the proposed development are predicted to apply to a portion of the regional population in an unpredictable, episodic manner for a few days per year for more than a decade. All of the disturbance-related residual effects will be reversible in less than 10 years after operations cease. Although unlikely, any grizzly bear mortalities related to the development would be of moderate significance.

4.8.4.4 Furbearers

Arctic and red foxes are highly adaptable to human activities and are unlikely to sustain measurable disturbance or population effects. However, wolves and wolverines are generally more sensitive to disturbance and have population characteristics that increase the consequences of even minor population effects.

Wolves are sensitive to human activity and display higher levels of avoidance than many other species. If wolves and grizzly bears are similarly sensitive to disturbance, and the ZOI around the proposed developments is the same for wolves as it is for grizzly bears, then the effectiveness of 32.7 km² of potential habitat will be reduced for wolves. Wolves that den in the Lac de Gras area are migratory, and follow caribou to their wintering grounds. Annual ranges for radio-collared males averaged over 63,000 km², so the loss of habitat from the proposed EKATI™ development is negligible when considered over a year. However, wolf home ranges during the summer (pup-rearing) are estimated at around 1,200 km² to 2,000 km², so habitat disruption during summer has a larger relative effect. Thus, potential disruptions to den sites or foraging opportunities during pup-rearing could have greater consequences for the population.

Wolves possess demographic characteristics, especially their high productivity and dispersal capabilities, that provide them with resiliency to modest levels of human disturbance of their habitat and populations. However, there is a threshold and human activities and developments have been implicated in wolf declines and extirpations. Wolf population sizes in the NWT are unknown, and variable and unpredictable mortality levels may act cumulatively with other perturbations to negatively affect populations.

Wolverines have relatively low demographic resilience and may be more vulnerable to population perturbations than grizzly bears. Habitat loss and disruption related to the proposed development are unlikely to affect regional wolverine populations, but even the low risk of development-related mortality warrants concern.

Based on the current assessment, the overall residual effects of the proposed Sable, Pigeon, and Beartooth development on Arctic and red foxes are: predicted to be of negligible significance. For wolves and wolverines, predicted residual effects are expected to be of minor significance (Figure 4.8-1).

4.8.4.5 Birds

In general, habitats lost due to the proposed Sable, Pigeon and Beartooth development consist mostly of heath tundra habitat units, which are poor in quality and low in value for birds. Although individuals with territories adjacent to the pits will be displaced, birds are adaptable. Structures such as buildings and communication and weather towers can provide nesting opportunities for birds.

In the short term, construction of the three pits will eliminate nesting and feeding habitat for some birds such as Lapland longspurs, sparrows, horned larks and rock ptarmigan.

However, based on recent breeding bird surveys, upland bird diversity around Pigeon Pond and Sable Lake is low compared to other breeding bird plots due to the prevalence of poor quality habitat. The wildlife monitoring program has determined that no loon territories have been documented on Sable Lake from 1995 to 1999. Raptors are not known to nest near these proposed pits. Thus, bird habitat loss in association with the pits is negligible with respect to the surrounding habitat within the wildlife study area.

Data collected during BHP's baseline program and from the WEMP indicate that the proposed Sable Road alignment is not in any known raptor areas. The road corridor is intentionally designed to follow upland habitat in heath tundra that will mitigate impacts on loon territories. The existence of roads may enhance bird habitat at closure. Ground squirrels and other small mammals may colonize these new habitats, in turn providing prey for raptors. Gravel-nesting birds such as plovers and jaegers may use abandoned road surfaces for nest sites.

Birds will encounter noise within the development area during migration or nesting. Based on bird surveys and other general observations collected on site between 1994 to 1999, data suggest that birds typically show no detectable responses to stressors and that effects from mining and associated activities are negligible. Thus, the overall residual effects of the proposed development of the Sable, Pigeon and Beartooth pipes and associated roads on birds are predicted to be negligible.

4.8.5 Social, Cultural and Economic Environment

The detailed analysis of effects on the social, cultural and economic environment is provided in Section 4.7. In assessing the effects of the proposed development, the analysis focuses on the Northwest Territories and the communities where employment, income and biophysical change might be expected. Table 4.7-13 of that section summarizes the effects of the proposed development on the socio-economic environment. The table includes mitigations/enhancement measures for each effect and indicates the significance of predicted residual effects.

Generally, Section 4.7 concludes that the proposed addition of Sable, Pigeon and Beartooth pipes will not change the pace or scale of planned operations, but will allow the mine to continue operating the 18,000 tonnes per day (t/d) production level for three years beyond the current life of the mine 15 years. Consequently, the predicted socio-economic effects of the proposed development will remain as predicted in the 1995 EIS for EKATI™ production at 18,000 tonnes per day (t/d).

The following provides a brief summary of the predicted residual effects identified in the socio-economic assessment.

4.8.5.1 Economy

The 1995 EIS determined that employment and income could potentially have the greatest socio-economic effects on the NWT economy over the life of EKATI™. The

extent of these effects depends upon BHP's expenditures in the NWT. The level of expenditures, in turn, depends on the ability of the NWT labour force and business sector to fulfill the employment, goods and services requirements. Predicted effects from this assessment are:

- The three pipes are estimated to contribute $973 million ($324 million annually) to GDP in the NWT.
- 4,108 person years of employment will be maintained for three years (direct, indirect and induced). This is equivalent to one job in fifteen in the NWT.
- The most significant beneficiaries of EKATI™ employment will be northerners, Aboriginals and women.
- The development is expected to contribute almost $250 million (81.9 million annually) to NWT labour income and increase income by 5% per year during operations.
- The federal government will receive an estimated $337 million ($112 million annually) in total revenues and expend approximately $12 million ($4 million annually) for a net positive change of $325 million ($108 million annually).
- The GNWT would receive $100 million ($33 million annually) or a net positive increase of $18 million ($6 million annually) in revenues. Additional expenditures are unlikely to occur and may actually be reduced by $14 million ($5 million annually) for a net positive change of $114 million ($38 million or annually) before FFG. Additional savings to the NWT due to additional employment could result in $4.8 million per year.
- No new demands on public infrastructure and services.
- Residual effects will continue to be major and positive.

4.8.5.2 Business-Opportunities and Diversification

The opportunities for local, regional and territorial businesses will be maintained for three more years as a result of the proposed development. Predicted effects are:

- $234 million ($78.3 million annual purchasing rate at 18,000 t/d) in incremental purchases will be made through northern and Aboriginal businesses.
- All socio-economic objectives have been surpassed in allocating goods and services to northern and Aboriginal businesses.
- Total northern and Aboriginal purchases during construction was $321 million, $145 million more than expected. During the first year of operations local purchases totalled more than $280 million demonstrating the ability of local businesses to meet the demand for the 18,000 t/d production levels.
- The integration of the proposed development will maintain the moderate positive residual effects on business opportunities identified in the EIS.
- Economic diversification of the NWT economy is represented by the level and distribution of expenditures across a wide range of industries. Approximately 78.7%

of all EKATI™ purchases were made in the North resulting in direct and spin-off impacts from mine activity. Joint ventures, alliances, expansions and new businesses reflect diversification as well as value-added activities.

- There will be a short-term, frequent and primarily positive and moderate effect on local opportunities for diversification. No change from EIS predictions.

4.8.5.3 Employment-Barriers and Workforce Availability

BHP's commitments to and success in reducing barriers to employment is evidenced by its diverse workforce and policies currently in effect. These policies and commitments implemented by BHP will remain throughout the life of the mine. Predicted effects are:

- 69.8% of BHP and contractor employees at EKATI™ are northerners and 33.3% of the total workforce are Aboriginal. 14% are women.
- The significance of the residual effects from the proposed development on barriers to employment will remain moderate and positive.
- The three-pipe development will not create additional demands for wage and salary employment at EKATI™.
- The capacity of the NWT labour force to supply skilled workers has proven to be positive and successful. BHP and the GNWT continue to provide opportunities to enhance the NWT labour force in all skill categories.
- The development will not change the distribution of positions or expected percentages of northern and Aboriginal labour force participation in each of the skill categories.
- The ability of BHP to secure northern and Aboriginal employment in all skill categories should continue unabated. There should be no change in the major positive employment effects predicted in the EIS as a result of the proposed development.

4.8.5.4 Traditional Economy/Harvesting/Tourism/Recreation

- Opportunities will continue for Aboriginal men and women, particularly in the smaller communities, to participate in the mixed economy.
- Work rotations allow hunting, trapping and fishing pursuits while income generates new purchases of recreation and hunting equipment.
- Caribou monitoring indicates no effects on caribou, harvesting of country food or on the loss of income-in-kind to outfitters in the area. Monitoring of caribou migration and mine-related effects will continue throughout the life of the mine.
- EIS predictions on potential residual effects of future mine production resulting from the three-pipe development on the traditional economy, harvesting and tourism will remain negligible.

4.8.5.5 Inflation

- There has been no significant increase in the cost of living in Yellowknife. The Consumer Price Index (CPI) for Yellowknife was lower than Canada and Edmonton.
- There is no evidence to suggest that the proposed development would lead to any increase. The development will continue, as predicted, to have no effect on inflation.

4.8.5.6 Human Health

- Monitoring of the air, water and land resources to date indicates that no hazards to human health have occurred and none are expected as development progresses.
- Changes in employment and income effects on human health and community wellness due to the three-pipe development are expected to remain moderate and positive. GNWT monitoring of community wellness throughout life of mine will allow for identification of residual effects.

4.8.5.7 Infrastructure

The EIS indicated that at benchmark production cycles, there would be excess capacity in the transportation systems for the re-supply of EKATI™.

- The number of annual re-supply trips to EKATI™ by ground transportation is currently lower than EIS predicted levels and will not be exceeded with the three-pipe development.
- Use of NWT infrastructure and residual effects on infrastructure are expected to remain negligible.

4.9 Cumulative Effects Assessment

The MVEIRB's Terms of Reference for this EAR requested that the environmental assessment include an evaluation of possible cumulative effects that may result from the proposed development. BHP was instructed to evaluate its proposal in combination with the other developments within EKATI™'s zone of influence. This includes proposals or "developments" within the regulatory process as of December 13, 1999.

For this evaluation the results of two major recent environmental assessment processes that reviewed possible cumulative effects in the region remain valid and are directly applicable. These reviews included the 1995/96 Environmental Assessment Review of the NWT Diamonds Project (EKATI™ Diamond Mine) and the 1998/99 Federal Comprehensive Study review of the Diavik Diamonds Project. Sections 1.4.1 and 1.4.2 of the EAR provide a brief description of these reviews. The Ministers of Environment and DIAND accepted the results of both these reviews without any changes to the reviewers' conclusions. BHP also recognizes that cumulative effects assessment represents a natural component and extension of a sound environmental assessment.

The *Mackenzie Valley Resource Management Act* (MVRMA) does not have specific Guidelines for Cumulative Effects Assessment (CEA). Therefore, the approaches presented in the Canadian Environmental Assessment Agency *Cumulative Effects Assessment Practitioners Guide* (the Guide) (CEAA, 1999c) were used as a framework for examining the potential cumulative effects of the proposed Sable, Pigeon and Beartooth development. The assessment methodology presented includes:

- definition of cumulative effects consistent with the terminology of the MVRMA;
- scoping of the assessment;
- analysis of the effects;
- identification of mitigation; and
- monitoring.

The Terms of Reference identified several projects/activities, as a minimum, to be included in the initial scoping for the cumulative effects assessment:

- BHP EKATI™ Diamond Mine (existing);
- Diavik Diamonds Project (approved);
- Echo Bay Mines Ltd. - Winter Road (existing);
- Echo Bay Mines Ltd. - Lupin Mine (existing).

The CEA discussion in the Comprehensive Study Report (CSR) for the Diavik Diamonds Project identified several other projects/activities, and their associated effects. The CEA for the Sable, Pigeon and Beartooth mines requires a systematic evaluation of the projects/activities in the area in as scientific and comprehensive a manner as possible.

4.9.1 Definition of Cumulative Effects

Part 5, Section 117(2) of the MVRMA specifies that:

Every environmental assessment and environmental impact review of a proposal for a development shall include a consideration of:

a) the impact of the development on the environment, including the impact of malfunctions of accidents that may occur in connection with the development and any cumulative impact that is likely to result from the development in combination with other developments; and

b) the significance of any such impacts.

During the 1995 hearings for the EKATI™ Diamond Mine, Ida McWilliam of Coppermine described cumulative effects in a more traditional and more understandable way:

> *It's all connected, it (the cumulative effects) might be a long way (off) but I think in the lakes, the area, the land, the food... or the wildlife that goes through there, I mean they all one way or the other eventually (will be affected)... It's like one long chain that eventually gets back to us of course. It's going to have some kind of effect on us...*(BHP, 1995).

Typically, cumulative effects assessment addresses effects that:

- extend over a larger area;
- are longer-term;
- act, in conjunction with other projects/activities, on the same VEC;
- are reasonably probable, considering possible future projects/activities and impacts; and
- extend the evaluation to one that is beyond the usual direct, local effects.

In consideration of the general conclusions of the two recent reviews of diamond mine projects in the NWT, BHP's approach to evaluating possible cumulative effects related to the current mine plan has involved the application of three basic premises:

- There must be an environmental, biophysical, social or cultural effect related to the BHP proposed development.
- The effect must be demonstrated to operate cumulatively, additively or synergistically with effects from other projects or activities.
- The other projects or activities exist or are likely to be carried out and are not hypothetical.

Additionally, there must be a demonstration of significant changes to the assumptions/activities considered, including the results of the last two major assessments. The use of previous assessments ensures that there is minimal duplication of effort and builds upon the body of knowledge available to all stakeholders.

Cumulative effects result from the combination of environmental effects from a number of individual activities. These effects may be the result of a number of developments within a geographic area or of a number of developments occurring over time. Although the residual effects of an individual activity may be acceptable, the combined residual effects of several developments may result in unacceptable effects. In the case of the Sable, Pigeon, Beartooth proposed development; the limit for the cumulative effects assessment was developed based on the regional extent of the projected residual effects and the extent of the residual effects associated with other projects/activities within the region.

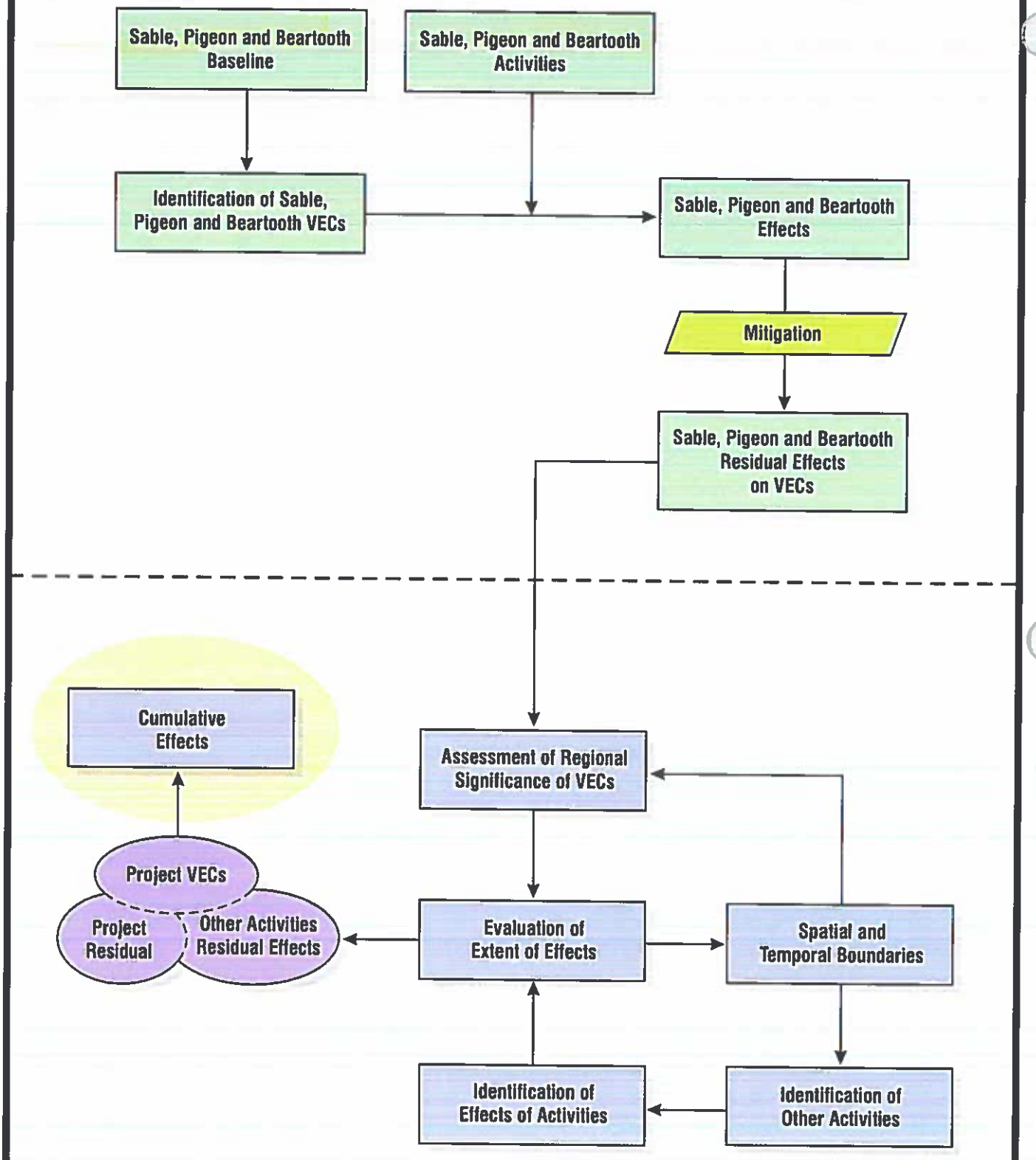
4.9.2 Scoping of the Cumulative Effects Assessment

A number of VECs have been assessed in this environmental assessment for the proposed Sable, Pigeon and Beartooth development. These VECs have been identified and refined over the past five years, as a result of the continuing compliance and effects monitoring and the effective dialogue that has taken place amongst the various stakeholders.

- Air Quality;
- Permafrost;
- Surface Water Quality and Quantity;
- Fish/Aquatic Habitat;
- Physical/Terrestrial Environment;
- Caribou/Habitats;
- Carnivores/Habitats;
- Breeding Birds/Habitats;
- Groundwater;
- Heritage Sites; and
- Socio-economic elements.

Each VEC needs to be evaluated individually to determine the regional extent and importance of residual effects on each VEC resulting from the proposed Sable, Pigeon, Beartooth development. This will then allow the cumulative effects assessment to proceed based on the most relevant of the VECs and to incorporate the residual effects of the other projects/activities (Figure 4.9-1).

The scoping for this cumulative effects assessment was carried out according to the Guide framework and involved:



Cumulative Effects Assessment for the Proposed EKATI™ Development

FIGURE 4.9-1

- identification of the issues of concern (regional);
- selection of appropriate VECs to match issues;
- identification of temporal and spatial boundaries;
- identification of other projects/activities that may affect the same VECs; and
- identification of the potential residual effects due to projects/activities.

This assessment draws on the experience gained from the permitting, construction and operation of the EKATI™ Diamond Mine, and the recent permitting application for the construction and operation of the Diavik Diamonds Project.

4.9.3 Identification of the Regional Issues

The Terms of Reference prepared by the MVEIRB were used as a guide for identifying the project-specific effects of the Sable, Pigeon and Beartooth project and the subsequent cumulative effects assessment. Therefore, following from this fundamental premise, the physical, biological, socio-economic and cultural components of the environment in the proposed development area and the region are included in the initial scoping for the cumulative effects assessment.

BHP Diamonds Inc. has been working in the area since 1991 and has been conducting environmental studies on their claim block since 1993. As a result, the company has a good understanding of the regional issues. The regional issues of concern associated with the proposed development were determined through BHP's ongoing consultations with Aboriginal, government and other interested parties and experience gained at the EKATI™ Diamond Mine. Additional guidance was provided by the:

- Environmental Impact Statement for the NWT Diamonds Project (BHP, 1995);
- Comprehensive Study Report for the Diavik Diamonds Project (CEAA, 1999b);
- Sable, Pigeon and Beartooth proposed development baseline investigations (1996 to 1999); and
- Diavik Diamonds Project Environmental Assessment (Diavik, 1998b).

The VECs included in the initial scoping for the cumulative effects assessment were limited to those already selected for this EAR. The fundamental assumption is that the effects of the proposed Sable, Pigeon, Beartooth development have been adequately addressed through evaluation of the VECs. The residual environmental effects from the assessment will be evaluated to identify those effects that may extend geographically and temporally to interact with other regional projects/activities.

4.9.4 Selection of Appropriate VECs

Scoping allows for the determination of the VECs that should be included in the cumulative effects assessment and provides a mechanism to determine if the specific Sable, Pigeon and Beartooth effects on the VECs will act cumulatively with other projects/activities (past, present or predictable future). This, therefore, provides the framework for the extent of the cumulative effects assessment.

Beanlands and Duinker (1983) stated that an essential step in the Environmental Impact Assessment process is the identification of VECs. They noted that "*it is impossible for an impact assessment to address all potential environmental effects of a project. Therefore, it is necessary that the environmental attributes considered to be important in project decisions be identified at the beginning of an assessment. This will normally require some form of public consultation or social scoping exercise to determine the values attached to various ecosystem components. Both the views addressed by the general public and those of the professional community should be considered when determining these values.*"

Best professional practice has been used, in conjunction with modelling, field data and scientific assessments, to develop a focused assessment analysis suited to the specific VECs. Initially, all the VECs will be examined to determine the potential extent of the effects of the proposed Sable, Pigeon and Beartooth development. These effects will be combined with potential effects from other projects/activities to determine if there are any potential regional cumulative effects.

The inclusion of VECs in the cumulative effects assessment will be determined based upon a ranking that includes:

- relative regional importance of the VEC; and
- magnitude and duration of potential effects.

Exploration and feasibility level work are ongoing for other projects in the region such as the Winspear Snap Lake and the Tahera Jericho Projects. However, publicly available data on other actual and potential projects/activities are limited, at this time.

The VECs considered in the cumulative effects assessment are those for which the proposed Sable, Pigeon and Beartooth development have identified a residual effect that is categorized as minor or greater. Additionally, only those effects that have changed from the 1995 EIS and the Diavik Diamonds Project EA will be addressed.

4.9.4.1 Air Quality

Issues of concern regarding the cumulative effects on air quality in the immediate vicinity of the proposed development have been identified and examined in previous studies (BHP 1995; Diavik, 1998a). This general discussion of air quality primarily uses information extracted from these sources.

Maintaining good air quality is important because of its potential effects on local vegetation, wildlife, soil, water and worker health and comfort. Moreover, air quality issues extend to regional and global scales to include possible acidic depositions (acid rain) and climatic effects (global warming). Locally and regionally, the aesthetic concerns associated with air quality include visibility and odour.

For the development of the cumulative effects assessment, the primary interest is regional and global scale issues. The development of other projects in the area and the general global interest in atmospheric pollution result in this VEC, in spite of not registering a "minor" residual effect for this EAR, being included in the assessment.

For the purpose of the assessment for air, the proposed development reflects a change to the mine plan from that presented in the EIS. The Leslie Pit has been removed from the mine plan and the Sable, Pigeon and Beartooth pipes added. Ore production from the Sable Pit and its associated haul road will be developed in a manner similar to the Misery Pit and haul road. Therefore, the assumptions of the 1995 EIS can be assumed to be applicable for this proposed development.

4.9.4.2 Land

The Land section includes four VECs:

- Permafrost;
- Groundwater;
- Physical/Terrestrial Environment; and
- Heritage Sites.

The effects of the proposed development on these VECs are discussed in Section 4.4. The conclusions of the initial screening assessment justify whether any of these VECs should be included in the assessment.

4.9.4.2.1 Permafrost

The overall BHP claim block, in which the local study area represents a portion, consists primarily of undisturbed tundra. Apart from the EKATI™ mine, the only other existing operation in the region is the recently re-opened Lupin gold mine approximately 100 km to the north. The Diavik Diamonds Project recently received regulatory approval, thereby allowing construction activities to begin the development of four kimberlite pipes within Lac de Gras. Currently, there are no other mining or large-scale activities in operation within the Coppermine River Basin.

The evaluation of the permafrost and groundwater VECs requires consideration of how the proposed activities may affect land use activities in adjacent areas. Consideration was given to the proposed Sable, Pigeon and Beartooth developments, the EKATI™ mine, the re-opened Lupin Mine, the permitted Diavik Diamonds Mine, and other proposed developments such as Tahera Resources' Jericho Property, Southern Era's Yamba Lake property, Winspear's Snap Lake property and the Monopros Kennady Lake property.

The consideration of the combined effects of development activities on a stationary VEC such as permafrost is not considered applicable beyond the limits of the immediate development area. The residual effects of the proposed Sable, Pigeon and Beartooth

development on permafrost have been determined to be negligible. Effects will be restricted to the immediate area, representing small portions of the local study area. As such, there is no need to consider the limited, localized effects on permafrost related to the proposed development in relation to any other previous, current and/or proposed activities within the region. There is no possibility that such localized effects will overlap. Cumulative loss of permafrost amounts to a negligible portion of the overall area of the region encompassed by all projects considered.

4.9.4.2.2 Groundwater

The presence of continuous permafrost precludes the consideration of groundwater as a major ecosystem pathway. Lakes not underlain by permafrost provide recharge to the groundwater system. Pigeon Pit will be mined entirely within permafrost, while Beartooth Pit will be developed to a depth of 155 m and, as such, any portion of a talik (unfrozen ground) that could extend to the bottom of permafrost is anticipated to be small. Potential effects related to groundwater inflows will not be an issue at either of these open pits. Sable Pipe is the only one of the three that will be mined below the anticipated depth of permafrost (320 m). The groundwater regime below the maximum depth of permafrost could be affected. However, these changes are not expected to measurably affect the water level in adjacent lakes. This effect will be reversible, as steady-state conditions will prevail once the pit is refilled.

The residual effects assessment for both permafrost and groundwater determined that the proposed development would have negligible effects. This, combined with the negligible effects of the other projects considered, warrants their removal from the cumulative effects assessment.

4.9.4.2.3 Physical/Terrestrial Environment

The physical/terrestrial environment includes an evaluation of the surface environmental resources, but excludes wildlife.

The environmental assessment rated all residual effects of activities affecting vegetation as negligible at the local scale, defined as a portion of the local study area which is represented by the Wildlife Environmental Monitoring Program (WEMP) boundary. The residual effects of the proposed development of the Sable, Pigeon and Beartooth pits on vegetation are expected to be confined to small portions of the WEMP area and will be undetectable beyond its borders. Negligible ratings for all residual effects associated with vegetation, and the fact that these effects are not detectable at the WEMP boundary, warrant the elimination of vegetation from a more detailed cumulative effects assessment.

The Diavik Diamonds Project Comprehensive Study Report (CEAA, 1999b) also concluded that a cumulative effects assessment with respect to vegetation was not warranted because the affected areas represented such a small portion of its regional study area.

4.9.4.2.4 Heritage Sites

The largest potential effect on heritage sites in the Sable, Pigeon and Beartooth development areas is site destruction or disturbance. However, few archaeological sites are threatened, and those that may potentially be affected by the proposed development can be mitigated. For the cumulative effects assessment, it is also necessary to consider the potential effects on archaeological sites beyond the current development areas as a result of increased human presence and activity levels.

In 1994, there were only five recorded archaeological sites within the BHP claim block. They were all found on the Coppermine River in the late 1970s and little was known beyond a brief description. Since 1994, 145 additional archaeological sites have been found. The mine development resulted in the identification of previously unrecorded heritage sites and so has contributed substantially to the general knowledge and understanding of past human use of the barrenlands.

Work conducted in advance of EKATI™ development permitted a more detailed examination of the archaeological record. It has contributed to the understanding of barrenland archaeological culture, including confirmation of the Arctic Small Tool tradition, which is believed to date from between 2500 and 3500 years BC (Gordon, 1996). The excavation and/or systematic surface collection of sites has also provided data on stone tool manufacture. These investigations have assisted greatly in the assessment of site significance and mitigation recommendations. Although mitigation is destructive, it also ensures that representative samples of archaeological material will be available regardless of natural or man-made disturbances.

A number of archaeological studies at proposed diamond properties were reviewed:

- Diavik Diamonds Project – Of a total of 195 sites, 64 were threatened as a result of the proposed Diavik development. Mitigation was undertaken at 24 of the 64 that were within the development footprint (Fedirchuk, 1999). This higher potential impact was primarily due to the location of the proposed mine on an island in Lac de Gras.
- Winspear Snap Lake – Archaeological investigations resulted in the discovery of 11 archaeological sites, 10 within the boundaries of two possible gravel sources and one to the north of the easternmost source.
- Jericho property – 45 Archaeological sites discovered.

Archaeological sites are known or predicted to be affected by other activities, including the original construction and continued maintenance of the Lupin winter road, the establishment of hunting and fishing camps and casual use of the barrenland by recreational canoeists.

Further development associated with the proposed Sable, Pigeon and Beartooth development could potentially increase the effect on archaeological resources. However, the diligent application of field investigations prior to exploration and development and the mitigation of sites as required generally contribute more to recorded knowledge than

is lost. If BHP continues its current strict archaeological site management procedures, future disruption of archaeological sites will remain minimal.

BHP's management strategy and the fact that effects on heritage resources are restricted to the direct footprint of the activity warrants the removal of this VEC from the cumulative effects assessment.

4.9.4.3 Surface Water Quality and Quantity

4.9.4.3.1 Surface Water Quality

The objective of this section is to assess any potential for cumulative effects on water quality as a result of the development of Sable, Pigeon, and Beartooth pipes with any other developments or activities in the region (including the existing EKATI™ mine).

The only predicted residual effects on water quality with a significance category of minor or greater resulting from the Sable, Pigeon and Beartooth pipe development were associated with:

- Sable Pit water discharge;
- Long Lake Containment Facility discharge; and
- construction/operation of the Pigeon Stream Diversion.

The Pigeon Drainage Area is part of the larger Yamba/Exeter Watershed that also includes the Horseshoe Watershed where the Sable Pit will be developed. The Beartooth Pit will be developed in the Koala Watershed, which flows into Lac de Gras. The temporal limitation of effects associated with the proposed development is approximately 35 years from initial pre-stripping to the completion of filling Sable Pit with water from Ursula Lake.

4.9.4.3.1.1 Yamba/Exeter Watershed

The predicted residual effects of the proposed development of Sable and Pigeon pipes are expected to be localized and limited to the sub-drainages of the Yamba/Exeter Watershed (Horseshoe Watershed, Pigeon Drainage Area). The Yamba/Exeter Watershed flows into the upper Coppermine Drainage Basin at Lake Providence (see Figure 4.2-2 in Section 4.2). The Yamba/Exeter Watershed does not drain into the Lac de Gras Watershed.

Exeter and Upper Exeter lakes are the first large downstream lakes from both the Horseshoe Watershed and the Pigeon Drainage Area, respectively. Since there are no existing or proposed developments on either of these lakes, there is no potential for cumulative effects on water from the proposed mine-related activities within the Yamba/Exeter Watershed.

Any residual effects associated with the Sable Pipe development are expected to remain within the Horseshoe Watershed; and any residual effects associated with the Pigeon Stream Diversion are expected to remain within the Pigeon Drainage Area (including Fay Lake). No detectable effects are anticipated in Exeter Lake. Exeter Lake is upstream of Yamba Lake, the site of a potential development by Tanqueray Resources Ltd. Given that the detectable effects boundaries associated with the Pigeon and Sable developments are at least 50 km upstream of Yamba Lake there will be no cumulative effects on water quality.

4.9.4.3.1.2 *Koala Watershed*

Within the Koala Watershed, potential surface water effects include:

- dewatering of Pigeon Pond;
- dewatering of Beartooth Lake; and
- discharge from the Long Lake Containment Facility, which will receive inputs from pit water (Pigeon, Beartooth), waste rock runoff (Pigeon, Beartooth), process water and kimberlite from the three new pits.

Discharge from the Long Lake Containment Facility combines with water from the Koala Watershed and drains into a relatively isolated bay in the northwest portion of Lac de Gras. This outflow is approximately 15 km east of the outflow for the entire lake. With the Diavik Diamonds Project located on an island in the eastern central part of Lac de Gras, the potential exists for cumulative effects on the water quality of Lac de Gras, because EKATI™ and Diavik share direct surface water pathways in the lake.

Mine water and waste rock runoff from both Pigeon and Beartooth will be introduced into the Long Lake Containment Facility for a period of approximately four years (2005 to 2009). Water from the Long Lake Containment Facility is discharged into downstream waterbodies when BHP's allowable discharge criteria, as outlined in its Type A Water Licence, are met. As demonstrated by Surveillance Network Program (SNP) monitoring, the discharge water meets the criteria for all regulated parameters of the Water Licence. The Long Lake Containment Facility contains several internal filter dykes designed to remove suspended solids in the water column and is currently capable of retaining water for an extended period, if required.

Water inputs from both Pigeon and Beartooth will be subjected to the mitigation measures currently in place at the existing mine site facilities for mining of Panda Pit. Pigeon and Beartooth pit water is expected to be similar to Panda Pit water and so current mitigation measures will continue to be effective. Field monitoring data show that the levels of regulated water quality parameters decrease with increasing distance downstream as the water flows through a series of lakes before reaching Lac de Gras. With this decrease in concentration, there is considered to be no potential for cumulative effects with Diavik in Lac de Gras for the parameters specified in the Type A Water Licence.

The only predicted potential residual effect on water quality is elevated nitrate levels. Pigeon and Beartooth pit operations are expected to contribute to the nitrogen content of the Long Lake Containment Facility. Nitrate is not a regulated parameter in the Type A

Water Licence, but has been monitored at EKATI™ as part of the Aquatic Effects Monitoring Program (AEMP) and the SNP. The introduction of nitrate to surface waters is a result of normal, world-wide accepted mining practices involving ammonium-nitrate based explosives. BHP has taken the initiative to respond to elevated nitrogen levels within the containment facility, and has designed and implemented improved management programs to reduce the amount of nitrate that is introduced to surface waters. Monitoring at EKATI™ to date has indicated that nitrate levels within the semi-isolated bay of Lac de Gras, where the Koala Watershed enters the lake have not changed since 1994 (Rescan, 1999a).

Natural background concentrations of nitrogenous compounds in surface waters in the area are extremely low (0.005 mg/L). Nitrogenous compounds are important nutrients for algae and plants and are required for the growth of these organisms. Some forms of nitrogenous compounds (ammonium, nitrite) can be toxic to fish and other aquatic life at elevated concentrations. Phosphorus is another important nutrient for algae and plants and is also found in very low concentrations in surface waters in the area. Algae and plants (primary producers) require phosphorus, nitrogen, carbon and other nutrients in order to live and grow. Therefore, the removal of the limitation on growth by the addition of the limiting parameter may trigger an algal bloom.

Published papers, as well as monitoring results, indicate that aquatic primary producers in the oligotrophic (low productivity, low nutrients) waters in the area, including Lac de Gras are most likely limited by phosphorus. In phosphorus-limited waters, the addition of phosphorus will cause an increase in the biomass and abundance of primary producers and a possible change in the species composition of primary producers. The most important primary producers in lakes in the claim block are phytoplankton (single-celled algae that live floating within the upper portion of the water column and use sunlight to grow).

Therefore, the addition of nitrogen to Lac de Gras is not expected to cause an increase in primary producer biomass or to result in a biological impact (in the absence of phosphorus). The nitrogen concentrations in waters may be elevated, but this alone will not cause a change in primary producers. Operational monitoring data and predictive evaluations indicate that concentrations of nitrite and ammonium - two forms of nitrogenous compounds that could be toxic - are expected to remain well below toxic levels.

Monitoring of discharge water from Cell E of the Long Lake Containment Facility has indicated that waters released from the facility have background levels of phosphorus, that are similar to levels found in pristine lakes in the area. Phosphorus is very particle-reactive (it attaches to sediments) and, as such, is likely to remain in the containment facility as the sediments accumulate. It is expected that phosphorus concentrations in the water exiting the containment facility will remain low and close to natural background levels. Therefore, water flowing from the downstream Koala Watershed will remain low in phosphorus and is not expected to cause a biological impact in Lac de Gras.

The development of the Diavik Diamonds Project has been predicted to introduce phosphorous into Lac de Gras (Diavik, 1998b), but the effects are expected to be localized (<20% of the area of Lac de Gras). The discharge from the project is predicted

to have an effect on primary production (Diavik, 1998b). The ideal ratio of nutrients in water for use by primary producers is 7N:1P by weight (referred to as the Redfield Ratio; Redfield 1934, 1963). This means that for every gram of phosphorus removed from the water by primary producers, seven grams of nitrogen will also be removed. In the case of Lac de Gras, nitrogen will not be removed from the water biologically unless phosphorus is present (hence the term phosphorus-limited). The addition of nitrogen alone will not cause an increase in primary producer biomass, but the addition of phosphorus alone could, because some algal species can obtain their nitrogen from the atmosphere as nitrogen gas and would always have an available supply of nitrogen.

The ratio of nitrogen and phosphorus concentrations that could be input to Lac de Gras from the Diavik Diamonds Project is higher than the ideal Redfield ratio. This is based on phosphorus loading calculations presented in the Diavik EA and assumptions made on normal mining activities and resultant nitrogen loading as measured at EKATI™. An input ratio of nitrogen to phosphorus that is much greater than the Redfield Ratio indicates that phytoplankton in Lac de Gras will consume all the available phosphorus produced by Diavik and still have excess nitrogen.

EKATI™ is not expected to introduce phosphorus into Lac de Gras. The small quantity of nitrogen associated with Pigeon and Beartooth that could potentially be introduced into Lac de Gras for a period of approximately four years is not expected to have any additive effect with nitrogen already being introduced to the lake from Diavik. Normal mining activities at the Diavik Diamonds Project will likely produce enough nitrogen to cause the biological uptake of their generated phosphorus, and any additional nitrogen contributed by EKATI™ is not expected to result in any additive impact to primary producers.

EKATI™ and the Diavik Diamonds Project together will possibly increase nitrogen levels in Lac de Gras without affecting aquatic life. The contribution to this effect on water quality (not on aquatic life) from EKATI™ will be for only a relatively short period of time. The mining of Pigeon and Beartooth pipes will be completed by 2009. Diavik is expected to be operating before 2005, so there will be four years of potential overlap of the discharges within Lac de Gras.

In summary:

- The water quality criteria included in BHP's Type A Water Licence will continue to be met at the discharge of the Long Lake Containment Facility, which is well upstream of the terminus of the Koala Watershed into Lac de Gras.
- The potential for cumulative effects from EKATI™ and Diavik on Lac de Gras water for parameters outlined in BHP's Water Licence is remote.
- The residual effect of elevated nitrogen levels in discharge from the Long Lake Containment Facility, due to existing project activities as well as the proposed pipes, has the potential to temporarily increase nitrogen levels locally in Lac de Gras.
- Potentially elevated nitrogen levels entering Lac de Gras from EKATI™ are not expected to result in a biological impact or biological change in Lac de Gras.

- It is expected that the discharge from the Long Lake Containment Facility will continue to have background levels of phosphorus, and that EKATI™ will not introduce phosphorus into Lac de Gras. The possible temporary increase in nitrogen levels in Lac de Gras from EKATI™ is not expected to have any biological impact.
- It is concluded that no cumulative effects on Lac de Gras primary producers will result from potential nitrogen loading from EKATI™ with and from the nitrogen and phosphorus loading from Diavik. Nitrogen concentrations may become elevated (effect on water quality; but a biological effect is only expected as a result of phosphorus loading.

4.9.4.3.2 Surface Water Quantity

The effects of the proposed development at Sable, Pigeon and Beartooth pipes on hydrological conditions are expected to be strictly confined to local drainage basins of the Exeter and Koala watersheds and will not be detectable beyond their borders. Negligible ratings for all residual effects associated with water quantity provide the justification for excluding water quantity from a cumulative effects assessment.

A number of other existing or potential water users that could affect water quality within the regional area have been identified: residential communities, outfitters and resource development projects (EKATI™, Diavik Diamonds Project). The residual effects from the development of Sable, Pigeon and Beartooth development at EKATI™ has been rated as negligible. These negligible residual effects, in combination with all other water quantity related activities, have been deemed negligible based on professional judgement. A further assessment of the cumulative effects of all water quantity issues is therefore not warranted.

Furthermore, the Comprehensive Study Report prepared for the Diavik Diamonds Project in 1999 concluded that "*potential changes in Lac de Gras water levels and outflows from the Diavik Diamonds Project would be small and well within the range of natural variability*" (CEAA, 1999b). The Diavik Diamonds Project is an approved project within the regional study area 30 km south of EKATI™. The Comprehensive Study Report also concluded that the "*cumulative effects of the proposed Diavik Diamonds Project and the existing EKATI™ Diamond Mine on the quantity of surface water in the region would be negligible.*"

4.9.4.4 Fish/Aquatic Habitat

This section identifies and evaluates the potential for cumulative effects on fish populations and fish habitat in the Lac de Gras and Yamba/Exeter watersheds resulting from development of the Beartooth, Pigeon and Sable pipes.

The assessment presented in Section 4.5 concluded that the effects on fish and fish habitat will be negligible at local levels. With the application of appropriate mitigation measures, the stocking of fish following pit flooding and habitat restoration, even long-term localized effects on fish and fish habitat should be reversible. The exception is Big

Reynolds Pond, which will be filled with waste rock and replaced with additional fish habitat from the flooded Pigeon pit.

There are an estimated 8,000 lakes in the BHP claim block. The lakes to be directly affected by the proposed developments represent approximately 0.06% of the surface area of lakes within this claim block (lakes in the claim block make up about one-third of the total area of 3,400 km^2). Assuming a similar lake to watershed ratio:

- Sable and Two Rock lakes make up 0.2% of the lake area within the Exeter Watershed and 0.04% of the Yamba/Exeter Watershed.
- Big Reynolds and Beartooth lakes comprise 0.02% of the lake area within the Lac de Gras Watershed.
- The total area of these lakes represents 0.004% of the Coppermine River Drainage Basin.

Information is not available to identify the number of lakes in these areas that support fish populations or their overall biomass of fish. However, it is likely that the combined biomass of fish in Beartooth Lake, Big Reynolds Pond, Sable Lake and Two Rock Lake represents only a very small fraction of fish biomass in the BHP claim block lakes or in the Lac de Gras, Yamba/Exeter and Coppermine watersheds. Combined, these lakes do not constitute a fishery as defined by the Fisheries Act.

In addition to the very limited fish biomass and production potential of the affected lakes, it is probable that fish populations in Beartooth Lake, Big Reynolds Pond, Sable Lake and Two Rock Lake have very little opportunity for genetic exchange with fish populations from other lakes. This is because migration is restricted due to poor stream migration habitat. The temporal loss of fish populations from these lakes would therefore not have an effect on population genetics elsewhere in the Lac de Gras or Yamba/Exeter watersheds.

The Pigeon Stream Diversion will be engineered to achieve No Net Loss of productive capacity of fish habitats. Presuming this to be the case, there should be no measurable effect on fish (Arctic grayling) production, biomass or population structure in Fay Lake or Exeter Lake.

For reasons given above, it is anticipated that there will be no cumulative effects at the regional level (Lac de Gras Watershed) due to the permanent loss of Big Reynolds Pond fish production. This conclusion is strengthened by the fact that Big Reynolds Pond drains into the Long Lake Containment Facility, thereby completely isolating its small fish population.

There are no other known developments or proposed developments within the Yamba/Exeter Watershed that have the potential to affect fish or fish habitat. The downstream residual effects do not extend beyond this watershed. Therefore, a discussion of cumulative effects due to mining development plans for the Pigeon and Sable pits and for Sable Road construction is, therefore, not warranted.

The Environmental Assessment for the Diavik Diamonds Project at Lac de Gras (Diavik, 1998b) concluded that, "*Changes to water quality, hydrology, direct habitat alteration and harvest were determined to have no cumulative effects on fish or fish habitat in Lac de Gras.*" This assessment was based on information and data from the EKATI™ Diamond Mine and from predictions of effects of the Diavik Diamond Mine project. Given that the effects of development of Beartooth and Pigeon pits will be highly localized, it can be concluded that these effects will not be detectable at the regional level and therefore, there will be no cumulative effects on fish and fish habitat from this development.

4.9.4.5 Wildlife

The wildlife VECs were selected from species known to occur or probably occur in the BHP regional study area (Figure 4.2-3). Data on the distribution of species were determined from past baseline and monitoring reports and the scientific literature. Species or species groups that contain species considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 1997) to be endangered, threatened or vulnerable were automatically considered as potential VECs. Other species that could occur within the study area were ranked in a selection process to determine if they could be considered as VECs. Emphasis was on species known to be permanent residents or to breed within the study area and those belonging to species groups not represented by the COSEWIC-listed species.

Following review of the relevant data, the wildlife VECs were determined to be:

- caribou and their habitats;
- carnivores and their habitats; and
- birds and their habitats.

Carnivores of the area include grizzly bears, wolves, wolverines, and red and Arctic foxes. Grizzly bears are of relatively high ecological importance, and more is known about their habitat affiliations, so they have been treated distinctly from other carnivores.

4.9.4.5.1 Caribou/Habitats

The Bathurst caribou herd is the largest of the major barren-ground caribou herds found on the mainland of the Northwest Territories and Nunavut. Each year on both its northern and southern migration at least part of this herd passes across the (EKATI™ Diamond Mine) claim block. This herd is of major importance to the integrity of tundra and taiga ecosystems within their range. Industrial activity could potentially affect caribou populations by influencing their distribution, health and mortality.

The health and long-term well-being of the Bathurst herd is of great interest to all residents of NWT and Nunavut. Due to their pivotal role in the lives of Aboriginal people and other residents of the Northwest Territories, barren-ground caribou were identified as a VEC in the NWT Diamonds Project EIS (BHP, 1995).

The potential effect of the EKATI™ Diamond Mine on the health, numbers and migratory patterns of the Bathurst caribou herd was one of the most important public concern raised during the EARP technical hearings in 1996 (CEAA, 1996). This reflected the central role of caribou in the physical and cultural well-being of Aboriginal peoples of the area.

The 1997, 1998 and 1999 Wildlife Monitoring Program focused on wildlife species or areas of study that were previously identified VECs during the 1995 EIS for the mine and further refined in 1998. Baseline studies from 1994 to 1996 also included caribou as a VEC.

The central importance of the caribou to the local residents, coupled with the extensive range and the proximity of the migration path to the Sable, Pigeon and Beartooth pipes, warrants their inclusion in the cumulative effects assessment.

4.9.4.5.2 Carnivores/Habitats

In assessing the effects of development on carnivores (Section 4.6) two distinct traits are apparent: species with small ranges; and species with large ranges. As the assessment requires an interaction with other regional activities, grizzly bears, wolves and wolverines were selected for assessment because:

- Individuals that could encounter EKATI™ comprise populations that span beyond-regional boundaries.
- They have annual home ranges that extend beyond the regional study area. Therefore, possible population effects that could occur with the proposed development would be cumulative with those incurred throughout the greater-than-regional study area.
- Grizzly bears and wolverines have low reproductive capacity.
- The effects on these species from the proposed development of the Sable, Pigeon and Beartooth pipes are predicted to be of at least minor significance.

However, the species with smaller home ranges, such as Arctic and red foxes, were excluded from cumulative effects assessment because effects of developments are predicted to be:

- of very local extent;
- essentially confined to the immediate footprints of individual developments;
- applicable only to local populations; and
- negligible.

4.9.4.5.3 Breeding Birds/Habitats

Passerines and waterfowl were not selected for cumulative effects assessment because effects of developments are predicted to be:

- of very local extent;

- essentially confined to the immediate footprints of individual developments; and
- negligible.

Raptors were not selected for cumulative effects assessment because the proposed development, individually or in conjunction with existing and potential developments, is predicted to have a negligible effect on their population abundance or distribution.

4.9.4.6 Socio-Economic Elements

The cumulative effects study area comprises the same NWT communities that were analyzed in the 1995 EIS. Resource developments that could potentially cause cumulative effects in these communities include the EKATI™ Diamond Mine, Diavik Diamonds Project and Lupin Mine. The Diavik Diamonds assessment of cumulative effects in the same region is referenced where applicable. The lack of published data prevents adequate assessment of future developments such as the Winspear and Tahera diamond projects. General assessment of future development was done in the EIS (BHP, 1995).

The EIS outlined a methodology for assessing cumulative effects. The evaluation focused on those elements of the environment that would experience a residual effect from some aspect of the proposed project development. The significance of residual effects (effects that may persist after mitigation has been implemented) was evaluated according to the following definitions:

- *Major:* the whole population of NWT affected over several generations
- *Moderate:* community affected over one or more generations
- *Minor:* a specific group of individuals within a community affected during less than one generation
- *Negligible:* specific group of community individuals affected during a short period

Only those elements affected by minor, moderate or major effects were considered in the assessment (BHP, 1995).

Where the proposed development has a negligible socio-economic residual effect, it is not a contributor to cumulative socio-economic effects. The extent to which potential effects of the proposed development interact with residual effects of the Diavik Diamonds Project, Lupin Mine and other future developments also depends on the timing, duration and geographic extent of interacting effects.

4.9.4.6.1 Socio-Economic Effects

BHP addressed potential socio-economic cumulative effects in the 1995 EIS (BHP, 1995) relative to the EKATI™ Diamond Mine, future mine development and outfitting operations. The EIS (BHP, 1995) stated that increased employment and expenditures on goods and services in the NWT would stimulate economic development and provide

opportunities for NWT residents to expand their skills and education. The EIS concluded that although there could be some income disparity in communities, the large number of jobs, training and business development opportunities would generally contribute to community stability. The EIS further identified that land use and outfitting operations may be disturbed by EKATI™ and future mine developments. However, BHP concluded that the socio-economic cumulative effects were as follows:

- Increased employment would be of major significance, creating a legacy of trained workers and thus providing a positive benefit to communities.
- Community tensions resulting from income disparity would be of minor significance and would depend on the availability of social services and community stability.
- Increased overall economic development would be of major significance and a positive benefit if future planning and development occur in the NWT.
- Improved social services would be of major significance and a positive benefit if future planning and development occur in the NWT.
- Integration of traditional lifestyles with rotating work schedules would be of moderate significance and a positive benefit primarily to Aboriginal communities.
- Disturbance or relocation of outfitting operations would be of minor significance given that outfitters should be able to sustain their activities in adjacent areas if necessary.

Table 4.7-13 in Section 4.7 indicates that the significance of the residual effects for the proposed Sable, Pigeon and Beartooth development will not change from that predicted for EKATI™ in the EIS. Mitigations and enhancements are also based on the EIS commitments as well as procedures implemented by BHP pursuant to its policies and various agreements.

Based on the significance of residual effects set out in Table 4.7-13, the following areas have potential for interactive cumulative effects with Lupin Mine, Diavik Diamonds, the Echo Bay Winter Road and other future developments:

- employment and income;
- opportunities for local, regional, and territorial business, and economic diversification;
- availability and use of NWT skilled workers;
- barriers to employment (job/education aspirations);
- government expenses and revenue; and
- human health and community well-being.

The Lupin Mine workforce is expected to be a mix of workers from the Kitikmeot (10% to 20%), other NWT locations and southern Canada. Although Echo Bay Mines Ltd. has begun hiring up to 320 workers to commence production at Lupin Mine (April 2000). BHP's proposed development will not begin until after the end of Echo Bay's planned production period (2004). Therefore, the employment, income and subsequent human

health and community wellness effects of the Lupin Mine are not likely to interact cumulatively with the residual effects of the proposed BHP development.

The "Diavik Socio-Economic Environmental Effects Report" (DSEER) (UMA Group, 1998) dealt with the cumulative effects of the Diavik Diamonds Project and the EKATI™ Diamond Mine. To avoid duplication, reference will be made to this report and its assessments. Diavik's main conclusion was that the projected labour market had sufficient capacity to supply the anticipated northern employment labour demand for both the Diavik and EKATI™ projects. This points to minimal new migration into the NWT, and hence no incremental population growth or pressure on infrastructure capacity. Further, the unemployment in the region would decline as a result of EKATI™ and Diavik. The estimated effects are found in Section 7.2.10 and the summary of cumulative effects in Section 7.6 in the DSEER.

The proposed development will not increase the annual traffic load on the Echo Bay Winter Road as the scale of BHP operations will not increase. The proposed development will continue BHP's traffic on the road an additional three years. There will be no change to the winter road operation and therefore no incremental effects.

In its EIS, BHP committed to ongoing assessment of the socio-economic effects of the EKATI™ mine. In the Report of the Environmental Assessment Panel (June 1996, Section 6.2 Cumulative Effects), the panel agreed with BHP's conclusion that:

> *...the cumulative socio-economic effects entailed by extending the life of the mine are likely to be positive since extension of the life of the mine would provide economic stability. However, continued socio-economic monitoring would still be required to determine actual effects and to ensure that any negative social or cultural effects are identified and mitigated.*

As discussed earlier, additional monitoring provisions were agreed to by BHP in the Environmental Agreement and its various licences. BHP's socio-economic effects, mitigations and commitments are specifically monitored through the Socio-Economic Agreement and the IBAs. The GNWT's commitments and monitoring role are also set out in the Socio-Economic Agreement. Commitments and mitigations have been discussed throughout this report. Ongoing communication with Aboriginal groups, communities, governments and other stakeholders assist in the assessment of any cumulative socio-economic effects (BHP, 1995). The EIS stated that the best approach for addressing the potential cumulative effects of the project would be the initiation of a monitoring program (BHP, 1995); the variables to be monitored were summarized in Table 5.8-1. These monitoring systems are currently in place and will be used to address any potential cumulative effects during the proposed development as well as during the life of the mine.

4.9.4.6.2 Human Health

With the possible exception of small air quality effects on the human health of workers in pits during temperature inversions, all other changes to the biophysical environment from the three developments are expected to have a negligible effect on human health.

With regard to the Diavik Diamonds Project, the issue of effects on air quality would be independent, short-term, infrequent and apply only to personnel working in affected pits. BHP currently has procedures in place to prevent and avoid safety risks to its workers. Air quality effects on human health from pit thermal inversions are monitored and safety precautions taken as required. Therefore, whether at EKATI™ or Diavik, cumulative effects on human health will be negligible.

The EIS (BHP, 1995) identified interacting residual effects of the EKATI™ mine, future mine development and outfitting activities on caribou as having potential cumulative effects on human health. The interacting effects of noise disturbance, habitat loss and sport hunting could potentially combine to affect caribou. This, in turn, might have an effect on the availability of country food loss in the immediate vicinity of the mine site.

Residual effects on human health from changes to the socio-economic environment resulting from the proposed developments are expected to be negligible and should not result in cumulative effects. Ongoing monitoring by the GNWT of mining effects on community wellness is expected to assist communities to identify and respond to their own needs.

The majority of the predicted socio-economic effects are positive. The predicted socio-economic residual effects for Sable, Pigeon and Beartooth development are the same as those predicted for the EKATI™ Diamond Mine in the 1995 EIS. As a result, socio-economic residual effects have not been carried forward into the cumulative effects analysis.

4.9.4.7 Other Regional Environmental Concerns

In addition to the VECs initially identified, the broader scope of the cumulative effects assessment means that other regional environmental concerns may, potentially, be affected by the development of the project. However, the initial scoping for the project, public meetings and the CSR for the Diavik Diamonds Project (CEAA, 1999b) did not identify additional issues that were regionally important and not covered under the scoping for the EAR. Therefore, no other VECs were added to the assessment.

4.9.4.8 Summary

Of the VECs examined for the local and regional environmental effects assessment, three have been selected for inclusion in the current cumulative effects assessment:

- Air Quality;

- Carnivores/Habitat; and
- Caribou/Habitat.

The carnivores VEC assessment will focus on grizzly bears and will be also used as a worst-case scenario for wolves and wolverines.

4.9.5 Identification of Temporal and Spatial Boundaries

Temporal and spatial boundaries are required to provide focus for the assessment. Generally, these are larger than the boundaries used for the specific development assessment. They vary with the VEC so that they accurately reflect the other regional projects/activities and the specific nature of the VECs under evaluation. Spatial and temporal boundaries place the proposed development into a geographic context and a specific timeframe. The MVEIRB Terms of Reference requested that the spatial boundaries of the cumulative effects assessment include an evaluation of possible effects from the Sable, Pigeon and Beartooth development in combination with other developments within the zone of influence of BHP's proposal, including "developments" within the regulatory process as of December 1999. The assessment was to include, at a minimum, consideration of the existing EKATI™ Diamond Mine, Diavik Diamonds Project, Echo Bay Mines Ltd. Winter Road and the Lupin Mine.

The boundaries need to include existing developments and known potential developments whose activities could possibly affect air quality, wildlife and wildlife habitat. In addition to the MVEIRB's Terms of Reference, the following sites have been initially included in the cumulative effects assessment: Winspear's Exploration Camp, Tahera Resources' Exploration Camp, RWED's Daring Lake Research Station, 12 Outfitter's Camps and the community of Snare Lake.

Cumulative effects analysis addresses the potential effects of activities operated by BHP as well as those of other developers, outfitters, and people utilizing the winter road in pursuit of other endeavours such as hunting and fishing.

4.9.5.1 Spatial Boundaries (General)

The spatial boundaries for the EAR are often arbitrary and may be based on a non-ecological suite of parameters (*e.g.*, a claim block). However, to more effectively assess the possible ecological effects, the boundaries need to be based on ecologically significant parameters (*e.g.*, a watershed). This is carried out by:

- identifying the key spatial parameters (ecological context) of the VEC (*e.g.*, home ranges for grizzly bear);
- identifying the spatial extent of the residual effects for the VEC by considering pathways (*e.g.*, detectable downstream water quality changes);
- understanding the limitations of the data set as the distance increases from the proposed Sable, Pigeon and Beartooth development;

- appreciating the (un)certainty of future development and predicting future potential effects;
- understanding the potential interactions between residual effects on a specific VEC;
- incorporating risk management; and
- making conservative assessments on the magnitude, geographic extent, duration, probability and reversibility of the effect.

The spatial boundaries also address:

- interests of other stakeholders;
- "downstream" effects on ecosystem components; and
- the ultimate limits where the residual effects of the proposed Sable, Pigeon and Beartooth development become insignificant.

These considerations mean that the spatial boundaries for the varioius VECs under consideration are different, as a different suite of parameters needs to be incorporated into the individual evaluations.

4.9.5.2 Temporal Boundaries (General)

Generally, the temporal boundaries for a cumulative effects assessment begin with the start of the project and end with the last residual effects remaining during the decommissioned and rehabilitated state. The ideal temporal boundaries are established at the start of development in the area. This usually results in increased dependency on qualitative data and less on quantitative data. For the Sable, Pigeon and Beartooth development, a good baseline for the area is available in the EIS for the EKATI™ Mine, and from the ongoing project-specific baseline monitoring studies.

4.9.5.3 Air Quality

4.9.5.3.1 Spatial Boundaries

The cumulative effects assessment for air quality is limited to the regional area where regulations and/or guidelines are applicable and is defined by:

- 25 km E-W by 35 km N-S area, centred between the Diavik and Misery sites (Diavik 1998b).
- 40 km by 40 km area encompassing the Misery and Sable sites, centred at the main EKATI™ facility (BHP, 1995).

4.9.5.3.2 Temporal Boundaries

A hierarchy of scales is used for assessing the short-, medium- and long-term cumulative effects on air quality, following those established in the air quality objectives of Environment Canada.

The ambient air quality objectives established by Environment Canada are averaged over periods ranging from 1 to 24 hours for short-term, annually for medium term and three years for long-term. For climatic effects, a 5-year to 30-year scale will be used, as is employed by Environment Canada. The EKATI™ mine life is currently 18 years with a rehabilitation period of up to 25 years for completing their filling of Sable Pit. However, the effects on air quality will be minimized at mine closure; therefore, the time scale will be established from pipe development to mine closure.

4.9.5.4 Caribou/Habitats

4.9.5.4.1 Spatial Boundaries

The range of the Bathurst Caribou herd covers approximately 250,000 km^2, with calving grounds near Bathurst Inlet and wintering grounds below the treeline. The annual range overlaps with three adjacent populations, primarily during the winter (Figure 3.7-1): the Bluenose East Caribou herd to the west in the vicinity of Great Bear Lake; Queen Maud Gulf Caribou herd (Gunn *et al.*, 2000), to the northeast, primarily during the winter; and with the Beverly Caribou herd in the area south of Great Slave Lake and extending to the Saskatchewan border. While the majority of the herd spends the winter below the treeline, some individuals remain in the barrenlands. Caribou have been reported in the Lac de Gras area during the winter. Caribou have not been documented on BHP's claim block during the winter (Banci and Moore, 1997; BHP Diamonds Inc., 1995; Golder, 1998; Golder, 1999; Rescan, 1999c).

In general, spring and fall migration periods begin in late April and mid-July, respectively, and last for approximately four weeks. During June and early July very few caribou are present in the Lac de Gras region (BHP, 1995c; Banci and Moore, 1997; Golder, 1998; Golder, 1999), however, by mid-July the largest numbers of caribou move onto the claim block from the north, as part of their post-calving movement. By October the herd has migrated south of Lac de Gras toward their wintering grounds below the treeline.

The spatial boundaries selected for evaluation of cumulative effects on caribou encompass the migrational corridor for the Bathurst herd (Figures 3.7-2, 3.7-3, 3.7-4). The north-south dimensions of this area extend from north of Contwoyto Lake south to the treeline, above McLeod Bay on Great Slave Lake. The west-east dimensions extend approximately 150 km west and 150 km east of EKATI™. The boundaries do not include the traditional calving grounds around Bathurst Inlet (Figure 3.7-1) or the traditional wintering range below the treeline.

The area of the migration corridor described is based on the distribution of satellite-collared caribou during 1997, 1998, 1999 and 2000 (RWED, 2000; RWED, 1999; RWED, 1998; RWED, 1997), and field studies conducted during baseline gathering (1994 to 1996) and wildlife monitoring (1997 to 1999).

4.9.5.4.2 Temporal Boundaries

Temporal boundaries for the cumulative effects assessment were selected to cover potential effects from development activities for the life of the proposed Sable, Pigeon and Beartooth development. This encompasses all phases of mine development from exploration through development and operation to decommissioning.

4.9.5.5 Carnivores/Habitats

4.9.5.5.1 Spatial Boundaries

The spatial boundary selected for carnivores includes the area of the Landsat Thematic Mapper (TM) image shown in Figure 4.2-3). The total area encompassed by this image is 31,222 km². The northern boundary is the northern limit of Landsat imagery that has been classified and was available for this project (H. Epp, NWT Centre for Remote Sensing, pers. comm.). Eastern, western, and southern boundaries were selected to encompass most regional land use activities.

Several development or activity sites were outside the boundary of the classified Landsat image, but were considered to have potentially cumulative effects. These sites were included as outliers from the contiguous CEA Study Area. For assessment of habitat effects, areas were calculated and assigned to the "unclassified" category. Therefore, the entire area considered for cumulative effects assessment was larger than 31,222 km².

Grizzly bear home ranges have been calculated for satellite-collared bears in the Slave Geological Province (SGP) (McLoughlin *et al.*, in press). Adult female home ranges averaged 2,074 km², and adult male home ranges averaged 6,685 km². Bears do not use their home ranges exclusive of other bears, and no precise bear density estimate exists for the SGP (D. Cluff, RWED, pers. comm.). Therefore, it is not possible to accurately estimate the grizzly bear population within this study area. However, Diavik (1998b) reported estimates of 30 to 90 adult and subadult bears within their 13,865 km² Regional Study Area. Applying these estimates, the extrapolated bear population within the carnivore CEA Study Area would be 67 to 202 adult and subadult bears. However, this extrapolation must be made cautiously as it is predicated upon rough estimates, and it implies equal quality of bear habitat (and equal bear densities) throughout the study area.

4.9.5.5.2 Temporal Boundaries

The carnivores present in the area tend to be long-lived and range over large areas. The presence of humans in the area means that the effects on grizzly bears could extend for a

considerable time. Therefore, the temporal boundary selected for carnivores corresponds to the predicted operational life of the Sable, Pigeon and Beartooth pits and the EKATI™ mine including the decommissioning and closure phases. With the requirement to complete the filling of the Sable Pit, human activity in the area will extend up to 25 years beyond the cessation of mining. Therefore, the temporal boundary is established from the start of operations to the end of closure (2002 to 2040).

4.9.6 Identification of Other Projects/Activities That May Affect the VECs

The activities included in the assessment have been developed from those requested in the Terms of Reference by the MVEIRB:

- BHP EKATI™ Diamond Mine;
- Diavik Diamonds Project;
- Echo Bay Mines Ltd. - Winter Road; and
- Echo Bay Mines Ltd. - Lupin Mine.

Several other local and/or smaller projects/activities were identified in the Diavik Diamonds Project EA and in investigations for this assessment:

- Local outfitters;
- Aboriginal land use; and
- Mining and exploration operations.

The locations of all of these operations are identified in Figure 4.9-2.

4.9.6.1 Mines and Echo Bay Winter Road

The activities associated with the mining operations are typical of most mines and can be summarized as follows:

- drilling and blasting;
- mining and processing;
- disposal of wastes and waste rock;
- support infrastructure; and
- fossil fuel consumption.

The winter road has a different suite of activities associated with it and with the additional access it affords to remote areas:

- access for hunting and recreation;
- fuel movement;

- road traffic (potential for collisions with animals, noise, *etc.*); and
- potential for spills.

Brief descriptions of each of these actions are provided in Appendix F. Details of each operation and the major activities that might result in residual effects are summarized in Table 4.9-1.

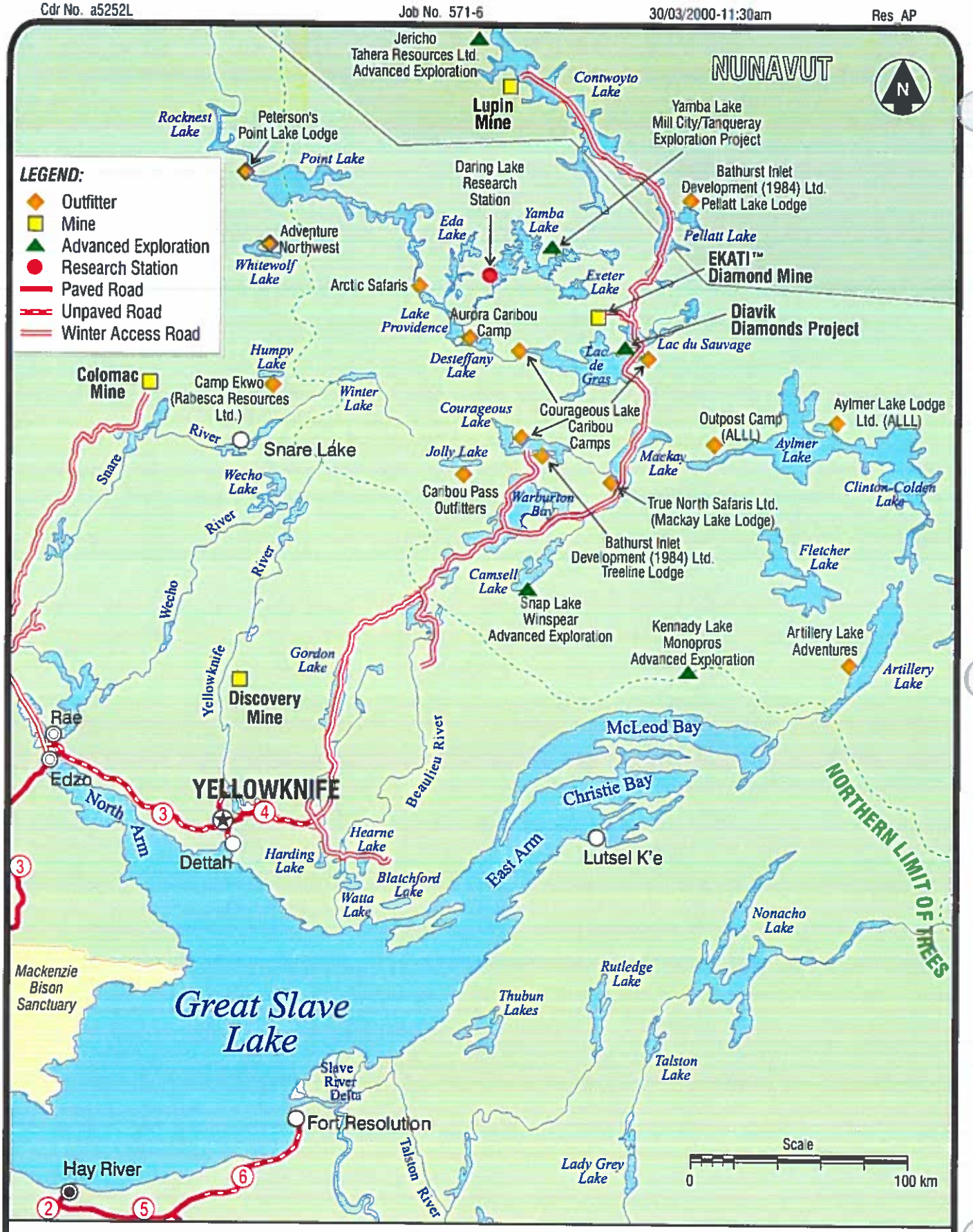
4.9.6.2 Local Outfitters/Research Stations

The proposed development area is in one of the more remote locations in Canada and, as such, is popular for sport and outdoor activities. Several outfitters offering a range of activities (*e.g.*, hunting, fishing, eco-tourism, *etc.*), together with RWED's Daring Lake scientific research station (Figure 4.9-2), are located in the area:

- Adventure Northwest Ltd.;
- Arctic Safaris;
- Artillery Lake Adventures;
- Aurora Caribou Camp;
- Aylmer Lake Lodge Ltd.;
- Bathurst Inlet Developments (1984) Ltd. - Treeline Lodge;
- Bathurst Inlet Developments (1984) Ltd. - Pellatt Lake Lodge;
- Camp Ekwo - Rabesca Resources Ltd.;
- Caribou Pass Outfitters;
- Courageous Lake Caribou Camps (Shoshone Wilderness Adventures);
- Peterson's Point Lake Camp;
- True North Safaris Ltd.; and
- Tundra Ecosystem Biological Research Station (Daring Lake Research Station).

Brief descriptions of the outfitter operations are presented in Appendix F. Details of each operation and the major activities that might result in residual effects are summarized in Table 4.9-2. Due to limited data, the regional significance of the camps can only be assessed qualitatively. The information presented in Table 4.9-2 summarizes the projects/activities associated with the camps, the VECs that could potentially be affected and their regional significance.

Most of the camps consist of some form of permanent structure (lodges, cabins, storage silos, outhouses) with additional semi-permanent structures such as tent cabins. Some of the outfitters also maintain outpost camps, consisting of semi-permanent to temporary structures (tent cabins, tents).



Outfitting, Exploration and Mining Operations

FIGURE 4.9-2

Table 4.9-1
Summary of Activities Requested by MVEIRB

Project Name	Location	Type of operation	Activities[1]	VEC Potentially Affected
BHP EKATI™ Diamond Mine	Between Exeter Lake and Lac de Gras	Operating diamond mine	Pre-stripping, blasting and excavation of pits	Air Quality Physical/Terrestrial Environment Water Quality
Diavik Diamonds Project	Lac de Gras	Diamond mine (under construction)	Waste rock storage/drainage	Air Quality Water Quality Physical/Terrestrial Environment Heritage Sites
			Disposal of processed ore	Water Quality Caribou/Habitat Carnivores/Habitat
			Combustion of fossil fuels	Air Quality Physical/Terrestrial Environment
			Generation and disposal of sewage and other waste	Water Quality Fish/Aquatic Habitat Carnivores/Habitat
			Water management (flow diversion, stream diversion, lake dewatering, pit water discharge, freshwater supply)	Permafrost Water Quality and Quantity Fish/Aquatic Habitat Caribou/Habitat Groundwater
			Traffic and fugitive dust generation	Air Quality Caribou/Habitat
			Presence of infrastructure (buildings, roads, airstrip, *etc.*)	Air Quality Permafrost Physical/Terrestrial Environment Caribou/Habitat Carnivores/Habitat Breeding Birds/Habitat Heritage Sites
			Human activity	Caribou/Habitat Carnivores/Habitat Breeding Birds/Habitat Heritage Sites

1: Activities presented in table are common to both of the operations listed.

(continued)

Table 4.9-1
Summary of Activities Requested by MVEIRB (Completed)

Project Name	Location	Type of operation	Activities	VEC Potentially Affected
Echo Bay Mines Ltd. – Winter Road	Yellowknife to Contwoyto Lake	Winter road	Combustion of fossil fuels	Air Quality Physical/Terrestrial Environment
			Traffic (collisions with animals, habitat disruption along migration route)	Caribou/Habitat Carnivore/Habitat
			Spills (diesel fuel, lubricants, coolant, *etc.*)	Water Quality Fish/Aquatic Habitat Caribou/Habitat Carnivores/Habitat
			Increased access for hunters	Caribou/Habitat Carnivores/Habitat
Echo Bay Mines Ltd. – Lupin Mine	Contwoyto Lake	Gold mine (recently re-opened)	Underground operations	Physical/Terrestrial Environment Water Quality
			Processing of ore/tailings disposal	Water Quality Caribou/Habitat
			Combustion of fossil fuels	Air Quality Physical/Terrestrial Environment
			Generation and disposal of sewage and other waste	Water Quality Fish/Aquatic Habitat Carnivores/Habitat
			Water management (mine water discharge, freshwater supply)	Permafrost Water Quality and Quantity Fish/Aquatic Habitat Caribou/Habitat Groundwater
			Presence of infrastructure (buildings, roads, airstrip, *etc.*)	Permafrost Physical/Terrestrial Environment Caribou/Habitat Carnivores/Habitat Breeding Birds/Habitat Heritage Sites
			Human activity	Caribou/Habitat Carnivores/Habitat Breeding Birds/Habitat Heritage Sites

Table 4.9-2
Summary of Activities by Outfitters

Project Name	Location	Type of operation	Activities[1]	VEC Potentially Affected
Adventure Northwest Ltd	Little Marten Lake/ Whitewolf Lake	Hunting camp Fishing camp	Fishing	Fish
Arctic Safaris	Obstruction Rapids (Lake Providence)	Hunting camp Fishing camp Ecotourism	Fugitive dust generation (along roads - Treeline Lodge)	Air quality Physical/terrestrial environment
Artillery Lake Adventures	Artillery Lake	Hunting camp Fishing camp	Generation and disposal of sewage and other waste	Water quality Groundwater Fish/aquatic habitat
Aurora Caribou Camp	Desteffany Lake	Hunting camp	Human presence	Caribou Carnivores Breeding birds
Aylmer Lake Lodge Ltd.	Aylmer Lake	Fishing camps Ecotourism		
BID[2] Treeline Lodge	Courageous Lake	Potential hunting and fishing camp, eco-tourism, exploration	Hunting	Caribou Carnivores
BID[2] Pellatt Lake Lodge	Pellatt Lake	Hunting camp Hunting camp	Noise generation (airplanes, snowmobiles, generators, *etc.*)	Air quality Caribou Carnivores Breeding birds
Camp Ekwo/Rabesca Resources	Humpy Lake	Hunting camp		
Caribou Pass Outfitters	Jolly Lake	Hunting camps		
Courageous Lake Caribou Camps	Courageous Lake and Lac de Gras	Hunting camps	Operation of gensets, heaters, outboard motors, *etc.*	Air quality Water quality (outboard motors)
Peterson's Point Lake Lodge	Point Lake	Fishing camp Hunting camps	Presence of buildings (lodges, cabins, tents, *etc.*)	Caribou Carnivores Breeding birds Physical/terrestrial environment Heritage sites
True North Safaris Ltd. (Mackay Lake Lodge)	Mackay Lake and Aylmer Lake	Fishing camp Ecotourism Research station		
Tundra Ecosystem Biological Research Station	Daring Lake		Water extraction	Water quality and quantity Fish/aquatic habitat
			Winter road use	Caribou Carnivores

1: Activities presented in table are common to all of the operations listed.
2: BID = Bathurst Inlet Development (1984) Ltd.

The local outfitters are only active for short periods during the year. Most are active for a maximum of three months, typically operating between July and September. However, the potential does exist for some operations (*e.g.*, Bathurst Inlet Development (1984) Ltd., Treeline Lodge) to be active year-round as a base camp for mining exploration. Guided hunters, fishers and/or ecotourists make limited use of the camps for short periods (typically no longer than one week at a time). Some of the camps are no longer being used regularly, nor are the outpost camps associated with some of the organizations. Because the structures associated with the inoperative camps and outpost camps still remain (to allow renewed activity if desired), they were included in the assessment.

The larger camps are:

- Aurora Caribou Camp (7 tent frames, peak season average capacity of 17);
- Aylmer Lake Lodge (full service lodge with capacity for 16);
- Bathurst Inlet Development (1984) Ltd. - Treeline Lodge (full service lodge with capacity for 32);
- Caribou Pass Outfitters (tent frames with capacity for 16);
- Courageous Lake Caribou Camps (one main building, 10-person quonset hut, 8 tent frames);
- True North Safaris Ltd. – Mackay Lake Lodge (full service lodge with 19 permanent structures and capacity for 24).

The evaluation of the effects was carried out qualitatively using the available information for each lodge. The criteria developed for the reviews of projects/activities in the EAR were also applied to the data available for the camps. The limited activities of the camps and their widespread distribution over approximately 16,000 km^2 suggests that their regional significance will be mostly negligible.

4.9.6.2.1 Summary

The individual operations are small in size, and therefore are of very limited geographic extent. The frequency and duration of any effects caused by the outfitters are short-term due to their relatively short operating period (two to three months). Effects may occur, but they are reversible. Furthermore, the future capacity of renewable resources is managed to remain high. The overall significance of the effects caused by outfitter operations is mostly negligible. Further details of the assessment of residual effects are provided in Appendix F.

4.9.6.3 Aboriginal Land Use

Regional land use on the claim block potentially involves four Aboriginal groups (Copper Inuit, Treaty 11 Dogrib Dene, North Slave Metis and Treaty 8 Yellowknives Dene) and includes activities such as:

- winter and summer travel routes;
- short-term traditional camps;
- general hunting and trapping areas (barren-ground caribou, Arctic fox, wolf, wolverine);
- fisheries - Long Lake (historically used by the Dogrib and Yellowknives Dene), Lac du Sauvage narrows and the outlet of Lac de Gras (used by all three groups);
- barrenland and caribou water crossings;
- graves;
- place names; and
- knowledge of wildlife denning.

As discussed previously in Sections 3.8.7 and 4.7.5, the proposed addition of the Sable, Pigeon and Beartooth development to the EKATI™ mine plan is not expected to have an adverse effect on traditional land use of the Lac de Gras region. Negative changes to traditional economies from the integration of Sable, Pigeon and Beartooth should be negligible.

The extension of mine life will maintain employment and income benefits for an additional three years. Sustained employment and income has the potential to maintain support to, and involvement in, the traditional economy. The additional employment and training opportunities will prepare Aboriginal employees to make positive productive choices in the mixed or wage economies of the NWT.

Because the addition of the Sable, Pigeon and Beartooth pipes to the EKATI™ mine plan is not expected to have an adverse effect on traditional land use of the Lac de Gras region, cumulative effects assessment of this issue is not required.

4.9.6.4 Mining and Exploration Operations

The discovery of diamonds in the Slave Geologic Province and gold prospecting and mining in the region have resulted in several exploration projects and numerous active and inactive mining operations (Figure 4.9-2):

- Tahera Corporation - Jericho Project;
- Winspear Resources Ltd. - Camsell Lake Property (Snap Lake Discovery);
- Mill City and Tanqueray Resources Ltd. - Yamba Lake;
- Monopros Limited - Kennady Lake (Gahcho Kue') Project;
- Courageous Lake area;
- Colomac Mine;
- Discovery Mine; and
- Other projects/activities.

Brief descriptions of each of these operations are provided in Appendix F. Details of each operation and the major activities that might result in residual effects are summarized in Table 4.9-3.

4.9.7 Analysis of Cumulative Effects

4.9.7.1 Air Quality

Of the projects (potential and existing) identified above, several have point and mobile sources of air contamination. Brief descriptions of each source follow.

4.9.7.1.1 EKATI™ Diamond Mine

Ambient air dispersion modelling results from the NWT Diamonds Project 1995 EIS show negligible concentrations for SO_2, NO_2 and total suspended particulates for 1-hour, 24-hour and 1-year averaging periods, at the location of the proposed Sable Pit, about 20 km from the main EKATI™ facility. Additionally, at the Beartooth and Pigeon pits (close to the main EKATI™ facility), the 1995 NWT Diamonds Project EIS shows ambient pollutant concentrations that are below the minimum acceptable Environment Canada ambient air quality objectives (generally by more than an order of magnitude).

4.9.7.1.2 Diavik Diamonds Project

The 1998 Diavik Diamonds Project EA included the EKATI™ mine in their cumulative air quality evaluation quality. From the general air dispersion modelling, it is concluded that:

- the EKATI™ mine is too distant from the Diavik site (30 km) to have a measurable cumulative impact (1998 Diavik Diamonds Project EA); and
- the EKATI™ and Misery sites are sufficiently separated to have no cumulative effects (1995 NWT Diamonds Project EIS).

From these results it can be inferred that the cumulative effects at the proposed project sites, which are even more distant from Diavik Diamonds Project than the main EKATI™ mine, will also be negligible.

The lakes and rivers of the region of the proposed EKATI™ mine development are highly sensitive to acidic depositions. In assessing the potential for acidic depositions (acid rain), modelling predictions (Diavik, 1998b) found that 10 km from the project site:

- wet sulphate deposition rates estimated at 0.1% of U.S.-Canadian recommendations; and
- nitrate deposition rates were estimated at 0.3% of the National Swedish Environmental Protection Board level for sensitive waters.

Table 4.9-3
Summary of Activities by Exploration Projects and Other Operations

Project Name	Location	Type of operation	Activities[1]	VEC Potentially Affected
Tahera Corporation – Jericho Project	Contwoyto Lake	Diamond exploration projects	Geophysical surveys (summer)	Heritage Sites
Winspear Resources – Camsell Lake Project	Camsell Lake		Site preparation, drilling, disposal of drilling mud, drill movement (winter)	Air Quality Physical/Terrestrial Environment Water Quality and Quantity Heritage Sites
Mill City/ Tanqueray Resources – Yamba Lake Project	Yamba Lake			
Monopros Ltd. – Kennady Lake Project	Kennady Lake		Presence of infrastructure (camp, winter roads, gensets, fuel cache, *etc.*)	Air Quality Permafrost Physical/Terrestrial Environment Water Quality and Quantity Caribou/Habitat Carnivores/Habitat Breeding Birds/Habitat Heritage Sites
			Helicopter use (noise generation)	Air Quality Caribou/Habitat Carnivores/Habitat
			Combustion of fossil fuels	Air Quality
			Generation and disposal of sewage and other waste	Water Quality and Quantity Fish/Aquatic Habitat Carnivores/Habitat
			Human activity	Caribou/Habitat Carnivores/Habitat Heritage Sites
Community of Wekweti (Snare Lake)	Snare Lake	Aboriginal community	Hunting by community residents within VEC-defined spatial boundary	Caribou/Habitat Carnivores/Habitat

1: Activities presented in table for diamond exploration projects are common to all four of the operations listed.

(continued)

Table 4.9-3
Summary of Activities by Exploration Projects and Other Operations (completed)

Project Name	Location	Type of operation	Activities	VEC Potentially Affected
Courageous Lake area[1]	Courageous Lake	Various activities	Generation and disposal of sewage and other waste	Water Quality and Quantity Fish/Aquatic Habitat Carnivores/Habitat
			Human activity (including hunting by outfitters)	Caribou/Habitat Carnivores/Habitat Heritage Sites
			Presence of infrastructure (camp, winter roads, gensets, fuel cache, *etc.*)	Air Quality Permafrost Physical/Terrestrial Environment Water Quality and Quantity Caribou/Habitat Carnivores/Habitat Breeding Birds/Habitat Heritage Sites
			Noise generation	Caribou/Habitat Carnivores/Habitat
			Combustion of fossil fuels	Air Quality
Colomac Mine	50 km east of Wekweti (Snare Lake)	Closed gold mine	Outside of VEC-defined spatial boundary	Not applicable
Discovery Mine	100 km north of Yellowknife	Closed gold mine	Outside of VEC-defined spatial boundary	Not applicable
Snare River Hydro Plant	Snare River	Hydroelectric power generating station	Outside of VEC-defined spatial boundary	Not applicable

1: Wide variety of interests in Courageous Lake area (mining exploration, abandoned mine (Tundra mine), outfitting, *etc.*).

The NWT Diamonds Project 1995 EIS predicted very low levels of acidic depositions. The removal of the Leslie Pit from the mine plan and its partial replacement with more distant sources such as the Sable Pit would, therefore, reduce the local levels of acidic depositions. Therefore, the cumulative effects of acidic depositions from this and other actions in the region are not expected to be an issue of concern.

4.9.7.1.3 Echo Bay Mines Ltd. – Winter Road

The winter road is considered to be a minor source of air emissions, and was excluded from the 1998 Diavik EA air pollution model. While the road is in operation during the winter, there is no dust. It is also argued that:

- greater volumes of truck haul traffic on other Canadian highways have not caused the exceedance of regional ambient air quality objectives; and
- the primary receptors for pollutants – vegetation – are inactive and largely snow-covered, reducing the potential for harm.

It is therefore reasonable to expect that the cumulative effect of vehicle exhaust along the winter road does not represent a substantive issue.

4.9.7.1.4 Echo Bay Mines Ltd. – Lupin Mine

The Diavik and NWT Diamonds Project EIS air dispersion model results show no appreciable cumulative effects between the two sites (EKATI™ and Diavik) located about 30 km apart. Located about 100 km from the proposed development, the Lupin mine is not expected to have any measurable cumulative effects on regional air quality.

4.9.7.1.5 Tahera Corporation – Jericho Project

Information on the proposed development is scarce. However, it is assumed that emission levels from the proposed mine will be of the same order as other mines in the region. At a distance of about 125 km from the proposed EKATI™ development, the Jericho project would not be expected to have any measurable cumulative effects on regional air quality.

4.9.7.1.6 Winspear Resources Ltd. – Camsell Lake Property

Located over 100 km from the proposed development area, this development would not be expected to have any measurable cumulative effects on regional air quality.

4.9.7.1.7 Mill City and Tanqueray Resources Ltd. – Yamba Lake

This project is located about 35 km from the main EKATI™ site, near the proposed Sable Pit. The project is currently at an initial exploration stage, but should this project proceed to development it might be a source of cumulative effects at the Sable Pit location.

However, based on the current status of the Yamba Lake project, the mine is unlikely to be developed before the closure of the Sable Pit. Nonetheless, model results from the main EKATI™ site indicate that ambient emissions levels will likely be far below any regulatory or guideline levels.

4.9.7.1.8 Monopros Limited – Kennady Lake Project

Located over 100 km from the proposed development area, this project would not be expected to have any measurable cumulative effects on regional air quality.

4.9.7.1.9 Courageous Lake Area

Located about 70 km from the proposed development area, this project would be expected to have no cumulative effects on regional air quality.

4.9.7.1.10 Wekweti (Snare Lake) Community

This community is far from the proposed development and is a negligible source of air emissions. No cumulative effects on regional air quality are expected from the Wekweti Community.

4.9.7.1.11 Other Issues

Globally, the production of greenhouse gases was addressed in the two reports:

- The EKATI™ contribution to the Canadian total emissions will be less than 0.05% (1995 NWT Diamonds Project EIS); and
- Diavik Diamonds Project CO_2 emissions will be about 0.03% of the Canadian total.

Based on current knowledge, the cumulative effect of greenhouse gas emissions from all the regional activities relative to the Canadian total, which represents about 2% of the global total, is marginal.

Both reports (BHP, 1995; Diavik 1998b) indicate that no cumulative environmental effects on air quality are anticipated to occur in the region and, therefore, no further assessment or mitigation measures are required. Thus the effects on greenhouse gases are considered to be negligible and will not be addressed further.

4.9.7.1.12 Summary

The evaluation of the potential for cumulative effects on air quality was based on the recognized national and global interest in and importance of this VEC. The NWT Diamonds Project and Diavik Diamonds Project environmental assessments projected that there would be no measurable cumulative effects on regional air quality. The

EKATI™ mine field monitoring results have confined the limited effects on air quality mine operation. The distance from other properties and the small size of the sources precludes any measurable cumulative effects resulting from other activities in the area.

4.9.7.2 Caribou/Habitat

Caribou represent the single most important VEC in the area of the EKATI™ Mine and the north in general. It is relied upon as a source of food by many communities including Umingmaktok, Bathurst Inlet, Cambridge Bay and Kugluktuk, N'dilo, Rae-Edzo, Dettah, Gameti, Wekweti, Wha Ti, Fort Resolution and Lutsel K'e. Residents of Deh Cho communities, Hay River, Fort Smith and Yellowknife also harvest caribou from the herd.

During the EARP public hearings in January and February of 1996, the potential effect of EKATI™ Dimaond Mine on the health, numbers and migratory patterns of the Bathurst Caribou herd was the most important public concern (CEAA, 1996).

The Bathurst Caribou herd is the largest of the four major barren-ground caribou herds found on the mainland of the Northwest Territories. Each year on both its northern and southern migrations (Plate 3.7-1), at least part of this herd passes across the BHP claim block The current population is estimated to number approximately 349,000 ± 95,000 (Gunn *et al.*, 1997). In the past, the herd has ranged in size from an estimated 174,000 caribou in 1982 to 486,000 caribou in 1986 (Case *et al.*, 1996).

Two unique features of the Bathurst Caribou herd are its large-scale migratory movements and its large-scale home ranges. The herd's range is approximately 250,000 km^2 with calving grounds near Bathurst Inlet and wintering habitat below the treeline (Figure 3.7-1). During winter, the annual range of the Bathurst herd overlaps with three adjacent caribou herds: the Bluenose East Caribou herd to the west in the vicinity of Great Bear Lake; Queen Maud Gulf Caribou herd (Gunn *et al.*, 2000), to the northeast, primarily during the winter; and with the Beverly Caribou herd in the area south of Great Slave Lake and extending to the Saskatchewan border.

Consequently, they can be exposed to a multitude of effects on their winter range or calving grounds, or anywhere in between. The majority of the Bathurst Caribou herd spends the winter below the treeline. Although a few caribou have been reported in the Lac de Gras area during the winter, caribou have not been documented on BHP's claim block during that season (Banci, V. and S. Moore, 1997; BHP, 1995; Golder, 1998; Golder, 1999; Rescan, 1999).

In general, spring and fall migration periods begin in late April and mid-October, respectively. During June and early July very few caribou are present in the Lac de Gras region (BHP, 1995c; Banci and Moore, 1997; Golder, 1998; Golder, 1999). By mid-July, large post calving aggregations will move into the Lac de Gras region from the north. By October, the herd is migrating southward to the wintering grounds below the treeline.

Caribou distribution and density varies from year to year, with the herd rarely using the same wintering area for more than two or three years out of ten (Case *et al.*, 1996). Nevertheless, BHP's claim block lies within the annual movements of these caribou (Section 3.7).

4.9.7.2.1 Criteria for Assessing Cumulative Effects

The proposed development is within the northern and southern movement corridors of the Bathurst Caribou herd. The effects of human disturbance on caribou may include:

- reduced or limited access to important habitats;
- reduced habitat quality;
- increased energy expenditure;
- decreased energy intake; and
- direct mortality from collisions with vehicles and hunting from roads.

Caribou may also be displaced into other areas resulting in reduced prey availability for predators.

Cumulative effects on populations of caribou are a function of the:

- frequency and intensity of disturbance events;
- proportion of the population that is exposed to disturbance;
- timing of the disturbance; and
- condition and experience of the individual animals.

Predicting cumulative effects for a population or sub-population of animals encountering various sources of disturbance during one or more portions of their annual cycle is challenging because:

- Thresholds for disturbance-induced changes for an individual animal or for a population of animals is dependent on the physical condition of the animals (Murphy *et al.*, 1998). Therefore, both individual and population-level effects will be variable among herds and among years for a particular herd;
- Defining a realistic exposure scenario for an individual caribou, which is the basis for most modelling efforts, is difficult (*e.g.*, Murphy *et al.*, 1998);
- Empirical information on habituation is lacking, so it is not possible to predict whether responses to various stimuli will change with repeated exposure; and
- To detect cumulative effects, the changes that caribou undergo in response to disturbance must exceed natural variability for the parameter in question (e.g., calf survival). Thus, small effects that may have biological significance may be difficult to detect statistically.

Cumulative effects practitioners use a number of techniques for assessing cumulative effects including field evaluations, monitoring, modelling, and trend analysis. This cumulative effects assessment for caribou is primarily qualitative and is based on:

- experience at EKATI™ based on baseline and monitoring data;
- predicted effects for Sable, Pigeon and Beartooth development;
- Diavik Diamonds Project EA model and those of other researchers for the Porcupine and Central Arctic herds;
- habitat evaluation;
- energetics evaluation;
- mortality evaluation; and
- level of significance for effects.

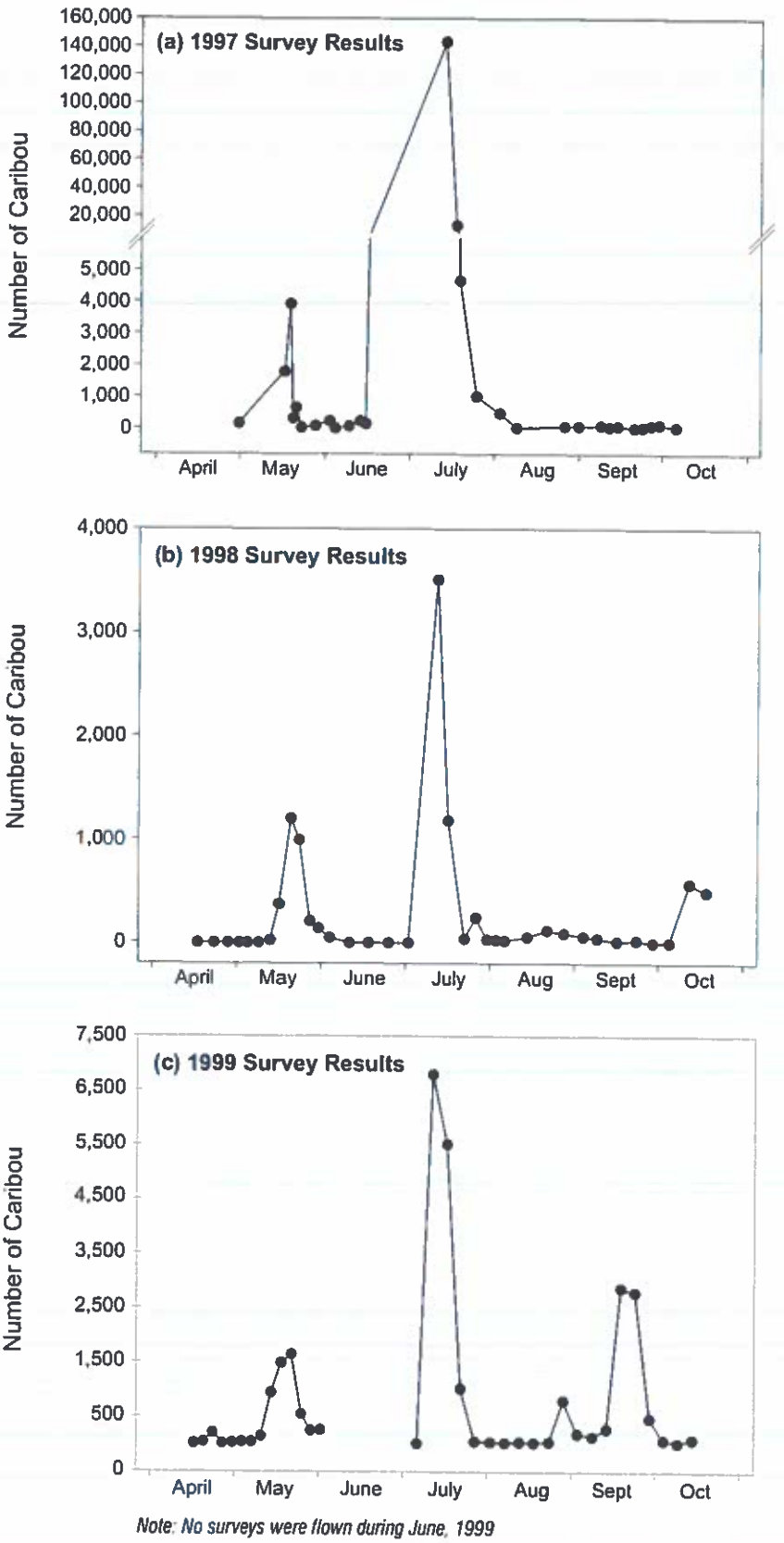
Habitat, energetics and mortality are assessed as they are the likely pathway for potential effects on individual caribou and the population. Habitat evaluation focuses on two issues: habitat loss and reduction in habitat effectiveness. Energetics evaluation focuses on assessing possible caribou energy demands as a result of encountering developments and the extrapolation of such effects to the population level. Mortality evaluation is based on assessing historic mortality rates.

4.9.7.2.2 Experience at EKATI™

For this assessment, the numbers of caribou observed at EKATI™, interactions by season with EKATI™, specific responses to various stimuli, and actual effects are reviewed. The information presented is based on observations documented during wildlife baseline monitoring studies carried out between 1994 and 1999. Further detail on the Bathurst herd is provided in Section 3.7.1.

4.9.7.2.2.1 Caribou Numbers Observed At EKATI™

Aerial caribou surveys were flown across the claim block between 1993 and 1996, and across the wildlife study area between 1997 and 1999. Figure 4.9-3 compares the number of caribou observed during aerial surveys over the last three years. For each year there are three spikes representing northern, southern and post-migration movements. These spikes correspond to the migration patterns of the herd as indicated by satellite-collared caribou for each year. The greatest number of caribou were recorded on the wildlife study area in 1997, followed by 1999 and 1998. In 1999, the estimated number of caribou across the wildlife study area during all surveys was 53,000 individuals, of which 20,700, (39%), were found within 14 km of the EKATI™ mine. In the spring, pregnant cows and associated juveniles move through first and are followed later by bulls. The caribou move through the claim block and continue heading towards their calving grounds. Few caribou remain in the vicinity of Lac de Gras following spring migration. Caribou do not calve near Lac de Gras nor BHP's claim block.



Note: No surveys were flown during June, 1999

Number of Caribou Observed During Each Aerial Survey in 1997 (a), 1998 (b) and 1999 (c)

FIGURE 4.9-3

A large post-calving aggregation movement occurs in late-June and July, when caribou leave the calving grounds and head southward toward Lac de Gras. By mid-July, large groups of caribou return to the Lac de Gras region (Rescan, 1999). By the end of July, the caribou disperse throughout the Lac de Gras region and spend time feeding to replenish their fat reserves. This continues through August and mid-September.

By mid-September caribou begin to aggregate into larger and more cohesive mixed herds. Fall migration towards the treeline occurs between mid-September and November. Caribou begin to move out of the region in "waves" beginning in mid-September, and by mid-October, most of the caribou are south of BHP's claim block (Rescan, 1999c).

4.9.7.2.2.2 Seasonal Caribou Interactions Near EKATI™

Large numbers of caribou pass through the mine site during northern migration and the post-calving aggregation movement:

- The peak number of caribou occurring on site during the northern migration occurs over a two-week period, May 15th to May 30th.
- The peak number of caribou occurring on site during the post-calving aggregation movement also occurs over a two-week period, approximately July 15th to 30th.

These two periods represent four weeks when large numbers of caribou may be present. They are continuously moving through the area and spend very little time near the mine.

During northern migration, caribou are focused on migration and are not readily disturbed by human activities. BHP's studies have examined interactions between caribou and the mine site, and associated human activities. For example, individual caribou and caribou groups have been observed to cross the Misery Road unimpeded. Their approach and departure angle remains unchanged. Other examples include interactions between caribou and the airstrip deterrence fence. Groups of caribou have been observed jumping the airport caribou fence and continuing unimpeded during northern migration. These two examples are not unique and show that, during northern migration, caribou are focused on movement and are not readily deterred by mine features.

During June and the first half of July, very few caribou are present in Lac de Gras region (Golder, 1998; Golder, 1999; Axys and Penner and Associates Ltd., 1997; Rescan, 1999c). With the commencement of insect season, caribou begin to form large groups and head southward (Urquhart, 1981), reappearing near the mine site by mid-July. These groups are commonly seen adjacent to the mine site where they have been documented exploiting disturbed sites for insect relief.

During this period insects influence caribou behaviour, causing them to seek out selected habitat types such as wind-swept ridges and eskers. Disturbed habitats around the mine site, such as drill pads, roads and habitat between the roads, are frequently used (Plate 4.6-2). During insect harassment, caribou are focused on finding insect relief and

pay little attention to human activity (Murphy pers. comm.; Rescan, 1999c). By the end of July insect season begins to diminish and caribou disperse into smaller groups to spend time feeding in the Lac de Gras region.

4.9.7.2.2.3 *Specific Responses to Various Stimuli at EKATI™*

The effects of disturbance on wildlife are perhaps some of the least understood and the most difficult to quantify of all the effects associated with development (Donihee and Gray, 1982). Nevertheless, for caribou, this assessment is based on individual behavioural responses to development at EKATI™ that have been collected over a six year period from 1994 to 1999 and presented in Section 4.6. These observations are compared with those in the published literature, interpreted and extrapolated to the population level.

Caribou passing through the mine site on their northern and southern migration may be disturbed by mining activities, such as blasting, vehicles, or haul trucks. Changes in the distribution and behaviour of caribou can lead to changes in their energy balance (*e.g.* Spend less time feeding or resting; more time staying alert or moving away from disturbance sources). A brief summary of the behavioural data obtained to date at EKATI™ follows.

Between 1997 and 1999 the relative abundance of caribou has been examined for two zones around EKATI™. The first zone covers the area within 14 km from the mine; while the second zone covers an area between 14 km to 30 km from the mine. For the last three years of monitoring, relative abundance of caribou around the mine site has been similar to areas beyond 14 km. For 1997 to 1999, the presence of the mine has not appeared to have an effect on the relative abundance of caribou. These findings are similar to other research results. For example, Matthew *et al.* (1998) found that caribou distribution during the post-calving period at the Prudhoe Bay oil field was independent of development infrastructure.

Similarly, the results for directional movement in relation to the mine from 1997 to 1999 (Rescan, 1999c) suggest that caribou do not change their direction of travel as they get closer to the mine during either the northern or southern migration. Relative to the entire Bathurst herd, the number of caribou exposed to the EKATI™ infrastructure is small. During northern migration, the average percentage of the Bathurst Caribou herd potentially influenced by mining activities during 1997, 1998 and 1999 has been 0.005%, 0.03% and 0.109% per day, respectively. For the southern migration, the results have been 3.4%, 0.02% and 0.21% per day for 1997 through 1999, respectively.

The average percentage of the Bathurst herd that has come within 1 km of the Misery Road during 1998 and 1999 during northern migration has been 0.004% and 0.006% per day; and for the southern migration, 0.001% and 0.06% per day, respectively.

Activity patterns were studied from 1997 to 1999 across the wildlife study area. In 1997, caribou demonstrated more comfort activities in areas away from the mine site compared to near the mine site. However, in 1998 and 1999, the data suggests that there was no difference between comfort levels away from the mine site compared to near the mine

site, suggesting that caribou comfort levels are independent of distance from the mine (Rescan, 1999c).

During the Wildlife Effects Monitoring Program, caribou response has been studied in relation to six different stressors including blasts, trucks, people, helicopters, sirens and airplanes. Results from wildlife monitoring indicate that caribou show greater proportions of comfort over movement for all six stressor types during the three years of monitoring to date. Pickup trucks and people on foot were two stressors that caused the greatest displacement, while blasting, helicopters, haul trucks and sirens caused minimal displacement.

Group composition (non-nursery verses nursery groups) has been examined in relation to distance from the mine. In 1998, the composition of caribou groups was not significantly related to distance from the mine. This was not the case for 1999, however, when there were more non-nursery groups than nursery groups within the 14 km zone than between 14 km to 30 km zone (Rescan, 1999c).

4.9.7.2.2.4 Summary of Experience at EKATI™

The numbers of caribou observed at EKATI™ vary from year to year. This is expected and is typical for caribou, as annual movements and range selection shift over time. Based on aerial surveys from 1994 to 1999, influxes of caribou can be predicted during the spring, summer and fall. While caribou numbers may vary, the timing of their arrival and departure remain consistent. Wildlife studies on specific caribou responses to various stimuli at EKATI™ have not shown an effect on caribou in general or, presumably, at the population level.

Overall, the results collected to date have shown or suggested that the relative abundance, direction of movement, group composition, and comfort activities observed during wildlife monitoring do not appear to be related to distance from the mine site. Exposure rates of caribou to the mine site are low. Caribou behaviour in response to specific stressor types (blasts, trucks, *etc.*), in most cases, show no or minimal reaction; of those few that have demonstrated a response, the stressor has caused only minor and temporary displacement.

4.9.7.2.3 Diavik Diamonds Project Models

Diavik employed the use of energetics and friction modelling (Diavik, 1998b) to predict potential effects on caribou at the population level, given various scenarios. Energetics models enable a researcher to examine how a change at the level of the individual might manifest itself at the population level. The friction model was developed for the spring and fall caribou migration and provided a prediction on how caribou move across the landscape based on friction and resistance as generated by topography and human intervention.

Diavik's energetics modelling predicted that, at their full development stage, the cumulative effects on caribou during spring migration from the winter range to the calving ground would be low. The increased energy requirement predicted was <1% for individual caribou encountering any of the mining operations or the proposed Misery Road.

Disturbance-related deviations from migration paths are expected to be slight based on observations from other mines and from baseline studies undertaken for the EKATI™ Diamond Mine and Diavik Projects.

During fall migration, Diavik's energetic modelling predicted that, at the stage of full development, the magnitude of effects were predicted to be slight. The effects would result in a <1% increase in the overall cost of migration through the Diavik RSA for individual caribou encountering any of the mining operations relative to baseline conditions (Diavik, 1998b).

4.9.7.2.4 Porcupine and Central Arctic Herd Models

Other caribou biologists (D. Russell, S. Murphy, B. Lawhead) are pursuing energetics modelling research on the Porcupine and Alaska Central Arctic herds. While these herds are unique and have different dynamics governing their populations they do provide significant insight into energy costs associated with caribou behaviour. Comments received from these experts on the cumulative effects assessment for the Bathurst herd suggest that energetics represent the most likely pathway by which disturbance effects could be manifested at the population level (D. Russel, S. Murphy, B. Lawhead, pers. comms.). Relevant data from the Porcupine and Alaska Central Arctic herds have been used to aid this assessment.

4.9.7.2.5 Assessment of Habitat Loss

The total extent of habitat predicted to be lost as a result of full development of the for EKATI™ mine site in the 1995 EIS was 2,447 ha. The GIS analysis performed for this EAR adjusted the original footprint size to 2,676 ha[11]. This represents approximately 0.01% of the Bathurst Caribou annual range. The extent of habitat lost due to the proposed development is calculated to be an additional 494.2 ha (397.1 ha for pits and 97.1 ha for roads) of Bathurst Caribou summer range (Table 4.6-2). Combined, the extent of habitat lost due to the addition of the proposed development totals 3,170 ha which remains equivalent to approximately 0.01% of the Bathurst Caribou annual range. This localized and limited habitat loss will persist until reclamation efforts have been completed, and natural and fostered vegetation has been re-established.

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[11] **It is important to note that the difference between 2447 ha and 2676 ha is attributable to the GIS databases and scales used for this assessment, and the GIS system's ability to delineate emergent vegetation. The 1995 results of 2447 ha were based on fieldwork which was based on a detailed biogeoclimatic mapping system. The 2000 results of 2676 ha were based on interpretation of RWED's larger-scale satellite imagery. Interpretation of RWED's satellite imagery generated more hectares of emergent vegetation as a result of incorporating more open water habitat into the wetland classification.**

4.9.7.2.5.1 *Reduction in Habitat Effectiveness*

The reduction of habitat effectiveness occurs in adjacent areas and is often caused by disturbances associated with blasting and heavy equipment operation. These activities will affect wildlife use of habitat outside the direct development footprint. This displacement will reduce habitat effectiveness for all species, but the zone of influence (ZOI) will depend on the specific level of sensitivity of individuals and species. Reductions in habitat effectiveness are mitigated completely and immediately upon cessation of activities that cause the disturbances.

A critical step in assessing changes in habitat effectiveness is determining a realistic ZOI around human developments within which habitat use is likely to be reduced by behavioural disturbance (Axys and Penner and Associates, 1998). The area of disturbance adjacent to proposed roads and pits was calculated using scenarios of different ZOIs:

- An 800 m ZOI was established on either side of the proposed development roads for migrating caribou passing near the mine site. This zone was chosen to represent an area where, any caribou contained within these boundaries would be interacting with the roads, either passively or actively. This ZOI occupies an area of 4,208 ha, or approximately 0.016% of the Bathurst Caribou's annual range.
- A 3 km ZOI was established around the proposed roads and pits and is based on the approach in the Diavik EA. Additional input was received from Anne Gunn of RWED (Gunn, pers. comm.). The 3 km ZOI represents an area that is effected to a lesser degree as ambient noise levels generated by the mine would be significantly reduced, and caribou would be beyond visual range of the mine. This zone occupies an area of 29,013 ha, or approximately 0.12% of the Bathurst Caribou's annual range.
- A 10 km ZOI was established around the proposed roads and pits because human hearing can periodically still detect noise generated by the mine, and presumably caribou as well. This is the least effected zone and occupies an area of 143,678 ha, or 0.57% of the Bathurst Caribou's annual range.

4.9.7.2.6 Cumulative Habitat Loss and Reduction in Habitat Effectiveness

The projected habitat loss for cumulative land use activities within the CEA Study Area is estimated to be 4,769 ha, representing <0.0019% the caribou's annual range (Table 4.9-4). This area includes the footprints of EKATI™, Diavik, Lupin and the proposed Sable, Pigeon and Beartooth developments.

The projected reduction in habitat effectiveness for cumulative land use activities within the CEA Study Area (Table 4.9-5) for the 3 and 10 km ZOIs are:

- With a 3 km ZOI, the projected reduction in habitat effectiveness within the CEA Study Area around EKATI™, Diavik, advanced exploration projects, Lupin, and proposed Sable, Pigeon and Beartooth development, represents 117,644 ha, or approximately 0.47% of the caribou's annual range.

Table 4.9-4
Area in Hectares, by Landsat Cover Classification, of Mine Footprints within the CEA Study Area

	Landsat Cover Classification												
Area Description	Water	Lichen Veneer	Esker Complex	Wetland/ Sedge Meadow	Tussock/ Hummock	Heath Tundra	Spruce Forest	Bedrock and Boulder Association	Tall Shrub	Birch Seep	Heath Bedrock and Boulder	Water + Unclassified	Total (hectares)
Entire Regional Study Area	940,320	106,994	33,462	110,951	303,293	934,257	10,446	124,079	9,963	34,309	513,481	656	3,122,212
Total footprint of EKATI™ EPD[1]	838	4	13	20	314	466	6	92	4	10	911	0	2,676
Diavik footprint	434	3	13	19	134	338	4	58	1	9	276	0	1,289
Lupin footprint evaluated; see Appendix D)	48	13	5	26	5	141	0	8	0	0	51	0	297
Total footprint of proposed SPB[2]	52	1	4	7	66	229	1	10	1	2	134	1	507
Total of all mine footprints (hectares)	1,372	21	35	72	519	1,173	10	168	6	21	1,371	1	4,769

[1] EPD: Existing and permitted development at EKATI™. "Pits" includes pits, waste rock piles, and infrastructure.

[2] SPB: Proposed Sable, Pigeon, and Beartooth development

[3] It is important to note that the difference between 2447 ha and 2676 ha is attributable to the GIS databases and scales used for this assessment, and the GIS system's ability to delineate emergent vegetation. The 1995 results of 2447 ha were based on fieldwork which was based on a detailed biogeoclimatic mapping system. The 2000 results of 2676 ha were based on interpretation of RWED's larger-scale satellite imagery. Interpretation of RWED's satellite imagery generated more hectares of emergent vegetation as a result of incorporating more open water habitat into the wetland classification.

Table 4.9-5
Area in Hectares, by Landsat Cover Classification, of Development Footprints and Disturbance Buffers (Zones of Influence[ZOI]) Around Developments within the CEA Study Area

	Landsat Cover Classification												
Area Description	Water	Lichen Veneer	Esker Complex	Wetland/ Sedge Meadow	Tussock/ Hummock	Heath Tundra	Spruce Forest	Bedrock and Boulder Association	Tall Shrub	Birch Seep	Heath Bedrock and Boulder	Water + Unclassified	Total (hectares)
Entire Landsat Image Area	940,320	106,994	33,462	110,951	303,293	934,257	10,446	124,079	9,963	34,309	513,481	656	3,122,212
Total footprints of Lupin, Diavik, EPD[1] + SPB[2]	1,372	21	35	72	519	1,173	10	168	6	21	1,371	1	4,769
Buffer Scenario A													
1 km buffer around outfitter and research camps	1,368	262	25	155	534	1,309	15	123	19	49	516	2,190	6,565
2 km shoreline buffer around hunting lakes[3]	91,567	15,873	1,749	7,963	21,109	52,050	984	6,182	942	2,344	22,319	0	223,082
3 km buffer around mines[4]	22,850	380	570	599	8,608	12,951	84	2,442	158	279	21,688	13,353	83,962
3 km buffer around Lupin (unclassified)													4,669
3 km buffer around proposed SPB	6,648	299	367	570	3,415	9,983	36	951	49	184	6,466	46	29,013
Total ZOI Scenario A (hectares)	122,433	16,814	2,710	9,287	33,666	76,293	1,119	9,697	1,168	2,856	50,990	15,589	347,291
Buffer Scenario 2													
3 km buffer around outfitter and research camps	13,296	1,793	270	1,339	3,845	11,188	110	1,106	179	437	3,878	20,012	57,454
2 km shoreline buffer around hunting lakes[3]	91,567	15,873	1,749	7,963	21,109	52,050	984	6,182	942	2,344	22,319	0	223,082
10 km buffer around mines[4]	113,766	3,003	2,601	3,735	28,252	60,308	413	9,060	1,146	1,617	61,900	130,793	416,593
10 km buffer around Lupin (unclassified)													37,555
10 km buffer around proposed SPB	42,948	1,811	1,566	2,629	15,061	33,964	117	5,299	152	518	39,434	179	143,678
Total ZOI Scenario B (hectares)	261,577	22,479	6,185	15,667	68,266	157,510	1,624	21,647	2,419	4,916	127,532	150,984	878,362

[1] EPD: Existing and permitted development at EKATI™. Includes pits, waste rock piles, and infrastructure.

[2] SPB: Proposed Sable, Pigeon, and Beartooth Development.

[3] Desteffany, Courageous, and MacKay Lakes. Lake water values deleted from this buffer.

[4] "Mines" include EKATI™, Diavik, and advanced exploration projects.

- With a 10 km ZOI, the projected reduction in habitat effectiveness within the CEA Study Area represents 596,826 ha, or approximately 2.39% of the caribou's annual range.

4.9.7.2.7 Assessment of Energetics

During migration periods through Diavik's RSA in spring and fall, energetic costs to caribou were expected to experience low to moderate increases within their RSA (0.2-2%; Diavik, 1998b). The potential for increased energetic costs for female caribou during spring migration is an important consideration. Analysis indicated that potential increases attributable to development in the RSA represent less than a 1% increase in energy expended for the entire migration path between wintering and calving grounds. The effects of BHP's proposed development and other land use activities within the CEA Study Area are not expected to measurably affect fitness, reproductive performance or abundance of the Bathurst herd.

4.9.7.2.8 Assessment of Mortality

Changes in the abundance of caribou (either short-term or long-term) result from direct changes in mortality rates and from reductions in health and reproductive fitness through altered energetics or diseases. Anticipated changes in caribou mortality resulting from the Diavik Project and cumulative land use activities within the Regional Study Area at full production are expected to be very low.

4.9.7.2.9 Assessment of Mortality

4.9.7.2.9.1 Non-Project Related Mortality

Non-project related caribou mortality is restricted to hunter harvests and vehicular collisions along the Echo Bay winter road. Hunting by outfitters and residents will remain the only source of human-induced caribou mortality, and is not expected to increase as a result of mine development.

The number caribou harvested through regional outfitters is less than 200 (Axys and UMA, 1998) compared to 14,000 to 18,500 harvested throughout the Bathurst Caribou herd's annual range. This level of harvest is not expected to increase within the RSA since the majority of caribou are below the treeline during construction and operation of the winter road.

It is unlikely there will be increased hunting pressure on the caribou in the RSA as a result of increased development. Winter road access is available from January to March, when the majority of the caribou are south of the RSA and below the treeline. The chance of increased mortality through increased hunting is low and insignificant at the population level.

Caribou mortality through vehicular traffic along the winter road is not expected to increase as commercial transport drivers are require to drive slowly, and a caribou – vehicle collision by recreational drivers has yet to be reported.

4.9.7.2.9.2 Mortality Related to Industrial Development

Cumulative effects on caribou mortality from industrial development will be slight. Over the last few decades very few caribou have been killed by industry. Published incidents from Lupin Mine site indicate that only one caribou is killed, on average, every five years (Hohnstein, 1996). BHP has not had any incidents involving caribou/vehicle collisions. Diavik Diamonds Project is predicting that caribou injury and mortality in the RSA is anticipated to be low and remain low under all conditions (Axys and Penner and Associates, 1998).

Diavik stated that increases in energetic costs as a result of having to circumnavigate obstacles or barriers could alter activity budgets and increased stress. If stress levels are high enough, individuals could experience reduced reproductive success and possibly mortality (Axys and Penner and Associates, 1998). Mortality originating along this pathway is remote.

4.9.7.2.9.3 Level of Significance

Changes in the abundance of caribou (either short-term or long-term) result from direct changes in mortality rates and from reductions in health and reproductive fitness through altered energetics or diseases. Anticipated changes in caribou mortality resulting from the proposed development and cumulative land use activities within the CEA Study Area at full production are expected to be negligible. This conclusion is based on the continuing application of adaptive management principles and sound environmental management practices.

4.9.7.2.10 Summary of Overall Significance

4.9.7.2.10.1 Habitat Loss

Caribou will be excluded from about 497 ha of former habitat usurped by the footprint of proposed and existing developments. Avoidance of disturbance and other habitat alterations may extend the area of habitat disruption for caribou, and intensive industrial activity could disrupt migration patterns.

Calving and winter range are not affected by existing or proposed development within the CEA Study Area. Diavik predicted that their proposed development, in conjunction with existing and permitted land uses within their Regional Study Area, would cause a net reduction of about 0.17 % of caribou summer habitat availability (Axys and Penner and Associates, 1998). Development of the proposed Sable, Pigeon, and Beartooth pipes would add minimally to this total habitat reduction.

Habitat effects will be limited to the local study area and will therefore not influence calving or winter range. Relative to the large size of the Bathurst herd's migration corridor and summer range, habitat disruption arising from the proposed development acting cumulatively with the existing EKATI™ development, Diavik, Lupin, and the winter road, is predicted to result in only very localized changes in habitat use with no measurable effect on broad seasonal distribution.

Caribou abundance may be influenced by indirect effects such as increased energetic costs associated with disturbance from human activities. Diavik predicted low to moderate (0.2-2%) increases in energetic costs within their Regional Study Area during spring and fall migration, in a development scenario exclusive of the proposed new development at EKATI™ (Axys and Penner and Associates, 1998). Specific to northern migration, predicted energetic increases were less than 1%. The proposed development of Sable, Pigeon and Beartooth can be expected to contribute small increased energetic costs to migrating caribou. However, the cumulative increases in energetic costs resulting from EKATI™, the full development scenario of Diavik, the winter road, the Lupin mine, and the proposed development, are not expected to measurably affect the abundance of the Bathurst herd.

4.9.7.2.10.2 Mortality

Potential direct mortality sources arising from the EKATI™ mine and the proposed development are related to possible collisions with vehicles. Effective environmental management and mitigation has resulted in no mortalities to date at EKATI™. Known mine-related mortality of caribou at Lupin has averaged less than one incident per five years (Hohnstein, 1996). Diavik predicted low direct mortalities resulting from their development considered cumulatively with EKATI™, the winter road, and hunting mortalities within their Regional Study Area (Axys and Penner and Associates, 1998). Including the proposed development at EKATI™, combined mortalities from all these sources within the CEA Study Area are predicted to remain very low and of no measurable significance.

4.9.7.3 Carnivores/Habitat

4.9.7.3.1 Identification of Potential Effects of Other Regional Activities

The scoping of the cumulative effects assessment identified other activities that are taking place within the home ranges of the grizzly bears that are potentially affected by the proposed Sable, Pigeon and Beartooth development. Each activity in the area has the potential to act cumulatively on the resident bear population.

4.9.7.3.1.1 Local Outfitters/Stations

Local caribou outfitting camps and the Daring Lake research station have the potential to affect grizzly bear distribution and abundance. Each eliminates bear access to the few

hectares of habitat directly occupied by the footprint. While in use, the camps also cause a decrease in habitat effectiveness within a zone of influence (ZOI) where bears avoid the disturbance associated with human activity.

Outfitting and research camps are also a potential source of bear mortality. Bears may be attracted to caribou carcasses or other potential food sources at the camps. This may cause an interaction with humans requiring a bear to be trapped and removed. In the worst cases, a bear may be shot. During the period 1986-1997, outfitting camps were responsible for 19 of 162 (11.7%) reported bear mortalities associated with humans in the Slave Geological Province (SGP) and Kugluktuk area (Table 4.9-6).

Table 4.9-6
Reported Human-Caused Grizzly Bear Mortalities in the Slave Geological Province and Kugluktuk Area, 1986-1997*

Year	Quota/Subsistence	Problem Kills				
		Inuit/Dene	Industry	Outfitting	Problem Kills Subtotal	Total Human Caused
1986	10	7	5	0	12	22
1987	7	10	4	1	15	22
1988	10	3	1	1	5	15
1989	5	2	0	0	2	7
1990[1]	3	0	0	2	2	5
1991	6	0	4	1	5	11
1992	7	1	2	0	3	10
1993	10	3	1	5	9	19
1994	8	4	3	3	10	18
1995	1	3	0	2	5	6
1996	5	0	0	2	2	7
1997	8	10	0	2	12	20
TOTAL	80	43	20	19	82	162

*** Data from Axys and Penner and Associates, 1998.**

For the other carnivores present in the area, bears are used as the "worst-case" as the effect on bears will be more severe than on the other carnivores (wolves and wolverines). Where appropriate, wolves and wolverines are referenced at the end of the relevant section.

Many caribou hunters are also interested in harvesting wolves and wolverines, and a few of each species are taken each year incidentally to caribou hunting.

4.9.7.3.1.2 Aboriginal Land Use

Aboriginal land use may also affect grizzly bear populations in the greater-than-regional area. As with any human activity, disturbance associated with Aboriginal hunting or

fishing camps has the potential to reduce habitat effectiveness within a ZOI. These habitat effects are temporary, coinciding with the period of occupation.

Aboriginal camps can also be a source of grizzly bear mortality. During 1986-1997, 43 of 162 (26.5%) of reported human-caused bear mortalities in the SGP and Kugluktuk area (Table 4.9-6) were related to Inuit or Dene settlements and camps.

Wolves and wolverines are also hunted by Aboriginal land users.

4.9.7.3.1.3 *Mining and Exploration*

Each active mine or mineral exploration camp constitutes a habitat impact for grizzly bears. Depending on the stage of development and the operation size, the area of direct habitat loss may range from a small footprint for an exploration camp to a larger footprint for an operating mine. However, the disturbance associated with these industrial activities affects a larger ZOI where habitat effectiveness is reduced.

As with all sites of human occupancy, mining-related camps are a potential source of bear mortality through the attraction and subsequent removal of problem individuals. Between 1986 and 1997, industry camps were responsible for 20 of 162 (12.3%) of reported bear mortalities caused by humans in the SGP and Kugluktuk area (Table 4.9-6). Wolverines and possibly wolves are also potentially affected by this mortality source.

4.9.7.3.1.4 *Echo Bay Mines Winter Road*

The winter road has no direct influence on distribution or abundance of grizzly bears, because during the period of its operation bears are inactive and in their dens. Therefore, there is no direct or indirect effect on bear habitat, with the exception of the remote possibility that denning bears could be displaced during annual construction of the road. This would occur if their dens were close to the road route. However, because most of the road route is located on frozen lakes and rivers, this event is unlikely.

Wolf and wolverine hunters may access the CEA Study Area via the winter road, and some harvest mortality may occur as a result.

4.9.7.3.2 Analysis of Effects

4.9.7.3.2.1 *Carnivores/Habitats*

Grizzly bears were used in the cumulative effects assessment to represent grizzly bears, wolves, and wolverines. The evaluation of cumulative effects consists of two models:

- A habitat model, which assesses the direct effects of habitat loss, as well as indirect effects including displacement and avoidance; and
- A mortality model, which evaluates potential direct population effects.

4.9.7.3.3 Habitat Model

The extent of the assessment was defined by the availability of Landsat–derived land cover data developed by the NWT Centre for Remote Sensing. The classification was based on a Landsat TM scene acquired in July 1989. However, it was not possible to match the Landsat data set with the BHP ecological mapping (Table 4.9-7). The discrepancies point to the scale differences and the differences of vegetation composition within the ecosite/land cover units labeled similarly by both mapping efforts. A full description of the satellite-derived land cover classes is presented in Appendix D.

Female grizzly bear radio-locations (from collared bears during 1995 and 1996) were used to develop a regional habitat suitability map using the Landsat image. To reduce problems associated with small sample sizes, the locations were divided into only two seasons:

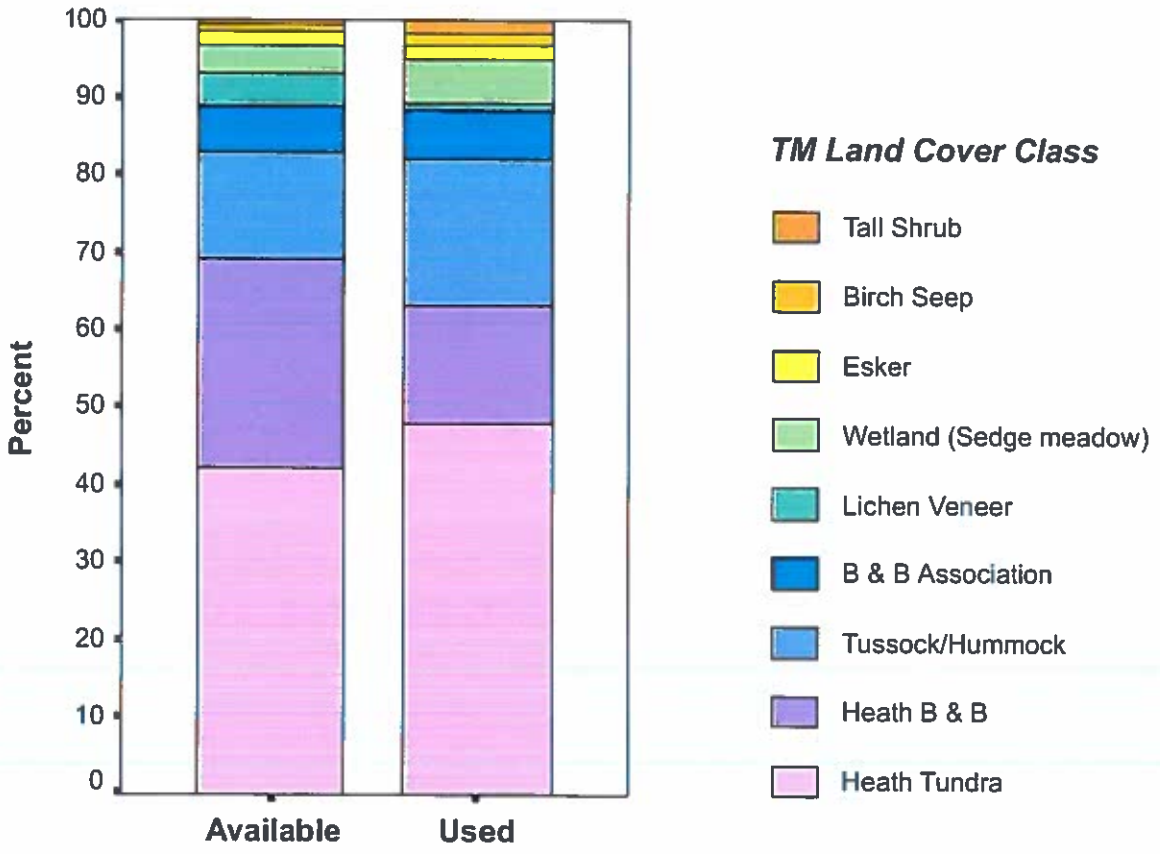
- Season I – Den emergence and continued until July 6, covering the period of post-emergence nutritional stress, the northern caribou migration, and the subsequent virtual absence of caribou from the local study area.
- Season II – 7 July to den entry, and included the period of southern caribou migration and berry availability.

4.9.7.3.3.1 Season I: Den emergence to July 6

Habitat preference rankings were developed using 231 radio-telemetry fixes of the six individual bears tracked over two years during Season I (Figure 4.9-4). Female grizzly bears statistically selected for the following land cover classes (in order of preference):

1. Tall shrub
2. Tussock/Hummock (68% of the maximum standardized residual)
3. Wetlands (57% of the maximum standardized residual)
4. Heath Tundra (56% of the maximum standardized residual)
5. Birch Seep (26% of the maximum standardized residual)

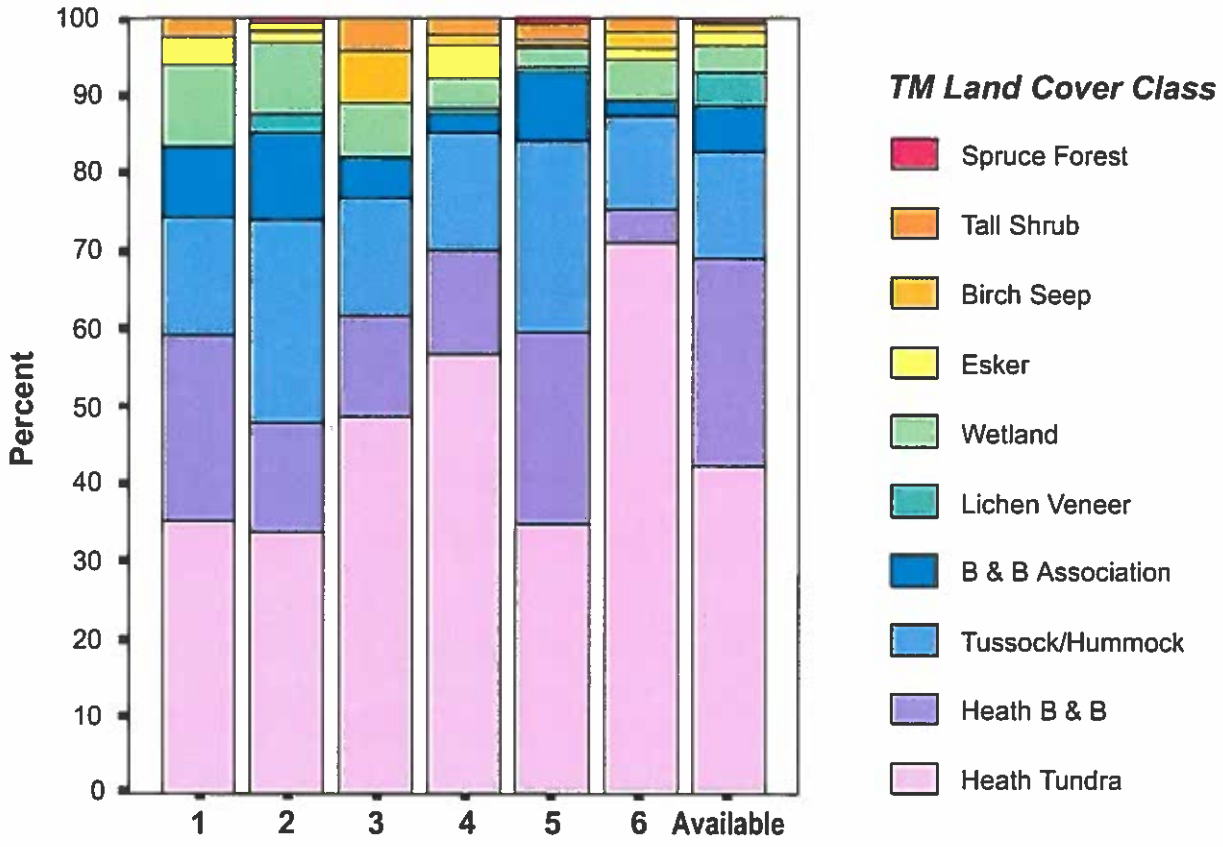
The analysis of each of the six bears confirmed that individuals exhibited a significant variation in habitat selection (Figure 4.9-5). However, with respect to the classes listed above, five out of six bears showed selection for tall shrub and wetlands (confirmed by compositional analysis as statistically significant; see Appendix D), and three out of six bears showed preference for heath tundra and birch seep.



Data are pooled from six adult female bears radio tracked during season 1, 1995 and 1996

Comparison of Available Habitat to Habitat Used by Grizzly Bears in Season I

FIGURE 4.9-4



Data are from six adult female bears radio tracked during season 1, 1995 and 1996

Comparison of Available Habitat to Habitat Used by Individual Grizzly Bears in Season I

FIGURE 4.9-5

BHP

Ekati diamond mine

Table 4.9-7
Percent of Satellite-Derived Land Cover Classes within Local Study Area Ecosite Types*

Satellite-derived & land cover types	Local Vegetation Map									
	Bedrock/Boulder Fields	Open Mat Tundra	Esker Complex	Closed Mat Tundra	Tundra/Wetland Complex	Birch/Hummock	Cotton Grass/Tussock	Wetland Complex	Birch Seep	Willow Riparian
Unclassified	0	0	5.3	0	0	0	0	0	0	0
Lichen Veneer	0	0	4.3	0	0	0	5.0	0	0	0
Deep Water	0	0		0	0	0	0	0	0	0
Esker Complex	0	0	18.3	0	0	0	0	0	0	0
Wetland (Sedge Meadow)	0	0	4.9	0	5.9	9.6	8.8	13.9	0	0
Tussock/Hummock	7.5	15.7	8.5	11.3	19.3	22.5	25.1	21.1	30.8	30.0
Heath Tundra	0	13.2	18.7	53.2	31.5	40.7	26.4	38.5	30.3	35.8
Spruce Forest	0	0	0	0		0	0	0	0	0
Bedrock Association	0	0	6.7	0	3.8	6.4	5.8	6.1	5.2	4.7
Tall Shrub	0	0	0	0	0	0	0	0		4.0
Birch Seep	0	0	0	0	0	0	0	0	8.7	8.7
Heath/Boulder	14.6	32.8	17.7	19.4	19.5	9.1	13.6	9.0	3.7	0
Heath/Bedrock	67.2	29.7	4.6	6.8	15.6	5.1	12.6	5.8	14.2	9.9
Boulder Association	5.9	0	10.7	0	0	0	0	0	0	0

*** Values represent the percent congruity between the Landsat Imagery classification and the habitat map developed by BHP.**

4.9.7.3.3.2 *Season II: 7 July to Den Entry*

Habitat preference rankings were developed using 387 female grizzly bear radio-telemetry locations of the six individual bears tracked over two years during Season II (Figure 4.9-6). Female grizzly bears selected for the following land cover classes (in order of preference):

1. Birch Seep
2. Tall Shrub (82% of the maximum standardized residual)
3. Eskers (47% of the maximum standardized residual)
4. Tussock/Hummock (35% of the maximum standardized residual)
5. Heath Tundra (28% of the maximum standardized residual)

The analysis of each of the six bears confirmed that individuals exhibited significant variation in habitat selection (Figure 4.9-7). However, with respect to the classes listed above, five out of six bears showed selection for birch seep, tall shrub, eskers and tussock/hummock only one bear showed selection for heath tundra.

4.9.7.3.3.3 *Habitat Loss and Disruption*

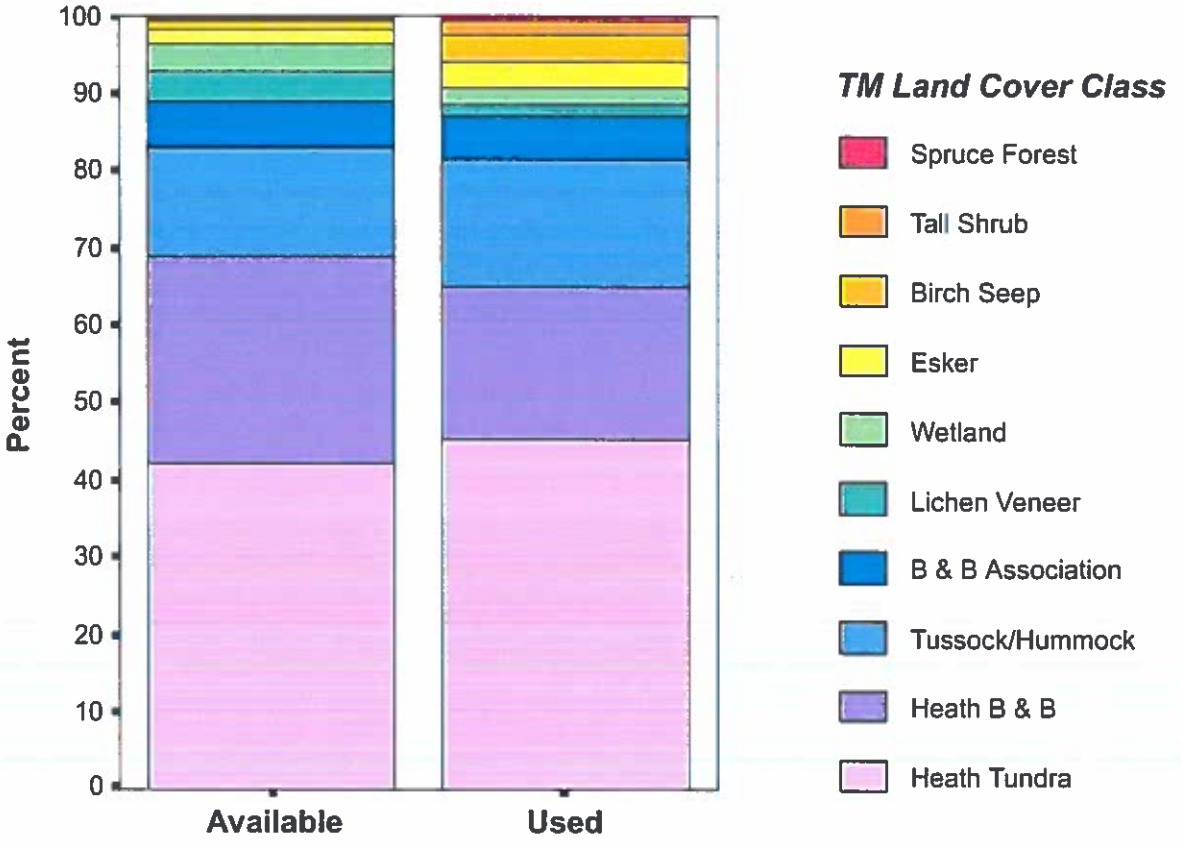
To quantify the amount of habitat lost and disrupted by human activity within the CEA Study Area, footprints and buffers were calculated for each identified land use using a Geographical Information System (Figure 4.9-8). Footprint calculations were based on estimated and calculated values for the EKATI™ and Lupin mines and Diavik Diamonds Project. All other activity sites (hunting and research camps, advanced exploration camps) were assumed to consist of only a central point.

Buffers were applied to all development sites to represent ZOI of disturbance, using two buffer scenarios:

- Hunting and research camps – non-motorized point disturbances (1 km and 3 km buffers)
- Lakes used by caribou outfitters (Desteffany, Courageous, and MacKay lakes) – 2 km buffers in both scenarios, to accommodate the area of most caribou hunting. Lakeshore buffers were considered as potential disturbance sources for grizzly bears although their effect is only during late summer/fall when caribou hunting occurs.
- Advanced exploration camps and operating mines plus their associated all-weather roads were classified as motorized, 24-hr disturbances, and were buffered by 3 km and 10 km.

In most grizzly bear habitat effectiveness models, motorized 24-hour disturbances in open habitats are usually buffered by 800 m to1,000 m (Mattson, 1998). However, larger buffers were applied in this cumulative effects assessment to account for:

- the scarcity of security cover throughout the study area;



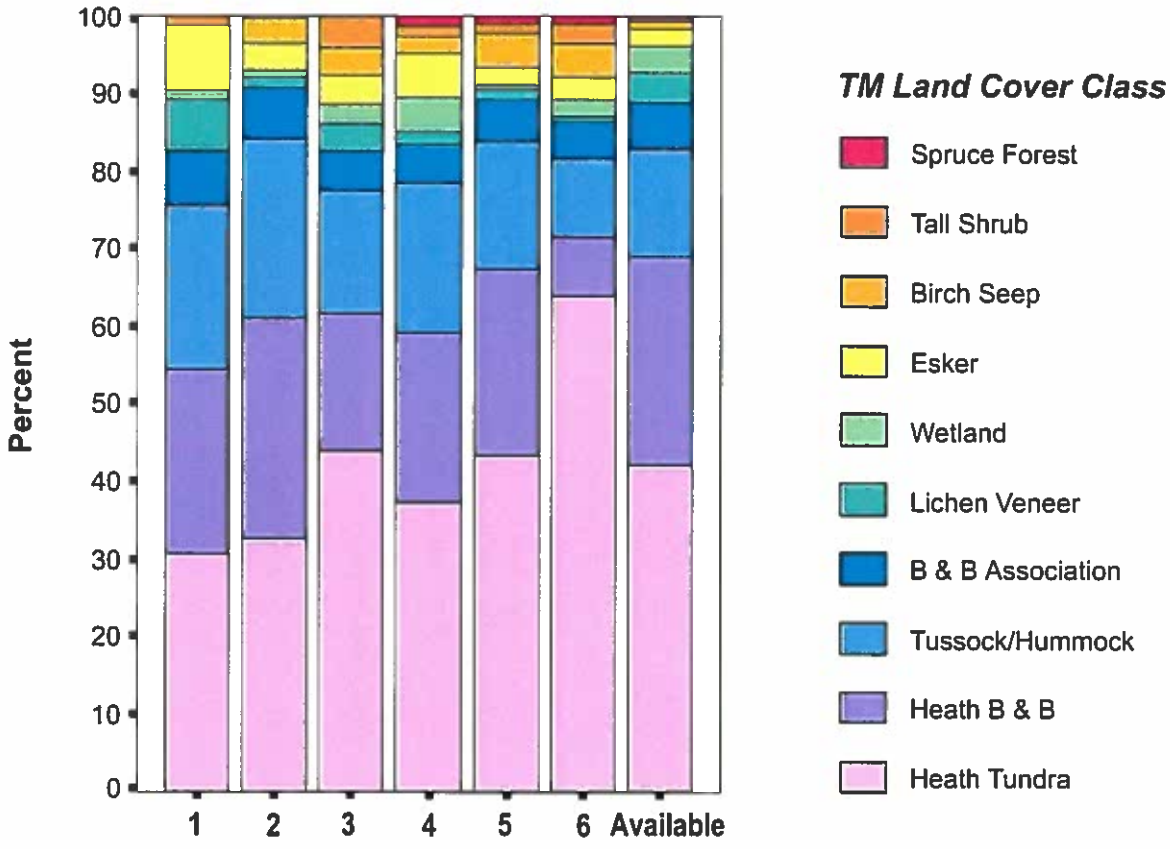
Data are from six adult female bears radio tracked during season II, 1995 and 1996

Comparison of Available Habitat to Habitat Used by Grizzly Bears in Season II

FIGURE 4.9-6

BHP

Ekati diamond mine



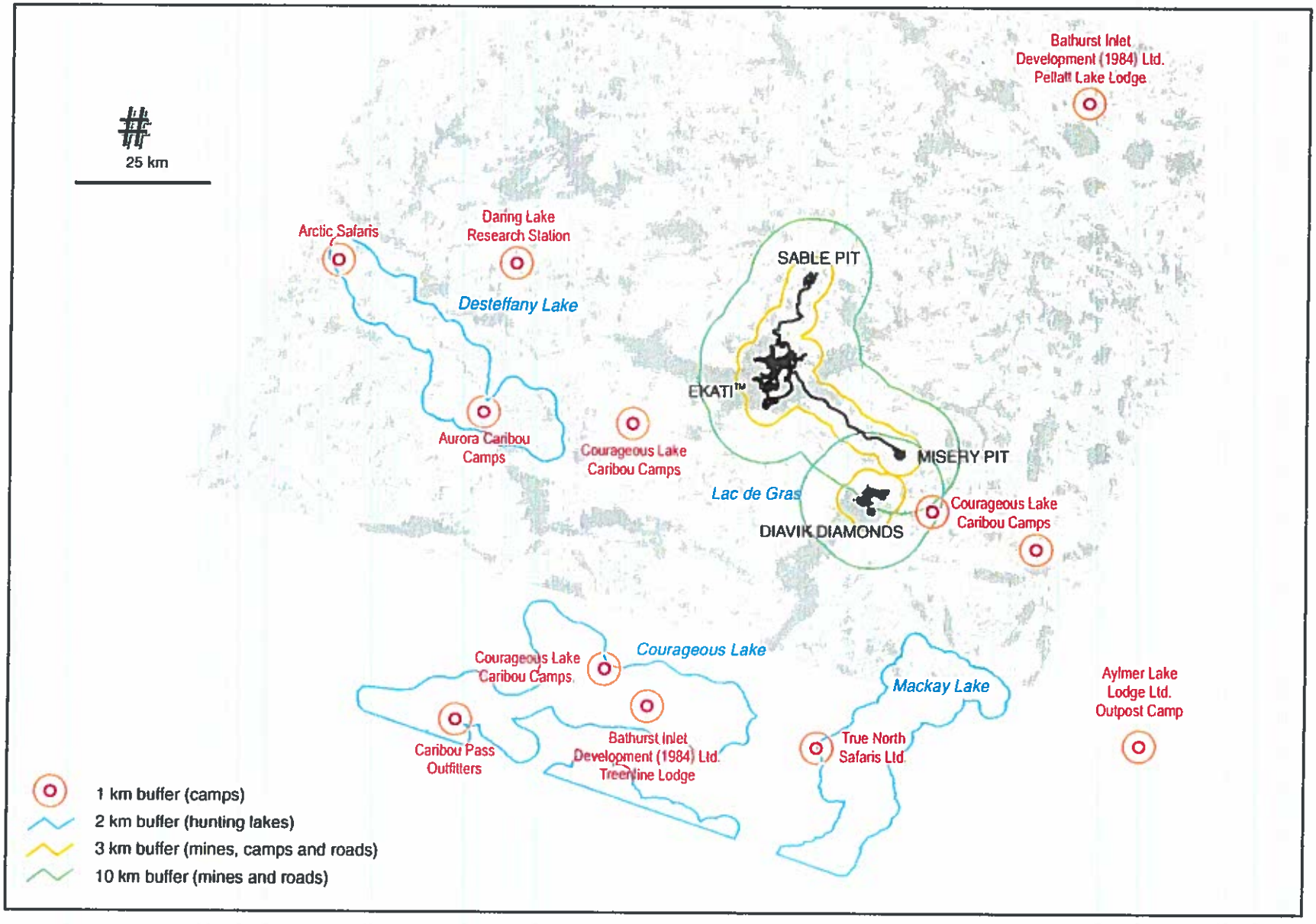
Data are from six adult female bears radio tracked during season II, 1995 and 1996

Comparison of Available Habitat to Habitat Used by Individual Grizzly Bears in Season II

FIGURE 4.9-7

BHP

Ekati diamond mine



Portion of the CEA Study Area with Human Developments and Buffers

FIGURE 4.9-8

- the persistence and magnitude of industrial activities;
- possible greater transmission of noise over the tundra; and
- the unknown response of grizzly bears to disturbance in the arctic tundra environment.

The total area of habitat lost to the combined footprints of the existing and permitted EKATI™ development, the Diavik planned development, the evaluated Lupin mine, and the proposed development of the Sable, Pigeon, and Beartooth pipes is 4,769 ha, of which 1,372 ha is water (Table 4.9-4). The proposed development of Sable, Pigeon, and Beartooth contributes 507 ha to this total, 52 ha of which is water. Zones of influence around disturbance sources, under two buffer scenarios, are shown in Table 4.9-5.

The effects of development on those cover classes preferred by grizzly bears are shown in Table 4.9-8. "Available" values are the total areas of those cover classes within the 31,222 km² Landsat image, and percent calculations are based on these totals. However, these percentages are inflated because they include references to footprint and buffer areas outside of the Landsat image (*e.g.*, Lupin, Jericho, Snap Lake).

Table 4.9-8
Preferred Grizzly Bear Habitat (Landsat Cover Classes) Affected by Developments within the CEA Study Area

Preferred Cover Class	Footprints			Buffer A		Buffer B	
	Available (ha)	Area (ha)	Percent of Available	Area (ha)	Percent of Available	Area (ha)	Percent of Available
Tall shrub	9,963	6	0.06	1,168	11.72	2,419	24.28
Birch seep	34,309	21	0.06	2,856	8.32	4,916	14.33
Wetlands	110,951	72	0.06	9,287	8.37	15,667	14.12
Heath tundra	934,257	1,173	0.13	76,293	8.17	157,510	16.86
Esker complex	33,462	35	0.10	2,710	8.10	6,185	18.48

Within the Landsat image, 49% of non-water habitat is comprised of cover classes "avoided" by bears (less than 40% of the maximum standardized residual). However, "avoided" cover classes comprise 62% of the combined footprints, 57% of the local (*e.g.* mines 3 km) buffer scenario, and 64% of the extended (*e.g.* mines 10 km) local buffer scenario.

Areas within footprints represent habitat effectively lost to bears, although bears may use them post-closure. However, areas within ZOI buffers are not lost, they are merely reduced in effectiveness (use). The habitat remains present, but bears' ability to use it is reduced by their avoidance of disturbance. Therefore, those effects persist only as long as the disturbance, and may be mitigated by habituation to the disturbance.

The degree to which habitat effectiveness is reduced is represented by a Coefficient of Habitat Effectiveness (CHE). Values for CHE have not been empirically determined for grizzly bears in tundra landscapes. Therefore, reductions in habitat effectiveness have not been quantified for this CEA and only the size and percent of the area of the ZOI within which habitat effectiveness may be reduced are defined. It is probable that relatively large reductions in habitat effectiveness apply to the area within 1 km to 3 km of high disturbance sources, and that reductions in habitat effectiveness beyond 3 km are probably small. It is also recognized that in areas where buffers overlap there is likely a multiplicative effect to the reduction of habitat effectiveness.

The total areas of preferred bear habitat that are lost or highly reduced in effectiveness are small, and are predicted to have a minor effect on bear population abundance within the greater-than-regional study area.

Other potential habitat-related effects are:

- Disruption of movements; and
- Fragmentation of home ranges particularly as a result of the distribution and orientation of roads.

Bears can still cross roads although they may move quickly through the area. Therefore, general movement patterns should not be greatly affected and the cumulative effects on movements are predicted to be minor.

4.9.7.3.3.4 *Mortality Model*

Most of the bear mortality associated with development is a result of human-bear interactions. There is no grizzly bear hunting in the North Slave Region, which encompasses the regional study area. Diavik estimated that an average of 0.12 to 0.24 grizzly bears per year were killed for every industrial camp operating in the Diavik assessment area during 1986-1997 (Axys and Penner and Associates, 1998b). Applying these estimates to the existing EKATI™ mine and the Diavik development, Diavik predicted that the magnitude of potential cumulative effects on human-caused grizzly bear mortality at full development would be:

- high (Diavik evaluation scale) in their Regional Study Area (RSA); and
- moderate (Diavik evaluation scale) at their greater-than regional scale.

They predicted that cumulative effects in their RSA could increase human-caused mortality rates from 0.5 bears (1.6% of the estimated minimum population of 30 bears in the RSA) per year to as many as 0.98 bears (3.3% of the estimated minimum population in their RSA) per year.

The proposed development of the Sable Pit and Sable Road adds a further potential mortality source to Diavik's cumulative effects assessment scenario. Increased human activity, especially in a previously-undisturbed portion of the study area, poses some risk

of exposure of bears to interactions with humans that may ultimately require removal of problem bears. Accidental exposure to and ingestion of toxicants such as petroleum products and ammonium nitrate is possible but unlikely. The highest potential additional mortality risk is for collisions with traffic on the Sable Road.

It is not possible to quantify these incremental risks. Adherence to BHP's existing policies will minimize the probability of each mortality source, but the risk cannot be completely eliminated. Therefore, it is reasonable to presume that the development and operation of the Sable Pit and road will very slightly increase mortality predictions in Diavik's cumulative effects assessment. With BHP's active mitigation program and based on experiences to date at EKATI™, it is reasonable to believe that a goal of zero mining-related bear mortalities is attainable.

4.9.7.3.4 Summary of Predicted Cumulative Effects

4.9.7.3.4.1 Distribution

Diavik predicted that their full-development scenario would result in moderate reductions (3%) in grizzly bear habitat availability at their regional study area level (Diavik Diamonds Project EIA, 1998b). They also predicted that multiple, incremental changes in habitat availability were unlikely to occur in a concentrated space, so the overall distribution of the bear population at the greater-than-regional scale would not likely be measurably affected.

Models of habitat loss and reduction for this cumulative effects assessment indicate minor reductions in availability of preferred habitat within the area of the Landsat image. Cumulatively, developments within the CEA Study Area are unlikely to affect the distribution of bears.

4.9.7.3.4.2 Abundance

Diavik (1998b) predicted that cumulative effects in their Regional Study Area, including the existing EKATI™ development (excluding the proposed development of the Sable, Pigeon, and Beartooth pits), could increase human-caused mortality rates from 0.5 bears (1.6% of the estimated minimum population of 30 bears in the RSA) per year to as many as 0.98 bears (3.3% of the estimated minimum population in their RSA) per year. The development of the Sable, Pigeon, and Beartooth pipes is predicted to contribute a slight increase to this mortality rate.

The estimated sustainable mortality rate for grizzly bears in the Slave Geological Province is 3% (R. Case, D. Cluff, RWED, pers. comm.). Therefore, if the predicted mortality rates are realized, the grizzly bear population in Diavik's RSA could be reduced. However, if the initial grizzly bear population is higher than the estimated minimum (55 bears rather than 30 in the RSA, and 750 bears rather than 407 in the SGP; Axys and Penner and Associates, 1998b; D. Cluff, RWED, pers. comm.), then the projected mortality rate would be within sustainable levels (*i.e.*, 1.8% of the population).

The grizzly bear harvest quota for the North Slave Region, which encompasses the regional study area, is zero (D. Cluff, RWED, pers. comm.). Therefore, subsistence and sport harvest is not directly relevant to the regional study area. However, grizzly bears are harvested in Nunavut in the vicinity of Kugluktuk, Bathurst Inlet, and Umingmaktok, and these bears are part of the same greater-than-regional population.

Loss of habitat and reductions in habitat effectiveness can affect population carrying capacity and, therefore, potentially the population size. However, the cumulative loss of habitat and reductions in habitat effectiveness within zones of influence around disturbance sources are predicted to have a negligible effect on bear population abundance.

Diavik (1998b) predicted that cumulative grizzly bear mortality associated with human activity within the Slave Geological Province would increase from 14.3 per year to 14.8 per year, and would be moderate (Diavik evaluation scale) in magnitude. Development of the Sable, Pigeon, and Beartooth pipes can be expected to slightly increase the possibility of mortality. Given the mortality risk associated with developments and activities within the CEA Study Area, cumulative effects on grizzly bear abundance are predicted to be potentially moderate at the local and regional scales, and minor to moderate at the greater-than-regional scale. However, interpretation of the significance of effects on the grizzly bear population is confounded by uncertainty as to population size, predicted mortality patterns, and effectiveness of efforts to mitigate mortality.

4.9.7.3.4.3 Wolves and Wolverines

Cumulative habitat effects on wolves and wolverines were estimated based on the habitat model developed for grizzly bears. Minor habitat loss and disruption are predicted to occur as a result of cumulative developments and activities within the CEA Study Area. Relative habitat quality for these species is unknown, but is likely closely tied to the presence of caribou and, therefore, cannot easily be mapped. Wolves have an affinity for esker complexes for denning. There are minor quantities of eskers within the disturbance ZOI (Table 4.9-7).

Wolves and wolverines are harvested within the regional and greater-than-regional study areas, and potentially within the local study area. Caribou hunters harvest a small number of each species. Occasionally, hunters access the regional study area by the Echo Bay winter road, where they may harvest wolves or wolverines. However, overall harvest and other human-caused mortality of these species is low and cumulative influences of activities and developments are likely to have no more than a minor effect on their populations.

4.9.8 Identification of Mitigation

As a pioneer in the development of diamonds resources in the NWT, BHP maintains its commitment to responsible environmental management and public consultation. The mitigation measures already established for the protection of caribou and carnivores will be

extended to address these concerns with the proposed Sable, Pigeon and Beartooth development. The goal of BHP is to have no wildlife mortality associated with its diamond mine. To date, the procedures established have proven effective in meeting this goal.

The monitoring programs (AEMP, WEMP) that are part of BHP Diamond Inc.'s standard operating procedures provide valuable tools to address concerns by:

- providing confirmation of the effectiveness of the environmental management programs; and
- allowing the early identification of emerging concerns so that adaptive environmental management strategies can be developed.

These programs will be adapted to include the proposed development, thereby providing the effective tools of confirmation and adaptive environmental management.

Beyond the claim block, BHP is an active participant in other research programs that represent building blocks leading to future regional cumulative effects monitoring. In particular, BHP is one of the largest financial contributors and supporters of the work of the West Kitikmeot Slave Study Society (WKSS).

The establishment of regional and territorial programs and alliances with Aboriginal organizations, the regulatory agencies and other regionally active companies will allow the appropriate development of mitigation measures for VECs in the Northwest Territories. BHP is committed to participating in these territorial-wide forums and will be an active partner in the development of mitigation measures that are appropriate to address regional concerns.

4.9.9 Cumulative Effects Monitoring

The best approach for addressing the potential cumulative effects of the EKATI™ Diamond Mine is through the continuation of its comprehensive environmental monitoring programs. Monitoring provides information on environmental baseline conditions and enables assessment of actual effects.

Potential cumulative effects will be monitored using similar monitoring methods to those described in Section 5. Long-term effects monitoring has been integrated within the overall monitoring plan at EKATI™.

In the Northwest Territories, the MVRMA and the CEAA provide the framework for the assessment of cumulative effects. Both require project-specific cumulative effects assessment and the associated need to manage cumulative effects on a project-specific basis. The Mackenzie Valley Cumulative Impact Monitoring Program (MVCIMP), coordinated by DIAND, is a result of the implementation plans for the Sahtu Dene and Metis Land Claim Agreement and the Gwich'in Comprehensive Land Claim Agreement. Together these statutes and agreements have set much of the context for cumulative effects assessment and monitoring in the NWT.

Momentum for and interest in regional cumulative effects monitoring has increased considerably with the recent (1999) release of the CSR for the Diavik Diamonds Project. This report identified the need to develop a regional cumulative effects management framework to address future potential developments in the NWT. This recommendation was supported by the Aboriginal groups, the public, NGOs and, in particular, the MVEIRB.

The report was strongly endorsed by the Minister of the Environment. It triggered a series of actions, including preliminary workshops attended by a range of interested people, including Board members in Yellowknife (December 1999) and the formation of a multi-stakeholder Working Group with representatives from:

- environmental organizations;
- federal, territorial and Aboriginal governments;
- industry (including BHP); and
- other interested parties.

The Working Group has been working diligently to develop a workplan, identify activities, milestones and resource requirements for CEA and the establishment of a management framework. The framework is to include regional multi-year programs of action including:

- identifying priorities for baseline data collection;
- monitoring; and
- funding requirements.

It is expected to be submitted to the Ministers of DIAND and Environment Canada for their review in the near future.

Currently, BHP is carrying out comprehensive environmental monitoring programs within its area of influence under the terms of site-specific regulatory instruments, commitments and agreements, in addition to its own corporate Environmental Policy. The following presents a brief review of the key regulatory instruments and commitments. Also provided is a summary of several key government initiatives that relate to the subject of regional cumulative effects management and monitoring.

4.9.9.1 Instruments for Cumulative Effects Monitoring

4.9.9.1.1 Water Licence

The most important such instrument is BHP's Type A Water Licence No. N7L2-1616 issued effective January 1, 1997. Its expiry date is December 31, 2004. The matter of cumulative effects monitoring is addressed in many ways. The most important is Part J, the Aquatic Effects Monitoring Program, commonly referred to as AEMP, which deals with the "*collection of sufficient data to establish long-term trends*" and requires BHP to

incorporate the results of this program into its overall adaptive environmental management strategies. And finally, the Surveillance Network Program (SNP), required by the NWT Water Board, is a comprehensive sampling program designed to provide the database for early warning of any long-range problems.

4.9.9.1.2 Environmental Agreement

The contractual instrument that is of greatest significance from the perspective of cumulative effects follow-up and monitoring is the Environmental Agreement dated as of January 6, 1997, made between Canada, the Northwest Territories (GNWT) and BHP.

The Agreement establishes an Independent Environmental Monitoring Agency (Agency) whose mandate, among other things, includes the making of recommendations concerning the environmental effects monitoring program respecting "*short-term, long-term and cumulative impacts*" carried out by BHP pursuant to that Agreement. Canada, the GNWT and BHP are required to give full and serious consideration to the recommendations of the Agency and to implement those recommendations of the Agency that they consider appropriate. Canada, the GNWT and BHP are required to respond to the Agency with their written reasons for not accepting recommendations that are not deemed appropriate.

The Environmental Agreement also requires BHP to prepare comprehensive environmental management plans in very specific areas, including but not limited to:

- air quality management plans;
- aquatic life management plans;
- wildlife management plans; and
- waste management plans.

Further, BHP is required to undertake compliance and environmental effects monitoring programs designed to measure compliance with regulatory requirements, to determine the environmental effects of the project and to test impact predictions. The testing of impact predictions is directly related to the issue of cumulative effects. BHP is required to carry out the monitoring and research activities contemplated in the Agreement in a manner that will provide data that will be useful in cumulative effects monitoring programs. BHP is required to consult and co-operate with regulatory agencies undertaking such programs, as appropriate. Under the Agreement, BHP also submits an Annual Environmental Report, and is required to provide an Environmental Impact Report once every three years. The first of these reports, the Impact 2000 Report, will be submitted in April, 2000.

4.9.9.1.3 Government Initiatives

Two initiatives of the federal government are directed to addressing a regional cumulative effects management framework.

The first initiative was taken in November of 1999 by the Minister of Environment, David Anderson, when he announced approval of the Diavik Diamonds Project. Because of concerns raised through public consultation and the views expressed by the MVEIRB, the Minister decided that specific commitments were warranted. Those commitments specify that a regional cumulative effects management framework would be designed and implemented. All appropriate federal, territorial and Aboriginal governments, regulatory agencies, non-governmental organizations, as well as appropriate industry, including Diavik (and BHP), are to be involved in the design and implementation of the management framework. Adaptive management is to be a key element to ensure sustainable development. In conjunction with the regional cumulative effects management framework, the Minister indicated that a monitoring mechanism would be established to ensure that monitoring of the Diavik operation occurs. Those monitoring activities are also to be integrated into the overall regional cumulative effects management framework. Minister Anderson also concluded that the design and the implementation of a follow-up program, to determine the effectiveness of measures taken to mitigate any adverse environmental effects and to verify the accuracy of the environmental assessment of the project, was warranted.

The second government initiative from a regional cumulative effects perspective involved DIAND in December of 1999, when that department conducted a cumulative effects assessment and management workshop. While it was acknowledged that the requirement for project-specific CEAs is currently in place through the application of the MVRMA and CEAA, there is a need to look at cumulative effects on a broader regional and territorial scale. It is for this reason that the MVCIMP, coordinated by DIAND, has been established. This program is a result of the implementation of plans resulting from the Sahtu, Dene and Metis Land Claim Agreement and the Gwich'in Comprehensive Land Claim Agreement. Together, these statutes and agreements have set much of the context for cumulative effects assessment and monitoring in the Northwest Territories.

4.9.9.1.4 Mackenzie Valley Resource Management Act, Part 6

Part 6 of the MVRMA deals with environmental monitoring and audit. It is specifically directed to require a responsible authority to analyze data collected by it for the purpose of monitoring the cumulative effects on the environment of concurrent and sequential uses of land and water and deposits of waste in the Mackenzie Valley. This is to be done in consultation with First Nations.

There is also a requirement placed upon the Minister of Indian Affairs and Northern Development to have an environmental audit conducted at least once every five years by a person or body that is independent. Presumably, that is an environmental audit in respect of the status of the environment of the Mackenzie Valley. The purpose is to determine trends in environmental quality, potential contributing factors to changes in the environment and the significance of those trends. The purpose is clearly to attempt to measure the cumulative impact on the environment as a result of uses of land and water.

4.10 Accidents and Malfunctions

4.10.1 Hazardous Spills and General Emergencies

The EKATI™ Diamond Mine has a "Spill and General Contingency Plan" in the event of spills and/or malfunctions. The plan outlines the organization of the EKATI™ spill response team, alerting and notification procedures and cleanup strategies as well as the duties and responsibilities of key response personnel. Emergency contacts are listed for BHP, BHP contractors, government agencies, private response organizations and neighbouring site operations.

Maintenance and Supply personnel check all stationary hydrocarbon and other liquid material storage tanks on a regular basis. There are 58 storage tanks for petroleum products and glycol ranging in size from 2,200 to 9,900,000 litres in capacity. Should any deficiencies and/or defects be found during the inspection, corrective action is immediately taken. A summary of spill incidents for calendar years 1997 through 1999 is presented in Table 4.10-1.

Table 4.10-1
Summary of Spills at the EKATI™ Diamond Mine

	Product	Sum of Quantity (L)	# of Spills
1997	Diesel	4,887	18
	Glycol	2,840	4
	Hydraulic Fluid	602	12
	Oil	713.5	9
	Transmission Fluid	10	1
	Totals	9,052.5	44
	Product	**Sum of Quantity (L)**	**# of Spills**
1998	Diesel	9,437	13
	Drainage off coarse rejects pile	30,000	1
	Dry Flocculent approx. 100 kg	0	1
	Glycol	40,460	4
	Hydraulic Fluid	851	5
	Oil	180	5
	Sewage	950	2
	Totals	81,878	31
	Product	**Sum of Quantity (L)**	**# of Spills**
1999	Diesel	4,300	4
	Hydraulic Fluid	4,355	9
	Oil	740	3
	Totals	9,375	16

Training is conducted annually for all personnel involved in the response, cleanup of fuel and hazardous material spills, in particular for the members of the Emergency Response Teams. In addition to actual real life training exercises, training includes the review of:

- The spill response plan and responsibilities of personnel;
- The nature and status of fuel and chemical storage facilities;
- On-site and off-site response equipment; and
- Emergency contact lists.

The Spill Response Team is also responsible for emergency measures such as mine rescue, fire fighting and response to general emergencies. Mine rescue training is held a minimum of once a month. Basic fire fighting, HAZMAT incidents, pre-hospital trauma life support, surface and underground mine rescue capabilities are all features of the on-site capabilities. Compared to a typical community, the site has much greater capabilities and equipment to effectively respond to any emergency.

The EKATI™ mine has fire suppression equipment, vehicle extraction equipment, rappel and rigging equipment, and HAZMAT suits. Having this equipment allows general emergencies which might occur at the EKATI™ mine to be addressed efficiently and effectively.

4.10.2 Risk of Malfunctions of Engineered Systems

The engineered systems for water and waste materials management described in this report have been designed using state-of-practice techniques for resource development under arctic conditions. These techniques have been calibrated to the site, based on performance of structures during the three years since the first dam or diversion structure was placed into service. There is always a risk that an engineered structure may not function as intended or that the design criteria will be exceeded. A failure could result in an uncontrolled release of potentially toxic materials to the environment. The design methodology includes an implicit evaluation of that risk following engineering principles such as the Canadian Dam Safety Guidelines. This section discusses the relative magnitudes of the risks and how they have been considered in the design process. BHP does not intend to conduct underground mining operations at the Sable, Pigeon, and Beartooth kimberlite pipes.

Any risk evaluation for engineered structures must first examine the relative probability of failure. That is done by firstly considering the probability of an event occurring that could trigger a failure. The second component of relative probability of failure is to assess the most likely failure mode given that the trigger event does occur. For the containment dams the trigger mechanisms that have been considered are:

- Climatic extremes such as precipitation;

- Earthquakes; and
- Permafrost thaw (cracking, thermal erosion, global warming).

The probability of climatic extremes and earthquakes have been expressed quantitatively as an annual exceedance probability such as 1/100. That ratio expresses the probability that an event of specified magnitude will be exceeded in any year. If the design event were to occur, the probability of some form of failure being initiated has been considered and how such a failure would progress. For example, all of the dams are designed to withstand short-term overtopping, therefore instantaneous release of all the ponded water has a very low probability. The failure would be either by overtopping or by excessive seepage losses initiated by thaw of the dam core or foundation. The design criteria selected and the potential failure modes are described in the preliminary design report (EBA, 2000).

If a failure, such as overtopping a dam, were to occur the magnitude, location and consequences of any uncontrolled release have been considered. The consequences are expressed as the magnitude of the release and the potential toxicity of the water. A short-term release of non-toxic dirty water that does not pose a safety hazard would receive a low consequence rating. A release of water with substantial suspended kimberlite fines into streams or lakes containing fish would have an intermediate consequence rating.

The new structures required for the proposed development are of low consequence ratings with the exception of the Bearclaw Diversion Dam which is considered a high consequence dam because water would be released into an operational pit. This poses a safety hazard to the employees working in the pit. Any structure with a low probability of failure but high consequence is considered of greater overall risk. Conversely, a structure with a higher probability of failure but of low consequence will also have an elevated risk. The design criteria for these higher risk structures have been carefully chosen to further diminish the probability of failure by adopting greater contingencies to manage such unforeseen events. These contingencies include increased freeboard to reduce the probability of overtopping and designs that are highly resistant to erosion.

Where the management plan includes mechanical components such as the pumps and diversion pipeline for Bearclaw diversion, the designs recognize the risk of system failures. The reservoir capacities have been set to allow a year of storage in the event of late annual pump startup or failure. If the mine were to be placed into temporary shutdown, it would be necessary to maintain a workforce for care and maintenance of all mechanical systems.

Risk assessment for the water management structures has identified two instances where water of unknown quality could inadvertently be released to the environment. The potential failure scenarios for water management structures are further described in EBA, (2000). The cases that justify environmental effects assessment are:

- overtopping or seepage from the Dam at Two Rock Lake; and
- discharge of runoff water from the toe of the waste rock piles.

The dam at the outlet of Bearclaw Lake is not considered an environmental hazard because any uncontrolled release of water would end up in Beartooth Pit where it would be collected and pumped to the Long Lake Containment Facility.

4.10.2.1 Uncontrolled Discharge from Two Rock Lake

An uncontrolled discharge by excessive seepage or overflow from the dam at Two Rock Lake would result in increased flows downstream. Winter seepage would form a blanket of ice below the dam. That ice blanket would enhance spring freshet and would affect vegetation over a limited area. There could be an unexpected silt loading to the stream and to Horseshoe Lake.

The following is an assessment of the worst-case failure scenario where turbid water from the Two Rock Dam is released into Horseshoe Lake.

1. Geographical extent: poor quality water could potentially flow throughout the Horseshoe Watershed which would be local (minor); the effects on water quantity would likely dampen out once the water reached Exeter Lake; fish habitat would likely only be affected in a portion of the local area;
2. Duration of the uncontrolled discharge would be very short-term as water would quickly flush through the watershed, any erosion damage and hence habitat alteration could be short to moderate term;
3. Frequency would be very rare;
4. Reversibility. The effect on water quality and quantity would be reversible within a short period of time, eroded habitat would be reversible (by reconstruction) but on a longer time scale;
5. Probability of a complete dam failure is "inconsequential" and the probability of an uncontrolled seepage loss is considered "unlikely" (EBA, 2000); and
6. Future capacity of renewable resources would not be reduced; erosion may cause a temporary reduction in habitat only.

The overall significance rating of the effect on water quality, quantity, and fish/aquatic habitat in the event of uncontrolled discharge from Two Rock Dam is expected to be negligible to minor, based on the impact attributes presented in Section 4.2.

4.10.2.2 Waste Rock Runoff

A complete failure of the system designed to retard or eliminate runoff from the waste rock piles would result in seepage entering lakes adjacent to the Sable Pit and Bearclaw lake. The Pigeon waste rock dump is not considered an environmental hazard because all overland flow at that site is toward the Long lake Containment Area.

All waste rock storage piles are located at least 100 m away from lakes providing a tundra buffer zone for percolation before runoff enters any lake. Some water quality parameters that may be outside compliance limits, such as nitrogen compounds, would likely be reduced prior to reaching open water. Elevated concentrations of nitrogenous compounds would not likely induce increases in primary production in the absence of increased phosphorous levels. The 100 m tundra buffer does offer some backup mitigation in the event of berm failure. As well, the waste rock is not anticipated to be acid generating although test work is planned before final design.

The following is an assessment of the effects on water VECs in the event of failure to contain runoff from waste rock piles within close proximity of lakes:

1. Geographical extent would be a portion of the local area or the local area in the absolute worst case. Current runoff from the Panda waste rock storage pile is only detectable in a very localized area;

2. Duration could be moderate to long term, if failure occurred after BHP mining operations were complete. However, the water quality would improve with time. Unless the waste rock is found to be acid-generating, water quality would likely improve in less than ten years;

3. Frequency would be continuous during the open water seasons;

4. Reversibility. The effect would likely be reversible as water quality would be expected to improve with time;

5. Probability of complete failure of the containment system is considered very low although probability of some runoff escape is high;

6. Future capacity of renewable resources would likely not be reduced permanently, as the runoff from the waste rock piles is not expected to be toxic;

The overall significance rating of the effect on water quality and fish/aquatic habitat in the event of failure of the containment system is expected to be minor to moderate, based on the impact attributes presented in Section 4.2. The effects can be mitigated with an effective structure maintenance and monitoring program, which will substantially reduce the overall risks. Additional field experimentation and testing is planned to advance the design and improve the risk assessment.

5. ENVIRONMENTAL MANAGEMENT

5.1 Environmental Management at EKATI™

BHP is fully committed to operating the EKATI™ Diamond Mine in an environmentally responsible manner to protect and sustain the northern environment throughout the life of the development, and for future generations. The environmental management plans developed during the early stages of EKATI™ Diamond Mine are consistent with BHP's corporate Environmental Policy, its regulatory instruments and the Environmental Agreement. This section focuses on the approach developed at EKATI™ to environmental management and describes specific monitoring and management plans contained in the Operating Environmental Management Plan (OEMP). These plans have been designed to mitigate any potential environmental effects that may result from the development of kimberlite pipes within the BHP claim block, such as Sable, Pigeon and Beartooth. Continued application of BHP's environmental management plans, monitoring programs, adaptive management strategy, and mitigation techniques promote responsible development of the proposed pipes.

The dedication of the EKATI™ Diamond Mine to follow the Vision and Core Guiding Principles of BHP Diamonds Inc. is reflected in this section. To achieve excellence in environmental care, EKATI™ employees commit themselves to "conduct all activities as responsible stewards of the environment."

BHP's corporate Environmental Policy, described in Chapter 1 (Figure 1.1-4), clearly recognizes that environmental management is an important corporate priority for conducting its business in an environmentally sound manner. The company seeks continuous improvement in its environmental performance by taking account of evolving scientific knowledge, traditional knowledge, mine experience and community expectations.

Important regulatory requirements governing environmental management at EKATI™ are the provisions of the Type A Water Licence issued by the NWT Water Board, and the contractual obligations established between the Government of Canada, the Government of the NWT and BHP in the Environmental Agreement.

The Environmental Agreement was designed to cover issues raised by the Environmental Assessment Review Report that were not covered by existing legislation and to tailor the regulatory regime to the circumstances of the EKATI™ mine. The incorporation of traditional knowledge and the enhancement of the Territorial Land Use Regulations related to archaeology are two specific examples. The terms and conditions of the Environmental Agreement are referenced in the federal Land Leases for EKATI™ (listed in Chapter 2). The Environmental Agreement is linked to both the Land Leases and the Impact and Benefit Agreements, providing a structured framework for environmental management.

BHP currently conducts compliance monitoring based on the Surveillance Network Program (SNP) specified in BHP's Type A Water Licence, and aquatic effects

monitoring based on the Water Licence and Environmental Agreement. As illustrated in Figure 5.1-1, the two monitoring programs overlap with regard to water quality and aquatic effects. The integrated program was developed through the joint co-operation and support of the NWT Water Board, the federal responsible authorities and BHP. As a result, the annual Water Licence report for the Water Board and the Aquatic Effects Monitoring Program (AEMP) report for the Environmental Agreement have now been combined into a single annual report.

All other environmental effects monitoring is carried out under EKATI™'s OEMP, which is also a component of the Environmental Agreement.

5.2 Operating Environmental Management Plan

The OEMP for the EKATI™ Diamond Mine evolved from the earlier Construction Phase Environmental Management Plan (CEMP). These documents have been reviewed and endorsed by the federal and territorial regulatory and resource management agencies, the Aboriginal groups and the Independent Environmental Monitoring Agency (Agency). The OEMP has been in place since the official opening of EKATI™ Diamond Mine on October 14, 1998. The OEMP is the umbrella document for the programs, plans and procedures needed to effectively mitigate and manage environmental effects and risks associated with mining-related activities at EKATI™ (Figure 5.2-1). The OEMP complements the requirements of the legislated permits, licences and authorizations to reduce unnecessary duplication. The OEMP emphasizes BHP's firm commitment to its environmental policy and the critical need to protect the natural resources and ecosystems of the development area and the surrounding region.

The objectives of the OEMP are to:

- develop a framework within which the BHP Environmental Policy can be implemented;
- provide a framework for continual improvement of environmental performance;
- check compliance of activities with statutory environmental obligations;
- detail environmental monitoring programs and recording procedures;
- reduce the potential for environmental liability resulting from the routine conduct of all activities;
- provide a framework for promoting awareness and responsibilities of the company and individuals towards protecting the environment; and
- manage all activities at the EKATI™ Diamond Mine to mitigate potential environmental impacts.

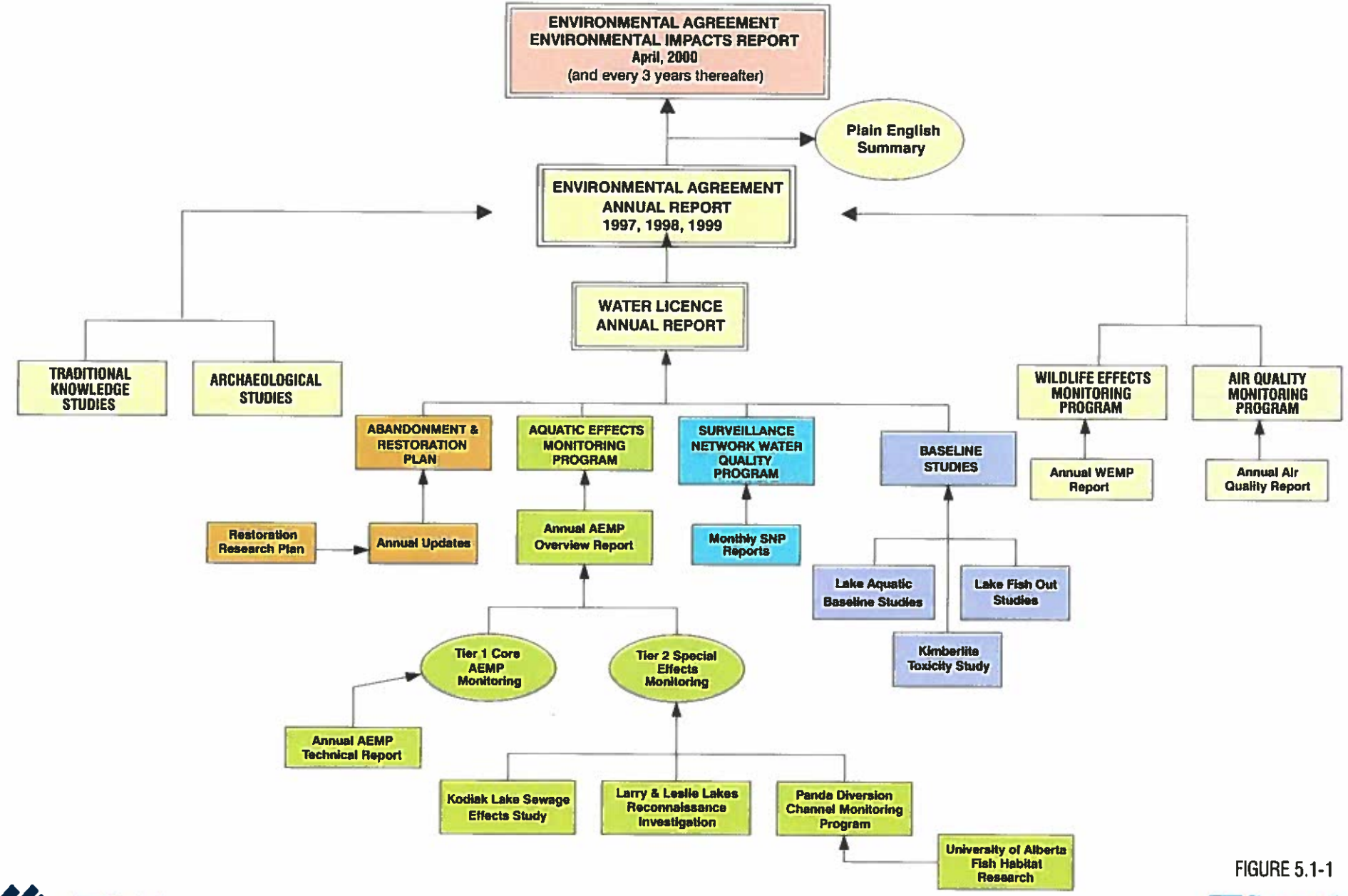


FIGURE 5.1-1

EKATI™ Environmental Monitoring Schematic

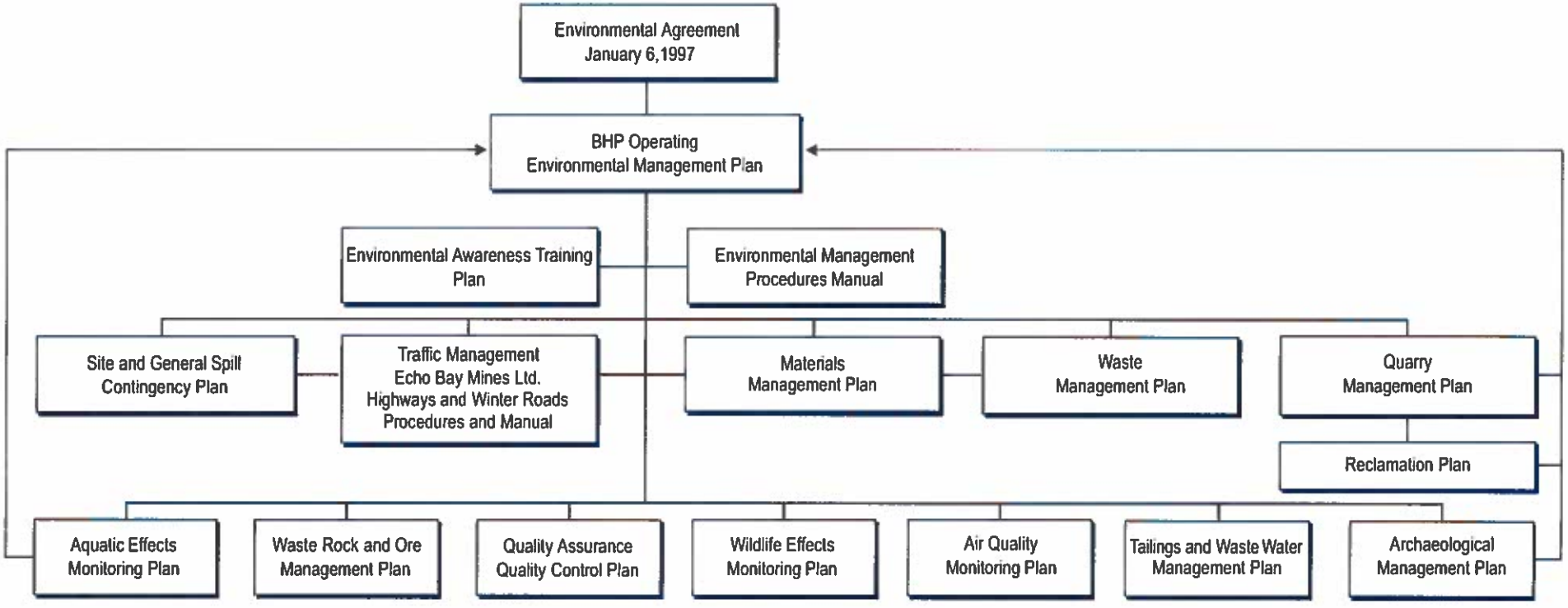


FIGURE 5.2-1

EKATI™ Management Plans

The OEMP facilitates the implementation of adaptive environmental management at EKATI™ in a manner consistent with the principles of sustainable development. It helps to merge economic, environmental and social considerations into an integrated management process that seeks to minimize the overall potential adverse effects of EKATI™ on the Lac de Gras region. The EKATI™ mine is managed in a manner that envisions reuse of the mine site for other activities such as wildlife habitat after decommissioning. Finally, while any given mineral deposit has a finite economic life, properly managed mining is a sustainable economic activity in the Northwest Territories.

Implementation of the OEMP has been a significant element in the development of an environmentally responsible corporate culture at BHP Diamonds. This has been accomplished through the clear demonstration of management commitment to BHP's Environmental Policy, the implementation of appropriate management procedures, and the provision of time and resources to educate and train employees and contractors. Effective environmental management is a priority at EKATI™. It has over the last two years been fully integrated into all activities – including exploration, operations and decommissioning.

The OEMP provides EKATI™'s management framework for achieving compliance with the regulatory requirements of Canada, the GNWT and BHP. BHP Diamonds has accomplished this by incorporating best practices derived from both scientific and traditional knowledge into its operational activities. The OEMP is a strategic plan to deal with potential environmental effects and their mitigation during the operation and decommissioning of the mine. It contains strategies and commitments that are technically practicable. The sound application of the OEMP will continue to ensure that the environment of the mine area and the regional ecosystems will be afforded optimal protection.

BHP views the OEMP as a "living document" that will be updated and continually improved upon, throughout the life of the EKATI™ Diamond Mine. Opportunities for improvement include changes in the mine plan, such as the proposed development, the availability of monitoring results and the acquisition of new scientific and traditional knowledge information. The OEMP will be modified to accommodate the inclusion of Sable, Pigeon and Beartooth pipes into the EKATI™ mine plan after all regulatory permits are in place.

A brief description of each of the 13 specific management and monitoring plans that comprise the OEMP is provided in Section 7.5.3 in this report. However, since environmental monitoring issues and follow-up are of particular interest to this assessment, some additional information is provided for each of the ongoing monitoring programs for wildlife, the aquatic system and air quality. In addition, information is provided on the Environmental Impact Report, which is a separate report required every three years in accordance with the Environmental Agreement.

This is followed by two specific sections on hazardous waste management and the management of ammonium nitrate at the mine site.

5.2.1 Wildlife Effects Monitoring Program (WEMP)

The Wildlife Effects Monitoring Plan (WEMP) for the EKATI™ Diamond Mine is in its third year. The objectives of the program are as follows:

- to measure compliance with regulatory requirements;
- to determine the short- and long-term effects on wildlife resulting from EKATI™;
- to test impact predictions; and
- to measure the performance of operations and effectiveness of impact mitigation measures.

The monitoring plan was developed in consultation with stakeholders using a risk-based approach and is enhanced each year as traditional and scientific knowledge is gained. This approach was used to focus the program on key species (Valued Ecosystem Components) and key potential effects on these species.

The following Valued Ecosystem Components (VECs) were selected for study:

- Caribou/habitats;
- Carnivores/habitats - Grizzly Bears, Wolves, Wolverines;
- Breeding Birds/habitats - Upland Breeding Birds, Loons, Raptors.

Hypotheses, or key questions, regarding the potential effects on these VECs were posed for the monitoring program. In addition, the program tested effect predictions made in the 1995 Environmental Impact Statement against field data collected annually. The last aspect was to monitor changes in operations to determine if mitigation measures were successful. The design of the program is updated as needed to provide data to address these objectives.

After completion of the 1999 programs, stakeholders — including all four Aboriginal groups, non-governmental environmental organizations, government scientists, industry and the Agency — were all given the opportunity to comment on the proposed program for the year 2000 at a workshop held between February 9 and 10, 2000. Active participation by the stakeholders assisted BHP in adapting and evolving the WEMP for the year 2000 programs.

The 1999 field season provided further data to test the success of mitigation measures and provide comparisons to predictions made in the 1999 Wildlife Effects Monitoring Plan. The results, as presented in the 1999 report, permitted BHP to better characterize the nature and likelihood of residual effects on the Valued Ecosystem Components related to wildlife.

5.2.2 Aquatic Effects Monitoring Program (AEMP)

The purpose of the Aquatic Effects Monitoring Program (AEMP), which is in its third year, is:

To ensure that the project does not and will not have significant adverse impacts on the receiving and surrounding aquatic ecosystems.

The AEMP serves to focus and integrate monitoring efforts to ensure compliance with regulatory instruments and agreements. In addition, the AEMP leads to the protection of valued ecosystem components. These are, in risk assessment terminology, the potential receptors of any environmental effects. Receptors are the organism(s) or ecological resource(s) that might be adversely affected by contact with or exposure to a stressor. The 1995 EIS identified two Valued Ecosystem Components:

- Water quality - water quality and sediment quality
- Fish/aquatic habitat
  - habitat for fish and key elements of the aquatic food chain (*i.e.*, the aquatic community)
  - fish and key elements of the aquatic food chain (phytoplankton and zooplankton, periphyton and benthos).

The principles of the AEMP derive from the Environmental Agreement. Specifically, the AEMP demonstrates BHP's commitment to:

- respect and protect water;
- facilitate the use of holistic and ecosystem-based approaches;
- fully consider both traditional knowledge and other scientific information;
- apply adaptive management principles making use of the best available information and appropriate technology;
- maximize environmental quality to the extent reasonably practicable; and
- act when necessary where there are threats of serious or irreversible damage.

The AEMP must meet the requirements of the Fisheries Authorization, the Fish Habitat Compensation Agreement, and both the Environmental Agreement and the Water Licence. In addition to the above, these authorizations and agreements specifically:

- measure compliance with regulatory requirements;
- determine any environmental effects of the project;
- test impact predictions; and
- measure the effectiveness of mitigation measures.

All aspects of the AEMP feed back into BHP's operating environmental management plan. This plan provides for timely and appropriate responses and actions.

5.2.3 Air Quality Monitoring Program

Air quality is a valued ecosystem component at EKATI™ because of possible effects on worker health and safety, and its importance for wildlife, vegetation, and water quality. The goal of this management and monitoring plan is to ensure the preservation of the existing ambient air quality throughout the life of EKATI™. The air program has been designed to:

- determine any environmental effects of the project;
- test impact predictions; and
- measure the effectiveness of mitigation measures.

Air quality management focuses on prevention. Prevention is first accomplished with the use of environmentally acceptable products, efficient equipment and sound engineering practices. Prevention is maintained through programs of continuous inspection by the responsible EKATI™ department or by the responsible contractor. Preventative maintenance inspections expand as new infrastructure, facilities and equipment become active.

Air monitoring and management programs are undertaken to gather air quality data. This information is used to update the operational management and monitoring plan for air quality.

BHP manages and monitors air quality through a combination of:

- mass-balance emissions calculations;
- high volume air sampling at selected sites;
- snow surveys; and
- vegetation studies.

Air emissions management is intended to be preventative rather than reactive. This section outlines the strategies undertaken to control and/or minimize particulate and gaseous air emissions to ensure that Ambient Air Quality Objectives are not exceeded. In the absence of regulated air quality standards in the NWT, BHP is operating under the guidelines of its global commitments to reduce air emissions. In summary, BHP's emissions are reduced at source by:

- use of low sulphur fuels;
- fabric filters to capture dust from ore processing;

- preventative maintenance programs to ensure optimum operation of all combustion and fugitive emission sources; and
- control of fugitive dust emissions through road watering, use of granite waste rock as construction materials, vehicle speed regulation, and vehicle trip reduction through scheduling and routing programs.

5.2.4 Environmental Impact Report

BHP is required to submit a comprehensive Environmental Impact Report by April 30, 2000, and every third year thereafter until full and final reclamation of the EKATI™ site has been completed in accordance with the Environmental Agreement. The Environmental Impact Report is a document that reports on any long-term effects of the EKATI™ mine, the results of environmental monitoring programs and the actual performance of EKATI™ in comparison to what was predicted in the 1995 EIS. In addition, the Environmental Impact Report provides an evaluation of how adaptive environmental management has performed to date. The Environmental Impact Report provides the following:

- a summary of operational activities during the reporting period;
- actions taken or planned to address impacts or compliance problems that are set out in the Environmental Impact Report;
- a summary of operational activities for the next reporting period; and
- list and abstracts of all environmental plans and programs.

5.2.5 Hazardous Waste Management

All hazardous wastes generated as part of the proposed development will be processed at the existing EKATI™ site in accordance with the existing Waste Management Plan. All transportation, handling, storage and disposal practices included in this plan are in accordance with applicable federal and territorial legislation. No changes to the Waste Management Plan are required to accommodate hazardous wastes resulting from activities at Sable, Pigeon and Beartooth. No new waste types will be generated at these locations.

The primary activity resulting in the generation of hazardous waste will be mobile equipment maintenance. Used oil, used antifreeze, used parts, washing fluids (solvents), lead-acid batteries and miscellaneous waste such as empty aerosol cans (cleaners, degreasers, *etc.*) are all generated through maintenance of the mobile equipment fleet.

Maintenance of the mobile equipment fleet used at Pigeon and Beartooth pipes will be undertaken at existing facilities (Truck Shop). Hazardous wastes generated in the Truck Shop are stored on a temporary basis before being re-directed to the Waste Management Building. The Waste Management Building is a dedicated facility used to prepare hazardous wastes for recycling/disposal in accordance with the existing Waste Management Plan. The location of the Waste Management Building is presented in

Figure 5.2-2. No changes to equipment, personnel or infrastructure will be required to support the small increase in hazardous waste to be generated by the proposed new pits.

Regular maintenance of the mobile equipment fleet used at Sable pipe will be undertaken at a two-bay garage adjacent to the proposed pit. Hazardous wastes generated through maintenance activities will be collected and stored in a centralized location of the garage. They will subsequently be back-hauled to the existing Waste Management Building at the main site. Materials will be stored in receptacles appropriately designed and labelled for back-haul to the Waste Management Building. The design basis for the equipment, infrastructure and procedures in the two-bay garage will parallel those of the existing EKATI™ Truck Shop.

5.2.6 Ammonium Nitrate (AN) – Waste Rock Management

Seepage of soluble inorganic nitrogen compounds originating from waste rock and pit dewatering are common in mining and occur at EKATI™. Some forms of nitrogen such as anionic ammonia or free ammonia (2.2 mg/L based on a temperature of 10°C and a pH of 7.00) and nitrite (0.06 mg/L) can be detrimental to fish at elevated concentrations. The addition of Sable, Pigeon and Beartooth to the existing mine plan does not alter the low levels of free ammonia and nitrite entering the aquatic receiving environment.

Nitrate, although not toxic to fish, is a nutrient, which in isolation poses no harmful effect to fish, but in the presence of phosphorus, can contribute to the process of freshwater eutrophication or nutrification. The natural concentration of phosphorus in lakes in the Lac de Gras region is low. BHP has implemented measures to limit phosphorous loading to both the aquatic receiving environment and the Long Lake Containment Facility. This involves control of sediment loading to surface waters during construction and minimization of the use of phosphate containing products on site.

The primary source of inorganic nitrogen typically found at mine sites is undetonated ammonium nitrate (AN)-based explosives. Explosives represent a significant cost at EKATI™, thus there are economic as well as environmental incentives to control losses. Nitrate can leach into surface water by one or more of the following pathways:

- spillage, which is the most common source of ammonium nitrate loss and the easiest to control;
- improper selection of explosives medium, leading to losses of explosives through incomplete detonation; and
- site peculiarities such as geology and groundwater affecting the migration of explosives into permeable fractures or fault systems and causing incomplete detonation.

Due to potential environmental concerns related to the introduction of nitrogen compounds at EKATI™, BHP has introduced operating procedures to limit, control and mitigate the release of undetonated explosives from blasting operations. These procedures will also apply to the proposed Sable, Pigeon and Beartooth development.

Waste Management Building Location Plan

FIGURE 5.2-2

BHP

Ekati diamond mine

The AN-based explosives handling procedures require that personnel who handle explosives take the necessary precautions to prevent spillage during blasting operations. The Environment, Engineering and Operations departments at EKATI™ are working together to ensure the mining operations team is fully aware of and employs proper explosives handling procedures related to environmental protection.

When AN-based explosives come in contact with water, some dissolution of ammonium nitrate occurs. To limit explosives-water contact, areas that are subject to groundwater flows are identified, and dewatered prior to blasting. At EKATI™, an emulsion based ammonium nitrate-fuel oil (ANFO) mixture is used that contains emulsifiers that decrease AN dissolution. The objectives of using an emulsion-based ANFO product are to minimize AN dilution in water and to improve blast performance.

Occasionally the detonation of a blasthole is incomplete, leaving a volume of undetonated explosives. This condition is known as a misfire. If left unmitigated it contributes to the volume of potentially soluble AN in the waste rock and pit water. At EKATI™ blast performance is monitored and there is an established procedure for dealing with misfires. When a misfires occurs, AN-contaminated waste rock is identified and marked for transport to a previously identified location in the waste rock storage pile where the potential for AN seepage can be controlled. Waste rock segregation is also used in the event of "poor" or inefficient blasts due to groundwater, unpredictable geology or human error. Efforts are currently being made to mitigate these potentially unfavourable conditions through pit dewatering efforts, better geological control and QA/QC audits of blasting activities.

5.3 Adaptive Management

Mitigating the potential environmental effects of mining in the barrenlands requires the implementation of clear management goals and objectives. A sound understanding of the effects of management decisions and a working knowledge of the physical and socio-political environments is essential.

To achieve industry leadership in environmental management, BHP employs a management strategy that stresses iterative learning, long-term planning, exchange of knowledge and cooperation between organizations. This strategy, known as adaptive management, is a formal process for formulating and continually improving resource management policies and practices by learning from the outcome of operational programs (Holling, 1978; Walters, 1986; Lee, 1993). The successful application of this strategy, illustrated in Figure 5.3-1, results in a process of continuous improvement. Through the application of this strategy, available information is used to make the most appropriate current management decisions, while concurrently fine-tuning the information collection process as necessary to make more informed decisions in the future. Of key importance to adaptive environmental management is the acknowledgement that various sources of uncertainty are inherent in both biological systems and management efforts.

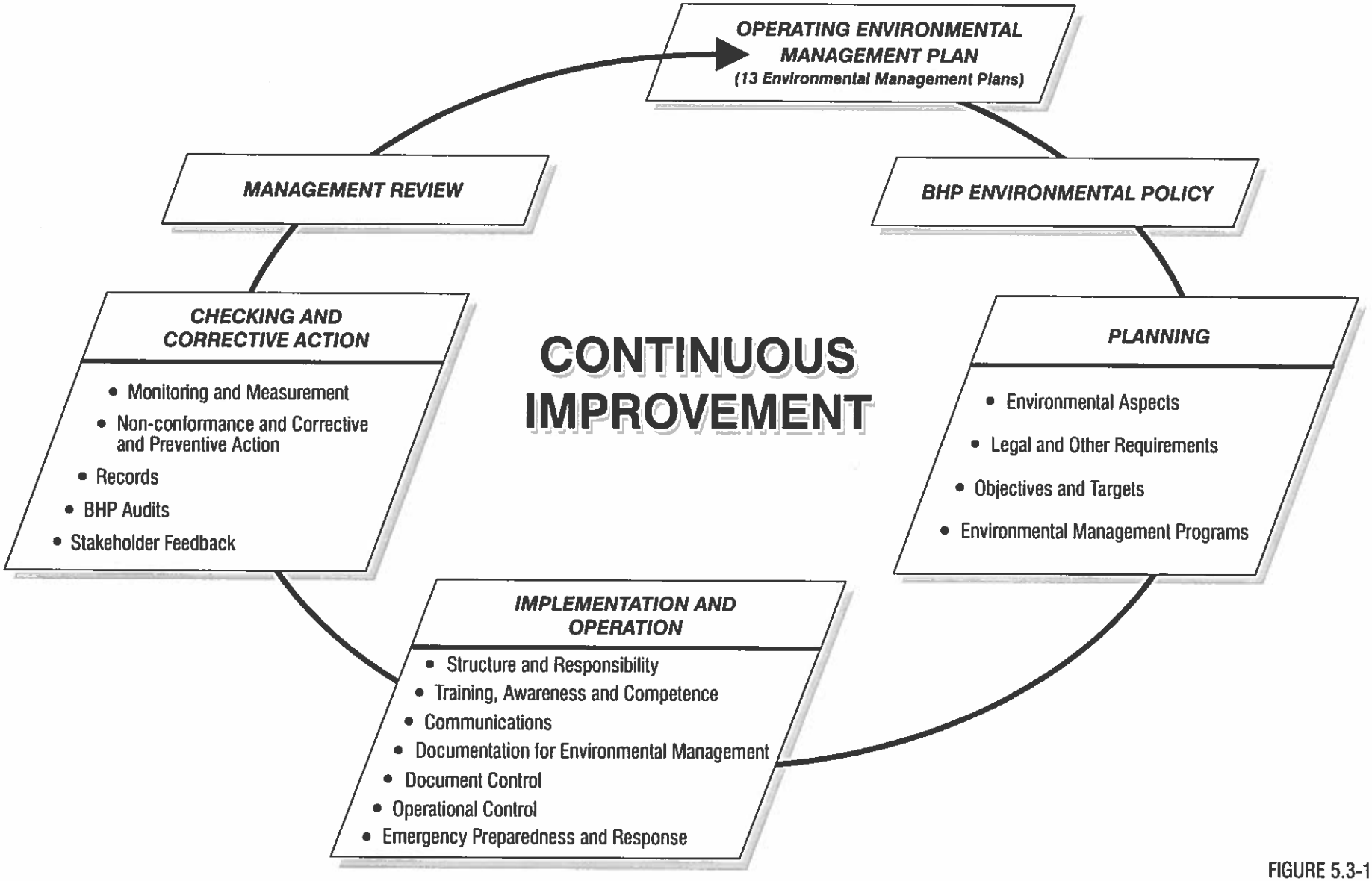


FIGURE 5.3-1

Adaptive Environmental Management Process

BHP

Ekati diamond mine

The following steps are often used to demonstrate the process:

1. Define overall management objectives;
2. Design and select the practices to be applied;
3. Carefully implement the policies and practices. This is referred to as the "plan of action";
4. Monitor key response indicators;
5. Evaluate and analyze the outcome in consideration of the original objectives, and;
6. Make adjustments to policies and practices by incorporating improvements.

The effective application of adaptive management principles contributes to improved understanding in several ways. While remaining focused on current program objectives and immediate interactions, adaptive management works towards an improved understanding of uncertainty and the overall effects of development. Based on this, adaptive management is described as having dual management benefits – focusing simultaneously on the immediate and long-term effects of management actions (Walters and Hillborn, 1978).

Experience to date at EKATI™ has already produced a number of good examples of the effective application of adaptive management principles based on lessons learned from existing programs. For example, when EKATI™ was originally approved, treated sewage effluent was permitted to be discharged into Kodiak Lake. Concurrent with the authorization, a specific effects monitoring (SEM) study was conducted to evaluate the effects of the treated sewage effluent discharge and other inflows on the aquatic environment of Kodiak Lake.

In the first year of monitoring (1997) evidence of nutrient enrichment (eutrophication) due to elevated phosphorus loadings was detected. It resulted in increased primary production and elevated biochemical oxygen demand. This in turn led to depressed winter oxygen concentrations in the lake that rapidly approached critically low concentrations for fish. BHP's initial response was to artificially aerate the lake during the winter of 1997-1998. Subsequent modelling and continued monitoring determined that the treated effluent should be redirected to comingle with the processed kimberlite from the process plant in the Long Lake Containment Facility. This measure was implemented in January of 1999, and within the first open water season (1999) signs of recovery were observed in Kodiak Lake. In particular, phytoplankton and zooplankton biomass concentrations began to decrease in 1999 relative to 1998 values, and water quality parameters were once again close to baselines values (Rescan, 2000, Kodiak Lake Report).

However, even without the treated sewage discharge, other nutrient inputs from the Panda Diversion Channel will continue to have some effect on Kodiak Lake. As a result, ongoing monitoring and winter aeration of the lake is expected to be required for a number of years as the lake slowly returns to a self-sustaining condition.

The experience gained from operation of the Panda Diversion Channel has emphasized the importance of design and construction techniques that can readily adapt to changing geotechnical conditions. This experience will be directly applied to the final design of the Pigeon Stream diversion.

Over the past year, monitoring of runoff from the Panda waste rock piles has indicated the potential for a water quality issue. This has led BHP to develop a concept for constructing frozen-core berms around sections of the Panda waste rock pile where runoff could enter the aquatic receiving environment. A test program is currently being designed for the Panda waste rock storage area. This system, which is described in Section 2.2.3.3, takes advantage of cold climate and permafrost conditions to minimize the risks of undesirable runoff.

An example of how adaptive management principles, combined with traditional knowledge, have been used to protect caribou and people is illustrated through BHP's experience with fencing around the airstrip at EKATI™. Traditional knowledge and the results of a study sponsored by the West Kitikmeot Slave Study Society (WKSS) during the mid-1990s at the Lupin Mine suggested that rope fences decorated with flags could be effective as a passive means to direct caribou safely around critical areas of activity such as the airstrip.

The rope fences are suggestive of traditional cut-tree drive lanes decorated with coloured ribbons, but for the airstrip application it needed to function as a stand-alone structure, whereas traditional caribou fences incorporated people into the system. As a result of the input received, in 1997 BHP built a rope fence around the EKATI™ airport. The fence was modified and improved between 1997 and 1999 with the help of the Yellowknives and Inuit by increasing the height and the number of rope strands employed.

Throughout the three years, behavioural monitoring was conducted to measure the effectiveness of fencing to deter caribou form the airstrip. While the fence seemed effective initially, some caribou crossed over or through the fence each year. After consulting further with the Aboriginal groups and biologists, BHP replaced the original rope fence with an electric "bear" fence in late 1999. The more traditional rope fence continues to be employed around the outside perimeter of the electric fence to discourage as many caribou as possible from approaching the new fence.

One further example of adaptive management at work involves BHP's response to a number of diesel fuel spills at two fuel storage tanks at EKATI™. Last winter, the tanks were inadvertently overfilled on four occasions because pumps and valves either froze or were not working properly. The total amount of diesel fuel spilled was 9,600 litres. BHP worked quickly to clean up the fuel covered snow and ice. The diesel fuel was later separated from the melted snow and ice and sent south to be recycled.

BHP has learned from these incidents and developed a better fuelling system in mid-1999. There have been no fuel spills at these tanks since the system was improved.

Changes to the fuelling system include:

- The fuelling control system was hooked up to an alarm station that is monitored 24 hours per day. If the alarm goes off, the entire fuel distribution system at EKATI™ shuts down.
- Heated buildings were constructed around some of the fuel tanks. This will ensure that the shut-off switches do not freeze during the winter.
- BHP has increased the frequency of inspections of the entire fuel distribution system.

BHP is also always looking for ways to reduce the amount of diesel fuel that is burned at EKATI™. The generators that power the camp produce hot exhaust which rises into the atmosphere. BHP has developed a heat-recovery system that makes effective use of this exhaust. The hot exhaust is passed through pipes that are covered in antifreeze jackets. The pipes run throughout the main camp buildings. Once the anti-freeze is hot, it circulates by pipe through the buildings to provide heat. This system saves fuel and reduces emissions by allowing BHP to turn off the boilers that usually heat the buildings.

In addition, a waste oil filtration and pumping system was recently installed at the Waste Management Building. This system is producing large amounts of recycled oil that is being used to heat other buildings at EKATI™. This system is helping to significantly reduce the amount of used engine oil that must be transported south from the mine. This recycling and heating system is part of on-going improvement at the mine. These are all examples of BHP's commitment to finding new ways to minimize the environmental effects of mining in the barrenlands.

5.3.1 Role of Traditional Knowledge

BHP values the perspective of Aboriginal elders and experienced land users. The company and its contractors have benefited from the experience of the Inuit and Dene people who have worked at EKATI™ and on the company's Slave Geological Province gold projects.

BHP stated at the 1996 EARP hearing on traditional knowledge that the best way to integrate traditional knowledge into environment management was to hire skilled Aboriginal people. The company tries to place skilled land users in positions where their knowledge will help BHP adapt to tundra conditions. Over the last five years, Aboriginal people have worked as compliance, fisheries and wildlife technicians, and summer students for the Environment Department. Increasing northern involvement in the mine will help to integrate the knowledge of Aboriginal people into environmental management.

Elders and skilled land users have been contracted to identify potential traditional fisheries, develop the fish-out process, pick winter roads routes, act as exploration camp managers and work on logistics projects. The skills these individuals bring to BHP are in part responsible for the company's safety record and infrequent conflicts with wildlife.

Dogrib and Inuit traditional knowledge projects on the Bathurst caribou herd have the potential to contribute to herd level management issues. These include the effect of fire on the winter range, migration behaviour and calving ground management.

BHP plans to ask elders to help evaluate the effectiveness of caribou crossings on the new Misery Road. Feedback from the elders will provide BHP with an opportunity, if necessary, to alter the design and construction of the Sable Road.

BHP has determined that the processed kimberlite is slightly saline. At the suggestion of the Inuit, the company is examining the potential use of salt-tolerant marine estuary plants in the reclamation of processed kimberlite. While it is too early to know if this is an appropriate idea, it shows the type of creative thinking knowledgeable land users can bring to modern industrial situations.

BHP is confident that the traditional knowledge research being conducted by the Dogrib on tundra vegetation will eventually contribute to the EKATI™ reclamation program.

The integration of traditional knowledge into the EKATI™ Diamond Mine is a partnership. Aboriginal people are learning about mine operations. BHP is learning and adapting to working on the barrenlands. The knowledge and advice of the Aboriginal people is helping BHP to learn the lessons necessary to operate successfully in this challenging arctic environment.

5.4 Follow-up Programs

5.4.1 General

Section 3.7 of the MVEIRB Terms of Reference requested information on any new concerns and environmental management issues that result from the proposed development of Sable, Pigeon and Beartooth. A description of reporting (feedback) procedures was to be provided, with an indication of how the company's organization would be adapted to manage environmental management issues and the associated monitoring programs that result from the development of Sable, Pigeon and Beartooth. The following section addresses these requests.

5.4.2 BHP's Environmental Management Organization

Responsibility for Environmental Management at BHP for the EKATI™ mine is described in Chapter 1, Section 1.1.1.5, and illustrated in Figure 1.1-3. At EKATI™, the Manager, Environment and Resource Planning, reports directly to the Vice President of Operations. He in turn has a Manager, Environment, who is supported by a current permanent staff of 10 environmental specialists and technicians.

The Environment Department of EKATI™ is a service organization that provides expertise to line managers, monitors potential environmental effects, documents compliance and recommends mitigation as required to effect continuous improvement in overall performance of the operations. The direct involvement of the line managers in implementing environmental management procedures in each of their areas of

responsibility on a day-to-day basis is critical to the success of the overall environmental programs at EKATI™.

The majority of the annual environmental monitoring programs are conducted by experienced environmental consultants under the direction of BHP Environment personnel and with the assistance of a number of seasonally employed technicians.

The current environment management team at EKATI™ has expanded and evolved to meet the needs of the regulatory requirements as reflected in the OEMP (Section 5.2). The OEMP was developed under the Environmental Agreement in response to regulatory and contractual requirements and BHP's corporate Environmental Policy. The organization will evolve as necessary in the future to ensure the continued effective management of environmental issues at the EKATI™ mine.

5.4.3 Adaptive Environmental Management and Continuous Improvement

Chapter 1, Section 1.1.1.5, and Section 5.3 of this chapter have emphasized the importance that BHP places on the application of adaptive management principles and strategies. These will result in continuous improvement in performance in all areas of mine operations including environmental management practices over the life of the mine.

BHP is committed to achieving and maintaining industrial leadership in environmental management at EKATI™ through the effective application of these strategies, which have been fully integrated into the OEMP. As stated in Section 5.2, the OEMP is viewed as a "living document" that will be updated and continually improved upon throughout the life of the EKATI™ mine.

As the development of the Sable, Pigeon and Beartooth pits proceeds, all applicable components of the OEMP will be modified as necessary to address new or specific issues related to the development of these pits and the associated infrastructure.

5.4.4 Environmental Management Initiatives

The assessment of the proposed Sable, Pigeon and Beartooth pits has resulted in the identification of a number of issues that need to be evaluated and appropriately addressed.

One initiative involves the management of inorganic nitrogen products resulting from blasting activities, which are associated with waste rock runoff and pit water. BHP's initial response to this potential concern has been to refine and tighten its procedures to limit, control and mitigate the release of undetonated explosives from blasting operations (Section 5.2.6). Further, the company is developing a waste rock perimeter berm system to minimize or eliminate the release of undesirable runoff from waste rock storage areas into the receiving aquatic environment (Section 2.2.3.3).

The effective application of these two strategies is expected to result in a reduction of nitrogen products that enter the receiving environment, at both the existing operations and the proposed new development. In addition, BHP is continuing to evaluate other options for further reducing nitrogen losses to the receiving environment and will determine in due course if further mitigation measures are necessary. These include consideration of terrestrial irrigation and evaporation.

The proposed new development provides BHP the opportunity to test its concepts for pit lake reclamation at a much earlier date than was previously planned. Beartooth Pit will be available for reclamation and restoration to lake status within about seven years (2008). Reclamation of this pit will involve partial re-filling with processed kimberlite and the subsequent re-establishment of a viable and sustainable aquatic ecosystem in the new pit lake. Experience gained from the operation and monitoring programs associated with Beartooth Pit reclamation will be of considerable value to in planning for the reclamation of other mined-out pits to lake status.

5.4.5 Environmental Monitoring Programs

As indicated earlier, BHP's OEMP, including all of the environmental monitoring programs included therein, will continue to be modified on an annual basis as is necessary to accommodate operational changes, trends observed in monitoring, and inputs received from stakeholders at the annual environmental workshops.

Based on existing information and the results of the environmental assessment contained in Chapter 4 of this report, Table 5.4-1 presents a summary of BHP's proposed additions to the existing monitoring programs for the Sable, Pigeon and Beartooth pits.

As the proposed development moves into the regulatory process, BHP anticipates that additional monitoring requirements may be identified. Proposed changes will be reviewed and discussed with the appropriate regulatory agencies, the Agency and other interested stakeholders.

5.5 Reclamation and Closure

Reclamation will provide the major means for mitigating the effects associated with development at EKATI™. The overall goals for reclamation are as follows:

- Re-establish land use;
- Re-establish safe/stable landforms; and
- Protect local water resources.

Table 5.4-1
Summary of Proposed Monitoring for Development of Sable, Pigeon and Beartooth Pits

VEC	Monitoring Required	Monitoring Instrument
Air Quality	• Effects from Fugitive Dust and Air Emissions (Sable, Pigeon, and Beartooth Pits)	OEMP - Air Quality Monitoring Plan
Permafrost	• Pit wall stability (Sable Pigeon and Beartooth)	NWT Mine Safety Act and Regulations
	• Dam Stability	Water Licence
Physical/ Terrestrial Environment	• Mine Footprint and reclamation/re-vegetation status (Disturbance resulting from Sable, Pigeon and Beartooth Pits)	OEMP – Interim Abandonment and Reclamation Plan
Heritage Sites	• Areas of development for potential disturbance of sites. Specific areas include Ursula and Exeter eskers, waste rock storage area at Sable and Pigeon Pits, and the road between Beartooth and Pigeon pits	OEMP – Archaeological Management Plan
Water Quality/Quantity	• Lake dewatering (Sable, Pigeon and Beartooth)	Water Licence
	• Downstream of Sable Pit and associate infrastructure (development and operation)	OEMP -Aquatic Effects Monitoring Program
	• Downstream effects from Bearclaw lake water diversion (development and operation)	OEMP - Aquatic Effects Monitoring Program
	• Ursula Lake discharge during Sable Pit reclamation (Water Quantity)	OEMP - Aquatic Effects Monitoring Program
	• Upper Exeter Lake discharge during Pigeon Pond Reclamation (Water Quantity)	OEMP - Aquatic Effects Monitoring Program
	• Waste Rock Run-off (Sable, Pigeon and Beartooth)	Water Licence
	• Pit Lakes (Sable, Pigeon and Beartooth) prior to discharge	Water Licence
	• Downstream effects from reclaimed pits	OEMP –Aquatic Effects Monitoring Program
	• Pit Lakes prior to and after re-introduction to watershed (Sable, Pigeon and Beartooth)	Fisheries Authorization – AEMP study (SEM)
Fish/Aquatic Habitat	• Pigeon Diversion Stream	OEMP - Aquatic Effects Monitoring Program
	• Downstream effects from reclaimed pits	OEMP – Aquatic Effects Monitoring Program
	• Pit Lake reclamation status	Fisheries Authorization – AEMP Study (SEM)[1]
Caribou/ Habitats	• Effects from Sable haul road – vehicular traffic and road presence	OEMP - Wildlife Effects Monitoring Plan
Carnivores/Habitats	• Effects from Sable haul road – vehicular traffic and road presence	OEMP – Wildlife Effects Monitoring Plan
Breeding Birds/Habitats	• Effects from development presence	OEMP – Wildlife Effects Monitoring Plan

1: Special Effects Monitoring Study under the AEMP.

Reclamation at EKATI™ is progressive. It will be accomplished throughout the life of the mine. This approach allows for the development of solutions, modifications to reclamation techniques, implementation of additional mitigation measures (remediation) and assessment of reclamation performance. For these reasons BHP is confident that the reclamation strategy described for Sable, Pigeon and Beartooth pits will be effective in accomplishing these goals.

5.5.1 Reclamation Substrate

The most suitable material under consideration for reclamation purposes is lakebed sediment. Other materials, including biosolids, organic soils and processed kimberlite, will also be considered. The extent to which these materials can be used will depend on the quantities available, the feasibility of excavating and stockpiling them, the results of revegetation studies and site conditions appropriate for their use.

5.5.1.1 Lakebed Sediment

Lakebed sediment is obtained from the bottoms of lakes that have been dewatered for mining. It consists primarily of saturated silts, sands and gravels. Lakebed sediments and glacial till overburden overtopping the three pipes will be excavated and stockpiled at the margins of each waste rock storage area to allow easy access for use during reclamation efforts. Lakebed material, containing organic matter, may support wetland vegetation, and could potentially be used as top-dressing, or mixed with other available substrate for reclamation at disturbed sites in the vicinity of the three pits. Unfortunately the high silt content of lake sediments enhances soil compaction, and retards root growth. Soil that is high in silt is subject to erosion by wind and water. However, mixing the sediment with coarser textured material like sand may improve its physical structure. Current reclamation research will help identify the limitations associated with trying to establish vegetation on lakebed sediment and, if necessary, develop techniques for improving the properties of the lakebed sediment for rehabilitating disturbed areas.

5.5.1.2 Biosolids

All sewage collected at the three proposed development sites will be backhauled to EKATI™ for treatment. Sewage sludge (biosolids) from the treatment plant is currently stored in the Panda waste rock storage pile. If this is determined to be a useful product, it will then be saved for use.

5.5.1.3 Organic Soil

Organic matter in soils improves the water retention capacity, provides important nutrients and improves soil texture for seed germination and root development. There is limited opportunity for collecting and stockpiling organic soil in the area of the three pits

because much of the terrain is composed of boulder fields. However, where opportunities present themselves, efforts will be made to salvage organic soil.

5.5.2 Vegetation Re-establishment

The principle means of vegetation recovery of Land Development Units (LDUs) associated with the three pits will likely be through natural colonization. Those areas with physical characteristics suitable for establishment and support of vegetation will be scarified and seeded. Allowing some units to recover naturally while establishing vegetation in other units will direct the limited resources available (plant materials and soil amendments) to where they are most likely to be effective. Revegetation research was initiated in 1994 and continues to be an ongoing effort. Findings from revegetation research will be incorporated into the reclamation plan to further refine techniques and amend current approaches, where appropriate. At present no revegetation efforts are planned for the waste rock storage areas, gravel roads, pads and dykes, but the surface topography of these areas will be re-worked to create conditions more favourable for natural colonization.

5.5.2.1 Native-Grass Cultivars and Forbs

Preliminary revegetation studies (Interim Abandonment and Restoration Plan, 1999) indicate that native-grass cultivars are better adapted to arctic conditions than their agronomic cousins. Without the addition of organic amendments such as periodic applications of fertilizer, persistent plant cover will be minimal (Jorgenson and Cater, 1991; Kidd and Rossow, 1997). Native-grass cultivars are an important reclamation plant resource since they establish rapid cover, improve soil properties by increasing soil biological activity and soil moisture, and capture wind-dispersed plant propagules. They also serve an important role in controlling erosion and stabilizing land disturbances. To overcome some of the limitations associated with grasses and expand the suite of species available for reclamation, research into the use of legumes and other forbs for revegetating disturbed mine-soils has been conducted in Alaska for the past several years (Moore, 1993; Kidd and Jorgenson, 1994; Kidd and Rossow, 1997). Legumes are attractive revegetation candidates because of their association with nitrogen-fixing bacteria (Rhizobia) and their potential contribution to long-term productivity. They also appear to be well adapted to gravelly soils with low soil moisture content and little organic matter, typical of the local area.

5.5.2.2 Indigenous Species

Indigenous plants have been collected for use in revegetation experiments (Wein and MacLean, 1973; Jorgenson and Cater, 1991; Jorgenson *et al.*, 1990; Jorgenson and Joyce, 1994). With the exception of some grasses, no native plants are available at the commercial scale, and thus collections tend to be small, localized and site-specific.

5.5.2.3 Seeds, Shrubs, Cuttings and Sprigs

Preliminary observations of seed germination of grasses, sedges, forbs and willow species indicate that the technique is feasible, although germination and seedling growth are slow. The availability of seed depends on the success of seed production in a given year. The potential for using tree and woody shrub cuttings has been initiated in revegetation of riparian zones. Trials using dormant cuttings of willow (*Salix* spp.) are so far encouraging. *Arctophila* (Arctic Pendant Grass) is being evaluated for wetland creation in the main project area. Sprigs transplanted in the Panda Diversion Channel in 1998 and 1999 are doing well. Cultivation of grasses and forbs in dry upland sites, and of shrubs and sprigs in riparian zones is integral to the reclamation of disturbed areas at each of the three pits. To this end, experiments will continue to be conducted on species/substrate suitability.

5.5.3 Site Facilities and Infrastructure

At closure all temporary structures will be removed and permanent structures dismantled. The steel piles used to support permanent buildings will be cut off at ground level and covered. Concrete foundations will be left intact and capped with waste rock.

5.5.4 Sediment Containment Area

The Two Rock Lake sedimentation pond will be returned to the watershed as a productive lake when water quality meets acceptable standards. An overflow weir will be cut into the retention dam and the internal separator dyke to create a stable, long-term water level. Water flow will then be re-established from Sable Lake to Two Rock Lake.

5.5.5 Waste Rock Storage Area

Waste rock storage areas will be constructed near Sable and Pigeon pits. Waste rock from the Beartooth Pit will be stored in the Panda Waste Rock Storage Pile. To meet reclamation closure requirements, several strategies will be implemented to reclaim the waste rock storage areas. Slopes will be stabilized and contoured by placing finer material over the surface. Wildlife access ramps will be constructed to allow safe access for caribou that may seek higher ground to find refuge from insects.

5.5.6 Roads and Trails

Main roads will be left in an as-built condition at closure, but any existing shoulder berms will be knocked down and contoured to improve access for caribou and other wildlife. Culverts will be removed and drainage re-established; the banks will be stabilized with riprap to prevent erosion. The surface of the roads will be re-worked or scarified (where possible) to introduce topographic diversity. Although the roads will result in the loss of some tundra vegetation and may remain barren for many decades, they will provide travel

corridors for wildlife and insect relief habitat for caribou. Trails will be recontoured to the natural topography and revegetated where possible to encourage return of surrounding flora. Sections of eskers that have been excavated for granular resources will also be reclaimed by reshaping and revegetating the areas with species representative of the surrounding landscape.

5.5.7 Re-establishment of Surface Drainage and Lake Recharge

5.5.7.1 Dams, Dykes and Stream Diversions

Various retention dams, dykes, diversion berms and a diversion stream will be constructed to control water flows at Sable, Pigeon, and Beartooth. After pit operations have ceased, dams at Sable and Beartooth will be breached to re-establish natural drainage, and the faces of the breached areas will be riprapped to stabilize slopes. Stream flow from Sable Lake will be encouraged by breaching Sable Road and allowing flow to enter Two Rock Lake. At Pigeon, the diversion constructed to realign Pigeon Stream flow will remain in place permanently. The old channel to Pigeon Pond will be opened to Pigeon Pit Lake when water quality meets acceptable standards. When the diversion berm is opened, the slopes of the breached area will be stabilized with riprap. Fish access will be restored between Pigeon Stream and the reclaimed lake. The diversion pipeline connecting Bearclaw Lake to Beartooth Stream will be dismantled, and drainage will be restored to its natural course from Bearclaw Lake to Beartooth Pit Lake and then into North Panda Lake.

5.5.7.2 Open Pits

All three pits will be reclaimed such that natural hydrological regimes will be re-established within their respective watersheds. Reclaimed pits will be filled as quickly as practical with either water from nearby large lakes or with processed kimberlite and a water cover. Sable and Pigeon pits will be filled with lake water by pumping from Ursula and Exeter lakes, respectively. The pumping will be confined to the summer season at flow rates specified by the Water Licence. Authorized pumping rates are not expected to have a measurable effect on lake levels at either lake because of their large surface and ultimate catchment areas. This method will reduce the pit filling time from 16 to 5 years at Pigeon and from several hundred years to 25 years or less at Sable.

The Beartooth Pit will be partially filled with processed kimberlite that would otherwise be directed to the Long Lake Containment Facility. The lake will then be topped with flow from Bearclaw Stream and a water quality monitoring program initiated. Once water quality meets acceptable standards, the lake will be returned to the downstream watershed.

5.5.8 Fisheries Replacement

Reclamation measures will also be undertaken to further facilitate the establishment of essential habitat components and productive fish communities in each of the three lakes. Lake restoration will be conducted in accordance with the DFO policy of No Net Loss and the present BHP Interim Abandonment and Restoration Plan. Once pit operations cease, all three pits will be modified to create littoral and beach zones. Select areas of the pit lip will be sloped back at a shallow angle to form beach areas, with a drop-off to the first bench at approximately 5 m of water depth. Granitic waste rock will then be deposited into the pit to form steep slopes extending from a littoral zone down to the first bench. Within the constructed littoral zone, esker material or crushed granite will provide suitable material for lake trout and whitefish spawning. Boulders will be strategically placed to serve as reef structures and wave breaks for refuge areas. If necessary, fish stocks can be introduced into the lake once acceptable water quality conditions have been achieved.

5.5.9 Reclamation Schedule

Reclamation research at BHP was first initiated in 1994 and will continue through mine operation. In 1998 BHP developed an Interim Abandonment and Restoration Plan as part of the conditions of the Water Licence. When all lease and licence applications for Sable, Pigeon and Beartooth kimberlite pipes are approved, these pipes will be incorporated into the plan. This is consistent with BHP's commitment to update the reclamation plan in response to changes in the mine plan or schedule, new targets, economic regimes, regulatory requirements, research results and technological advances.

The current dates projected for completion of mining of the pipes are Sable 2012, Pigeon 2009 and Beartooth 2008. Most of the reclamation effort at each pit will take place during pit closure because the infrastructure is required for the life of the pit operation. However, reclamation will be undertaken progressively as sites become available for reclamation and when mining is completed. Ongoing reclamation research will continue through mine operations at all pits. Progressive reclamation of the Long Lake Containment Facility will also continue as the cells are filled. The planned reclamation schedule for the three pits is presented in Figure 5.5-1. The schedule starts in the first year of operation at Beartooth and finishes with the final year of reclamation work. The schedule utilizes a calendar based on quarters, the second and third of which are the normal open water periods.

5.5.10 Description of Sites at Closure and After Restoration

Closure is identified here as completion of pit operation before the removal of site facilities and final reclamation work. Post restoration is defined as the time when pit operations are complete, infrastructure has been removed and the pit and surrounding land have been restored to a stable and productive landscape. A brief summary of site status at closure follows for each of the development areas.

5.5.10.1 Sable Pit

Sable Pit will be the last of the three pits to cease operation and then be reclaimed. Sable Pit at closure is presented in Figure 5.5-2. Permanent and temporary buildings, fuel tanks and explosive storage areas will be removed and reclaimed as stated in previous sections. Reclamation work will focus on:

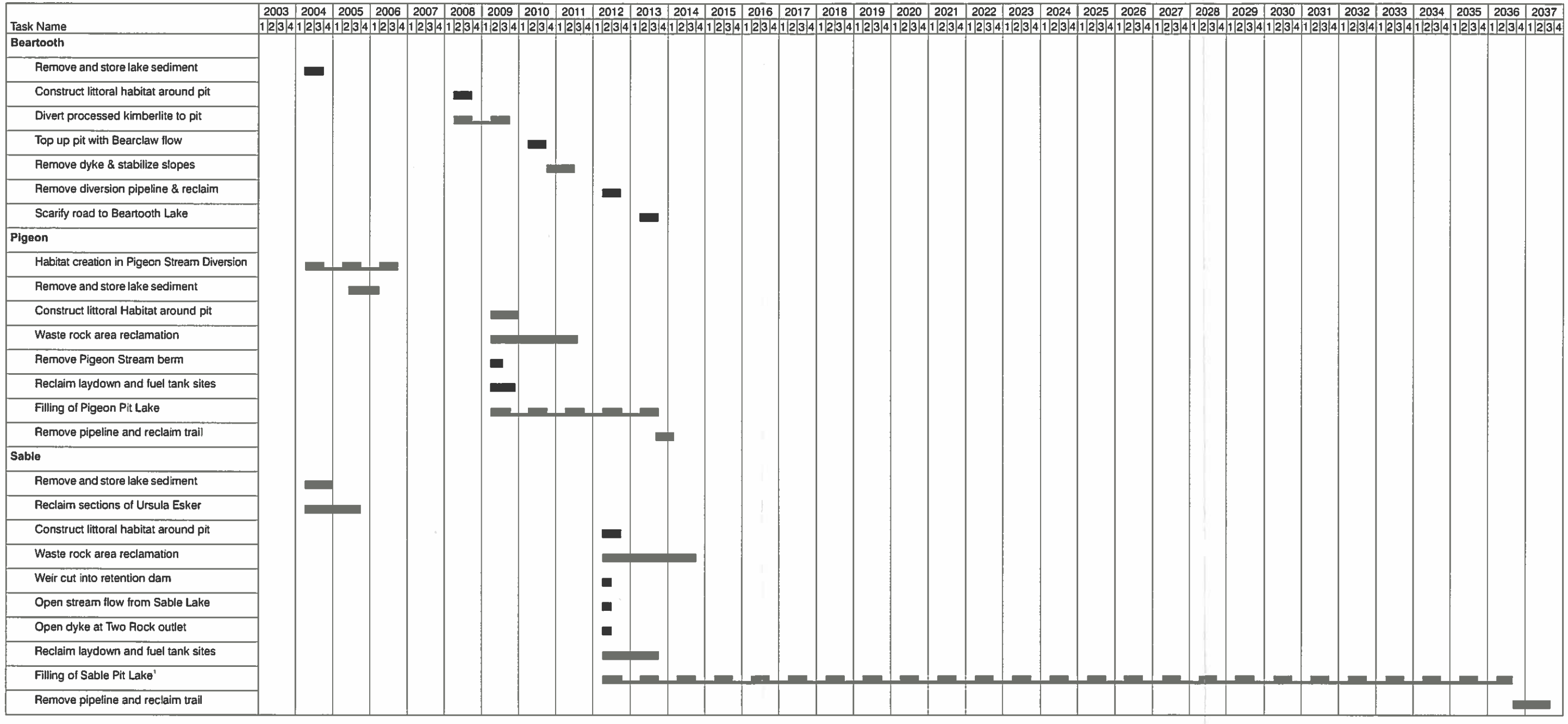
- constructing a berm around Sable Pit to protect wildlife;
- constructing fish and aquatic habitat around the perimeter of Sable Lake at closure;
- progressive filling of Sable Lake with water from Ursula Lake (15 to 25 years);
- excavating a weir in the Two Rock Lake sedimentation pond retention dam;
- re-establishing of streamflow from Sable Lake into Two Rock Lake;
- reclaiming of the temporary buildings and fuel tank area;
- stabilizing and recontouring the Sable waste rock storage areas for wildlife use;
- scarifying of the roads associated with Sable Pit;
- removing the pipeline to Ursula Lake and recontouring the access trail;
- reclaiming Ursula Esker; and
- removing the culvert at Pigeon Stream and other stream crossings.

Final reclamation of Sable after restoration is presented in Figure 5.5-3.

5.5.10.2 Pigeon Pit

The infrastructure at Pigeon Pit at closure will consist of a diversion berm, streamdiversion, truck line-up area with fuel tanks and the open pit, as presented in Figure 5.5-4. No permanent buildings or facilities will be erected at Pigeon for pit operations. Reclamation work will proceed as previously outlined for each of the land use units. Reclamation work will focus on:

- constructing riparian and fish habitat within the diversion stream during pit operation;
- constructing fish and aquatic habitat around the perimeter of Pigeon Lake at closure;
- creating a wildlife berm around Pigeon Pit;
- filling Pigeon Lake with water from Upper Exeter Lake;
- reclaiming the truck line-up and fuel tank area;
- stabilizing and manipulating the Pigeon waste rock storage area for wildlife use;
- scarifying the roads associated with Pigeon Pit; and
- removing the pipeline to Exeter Lake and recontouring the access trail.



1: Sable Pit flooding has been estimated to take from 15 to 25 years (Subsection 4.5.2.1.4.1).
The upper bound estimate of 25 years has been adopted for purposes of the Environmental Assessment.

FIGURE 5.5-1

EKATI™ Diamond Mine Reclamation Schedule

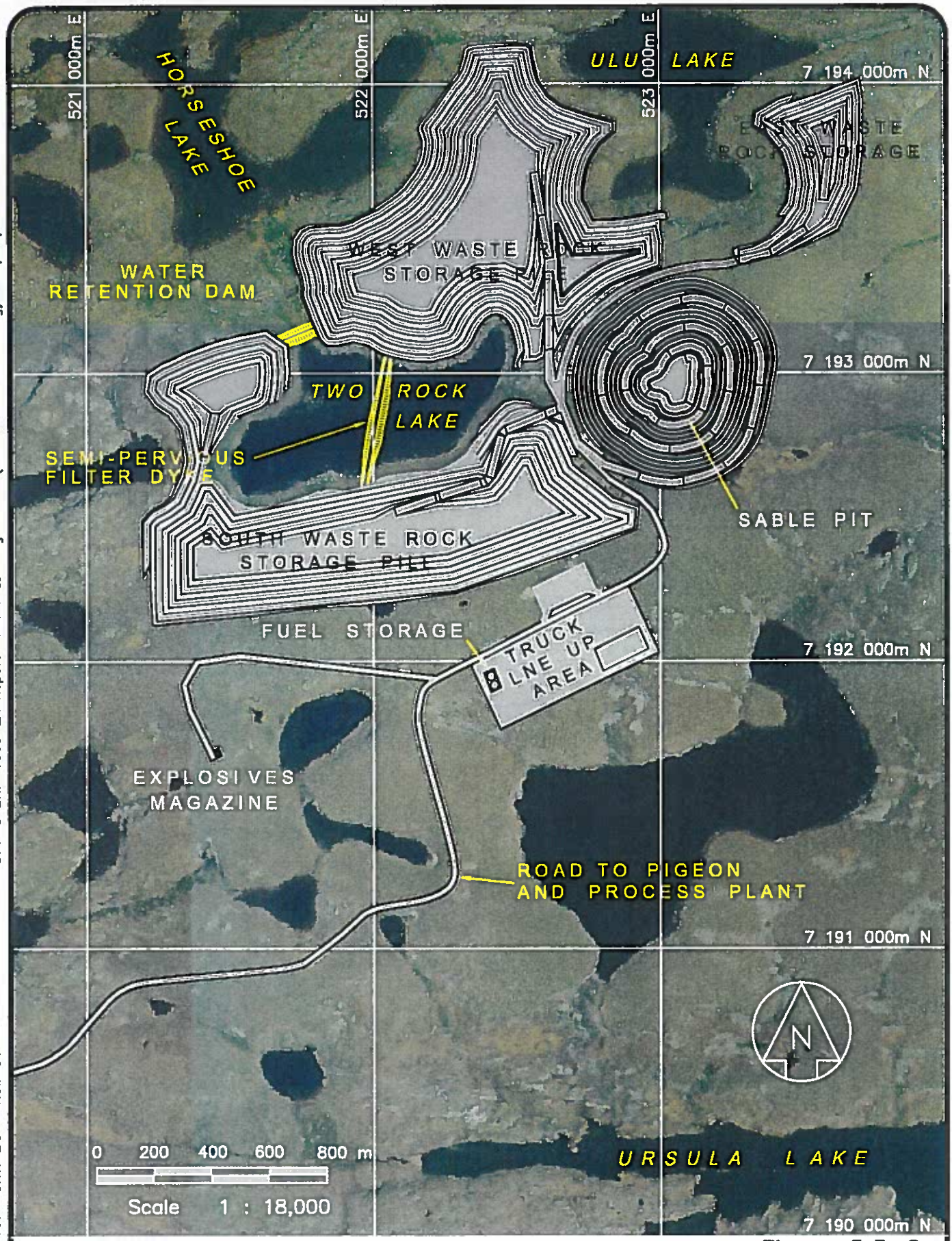


Figure 5.5-2

Sable Site Development at Closure (2012)

BHP

Ekati diamond mine

Cad No. C1167 SHT. 28 View C1 Job No. 571-6 BHP 1999 EA Report Ref : EBA Fig 5.5-2 (0101-11580M10G.dwg) 04/11/2000- 10:06am EKATI_AP

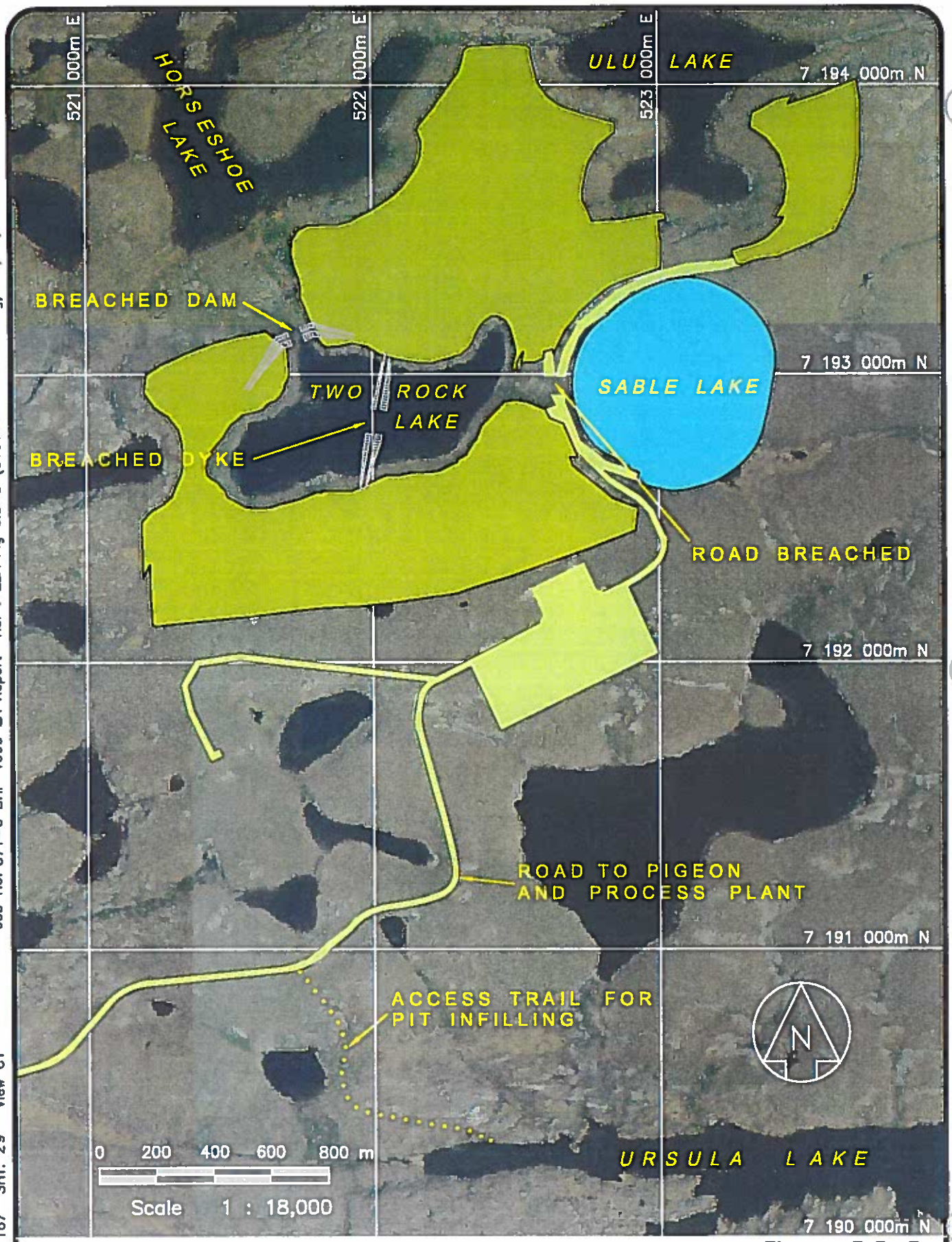


Figure 5.5–3

Sable Site After Reclamation

BHP

Ekati diamond mine

Cad No. C1167 SHT. 29 View C1 Job No. 571–6 BHP 1999 EA Report Ref : EBA Fig 5.5–3 (0101–1158OM14FG.dwg) 04/11/2000– 10:06am EKATI_AP

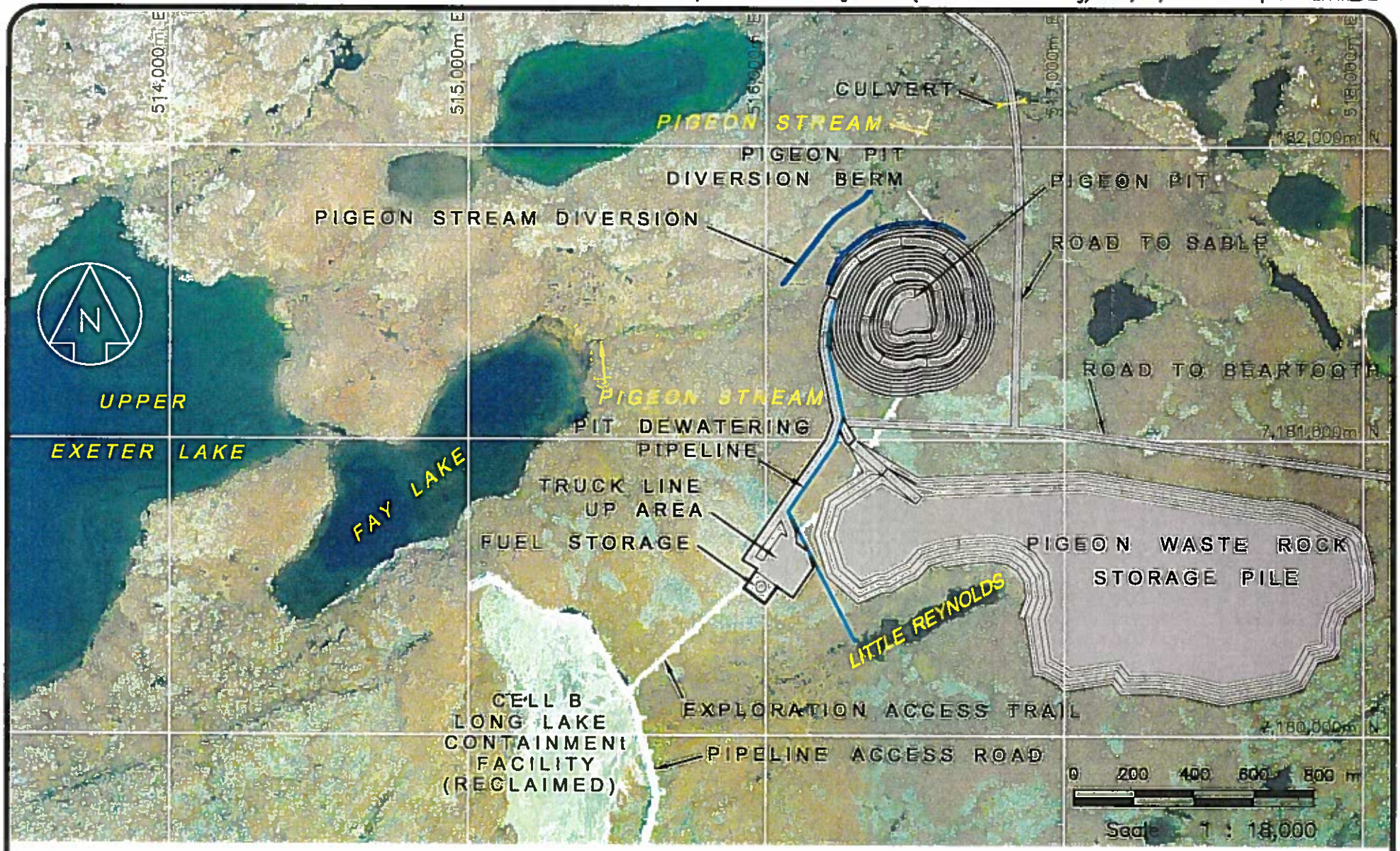


Figure 5.5-4

Pigeon Site Development at Closure (2009)

Final reclamation of Pigeon after restoration is presented in Figure 5.5-5.

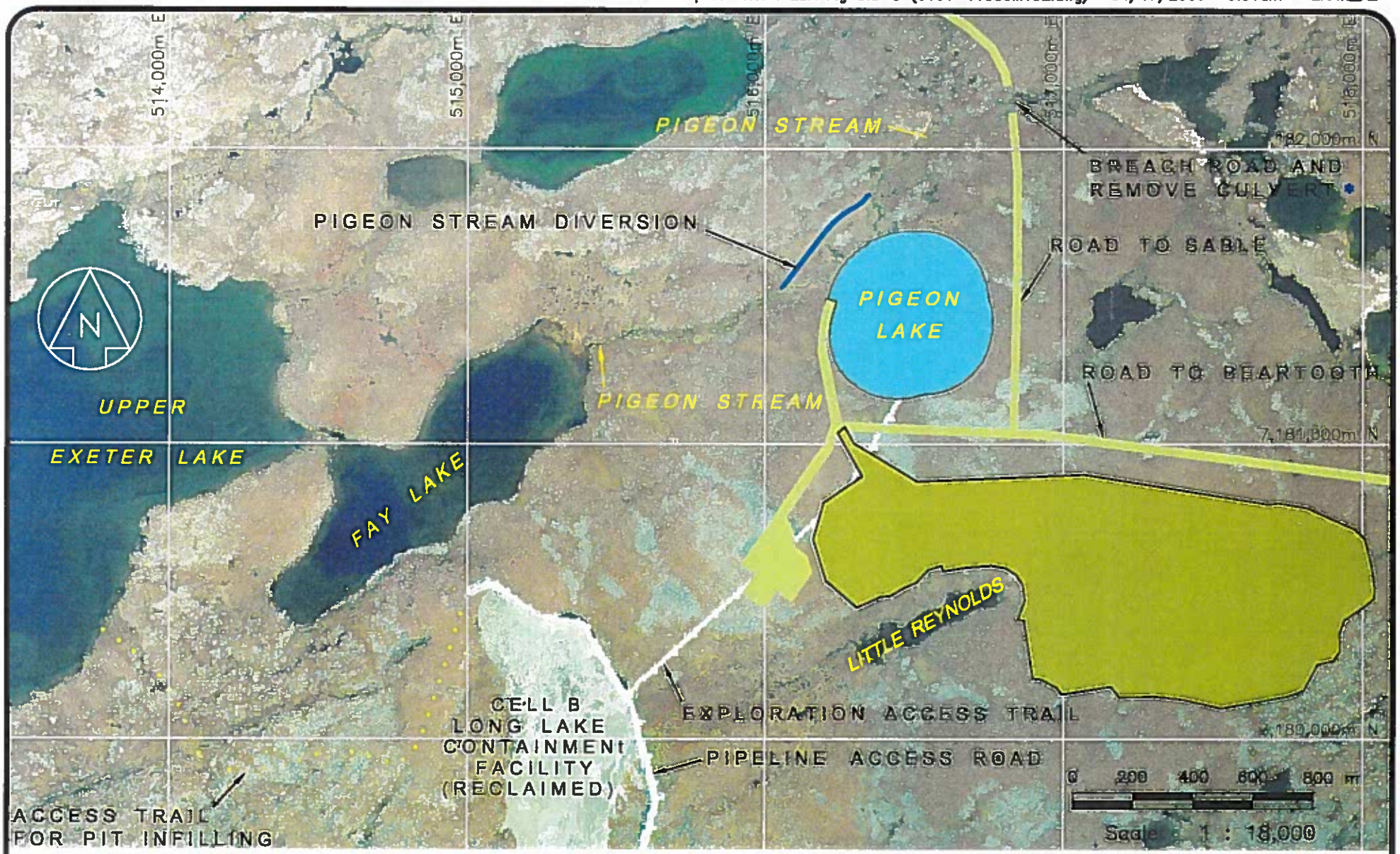
5.5.10.3 Beartooth Pit

Infrastructure at Beartooth Pit at closure is presented in Figure 5.5-6. Because of its close proximity to the EKATI™ main camp, no buildings, fuel tanks or explosives storage facilities will be located at Beartooth Pit. Reclamation will simply be focused on removal of the pipeline, re-establishment of the natural flow from Bearclaw Lake to Beartooth and then to North Panda Lake, creation of a lake in Beartooth Pit and scarification of the road. A berm will be constructed around Beartooth Pit during refilling to protect wildlife. Waste rock from Beartooth pit will be incorporated within the Panda Waste Rock Storage Area. Final reclamation of Beartooth is presented in Figure 5.5-7.

5.5.11 Reclamation and Closure Cost Estimate

At closure all temporary structures (trailers, modules) and vehicles will be removed from the respective sites. Salvageable material and equipment will be removed and sold to offset salvage costs. Materials that cannot be removed will be disassembled and buried within the waste rock storage piles or in the bottom of pits.

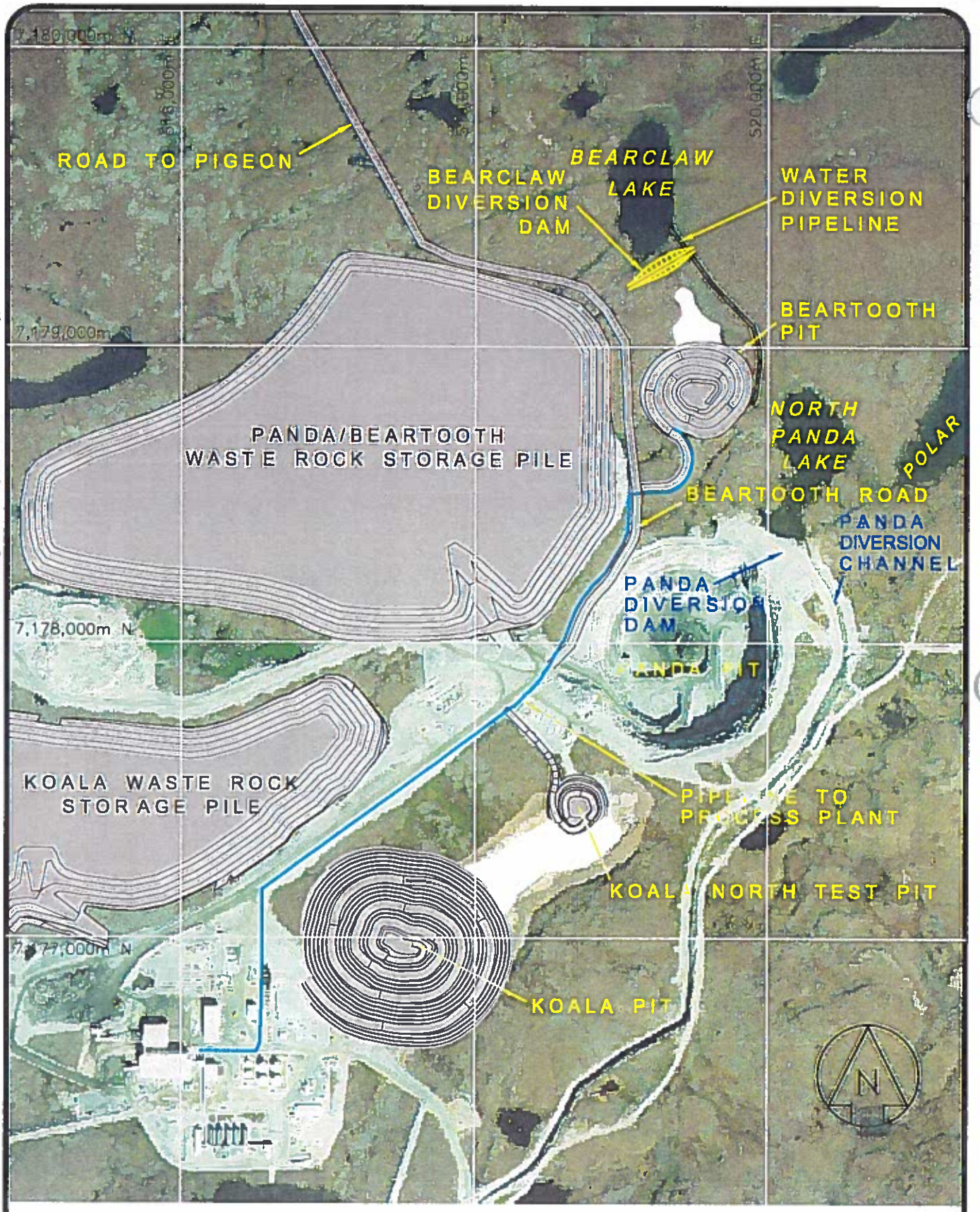
The cost estimate has been based on year 2000 prices. All monitoring and reporting costs will be covered under the mine costs. The total reclamation and closure cost for Sable, Pigeon and Beartooth is estimated to be $5.9 million.



* Completed after Sable Pit Reclamation

Figure 5.5-5

Pigeon Site After Reclamation



Beartooth Site Development at Closure (2008)

0 200 400 600 800 m

Scale 1 : 18,000

Figure 5.5–6

BHP

Ekati diamond mine

Cad No. C1168 SHT. 32 View C1 Job No. 571–6 BHP 1999 EA Report Ref : EBA Fig 5.5–6 (0101–11580M12G.dwg) 04/12/2000– 8:11am EKATI_AP

Cad No. C11cd SHT. 33 View C1 Job No. 571-6 BHP 1999 EA Report Ref : EBA Fig 5.5-7 (0101-11580M15E.dwg) 04/12/2000- 8:11am EKATI_AP

Beartooth Site After Reclamation

0 200 400 600 800 m

Scale 1 : 18,000

Figure 5.5-7

BHP

Ekati diamond mine

5.6 Abandonment and Restoration

Procedures for abandonment and reclamation at EKATI™ are governed by guidelines and regulations set by federal and territorial regulators and industry policies. The following is an outline of pertinent procedures relating to EKATI™. Due to the volume of the literature, those regulations that directly affect ongoing mine operations are presented in greatest detail, while those used as guidelines are only highlighted.

5.6.1 Government Regulations and Guidelines

The regulatory instruments and BHP agreements provide the context within which BHP operates the EKATI™ Diamond Mine. BHP is committed to develop, mine and decommission the Sable, Pigeon and Beartooth pits based on principles of continuous improvement and in compliance with all relevant legislation, permits, licences, leases and authorizations.

Regulated licences and permits obtained to date include a Type A Water Licence (N7L2-1616), Fisheries Authorization, Mining Leases, Land Leases, Navigable Waters Authorization and Land Use Permit. In addition to these permits, BHP entered into an Environmental Agreement (January 7, 1997) with the Government of Canada and the Northwest Territories.

5.6.2 Regulations

5.6.2.1 Water Licence (N7L2-1616)

The following excerpts were taken from the existing Type A Water Licence, which is currently under the control of the Northwest Territories Water Board, Department of Indian and Northern Affairs. However, the Mackenzie Valley Land and Water Board (MVLWB) will soon become the responsible regulatory body to oversee this licence.

General Conditions

1. The Licensee shall file an Annual Report with the Board not later than March 31st of the year following the calendar year reported which shall contain the following information:

   v) any revisions to the approved Abandonment and Restoration Plan;

   w) a summary of any abandonment and restoration work undertaken during the year and an outline of any work anticipated for the next year; and

x) an updated estimate of the current mine restoration liability based upon the results of the mine restoration research, the mine development monitoring, and any modifications to the mine plan.

Conditions applying to abandonment and restoration

1. The Licensee shall submit to the Board for approval within nine (9) months of issuance of this Licence, an Interim Abandonment and Restoration Plan in accordance with the Board's "Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories, September 1990", and shall provide the following additional elements to address abandonment and restoration concerns:

a) specific abandonment and restoration objectives for each mine component which shall include, but not be limited to the following:

(i) open pits;

(ii) underground workings;

(iii) tailings and sewage containment areas;

(iv) waste rock storage areas;

(v) water management structures (dams, diversion channels, intake and delivery systems, treatment plants);

(vi) sedimentation ponds;

(vii) borrow pits, ore storage stockpiles and other disturbed areas;

(viii) surface structures (process plant, camps, roads airstrip);

(ix) all petroleum and chemical storage areas;

(x) any other areas potentially contaminated with hazardous materials; and

(xi) any facilities or areas which may have been affected by development such that potential pollution problems exist.

b) a description of the measures required, or actions taken, to achieve the objectives stated in the Board's Guidelines and Part K, Item 1 a) for each mine component;

c) a detailed description, including maps and other visual representations, of the pre-disturbance conditions for each site, accompanied by a detailed description of the final desired landscape, with emphasis on the restoration of stream banks and surface drainage over the restored units;

d) a comprehensive assessment of materials suitability, including geochemical and physical characterization and availability for restoration needs, with attention to top-dressing materials, including maps where appropriate showing sources and stockpile location of all borrow materials;

e) a description of the process to be employed for progressive restoration, plus details of restoration scheduling and procedures for coordinating restoration activities with the overall mining sequence and materials balance;

f) a description of any post-closure treatment potentially required for drainage water that is not acceptable for discharge from any of the reclaimed mine components;

g) a description of how the potential for post-closure groundwater contamination will be assessed and monitored during the term of the Licence;

h) a detailed description of proposed revegetation plans, incorporating a description of how initial vegetation cover will promote successional development on reclaimed landscape units, what the expected progression and time-frame will be, and how it will be compatible with local ecosystem characteristics;

i) an identification of the research needs for restoration;

j) a description of the monitoring program to be employed in recording the progress of mining activities as they relate to ongoing restoration needs. The relevant components of the restoration monitoring program should be designed to generate data in forms suitable for use in the RECLAIM model or its equivalent. Sampling and testing protocols for determining the success of restoration measures undertaken should be documented. The programs shall include, but not be limited to, the following:

   (i) pitwall geochemistry and potential for acid/alkaline drainage and metal leaching;

   (ii) water quality trends in pit water, waste rock dump and ore stockpile seepage;

   (iii) volumes of waste materials produced and stored by type and location, with particular attention to materials requiring measures to mitigate impacts from water that is not acceptable for discharge;

   (iv) areas, slope angles, and relevant topography of waste rock dumps;

   (v) areas of tailings; beaches and consolidated slurries;

   (vi) methods, timing, and details respecting the placement of rock cover and the development of permafrost in tailings material as part of tailings restoration;

(vii) stability of surface drainage channel(s) over reclaimed tailings; and

(viii) success of applying restoration research results.

k) details of closure measures proposed in the event of a premature or temporary shutdown at any time during the term of the Licence;

l) an explanation of how aesthetic concerns will play a role in restoration; and

m) the qualifications, status and authority of those individuals who will be responsible for, and who will conduct, restoration activities during the term of the Licence.

2. The Licensee shall provide the Board annually with an updated estimate of the current mine restoration liability using the current version of RECLAIM, its equivalent or some other method acceptable to the Board.

3. The Licensee shall submit a Restoration Research Plan that includes, but may not be limited to, the following:

a) an update of restoration research to date and how the results may affect restoration planning;

b) details of further restoration research the Licensee will undertake to resolve the needs identified in Part J, Item 2 (i);

c) a description of a process to ensure that the restoration procedures that might result from the research are ecologically appropriate, viable and achievable;

d) a description of how the research will incorporate objectives relating to the restoration or creation of viable wildlife habitat;

e) a description of how metal uptake in revegetated plant communities will be monitored;

f) a schedule of anticipated restoration research expenditures on an annual basis; and

g) a description of Quality Assurance/Quality Control protocols for conducting research, how research progress will be monitored, and how results may affect the operational restoration program.

4. The Licensee shall initiate the restoration research not later than six months after submission of the Abandonment and Restoration Plan, or as soon as practical thereafter;

5. The Licensee shall revise the Plan(s) referred to in this section as required by the Board in its review of the Plan(s). Revisions to the Plan(s) shall be submitted to the

Board for its approval within six (6) months of receiving notification of the Board's requirement for revision.

6. The Licensee shall implement the Plan(s) as approved by the Board in accordance with the schedules and procedures specified in the Plan(s) and endeavour to carry out progressive restoration of areas as soon as is reasonably practicable.

7. The Licensee shall review the Abandonment and Restoration Plan annually, and shall modify the Plan as necessary to reflect changes in operations, technology, and results from restoration research and other studies. All proposed modifications to the Plan shall be submitted to the Board for approval.

8. Compliance with the Abandonment and Restoration Plan specified in this Licence does not limit the legal liability of the Licensee, other than liability arising from provisions of the Act and its Regulations.

5.6.2.2 Fisheries

The Department of Fisheries and Oceans (DFO) as part of the Government of Canada is the regulatory body having jurisdiction over fisheries related matters.

The objective of the DFO *Policy for the Management of Fish Habitat* (1986) is to obtain a net gain in the productive capacity of fish habitat in Canada. This is achieved through:

1. conservation of existing habitats;
2. restoration of damaged habitats; and
3. development of new habitats.

With respect to development activities which affect fish habitat, the current productive capacity of existing habitats is maintained by applying the guiding principle of No Net Loss. Through this principle, existing fish habitat is protected and habitat removals are balanced by the development of new habitat.

When development activities affect fish habitat, mitigation measures are developed according to a hierarchy of preferences:

1. redesign or relocate the project;

2. incorporate mitigation measures into the design of the project such that impacts on fish habitat are avoided; and

3. compensate for impact on habitat in cases where it is impossible or impractical to relocate, redesign or mitigate, or where residual impacts still occur by:

    i. "like for like" replacement of habitat at or near the site,

ii. "like for like" replacement off-site,

iii. enhancement of existing habitat or development of new habitat off-site, or

iv. artificial production to supplement the fishery.

BHP Diamonds Inc. will be seeking a *Fisheries Authorization* for waterbodies impacted by the proposed development. The nature of diamond mining in the Northwest Territories is such that impacts on fish habitat are not always avoidable. Since the kimberlites most often occur under lakes, portions of or entire lakes need to be dewatered to access the orebodies. It is therefore not possible to redesign the project so that impacts are entirely avoided. However, where possible, the development will incorporate measures which minimize the effect of the development on fish habitat.

During the development of the Sable, Pigeon and Beartooth Pits, six waterbodies will be affected. Three waterbodies, Sable Lake, Beartooth Lake and Big Reynolds Pond will either be dewatered or buried by a waste rock storage pile. Two Rock Lake will be used as a sedimentation pond. As these are fish-bearing waterbodies, current application of No Net Loss requires that compensation be achieved for these lakes. Little Reynolds Pond will receive mine water. However, because this pond does not support a fish community, No Net Loss will not apply. Pigeon Stream will be diverted around the Pigeon Pit. The diversion stream will replace the lost habitat.

BHP Diamonds Inc. has developed a number of habitat compensation strategies to replace habitat lost through the mine development (BHP, 1999c). Options for compensation include the re-construction of habitat in mined-out pits, the modification of unproductive lakes such that fish communities may be established, increasing the productivity of currently productive lakes, or monetary remuneration. Compensation will be provided that meets the approval of the DFO.

5.6.2.3 Abandonment and Restoration

At present Abandonment and Restoration of mines in the Northwest Territories is addressed by the NWT Waters Act, and the Territorial Lands Act (TLA). The TLA is administered by the Department of Indian and Northern Development (DIAND), and the NIWA administration is shared by DIAND and the NWT Water Board. As discussed in Section 2.1.1.1, the Mackenzie Valley Land and Water Board will eventually be the responsible authority for administering these acts.

The TLA is administered by two sets of regulations governing surface use:

- the Territorial Land Use Regulations (TLUR)
- and the Territorial Land Regulations (TLR).

The relevant control mechanisms for Abandonment and Restoration are the TLR and NIWA. The TLR governs the issue of land leases and collection of security deposits. The NIWA regulates the issue of water licences, determines the security paid and return time

to the licensee, and requires an Abandonment and Restoration Plan for the minesite, which is updated annually.

5.6.3 Agreements

5.6.3.1 Environmental Agreement

The following excerpts were drawn from the Environmental Agreement, dated January 6, 1997. The regulatory agencies that hold jurisdiction with regard to this agreement are the Government of Canada, Department of Indian Affairs and Northern Development and the Northwest Territories Department of Resources and Wildlife and Economic Development.

Article VIII

Closure and Reclamation Plan

(a) BHP shall concurrently with delivery thereof as required by the Water Licence but in any event within 2 years from the date of this Agreement, deliver to the Minister, the GNWT and the Monitoring Agency for their review and the Minister's approval a plan of reclamation of the Project site, including other areas which may be adversely affected in a material way by the Project, (including any amendments, revisions or replacements to such plan, hereinafter referred to as the "Reclamation Plan"). The Reclamation Plan shall be prepared in consultation and in co-operation with the Minister, the GNWT and the Monitoring Agency and shall include, without limitation.

(i) specific and comprehensive plans to deal with the reclamation of the Project site as contemplated in Section 8.3;

(ii) ongoing reclamation during the term of the Surface Leases; and

(iii) plans to address the following;

- buildings and structures;
- roads and airstrips;
- petroleum and chemical storage areas and facilities;
- site drainage systems;
- tailings disposal facilities;
- pipelines and electrical transmission installations;

- water supply facilities;
- waste rock disposal sites;
- garbage, sewage and waste storage or disposal sites and facilities;
- site drainage systems, granular material deposits and open pit areas;
- other facilities or sites utilized during the operation of the Project;
- the Project site generally; and
- other areas which may be adversely affected by the Project in a material way.

(b) BHP shall include in each Annual Report a progress report for the preceding year describing the ongoing reclamation of the Project site.

8.2 Review of Reclamation Plan

(a) In the event that, at any time, the Minister, including at the request of the Monitoring Agency, the GNWT or the Aboriginal Peoples, determines that the Reclamation Plan is inadequate or incomplete, the Minister may provide BHP with a Minister's Report and BHP shall forthwith, but in any event within sixty (60) days of the receipt of the Minister's Report provide:

(i) the Minister with revisions to the Reclamation Plan which address satisfactorily the deficiencies described in the Minister's Report;

(ii) a replacement Reclamation Plan which addresses satisfactorily the deficiencies described in the Minister's Report; or

(iii) specific replies to the deficiencies described in the Minister's Report and BHP's detailed explanation as to why, in BHP's view, the Reclamation Plan need not be revised or replaced to deal with the deficiencies described in the Minister's Report.

(b) In relation to matters substantially within the jurisdiction of the GNWT, the Minister shall provide BHP with a Minister's Report pursuant to Section 8.2(a) when the Minister receives a request from the GNWT pursuant to the section and the GNWT request shall be included in such Minister's Report.

8.3 Natural Recovery

Closure and reclamation shall be undertaken in such a manner as to enhance the natural recovery of the areas affected by the Project by:

(a) ensuring that mine facilities and infrastructure are abandoned in such a manner that:

(i) the Project site is physically stable and any requirement for long-term maintenance and monitoring is minimized;

(ii) any threat to public safety is eliminated; and

(iii) all buildings and such man-made structures are removed as required by the approved Reclamation Plan;

(b) preventing continuing impacts from contaminants and wastes on the environment including those associated with acid rock drainage; and

(c) returning affected areas to a state where negative effects on the use of the surrounding lands compatible with the original undisturbed conditions are minimized to the fullest extent reasonably possible giving due consideration to factors such as aesthetics, economics, future ecosystem productivity and future uses.

8.4 Progressive Reclamation

Reclamation of the Project site shall be undertaken progressively during the life of the Project, to the extent feasible, given the mining methods employed.

8.5 Failure to Restore

In the event that BHP fails to restore the Project site as required by the Reclamation Plan and the regulations to the Territorial Lands Act (Canada), the Minister shall:

(a) as appropriate, use the Security Deposit to cause the reclamation of all or any part of the Project site;

(b) comply with the laws of general application with respect to carrying out such reclamation; and

(c) apply any money recovered from the realization of the Security Deposit only for the purpose of remedying any default or defaults by BHP under this Agreement.

8.6 Approval of Reclamation Plan

(a) Each of Canada, the GNWT and BHP expressly agree that approval of the Reclamation Plan, including approval of any amendments or revisions to the Reclamation Plan, is a matter within the discretion of the Minister. Accordingly, the Dispute Resolution procedure provided for in Article XIV shall not apply to the resolution of disputes with respect to the approval of the Reclamation Plan including the approval of any amendments or revisions to the Reclamation Plan.

(b) In the event that the Minister in his discretion does not approve the Reclamation Plan and/or any amendments or revisions to the Reclamation Plan, either of the Minister or BHP may refer the matter to an independent advisory panel of three advisors (the "Advisory Panel") composed of an appointee selected by the other two appointees. The parties shall select appointees for the Advisory Panel who have expertise with respect to mine site reclamation. Any recommendation made to the Advisory Panel shall not be binding on the Minister.

(c) The parties shall bear their own costs in relation to submissions to any Advisory Panel and the cost of the Advisory Panel shall be paid as to fifty (50%) percent by Canada, unless the Advisory Panel in its recommendations assesses any costs against any specified party or parties.

For greater certainty, the parties acknowledge that the Dispute Resolution Procedure provided for in Article XIV shall apply to any disputes with respect to the adequacy of reclamation carried out by BHP pursuant to an approved Reclamation Plan.

5.6.4 Guidelines

The following sections provide excerpts taken from a number of government guidelines with regards to mine reclamation, restoration and abandonment.

5.6.4.1 Northern Water Resources Studies, Mine Reclamation in Northwest Territories and Yukon

Northern Affairs Program. Published under the authority of the Hon. Tom Siddon, P.C., M.P., Minister of Indian Affairs and Northern Development, Ottawa. April, 1992.

Excerpt from the Executive Summary.

At the closure of mining, the mine site and the land affected by the mining operation are to be reclaimed in order to, and in order of priority to:

- protect public health and safety;
- reduce or prevent environmental degradation; and

- allow a productive land use of the mine site, either its original use or an acceptable alternative.

It is in the interest of all mines, both in operation and proposed, that they develop closure plans to meet the above objectives, and where practicable carry out reclamation activities during mining operations in order to reduce the reclamation costs at the closure of the mine that is more economical and meet the above objectives.

In general, the reclamation plan consists of ensuring that the physical structures that remain after mine closure do not impose a long-term hazard to public health and safety and the environment, which includes ensuring that the land and watercourses are returned to a safe and environmentally sound state and to an acceptable end use.

In developing the design for a post closure mine component the assessment of the reclamation objectives should be made in three broad categories as follows:

- physical stability;
- chemical stability; and,
- land use and aesthetics.

5.6.4.2 Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories

Prepared by the Northwest Territories Water Board and Northwest Territories Region Northern Affairs Program. Department of Indian Affairs and Northern Development. September, 1990.

1.1 The Goal of Restoration

The goal of restoration is to prevent progressive degradation, and to enhance natural recovery of areas affected by mining.

1.2 The Specific Objectives of Restoration

(a) To ensure that mine facilities, wastes and tailings are abandoned in such a manner that the requirements for long-term maintenance and monitoring is minimized;

(b) To prevent continued loadings of contaminants and wastes to the environment;

(c) To prevent acid mine drainage; and

(d) To return affected areas to a state compatible with the original undisturbed conditions, giving due consideration to practical factors including economics, aesthetics, future productivity, and future users.

A planned approach of addressing abandonment and restoration throughout the life of the project should be taken.

1.3 Precept

Using these guidelines as a base, and considering the project's site-specific implication, the onus will be on the operator to obtain all the information necessary to design for operation, abandonment and the restoration of areas affected by mining and to ensure that the intent of these guidelines will be met.

5.6.4.3 Reclamation Guidelines for Northern Canada

Indian and Northern Affairs Canada, 1987.

(i) What is Reclamation?

Reclamation is any process which promotes soil conservation and returns land to a productive state. Generally, physical and biological methods are employed in achieving reclamation goals. The physical methods are directed at maintaining the stability of the soil surface and may consist of surface contouring, and drainage and erosion control structures. The biological methods are directed at re-establishing a vegetative cover to help stabilize the soil.

(ii) Why Reclaim?

There are several reasons for reclaiming disturbed sites.

(1) Reduction of soil erosion – Soil is a valuable resource and where it is lost, reclamation will be more difficult and costly.

(2) Facility integrity – Reclamation can assist in protecting structures such as roads, pipelines, and earthworks by maintaining surface stability.

(3) Disturbance minimization – Reclamation can confine disturbances to the project areas and protect downstream and downslope areas from the effects of erosion and sedimentation.

(4) Maintenance savings – If the project area is stabilized as part of reclamation, the need to return to the site for maintenance is minimized. This may be particularly important in isolated areas where it may be expensive to move maintenance equipment to the site.

(5) Habitat recovery assistance – Reclamation can promote the recovery of natural habitat by stabilizing the surface and protecting the soil so that invasion by natural vegetation can occur.

(6) Aesthetics - Reclamation can be used to improve the appearance of disturbed areas, especially those areas visible from public roads.

5.6.5 Industry Standards

At present, the Mining Association of Canada has no national standards for the mining of minerals in Canada. BHP does, however, have internal company policies that are instrumental in setting environmental standards for all employees. This policy is outlined as follows:

BHP Environmental Policy

It is BHP's policy to achieve a high standard of environmental care in conducting its business as a resources and industry company contributing to society's material needs. BHP's approach to environmental management seeks continuous improvement in performance by taking account of evolving scientific knowledge and community expectations. BHP's Environmental Policy is presented in Section 1.1.2.1.

5.6.6 Abandonment and Restoration Mitigation Strategies

5.6.6.1 Introduction

Mitigation strategies in this section are outlined for those effects pertaining to abandonment and restoration. Although common effects are identified at all three sites, differences are observed with regard to dewatering process, reduction of fish passage and specific water containment and diversion structures. Therefore, effects have been identified by site, followed by the relevant mitigation strategy.

5.6.6.2 Sable

Fish habitat loss has been identified as an impact at Sable Lake as a result of dewatering, and at Two Rock Lake from construction of a sedimentation pond.

The primary mitigation strategy for this loss will include flooding of the exhausted Sable Pit to replace fish habitat in accordance with DFO's policy of No Net Loss. At closure the pit will be modified to create littoral and beach zones. Select areas of the pit perimeter will be sloped at a shallow angle to form beach areas, with a drop-off to the first bench at approximately 5 m of water depth. Granitic waste rock will then be deposited into the pit to form slopes extending from the littoral zone down to the first bench. Within the constructed littoral zone, esker material and/or crushed granite will provide suitable material for lake trout and whitefish spawning. Also boulders will be strategically placed to serve as wave breaks and refuge areas.

Sable Pit Lake will be infilled by pumping water from Ursula Lake, which is part of the greater Lac de Gras watershed. The water will be pumped at a controlled rate as governed by the Water Licence. It is estimated that the filling time will range from 15 to 25 years.

Potential effects on water quality may occur from runoff from waste rock, seepage of soluble inorganic nitrogen compounds originating from waste rock and pit dewatering.

A number of strategies will be implemented to mitigate possible effects on water quality. Upon completion of the geochemical analysis program and depending upon its outcome, perimeter toe berms will be constructed where required around the base of waste rock storage piles. These frozen-core barriers will reduce the risk of runoff water from waste rock entering the downstream aquatic environment. Further discussion regarding this strategy is provided in Section 2.2.3.3.

Soluble inorganic compounds of ammonia and nitrate resulting from rock blasting will be controlled by the following procedures:

- identification of pit areas that are subject to increased groundwater flows;
- use of emulsifiers in ammonium nitrate-fuel oil (ANFO) mixtures that will decrease dissolution and limit contact with infiltrating waters;
- improvement of blast performance and identification of misfires and areas affected by inefficient blasts; and
- removal of affected waste rock to controlled seepage areas in the waste rock storage area.

A more detailed description of Ammonium Nitrate (AN) – Waste Rock Management is presented in Section 5.2.6.

Dewatering impacts from Sable Lake will be minimized by:

- gradual dewatering;
- dewatering over periods of low precipitation;
- use of sedimentation ponds to reduce turbidity; and
- monitoring of water quality at Two Rock Lake discharge.

5.6.6.3 Pigeon

Fish habitat and passage loss will occur at Pigeon Pond and Pigeon Stream with pit construction. The primary mitigation strategy will include replacement of stream habitat and passage through the construction of a permanent stream diversion, and creation of new lake habitat through flooding of Pigeon Pit. At closure Pigeon Pit will be infilled by pumping water from Upper Exeter Lake, which is part of the greater Yamba/Exeter watershed. The anticipated pit filling time will be approximately five years. The water

will be pumped at a controlled rate as governed by the Water Licence. During the final stages of flooding, the pit lake will be monitored to determine the need for nutrient supplements or fish re-stocking. Construction of a littoral zone and re-establishment of a viable pit lake upon closure will follow that outlined above for Sable Lake Pit.

Water quality impacts will be mitigated in a manner similar to that employed at Sable Pit. Two exceptions are the dewatering of Pigeon Pond and realignment of Pigeon Stream, which will take place during winter to avoid affecting fish; and the direction of water removed from Pigeon Pond to Little Reynolds Pond, which drains to the Long Lake Containment Facility. The Pigeon waste rock storage pile will also be placed within the Long Lake Containment Facility drainage area.

Other water quality impacts at Pigeon Pit Lake are expected to be similar to those at Sable. Mitigation measures will follow those previously presented for Sable Pit.

5.6.6.4 Beartooth

Fish habitat will initially be lost as a result of the development of the Beartooth Pit. However, because of its proximity to the EKATI™ mine process plant, the restoration of this pit to a viable lake will involve a different approach that will serve as a pilot project for other nearby pits, including Panda and Koala. The pit will be partially infilled by temporarily directing the discharge of processed kimberlite from the plant into the pit over two summer seasons. The processed kimberlite will be allowed to settle, and the lake will then be topped with freshwater; a water quality monitoring program will be initiated. Once water meets acceptable standards, the lake will be reconnected to the downstream watershed.

6. COMMUNICATIONS AND PUBLIC CONSULTATION

Good environmental assessment and resource development must be based on effective, open and honest communications. Since 1992, BHP has striven to build trust with its stakeholders through transparent and timely communications. All of these actions are integral parts of BHP Diamonds Inc.'s business policies. As a world-class mining company, BHP recognizes its social responsibilities with communities – Aboriginal peoples, governments, employees, general public, shareholders, plus others. BHP maintains an open-door policy and is willing to meet, discuss and provide information to all stakeholders regarding the proposed development of Sable, Pigeon and Beartooth.

The negotiated agreements discussed in Section 2.1.2 and traditional knowledge studies with the Aboriginal groups ensure that environmental and socio-economic consultations are included in management plans and in the operation of the EKATI™ Diamond Mine. As part of the agreements, government, Aboriginal groups and the general public are regularly informed about the environmental management of the mine. BHP has conducted the pre-consultation component for this environmental assessment consistent with the agreements and several guiding principles. These are briefly discussed below.

1. BHP has a corporate Community Relations Policy (Figure 6-1) that defines the company's commitment to ensuring open communications in all its operations.
2. In addition to its corporate policy, BHP Diamonds Inc. has commitments through:
   - IBAs, which ensure ongoing communications and consultations between BHP and the four potentially affected Aboriginal groups. The appointment of the IBA representative ensures frequent communication between the parties. BHP and the Aboriginal leadership meet on an as-needed basis to discuss the EKATI™ operations and important issues related to the IBA; and
   - Environmental and Socio-Economic Agreements that require BHP to make at least annual visits to the affected communities to discuss the previous year's environmental programs, socio-economic performance and other potential issues. In 1999, these forums were utilized to provide information on the Sable, Pigeon and Beartooth proposal.
3. Under the Environmental Agreement, the Independent Environmental Monitoring Agency (Agency) also has a mandate to:

   ...provide programs for the effective dissemination of information to the Aboriginal Peoples and general public on matters pertaining to the Monitoring Agency's mandate...

Since the early 1990s, BHP has maintained an active process of community consultation with the people of the North Slave and Kitikmeot regions.

COMMUNITY RELATIONS POLICY

BHP is committed to responsible corporate citizenship. We will work cooperatively with all communities affected by proposed or existing operations for their long-term benefit and that of our shareholders.

Accordingly, BHP will:

- pursue socially responsible community relations initiatives that reflect the community's needs, enhance our reputation and promote the proper conduct of our businesses;
- recognize and respect the importance of culture, heritage and the traditional rights of indigenous people;
- ensure the Company has management systems to identify, assess, monitor and control BHP's existing and potential impacts on communities;
- consult with communities, and understand and respond to their concerns and wishes about the responsible management of these impacts;
- comply with all applicable laws, regulations and standards and, where laws do not exist, adopt and apply standards that reflect the Company's commitment to socially responsible behaviour.

We will have achieved our goal when we have earned a reputation as a trusted and responsible citizen, having developed a sense of community partnership that provides a base of support for our business.

FIGURE 6-1

6.1 Consultation Objectives

The proposed Sable, Pigeon and Beartooth development was referred to the MVEIRB partly because of the potential for public concern and to identify potential issues. The main objectives of the consultation and communications program were:

- to inform the potentially affected communities, government agencies and general public about the physical work that is being proposed;
- to identify any potential issues Aboriginal people and the general public might have;
- to adapt, if possible, the mine plan and design in response to issues of public concern while respecting the laws of the land and BHP's business plan objectives; and
- to maintain effective participation of Aboriginal people in the environmental planning of the proposed development.

At the public meetings held during the preliminary consultative phase, it was apparent that many people in attendance were unaware of the new environmental assessment process under the MVRMA. At meetings where a MVEIRB staff member was not available, BHP provided information about the MVRMA and described the environmental assessment process established under this new legislation.

An ancillary objective of the consultation program was to update the people of the North on the removal of the Leslie Pipe from the mine plan and to introduce the addition of Sable, Pigeon and Beartooth pipes to the mine reserves. BHP has a responsibility and commitment to share mine plan and ore reserve information with the public, with stakeholders and with shareholders in an open and timely manner.

6.2 Consultation Methods

BHP has provided many avenues for Aboriginal people and the general public to become involved in the assessment of the Sable, Pigeon and Beartooth kimberlite pipes. The inclusivity of the consultation process ensures information-sharing, more opportunities to raise potential issues and access to the public registry.

6.2.1 Reports - Project Description

The second version (February 1999) and the third version (October 1999) of the Project Description was distributed to:

- Aboriginal groups;
- government agencies;
- Yellowknife NGOs - CARC, Ecology North, World Wildlife Fund, Ducks Unlimited, CPWS;

- City of Yellowknife;
- Yellowknife Chamber of Commerce;
- NWT Chamber of Commerce;
- Mackenzie Valley Land and Water Working Group;
- Independent Environmental Monitoring Agency; and
- Other diamond exploration and mining companies.

6.2.2 Site Visits

For the purposes of this assessment, Aboriginal people and government agencies have made 10 visits to EKATI™ to view areas of the proposed development. During these visits the Aboriginal visitors viewed the proposed development sites.

6.2.3 Meetings

As stated above, public participation remains a fundamental principle of BHP's communication policy. Face-to-face community meetings are key to BHP's approach.

Based on Section 127 of the MVRMA, BHP has conducted its consultation process using the list of communities established by the EARP scoping process for the NWT Diamonds Project in 1995. These communities include Yellowknife, and Aboriginal organizations in N'dilo, Dettah, Rae-Edzo, Wha Ti, Rae Lakes, Snare Lake, Lutsel K'e and Kugluktuk.

Table 6.2-1 summarizes the formal meetings that have been held since the spring of 1999. Several informal meetings were also arranged, which have been documented by letters to the MVEIRB public file.

For the combined Dettah/N'dilo community meeting, BHP, at the request of the Yellowknives Dene, bussed people from N'dilo to Dettah where the consultation took place. The October 6, 1999, Dettah/N'dilo community consultation was not completed because of time constraints. A follow-up meeting took place on November 3, 1999.

Initially, BHP requested visits to all four Dogrib Treaty 11 communities in mid-May 1999. BHP was permitted by the Dogrib leadership to schedule community meetings for early September 1999. Subsequently, the Dogrib leadership requested that those visits be cancelled in favour of a regional meeting to be held in Rae-Edzo on October 7, 1999. A letter signed by the four chiefs informed BHP that this meeting would constitute the preliminary phase of consultation required by the MVEIRB. During the meeting, BHP was only allowed to give a partial presentation on the 1998 Socio-Economic Agreement Annual Report because of time constraints imposed by the Dogrib Treaty 11 leadership. Consequently, BHP's future mine plans were not discussed.

Table 6.2-1
Community and Governmental Meetings

Date	Group	Community
April 21, 1999	Treaty 8-Lutsel K'e Land and Env. Committee	Lutsel K'e
August 3, 1999	Inuit of Kugluktuk	Kugluktuk
August 3, 1999	Yellowknife City Council	Yellowknife
August 25, 1999	Regulatory Agencies	Yellowknife
September 7, 1999[1]	Treaty 11	Gameti
September 29, 1999	Treaty 8-YK Dene Land and Env. Committee	Dettah
September 30, 1999	Treaty 8-Lutsel K'e Community Meeting	Lutsel K'e
October 5, 1999	North Slave Metis Alliance	Yellowknife
October 6, 1999	Treaty 8 – Community Meeting	Dettah/N'dilo
October 7, 1999[2]	Treaty 11-Tribal Council	Rae-Edzo
October 12, 1999	Treaty 8-Lutsel K'e Community Meeting	Lutsel K'e
October 19, 1999	Treaty 8-YK Dene Land and Env. Committee	Dettah
October 25, 1999	General Public	Yellowknife
November 3, 1999	Treaty 8 – Community Meeting	Dettah/N'dilo
November 19, 1999	Yellowknife Chamber of Commerce	Yellowknife
November 25, 1999	Geoscience Forum	Yellowknife
December 1, 1999	Treaty 11 and Metis IRMA Funding Workshop	Rae-Edzo
December 6, 1999	Treaty 8 – 3 Chiefs	Yellowknife
January 20, 2000[3]	Treaty 11 – Chiefs and Councillor	Yellowknife
February 3, 2000	Kitikmeot Hunters and Trappers Association – Biannual Meeting	Kugluktuk
February 7-10, 2000	AEMP/Wildlife Workshops	Yellowknife
March 9, 2000	Kitikmeot Inuit Association – Quarterly Board Meeting	Talaoyak
March 19, 2000	Dogrib Leadership and Elders	EKATI™

1. This meeting was cancelled on the day of the meeting; see text.
2. The updated mine plan was not discussed; see text.
3. The meeting notes from this luncheon are on file at the MVEIRB.

Since October, BHP has been working cooperatively to re-schedule consultation meetings with the Dogrib Treaty 11. The Dogrib leadership visited EKATI™ in early January 2000. In mid-January, BHP had a luncheon meeting with the Dogrib chiefs to discuss the proposed Sable, Pigeon and Beartooth development. On March 19, 2000, several members of the Dogrib community, including the Grand Chief, visited EKATI™. A comprehensive site tour was conducted, and a presentation was given on the Sable, Pigeon and Beartooth development.

The public consultation held in Yellowknife on October 25, 1999, was attended by 20 people (Plate 6.2-1). BHP advertised the meeting in the local newspaper (Figure 6.2-1).

Plate 6.2-1 October 25, 1999 Consultation meeting in Yellowknife, BHP providing an overview on the development proposal.

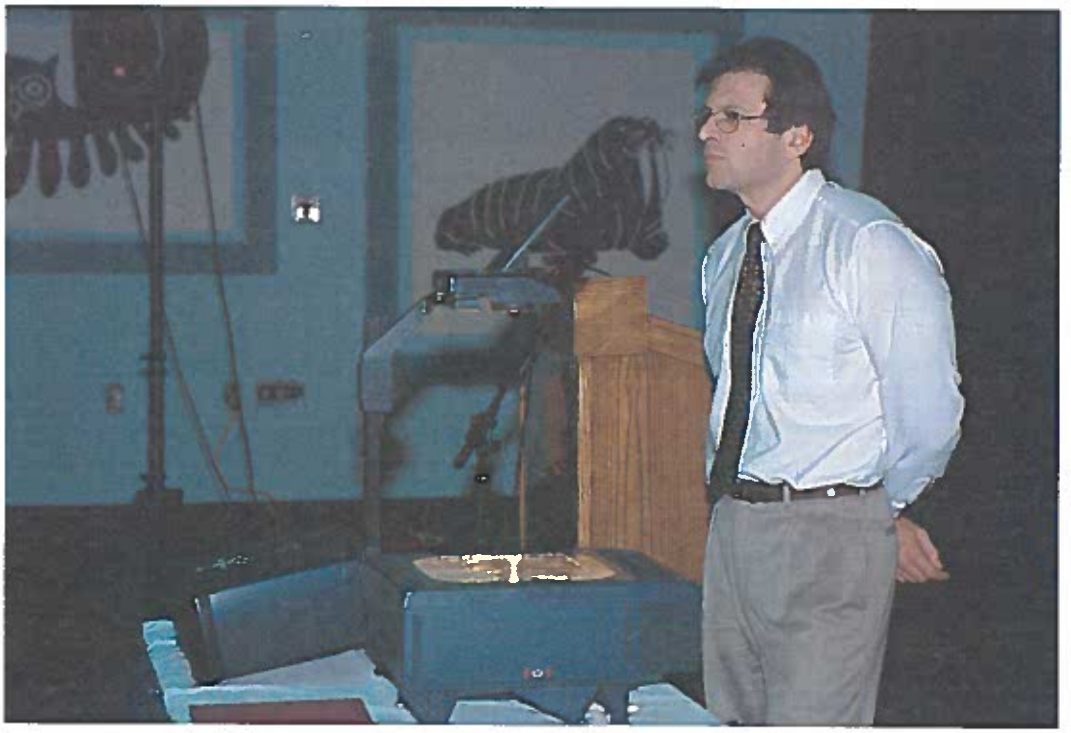


Plate 6.2-2 October 25, 1999 Consultation meeting in Yellowknife, MVEIRB staff member discussing environmental assessment.

BHP Diamonds Inc. and Dia Met Minerals Ltd.
invite residents to

PUBLIC CONSULTATION MEETINGS

Monday, October 25, 7:00-9:00 p.m.

- 1998 environment agreement annual report
- additional kimberlite resource planning and permitting

Tuesday, October 26, 7:00-9:00 p.m.

- the 1998 socio-economic agreement annual report

The meetings will take place in

THE KATIMAIK ROOMS A & B,
EXPLORER HOTEL.

BHP DIA MET MINERALS LTD.

FIGURE 6.2-1

BHP

Notice of Yellowknife Public Consultation

Ekati diamond mine

An MVEIRB staff member (Plate 6.2-2) presented a general overview of the environmental assessment process under the MVRMA.

BHP has filed a copy of all its community meeting notes, not including those in March, with the MVEIRB for its public registry.

In addition to community meetings, since late 1998 BHP has been meeting regularly with the Inter-Agency Coordinating Team (IACT) comprised of the Agency and Regulatory Authorities, and others to discuss mine-related environmental issues and studies related to the proposed development.

6.2.4 BHP Newsletter

Three or four times each year, BHP Diamonds Inc. publishes a newsletter, which is distributed to BHP employees and more than 500 outside recipients. In the September 1999 issue, BHP provided an update on the addition of the three new pipes. A copy of the newsletter is provided in Appendix G.

6.2.5 Environmental Workshops – Wildlife and Aquatic Effects

From February 7 to February 10, 2000, BHP held its annual workshops on the aquatic and wildlife effects monitoring programs. Stakeholders from the four Aboriginal groups, inclusive of elders, government agencies, consultants, the Agency and BHP environmental management employees, attended the workshops. The purpose and intent of the workshops was to review the 1999 aquatic and wildlife monitoring effects programs and to discuss the year 2000 programs.

At this venue, a general overview of the Sable, Pigeon and Beartooth development description was provided along with an overview of the physical scope and potential effects of this incremental development.

6.2.6 Media – Newspaper and Radio

The MVEIRB Terms of Reference directed BHP to provide public notification that the company was preparing an EAR for the Sable, Pigeon and Beartooth development. To this end, BHP ran public affairs announcements from December 29, 1999, to January 7, 2000, on CJCD and CBC. The announcements were broadcast twice per day on CBC and more frequently on CJCD. CBC translated the announcements into Dogrib and Chipewyan and broadcast them in the affected communities. The announcement (Figure 6.2-2) was published in the Yellowknifer and the News North on December 29, 1999, and January 3, 7, 10 and 12, 2000.

Ekati™ diamond mine

BHP Diamonds Inc., as operators of EKATI™ Diamond Mine, hereby gives notice that it is preparing an ENVIRONMENTAL ASSESSMENT REPORT (EAR) pursuant to Section 126 of the Mackenzie Valley Resource Management Act for the proposed development of Sable, Pigeon and Beartooth kimberlite pipes. The EAR will assist the Mackenzie Valley Environmental Impact Review Board in the assessment of the potential environmental consequences of the proposed development. The addition of the three new pipes, which are located in close proximity to the existing mine infrastructure, will increase the life of the mine from 15 to 18 years.

On November 5, 1999 BHP Diamonds Inc. submitted a Project Description report to the Review Board. Copies of the Project Description report are available for public viewing at:

- the Mackenzie Valley Environmental Impact Review Board's office in Yellowknife at #200, Scotia Centre, 5102 50th Avenue;
- the Yellowknife Public Library;
- the Yellowknife office of BHP Diamonds Inc.

Comments on the proposed development should be submitted to BHP Diamonds Inc. by January 17, 2000. BHP plans to have the EAR completed and submitted to the Review Board in February 2000.

Comments on the project description and requests for further environmental information regarding the proposed development should be addressed to either:

Tina Markovic
Senior Resource Planning Coordinator
BHP Diamonds Inc.
(867) 669-6142

Chris Hanks
Senior Environmental Specialist
BHP Diamonds Inc.
(867) 669-6145

BHP Diamonds Inc.
Suite 1102, 4920 52nd Street, Yellowknife NT X1A 3T1
Fax: (867) 669-9293

BHP

DIA MET MINERALS LTD.

FIGURE 6.2-2

BHP

Notice of Public Consultation for EAR

Ekati® diamond mine

Inquiries to the public announcements ranged from requests for more information about the advertisements to a request for community visits to Bay Chimo and Bathurst Inlet. BHP responded favourably to these requests. In total, the public notification campaign elicited five responses from the general populace of approximately 20,000 people. BHP filed a memorandum with the MVEIRB on January 20, 2000, that summarized public response to the notification.

6.3 Consultation Feedback

Throughout the consultation process, BHP has documented the concerns of stakeholders. The main areas of stakeholder concern are as follows:

- the Sable access road and its potential effect on caribou migration;
- the waste rock storage areas around the Sable development site;
- the siting of the Sable and Pigeon developments in a new watershed; and
- the potential for backfilling exhausted pits with waste rock.

Wherever possible, BHP has adapted its mine plan to lessen the potential effect of its operations on the environment. The Sable Road has been designed to incorporate the same design features as the Misery haul road. Several mitigation strategies are employed at the EKATI™ mine to ensure that no vehicle-animal collisions occur.

The waste rock storage piles at Sable pit were re-designed to lessen the direct effect on Ulu Lake. Backfilling pits with waste rock is an alternative that BHP evaluates when developing its mining plan and development proposals. Backfilling with waste rock will not be employed at the Sable and Pigeon pits, but BHP does intend to backfill the Beartooth Pit with processed kimberlite. This will provide BHP with an opportunity to develop its lake restoration methodologies earlier in the life of mine.

Stakeholders raised questions about the principles of mine planning. The removal of Leslie Pipe and the addition of the three pipes raised concerns about the proposed schedule for developing and mining the pipes and the overall mine life. The principles and reasoning behind the EKATI™ mine plan were described and explained.

The communities of Rae-Edzo and Dettah raised concerns about specific issues covered under the IBAs. BHP listened to the concerns and indicated that issues should be referred to their IBA representative, who would convey them to BHP under the terms of the IBA. Subsequently, BHP has been notified about these issues. Meetings will take place under the issue resolution parameters defined in the IBA.

6.4 Future Consultation

Upon submittal of the Environmental Assessment Report, BHP intends to continue its consultation process through community visits, stakeholder meetings, and mine site visits.

In addition, BHP has responded to formal requests from the communities of Bay Chimo and Bathurst Inlet to provide information sessions on the proposed developments.

BHP's consultation programs are not limited to the proposed Sable, Pigeon and Beartooth development. Active ongoing communications with interested Northerners regarding the EKATI™ Diamond Mine is the basis of BHP's approach. Responding to public concerns is key to continuous improvement of communication with the public. BHP is a responsible developer in the NWT. It has shown that communicating openly to involve Northerners is key to developing resources in the North.

7. SUPPORTING DOCUMENTATION

The following is a list and short description of relevant reports prepared by either BHP or their consultants from 1993 through 2000 covering a broad scope of environmental and engineering issues. This annotated bibliography is presented chronologically by year of report publication and by subject area.

7.1 Pre-1995 Reports

7.1.1 Pre-1995 Archaeology / Traditional Knowledge

Title: Report on Field Investigations for the BHP NWT Diamonds Project

Prepared by: Points West Heritage Consulting Ltd., July 1994

Description: Describes the results of an archaeological inventory and impact assessment of the development study area. Includes field methodologies, characteristics and locations of each archaeological site discovered, preliminary assessment of site significance, potential impacts, and mitigation recommendations.

7.1.2 Pre-1995 Bulk Sampling (Drilling)

Title: Bulk Sampling Project Description Addendum Report

Prepared by: Rescan™ Environmental Services Ltd., March 1994

Description: An addendum to the Bulk Sampling Project Description report for the Koala and Fox Lake bulk sampling program and an outline of the bulk sampling program intended for Panda Lake.

Title: Bulk Sampling Project Description Addendum Report Misery Lake

Prepared by: Rescan™ Environmental Services Ltd., August 1994

Description: An addendum to the Bulk Sampling Project Description to outline the program intended for bulk sampling of two kimberlite pipes at Misery Lake.

Title: Koala Lake: Evaluation of Underwater Drill Chip Disposal Program

Prepared by: Rescan™ Environmental Services Ltd., July 1994

Description: Addresses the environmental monitoring and the effect of the discharge of drill chips to Koala Lake associated with drilling operations.

7.1.3 Pre-1995 Aquatics Monitoring

Title: Panda Lake Diversion and Fish Habitat Enhancement Channel Design

Prepared by: Rescan™ Environmental Services Ltd., June 1994

Description: Describes the design parameters of the Panda Diversion Channel and measures for fish habitat creation and enhancement within the channel.

7.1.4 Pre-1995 Environmental Baseline

Title: Lake Bathymetry and Morphology

Prepared by: Rescan® Consultants Inc., October 1993

Description: Lake bathymetry maps and related data for lakes located near the then proposed project development areas.

7.1.5 Pre-1995 Other Reports

Title: Project Description Report

Prepared by: BHP Diamonds Inc., December 1994

Description: Explains project development plans for the then proposed mine development. Prepared to meet the requirements of the federal Environmental Assessment and Review Process (EARP).

7.2 1995 Reports

7.2.1 1995 Environmental Impact Statement

Title: NWT Diamonds Project Environmental Impact Statement plus Accompanying Volumes:

Vol. I Project Description and Appendix

Vol. II Environmental Setting and Appendix

Vol. III Environmental Management and Appendix

Vol. IV Impacts & Mitigation and Appendix

Prepared by: BHP Diamonds Inc. & DIA MET Minerals Ltd., July 1995

Description: The EIS executive summary and its four supporting technical documents represent three and one-half years of intensive sampling and exploration, more than two years of environmental baseline work, over three years of extensive community consultations, and over two years of engineering design. Detailed information and analyses is provided in four accompanying volumes of the EIS, plus a number of Appendices.

Title: NWT Diamonds Project Environmental Impact Statement – Additional Information Response

Prepared by: BHP Diamonds Inc. & DIA MET Minerals Ltd., December 1995

Description: Requested information provided to EIS Panel.

7.2.2 1995 Wildlife Monitoring

Title: Ecological Mapping, 1995 Baseline Study Update

Prepared by: BHP Diamonds Inc., December 1995

Description: This report provides baseline ecosystem (terrain and vegetation) maps of the claims area, that provide an integrated inventory of terrain, soil, and vegetation resources, so that potential impacts such as negative air quality effects or the loss of rare species or limited habitats can be evaluated.

Title: Bird Inventory & Habitat Assessment: 1995 Baseline Study Update

Prepared by: BHP Diamonds Inc. and Rescan™ Environmental Services Ltd., December 1995

Description: Provides the results of the 1995 baseline study on birds in the project area.

Title: Small Mammals Inventory & Habitat Assessment: 1995 Baseline Study Update

Prepared by: BHP Diamonds Inc. and Rescan™ Environmental Services Ltd., December 1995

Description: Provides the results of the 1995 baseline study on small mammals in the project area.

Title: Eskers, Carnivores & Dens: 1995 Baseline Study Update

Prepared by: BHP Diamonds Inc., December 1995

Description: Presents the 1995 baseline and research data on eskers, carnivores, and grizzly bears.

Title: Caribou Assessment: 1995 Baseline Study Update

Prepared by: BHP Diamonds Inc., December 1995

Description: This work was a continuation of 1994 efforts to collect baseline data on caribou within the mine claims area.

7.2.3 1995 Aquatics Monitoring

Title: Misery Lake 1995 Environmental Data Report

Prepared by: Rescan™ Environmental Services Ltd., October 1995

Description: Results of environmental monitoring program of Misery Lake conducted in 1995 to assess the affects of winter exploration drilling. The study included collecting data and documenting water quality, and primary/secondary producers.

7.2.4 1995 Environmental Baseline

Title: Waste Rock Leaching 1995 Baseline Update

Prepared by: Rescan™ Environmental Services Ltd., December 1995

Description: Presents the results of testwork for the prediction of drainage chemistry at a minesite, including static and kinetic tests on waste rock and kimberlite

Title: Fisheries & Aquatic Life: 1995 Baseline Study Update

Prepared by: Rescan™ Environmental Services Ltd., December 1995

Description: Presents the results of the 1995 fisheries and aquatic life sampling programs in the project area. The data from this study helps to form part of an information baseline, which will be used as a reference against which future monitoring results are compared. Data collection and reporting was undertaken during 1995 on periphyton, benthos, zooplankton, and larval drift.

7.2.5 1995 Bulk Sampling (Drilling)

Title: Drill Chip Underwater Disposal Testwork Program

Prepared by: Rescan™ Environmental Services Ltd., January 1995

Description: Presents the results of testwork done for a drill chip treatment design process which will ensure that drill chip return water discharged to the environment, as a result of the drilling program, will be non-toxic to aquatic organisms.

Title: Bulk Sampling Misery Lake Additional Information

Prepared by: BHP Diamonds Inc., January 1995

Description: This report provides additional information to address previous deficiencies identified and illustrates how the construction of a road to Misery could occur with minimal disturbance to the Lac de Gras region.

Title: Meteorology, Hydrology & Water Quality: 1995 Baseline Study Update

Prepared by: BHP Diamonds Inc., December 1995

Description: Provides a summary of the meteorological, hydrological and water quality data collected during the 1995 baseline year.

7.2.6 1995 Geotechnical

Title: Panda Diversion Dam Geotechnical Investigation Program, Phase II

Prepared by: EBA Engineering Consultants Ltd., June 1995

Description: A summary of the geotechnical and geophysical data collected at the then proposed Panda Diversion Dam location.

Title: NWT Diamonds, Tailings Management Plan (Section A)
Tailings Dams Preliminary Design (Section B)
Sedimentation Ponds Preliminary Design, NWT Diamond Project (Section C)

Prepared by: EBA Engineering Consultants Ltd., December 1995

Description: Three part report documents the initial Tailings Management Plan (Section A), preliminary designs for dams and associated earthworks for water and processed kimberlite retention facilities (Section B), and the preliminary design for sediment ponds (Section C).

7.2.7 1995 Other Reports

Title: Fisheries Mitigation Strategy: "No Net Loss Policy"

Prepared by: Rescan™ Environmental Services Ltd., March 1995

Description: Details three potential approaches that could be adopted in order to satisfy the Federal Department of Fisheries and Oceans (DFO), "no net loss" principle. The developed approaches would ensure that BPH's obligations under the Fisheries Act are fully met.

Title: Towards a Fisheries Compensation Plan: Estimation of Fish Habitat in Koala District Lakes and Streams

Prepared by: Rescan™ Environmental Services Ltd., November 1995

Description: Estimates the stream and lake habitat that will be lost due to planned mining operations. This estimate was to form the basis for discussions with the Central Arctic Region of DFO regarding appropriate habitat compensation.

Title: Communications Program & Public Involvement Update

Prepared by: BHP Diamonds Inc. & DIA MET Minerals Ltd., December 1995

Description: An update of BPH's ongoing communications program, the overall purpose of which is to establish a dialogue with all of the different groups who have an interest in the project.

Title: NWT Community Mobilization Partnership Strategy

Prepared by: BHP Diamonds Inc. & DIA MET Minerals Ltd., December 1995

Description: An update of BHP's efforts with regard to the NWT community mobilization and partnership strategy.

Title: Koala Plant Site Geotechnical Investigation Program, Phase II

Prepared by: EBA Engineering Consultants Ltd., January 1995

Description: Summary of the geotechnical investigation of the Koala Plant Site.

Title: Koala Mine Airport Esker Evaluation

Prepared by: EBA Engineering Consultants Ltd., March 1995

Description: An evaluation of the Airport Esker as a source of aggregate for proposed mine site construction activities.

7.3 1996 Reports

7.3.1 1996 Archaeological / Traditional Knowledge

Title: 1996 Archaeological Investigations for BHP Diamonds Inc.

Prepared by: Points West Heritage Consulting Ltd., March 1996

Description: Describes the results of a continuing archaeological inventory and impact assessment of the development study area first initiated in 1994. Visits to 1994 and 1995 sites were made to assess potential impact and to provide information to be used as a basis for an archaeological management plan. This report includes field methodologies, characteristics and locations of each archaeological site discovered, assessment of site significance, potential impacts, and mitigation recommendations.

7.3.2 1996 Environmental Impact Statement / Water License

Title: Additional Information Response, Part C.

Prepared by: BHP Diamonds Inc and DIA MET Minerals Ltd., January 1996

Description: Presents additional information that was requested by EARP after its review of the EIS. Among other subjects it presents information gaps, additional references, errata, glossary, water flow patterns, information on flocculants, and community issues.

Title: Application for Class "A" Water Licence Under the Northwest Territories Waters Act

Prepared by: BHP Diamonds Inc., March 1996

Description: BHP's application for Class "A" Water Licence consisting of cover letter, application for licence, supplemental information on reclamation and spill contingency/emergency response, as well as various mine development plans and figures.

Title: In Support of Application for Class "A" Water Licence Under the Northwest Territories Waters Act

Prepared by: BHP Diamonds Inc., August 1996

Description: Provides a summary of information contained in the Environmental Impact Statement.

Title: Response to Suggestions Outlined by the Environmental Assessment Panel: Radioisotope Data

Prepared by: Rescan™ Environmental Services, November 1996

Description: Addresses concerns outlined by Health Canada and Natural Resources Canada with respect to the levels of naturally occurring radionuclides in water, granitic waste rock,and kimberlite ore reported in the 1995 EIS. The document essentially clarifies reporting errors associated with previously published data and discusses results from additional measurements made on various kimberlite and waste rock samples.

7.3.3 1996 Aquatics Monitoring

Title: Misery Lake 1996 Environmental Data Report: Primary & Secondary Production

Prepared by: Rescan™ Environmental Services Ltd., August 1996

Description: Summarizes the results of primary and secondary producer sampling and analyses performed in July 1996 on Misery Lake. This data along with data collected previously in 1995 was compared to pre-drilling data collected from 1994.

Title: Sable Lake 1996 Environmental Data Report: Primary and Secondary Producer

Prepared by: Rescan™ Environmental Services Ltd., September 1996

Description: Results of environmental monitoring program of Sable Lake conducted in 1996, the primary purpose of which was to assess potential environmental effects from an extensive winter drilling targeted at the Sable kimberlite conducted in 1995. The study included collecting data and documenting water quality and primary/secondary producers. Comparisons with other lakes in the area are also made.

7.3.4 1996 Environmental Baseline

Title: Baseline Limnology, Water and Sediment Chemistry, and Lower Trophic Level Data for Zach Pond, NWT

Prepared by: Dillon Consulting Limited and North/South Consultants Inc., November 1996

Description: Results of environmental baseline study of Zach Pond conducted in 1996, the primary purpose of which was to provide reference information in support of exploratory diamond drilling of a kimberlite pipe located beneath the lake. The study included collecting data and documenting limnology, primary/secondary producers, and aquatic/sediment chemistry.

Title: Environmental Baseline Assessment: Beartooth & Bear Claw Lakes NWT

Prepared by: Bryant Environmental Consultants Ltd., December 1996

Description: Describes the results of the baseline study performed on Beartooth and Bear Claw Lakes and connecting stream. Data collected, analyzed, and reported included bathymetry, hydrology, water chemistry, sediment chemistry and size distribution, secondary production analysis and aquatic vertibrates.

Title: Meteorology, Hydrology, Water Quality & Fisheries and Aquatic Life – 1996 Environmental Data Report

Prepared by: Rescan™ Environmental Services Ltd., December 1996

Description: Presents the results of environmental studies in the area of the project area. The data from this study helps to form part of an information baseline, which will be used as a reference against which future monitoring results are compared. Data collection and reporting was undertaken during 1996 on meteorology, hydrology, water quality, aquatic life and fisheries, wildlife and wildlife habitat, ecological mapping, and archaeology.

7.3.5 1996 Revegetation / Reclamation

Title: Natural Resources Inventory & Pilot Revegetation Study, Fox Decline Mine Site, NWT First Annual Report

Prepared by: ABR Inc., March 1996

Description: The first annual report describes results of the natural resources inventory at the mine site and describes the revegetation study initiated at the Fox decline. A preliminary assessment of the biophysical characteristics of the soil amendments used from the study area presented. The studies were initiated to investigate techniques for rehabilitating areas disturbed by mining at the site.

7.3.6 1996 Geotechnical

Title: 1996 Long Lake Geophysical Investigation

Prepared by: EBA Engineering Consultants Ltd., October 1996

Description: Presents the results of a geophysical program designed to collect bathymetric and sediment information at three site specific locations on Long Lake.

Title: Granular Resource Investigation Lac de Gras, NWT Geophysical Report

Prepared by: EBA Engineering Consultants Ltd., November 1996

Description: Documents the results of a geophysical survey on the Misery Esker at Lac de Gras. The objective of the geophysical program was to complement a concurrent geotechnical drilling program at the same site.

7.3.7 1996 Other Reports

Title: Fish Sampling Protocols for the BHP NWT Diamonds Project 1996

Prepared by: Rescan™ Environmental Services Ltd., August 1996

Description: A summary of the methods proposed to capture fish in lakes and streams.

7.4 1997 Reports

7.4.1 1997 Environmental Management Plans

Title: Waste Rock & Ore Storage Management Plan

Prepared by: BHP Diamonds Inc., July 1998

Description: Current management plan that details environmental practices and policies pertaining to the generation, handling, and storage of materials resulting from the mining and ore processing operations. Also included are results and interpretations of geochemical testing, and drainage quantities and qualities originating from waste rock storage areas and temporary stockpiles.

Title: Construction Phase Environmental Management Plan, Appendices Volumes 1 and 2

Prepared by: BHP Diamonds Inc.

Description: Outlines environmental practices and policies followed at the EKATI™ during the construction phase of the work including air quality management, materials management, wildlife management, traffic management, aquatic life management, waste management, quarry management, and environmental monitoring.

Title: Construction Mine Site Spill Contingency Plan

Prepared by: BHP Diamonds Inc., October 1997

Description: Spill Contingency Plan used during the construction phase of the project and has since been revised and incorporated into existing Spill and General Contingency Plan, March 1998.

7.4.2 1997 Wildlife Monitoring

Title: 1996 Wildlife Studies

Prepared by: Rescan™ Environmental Services Ltd., February 1997

Description: Describes the wildlife studies conducted during 1996, completing the collection of baseline data initiated in 1994, to provide the basis for future effects monitoring. The wildlife covered by this report includes caribou, carnivore dens and diets, grizzly bears, birds, and small mammals.

7.4.3 1997 Aquatics Monitoring

Title: 1997 Kodiak Lake Sewage Effects Study

Prepared by: Rescan™ Environmental Services, December 1997

Description: The first year of a three year study undertaken to determine the effects of treated sewage effluent on the aquatic environment and biota of Kodiak Lake. Study examined potential effects to primary and secondary producers, lake benthos and sediments, and water quality.

Title: Report: Lake Bottom Characteristics for Fish Habitat, Grizzly Lake NWT

Prepared by: Bryant Environmental Consultants Ltd., January 1997

Description: Presents the results of a lake bottom characterization study of Grizzly Lake. The study was initiated to determine potential impact to fisheries habitat in the development area, and to provide sufficient information in obtaining necessary regulatory approvals to proceed with the construction and operation of the Grizzly Lake water intake system.

Title: Sediment Loading to Kodiak Lake Through the Panda Diversion Channel

Prepared by: Rescan™ Environmental Services Ltd., September 1997

Description: Presents the methodology and results of a survey undertaken in August, 1997, to determine the extent of channel sediments deposited in Kodiak Lake

Title: 1997 Aquatic Effects Monitoring Plan

Prepared by: BHP Diamonds Inc. and Rescan™ Environmental Services, August 1997

Description: Details the development and key features of the Aquatics Effects Monitoring Program (AEMP). The monitoring program specified by the Environmental Agreement is intended to measure compliance with regulatory requirements, determine the environmental effects of the Project, test impact predictions, and measure the performance of operations and effectiveness of impact Mitigation.

7.4.4 1997 Environmental Baseline

Title: Beartooth Lake 1997 Fisheries Resource & Habitat Survey

Prepared by: Rescan™ Environmental Services Ltd., November 1997

Description: Results of environmental baseline study of Beartooth Lake conducted in 1997, the primary purpose of which was to provide reference information in support of planned bulk sampling of a kimberlite pipe located beneath the lake. The study included collecting data and documenting limnology, water quality, and fish communities and habitat characterization.

7.4.5 1997 Revegetation / Reclamation

Title: Pilot Revegetation Studies at the Fox Portal Site, NWT – Second Annual Report

Prepared by: ABR Inc., May 1997

Description: The second annual report describes results of three components of revegetation studies at the Fox portal that includes use of different topdressings and plant materials, propagation studies of several plants, and germination testing. The studies were initiated to investigate techniques for rehabilitating areas disturbed by mining at the site.

7.4.6 1997 Geotechnical

Title: 1997 Phase I Tailings Dam Inspection

Prepared by: EBA Engineering Consultants Ltd.

Description: Details the results of the 1997 annual inspection of the Phase I Tailings Dam. Fulfills a requirement of the NWT Water Board.

Title: Quarry Management Plan, Airstrip Esker

Prepared by: BHP Diamonds Inc. and EBA Engineering Consultants Ltd., August 1997

Description: Quarry Management Plan providing development recommendations for the Airstrip Esker.

Title: Paul Lake Bridge Crossing, Geotechnical Investigation

Prepared by: EBA Engineering Consultants Ltd., November 1997

Description: Presents the results of a geotechnical for construction of the proposed Paul Lake Bridge. The objective of this evaluation was to develop geotechnical recommendations for the design and construction of the bridge abutments and approach embankments.

Title: Granular Resource Investigation Lac de Gras, NWT Geotechnical Report

Prepared by: EBA Engineering Consultants Ltd., February 1997

Description: Presents the results of geotechnical investigations conducted on the Airport and Misery Lake Eskers. The objective of the investigations was to determine ground stratigraphy and to delineate ground ice conditions in the eskers.

Title: Long Lake Outlet Dam, Final Design Report

Prepared by: EBA Engineering Consultants Ltd., September 1997

Description: Presents the final design basis for the Outlet Dam, which is designed to retain excess process and allow controlled discharge into the natural environment at Leslie Lake. The Outlet Dam is designed as a zoned dam with a core of frozen sand and gravel.

7.4.7 1997 Other Reports

Title: Acid/Alkaline Rock Drainage (ARD) and Geochemical Characterization Program

Prepared by: Norecol Dames & Moore, December 1997

Description: The metal leaching characteristics of wastes produced by the mine were evaluated using tests designed primarily to evaluate the potential for acid generation.

This study satisfied a requirement of the Water Licence to update and expand the previous findings and provide specific measures to address leaching of waste rock, mine surfaces and processed kimberlite.

Title: Landfarm Operating Manual, NWT Diamonds Project, Lac de Gras, NWT

Prepared by: EBA Engineering Consultants Ltd., September 1997

Description: Interim operating plan for the landfarm. The operation plan deals with both the theory and practical day-to-day operations of a landfarm to treat hydrocarbon contaminated soils at the site.

7.5 1998 Reports

7.5.1 1998 Archaeology / Traditional Knowledge

Title: 1997 Archaeological Investigations for BHP Diamonds Inc. EKATI™ Mine, NWT

Prepared by: Points West Heritage Consultants Ltd, March 1998

Description: Describes the results of a continuing archaeological inventory and impact assessment of the development study area undertaken during 1997. This report includes field methodologies, characteristics and locations of each archaeological site discovered, assessments of site significance, potential impacts, and mitigation recommendations.

7.5.2 1998 Management Plans

Title: Air Quality Management and Operating Plan

Prepared by: Ferguson Simek Clark Engineers & Architects, April 1998

Description: Original air quality management plan developed to ensure continuing preservation of existing ambient air quality throughout the life of the mine. Has since been updated, December 1998.

Title: Wastewater and Tailings Management Plan

Prepared by: EBA Engineering Consultants Ltd., June 1998

Description: Presents the current operational wastewater and processed kimberlite management plan. This document updated the previous plans based on information from

further processed kimberlite characterization and comments received from the NWT Technical Advisor Committee and the Independent Environmental Monitoring Agency.

Title: Spill & General Contingency Plan

Prepared by: BHP Diamonds Inc., March 1998

Description: An operational plan, complying with BHP's environmental policy and federal/territorial regulations and guidelines, that provides emergency information to cleanup crews, management, and government agencies in the event of a spill. It promotes safe and effective recovery of spilled materials while minimizing potential environmental impacts to water and land. Replaced two earlier versions of this document.

7.5.3 1998 Operational Environmental Management Plans

Title: Operating Environmental Management Plan: Supporting Documents H & L

Prepared by: BHP Diamonds Inc., December 1998

Description: This support document to the OEMP provides detailed information and guidance on the following topics:

Wildlife Effects Monitoring Plan outlines the basic hypotheses and methodologies used to monitor wildlife in the claim block.

Aquatic Effects Monitoring Plan outlines the basic hypotheses and methodologies used to monitor aquatic resources in the claim block.

Title: Operating Environmental Management Plan

Prepared by: BHP Diamonds Inc., December 1998

Description: Outlines environmental practices and policies followed at the EKATI™ . This general plan covers all major environment-related issues such as Air Quality Management, Materials Management, Wildlife Management, Traffic Management, Aquatic Life Management, Waste Management, Quarry Management, and Environmental Monitoring. The plan is supported by 13 Support Documents.

Title: Operating Environmental Management Plan: Support Document B

Prepared by: BHP Diamonds Inc., December 1998

Description: This support document to the OEMP provides detailed information and guidance on the following topics:

Environmental Awareness and Training Plan describes the company's approach to educating and training BHP employees, contractors and subcontractors on all relevant environmental matters.

Environmental Management Procedures Manual describes specific procedures and instructions for personnel to follow in order to effectively deal with mine-related environmental issues. All BHP employees, contractors and subcontractors are to refer to this manual when seeking advice or information on recommended or required environmental mitigation measures.

Air Quality Monitoring Plan describes the air quality monitoring program being implemented at the EKATI™ mine. The plan identifies the parameters to be measured, monitoring methods, sampling locations, monitoring frequencies and QA/QC procedures.

The Project Spill and General Contingency Plan facilitates prompt reporting and efficient cleanup of spills.

Materials Management Plan describes the legislation and procedures to be employed to ensure the safe transportation, storage, handling and use of hydrocarbon products, ammonium nitrate and all other chemicals used at the mine site.

Waste Management Plan describes the procedures for ensuring that all wastes produced by the EKATI™ Diamond Mine are handled, stored, treated and/or disposed in a safe and responsible manner.

Echo Bay Highway and Winter Road Policy and Procedures Manual, which is followed by BHP and contractor employees, describes the policies and rules Echo Bay Mines Ltd. has set for driving vehicles on the winter roads.

Quarry Management Plan ensures that granular material resources used for construction at EKATI™ and associated dams and dykes are extracted in accordance with accepted northern engineering practices and federal government Environmental Guidelines for Pits and Quarries and BHP's environmental policies.

Interim Abandonment and Restoration Plan for EKATI™ was developed in accordance with the NWT Water Board's Guidelines for Abandonment and Restoration Planning for Mine Sites in the Northwest Territories, September 1990. The Plan provides a protocol for reclamation of mining-affected lands within the BHP Claim Block, and determines the extent of financial assurance required to guarantee the restoration of the EKATI™ Diamond Mine.

Archaeological Management Plan outlines a program for ensuring that mine operations are conducted in a manner that minimizes its impact on archaeological sites.

Quality Assurance/Quality Control Plan (QA/QC) describes procedures employed by BHP and its contractors that meet the needs of the Class "A" Water Licence and accepted scientific sampling, sample preservation and analytical protocols.

7.5.4 1998 Wildlife Monitoring

Title: 1997 Wildlife Monitoring Program Construction Phase

Prepared by: Golder Associates Ltd., January 1998

Description: Presents the results and discussions for the 1997 Wildlife Monitoring Program for the first year of the construction phase. The 1997 program followed on from previous studies conducted in 1995 and 1996 and focused on monitoring potential impacts of the construction phase of the project.

Title: Wildlife Effects Monitoring Plan

Prepared by: Golder Associates Ltd., March 1998

Description: Wildlife monitoring plan as developed using a risk-based approach to mitigation and monitoring. Stakeholders had input into this plan during a Wildlife Effects Workshop held in February in Yellowknife. Spatial and temporal boundaries of the study area, as well as wildlife specific monitoring tasks were documented.

7.5.5 1998 Aquatics Monitoring

Title: Stream Habitat Compensation Program: Panda Diversion Channel, Version 03, Final

Prepared by: BHP Diamonds Inc.

Description: Program and Plans developed as a Technical Working Document to facilitate the phased implementation strategy adopted for the program. A guide for creating and enhancing fish habitat as well as for implementation of a monitoring program. Overall goal is the promotion of stable, accessible, and effective diversion channel habitat. This document meets the DFO's requirements for authorization under the Fisheries Act.

Title: 1998 Aquatic Effects Monitoring Program (AEMP) Technical Report, and Appendices

Prepared by: Rescan™ Environmental Services, December 1998.

Description: A presentation of the results of the 1998 aquatic effects monitoring program (AEMP) focused primarily on lakes and streams in the Koala Watershed, downstream of mine operations. 1998 was the first year of post-baseline monitoring. The report presents the 1998 data, results, discussion, statistical analyses to determine

specified null hypotheses, as well as a comparison of 1998 data with baseline data to examine possible effects of project activities on the aquatic ecosystem.

Title: Panda Lake Diversion Channel: Sedimentation Management & Contingency Planning

Prepared by: Dillon Consulting Limited, February 1998

Description: Developed as part of the BHP's Stream Habitat Compensation Program. This plan outlines and describes requirements for the management of potential sedimentation associated with restoration activities at the Panda Diversion Channel and Grizzly Creek.

Title: 1998 Waste Rock Storage Area Seepage Survey

Prepared by: BHP Diamonds Inc., November 1998

Description: Documents result of the 1998 seepage survey of waste rock storage areas.

Title: Aquatic Effects Monitoring Program (AEMP) Technical Overview Working Document, Final

Prepared by: EVS Environmental Consultants, April 1998

Description: Presents details of the agreed to framework for the AEMP, finalized following discussions at a Technical Workshop held in February 1998, involving consultants, IEMA, regulatory bodies, and stakeholders.

7.5.6 1998 Environmental BAseline

Title: 1997 EKATI™ Mine Aquatic Monitoring Baseline Study

Prepared by: Rescan™ Environmental Services, January 1998

Description: Presents the results of the 1997 aquatic environmental monitoring program along with analyses of aquatic data obtained in previous years in the project area.

Title: Environmental Baseline Assessment: Point Lake, NWT

Prepared by: Bryant Environmental Consultants Ltd. and Beak International Incorporated, December 1998

Description: Results of environmental baseline study of Point Lake conducted in August 1998, the primary purpose of which was to provide reference information in support of

planned bulk sampling of a kimberlite pipe located beneath the lake. The study included collecting data and documenting bathymetry, hydrology, water and sediment quality, phytoplankton and zooplankton, benthos, and fish communities and habitat characterization.

Title: Sable Lake 1997 Fisheries Resource & Habitat Survey

Prepared by: Rescan™ Environmental Services Ltd., April 1998

Description: Results of environmental baseline study of Sable Lake conducted in 1997, the primary purpose of which was to provide reference information in support of a future Fisheries Authorization required for possible future mining of the Sable kimberlite, that had previously been bulk sampling by large diameter drilling. The study included collecting data and documenting limnology, water quality, and fish communities and habitat characterization.

Title: Zach Pond 1997 Fisheries Resource & Habitat Survey

Prepared by: Rescan™ Environmental Services Ltd., April 1998

Description: Results of environmental baseline study of Zach Pond conducted in 1997, the primary purpose of which was to provide reference information in support of planned bulk sampling of a kimberlite pipe located beneath the lake. The study included collecting data and documenting bathymetry, hydrology, water quality, and fish communities and habitat characterization.

Title: Environmental Baseline Assessment: Gazelle Lake, NWT

Prepared by: Bryant Environmental Consultants Ltd. and Beak International Incorporated, December 1998

Description: Results of environmental baseline study of Gazelle Lake conducted in August 1998, the primary purpose of which was to provide reference information in support of planned bulk sampling of a kimberlite pipe located beneath the lake. The study included collecting data and documenting bathymetry, hydrology, water and sediment quality, phytoplankton and zooplankton, benthos, and fish communities and habitat characterization.

Title: 1998 Larry Lake and Leslie Lake Reconnaissance Surveys

Prepared by: Rescan™ Environmental Services Ltd., December 1998

Description: Presents the results of reconnaissance surveys performed on Larry and Leslie Lakes which collected data regarding limnology, water chemistry, phytoplankton / zooplankton. The study was initiated in response to the 1997/98 IEMA Annual Report

that identified these lakes as being of potential concern due to history of potential impacts from various effluents.

Title: 1997 EKATI™ Mine Aquatic Monitoring Baseline Study and Appendices

Prepared by: Rescan™ Environmental Services Ltd., January 1998

Description: Results of baseline study of six lakes (Vulture, Grizzly, Kodiak, Moose, Nema, and Slipper) plus five stations in Lac de Gras, and two lakes outside the Koala Watershed (Nanuq and Counts) undertaken as part of the aquatic effects monitoring program (AEMP). Lakes and stations were sampled for water quality, sediment quality, limnological properties, primary and secondary producers. Includes data from previous years.

Title: Assessment of Kodiak Lake Mitigation for Oxygen Depletion - Report Brief

Prepared by: Dillon Consulting Limited, February 1998

Description: An assessment of BPH's response and follow-up mitigation to rapid oxygen depletion within Kodiak Lake. The potential severity of the effects of the oxygen decrease within the lake was identified. Further potential mitigation methods were researched and documented.

7.5.7 1998 Fish-Out Programs

Title: 1997 Lake Fish-Out Program: Koala Lake Report

Prepared by: Rescan™ Environmental Services Ltd., August 1998

Description: Presents the results of biological data collection of the fish-out program carried out on Koala Lake in preparation for mining activities. In addition, lake bathymetry, benthos and water quality surveys were performed. The report contains all the data required under the modified Fisheries Authorization.

Title: Airstrip Lake 1997 Fisheries Resource & Habitat Survey

Prepared by: Rescan™ Environmental Services Ltd., August 1998

Description: Presents the results of biological data collection of the fish-out program carried out on Airstrip Lake. The lake was dewatered so as to provide access to sand and gravel resources needed for construction. The report contains all the data required under the modified Fisheries Authorization requirements.

Title: 1997 Lake Fish-Out Program: Long Lake Data Report

Prepared by: Rescan™ Environmental Services Ltd., July 1998

Description: Presents the results of biological and limnological data collection of the fish-out program carried out on Long Lake in compliance with the Fisheries Authorization. The fish-out activities were carried out in preparation for water lowering and cell construction.

Title: 1997 Lake Fish-Out Program: Panda Lake Report

Prepared by: Kam River Environmental Services Ltd. and Rescan Environmental Services, July 1998

Description: Presents the results of limnological studies biological data collection of the fish-out program carried out on Panda Lake in preparation for mining activities. The report contains all the data required under the modified Fisheries Authorization.

7.5.8 1998 Revegetation / Reclamation

Title: Pilot Revegetation Studies at the Fox Portal Site , EKATI™ Diamond Mine, NWT- Third Annual Report

Prepared by: ABR Inc., August 1998

Description: The third annual report describes results of three components of revegetation studies at the Fox portal that includes use of different topdressings and plant materials, propogations studies of several plants, and germination testing. The studies were initiated to investigate techniques for rehabilitating areas disturbed by mining at the site.

7.5.9 1998 Geotechnical

Title: Contaminated Soil Landfarm As-Built Construction Report

Prepared by: EBA Engineering Consultants Ltd., October 1998

Description: Documents information pertaining to the construction of the contaminated soil landfarm facility. The purpose of the landfarm is to treat hydrocarbon contaminated soil, which results from accidental spills arising from various site activities.

Title: 1998 Phase I Tailings Dam and Panda Dam Inspection

Prepared by: EBA Engineering Consultants Ltd., August 1998

Description: Details the results of the 1998 annual inspection of the Panda Dam and Phase I Tailings Dam. Fulfills a requirement of the Class A Water License.

Title: 1998 Geotechnical Site Investigation

Prepared by: EBA Engineering Consultants Ltd., June 1998

Description: Presents the results of a surface geology assessment and a geotechnical site investigation carried out for the proposed Misery Sedimentation Pond impoundment structures, the Misery Biotite Schist Waste Rock Stockpile areas and the Panda/Koala Waste Rock Stockpile area.

Title: Final Design, Long Lake Intermediate Dykes

Prepared by: EBA Engineering Consultants Ltd., June 1998

Description: Summarizes available site geotechnical data and discusses the basis for selecting dyke design concepts that rely on crushed granite as the principal means of process water filtration. Presents the results of stability analyses and a construction plan.

Title: Construction Specifications, Long Lake Intermediate Dykes

Prepared by: EBA Engineering Consultants Ltd., June 1998

Description: Technical specifications for the four Intermediate Dykes, that are zoned rockfill dykes used to retain processed kimberlite and remove suspended solids from water that seeps through the dykes. The intermediate dykes subdivide the Processed Kimberlite Containment Area into five cells to facilitate the orderly placement of processed kimberlite and systematically control water quality.

Title: BPH Tailings Characterization Study

Prepared by: EBA Engineering Consultants Ltd., June 1998

Description: A re-evaluation of the physical characteristics of processed kimberlite by means of laboratory studies. A scope of work for a field study was also presented.

Title: EKATI™ Diamond Mine, Long Lake Outlet Dam, As-Built Construction Report

Prepared by: EBA Engineering Consultants Ltd., August 1998

Description: Documents information pertaining to the construction of the Long Lake Outlet Dam. The principal function of this dam is to retain excess processed kimberlite water within the Processed Kimberlite Containment Area and allow controlled discharge into Leslie Lake.

Title: 1998 Geotechnical Site Investigation, Misery Site Development and Panda/Koala Waste Rock Stockpile

Prepared by: EBA Engineering Consultants Ltd., June 1998

Description: Presents the results of a surface geology assessment and a geotechnical site investigation carried out for the proposed Misery Sedimentation Pond impoundment structures, the Misery Biotite Schist Waste Rock Stockpile areas and the Panda/Koala Waste Rock Stockpile area.

7.5.10 1998 Other Reports

Title: EKATI™ Mine Meteorology, Hydrology & Air Quality Studies: 1997 Environmental Data Report

Prepared by: Rescan™ Environmental Services Ltd., 1998

Description: Summarizes the key results of the 1997 meteorology, hydrology and air quality monitoring program.

Title: Air Quality Monitoring of the EKATI™ Mine Using Snow Surveys

Prepared by: BHP Diamonds Inc., August 1998

Description: Summarizes the key results of the snow survey monitoring program.

Title: Aquatic Toxicity Associated with Diamond Ore (Kimberlite) Mining

Appendix 1- Acute and Chronic Toxicity Assessment, Toxicity Identification Evaluation, Health and Body Condition Assessment

Appendix 2 – Histopathological Assessment

Appendix 3 – Stress and Reproductive (Circulating) Hormones Assessment

Appendix 4 – Immunological Hematological Assessment

Prepared by: Enviro-Test Laboratories, December 1998

Description: Presentation of methodology and results regarding the potential toxicity and sub-lethal effects of kimberlite solutions to aquatic organisms. The study involved both acute and chronic toxicity testing using aquatic organisms representative of the major trophic levels present in the aquatic receiving environment. This study was implemented as a condition of the Water Licence.

Title: BHP Diamonds Inc. Koala Mine: Meteorological Station Calibration

Prepared by: EnTech Environmental, January 1998

Description: Results of a performance audit of the Koala meteorological station. The performance audit consisted of calibration of wind speed, wind direction, relative humidity, and air temperature. The high volume air sampler operation and calibration procedure was also reviewed.

Title: EKATI™ Diamond Mine Environmental Agreement Annual Report 1997

Prepared by: BHP Diamonds Inc., April 1998

Description: A comprehensive review of all elements of the environmental programs at EKATI™ Diamond Mine as required by the Environmental Agreement (EA). The review includes requirements outlined in the EA, as well as environmental activities relevant to the environmental management of the mine.

7.6 1999 Reports

7.6.1 1999 Archaeology / Traditional Knowledge

Title: Five Years of Archaeological Research at the EKATI™ Diamond Mine, NT 1994-1999

Prepared by: Points West Heritage Consultants

Description: Compilation of available archaeological data for the mine claim block obtained from year 1994 through 1999.

Title: 1998 Archaeological Investigations for BHP Diamonds Inc. at the EKATI™ Diamond Mine

Prepared by: Points West Heritage Consultants Ltd., March 1999

Description: Describes the results of a continuing archaeological inventory and impact assessment of the development study area undertaken during 1998. This report includes field methodologies, characteristics and locations of each archaeological site discovered, assessments of site significance, potential impacts, and mitigation recommendations

7.6.2 1999 Environmental Assessment

Title: Project Description Proposed Development of Sable, Pigeon and Beartooth Kimberlite Pipes (Revision 3)

Prepared by: BHP Diamonds Inc., October 1999

Description: Describes the proposed new Pigeon, Beartooth, and Sable open pit mine developments and their integration into the existing EKATI™ Mine Plan. This document was submitted to the MVEIRB and provides a basis for the Environmental Assessment document.

7.6.3 1999 Wildlife Monitoring

Title: EKATI™ Diamond Mine: 1998 Wildlife Effects Monitoring Program (WEMP), Construction Phase

Prepared by: Golder Associates Inc., January 1999

Description: Presents the results and discussions for the 1998 WEMP. It also includes the results of work completed in 1995, 1996, and 1997. Caribou, grizzly bears, wolves, wolverines, upland breeding birds, loons, and raptors were studied. Residual impacts of mine activities were assessed with aerial surveys, detailed behavioral observations, mine traffic monitoring, landfill activities, and wildlife interactions with the Processed Kimberlite Containment Area.

7.6.4 1999 Aquatics Monitoring

Title: Panda Diversion Channel Monitoring Program, 1998 Final

Prepared by: Dillon Consulting Limited, January 1999

Description: Describes year one of a 10 year monitoring program to assess fish habitat utilization, function, and physical stability. This program is a Tier 2 secondary monitoring, special effects monitoring (SEM) program, part of the aquatic effects monitoring program (AEMP). Details for implementing this monitoring program are contained in the Stream Habitat Compensation Report.

Title: 1999 Kodiak Lake Sewage Effects Study Technical Report, 2 volumes including Appendices

Prepared by: Rescan™ Environmental Services, January, 1999

Description: The final year of a three year monitoring program undertaken to examine the effects of treated sewage effluent on the water quality, sediment quality, aquatic life (primary and secondary producers) and fish in Kodiak Lake and Kodiak-Little Stream.

Title: Kodiak Lake Management Plan – Modeling Component

Prepared by: Dillon Consulting Limited and Rescan Environmental Services Ltd, January 1999

Description: Description of the results of water quality modelling of Kodiak Lake undertaken to assess the long-term feasibility of using Kodiak Lake as the receiving body for treated sewage.

Title: Panda Diversion Channel Monitoring Program, 1998 Final

Prepared by: Dillon Consulting Limited, January 1999

Description: Describes year one of a 10 year monitoring program to assess fish habitat utilization, function, and physical stability. This program is a Tier 2 secondary monitoring, special effects monitoring (SEM) program, part of the aquatic effects monitoring program (AEMP). Details for implementing this monitoring program are contained in the Stream Habitat Compensation Report.

Title: 1998 Aquatic Effects Monitoring Program (AEMP) Overview Report

Prepared by: Rescan™ Environmental Services Ltd., March 1999

Description: Summarizes the results for the AEMP Tier 1 Program and Special Effects Monitoring (Tier 2) Programs conducted during 1998 field season. The Tier 2 programs results presented include the Kodiak Lake Sewage Effects Study and the Panda Diversion Channel Study. A reconnaissance level survey on Larry and Leslie Lake are also presented in this report.

Title: 1998 Kodiak Lake Sewage Effects Study Technical Report, 2 volumes including Appendices

Prepared by: Rescan™ Environmental Services, March 1999

Description: The second year of a three year monitoring program undertaken to examine the effects of treated sewage effluent on the water quality, sediment quality, aquatic life (primary and secondary producers) and fish in Kodiak Lake and Kodiak-Little Stream.

7.6.5 1999 Environmental Baseline

Title: King Pond 1999 Fish Community and Habitat Survey

Prepared by: Rescan™ Environmental Services Ltd., September 1999

Description: Summarizes the results of a fish habitat and resource survey of King Pond during summer 1999.

7.6.6 1999 Fish-out Programs

Title: 1998 Long Lake Cell C Fish Out Program Data Report

Prepared by: Rescan™ Environmental Services Ltd., April 1999

Description: Presents the results of biological and limnological data collection of the fish-out program carried out on Cell C of Long Lake in compliance with the Fisheries Authorization.

7.6.7 1999 Geotechnical

Title: Panda Diversion Channel Overlflow Remediation, Sta. 1+175 to 1+400 As-Built Construction Report

Prepared by: EBA Engineering Consultants Ltd., November 1999

Description: Documents construction aspects pertaining to the Panda Diversion Channel Overflow Remediation between Stations 1+175 and 1+400 and describes the construction materials, and practices. It provides a summary of the quality assurance testing conducted.

Title: Grizzly Creek Remediation Program , As-Built Construction Report

Prepared by: EBA Engineering Consultants Ltd., August 1999

Description: Documents the Grizzly Creek Remediation Program, which was constructed between late March and early May 1998. The purpose of the remediation program was to ensure positive drainage and provide continuity to Grizzly Creek, which will prevent erosion and degradation of the lacustrine lowland.

Title: Final Design, West Long Lake Watershed, Diversion Structures

Prepared by: EBA Engineering Consultants Ltd., February 1999

Description: Presents a design and construction work plan for the West Long Lake Watershed Diversion Structures. These structures are designed to direct a portion of the natural runoff normally entering Containment Cells A and D into Cell E. This will reduce the amount of natural runoff that encounters processed kimberlite and turbid water, thus maximizing the amount of runoff water that can be released annually from the containment area.

Title: Processed Kimberlite Containment Area, Intermediate Dyke "B" As-Built Construction Report

Prepared by: EBA Engineering Consultants Ltd., December 1999

Description: Documents information pertaining to the construction completion of Intermediate Dyke "B". It includes descriptions of the manner in which construction materials were produced, a summary of the quality assurance testing conducted, and documents construction activities and materials placement methodology.

Title: EKATI™ Diamond Mine – Long Lake Spillway Dam Final Design Report

Prepared by: EBA Engineering Consultants Ltd., August 1999

Description: Presents the design basis from the Spillway Dam, located at the south end tip of the Processed Kimberlite Containment Area. The Spillway Dam is designed as a zoned rock fill and processed coarse ore fill dam with a core of frozen sand and gravel and a cut-off trench containing a sand/bentonite mixture. Its principal function is to retain excess process water and allow controlled discharge into the natural environment at Leslie Lake, through a planned spill way just east of the dam.

Title: 1999 Annual Water Licence Geotechnical Inspection (1999)

Prepared by: EBA Engineering Consultants Ltd., July 1999

Description: Details the results of the 1999 annual inspection of the Outlet Dam, Panda Diversion Dam and Phase I Tailings Dam. Fulfills a requirement of the NWT Water Board for an annual geotechnical inspection of the onsite water retaining structures.

7.6.8 1999 Other Reports

Title: 1998 Annual Water Licence Report

Prepared by: BHP Diamonds Inc., March 1999

Description: Summary of compliance reports to the Water Board for the year 1998.

Title: Assessment of Temporary Snow Fence for Panda Diversion Channel, EKATI™ Mine Site

Prepared by: Rowan Williams Davies & Irwin, November 1999

Description: Results of a study undertaken to determine the optimal placement of a snow fence adjacent to the Panda Diversion Channel, to protect it from drifting snow. Part of the Panda Diversion Channel Management Plan.

Title: Conceptual Strategies for No Net Loss of Fish Habitat at the EKATI™ Mine

Prepared by: Rescan™ Environmental Services, May 1999

Description: A review of conceptual strategies that can be used to address applicable regulatory obligations that BHP has undertaken to satisfy DFO's "no net loss principle".

Title: Environmental Agreement, Annual Report 1998

Prepared by: BHP Diamonds Inc., April 1999

Description: A comprehensive annual review of all elements of the environmental programs at EKATI™ Diamond Mine during 1998 as required by the Environmental Agreement (EA). The review includes requirements outlined in the EA, as well as environmental activities relevant to the environmental management of the mine. A plain English summary of this report is also available.

Title: 1999 Waste Rock Storage Area Seepage Survey

Prepared by: BHP Diamonds Inc., November 1999

Description: Documents result of the 1999 seepage survey of waste rock storage areas.

Title: Application of the Fisheries Act to King Pond

Prepared by: Rescan™ Environmental Services Ltd., September 1999

Description: An analysis of the applicability of the Fisheries Act to King Pond.

Title: 1998 Air Quality Monitoring

Prepared by: BHP Diamonds Inc., 1999

Description: Results of the 1998 Air Quality Monitoring Program.

7.7 2000 Reports

7.7.1 2000 Aquatics Monitoring

Title: 1999 Aquatic Effects Monitoring Program (AEMP) Technical Report, and Appendices

Prepared by: Rescan™ Environmental Services, January 2000.

Description: A presentation of the results of the 1999 aquatic effects monitoring program (AEMP) focused primarily on lakes and streams in the Koala Watershed, downstream of mine operations. 1999 was the second year of post-baseline monitoring. The report presents the 1999 data, results, discussion, statistical analyses to determine specified null hypotheses, as well as a comparison of 1999 data with 1998 and baseline data to examine possible effects of project activities on the aquatic ecosystem.

Title: Panda Diversion Channel Monitoring Program, 1999

Prepared by: Dillon Consulting Limited, January 2000

Description: Describes year two of a 10 year monitoring program to assess fish habitat utilization, function, and physical stability. This program is a Tier 2 secondary monitoring, special effects monitoring (SEM) program, part of the aquatic effects monitoring program (AEMP). Details for implementing this monitoring program are contained in the Stream Habitat Compensation Report.

Title: 1999 Environmental Baseline Technical Report

Prepared by: Rescan™ Environmental Services, January 2000.

Description: Presents the results of the 1999 aquatic baseline studies conducted for lakes and streams that may be impacted by proposed development plans for new kimberlite targets on the property.

Title: 1999 Kodiak Lake Sewage Effects Study Technical Report, 2 volumes including Appendices

Prepared by: Rescan™ Environmental Services, January 2000

Description: Presents the results for the final year of a three year monitoring program undertaken to examine the effects of treated sewage effluent on the water quality, sediment quality, aquatic life (primary and secondary producers) and fish in Kodiak Lake and Kodiak-Little Stream.

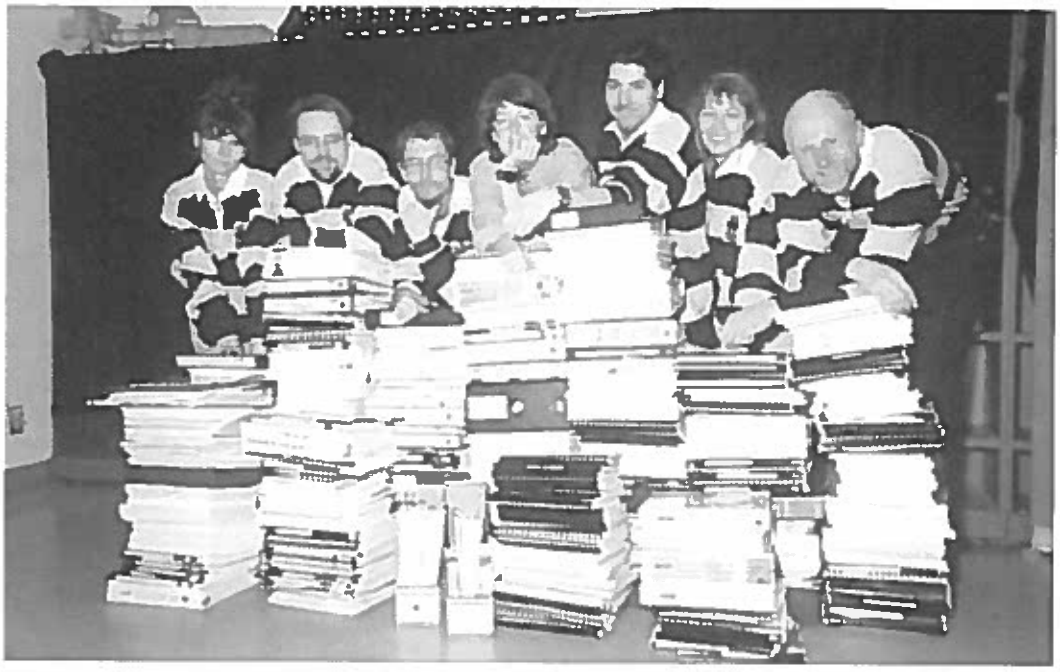


Plate 7.7-1 EKATI™'s Site Environmental Management team standing behind the collection of environmental reports, February 2000.

Title: Environmental Agreement Annual Report 1999

Prepared by: BHP Diamonds Inc.

Description: A comprehensive annual review of all elements of the environmental programs at EKATI™ Diamond Mine during 1999 as required by the Environmental Agreement (EA). The review includes requirements outlined in the EA, as well as environmental activities relevant to the environmental management of the mine. A plain English summary of this report is also available.

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APPENDIX A – BHP ENVIRONMENTAL AGREEMENT COMPLIANCE REPORT

BHP

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February 1, 2000

Gordon Lennie
Chairperson
Mackenzie Valley Environmental Impact Review Board
Box 938, 200 Scotia Centre
Yellowknife, NT X1A 2N7
Fax: 920-4671

Re: Compliance Report for BHP's proposed Beartooth, Pigeon and Sable Extension Project

Dear Mr. Lennie;

As directed by Section 4.2 of the Mackenzie Valley Environmental Impact Review Board (MVEIRB)'s Terms of Reference for the Beartooth, Pigeon and Sable Extension Project, "BHP is to include a brief and succinct compliance report from the Independent Environmental Monitoring Agency." (line 637-638). The Agency is pleased to assist the MVEIRB in this matter.

Under Article IV of the Environmental Agreement, the Agency has been established to be a public watchdog of the environmental management of EKATI™ Diamond Mine. It has the role to:

- **Independently review, report and make recommendations** on the environmental management of the mine, environmental effects monitoring programs, government regulation and compliance monitoring reports, as well as, the integration of traditional knowledge and Aboriginal experience in BHP's environmental plans and programs;
- **Facilitate an integrated approach** to management of the EKATI™'s environmental impact;
- Provide effective means to **bring Aboriginal Peoples and general public's concerns to BHP and government**; and,

- **Provide information** to Aboriginal Peoples and the public on EKATI™'s environmental management, including maintaining a public registry of environmental data, studies and reports, as well as, producing an annual report.

The attached compliance report evaluates BHP's environmental performance under the Environmental Agreement. BHP also holds a *NWT Water Board Class A Water License*, Department Of Indian And Northern Affairs land leases, quarry and land use permits, a *Harmful Alteration, Disruption or Destruction of Fish Habitat Authorisation* from the Department of Fisheries and Oceans, *Navigable Waters Protection Act Authorisation*, Government of the Northwest Territories (GNWT) *Hazardous Waste Generator Registration*, GNWT *Wildlife Research Permit*, as well as, NWT Archaeologists Permits. Our compliance report relates to these regulatory authorisations, but focuses on compliance with the Environmental Agreement. The Agency is not able to comment on instances of non-compliance that are still under investigation, as the relevant information is not yet public, nor available to the Agency.

If you require further information, the Agency's office can be reached at 867-669-9141, or on our website at www.monitoringagency.net.

Sincerely,

Red Pedersen
Chairperson

CC: Independent Environmental Monitoring Agency Society Members: Yellowknife Dene First Nation, Lutsel K'e Dene First Nation of Akaitcho Treaty 8, BHP, DIAND, Dogrib Treaty 11, GNWT, Kitikmeot Inuit Association and the North Slave Metis Alliance.

THE BHP ENVIRONMENTAL AGREEMENT COMPLIANCE REPORT

For
Mackenzie Valley Environmental Impact Review Board's
Environmental Assessment of

BHP Diamonds Inc.'s
Proposed Beartooth, Pigeon and Sable Kimberlite Pit Mine
Extension Project

Submitted by

The Independent Environmental Monitoring Agency

February 1, 2000

The Independent Environmental Monitoring Agency (The Agency) herein discusses BHP Diamonds Inc.'s compliance between 1997and 1999 within the context of the Environmental Agreement for the EKATI™ mine, specifically Article I, which explains the purpose and spirit of the Environmental Agreement; and, Articles V-XII, which deal with environmental impacts. (All references to "Article" relate to the Environment Agreement. For more information about the specifics of the Articles, please consult the Environmental Agreement.)

Article I: Statement of Purpose

Throughout the life of the Project, a number of tools have been informally created to assist in achieving an integrated and ecosystemic approach to mine management. Most of the instruments have arisen in response to a need for increased communication and coordination. These tools contribute to adaptive management, as they assist in a critical examination of the most pertinent issues and problem-solving by a wide variety of perspectives. They are, as follows:

The Inter-Agency Coordinating Team (IACT): The proponent, regulatory agencies and the Agency meet approximately every month in order to update each other on the technical aspects of the project and the regulation of existing authorisations. The IACT has been an integral part of ensuring that regulatory agencies, BHP and the Agency use a coordinated effort to manage and monitor the impacts of the Project.

The BHP February Workshops on Aquatic and Wildlife Effects: As a response to concerns regarding the aquatic and wildlife effects, BHP has instituted annual workshops in February for the purpose of getting input on these two management plans and monitoring programs. The February workshops have been an effective means of reporting results and soliciting input from scientists and traditional knowledge experts on monitoring decisions. They were essential to developing robust monitoring programs in year one; and, for continuing to improve these programs in subsequent years.

Public Outreach: The Agency meets with its Society Members in order to listen to concerns and provide updates on the environmental management of EKATI™. Community consultation, Agency newsletters, website and Annual Reports, as well as, BHP's Annual Reports, which include a plain English summary, help disseminate information to Aboriginal Peoples and the general public. All of the public information on the Project, and its impacts, is accessible to the public throughout the work week at the Agency's office. More efforts must be made on the part of all parties to increase the understanding of mine management by publishing more information in non-technical language.

Elders Visits: BHP has regularly invited the Aboriginal Elders with traditional knowledge to visit the EKATI™ mine site. BHP reports that traditional knowledge is being offered which can aid in the design of environmental plans and programs, as the Elders become more familiar with the site and mine management.

Traditional Knowledge Workshop: The Agency and BHP co-hosted a traditional knowledge workshop at the Smokehouse Café, N'Dilo in December 1998. The consideration of traditional knowledge (TK) in problem-solving and the review of documentation would be further enhanced by creating the Traditional Knowledge Working Group, as suggested by the Aboriginal organisations. Although consensus was reached by the participants of the workshop on the need for a Traditional Knowledge Working Group, the group has yet to be established since agreement on the terms of reference, representation and available resources has not been achieved.

Article V: Reporting Requirements

As per Article V, BHP has submitted annual reports for 1997 and 1998. Both documents describe activities and monitoring programs through out the year and provided the required information. BHP has improved the annual reports based on comments received from others, including the Agency. A more critical analysis of events with an eye to future improvements is needed. The reports would have been more useful if they had focused upon the unpredicted impacts and improvements made in adapting to the unexpected findings.

In addition to the annual report, BHP must produce a comprehensive report every three years "on the longer term effects of the project and the results of environmental monitoring programs and the actual performance of the Project in comparison to the results in the Impact Statement" (ArticleV.2.a). The document must also evaluate how BHP's adaptive management has performed to date. BHP has consulted the Agency and regulatory agencies on the Framework for the first Environmental Impact Report, which is due April 30, 2000.

Although BHP has made the annual reports available to the public and held meetings in affected communities to review and discuss the reports as required by Article V.3, the public discussion forum has been limited. In 1999, these consultations were combined with a full agenda also consisting of the proposed Beartooth, Pigeon, Sable Expansion Project and the socio-economic agreement. As a result, the Aboriginal organisations and general public have had little opportunity to reflect and comment on the 1998 annual report.

Article VI: Environmental Management Plans

BHP has captured all of the requirements for environmental management plans in the Construction Environmental Management Plan (CEMP) and Operating Environmental Management Plan (OEMP). The Agency did not recommend approval of the CEMP final plan based on the inadequacies of the aquatic and wildlife effects monitoring programs until they were revised, as a result of BHP's February 1998 workshops. The CEMP was found acceptable by the Agency in March 1998. This construction phase plan was eventually superceded by the OEMP.

The Operating Environmental Management Plan:

BHP revised the OEMP based on many of the recommendations of the Agency and other regulatory agencies. Aboriginal organisations and traditional knowledge holders were also given the opportunity to comment on the aquatic life and wildlife management plans through the February workshops (1998 & 1999) and Elders' visits.

The Agency suggested that BHP include the Wastewater and Tailings Management Plan, Waste Rock Management Plan, as well as, the results from related studies in the OEMP. BHP has agreed to amend the plan in this fashion for the next version of the OEMP, which is expected to be complete at the end of February 2000.

Furthermore, the Agency has asked to have more detail regarding the Environmental Management System described in the OEMP since it is crucial to describing how monitoring data are evaluated, programs adapted as required, and decisions are made within the company to deal with impacts to the environment. BHP has taken the position that the Environmental Management System is internal and proprietary, and, therefore, not subject to review by others.

Article VI.I also states that "such plans shall include, without limitation,": (a) quality control and assurance programs, (b) environmental awareness training, (c) regular on-site briefings, and (d) detailed environmental mitigation measures. The OEMP's *Support Document M* provides quality control and assurance programs for water quality testing only. An *Environmental Awareness Training Plan* is provided in *Support Document A* of the OEMP. Details of the environmental mitigation measures are provided in the environmental management plans of the OEMP.

Outstanding issues exist with respect to specific management plans. These issues are, as follows:

a. *Waste Rock Management:* BHP will store waste rock in the Panda, Koala and Misery dumps. The Agency has concerns related to the significant quantities of potentially acid generating biotite schist, which will be permanently deposited in the Misery waste rock dump. BHP believes that the Misery site will provide the necessary amount of neutralizing, alkaline rock to buffer any acid drainage. The Agency has recommended that additional minerological studies be conducted to identify the neutralising mineral since it is possible that the volume of neutralizing rock needed (*i.e.* neutralizing mineral) may not be available at the Misery site. In a letter to the Agency, dated January 4, 1999, the federal government agreed with the recommendation. BHP has yet to agree that the studies are necessary.

b. *Tailing Management*: The Wastewater and Tailing Management Plan (Sept. 1997) and Tailing Characterization Study (June 1998) were conducted by EBA Engineering Consultants for BHP. Between the two documents, there are inconsistencies in the information that have led the Agency to conclude that there may be problems in the future with respect to the room available in the Long Lake facility and the need to treat water before discharge. An evaluation of field testing results will help to resolve

this issue over time. It is expected that these results will be used to regularly update the Tailings Management Plan, as well as, the Restoration and Abandonment Plan

Article VII: Environmental Monitoring Programs

The current monitoring activities are generally meeting the environmental monitoring objectives related to the environmental components listed in Article VII.2.

Over the last three years, BHP's overall monitoring and compliance has been acceptable. The Department Of Indian And Northern Affairs (DIAND) Land Use Inspector and Geotechnical Engineers visit the site regularly to monitor compliance under the NWT Water Board Class "A" Water License and DIAND Land Use Permits. The Environment Canada inspector monitors hazardous waste management facilities and fuel handling facilities, as well as, compliance under Section 36 of the Fisheries Act. Generally, the compliance reports note BHP's willingness to comply with the terms and conditions of its authorisations. According to the inspection reports, incidences of non-compliance have been handled responsibly by the company.

A number of unpredicted project-related impacts to the aquatic ecosystem have been identified, which deserve particular attention:

a) *Sedimentation in Panda Diversion Channel* - The route of the Panda Diversion Channel passes through an area of ancient lake sediments near the mouth of Grizzly Creek. Erosion of these ice-rich materials resulted in sedimentation of bottom substrates within the channel itself and downstream in Kodiak Lake. Sedimentation in the channel degraded fish habitat for those species, principally grayling and slimy sculpin, that use the stream for spawning and as nursery, rearing and feeding areas. In 1998 BHP began a program to stabilize the area of erosion, enhance stream habitat for fish and replace culverts that were partial barriers to fish passage. This program continued in 1999. These changes have improved fish habitat and benefited fish populations. In 1998 and 1999, grayling spawned successfully in the channel. Other species (lake trout, round whitefish, slimy sculpins and burbot) were also observed in the channel.

Overall, the Agency is impressed with the success of the erosion stabilization and habitat enhancement program.

b) *Winter Oxygen Deficits in Kodiak Lake* - In early February 1998, a severe oxygen deficit developed in Kodiak Lake. The deficit was largely the result of bacterial degradation of organic substances in the lake. There were two major sources of these: first, sewage effluents from the sewage treatment plant, which were being disposed of in the lake; and second, algae, produced within the lake, which died and decayed. The amounts of sewage effluents entering the lake were near maximum since there were large numbers of construction personnel in camp as well as BHP's own employees. The production of algae within the lake was also very high because of heavy loadings of phosphorus, the limiting nutrient. The two largest sources of

this phosphorus were the sewage effluents and eroded materials from the Panda Diversion Channel.

When the problem of declining oxygen levels was identified, BHP acted promptly, aerating the waters of Kodiak Lake and modifying its sewage handling procedures. There is no evidence that the deficit was ever serious enough to harm overwintering fish. Aeration of Kodiak Lake has continued every winter since 1997/98. In 1998/99, Little Lake, immediately downstream of Kodiak was found to be developing a potentially serious oxygen deficit and it too has been aerated the last two winters.

Sewage effluents are no longer discharged to Kodiak Lake except under upset conditions and erosion from the Panda Diversion Channel is now under control. The problem of oxygen deficits will continue, however, because high levels of phosphorus are still present in the lake and continue to cycle internally. Flushing of this excess phosphorus will take an unknown number of years. In the meantime, it will affect the productivity of Kodiak Lake and other lakes downstream. There is evidence of enrichment (the process is called eutrophication) as far downstream as Slipper Lake, the lowermost in the drainage.

Delivery of Data: The exchange of information on the monitoring plans and programs has not always been effective since the Environmental Agreement does not stipulate exactly how information should be shared and with whom. The Agency has been generally satisfied with the delivery of monitoring data produced by the company.

Cumulative Effects: The region would benefit from a cumulative effects framework, which identifies valued ecosystem components, indicators of ecosystem health, land use planning objectives and thresholds of acceptable change. The design of the monitoring program could then be established according to the framework and results analyzed in the context of an integrated system, which tracks changes of the environment from various sources over time. No such programs are in place at this time, although DIAND recently hosted a workshop to develop a framework and BHP participated in the initiative. Furthermore, other significant developments in the area are in the project approval stage and, as a result, the usefulness of the monitoring data for cumulative effects monitoring as required by Article VII.4 has not been examined in its full context.

Article VIII: Closure and Reclamation Plan

Under Article VIII.I, BHP is required to prepare, in consultation and in cooperation with government agencies and the Monitoring Agency, a closure and reclamation plan by January 7, 1999. BHP submitted an *Interim Abandonment & Restoration Plan (A&R Plan)* to the Northwest Territories Water Board on October 1, 1997. The Water Board did not approve this plan as it was lacking in a number of areas. A revised plan was submitted in December 1998. This revised plan was approved by the NWT Water Board on June 29, 1999, although a number of deficiencies were noted for correction in later revisions. The Agency anticipates that the next annual review of the A&R plan will take into consideration these deficiencies especially in relation to the inadequacy of described

closure and reclamation plans for the Misery site. The Minister of DIAND has yet to approve the A&R plan under Article VIII.1.a.

Article IX: On-Going Environmental Compliance and Authorisations

The Monitoring Agency evaluates BHP's on-going environmental compliance by reviewing reports prepared by government inspectors and the company. **The Agency has detected no serious compliance issues with respect to overall environmental management of the site. Generally, the company's performance, and compliance with environmental regulations, standards and policies has been acceptable.**

Article IX also contains several specific requirements for the storage of fuel and hazardous chemicals on site. In response to repeated spills, the inspection reports indicate that BHP has instituted staff training procedures on fuel handling and awareness programs for spill response. It has also increased the effectiveness of its spill containment areas and decreased the chances of overflowing by installing gauges on fuel valves. Furthermore, BHP has corrected a problem with the storage facility of explosive material, which caused a hazard to birds.

With respect to the Phase I Tailings Containment Area, fluctuating ammonia levels have been indicated due to leaching from a waste disposal site permitted under BHP's Class "B" water license for bulk sampling. Following consultation with the DIAND inspector, areas have been lined and sedimentation ponds created to mitigate this impact as much as possible. All other mitigation measures will occur as a part of the reclamation process.

Article X: Archaeological Sites

As part of the OEMP's Archaeological Management Plan in *Support Document K*, BHP lists its procedures for identifying heritage sites, the sites already located and mitigation measures for each site. As a part of negotiating Impact Benefit Agreements (IBA) with the Dogrib Treaty 11 and Akaitcho Treaty 8, traditional knowledge holders worked with Jean Bussey, contract Archaeologist, on a pilot project to include TK in archaeological surveys. A letter, dated Feb. 26, 1999 invited all of the other Aboriginal organisations to participate in an expanded program. The Agency looks forward to hearing if BHP managed to complete the program in the 1999 field season.

Article XI: Traditional Knowledge

Article XI.I requires BHP to complete the Phase II Traditional Knowledge Studies in partnership with Aboriginal Peoples, to the greatest extent possible. The TK gathered in the Studies remains the property of the Aboriginal Peoples and may not be disclosed without their permission. Article XI.3 stipulates that "BHP shall incorporate all available TK in the Environmental Plans and Programs and shall give all available TK full

consideration along with other scientific knowledge as the Environmental Plans and Programs are developed and revised."

BHP is funding Phase II TK studies for the Kitikmeot Inuit Association, the Lutsel K'e Dene First Nation, the Yellowknives Dene First Nation, the Dogrib Treaty 11 and The North Slave Metis Alliance. The studies are in various stages of completion ranging from having not been started to nearing finalization. The focus of the studies range in topic and methodology. Although it is difficult to ascertain the usefulness of the studies so far to the environmental management of EKATI™ mine, geographical information system (GIS) databases are being created for a number of organisations, which may facilitate resource management and land use planning initiatives in the region. As TK is incorporated into BHP's management plans and monitoring programs, the annual reports and environmental impact reports should clearly indicate how and where TK improved the environmental management of EKATI™ mine.

In December 1998, The Agency and BHP co-hosted a Workshop at the Smokehouse Café in N'Dilo on the Phase II TK Studies. The study coordinators, Elders and researchers jointly proposed that a TK Working Group be formed. This Group has yet to come to fruition since its terms of reference are still not resolved between the Aboriginal groups and BHP. The Agency has recommended that the group be formed as soon as a resolution can be found on the structure and purpose of the Group.

Article XII: Studies and Research: Reclamation Plan

It is premature for the Agency to comment on the results of the revegetation and reclamation studies required under Article XII.1, as they are still on-going at the site. The Agency hopes to ascertain the effectiveness of these studies from BHP's next annual report.

Pursuant to Article XII.2, BHP submitted a *Report on the Aquatic Toxicity Associated with Kimberlite Mining*, completed by Enviro-test Laboratories in December 1998. Both Department of Fisheries and Oceans (DFO) and the Agency had concerns regarding the methodology used in the study. The use of control water and rainbow trout as a biomarker may not reflect the natural waterbodies actually receiving kimberlite tailings effluent. Kimberlite toxicity exists, but the exact cause has not been identified. BHP has agreed to participate in further lab and field studies co-ordinated by Environment Canada. A joint research proposal has been submitted by Environment Canada, which involves DIAND, DFO, BHP, Environment Canada and the University of Saskatchewan's Toxicology Centre.

Other Studies related to the Unpredicted Problems

In order to further understand the unpredicted water quality problems on site, recommendations for additional studies have been made. BHP completed the Kodiak Lake Sewage Effluent Study in March 1999. In response to an Agency recommendation,

BHP conducted reconnaissance surveys of Larry and Leslie Lakes in September 1998 in order to determine if similar eutrophication occurred as a result of exploration stage sewage disposal. Although similar effects were evident, on-going monitoring and mitigation is not necessary at this time.

Conclusion

BHP's environmental management and compliance has, to date, been good and improving. BHP, the regulatory authorities, the Aboriginal organisations and the Agency contribute to the on-going improvement of the environmental management at EKATI™. The company has made efforts to comply with the terms of its authorisations, as is evident from the available inspection reports. Overall, BHP has responded well to facing the challenges of being the first operating diamond mine in the North. The IACT meetings, annual workshops, regular meeting among stakeholders and Elders' visits have contributed significantly to meeting these challenges, especially related to aquatic effects and wildlife.

More opportunities exist for creating better partnerships with Aboriginal Peoples, especially with respect to incorporating traditional knowledge into environmental plans and programs. The Agency would welcome the opportunity to interact with the TK Working Group, should it be created.

In time, a more formalised mechanism to share information will arise and facilitate the early identification of environmental problems. A systematic means of addressing potential problems will develop and the impacts of the project will be better understood. By streamlining the process and fostering cooperation, more effort can then be directed towards the education of the communities and the public on the environment impact of EKATI™ and its mitigation.

BHP's Annual Report on Northern and Aboriginal Employment

Operational Phase – January 1, 1999 to December 31, 1999

On October 22, 1996, BHP Diamonds Inc. and the Government of the Northwest Territories entered into a Socio-Economic Agreement wherein the parties deemed that it was in their mutual interests to address certain socio-economic impacts relating to the BHP Diamonds Project, (EKATI™ Diamond Mine). BHP undertook to make available, to the greatest degree reasonably practicable, training, employment and business opportunities, to Aboriginals and Northern Residents, while the GNWT undertook to provide programmes to the people of the NWT to take advantage of the training, employment and business opportunities arising from the operations of the Project. Each of the parties are responsible for annual reports to monitor their progress in meeting their respective goals as set out in the Agreement.

This report represents the 1999 annual monitoring report of BHP's efforts in the employment commitments undertaken above. During the year 1999, BHP concluded its first full year of the Operational Phase at the EKATI™ Diamond Mine. October 1, 1998 to December 1998, in last year's report, represented the first three months of the Operational Phase. The figures in this report show 1999 annual statistics. Future annual reports will reflect annual results of the Operation Phase until the close of the Mine.

The GNWT and BHP have previously agreed to meet annually to discuss not only the contents of this report but also those reports which have been prepared concurrently by the GNWT in order to consult with local boards, communities and organizations. The information contained herein is presented for these discussions. Please note that these figures, as with previous years, are presented in aggregate to protect the confidentiality of the Aboriginal IBA's and Contractors' private records.

Methodology and Assumptions

Throughout this report certain methodologies and assumptions have been used by BHP Diamonds Inc. to objectively develop and measure its commitments. It is the intent of this section of the report to highlight the main assumptions/methodologies utilized and to provide further clarification, when needed, in specific sections.

Definitions

Certain words and phrases are used throughout this report. These meanings are taken from Section 1.1, Definitions, Socio-Economic Agreement and are included here for easy reference. The Agreement's Definition and Extended Meaning clauses should be consulted for further clarity if the context requires. Other meanings are BHP's definitions based on the use of the word throughout the report.

Northern Resident – means a person:

a) who maintains a self-contained domestic establishment in the Northwest Territories other than a residence at a remote work site, and who primarily resides at that domestic establishment when not residing at a remote work site or attending an educational institution full time, and

b) who has continuously been a Northwest Territories resident for a period of at least six months immediately prior to being hired, or is an Aboriginal.

For the purpose of determining whether a person is a Northern Resident, the possession of a Northwest Territories Health Card, with an address other than that of the Mine or a transient address at another remote mines site, shall be *prima facie* evidence of Northern Resident status. (See Socio-Economic Agreement - Section 1.2.3)

Aboriginal – means any Indian, Inuit or Metis person who is indigenous to the Northwest Territories.

Contractor – means each and every contractor and sub-contractor used by BHP for the Project.

Operations - means every kind of work done or in respect to the production and the abandonment of the Mine including, investigating, exploring, developing and maintaining the Mines, preparing reports, estimates and studies, designing, equipping, improving, surveying, constructing, coring, mining, processing, rehabilitation, reclamation and environmental protection.

Operational Phase – means that period of time commencing on the date that the first Mine goes into commercial production (when diamonds in sizable quantities are recovered and offered for sale on a regular basis) within the Claim Block, until the permanent closure of the last Mine of the Project.

Person Year – One person year shall equal 1725 hours per year. The Person Year calculation does not include vacation, statutory holidays and assumes no sick days. *(The basis for the calculation is 7.5 hours per day x 5 days per week x 46 weeks per year = 1725 hours per person year.)* Each Contractor, sub-contractor and employee of BHP has provided BHP with the total number of hours worked by their employees in the reporting calendar year.

Employee – For the purpose of this report, "employee" shall refer to the number of individuals who have worked in connection with the EKATI™ Diamond Mine, irrespective of the number of hours worked.

Time Period

For the purposes of this report the Operational Phase shall consist of annual statistics gathered from January 1, 1999 to December 31, 1999. (See Schedule "B", Employment Objectives, Operation Phase, Socio-Economic Agreement) It should be noted that presently the Mine is operating at the 9,000 t/d level, and thus those applicable target percentages shall apply.

Contractor statistics will consist of the length of time for their individual contract. For example, if a Contractor ended their service in May 1999 their figures will reflect that period and would necessarily end in May, even though the Operational Phase continues on. The compilation of hours worked and the calculation of person years will ultimately reflect the proportionate time a Contractor's employees actually worked at the EKATI™ Diamond Mine.

Women's Traditional vs. Non-traditional Occupations

As stated in previous years, several arbitrary decisions were made by BHP as to what was considered to be traditional and non-traditional occupations by women. BHP acknowledges that there can be cultural, societal and regional confusion and misunderstanding in making blanket assumptions. BHP makes no representation of expert authority nor does it attribute any political judgement on the distinction it has made herein. Rather, the assumptions are made purely for the purposes of reporting the information which has been requested. Arguably, any woman who works for a mining company or its contractors might, in some circles, be considered non-traditional. BHP utilized a simple approach that if a woman worked outside the

home, was not a nurse, secretary, teacher or other historically categorized female occupation, their jobs would be considered, for the purposes of this report, to be non-traditional.

Classification of Job Categories

Job categories have been classified into four (4) classifications. They are:

Professional – degree or twenty (20) years experience plus
Skilled – College / Techncial School diploma, certificate, specialized trades
Semi-skilled – GED and related work-experienced, e.g., equipment operator
Unskilled – labourer, non-specialized workers, etc.

Note: Each Contractor was asked to provide their internal job title to their employee list. BHP sorted those descriptions into the above listed categories. (See Appendix for detailed classifications of job categories)

Employment Target Objectives

Pursuant to Schedule "B" of the Socio-Economic Agreement, BHP identified certain targets in reference to employment during the Operational Phase of the EKATI™ Diamond Mine. (Operations are currently at the 9,000 t/d levels.) They are:

Northern Resident Employment	–	*62% of the total employment, including Contractors*
Aboriginal Employment	–	*50% of the Northern Resident employment (31% of the total)*

Calculations of Employment Figures

BHP Diamonds Inc.'s internal statistics and its Contractors statistical results for 1999 are combined in this report since the commitment made by BHP under the GNWT Socio-Economic Agreement is an aggregate number based on BHP and its Contractors' performance. Contractors utilized during the Operational Phase are listed in the Appendix.

Some of the Contractors are small, specialized or not in a position to hire, preferentially, any new employees, (Sec. 4.2.3, GNWT SE Agmt, the GNWT acknowledges this practice) nevertheless, their employment numbers were added into the totals.

Contractors who were awarded contracts wherein hiring was anticipated were required to adhere to BHP's hiring policies, where reasonably practicable, and therefore report detailed statistics (names of individuals, hours, etc.).

1999 Statistical Results

OPERATIONAL PHASE

Comparative charts are provided immediately following this section to compare data on a pecentage basis.

Total Number of Employees and Person Years

1. The approximate total number of employees of BHP Diamonds Inc. and its Contractors:

TOTAL BHP EMPLOYEES:	600
TOTAL CONTRACTOR:	892
	1,492

2. The total number of employee hours worked:

TOTAL BHP HOURS:	1,037,524
TOTAL CONTRACTOR:	510,969
	1,548,493

3. The total number of employee person years:

TOTAL BHP PERSON YEARS:	601.5
TOTAL CONTRACTOR:	296.2
	897.7

Total Number of Northern Residents and Person Years Worked

1. *The total number of Northern Residents:*

TOTAL BHP RESIDENTS:	482
TOTAL CONTRACTOR:	471
	953

2. *The total number of Northern Resident hours worked:*

TOTAL BHP HOURS:	821,332
TOTAL CONTRACTOR:	258,890
	1,080,222

3. *The total number of Northern Resident person years:*

TOTAL BHP PERSON YEARS:	476.1
TOTAL CONTRACTOR:	150.1
	626.2

Total Number of Aboriginal Employees and Person Years Worked

1. *The total number of Aboriginal Employees:*

TOTAL BHP ABORIGINAL EMPLOYEES:	253
TOTAL CONTRACTOR:	193
	446

2. *The total number of Aboriginal hours worked:*

TOTAL BHP ABORIGINAL HOURS:	417,748
TOTAL CONTRACTOR:	95,975
	513,723

3. *The total number of Aboriginal person years:*

TOTAL BHP ABORIGINAL PERSON YEARS:	242.2
TOTAL CONTRACTOR:	55.6
	297.8

Classification of Employment Totals by Job Category

1. *Number of Professionals:*

TOTAL BHP:	71
TOTAL CONTRACTOR:	106
	177

2. *Number of Skilled Jobs*:

TOTAL BHP :	257
TOTAL CONTRACTOR:	458
	715

3. *Number of Semi-skilled Jobs:*

TOTAL BHP :	218
TOTAL CONTRACTOR:	124
	342

4. *Number of Unskilled Jobs*:

TOTAL BHP:	54
TOTAL CONTRACTOR:	204
	258

Total Number of Jobs Held by Women/Traditional vs. Non-Traditional Roles

1. *The approximate total number of women employed:*

TOTAL BHP WOMEN EMPLOYED:	108
TOTAL CONTRACTOR:	107
	215

2. *Total number of women in traditional job roles*:

BHP TOTAL:	30
CONTRACTOR TOTAL:	76
	106

3. *Total number of women in non-traditional job roles*:

BHP TOTAL:	77
CONTRACTOR TOTAL:	32
	109

COMPARATIVE STATISTICS / CHARTS

1999 OPERATIONAL PHASE

Chart 1: Employment Performance - Hiring Targets

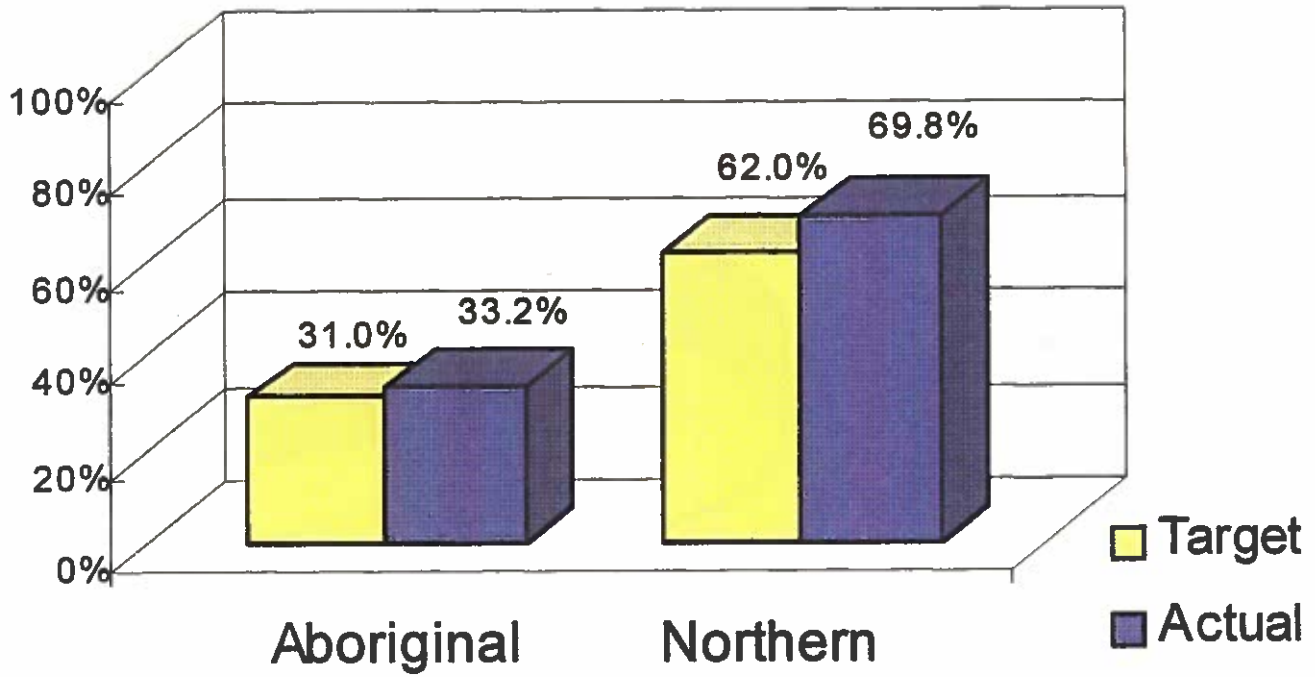


Chart 2: Job Classification

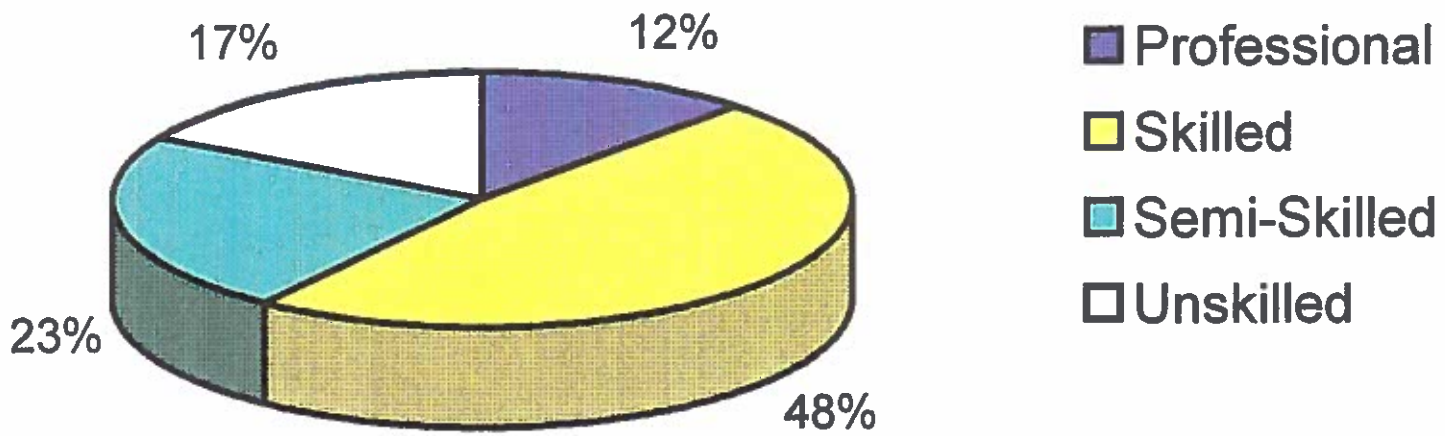


Chart 3A: Distribution of Unskilled Positions

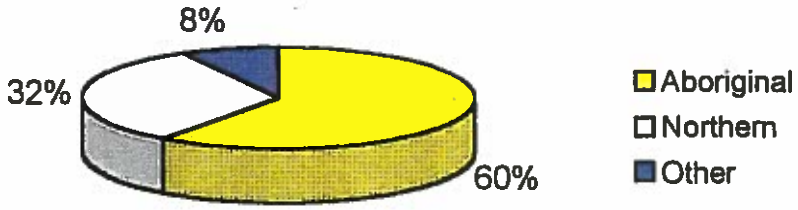


Chart 3B: Distribution of Semi-Skilled Positions

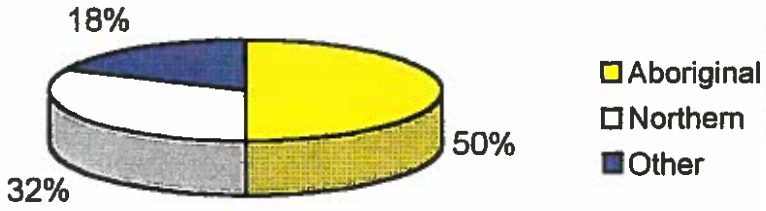


Chart 3C: Distribution of Skilled Positions

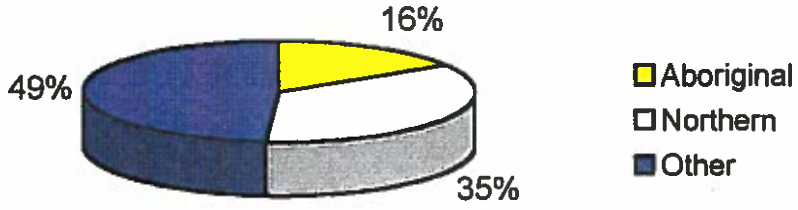


Chart 3D: Distribution of Professional Positions

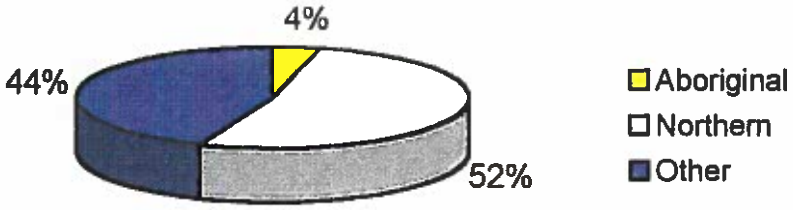


Chart 4A: Gender Distribution

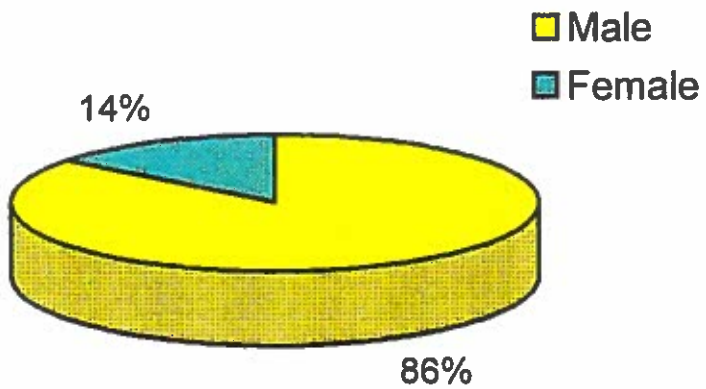


Chart 4B: Employment of Women

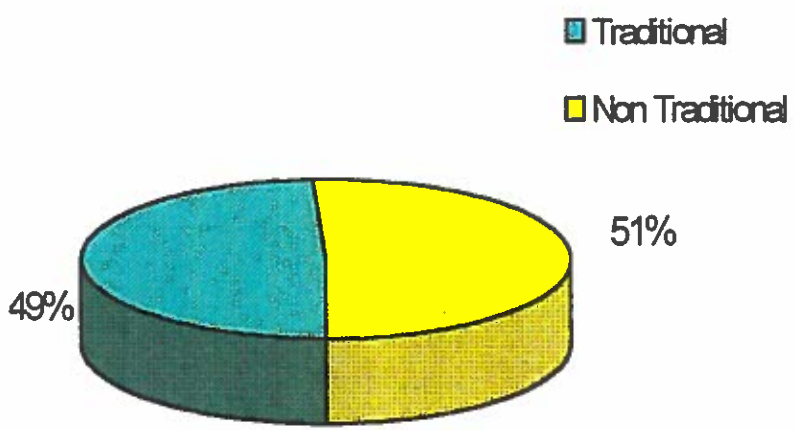
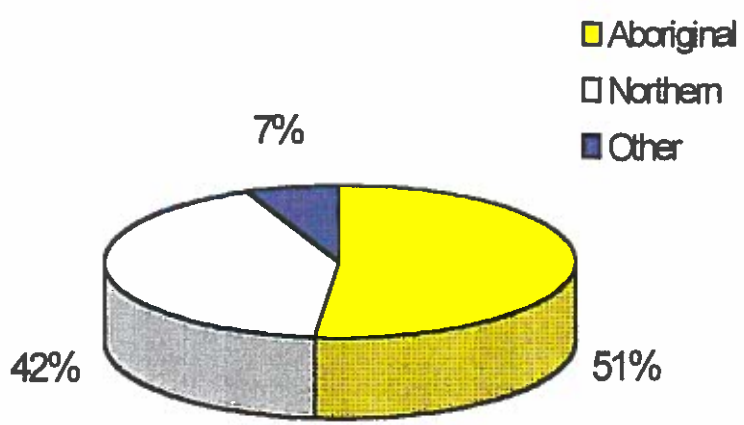


Chart 4C: Women in the Workforce



Conclusion

Target Percentages – Operational Phase

The Socio-Economic Agreement sets, as an objective, Northern Resident employment at 62% of the total employment, including Contractors. Aboriginal employment was targeted to be 50% of the Northern Resident employment or 31% of the total employment. (Schedule "B", Employment Objectives, Operation Phase) Based on person hours worked from January 1, 1999 to December 31, 1999, Northern Resident employment reached 69.8% while Aboriginal employment was 33.2% of the total employment. Other statistical data is provided pursuant to the requirements of the Agreement and are placed in charts to give comparative analyses.

This Socio-Economic report was compiled to provide statistical data which serves as the basis for further discussions between BHP and the GNWT.

ANNUAL REPORT ON

LOCAL PURCHASES

1999 OPERATIONAL PHASE

Annual Report on Local Puchases

Operational Phase – January 1, 1999 to December 31, 1999

Introduction

The Socio-Economic Agreement for the BHP Diamonds Project (EKATI™ Diamond Mine), dated October 22, 1996, provides for a series of annual monitoring reports for local business expenditures made by BHP Diamonds Inc. (BHP) during the Operational Phase. This report covers Northern Local Purchases for 1999. Previous reports have covered business expenditures in 1996, 1997 and 1998 respectively.

Results

Schedule G of the Agreement, entitled "Business Objectives, Operational Phase", outlines the information to be contained in the annual reports for the Operational Phase. In addition, Schedule H of the Agreement outlines a number of principles to be followed for the monitoring of activities. The following information is organized in accordance with these requirements and principles:

1. Total value of goods and services purchased during the Operational Phase.

   The total value of goods and services purchased by BHP during the 1999 calendar year was $356,072,300.

   Of this total, $280,329,483 or about 78.7%, was purchased from Northern Local Businesses.

2. Total value of goods and services purchased through Local Businesses by geographic location:

Yellowknife	$ 271,130,441	96.7%
Hay River	$ 8,921,826	3.2%
Other NWT	$ 277,216	0.1%

3. Value of Local Business purchases by industry categories:

   This information is provided in Table 1.

Table 1: 1999 Northern Spending – Local Business Purchases by Industry Category					
Category	Northern	Aboriginal	Total Northern and Aboriginal	Other	Total Spending
Air Support	$ 0	$ 6,980,283	$ 6,980,283	$ 69,325	$ 7,049,608
Rent and Accomodation	$ 0	$ 451,500	$ 451,500	$ 39,028	$ 490,528
Land Freight	$ 3,200,300	$ 212,300	$ 3,412,600	$ 0	$ 3,412,600
Contractors	$ 5,149,200	$ 2,187,600	$ 7,336,800	$ 27,900	$ 7,364,700
Northern Labour Services	$ 0	$ 8,428,000	$ 8,428,000	$ 304,900	$ 8,732,900
Community Relations	$ 0	$ 233,600	$ 233,600	$ 0	$ 233,600
Goods and Services	$ 176,453,233	$ 28,181,267	$ 204,634,500	$ 75,167,964	$ 279,802,464
Fuel	$ 26,706,620	$ 5,024,880	$ 31,731,500	$ 0	$ 31,731,500
Fees, Licences, Assessments	$ 16,987,000	$ 133,700	$ 17,120,700	$ 133,700	$ 17,254,400
Total	**$ 228,496,353**	**$ 51,833,130**	**$ 280,329,483**	**$75,742,817**	**$ 356,072,300**

Table 2: 1999 Northern Spending by Geographic Area	
Cambridge	$ 60,972
Fort Smith	$ 75,800
Gameti	$ 44,556
Hay River	$ 8,921,826
Inuvik	$ 3,700
Kugluktuk	$ 6,700
Lutsel K'e	$ 33,653
Rae	$ 114,891
Wha Ti	$ 406
Yellowknife	$ 271,066,979
1999 Total Northern Spending	**$ 280,329,483**

4. Total annual value of goods and services purchased through Aboriginal Local Businesses:

   The total value of goods and services purchased from Aboriginal Local Businesses was $51,833,130.00 or 18.5% of the Northern Local Purchases.

Achievement of Target

The Socio-Economic Agreement sets, as an objective, that Northern Local Businesses will supply 70% of the total annual value of goods and services purchased during the Operations Phase.

In 1999, as in 1996, 1997 and 1998, this objective was exceeded by a substantial margin, with about 78.7% of 1999 purchases being made from Northern Local Businesses. Of these purchases 18.5 % were from Aboriginal businesses.

METHODOLOGY AND ASSUMPTIONS

Time Period

The Operational Phase covered by this Annual Report begins January 1, 1999 and continues through December 31, 1999.

Categorization of Vendors

All of BHP Diamond Inc.'s vendors have been categorized by:

1. Industry type - The industry type were developed by BHP Diamonds Inc. have been revised to reflect new coding procedures instituted for the Operational Phase and represent a logical breakdown of the major areas of expenditure. Table 1 shows these types according to the following code:

   1 – Air Support
   2 – Rent & Accommodations
   3 – Land Freight
   4 – Contractors
   5 – Northern Labour Service
   6 – Community Relations
   7 – Goods & Services
   8 – Fuel & Lubes
   9 – Fees, Licenses, Assessments

2. Geographic location - Location is determined according to the NWT community where the address of the main business office is located.

3. Local or other - "Local Business" is defined in the Socio-Economic Agreement as any business organization in which Northern Residents have substantial management authority or in which Northern Residents have a significant working interest.

   In order to reflect this definition on a practical level, each business in the vendor list was classified as "Local" or "Other" based on the following criteria:

   - The location of an office and management staff which BHP deals with and issues cheques to;
   - Registration as a NWT company (as identified in BHP's "Community Suppliers Survey"); and
   - Whether the business has identified itself as having significant Aboriginal ownership.

4. Aboriginal - A business was classified as Aboriginal according to whether there is a significant Aboriginal ownership, as identified in BHP's "Community Suppliers Survey" and other directories.

COMPARATIVE STATISTICS / CHARTS

1999 OPERATIONAL PHASE

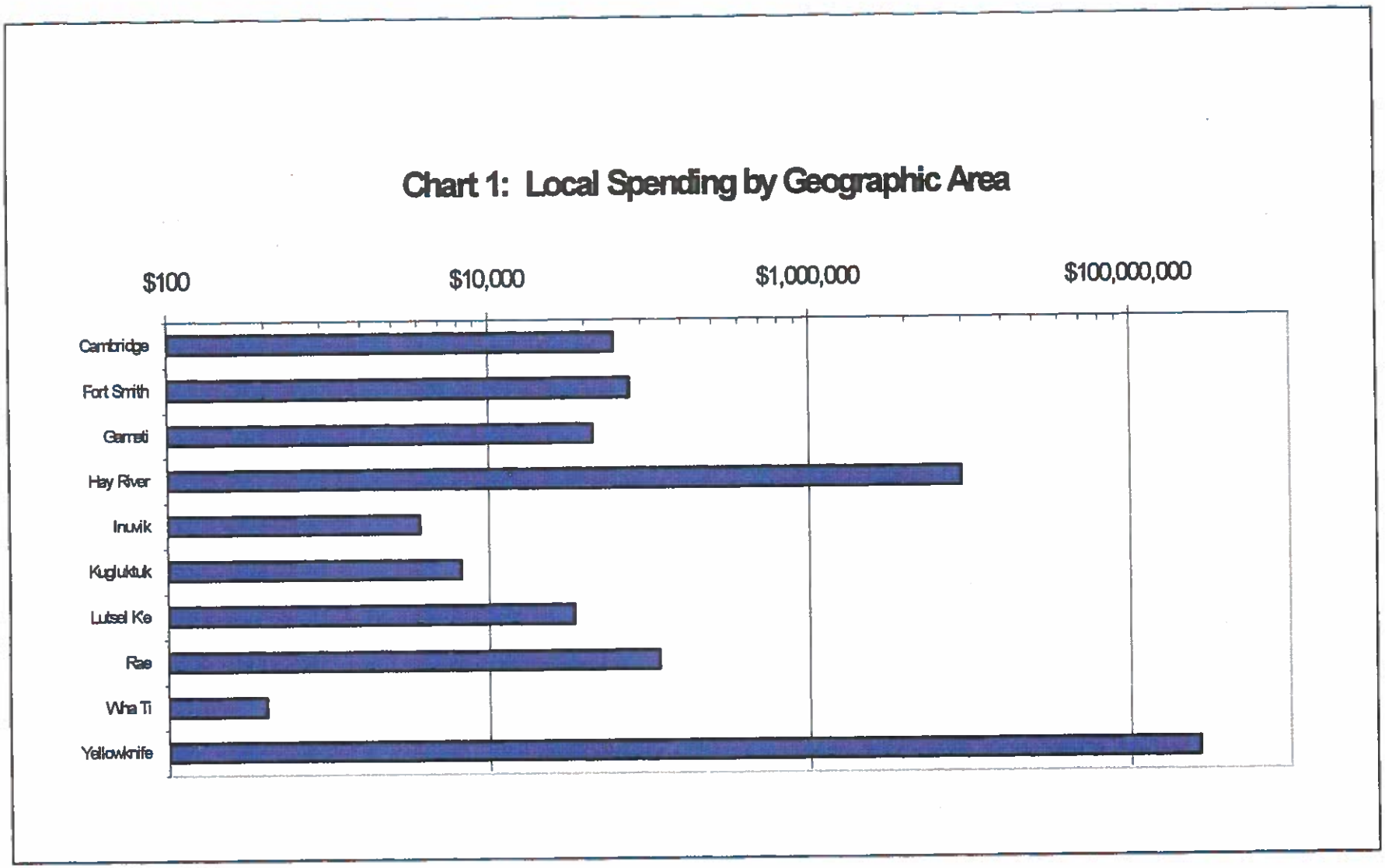
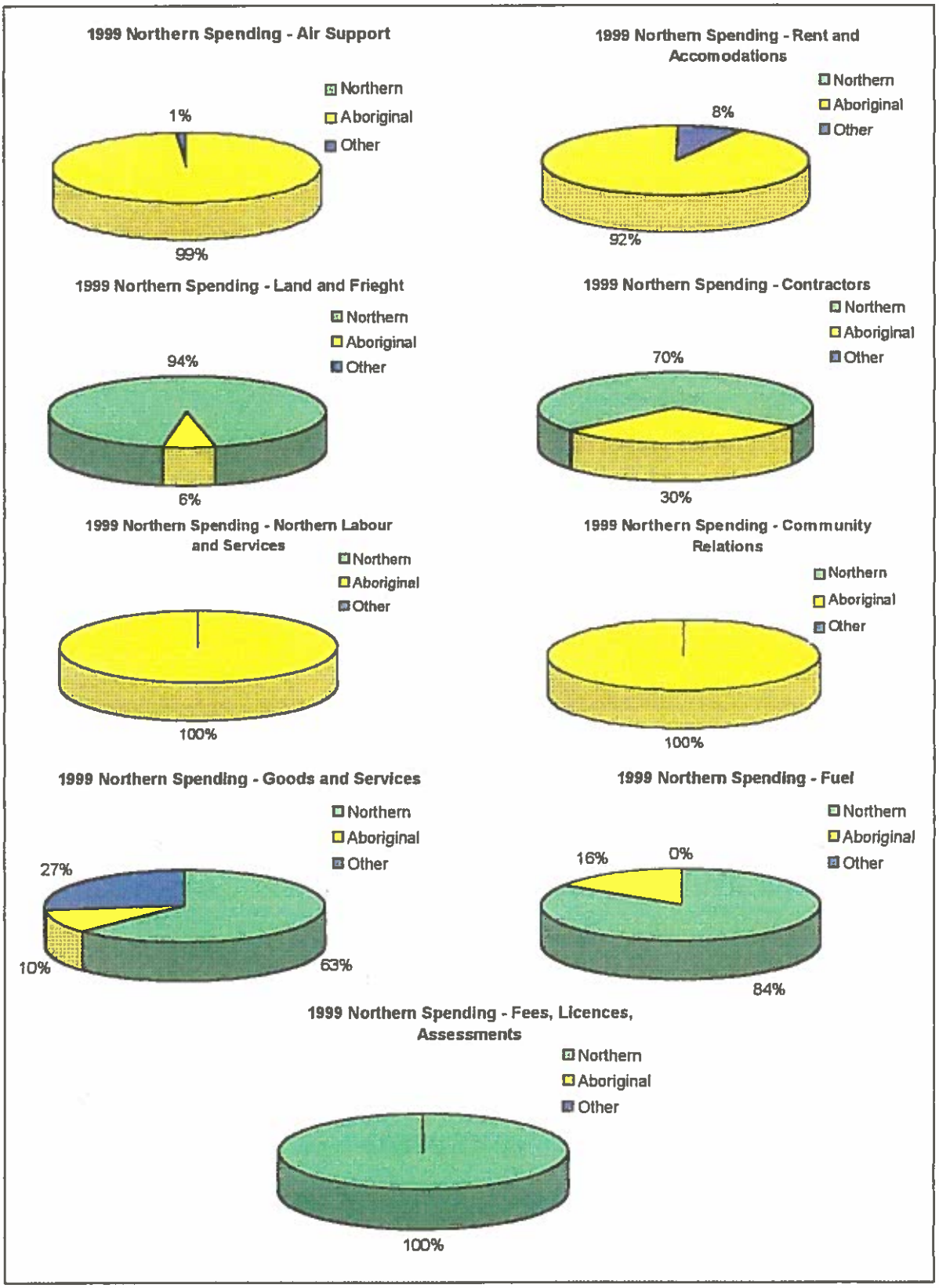


Chart 1: Local Spending by Geographic Area
$100
$10,000
$1,000,000
$100,000,000
Cambridge
Fort Smith
Garnati
Hay River
Inuvik
Kuglukluk
Lutsel Ke
Rae
Wha Ti
Yellowknife


1999 Northern Spending - Air Support
Northern
Aboriginal
Other
1%
99%
1999 Northern Spending - Rent and Accomodations
Northern
Aboriginal
Other
8%
92%
1999 Northern Spending - Land and Frieght
Northern
Aboriginal
Other
94%
6%
1999 Northern Spending - Contractors
Northern
Aboriginal
Other
70%
30%
1999 Northern Spending - Northern Labour and Services
Northern
Aboriginal
Other
100%
1999 Northern Spending - Community Relations
Northern
Aboriginal
Other
100%
1999 Northern Spending - Goods and Services
Northern
Aboriginal
Other
27%
10%
63%
1999 Northern Spending - Fuel
Northern
Aboriginal
Other
16%
0%
84%
1999 Northern Spending - Fees, Licences, Assessments
Northern
Aboriginal
Other
100%

SOCIO-ECONOMIC AGREEMENT REPORT

1999 OPERATIONAL PHASE

APPENDICES

BHP, Contractors and Sub-Contractors
Operational Phase 1999

AD Williams Engineering
ABR
ADCO North
Air Tindi
Alberta Rewind & Pump
Approach Nav Systems
Archie Beaulieu
ACS
Back Bay Welding
Blue Smoke Firework
Braden Burry Exp.
Camillus Engineering
Canadian Boiler Industries
Carealot Cleaning
Central Mechanical
Crane Safety
Dillon Consulting
EBA Engineering
Elite Commercial Flooring
Finning Power Systems
Fitzgerald Carpeting
Fynsott
GKO Engineering
Golder Associates
Grant Custom Carpentry
Great Slave Helicopter
Honeywell
Hydro Blast
Industrial Equipment
Johnson Controls
JT Electric
JT Thomas/Major Drilling
Karpon Konsy
Kaverit Steel & Crane
Kingland Ford
Klemke Mining
Ledcor
Levitt Safety
Lutra Associates
Nahanni Construction
Ninety North Construction
Norpo
Northern Metallic
Norwesco
NSM Industrial
Nuna Logistics
NWT McCaws JV
NWT Rock
Overhead Door
Paul Bros. Welding
Polar Explosives
Polar Painting
Rescan Environmental
RTL Robinson
Runge Canada
Secure Check
Siemes Building
Silverado Painting
Simplex International
Sodoxho Marriott Services
Sub-Arctic Surveys
Supreme Steel
Territorial Refrigeration
Wash Tub
Thermon Heat
Thyssen Dover Elevators
Tire North
Tli Cho Domco
Tli Cho Logistics
Transwest Mining Systems
Tundra Site Services
Two Way Enterprises
Wenco Int'l Mining Systems

Typical Jobs Available in Mining			
Position	Skill Level	Position	Skill Level
Aboriginal Affairs Coordinator	P	Instrument Technicians	S
Accountants	P	Lab Technician	S
Administration Manager	P	Machinist	S
Camp Management	P	Mechanics	S
Chief Accountant	P	Millwright	S
Chief Geologist	P	Operator / Electrician	S
Chief Maintenance Engineer	P	Power Crew	S
Chief Mine Engineer	P	Prep. Plant Foreman	S
Environmental Chemist	P	Prep. Plant Operators	S
Environmental Engineer	P	Purchasing Agent	S
Environmental Supervisor	P	Purchasing Supervisor	S
Geologist	P	Recovery Plant Foreman	S
Human Resources Manager	P	Recovery Plant Operator	S
Maintenance Manager	P	Rodman Technician	S
Mechanic Superintendent	P	Secretarial	S
Metallurgist	P	Security Controller, Site	S
Mine Engineer	P	Security Supervisor	S
Mine Superintendent	P	Senior Warehouseman	S
Nurse	P	Shift Foreman	S
Operations Manager	P	Skip Loader	S
Personnel Superintendent	P	Statistician	S
Planner (Plant)	P	Supervisor	S
Plant Superintendent	P	Tailings Operator	S
Production Manager	P	Technical Services Supervisor	S
Safety Advisor	P	Technicians	S
Safety Engineer	P	Trainer	S
Security Manager	P	Training Supervisor	S
Senior Accountant	P	Warehouse	S
Senior Engineer	P	Warehouse Supervisor	S
Senior Mine Engineer	P	Warehouseman	S
Surveyor	P	Welder	S
Underground General	P	Clerks	S / SS
Underground Mine	P	Construction Crew	S / SS
Employee Relations Officer	P / S	Fuel / Lube / Oil	S / SS
Administration Supervisor	S	Apprentices	SS
Air Control	S	Crusher Operators	SS
Blaster	S	Dozer Operator	SS
Cager	S	Drift Support	SS
Camp Foreman	S	Drivers	SS
Chute Puller	S	General Operators	SS
Draftsman	S	Grader Operator	SS
Drift Maintenance	S	Loader Operator	SS
Driller	S	Operators	SS
Electrical Supervisor	S	Security Officer	SS
Electricians	S	Shovel Operator	SS
Expediter	S	Stockpile Reclaim	SS
First Aid Attendant	S	Transport	SS
Foreman	S	Truck Driver	SS
Foreman (Production)	S	Truck Driver	SS
Foreman (Shift)	S	Water Truck Driver	SS
Foreman (Underground)	S	Wheel Dozer Operator	SS
General Foreman	S	Clerks	SS / S
General Foreman (Ancil.)	S	Helpers	US
General Foreman (Mine)	S	Helpers	US
General Foreman (Plant)	S	Labourer	US
General Foreman (Power)	S	Recovery Plant Labourer	US
Health & Safety Supervisor	S	Blaster's Helper	US / SS
Hoist Operator	S		

Northern and Aboriginal Employment
1999 Operational Phase (January 1, 1999 – December 31, 1999)

Table 1: Contractor and BHP Employment Statistics

		Contractors	BHP	1999 Total
1	Number of Employees.	892	600	1492
2	Total number of employee hours worked.	510,969.0	1,037,524	1,548,493
3	Total number of employee person years.	296.2	601.5	898
4	Total number of northern residents.	471	482	953
5	Total number of northern resident hours worked.	258,890	821,332	1,080,222
6	Total number of northern resident / person years.	150.1	476.1	626
7	Total number of northern aboriginal employees.	185	253	438
8	Total number of northern aboriginal hours worked.	95,975.0	417,748	513,723
9	Total number of northern aboriginal person years.	55.6	242.2	298
10	Number of professional jobs.	106	71	177
11	Number of skilled jobs.	458	257	715
12	Number of semi-skilled jobs.	124	218	342
13	Number of unskilled jobs	204	54	258
14	Total number of women employed.	107	108	215
15	Total number of women in traditional jobs.	76	30	106
16	Total number of women in non-traditional jobs.	32	77	109

Table 2: Distribution of Positions by Skill Level

	Aboriginal	Northern	Other
Professional Positions – Contractor	2	38	66
Professional Positions- BHP	5	54	12
Skilled Positions – Contractor	43	139	276
Skilled Positions – BHP	68	112	77
Semi-Skilled Positions - Contractor	37	52	35
Semi-Skilled Positions – BHP	134	56	28
Un-Skilled Positions – Contractor	111	74	19
Un-Skilled Positions – BHP	45	8	10

APPENDIX C – RESULTS OF ABA TESTWORK AND ICP ANALYSIS

BHP

Table 1
Sable Waste Rock ABA Data

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP	NP	NNP	NP/AP
								kg $CaCO_3$/t			
37	SDC-07	152.3-152.73	Epi alt 2MG	7.5	0.3	<0.01	0.3	9.38	2.6	-6.75	0.3
18	SDC-02	48.58-49.28	Pegmatite, Two mica granite	9.1	0.05	<0.01	0.05	1.56	0.8	-0.8125	0.5
26	SDC-05	152.00-152.50	2 Mica Granite	9.8	0.06	<0.01	0.06	1.88	1.9	0	1.0
28	SDC-05	224.00-224.23	mgr 2MG with trace pyrite.	9.8	0.03	<0.01	0.03	0.94	2.6	1.6875	2.8
34	SDC-07	114.32-114.68	Fine Grained Granite\2Mica Granite with Pyrite	9.2	0.06	<0.01	0.06	1.88	6.3	4.375	3.3
49	SDC-12	386.18-386.58	2 Mica Granite with trace dissem. Pyrite	9.6	0.12	<0.01	0.12	3.75	12.8	9	3.4
36	SDC-07	150.37-150.60	Pegmatite, Two mica granite	9.7	0.01	<0.01	0.01	0.31	1.6	1.3125	5.2
39	SDC-07	91.35-91.80	2Mica Granite	9.7	0.01	<0.01	0.01	0.31	3.3	2.9375	10.4
22	SDC-04	47.5	Coarse grained 2MG – slightly pegmatitic.	9.6	<0.01	<0.01	<0.01	0.00	0.9	0.875	~~~
46	SDC-12	11.28-11.68	K+ altered - Two Mica Granite (2MG)	9.3	<0.01	<0.01	<0.01	0.00	0.9	0.875	~~~
33	SDC-07	113.0-113.3	Medium grained 2Mica Granite	9.6	<0.01	<0.01	<0.01	0.00	1.0	1.03125	~~~
21	SDC-04	47.0-47.3	contact bt fgr-mgr 2MG and vcgr (peg) 2MG	9.7	<0.01	<0.01	<0.01	0.00	1.1	1.125	~~~
19	SDC-02	56.0-56.3	slightly K+ altered – 2MG	9.5	<0.01	<0.01	<0.01	0.00	1.1	1.125	~~~
44	SDC-11	52	K+ altered – Two Mica Granite (2MG)	9.7	<0.01	<0.01	<0.01	0.00	1.6	1.625	~~~
50	SDC-12	88.89-89.29	Medium-Course grained 2 Mica Granite	9.7	<0.01	<0.01	<0.01	0.00	1.8	1.75	~~~
56	SDC-13	37.52-37.79	K+ altered (moderately) two Mica Granite (2MG)	9.7	<0.01	<0.01	<0.01	0.00	1.9	1.875	~~~
47	SDC-12	186.64-187.04	mgr K+ altered, 2MG	9.4	<0.01	<0.01	<0.01	0.00	2.1	2.125	~~~
17	SDC-02	20.5	contact with fgr-mgr 2MG with pegmatite	9.2	<0.01	<0.01	<0.01	0.00	2.3	2.25	~~~
20	SDC-03	26.0-26.3	fgr 2MG, slightly schistose – HQ core	9.7	<0.01	<0.01	<0.01	0.00	2.3	2.25	~~~
52	SDC-13	154.64-154.89	Two Mica Granite (Minor Peg)	9.2	<0.01	<0.01	<0.01	0.00	2.3	2.25	~~~
48	SDC-12	303.89-304.39	Course Grained 2 Mica Granite	9.8	<0.01	<0.01	<0.01	0.00	3.4	3.375	~~~
40	SDC-08	54.1-54.43	2 Mica Granite	9.4	<0.01	<0.01	<0.01	0.00	4.0	4	~~~
35	SDC-07	114.7-115.6	Fine Grained BT Granite with dissem. Pyrite	9.5	0.08	<0.01	0.08	2.50	2.8	0.25	1.1
16	SDC-01	68.5-68.9	fgr to mgr Biotite Granite with Pyrite on fractures.	9	0.03	<0.01	0.03	0.94	2.0	1.0625	2.1
38	SDC-07	157.03-157.42	Biotite Granite with Aplite vienlet	9.8	0.05	<0.01	0.05	1.56	3.5	1.9375	2.2
31	SDC-06	117.93-118.36	Biotite Granite	9.8	0.05	<0.01	0.05	1.56	4.9	3.3125	3.1
23	SDC-04	77.0-77.42	Course Grained Biotite Granite	9.4	0.01	<0.01	0.01	0.31	1.1	0.8125	3.6
55	SDC-13	30.14-30.45	Biotite Granite	9.4	0.03	<0.01	0.03	0.94	5.8	4.8125	6.1
57	SDC-13	96.97-97.23	Biotite Granite minor Hb + Mt dissem.	9.5	0.02	<0.01	0.02	0.63	6.1	5.5	9.8
30	SDC-05	98.73-98.88	Biotite Granite with Pegmatite	9.5	<0.01	<0.01	<0.01	0.00	1.0	1	~~~
32	SDC-06	36.7-37.32	Biotite Granite with Pyrite	9.5	<0.01	<0.01	<0.01	0.00	1.4	1.375	~~~
43	SDC-11	36.95-37.27	Alt. Of Biotite Granite and 2Mica Granite	9.9	<0.01	<0.01	<0.01	0.00	1.9	1.875	~~~

Table 1
Sable Waste Rock ABA Data

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP kg $CaCO_3$/t	NP kg $CaCO_3$/t	NNP kg $CaCO_3$/t	NP/AP
45	SDC-11	55.60-56.00	Alt. Of Biotite Granite and 2Mica Granite	9.6	<0.01	<0.01	<0.01	0.00	2.4	2.375	~~~
27	SDC-05	17.0-17.31	Biotite Granite	9.8	<0.01	<0.01	<0.01	0.00	3.0	3	~~~
54	SDC-13	199.96-200.25	K+ Sauss Biotite Granite	9.8	<0.01	<0.01	<0.01	0.00	4.9	4.875	~~~
41	SDC-08	88.38-89.00	fgr BT – possible Magnetite rich stringers.	9.2	<0.01	<0.01	<0.01	0.00	5.0	5	~~~
25	SDC-05	151.23-151.75	Biotite Schist with Pyrite	10	0.09	<0.01	0.09	2.81	3.5	0.6875	1.2
24	SDC-04	83.0-83.35	Biotite Schist with Biotite Granite	10.1	<0.01	<0.01	<0.01	0.00	4.3	4.25	~~~
53	SDC-13	164.64-164.91	Diabase Dyke ?	8.9	0.01	<0.01	0.01	0.31	9.0	8.6875	28.8
42	SDC-08	90.78-91.39	Granite monzonite.	9.2	0.07	<0.01	0.07	2.19	5.3	3.0625	2.4
51	SDC-13	106.58-106.89	Migmetite Zone	10	0.16	<0.01	0.16	5.00	3.5	-1.5	0.7
29	SDC-05	233.90-234.17	moderately schistose – 2MG	9.5	0.02	<0.01	0.02	0.63	3.9	3.25	6.2

Table 2
Sable Waste Rock ICP Data

Sample No.	Drill Hole #	Sample Interval	Description	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm
37	SDC-07	152.3-152.73	Epi alt 2MG	<0.2	1.51	<5	500	<0.5	<5	0.52	1	14	142	7	3.83	1.33	0.96	335
18	SDC-02	48.58-49.28	Pegmatite, Two mica granite	<0.2	0.06	<5	<10	<0.5	<5	0.03	1	1	343	7	0.44	0.05	0.07	45
26	SDC-05	152.00-152.50	2 Mica Granite	0.20	0.37	<5	20	<0.5	<5	0.13	<1	3	148	18	0.80	0.25	0.16	85
28	SDC-05	224.00-224.23	mgr 2MG with trace pyrite.	<0.2	0.62	<5	90	<0.5	<5	0.21	<1	5	225	3	1.43	0.48	0.36	170
34	SDC-07	114.32-114.68	Fine Grained Granite\2Mica Granite with Pyrite	<0.2	1.36	<5	350	<0.5	<5	0.52	<1	11	160	11	3.28	1.07	0.84	320
49	SDC-12	386.18-386.58	2 Mica Granite with trace dissem. Pyrite	<0.2	2.37	<5	470	0.50	<5	0.59	1	13	144	<1	3.30	1.07	2.90	485
36	SDC-07	150.37-150.60	Pegmatite, Two mica granite	<0.2	0.28	<5	30	<0.5	<5	0.07	<1	<1	219	<1	0.26	0.31	0.03	25
39	SDC-07	91.35-91.80	2Mica Granite	<0.2	0.47	<5	20	<0.5	<5	0.29	<1	1	162	1	0.99	0.31	0.22	150
22	SDC-04	47.5	Coarse grained 2MG – slightly pegmatitic.	<0.2	0.26	<5	10	<0.5	<5	0.04	<1	1	188	<1	0.38	0.16	0.07	50
46	SDC-12	11.28-11.68	K+ altered - Two Mica Granite (2MG)	<0.2	0.22	<5	10	<0.5	<5	0.05	<1	1	176	<1	0.31	0.16	0.05	35
33	SDC-07	113.0-113.3	Medium grained 2Mica Granite	<0.2	0.30	<5	20	<0.5	<5	0.05	<1	1	177	<1	0.47	0.19	0.10	75
21	SDC-04	47.0-47.3	contact bt fgr-mgr 2MG and vcgr (peg) 2MG	<0.2	0.53	<5	10	<0.5	<5	0.05	<1	2	177	<1	1.11	0.28	0.27	150
19	SDC-02	56.0-56.3	slightly K+ altered – 2MG	<0.2	0.28	<5	10	<0.5	<5	0.05	<1	1	187	<1	0.44	0.16	0.10	55
44	SDC-11	52	K+ altered – Two Mica Granite (2MG)	<0.2	0.27	<5	20	<0.5	<5	0.16	<1	1	193	<1	0.50	0.13	0.13	65
50	SDC-12	88.89-89.29	Medium-Course grained 2 Mica Granite	<0.2	0.51	<5	30	<0.5	<5	0.07	<1	2	217	1	1.03	0.26	0.28	145
56	SDC-13	37.52-37.79	K+ altered (moderately) two Mica Granite (2MG)	<0.2	0.47	<5	30	<0.5	<5	0.10	<1	3	224	<1	0.97	0.34	0.22	120
47	SDC-12	186.64-187.04	mgr K+ altered, 2MG	<0.2	0.31	<5	20	<0.5	<5	0.19	<1	1	174	1	0.63	0.14	0.19	90
17	SDC-02	20.5	contact with fgr-mgr 2MG with pegmatite	0.20	0.37	<5	10	<0.5	<5	0.18	<1	1	206	<1	0.62	0.21	0.14	110
20	SDC-03	26.0-26.3	fgr 2MG, slightly schistose – HQ core	0.20	0.55	<5	40	<0.5	<5	0.16	<1	2	214	<1	1.12	0.34	0.27	115
52	SDC-13	154.64-154.89	Two Mica Granite (Minor Peg)	<0.2	0.41	<5	20	<0.5	<5	0.12	<1	1	202	3	0.64	0.22	0.15	90
48	SDC-12	303.89-304.39	Course Grained 2 Mica Granite	<0.2	0.38	<5	30	<0.5	<5	0.34	<1	2	187	<1	0.68	0.25	0.15	110
40	SDC-08	54.1-54.43	2 Mica Granite	<0.2	1.07	<5	60	0.50	<5	0.26	<1	6	145	2	1.92	0.19	1.01	220
29	SDC-05	233.90-234.17	moderately schistose – 2MG	<0.2	0.87	<5	60	<0.5	<5	0.32	<1	6	189	<1	1.71	0.60	0.47	245
35	SDC-07	114.7-115.6	Fine Grained BT Granite with dissem. Pyrite	<0.2	1.46	<5	440	<0.5	<5	0.53	<1	13	150	18	3.71	1.16	0.92	305
16	SDC-01	68.5-68.9	fgr to mgr Biotite Granite with Pyrite on fractures.	<0.2	1.01	<5	110	<0.5	<5	0.19	<1	6	240	<1	1.98	0.71	0.47	180
38	SDC-07	157.03-157.42	Biotite Granite with Aplite vienlet	<0.2	1.49	<5	330	<0.5	<5	0.52	<1	13	137	11	3.79	1.21	0.89	430
31	SDC-06	117.93-118.36	Biotite Granite	<0.2	1.47	<5	420	<0.5	<5	0.44	1	12	202	6	2.76	1.23	1.00	305
23	SDC-04	77.0-77.42	Course Grained Biotite Granite	<0.2	0.21	<5	20	<0.5	<5	0.06	<1	<1	146	<1	0.20	0.16	0.03	20
55	SDC-13	30.14-30.45	Biotite Granite	<0.2	1.88	<5	630	<0.5	<5	0.53	<1	16	188	<1	3.10	1.55	1.50	340
57	SDC-13	96.97-97.23	Biotite Granite minor Hb + Mt dissem.	<0.2	1.90	<5	710	<0.5	<5	0.61	<1	17	202	<1	3.20	1.57	1.68	415
30	SDC-05	98.73-98.88	Biotite Granite with Pegmatite	<0.2	0.33	<5	10	<0.5	<5	0.08	<1	1	183	2	0.57	0.20	0.11	100
32	SDC-06	36.7-37.32	Biotite Granite with Pyrite	0.20	0.25	<5	10	<0.5	<5	0.06	<1	<1	192	4	0.35	0.15	0.06	40
43	SDC-11	36.95-37.27	Alt. Of Biotite Granite and 2Mica Granite	<0.2	0.32	<5	30	<0.5	<5	0.14	<1	1	226	<1	0.58	0.20	0.13	75
45	SDC-11	55.60-56.00	Alt. Of Biotite Granite and 2Mica Granite	<0.2	0.26	<5	20	<0.5	<5	0.29	<1	<1	171	<1	0.23	0.21	0.03	35
27	SDC-05	17.0-17.31	Biotite Granite	<0.2	0.65	<5	40	<0.5	<5	0.23	<1	4	188	<1	1.36	0.48	0.30	170
54	SDC-13	199.96-200.25	K+ Sauss Biotite Granite	<0.2	1.03	<5	30	<0.5	<5	0.30	1	7	185	<1	2.18	0.81	0.60	290
41	SDC-08	88.38-89.00	fgr BT – possible Magnetite rich stringers.	<0.2	2.16	<5	20	0.50	<5	0.30	<1	5	87	<1	2.32	0.08	2.91	240
25	SDC-05	151.23-151.75	Biotite Schist with Pyrite	<0.2	2.69	<5	200	<0.5	<5	0.14	<1	27	299	30	5.03	2.61	1.89	565
24	SDC-04	83.0-83.35	Biotite Schist with Biotite Granite	<0.2	3.97	<5	780	<0.5	<5	0.13	<1	38	325	<1	6.93	3.82	2.87	820
53	SDC-13	164.64-164.91	Diabase Dyke ?	<0.2	1.68	<5	50	<0.5	<5	1.26	<1	33	80	290	7.22	0.15	1.03	590
42	SDC-08	90.78-91.39	Granite monzonite.	<0.2	3.92	<5	20	0.50	<5	0.16	<1	12	264	<1	4.19	0.06	5.86	350
51	SDC-13	106.58-106.89	Migmetite Zone	<0.2	2.02	<5	280	<0.5	<5	0.17	1	22	292	60	3.86	1.75	1.45	435

Table 2
Sable Waste Rock ICP Data

Sample No.	Drill Hole #	Sample Interval	Description	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm
37	SDC-07	152.3-152.73	Epi alt 2MG	2	0.07	15	1800	10	<5	4	<10	26	0.27	64	<10	13	130
18	SDC-02	48.58-49.28	Pegmatite, Two mica granite	8	0.01	5	20	2	5	<1	<10	1	0.01	1	<10	<1	424
26	SDC-05	152.00-152.50	2 Mica Granite	2	0.05	5	460	10	<5	<1	<10	7	0.05	5	<10	2	47
28	SDC-05	224.00-224.23	mgr 2MG with trace pyrite.	4	0.07	8	500	6	<5	1	<10	20	0.11	18	<10	4	53
34	SDC-07	114.32-114.68	Fine Grained Granite\2Mica Granite with Pyrite	2	0.06	16	1810	16	<5	3	<10	25	0.23	52	<10	11	129
49	SDC-12	386.18-386.58	2 Mica Granite with trace dissem. Pyrite	2	0.06	28	1270	4	<5	4	<10	26	0.12	61	<10	7	107
36	SDC-07	150.37-150.60	Pegmatite, Two mica granite	4	0.05	5	300	4	<5	<1	<10	7	<0.01	1	<10	1	3
39	SDC-07	91.35-91.80	2Mica Granite	2	0.05	3	1380	4	<5	1	<10	5	0.03	4	<10	6	45
22	SDC-04	47.5	Coarse grained 2MG – slightly pegmatitic.	4	0.05	3	140	4	5	<1	<10	4	0.01	1	<10	1	7
46	SDC-12	11.28-11.68	K+ altered - Two Mica Granite (2MG)	4	0.04	4	220	4	<5	<1	<10	4	<0.01	1	<10	<1	10
33	SDC-07	113.0-113.3	Medium grained 2Mica Granite	4	0.04	4	200	10	<5	<1	<10	5	<0.01	1	<10	1	20
21	SDC-04	47.0-47.3	contact bt fgr-mgr 2MG and vcgr (peg) 2MG	4	0.07	5	140	6	<5	<1	<10	5	0.03	3	<10	2	52
19	SDC-02	56.0-56.3	slightly K+ altered – 2MG	4	0.04	2	170	<2	5	<1	<10	3	<0.01	1	<10	<1	9
44	SDC-11	52	K+ altered – Two Mica Granite (2MG)	4	0.05	5	710	2	<5	<1	<10	6	<0.01	2	<10	3	15
50	SDC-12	88.89-89.29	Medium-Course grained 2 Mica Granite	4	0.07	5	200	8	<5	<1	<10	8	0.03	5	<10	2	48
56	SDC-13	37.52-37.79	K+ altered (moderately) two Mica Granite (2MG)	4	0.05	4	260	6	<5	<1	<10	8	0.06	5	<10	2	42
47	SDC-12	186.64-187.04	mgr K+ altered, 2MG	2	0.05	3	760	6	<5	<1	<10	8	0.01	3	<10	3	27
17	SDC-02	20.5	contact with fgr-mgr 2MG with pegmatite	4	0.05	6	810	8	5	<1	<10	4	0.01	2	<10	4	23
20	SDC-03	26.0-26.3	fgr 2MG, slightly schistose – HQ core	4	0.06	4	730	6	5	<1	<10	7	0.03	5	<10	5	92
52	SDC-13	154.64-154.89	Two Mica Granite (Minor Peg)	4	0.04	4	480	2	<5	<1	<10	5	0.01	3	<10	2	18
48	SDC-12	303.89-304.39	Course Grained 2 Mica Granite	4	0.05	4	1350	4	<5	<1	<10	10	0.04	3	<10	5	28
40	SDC-08	54.1-54.43	2 Mica Granite	2	0.06	9	930	4	<5	1	<10	15	0.05	25	<10	4	35
29	SDC-05	233.90-234.17	moderately schistose – 2MG	2	0.08	9	1020	10	<5	1	<10	13	0.13	19	<10	5	88
35	SDC-07	114.7-115.6	Fine Grained BT Granite with dissem. Pyrite	2	0.07	15	1780	10	5	3	<10	25	0.25	64	<10	12	127
16	SDC-01	68.5-68.9	fgr to mgr Biotite Granite with Pyrite on fractures.	4	0.11	14	560	6	5	2	<10	13	0.12	23	<10	5	72
38	SDC-07	157.03-157.42	Biotite Granite with Aplite vienlet	2	0.06	9	1960	8	<5	3	<10	17	0.26	66	<10	11	152
31	SDC-06	117.93-118.36	Biotite Granite	4	0.10	13	1220	6	<5	4	<10	36	0.26	50	<10	6	99
23	SDC-04	77.0-77.42	Course Grained Biotite Granite	2	0.03	3	230	6	<5	<1	<10	4	<0.01	1	<10	1	<1
55	SDC-13	30.14-30.45	Biotite Granite	2	0.09	30	1190	4	<5	4	<10	61	0.29	68	<10	7	79
57	SDC-13	96.97-97.23	Biotite Granite minor Hb + Mt dissem.	4	0.09	33	1300	4	<5	3	<10	75	0.28	69	<10	6	90
30	SDC-05	98.73-98.88	Biotite Granite with Pegmatite	4	0.05	4	340	6	<5	<1	<10	4	0.01	1	<10	2	30
32	SDC-06	36.7-37.32	Biotite Granite with Pyrite	4	0.05	3	260	4	<5	<1	<10	3	<0.01	1	<10	1	14
43	SDC-11	36.95-37.27	Alt. Of Biotite Granite and 2Mica Granite	4	0.05	5	620	6	5	<1	<10	6	<0.01	2	<10	2	20
45	SDC-11	55.60-56.00	Alt. Of Biotite Granite and 2Mica Granite	4	0.03	3	1410	2	<5	<1	<10	5	<0.01	1	<10	6	5
27	SDC-05	17.0-17.31	Biotite Granite	4	0.06	5	980	6	5	1	<10	7	0.08	8	<10	5	72
54	SDC-13	199.96-200.25	K+ Sauss Biotite Granite	4	0.08	8	920	8	<5	1	<10	11	0.16	22	<10	4	121
41	SDC-08	88.38-89.00	fgr BT – possible Magnetite rich stringers.	2	0.08	16	1540	2	<5	3	<10	12	<0.01	29	<10	5	43
25	SDC-05	151.23-151.75	Biotite Schist with Pyrite	2	0.08	88	410	14	5	9	<10	10	0.39	108	<10	5	227
24	SDC-04	83.0-83.35	Biotite Schist with Biotite Granite	<2	0.07	113	300	6	5	13	<10	14	0.59	158	<10	3	291
53	SDC-13	164.64-164.91	Diabase Dyke ?	<2	0.15	36	1100	10	<5	3	<10	37	0.55	291	<10	16	136
42	SDC-08	90.78-91.39	Granite monzonite.	10	0.06	43	790	4	<5	2	<10	7	0.01	76	<10	3	54
51	SDC-13	106.58-106.89	Migmetite Zone	14	0.06	70	410	4	<5	9	<10	9	0.31	93	<10	6	99

Table 3
Pigeon Waste Rock ABA Data

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP kg $CaCO_3$/t	NP	NNP	NP/AP
3	97-54	188.69-189.09	Biotite Granite	9.7	<0.01	<0.01	<0.01	0.00	4.6	4.6	~~~
6	97-54	373.10-373.38	Biotite Granite	9.7	<0.01	<0.01	<0.01	0.00	4.0	4.0	~~~
10	97-55	295.01-295.75	Biotite Granite	9.8	<0.01	<0.01	<0.01	0.00	5.4	5.4	~~~
11	97-55	56.00-56.59	Biotite Granite	9.5	0.02	<0.01	0.02	0.63	3.4	2.8	5.4
5	97-54	29.57-30.00	Biotite Schist	8.4	0.05	<0.01	0.02	1.56	3.1	1.6	2.0
1	97-54	126.14-126.46	Diabase	9.1	0.04	<0.01	0.02	1.25	10.5	9.3	8.4
2	97-54	18.88-19.08	Diabase	9.1	0.05	<0.01	0.02	1.56	11.1	9.6	7.1
4	97-54	20.54-20.65	Diabase	8.2	0.01	<0.01	0.02	0.31	10.6	10.3	34.0
7	97-54	41.30-42.03	Diabase	8.6	0.06	<0.01	0.02	1.88	8.6	6.8	4.6
8	97-54	52.75-53.29	Diabase	9.5	0.05	<0.01	0.02	1.56	7.9	6.3	5.0
9	97-54	81.07-81.38	Diabase	9.4	0.03	<0.01	0.02	0.94	9.1	8.2	9.7

Table 4
Pigeon Waste Rock ICP Data

Sample No.	Drill Hole #	Sample interval	Description	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm
3	97-54	188.69-189.09	Biotite Granite	<0.2	1.50	<5	170	<0.5	<5	0.28	<1	10	169	1	2.40	1.01	0.97	225
6	97-54	373.10-373.38	Biotite Granite	<0.2	2.25	<5	340	<0.5	<5	0.33	<1	15	168	2	3.08	1.59	1.40	270
10	97-55	295.01-295.75	Biotite Granite	<0.2	1.16	<5	100	<0.5	<5	0.18	<1	7	179	<1	1.79	0.93	0.75	205
11	97-55	56.00-56.59	Biotite Granite	<0.2	2.66	<5	350	<0.5	<5	0.18	<1	20	213	4	4.39	1.78	1.75	300
5	97-54	29.57-30.00	Biotite Schist	<0.2	2.85	<5	70	0.50	<5	0.15	<1	23	136	21	4.46	0.39	1.98	170
1	97-54	126.14-126.46	Diabase	<0.2	1.79	<5	120	<0.5	<5	1.26	<1	30	92	329	6.94	0.43	1.14	380
2	97-54	18.88-19.08	Diabase	<0.2	1.55	<5	60	<0.5	<5	1.28	<1	32	77	294	6.91	0.32	1.03	415
4	97-54	20.54-20.65	Diabase	<0.2	2.79	10	180	<0.5	<5	1.27	<1	55	61	370	8.42	0.33	2.76	350
7	97-54	41.30-42.03	Diabase	<0.2	1.56	<5	230	<0.5	<5	0.89	<1	36	53	248	5.63	0.73	1.11	230
8	97-54	52.75-53.29	Diabase	<0.2	1.64	<5	150	<0.5	<5	1.10	1	29	83	227	5.44	0.64	0.94	270
9	97-54	81.07-81.38	Diabase	<0.2	1.63	<5	70	<0.5	<5	1.19	<1	30	89	291	6.82	0.34	1.03	365

Table 4
Pigeon Waste Rock ICP Data

Sample No.	Drill Hole #	Sample interval	Description	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm
3	97-54	188.69-189.09	Biotite Granite	4	0.06	19	1110	8	<5	5	<10	11	0.11	35	<10	7	47
6	97-54	373.10-373.38	Biotite Granite	2	0.11	34	550	6	5	7	<10	19	0.21	72	<10	6	53
10	97-55	295.01-295.75	Biotite Granite	6	0.06	16	440	6	<5	2	<10	12	0.10	24	<10	4	37
11	97-55	56.00-56.59	Biotite Granite	4	0.05	56	650	8	5	9	<10	11	0.20	93	<10	7	73
5	97-54	29.57-30.00	Biotite Schist	2	0.02	88	590	4	5	4	<10	8	<0.01	51	<10	8	6
1	97-54	126.14-126.46	Diabase	2	0.18	34	1470	18	<5	4	<10	57	0.40	284	<10	16	143
2	97-54	18.88-19.08	Diabase	<2	0.15	30	1500	16	<5	3	<10	51	0.43	293	<10	17	127
4	97-54	20.54-20.65	Diabase	<2	0.04	62	1820	10	<5	18	<10	36	0.57	337	<10	21	114
7	97-54	41.30-42.03	Diabase	<2	0.17	30	1510	6	<5	9	<10	51	0.37	333	<10	17	115
8	97-54	52.75-53.29	Diabase	2	0.24	23	1390	8	<5	3	<10	70	0.42	284	<10	11	86
9	97-54	81.07-81.38	Diabase	<2	0.13	35	1360	6	<5	3	<10	44	0.42	314	<10	15	111

Table 5
Beartooth Waste Rock ABA Data

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP kg $CaCO_3$/t	NP	NNP	NP/AP
58	96-35	13.50-13.95	Biotite Granite	9.8	<0.01	<0.01	<0.01	0.00	8.4	8.375	----
59	96-35	30.14-30.62	Biotite Granite	9.8	<0.01	<0.01	<0.01	0.00	5.8	5.75	----
62	96-35	46.28-46.78	Biotite Granite	9.8	<0.01	<0.01	<0.01	0.00	7.8	7.75	----
63	96-35	221.27-221.83	Biotite Granite	9.7	0.01	<0.01	0.01	0.31	8.3	7.9375	26.4
12	BDC-05	40.20-40.53	Biotite Granite	9.8	0.05	<0.01	0.05	1.56	4.4	2.8125	2.8
13	BDC-05	48.01-48.44	Biotite Granite	9.9	0.1	<0.01	0.1	3.13	5.6	2.5	1.8
14	BDC-05	63.74-64.07	Biotite Granite	9.5	0.03	<0.01	0.03	0.94	7.6	6.6875	8.1
60	96-35	36.98-37.43	Diabase	9.6	<0.01	<0.01	<0.01	0.00	9.4	9.375	----
61	96-35	42.02-42.63	Diabase	9.7	<0.01	<0.01	<0.01	0.00	8.6	8.625	----
15	BDC-07	224.63-225.02	Granite	9.9	0.01	<0.01	0.01	0.31	7.5	7.1875	24.0

Table 6
Beartooth Waste Rock ICP Data

Sample No.	Drill Hole #	Sample interval	Description	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm	Mo ppm
58	96-35	13.50-13.95	Biotite Granite	<0.2	2.45	<5	500	<0.5	<5	0.61	<1	20	269	6	3.49	2.10	2.14	390	4
59	96-35	30.14-30.62	Biotite Granite	<0.2	2.01	<5	480	<0.5	<5	0.37	<1	17	177	5	3.20	1.91	1.84	355	2
62	96-35	46.28-46.78	Biotite Granite	<0.2	2.35	<5	510	<0.5	<5	0.52	<1	18	245	14	3.62	2.12	2.04	415	2
63	96-35	221.27-221.83	Biotite Granite	<0.2	2.14	<5	500	<0.5	<5	0.56	<1	18	225	6	3.50	2.03	1.95	365	2
12	BDC-05	40.20-40.53	Biotite Granite	<0.2	2.00	<5	400	<0.5	<5	0.33	<1	17	221	68	3.07	1.76	1.57	275	4
13	BDC-05	48.01-48.44	Biotite Granite	<0.2	2.81	<5	610	<0.5	<5	0.23	<1	23	295	5	4.64	2.40	2.24	250	4
14	BDC-05	63.74-64.07	Biotite Granite	<0.2	2.27	5.00	490	<0.5	<5	0.60	<1	19	200	1	3.38	1.96	2.08	355	2
60	96-35	36.98-37.43	Diabase	<0.2	1.31	5.00	200	<0.5	<5	1.13	<1	14	204	4	2.10	0.86	1.71	380	<2
61	96-35	42.02-42.63	Diabase	<0.2	1.72	<5	360	<0.5	<5	0.86	<1	18	239	31	2.67	1.58	2.09	400	2
15	BDC-07	224.63-225.02	Granite	<0.2	2.19	<5	500	<0.5	<5	0.52	<1	19	198	9	3.50	2.03	1.96	360	2

Table 6
Beartooth Waste Rock ICP Data

Sample No.	Drill Hole #	Sample interval	Description	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm
58	96-35	13.50-13.95	Biotite Granite	0.15	54	1090	6	<5	5	<10	60	0.28	82	<10	6	76
59	96-35	30.14-30.62	Biotite Granite	0.08	49	980	6	<5	4	<10	33	0.26	73	<10	6	71
62	96-35	46.28-46.78	Biotite Granite	0.11	47	1050	8	<5	3	<10	45	0.27	81	<10	6	80
63	96-35	221.27-221.83	Biotite Granite	0.08	48	1170	10	<5	3	<10	38	0.27	75	<10	5	85
12	BDC-05	40.20-40.53	Biotite Granite	0.11	39	550	4	5	3	<10	36	0.28	68	<10	2	54
13	BDC-05	48.01-48.44	Biotite Granite	0.10	70	210	6	<5	19	<10	19	0.35	136	<10	6	93
14	BDC-05	63.74-64.07	Biotite Granite	0.09	55	1090	16	5	4	<10	49	0.27	72	<10	6	110
60	96-35	36.98-37.43	Diabase	0.07	79	2550	6	<5	3	<10	41	0.14	38	<10	19	50
61	96-35	42.02-42.63	Diabase	0.06	94	2350	8	<5	2	<10	31	0.21	54	<10	8	57
15	BDC-07	224.63-225.02	Granite	0.10	47	1080	4	5	3	<10	41	0.28	78	<10	5	69

Table 7
Acid Base Accounting Data for Sable Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP	NP kg $CaCO_3$/t	NNP	NP/AP
80	95-25	138m		8.1	0.32	0.05	0.27	8.44	142.5	134.0625	16.9
81	95-25	297m		8.4	0.04	0.01	0.03	0.94	185.6	184.6875	198.0
82	SDC-01	126m	FAT	8	0.09	0.03	0.06	1.88	128.1	126.25	68.3
83	SDC-03	132m	CAT	7.8	0.06	0.02	0.04	1.25	177.5	176.25	142.0
83	SDC-03	132m	CAT	7.8	0.06	0.02	0.04	1.25	177.5	176.25	142.0
84	SDC-03	266m	TK	8.8	0.13	0.02	0.11	3.44	175.9	172.5	51.2
85	SDC-04	130m	CAT	8.1	0.07	0.03	0.04	1.25	169.1	167.8125	135.3
86	SDC-06	155m	FAT	8	0.04	<0.01	0.04	1.25	195.6	194.375	156.5
87	SDC-06	290m	MTK	8.9	0.13	0.02	0.11	3.44	203.8	200.3125	59.3
88	SDC-08	126m	MTK	8.2	0.11	0.02	0.09	2.81	154.1	151.25	54.8
89	SDC-10	207m	CTK	8.7	0.12	0.03	0.09	2.81	184.7	181.875	65.7
90	SDC-12	423m	CTK	9.6	0.15	0.02	0.13	4.06	161.3	157.1875	39.7
91	SDC-13	236m	CTK	8.8	0.07	0.01	0.06	1.88	157.2	155.3125	83.8
95	SDC-03	26.0-26.3 RE		9.7	<0.01	<0.01	<0.01	0.00	3.3	3.25	----
96	SDC-05	98.73-98.88 RE		9.3	N/D	N/D	N/D	0.00	0.5	0.53125	----
97	SDC-08	54.1-54.43 RE		9.1	N/D	N/D	N/D	0.00	5.0	5	----
98	SDC-12	88.89-89.29 RE		9.6	N/D	N/D	N/D	0.00	0.8	0.78125	----
88 (dup.)	SDC-08	126m	MTK	N/A	0.12	0.02	0.1	3.13	N/A	N/A	N/A

Table 8
ICP Data for Sable Kimberlite Pipes

Sample No.	Drill Hole #	Sample interval	Description	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %
80	95-25	138m		<0.2	1.17	<5	410	0.5	<5	1.69	1	59	234	15	4.37
81	95-25	297m		<0.2	1.7	<5	3800	0.5	<5	1.38	<1	57	255	14	4.24
82	SDC-01	126m	FAT	<0.2	1.37	<5	1300	0.5	<5	2.05	<1	59	286	24	4.4
83	SDC-03	132m	CAT	<0.2	1.1	<5	1570	0.5	<5	4.68	<1	59	307	28	4.19
83	SDC-03	132m	CAT	<0.2	1.11	<5	1590	0.5	<5	4.75	<1	61	316	29	4.25
84	SDC-03	266m	TK	<0.2	1.27	<5	1070	0.5	<5	1.81	<1	66	319	19	4.63
85	SDC-04	130m	CAT	<0.2	1.34	<5	1220	0.5	<5	1.77	<1	66	286	20	4.68
86	SDC-06	155m	FAT	<0.2	0.89	<5	1920	<0.5	<5	4.65	<1	54	300	32	4.58
87	SDC-06	290m	MTK	<0.2	1.54	<5	1620	0.5	<5	3.4	<1	41	237	26	3.62
88	SDC-08	126m	MTK	<0.2	1.54	<5	1160	0.5	<5	2.06	<1	53	232	19	4.32
89	SDC-10	207m	CTK	<0.2	1.36	<5	1560	0.5	<5	2.67	1	58	271	18	4.4
90	SDC-12	423m	CTK	<0.2	0.94	<5	1530	0.5	<5	2.29	<1	62	321	23	4.55
91	SDC-13	236m	CTK	<0.2	1.29	<5	1160	0.5	<5	2.31	<1	63	296	29	4.78
95	SDC-03	26.0-26.3 RE		0.2	0.55	<5	40	<0.5	<5	0.16	<1	2	214	<1	1.12
96	SDC-05	98.73-98.88 RE		<0.2	0.33	<5	10	<0.5	<5	0.08	<1	1	183	2	0.57
97	SDC-08	54.1-54.43 RE		<0.2	1.07	<5	60	0.5	<5	0.26	<1	6	145	2	1.92
98	SDC-12	88.89-89.29 RE		<0.2	0.51	<5	30	<0.5	<5	0.07	<1	2	217	1	1.03
88 (dup.)	SDC-08	126m	MTK	<0.2	1.51	<5	1150	0.5	<5	2.02	<1	52	228	19	4.2
	SDC-01	68.5-68.9		<0.2	1.01	<5	110	<0.5	<5	0.2	<1	6.0	240	<1	1.98
	SDC-02	20.5		0.2	0.37	<5	10	<0.5	<5	0.2	<1	1.0	206	<1	0.62
	SDC-02	48.58-49.28		<0.2	0.06	<5	<10	<0.5	<5	0.0	1	1.0	343	7	0.44
	SDC-02	56.0-56.3		<0.2	0.28	<5	10	<0.5	<5	0.1	<1	1.0	187	<1	0.44
	SDC-04	47.5		<0.2	0.26	<5	10	<0.5	<5	0.0	<1	1.0	188	<1	0.38
	SDC-04	47.0-47.3		<0.2	0.53	<5	10	<0.5	<5	0.1	<1	2.0	177	<1	1.11
	SDC-04	77.0-77.42		<0.2	0.21	<5	20	<0.5	<5	0.1	<1	<1	146	<1	0.2
	SDC-04	83.0-83.35		<0.2	3.97	<5	780	<0.5	<5	0.1	<1	38.0	325	<1	6.93
	SDC-05	151.23-151.75		<0.2	2.69	<5	200	<0.5	<5	0.1	<1	27.0	299	30	5.03
	SDC-05	152.00-152.50		0.2	0.37	<5	20	<0.5	<5	0.1	<1	3.0	148	18	0.8
	SDC-05	17.0-17.31		<0.2	0.65	<5	40	<0.5	<5	0.2	<1	4.0	188	<1	1.36
	SDC-05	224.00-224.23		<0.2	0.62	<5	90	<0.5	<5	0.2	<1	5.0	225	3	1.43
	SDC-05	233.90-234.17		<0.2	0.87	<5	60	<0.5	<5	0.3	<1	6.0	189	<1	1.71
	SDC-06	117.93-118.36		<0.2	1.47	<5	420	<0.5	<5	0.4	1	12.0	202	6	2.76
	SDC-06	36.7-37.32		0.2	0.25	<5	10	<0.5	<5	0.1	<1	<1	192	4	0.35
	SDC-07	113.0-113.3		<0.2	0.3	<5	20	<0.5	<5	0.1	<1	1.0	177	<1	0.47
	SDC-07	114.32-114.68		<0.2	1.36	<5	350	<0.5	<5	0.5	<1	11.0	160	11	3.28
	SDC-07	114.7-115.6		<0.2	1.46	<5	440	<0.5	<5	0.5	<1	13.0	150	18	3.71
	SDC-07	150.37-150.60		<0.2	0.28	<5	30	<0.5	<5	0.1	<1	<1	219	<1	0.26
	SDC-07	152.3-152.73		<0.2	1.51	<5	500	<0.5	<5	0.5	1	14.0	142	7	3.83
	SDC-07	157.03-157.42		<0.2	1.49	<5	330	<0.5	<5	0.5	<1	13.0	137	11	3.79
	SDC-07	91.35-91.80		<0.2	0.47	<5	20	<0.5	<5	0.3	<1	1.0	162	1	0.99
	SDC-08	88.38-89.00		<0.2	2.16	<5	20	0.5	<5	0.3	<1	5.0	87	<1	2.32
	SDC-08	90.78-91.39		<0.2	3.92	<5	20	0.5	<5	0.2	<1	12.0	264	<1	4.19
	SDC-11	52		<0.2	0.27	<5	20	<0.5	<5	0.2	<1	1.0	193	<1	0.5
	SDC-11	36.95-37.27		<0.2	0.32	<5	30	<0.5	<5	0.1	<1	1.0	226	<1	0.58
	SDC-11	55.60-56.00		<0.2	0.26	<5	20	<0.5	<5	0.3	<1	<1	171	<1	0.23
	SDC-12	11.28-11.68		<0.2	0.22	<5	10	<0.5	<5	0.1	<1	1.0	176	<1	0.31
	SDC-12	186.64-187.04		<0.2	0.31	<5	20	<0.5	<5	0.2	<1	1.0	174	1	0.63
	SDC-12	303.89-304.39		<0.2	0.38	<5	30	<0.5	<5	0.3	<1	2.0	187	<1	0.68
	SDC-12	386.18-386.58		<0.2	2.37	<5	470	0.5	<5	0.6	1	13.0	144	<1	3.3
	SDC-13	106.58-106.89		<0.2	2.02	<5	280	<0.5	<5	0.2	1	22.0	292	60	3.86
	SDC-13	154.64-154.89		<0.2	0.41	<5	20	<0.5	<5	0.1	<1	1.0	202	3	0.64
	SDC-13	164.64-164.91		<0.2	1.68	<5	50	<0.5	<5	1.3	<1	33.0	80	290	7.22
	SDC-13	199.96-200.25		<0.2	1.03	<5	30	<0.5	<5	0.3	1	7.0	185	<1	2.18
	SDC-13	30.14-30.45		<0.2	1.88	<5	630	<0.5	<5	0.5	<1	16.0	188	<1	3.1
	SDC-13	37.52-37.79		<0.2	0.47	<5	30	<0.5	<5	0.1	<1	3.0	224	<1	0.97
	SDC-13	96.97-97.23		<0.2	1.9	<5	710	<0.5	<5	0.6	<1	17.0	202	<1	3.2

Table 8
ICP Data for Sable Kimberlite Pipes

Sample No.	Drill Hole #	Sample interval	Description	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm
80	95-25	138m		0.38	>15.00	630	2	0.04	1234	720	10	5	3	<10	222
81	95-25	297m		0.74	>15.00	660	<2	0.11	1215	830	8	5	4	<10	313
82	SDC-01	126m	FAT	0.41	>15.00	740	2	0.04	1198	1210	12	<5	6	<10	521
83	SDC-03	132m	CAT	0.55	>15.00	815	<2	0.05	1180	1640	12	5	7	<10	794
83	SDC-03	132m	CAT	0.56	>15.00	830	<2	0.05	1197	1700	12	5	7	<10	808
84	SDC-03	266m	TK	1.78	>15.00	695	2	0.27	1383	980	6	5	5	<10	473
85	SDC-04	130m	CAT	0.4	>15.00	740	<2	0.04	1357	1050	14	5	5	<10	443
86	SDC-06	155m	FAT	0.6	>15.00	1810	<2	0.05	1073	1560	14	<5	7	<10	794
87	SDC-06	290m	MTK	1.72	13.42	645	<2	0.32	752	1580	12	<5	7	<10	798
88	SDC-08	126m	MTK	0.38	>15.00	770	<2	0.04	1080	1260	12	5	5	<10	421
89	SDC-10	207m	CTK	0.7	>15.00	730	<2	0.14	1190	1070	8	5	5	<10	593
90	SDC-12	423m	CTK	1.58	>15.00	715	2	0.43	1258	1160	12	5	5	<10	528
91	SDC-13	236m	CTK	0.77	>15.00	900	2	0.1	1269	1430	14	5	7	<10	489
95	SDC-03	26.0-26.3 RE		0.34	0.27	115	4	0.06	4	730	6	5	<1	<10	7
96	SDC-05	98.73-98.88 RE		0.2	0.11	100	4	0.05	4	340	6	<5	<1	<10	4
97	SDC-08	54.1-54.43 RE		0.19	1.01	220	2	0.06	9	930	4	<5	1	<10	15
98	SDC-12	88.89-89.29 RE		0.26	0.28	145	4	0.07	5	200	8	<5	<1	<10	8
88 (dup.)	SDC-08	126m	MTK	0.36	>15.00	760	<2	0.04	1056	1240	10	5	5	<10	415
	SDC-01	68.5-68.9		0.71	0	180	4	0.11	14	560	6	5	2	<10	13
	SDC-02	20.5		0.21	0	110	4	0.05	6	810	8	5	<1	<10	4
	SDC-02	48.58-49.28		0.05	0	45	8	0.01	5	20	2	5	<1	<10	1
	SDC-02	56.0-56.3		0.16	0	55	4	0.04	2	170	<2	5	<1	<10	3
	SDC-04	47.5		0.16	0	50	4	0.05	3	140	4	5	<1	<10	4
	SDC-04	47.0-47.3		0.28	0	150	4	0.07	5	140	6	<5	<1	<10	5
	SDC-04	77.0-77.42		0.16	0	20	2	0.03	3	230	6	<5	<1	<10	4
	SDC-04	83.0-83.35		3.82	3	820	<2	0.07	113	300	6	5	13	<10	14
	SDC-05	151.23-151.75		2.61	2	565	2	0.08	88	410	14	5	9	<10	10
	SDC-05	152.00-152.50		0.25	0	85	2	0.05	5	460	10	<5	<1	<10	7
	SDC-05	17.0-17.31		0.48	0	170	4	0.06	5	980	6	5	1	<10	7
	SDC-05	224.00-224.23		0.48	0	170	4	0.07	8	500	6	<5	1	<10	20
	SDC-05	233.90-234.17		0.6	0	245	2	0.08	9	1020	10	<5	1	<10	13
	SDC-06	117.93-118.36		1.23	1	305	4	0.1	13	1220	6	<5	4	<10	36
	SDC-06	36.7-37.32		0.15	0	40	4	0.05	3	260	4	<5	<1	<10	3
	SDC-07	113.0-113.3		0.19	0	75	4	0.04	4	200	10	<5	<1	<10	5
	SDC-07	114.32-114.68		1.07	1	320	2	0.06	16	1810	16	<5	3	<10	25
	SDC-07	114.7-115.6		1.16	1	305	2	0.07	15	1780	10	5	3	<10	25
	SDC-07	150.37-150.60		0.31	0	25	4	0.05	5	300	4	<5	<1	<10	7
	SDC-07	152.3-152.73		1.33	1	335	2	0.07	15	1800	10	<5	4	<10	26
	SDC-07	157.03-157.42		1.21	1	430	2	0.06	9	1960	8	<5	3	<10	17
	SDC-07	91.35-91.80		0.31	0	150	2	0.05	3	1380	4	<5	1	<10	5
	SDC-08	88.38-89.00		0.08	3	240	2	0.08	16	1540	2	<5	3	<10	12
	SDC-08	90.78-91.39		0.06	6	350	10	0.06	43	790	4	<5	2	<10	7
	SDC-11	52		0.13	0	65	4	0.05	5	710	2	<5	<1	<10	6
	SDC-11	36.95-37.27		0.2	0	75	4	0.05	5	620	6	5	<1	<10	6
	SDC-11	55.60-56.00		0.21	0	35	4	0.03	3	1410	2	<5	<1	<10	5
	SDC-12	11.28-11.68		0.16	0	35	4	0.04	4	220	4	<5	<1	<10	4
	SDC-12	186.64-187.04		0.14	0	90	2	0.05	3	760	6	<5	<1	<10	8
	SDC-12	303.89-304.39		0.25	0	110	4	0.05	4	1350	4	<5	<1	<10	10
	SDC-12	386.18-386.58		1.07	3	485	2	0.06	28	1270	4	<5	4	<10	26
	SDC-13	106.58-106.89		1.75	1	435	14	0.06	70	410	4	<5	9	<10	9
	SDC-13	154.64-154.89		0.22	0	90	4	0.04	4	480	2	<5	<1	<10	5
	SDC-13	164.64-164.91		0.15	1	590	<2	0.15	36	1100	10	<5	3	<10	37
	SDC-13	199.96-200.25		0.81	1	290	4	0.08	8	920	8	<5	1	<10	11
	SDC-13	30.14-30.45		1.55	2	340	2	0.09	30	1190	4	<5	4	<10	61
	SDC-13	37.52-37.79		0.34	0	120	4	0.05	4	260	6	<5	<1	<10	8
	SDC-13	96.97-97.23		1.57	2	415	4	0.09	33	1300	4	<5	3	<10	75

Table 8
ICP Data for Sable Kimberlite Pipes

Sample No.	Drill Hole #	Sample Interval	Description	Ti %	V ppm	W ppm	Y ppm	Zn ppm
80	95-25	138m		0.04	35	<10	4	51
81	95-25	297m		0.05	38	<10	3	47
82	SDC-01	126m	FAT	0.06	45	<10	5	54
83	SDC-03	132m	CAT	0.07	46	<10	4	44
83	SDC-03	132m	CAT	0.07	48	<10	4	45
84	SDC-03	266m	TK	0.04	37	<10	4	51
85	SDC-04	130m	CAT	0.05	41	<10	4	50
86	SDC-06	155m	FAT	0.09	48	<10	4	45
87	SDC-06	290m	MTK	0.09	52	<10	6	50
88	SDC-08	126m	MTK	0.05	40	<10	5	59
89	SDC-10	207m	CTK	0.06	31	<10	4	48
90	SDC-12	423m	CTK	0.05	41	<10	4	51
91	SDC-13	236m	CTK	0.06	49	<10	4	50
95	SDC-03	26.0-26.3 RE		0.03	5	<10	5	92
96	SDC-05	98.73-98.88 RE		0.01	1	<10	2	30
97	SDC-08	54.1-54.43 RE		0.05	25	<10	4	35
98	SDC-12	88.89-89.29 RE		0.03	5	<10	2	48
88 (dup.)	SDC-08	126m	MTK	0.05	39	<10	5	58
	SDC-01	68.5-68.9		0	23	<10	5	72
	SDC-02	20.5		0	2	<10	4	23
	SDC-02	48.58-49.28		0	1	<10	<1	424
	SDC-02	56.0-56.3		<0.01	1	<10	<1	9
	SDC-04	47.5		0	1	<10	1	7
	SDC-04	47.0-47.3		0	3	<10	2	52
	SDC-04	77.0-77.42		<0.01	1	<10	1	<1
	SDC-04	83.0-83.35		1	158	<10	3	291
	SDC-05	151.23-151.75		0	108	<10	5	227
	SDC-05	152.00-152.50		0	5	<10	2	47
	SDC-05	17.0-17.31		0	8	<10	5	72
	SDC-05	224.00-224.23		0	18	<10	4	53
	SDC-05	233.90-234.17		0	19	<10	5	88
	SDC-06	117.93-118.36		0	50	<10	6	99
	SDC-06	36.7-37.32		<0.01	1	<10	1	14
	SDC-07	113.0-113.3		<0.01	1	<10	1	20
	SDC-07	114.32-114.68		0	52	<10	11	129
	SDC-07	114.7-115.6		0	64	<10	12	127
	SDC-07	150.37-150.60		<0.01	1	<10	1	3
	SDC-07	152.3-152.73		0	64	<10	13	130
	SDC-07	157.03-157.42		0	66	<10	11	152
	SDC-07	91.35-91.80		0	4	<10	6	45
	SDC-08	88.38-89.00		<0.01	29	<10	5	43
	SDC-08	90.78-91.39		0	76	<10	3	54
	SDC-11	52		<0.01	2	<10	3	15
	SDC-11	36.95-37.27		<0.01	2	<10	2	20
	SDC-11	55.60-56.00		<0.01	1	<10	6	5
	SDC-12	11.28-11.68		<0.01	1	<10	<1	10
	SDC-12	186.64-187.04		0	3	<10	3	27
	SDC-12	303.89-304.39		0	3	<10	5	28
	SDC-12	386.18-386.58		0	61	<10	7	107
	SDC-13	106.58-106.89		0	93	<10	6	99
	SDC-13	154.64-154.89		0	3	<10	2	18
	SDC-13	164.64-164.91		1	291	<10	16	136
	SDC-13	199.96-200.25		0	22	<10	4	121
	SDC-13	30.14-30.45		0	68	<10	7	79
	SDC-13	37.52-37.79		0	5	<10	2	42
	SDC-13	96.97-97.23		0	69	<10	6	90

Table 9
Acid Base Accounting Data for Pigeon Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP	NP kg $CaCO_3$/t	NNP	NP/AP
68	97-54	113m	MHYB	8.8	<0.01	<0.01	<0.01	0.00	250.0	250	----
69	97-54	117m	MHYB	8.7	<0.01	<0.01	<0.01	0.00	245.6	245.625	----
70	97-54	145-150m	MHYB	8.7	0.05	0.03	0.02	0.63	187.5	186.875	300.0
71	97-54	172-174m	MHYB	8.4	<0.01	<0.01	<0.01	0.00	113.8	113.75	----
72	97-54	210-215m	MHYB	8.9	0.02	0.01	0.01	0.31	157.8	157.5	505.0
73	97-54	310m	HYPB	8.8	0.05	<0.01	0.05	1.56	160.6	159.0625	102.8
74	97-55	79-83m	Kb Sand	7.6	0.26	0.06	0.2	6.25	83.4	77.1875	13.4
75	97-55	137m	Kb Sand /Congl.	7.8	0.25	0.05	0.2	6.25	121.9	115.625	19.5
76	97-55	198m	HYPB	8.2	0.04	0.04	0	0.00	150.3	150.3125	----
77	94-07	120m	ORT	8	0.27	0.05	0.22	6.88	135.3	128.4375	19.7
78	94-07	170m	HYPB	8.1	0.02	0.01	0.01	0.31	121.9	121.5625	390.0
79	94-07	225m	MYHB	8.9	0.02	<0.01	0.02	0.63	200.6	200	321.0
92	97-55	205-210m	MYHB	8.9	0.02	<0.01	0.02	0.63	198.1	197.5	317.0
93	97-55	250m	MYHB	8.6	0.04	<0.01	0.04	1.25	213.1	211.875	170.5
94	97-55	295.01-295.75 RE		9.7	<0.01	<0.01	<0.01	0.00	3.7	3.6875	----

Table 10
ICP Data for Pigeon Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm
68	97-54	113m	MHYB	<0.2	2.01	10	7000	<0.5	<5	9.33	<1	39	123	87	5.3	2.73	11.08	1390
69	97-54	117m	MHYB	<0.2	1.55	10	6400	<0.5	<5	9.12	<1	37	118	91	5.07	2.17	11.05	1235
70	97-54	145-150m	MHYB	<0.2	2.42	10	5640	<0.5	<5	7.72	<1	38	126	74	5.13	4.22	9.59	1155
71	97-54	172-174m	MHYB	<0.2	1.68	<5	1190	0.5	<5	2.68	<1	59	230	15	4.38	0.69	14.43	1065
72	97-54	210-215m	MHYB	<0.2	1.99	<5	1470	<0.5	<5	2.78	<1	67	557	40	5.24	2.72	>15.00	850
73	97-54	310m	HYPB	<0.2	2.04	<5	1440	<0.5	<5	3.64	<1	59	613	47	5.08	2.82	>15.00	875
74	97-55	79-83m	Kb Sand	<0.2	2.06	<5	1490	<0.5	<5	3.63	<1	59	616	47	5.07	2.83	>15.00	880
75	97-55	137m	Kb Sand /Congl.	<0.2	1.64	5	1490	0.5	<5	3.48	1	39	227	30	3.79	0.49	11.79	690
76	97-55	198m	HYPB	<0.2	1.7	<5	380	<0.5	<5	1.68	<1	65	306	30	4.77	1.26	>15.00	605
77	94-07	120m	ORT	<0.2	0.96	5	1810	0.5	<5	3.24	1	34	251	25	3.45	0.52	9.56	705
78	94-07	170m	HYPB	<0.2	1.7	<5	610	0.5	<5	1.55	<1	61	236	19	4.61	0.87	>15.00	705
79	94-07	225m	MYHB	<0.2	2.24	<5	1630	<0.5	<5	3.6	<1	63	676	50	5.31	2.98	>15.00	950
92	97-55	205-210m	MYHB	<0.2	2	<5	1320	<0.5	<5	3.39	<1	64	519	43	5.17	2.31	>15.00	835
93	97-55	250m	MYHB	<0.2	1.87	<5	1880	<0.5	<5	3.29	<1	61	545	42	4.93	2.46	>15.00	885
94	97-55	295.01-295.75 RE		<0.2	1.16	<5	100	<0.5	<5	0.18	<1	7	179	<1	1.79	0.93	0.75	205
	97-54	126.14-126.46		<0.2	1.79	<5	120	<0.5	<5	1.3	<1	30.0	92	329	6.94	0.43	1	380
	97-54	18.88-19.08		<0.2	1.55	<5	60	<0.5	<5	1.3	<1	32.0	77	294	6.91	0.32	1	415
	97-54	188.69-189.09		<0.2	1.5	<5	170	<0.5	<5	0.3	<1	10.0	169	1	2.4	1.01	1	225
	97-54	20.54-20.65		<0.2	2.79	10	180	<0.5	<5	1.3	<1	55.0	61	370	8.42	0.33	3	350
	97-54	29.57-30.00		<0.2	2.85	<5	70	0.5	<5	0.2	<1	23.0	136	21	4.46	0.39	2	170
	97-54	373.10-373.38		<0.2	2.25	<5	340	<0.5	<5	0.3	<1	15.0	168	2	3.08	1.59	1	270
	97-54	41.30-42.03		<0.2	1.56	<5	230	<0.5	<5	0.9	<1	36.0	53	248	5.63	0.73	1	230
	97-54	52.75-53.29		<0.2	1.64	<5	150	<0.5	<5	1.1	1	29.0	83	227	5.44	0.64	1	270
	97-54	81.07-81.38		<0.2	1.63	<5	70	<0.5	<5	1.2	<1	30.0	89	291	6.82	0.34	1	365
	97-55	56.00-56.59		<0.2	2.66	<5	350	<0.5	<5	0.2	<1	20.0	213	4	4.39	1.78	2	300
	97-55	79-83m		<0.2	1.39	5	1220	0.5	<5	2.2	1	29.0	201	20	3.43	0.57	7	515

Table 10
ICP Data for Pigeon Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm
68	97-54	113m	MHYB	<2	0.09	293	5220	32	<5	18	<10	2967	0.49	134	<10	15	65
69	97-54	117m	MHYB	<2	0.09	292	5440	34	<5	17	<10	2964	0.45	125	<10	15	61
70	97-54	145-150m	MHYB	<2	0.1	265	5070	32	<5	14	<10	2662	0.49	137	<10	13	64
71	97-54	172-174m	MHYB	<2	0.04	1191	920	8	5	4	<10	349	0.06	55	<10	3	43
72	97-54	210-215m	MHYB	2	0.06	1327	1410	14	5	8	<10	531	0.11	76	<10	4	46
73	97-54	310m	HYPB	<2	0.04	1034	1710	14	10	9	<10	658	0.14	76	<10	6	45
74	97-55	79-83m	Kb Sand	<2	0.04	1040	1720	16	10	9	<10	660	0.15	77	<10	6	46
75	97-55	137m	Kb Sand /Congl.	2	0.03	683	1330	14	<5	6	<10	746	0.09	56	<10	9	55
76	97-55	198m	HYPB	<2	0.05	1307	1190	8	5	5	<10	311	0.1	56	<10	4	46
77	94-07	120m	ORT	6	0.04	546	1200	14	5	6	<10	692	0.08	57	<10	12	58
78	94-07	170m	HYPB	<2	0.04	1268	1110	10	<5	5	<10	361	0.07	47	<10	4	44
79	94-07	225m	MYHB	<2	0.06	1142	1840	14	10	10	<10	762	0.14	87	<10	6	46
92	97-55	205-210m	MYHB	<2	0.05	1206	1390	12	10	9	<10	369	0.15	76	<10	5	49
93	97-55	250m	MYHB	<2	0.03	1150	1670	14	5	9	<10	411	0.16	84	<10	5	44
94	97-55	295.01-295.75 RE		6	0.06	16	440	6	<5	2	<10	12	0.1	24	<10	4	37
	97-54	126.14-126.46		2	0.18	34	1470	18	<5	4	<10	57	0	284	<10	16	143
	97-54	18.88-19.08		<2	0.15	30	1500	16	<5	3	<10	51	0	293	<10	17	127
	97-54	188.69-189.09		4	0.06	19	1110	8	<5	5	<10	11	0	35	<10	7	47
	97-54	20.54-20.65		<2	0.04	62	1820	10	<5	18	<10	36	1	337	<10	21	114
	97-54	29.57-30.00		2	0.02	88	590	4	5	4	<10	8	<0.01	51	<10	8	6
	97-54	373.10-373.38		2	0.11	34	550	6	5	7	<10	19	0	72	<10	6	53
	97-54	41.30-42.03		<2	0.17	30	1510	6	<5	9	<10	51	0	333	<10	17	115
	97-54	52.75-53.29		2	0.24	23	1390	8	<5	3	<10	70	0	284	<10	11	86
	97-54	81.07-81.38		<2	0.13	35	1360	6	<5	3	<10	44	0	314	<10	15	111
	97-55	56.00-56.59		4	0.05	56	650	8	5	9	<10	11	0	93	<10	7	73
	97-55	79-83m		2	0.04	414	1210	12	5	5	<10	448	0	53	<10	11	62

Table 11
Acid Base Accounting Data for Beartooth Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Paste pH	S(T) %	$S(SO_4)$ %	S(s) %	AP	NP kg $CaCO_3$/t	NNP	NP/AP
64	BDC-01	49m	ART	8.1	0.11	0.04	0.07	2.19	140.5	138.3125	64.2
65	BDC-01	186m	MTK	8.6	0.25	0.02	0.23	7.19	159.5	152.3125	22.2
66	BDC-04	100m	FAT	8.3	0.46	0.04	0.42	13.13	130.0	116.875	9.9
67	BDC-04	190m	CTK	8.5	0.14	0.02	0.12	3.75	166.8	163	44.5
64 (dup)	BDC-01	49m	ART	N/A	0.1	0.04	0.06	1.88	N/A	N/A	N/A

Table 12
ICP Data for Beartooth Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm
64	BDC-01	49m	ART	<0.2	0.86	<5	550	<0.5	<5	1.03	<1	74	458	9	4.84	0.35	>15.00	740
65	BDC-01	186m	MTK	<0.2	0.78	<5	660	<0.5	<5	1.61	<1	59	384	10	4.1	0.51	>15.00	780
66	BDC-04	100m	FAT	<0.2	1.51	5	930	0.5	<5	2.28	<1	46	353	24	4.24	0.76	14.54	585
67	BDC-04	190m	CTK	<0.2	0.89	<5	820	<0.5	<5	1.54	<1	66	389	9	4.63	0.51	>15.00	775
64 (dup)	BDC-01	49m	ART	<0.2	0.83	<5	540	<0.5	<5	1.02	<1	73	435	8	4.79	0.35	>15.00	720
	BDC-05	40.20-40.53		<0.2	2	<5	400	<0.5	<5	0.3	<1	17.0	221	68	3.07	1.76	2	275
	BDC-05	48.01-48.44		<0.2	2.81	<5	610	<0.5	<5	0.2	<1	23.0	295	5	4.64	2.4	2	250
	BDC-05	63.74-64.07		<0.2	2.27	5	490	<0.5	<5	0.6	<1	19.0	200	1	3.38	1.96	2	355
	BDC-07	224.63-225.02		<0.2	2.19	<5	500	<0.5	<5	0.5	<1	19.0	198	9	3.5	2.03	2	360

Table 12
ICP Data for Beartooth Kimberlite Samples

Sample No.	Drill Hole #	Sample interval	Description	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm
64	BDC-01	49m	ART	2	0.02	1568	520	10	5	4	<10	216	0.05	29	<10	3	53
65	BDC-01	186m	MTK	2	0.04	1187	640	8	5	4	<10	360	0.03	25	<10	5	45
66	BDC-04	100m	FAT	2	0.03	736	1110	12	5	6	<10	472	0.07	48	<10	9	63
67	BDC-04	190m	CTK	2	0.03	1332	680	8	5	4	<10	324	0.05	29	<10	4	44
64 (dup)	BDC-01	49m	ART	2	0.02	1537	520	10	5	4	<10	210	0.05	28	<10	3	52
	BDC-05	40.20-40.53		4	0.11	39	550	4	5	3	<10	36	0	68	<10	2	54
	BDC-05	48.01-48.44		4	0.1	70	210	6	<5	19	<10	19	0	136	<10	6	93
	BDC-05	63.74-64.07		2	0.09	55	1090	16	5	4	<10	49	0	72	<10	6	110
	BDC-07	224.63-225.02		2	0.1	47	1080	4	5	3	<10	41	0	78	<10	5	69

APPENDIX D – STATISTICAL OUTPUT

APPENDIX D: STATISTICAL OUTPUT

D.1 Season I

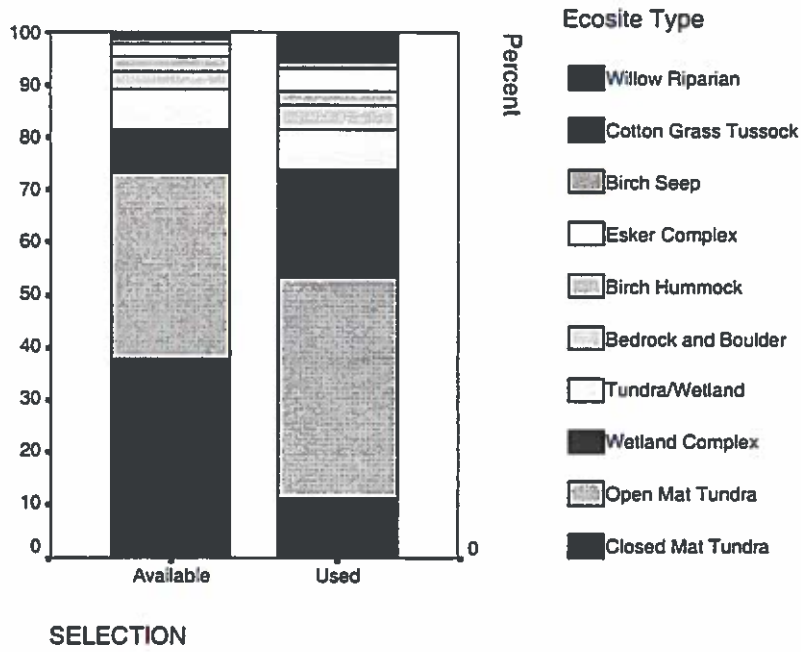
			Selection	
			Used	Available
Ecosite Type	Bedrock and Boulder	Adjusted Residual	.9	-.9
	Open Mat Tundra	Adjusted Residual	2.6	-2.6
	Esker Complex	Adjusted Residual	1.8	-1.8
	Closed Mat Tundra	Adjusted Residual	-8.7	8.7
	Tundra/Wetland Comple:	Adjusted Residual	-.2	.2
	Birch Hummock	Adjusted Residual	-.4	.4
	Cotton Grass Tussock	Adjusted Residual	-1.7	1.7
	Wetland Complex	Adjusted Residual	6.8	-6.8
	Birch Seep	Adjusted Residual	.0	.0
	Willow Riparian	Adjusted Residual	10.2	-10.2

Season I - cross-tabulation of use versus availability.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	205.121	9	.000
Likelihood Ratio	155.234	9	.000
Linear-by-Linear Association	19.393	1	.000
N of Valid Cases	4082		

a 3 cells (15.0%) have expected count less than 5. The minimum expected count is 1.80.



	Distance to Eskers	Distance to Tundra/Wetland	Distance to Birch Seep	Distance to Cotton Grass Tussock	Distance to Wetlands	Distance to Birch Seep	Distance to Willow Riparian
Mann-Whitney U	1635.000	1476.000	1646.500	1215.500	1201.000	1426.500	1045.500
Wilcoxon W	6291.000	2106.000	2276.500	1845.500	1831.000	2056.500	1675.500
Z	-.234	-1.061	-.174	-2.416	-2.492	-1.319	-3.300
Sig.	.407	.144	.431	.010	.010	.0.09	.001

Mann-Whitney test on distance to selected ecosite types.

D.2 Season II

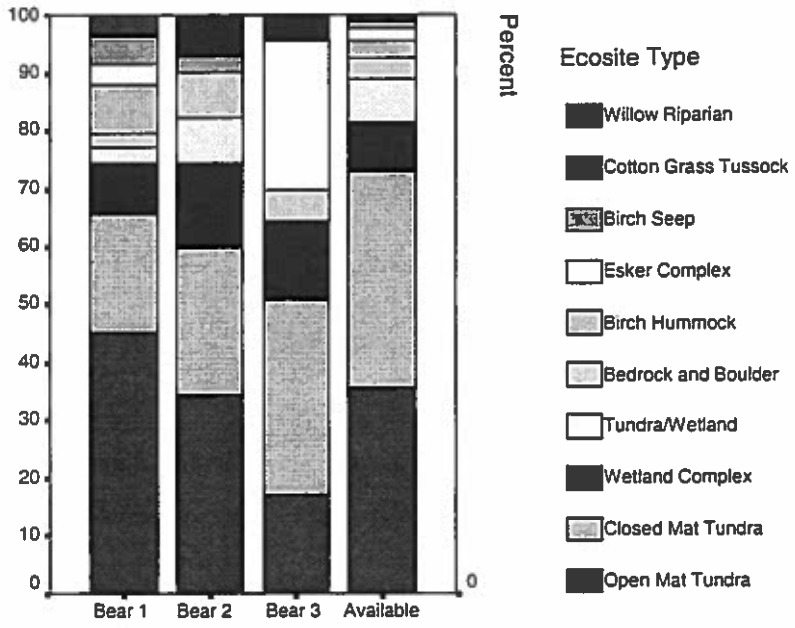
Habitat analysis as described by Neu at al. (1974):

G-test (adjusted) = 55.8616 ($P < 0.0001$)

Z (0.9975) = 2.8070 alpha = 0.050

Bailey simultaneous confidence intervals (only statistically significant results shown)

Resource	Proportion Lower	Upper	Available		df	Prob.
Esker	0.0548	0.1542	0.0220	Prefer	9	($P < 0.0001$)
Closed Mat Tundra	0.1956	0.3410	0.3762	Avoid		



Comparison of habitat selection by individual bears.

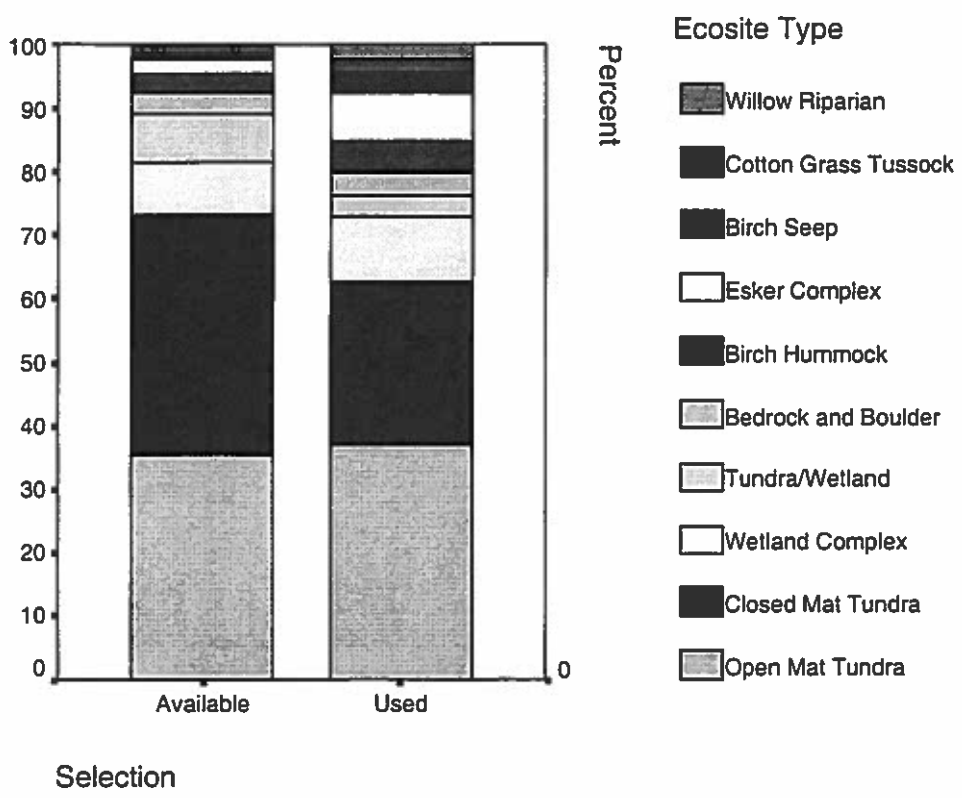
Ecosite Type * Selection Crosstabulation

			Selection	
			Used	Available
Ecosite Type	Bedrock and Boulder	Adjusted Residual	.1	-.1
	Open Mat Tundra	Adjusted Residual	.8	-.8
	Esker Complex	Adjusted Residual	7.9	-7.9
	Closed Mat Tundra	Adjusted Residual	-6.2	6.2
	Tundra/Wetland Complex	Adjusted Residual	-4.3	4.3
	Birch Hummock	Adjusted Residual	2.9	-2.9
	Cotton Grass Tussock	Adjusted Residual	2.2	-2.2
	Wetland Complex	Adjusted Residual	1.6	-1.6
	Birch Seep	Adjusted Residual	4.9	-4.9
	Willow Riparian	Adjusted Residual	6.0	-6.0

Cross-tabulation of use versus availability – pooled data, season II.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	178.607	9	.000
Likelihood Ratio	152.682	9	.000
Linear-by-Linear Association	8.949	1	.003
N of Valid Cases	4542		

a 1 cells (5.0%) have expected count less than 5. The minimum expected count is 4.42.



Use versus availability – pooled data (all bears) – season II.

	Distance to Eskers	Distance to Tundra/Wetland	Distance to Birch Seep	Distance to Cotton Grass Tussock	Distance to Wetlands	Distance to Birch Seep	Distance to Willow Riparian
Mann-Whitney U	2945.000	3509.000	3599.500	2870.000	2884.500	2940.000	2541.000
Wilcoxon W	7601.000	8165.000	8255.500	5796.000	5810.500	5866.000	5467.000
Z	-2.168	-.429	-.150	-2.399	-2.355	-2.183	-3.413
Sig.)	.015	.334	.440	.010	.010	.015	.001

Mann-Whitney test on distance to selected ecosite types. Season II

APPENDIX E – NATIVE JOURNAL ARTICLE

BHP

APPENDIX E NATIVE JOURNAL ARTICLE

MINING ON TRADITIONAL TERRITORY

BHP providing opportunities to Aboriginals

By Uluksuk

Mining has always been a significant contributor to Canada's economy. When BHP Diamonds Inc. opened Canada's first Diamond mine in 1998 called Ekati Diamond Mine, residents of the NWT were optimistic. Yellowknife was a long established gold mining city that was very familiar with the economic contributions made by the mining industry. Residents of Yellowknife and other western NWT communities were also reeling from a slow down in economic growth fueled by government cutbacks and stagnant base metal and non-renewable resources prices. With a downturn in most every economic sector in the western NWT, Ekati Diamond Mine seemed to come along at the right time.

Today Ekati Diamond Mine is demonstrating that mining can provide excellent employment opportunities to Aboriginal people and Northerners and ultimately Canada. Here are some of the facts on Ekati's employment opportunities:

* About 500 direct employment opportunities created by BHP Diamonds Inc. in the North;
* Aboriginal and Northern workers make up about 75 percent of BHP Diamonds Inc. employees who work in the Northwest Territories.

Native Journal spoke with Robert Beaulieu who is the Aboriginal Employment Coordinator with BHP Diamonds at Ekati Mine. Robert was born and raised in the North and as a Northern Aboriginal person, he is compassionately committed to helping Aboriginal people and Northerners find meaningful employment opportunities at Ekati Mine. "Mining has provided employment opportunities and training opportunities for Northerners. It has also increased the awareness and need for training," states Robert with keen dedication and continues, "People know if they don't get good education they will have limited opportunities when it comes to skilled jobs. It will be difficult for them to advance. People who recognize their own limited education or skill levels and take responsibility to work at increasing their skill levels and education will succeed when given the opportunity."

Ekati Diamond Mine has and continues to provide employment opportunities in many areas including: cooks; camp maintenance positions; carpenters; diesel mechanics; instrument technicians; mining engineers; administrators; equipment operators; computer technicians and other skilled and semi-skilled professions. "I like to see people being given opportunities. Sometimes they may not have the educational background but life-style and life-skills allow them to transfer their skills into the work environment," states Beaulieu.

Patrick Charlo a Dene resident of Dettah, a small Dene community located across the Yellowknife Bay from the City of Yellowknife is one Northerner that works at Ekati Diamond Mine. Patrick has demonstrated that norffierners are taking positive steps to benefit from employment opportunifies offered by mining companies like BHP's Ekati Diamond Mine.

Patrick is a family man with six children. He works two weeks at the mine site and has two weeks off at home in Dettah. Being the youngest child in his family, Patrick left school at grade 8 to pursue traditional family land skills and practices. His education level did not stop him from searching out employment opportunities and demonstrating that he is capable of transferring his skills into the work environment. Patrick states his experience by saying, "I made a big career change from working as a Crew Foreman with the Department of. Transportation to working as a Process Plant Operator at the mine. After 8 months, I moved to Equipment Operator."

In this position Patrick can work towards certification allowing him to practice his Equipment Operator skills anywhere in Canada if he desires.

Working out of town on shift rotations can be challenging to families but Patrick sees the overall benefits of the employment and the quality time off to spend with his family. "It was quite a learning experience and difficult to adjust to being away from home but I talked with my wife and family and we worked it out. On my time off, I can spend time with my family and go on the land with my children to teach them traditional skills," states Patrick and continues, "Jobs in mining with companies like BHP's Ekati Diamond Mine are providing good opportunities for Northern people. It's a real benefit for Northern people. Its cheaper to fly people in from close communities. People in small communities are used to short term jobs but eventually they get used to long term jobs. I bought two new snowmobiles and I'm thinking of renovating my house. My. daughters also understand the importance of having a good education. I teach them the importance of education and I tell them about my experiences at work and encourage them to finish school." Patrick Charlo is one Northerner who has demonstrated that he can gain meaningful employment in the mining industry and still maintain a quality life-style for his family and himself. Today Patrick continues to work at Ekati Diamond Mine and still keeps close ties to the land and his traditional cultural pursuits - maintaining a balance between traditional pursuits and modern wage employment.

Employment opportunities in mining at Ekati Diamond Mine in the NWT have provided Aboriginal people and Northeners with enhanced quality life-style choices that are benefitting Northern families and communities. Robert Beaulieu is optimistic about the benefits realized by Northerners through the provision of employment opportunities as he states, "People realize a sense of purpose, pride and increased self-esteem through these employment opportunities. Those that can balance the demand at home and in the workplace are succeeding."

Ekati Diamond Mine set a target of 62 percent of its workforce being from the North with 31 percent of this target being Aboriginal from the North. "We are now at 76 percent of the total workforce being Northern and out of that 42 percent are Aboriginal," states Robert Beaulieu. BHP's Ekati Diamond Mine is continuing to prove that mining is providing Northerners and Aboriginal people with quality employment opportunities that are in turn positively benefitting employees, families, the mining industry, northern communities, and Canada. ▲

APPENDIX F – IDENTIFICATION OF OTHER ACTIVITIES THAT MAY AFFECT THE VECS

APPENDIX F - IDENTIFICATION OF OTHER ACTIVITIES THAT MAY AFFECT THE VECS

Activities Requested in Terms of Reference

In the Terms of Reference issued by the MVEIRB, it was requested that a number of specific activities be considered in the cumulative effects assessment. These activities are:

- EKATI™ Diamond Mine;
- Diavik Diamonds Project;
- Echo Bay Winter Road; and
- Echo Bay Mines Ltd. - Lupin Mine.

EKATI™ Diamond Mine

The mineral claim block in which BHP operates covers an area of 344,000 ha. Exploration activities have continued since the initial discovery in 1991, leading to the identification of over 120 diamond bearing kimberlite pipes. Kimberlite ore mining actually began in the Panda Pit in early July 1998, but the ore was stockpiled until the Process Plant was commissioned in October 1998. By late 1999, Process Plant production levels had been ramped up to the nominal design rate of 9,000 tpd.

Recovery of diamonds from the kimberlite ore is a physical, rather than chemical, process. Processing of kimberlite ore involves:

- Several stages of crushing and scrubbing;
- Heavy media separation (separates diamonds and other heavy minerals from the host rock based on density); and
- Isolation of diamonds through X-ray sorting.

Kimberlite waste from the process plant is separated into two size categories:

- Coarse kimberlite (0.5 mm to 8 mm) - trucked to a designated area within the Panda Waste Rock Storage Area; and
- Fine kimberlite (<0.5 mm) - pumped, along with process water, to the Long Lake Containment Facility.

A dam constructed at the outlet of Long Lake isolates processed kimberlite and associated water from the rest of the Koala Watershed. Only water that meets Water

Licence criteria is discharged from Long Lake into the receiving environment. Water is also recycled from Long Lake to meet the Process Plant needs.

The Misery and Koala kimberlite pipes are next to be mined. Dewatering of Koala Lake took place in 1998 and 1999 and was completed in February 2000. Dewatering occurred in preparation for pre-stripping scheduled for 2000. The road to Misery will be completed by year-end 2000.

From April 1997 to January 1999, treated sewage effluent was discharged from the accommodation complex to Kodiak Lake. In 1999, a pumping station and force main were constructed to redirect the treated sewage effluent to the Process Plant where it is now co-mingled with processed kimberlite effluent and discharged to the Long Lake Containment Facility.

Effects associated with the mine will be mitigated by progressive reclamation, which has the following goals:

- re-establish productive land use;
- re-establish stable physical landforms; and
- protect water resources.

These goals will be achieved through progressive reclamation, research and the continual refinement and adaptation of reclamation methods. Research completed to date includes:

- Measuring growth rates of different vegetation types in various substrates (waste rock, lake bottom sediment, till, processed kimberlite);
- Determining the success of transplants;
- Determining nutrient requirements for different vegetation types; and
- Conducting soil surveys to evaluate natural substrate quality.

Areas reclaimed to date include:

- Exploration (Culvert) camp;
- Panda Diversion Channel (through the establishment of riparian habitat); and
- Several disturbed areas adjacent to site roads (through reseeding).

Exploration programs continue on a year-round basis. Active exploration in the form of geophysical surveys, *etc.* occurs in the summer and drilling of targets identified during the summer exploration programs typically starts in November. Generally one or two drills are used to evaluate 3 or 4 targets each year. Exploration work is based out of the main EKATI™ facilities and local support is provided by a skid-mounted camp.

Diavik Diamonds Project

The Diavik Diamonds Project is a proposal to mine four kimberlite pipes (A418, A154North, A154South and A21). The pipes were discovered in 1994-95, and are located beneath Lac de Gras, immediately offshore of a 20 km^2 island (east island). Mineable reserves have been calculated at 25.6 million tonnes at an average grade of 4.0 carats per tonne. Mine life is estimated to be 20 years. Diavik estimates that annual production will average just over six million carats.

The proposed project facilities will be confined to the east island, with the open pits and their water retention dikes located just offshore in Lac de Gras. Project facilities will include:

- kimberlite processing and diamond recovery plant;
- accommodation building;
- mine maintenance shop;
- fuel storage; and
- mechanical and administration complex.

A 1,800 m long airstrip will be constructed, which can handle a variety of aircraft. Most construction and production freight will be transported to the site along the existing Echo Bay winter road, which passes within 1.5 km of the Diavik site. It is expected that 2,200 to 2,400 truck loads per year will be required during construction and that 1,500 to 1,700 loads will be needed during operation. Diesel fuel will be the single largest commodity that is transported.

Electricity will be supplied by diesel-powered generators, which will provide up to 22 megawatts of electricity. Diesel will provide the bulk of Diavik's energy needs and will be used for power generation, mining equipment and heating. Fuel storage would be sufficient to supply one year's operating requirements. Tanks would have secondary containment systems to minimize contamination in the case of a tank failure.

Processed kimberlite will be placed in an engineered containment structure in the centre of the island. Some of the country rock that is mined to access the kimberlite pipes will be used to build dikes around the processed kimberlite containment area. Surplus country rock will be placed in storage piles to the north and south of the containment area.

Water retention dikes will be constructed around the kimberlite pipes to mine the kimberlite safely. Three dikes will be required; one around the A154South and North pipes, one around the A21 pipe and one around the A418 pipe. Construction of the dike around pipe A418 is expected to begin in 2000, using rock quarried from the east island. The dike around pipes A154South and North will be built with mined rock from A418

and is expected to be in place by 2004. Construction of the A21 dike will begin some 10 to 12 years after mine start-up.

Construction of the diamond recovery plant, airstrip, accommodations building and mine support infrastructure will be completed by 2002, when mining is scheduled to begin. The current mine plan is to develop three open pits to access the four kimberlite pipes that have been identified. Waste rock will be loaded by shovels into haul trucks and placed in storage piles on the north and south sides of the processed kimberlite containment area. The two rock piles will have a combined footprint of approximately 3.5 km^2 and will contain approximately 125 million m^3 (250 million tonnes) of rock. The piles will reach a height approximately 50 m above the current high point of the east island and will be designed to allow free and easy access to caribou that may move through the area.

Once mining has been completed, areas blocked off by the dikes will be reclaimed to produce productive fish habitat. This habitat creation will be accomplished by placing country rock and finer granular material between the dikes and pit crests. Water will be gradually re-introduced into the pits and when the water level equals that of Lac de Gras, the dikes will be breached and the areas within returned as part of Lac de Gras. The processed kimberlite containment area will be covered with a rock cap that would prevent fugitive dust emissions and would shed water to natural drainage routes and to Lac de Gras. Reclamation will be an ongoing process and will be refined with field testing during operations. Roads will be levelled and buildings will be taken down.

In March, 2000, the Diavik Diamonds Project was given approval to proceed to construction and operations. The planned construction schedule will overlap with the construction and operation of the EKATI™ Proposed Development.

Echo Bay Winter Road

The Echo Bay Winter Road (winter road) refers to the 567 km seasonal road between Tibbit Lake (terminus of Highway 4) and Echo Bay's Lupin Mine. The total road distance from Yellowknife to EKATI™ is approximately 442 km, including an initial 70 km along Highway 4 from Yellowknife to Tibbit Lake. The winter road distance from Tibbit Lake to Lac de Gras is 337 km. As a result of a tundra protection management program that was established as part of the winter road operation, approximately 72% of the road is constructed over lake ice and 28% is constructed over portages. Of the portage sections above the treeline, approximately one-half of the route crosses tundra. The winter road is typically 10 m wide over the portages, but the width varies considerably over the ice (>20 m).

The winter road is not part of the NWT Public Highway System, therefore the Department of Transportation does not monitor traffic volume on the road. However, Echo Bay Mines Ltd. and more recently, Nuna Logistics (as the operator), maintain data on the fuel and freight moved by commercial operators (Table F-1). The volume of commercial traffic on the winter road is predicted to double from 1999 to 2000. The

volume of public traffic, including hunters, anglers and adventure seekers, is not recorded.

Table F-1
Echo Bay Winter Road Haulage Statistics (1994-2000)

	1994	1995	1996	1997	1998	1999	2000 (projected)
Total	1713	1687	1990	3512	2543	1844	3950

N.B. One-way trips only, multiply by 2 to determine the total number of truck trips on the road. In almost all cases, trucks heading north are full and heading south are empty.

The annual winter road season typically extends from mid-January to the end of March, although opening and closing dates vary from year to year. Data from 1983 to 1995 show that the earliest opening and latest closing dates were 14 January and 14 April, respectively. The average winter road season lasts for approximately 10-12 weeks per year. There are two campsites/road maintenance depots along the route to handle the maintenance crews and provide meals and shelter (if required) to the road maintenance equipment operators and commercial truck drivers.

When the road is operating, trucking occurs 24 hours per day. The estimated travel time from Yellowknife to EKATI™, assuming no weather delays, is approximately 14 hours. Generally, trucks travel in pairs with normal on-ice speeds of 30 km/h loaded and 40 km/h empty. Travel on portages is restricted to 5 km/h.

The winter road provides an important access route for recreational opportunities (hunting and ice-fishing) to residents of Yellowknife and other communities. Limited information is available on hunting use along the road, as statistics are not recorded for road use or the number and nature of kills.

Echo Bay Mines Ltd. - Lupin Mine

The Lupin Mine is located near Contwoyto Lake in Nunavut, 402 km NE of Yellowknife (65°42' N, 110°50' W). Lupin is an underground mine which came into production in 1982. It was temporarily closed in early 1998, but is currently being re-opened after re-engineering studies identified significant cost saving measures. The new life of mine average operating costs are anticipated to be $245-$255 per ounce, well below the $284 per ounce operating cost that existed prior to the closure. Based on proven and probable reserves of 543,000 ounces, the mine plan projects production for at least five more years.

Local Outfitters/Research Stations

The proposed development area is situated in one of the more remote regions in Canada and as such, is popular with sportsmen and outdoorsmen. Several outfitters, offering a range of activities (*e.g.* hunting, fishing, ecotourism, *etc.*), together with a scientific research station are located in the area:

- ***Adventure Northwest Ltd.***
  - based out of Little Marten Lake Caribou Camp; located near Whitewolf Lake; operating radius of approximately 100 km around camp; established in 1990; they offer hunting for barren-ground caribou, wolf and wolverine as well as fishing; operate from August 15 to September 30; the camp consists of one main building, tent frames, storage silos, genset, water pump, propane tank (lights, refrigerator).
- ***Arctic Safaris***
  - located at Obstruction Rapids, downstream of Lake Providence; operating radius of approximately 100 km around camp; established in 1985; they offer hunting for barren-ground caribou, wolf, wolverine and small game as well as fishing and ecotourism; operate from July to September; the semi-permanent camp consists of tents and storage silos as well as a genset.
- ***Artillery Lake Adventures***
  - permanent camp located 220 km ENE of Yellowknife on northside of Artillery Lake; they offer hunting for barren-ground caribou and fishing for lake trout and arctic grayling.
- ***Aurora Caribou Camp***
  - located on Desteffany Lake; established in 1989; operated by Gameti Development Corporation and managed by Greg Robertson of Yellowknife; they offer hunting for barren-ground caribou, wolf and wolverine; operates from August 15 to September 15; camp consists of 7 tent frames, 2 storage silos, 2 outhouses and 1 wood shower building; average number of people occupying camp during peak season is 17.
- ***Aylmer Lake Lodge Ltd.***
  - located on Aylmer Lake (360 km NE of Yellowknife); full service lodge with a capacity for 16 guests (4 four-person cabins and one main lodge) as well as an outpost camp (capacity of 4-6 persons) located between Outram Lake and Aylmer Lake; activities limited to fishing and ecotourism and do not include hunting.

- ***Bathurst Inlet Developments (1984) Ltd. - Treeline Lodge***

  - camp located at site of old Tundra Mine on Courageous Lake; has been in operation since 1991; accommodations for 32 people; genset; 8 miles of road in and around the minesite; operates from July to September (trying to increase operating period); camp acts as a base for mining companies involved in exploration in the area; activities currently limited to fishing and ecotourism and do not include hunting.

- ***Bathurst Inlet Developments (1984) Ltd. - Pellatt Lake Lodge***

  - located on Pellatt Lake; camp consists of 5 buildings (16'x16') and a genset; camp is rented by Burnside Hunters and Trappers Association (HTA); location on Nunavut border has resulted in dispute over hunting rights.

- ***Camp Ekwo - Rabesca Resources Ltd.***

  - located at Humpy Lake; operating radius of approximately 30 km around camp; established in 1990; they offer hunting for barren-ground caribou; operates from mid-August to late September; camp has capacity for 10 hunters and consists of permanent lodge and tent frames with stoves, heating appliances, genset, diesel and propane tanks.

- ***Caribou Pass Outfitters***

  - base camp located on Jolly Lake; established in 1993; they offer hunting for barren-ground caribou; camp consists of a steel 14' grain silo (storage facility), several tent frames and five aluminum boats with 20 HP outboard motors; average occupancy during peak season is 16 people.

- ***Courageous Lake Caribou Camps (Shoshone Wilderness Adventures);***

  - located on Courageous Lake and Lac de Gras; they offer hunting for barren-ground caribou; main camp on Courageous Lake consists of one main building, 10-person quonset hut, 8 tents, small genset, storage silo, boats and motors; outpost camp(s) on Lac de Gras consists of tent frame cabin and storage silo.

- ***Peterson's Point Lake Camp***

  - located on Point Lake; they offer hunting for barren-ground caribou, wolf and wolverine as well as fishing excursions; permanent tent and outpost camps.

- ***True North Safaris Ltd.***

  - operate Mackay Lake Lodge located on Mackay Lake; offer hunting for barren-ground caribou, barren-ground grizzly, muskox, wolf and wolverine as well as fishing (lake trout, grayling) and ecotourism packages; operate spring and fall hunts; permanent and outpost camps; permanent camp can accommodate up to 24 people; consists of 19 fixed buildings, including a lounge, kitchen, generator shed, repair shop and workshop; outpost camps on Mackay Lake and Alymer

Lake (Mackay Lake outpost camp has capacity for 16 people in 4 cabins; Alymer Lake outpost camp has capacity for 4 people in 1 cabin).

- ***Tundra Ecosystem Biological Research Station***

  - located on Daring Lake; established in 1994 by GNWT Department of Resources, Wildlife and Economic Development; station consists of four all-season Weatherhaven tents (two 18'x20', one 12'x16', and one 8'x12') and two Jutland tents (11'x14'). One tent includes a laboratory facility. The insulated Weatherhavens have oil and propane heaters for winter use. Two floating docks are located on Daring Lake for mooring aircraft and boats. Six solar panels and a wind generator provide electrical power (both 120 AC and 12 volt DC), and back-up electricity is available from a gas generator. A solar powered electric bear fence has been installed to protect the camp facilities and researchers. Water is obtained from Daring Lake by a gas powered pump and PVC pipe connected to a 1000 L holding tank. A satellite phone is located on-site. There is one 4x4 All Terrain Vehicle available on site and two aluminum boats with outboard motors. An automated climate station is located at the camp and is maintained by Water Resources Division of the Department of Indian and Northern Affairs.

Mining and Exploration Operations

The discovery of diamonds in the project area and the long-standing tradition of gold prospecting and mining have resulted in several exploration projects and numerous active and inactive mining operations:

- Tahera Corporation - Jericho Project;
- Winspear Resources Ltd. - Camsell Lake Property (Snap Lake Discovery);
- Mill City and Tanqueray Resources Ltd. - Yamba Lake;
- Monopros Limited - Kennady Lake (Gahcho Kue') Project;
- Courageous Lake area;
- Colomac Mine;
- Discovery Mine; and
- Other Activities.

Tahera Corporation - Jericho Project

The Jericho Diamond Project (65°53' N, 110°50' W) is owned by Tahera Corporation (formerly Lytton Minerals). The property is located on the north shore of Contwoyto

Lake, 420 km NNE of Yellowknife and 28 km NNW of Echo Bay Mines Ltd.'s Lupin Mine.

Tahera Corporation has initiated a feasibility study on the Jericho Diamond Project to assess the economics of constructing a modest-sized open-pit mining operation based on the land-based Jericho kimberlite pipe. Tahera Corporation also filed a formal project proposal for the Jericho Diamond Project with the relevant authorities in May, 1999 thereby initiating the environmental assessment and regulatory approval process for the proposed Jericho Diamond mine.

The proposed development will consist of an open pit mine at the Jericho site and a 300,000 tonnes per year processing plant that will be constructed at the Lupin Mine. Ore will be mined for seven months of the year and hauled by truck from the Jericho site to Lupin via a winter road from mid-January to mid-May. Ore treatment will be through dense medium separation (DMS) with a cut-off particle size of 1.15 mm. Diamond sorting will occur at both on-site and off-site facilities. Processed kimberlite will be disposed of at the existing Lupin Mine tailings impoundment (fine tailings will be pumped into the impoundment; coarse material will be stockpiled and used as cover material during closure of the impoundment). A mine life of approximately 9 years is currently envisioned.

The Jericho site will be accessed by air and land. Air access will be via air charters to the Lupin Mine or by float and/or ski plane to Carat Lake (Jericho site). Land access will be via the Lupin Winter Road from Yellowknife to the Lupin Mine and from a winter road between the Lupin Mine and the Jericho site.

Winspear Resources Ltd. - Camsell Lake Project (Snap Lake Discovery)

The Snap Lake Discovery of the Camsell Lake Property is located within the Camsell Lake licence block and comprises 110 separate claims covering approximately 272,000 acres. The site (63°34' N, 110°31' W) is located 220 km NE of Yellowknife and approximately 100 km south of EKATI™. The project is a joint venture between Winspear Resources Ltd. (the operator, 67.7% ownership) and Aber Resources Ltd. (32.3% interest). The project site is in the transition zone from the open tundra to the tree line and is in the range of caribou wintering area.

Winspear Resources announced that an advanced exploration program designed to obtain all information required to support a "bankable" feasibility study has commenced on the property. Plans are to mine approximately 20,000 tonnes of kimberlite by developing a 600 m drive in kimberlite located 120 m below Snap Lake. To access the NW dyke below Snap Lake, a 1200 m long decline will be collared on the NW peninsula and driven out under Snap Lake to intersect that portion of the dyke along which mining will occur.

The kimberlite processing will be similar to that for the EKATI™ mine with a processed kimberlite containment area being required. Discharges are anticipated to be similar and, due to the lack of data, assumptions will be made on the design of the project.

Mill City and Tanqueray Resources Ltd. - Yamba Lake

The kimberlite discovery made by Tanqueray Resources Ltd. and its joint venture partners Mill City International Inc. and Cypango Ventures in the Yamba Lake region is located 320 km northeast of Yellowknife and approximately 30 km north of the EKATI™ Mine (64°24' N, 109°39' W). SouthernEra Resources Ltd. can earn a 51% undivided interest in the Yamba Lake property by spending $10 million by the end of 2002. Upon this expenditure, the remaining interests will be Tanqueray 19%, Mill City 19% and Cypango 11%.

The property covers an area of approximately 152,500 acres and consists of 7 kimberlite pipes including the Ptarmigan and T-10 pipes. During 1998, over 1,000 till samples were collected. During 1999, the exploration program flew an 8,000 line kilometer high resolution helicopter mounted magnetic and electromagnetic airborne geophysical survey over the entire property. Geophysical anomalies indicative of kimberlite pipe intrusions were drill tested during 1999 resulting in the discovery of one new kimberlite pipe (S-141). Diamond drilling to further test airborne geophysical anomalies that are indicative of kimberlite pipe intrusions will be completed during the spring of 2000. No further work is planned on the Ptarmigan and S-141 pipes.

This property is still in the initial exploration phase and no announcements have been made to start a feasibility study or initiate bulk sampling.

Monopros Ltd. - Kennady Lake (Gahcho Kue') Project

The Kennady Lake Project is a joint venture partnership between Mountain Province Mining, Camphor Ventures (the MPV group) and Monopros Ltd. which has the opportunity to earn a 60% interest in the project by bringing it to production. The property is located 300 km northeast of Yellowknife, adjoining the northern edge of the Gerle Gold property. This property is in the transition zone between the tundra and the tree line.

The bulk sampling of the 5034, Hearne, Tuzo and Tesla pipes was started January 11, 1999 and was completed April 6, 1999. The average modeled grade of 1.22 carats per tonne is greater than the initial bulk sample result of 1.02 carats per tonne reported on September 15, 1999. The average modeled value per carat decreased from the initial estimate of US $68 per carat, based on the 1998 mini-bulk sample, to US $43 per carat. With these results from the Tuzo pipe, both De Beers and Mountain Province agree that it is unlikely that the agreed upon rate of return will be achieved from the mining of the 5034, Hearne and Tuzo pipes. As a result, Mountain Province has agreed to extend the

feasibility study decision date and De Beers has agreed to carry all exploration, development and other project costs effective immediately.

De Beers will now embark on an aggressive exploration program, which will involve the drilling of 16 targets in both the eastern and central parts of the lower half of the AK claims. It is anticipated that a few additional targets will also be drilled in the southern part of Kennady Lake. These targets will depend on the results of the recently completed ground geophysics program. Additional ground and airborne geophysics surveys will be carried out on newly defined indicator mineral trains in the central and northern parts of the AK claims. In parallel with the aggressive exploration program De Beers will investigate several alternative mining scenarios in order to minimize capital and working costs associated with the possible mining of the Kennady Lake pipes.

Courageous Lake Area

There are and have been several exploration and mining projects centred on Courageous Lake, including:

- Rhonda Mining Corporation (exploration);
- Total/Battle Mountain (exploration); and
- Tundra Mine (closed).

Despite this activity, no significant discoveries have been made to date.

Colomac Mine

The Colomac Mine is approximately 210 km NNW of Yellowknife and 60 km northwest of the community of Snare Lake (64°12' N, 116°1' W). Colomac is a past-producing open-pit gold mine. The previous owner of the mine, Royal Oak Mines, declared bankruptcy in 1999 and the mine is now in receivership.

Discovery Mine

The Discovery Mine is located approximately 80 km north of Yellowknife (63°11' N, 113°54' W). It was in operation from 1950 to 1969 and produced approximately 1 million ounces of gold.

Other Activities

Other activities in the area that have been identified are:

- Wekweti (Snare Lake); and

- Snare River Hydro Plant.

Wekweti (Snare Lake)

Snare Lake is located approximately 180 km west of the EKATI™ mine, 195 km by air north of Yellowknife and is the closest community to the site. It has a population of approximately 120. It has been a part of Dogrib Dene hunting territory for as long as the region has been inhabited. There are regularly scheduled flights from Yellowknife. There are no roads going into this isoloated community. Hunting, trapping, and fishing are still the principle sources of employment.

Snare River Hydro Plant

The Snare Rapids hydro plant is located near the outlet of Big Spruce Lake and was built in 1948 to serve Yellowknife and the Giant Mine. The 4.3 MW Snare Cascades plant was recently added in the region by the Dogrib Power Corporation. Both projects are low-level and have minor impacts on the rivers. Hydro lines run from the generating stations to nearby communities and Yellowknife.

Activities and Potential Regional Effects

The limited activities of the various developments (outfitters, mining and exploration developments, miscellaneous other activities) and their widespread distribution over approximately 16,000 km^2 suggests that their regional significance will be negligible. The activities, their effects and their potential regional effects as they relate to the VECs are:

- *Air Quality*

  Noise generation (float planes, snowmobiles, ATVs, motorboats, generators, guns, etc.) resulting in increased noise close to camps and hunting areas. Due to the limited number of operations and their wide distribution throughout the region, noise generation will be minimal and no regional effects on air quality are expected.

  Combustion of fossil fuels (operation of generators, outboard motors, etc.) resulting in increased greenhouse gas emissions. Due to the limited number of operations, the small size of most of their fuel-burning machines and the short operating period (summer only), increases in greenhouse gas emissions will be negligible and no regional effects on air quality are expected.

  Use of roads that exist at some operations resulting in fugitive dust emissions. The only permanent road is at Treeline Lodge (old Tundra mine) and the fugitive dust emissions produced over the hunting season will be negligible. No regional effects on air quality are expected.

- *Water Quality and/or Quantity*

  Extraction of water for use in camps resulting in decreased water quantity in adjacent waterbody. This is negligible due to the relatively small size of most operations and the large volume of water contained in the waterbodies that these operations are adjacent to. No regional effects on water quantity are expected.

  Operation of outboard motors resulting in potential hydrocarbon contamination and reduction in water quality. Due to the limited number of boats, general maintenance and operating procedures and the large size of the waterbodies, it was determined that hydrocarbon contamination will be negligible and no regional effects on water quality are expected.

  Disposal of sewage and wastes through use of septic/outhouse systems resulting in potential faecal coliform or other contamination and reduction in water quality. There are a limited number of camps that are relatively small size and wide distribution throughout the region, therefore, the potential contamination related to sewage and waste disposal will be negligible and no regional effects on water quality are expected.

- *Physical/Terrestrial Environment*

  Construction and presence of lodges/cabins/tents resulting in destruction of vegetation. The operations are generally small in extent, so although vegetation will be or has been destroyed in a very limited area, no regional effects on the physical/terrestrial environment are anticipated.

  Generation of fugitive dust through use of roads and resulting deposition on vegetation. The generation fugitive dust is extremely limited (Treeline Lodge) so no regional effects on the physical/ terrestrial environment are anticipated.

- *Heritage Sites*

  Construction and presence of lodges/cabins/tents resulting in destruction of sites. There are limited footprints associated with the camps and the access to other areas by humans is limited. Therefore, although heritage sites may have been destroyed in localized areas, no regional effects on heritage sites are expected to occur.

- *Caribou/Habitat*

  Hunting resulting in caribou mortality. The number of caribou killed by outfitters relative to the overall size of the Bathurst caribou herd is small (average annual harvest is approximately 700 caribou compared to a herd size of approximately 350,000 caribou, which equates to 0.2%). Thus, no regional effects on caribou are expected.

Noise generation resulting in changes to caribou distribution and/or behaviour. Changes to caribou distribution and/or behaviour as a result of noise generation from the outfitter camps will be negligible due to the limited size of the camps and their wide distribution throughout the region. Thus, no regional effects on caribou are anticipated.

Presence of humans will change caribou distribution and/or behaviour as they will move downwind of humans who are viewed as potential predators. Thus, changes in caribou distribution and/or behaviour are negligible and no regional effects on caribou are expected.

Presence of buildings. Caribou are not noticeably affected by the presence of structures in the absence of humans. Therefore the changes in caribou distribution and/or behaviour (especially during the off-season) will be negligible and no regional effects on caribou are anticipated.

Use of winter road to transport materials to some camps during winter resulting in possible caribou mortality (collisions) and changes to caribou distribution and/or behaviour (noise generation and presence of road). There are strict guidelines for the use of the winter road to avoid wildlife collisions. Additionally, a limited number of camps are accessible by the winter road. There will be negligible caribou mortality because of collisions and negligible changes in caribou distribution and/or behaviour and no regional effects on caribou.

- ***Carnivore/Habitat***

Hunting resulting in carnivore (wolf, wolverine) mortality. A limited number of carnivores are killed by outfitters and other general hunters (average annual harvest is approximately 10 wolves and/or wolverines) each year. Therefore, regional effects on carnivores will be negligible.

Noise generation. There may be changes to carnivore distribution and/or behaviour as carnivores will typically investigate any new sounds to determine if they represent a potential food source or threat. If a noise becomes associated with a negative consequence (*e.g.* bears that have been drugged from helicopters will run away from helicopters in future encounters). As such, there may be negligible to minor changes in carnivore distribution and/or behaviour while the camps are in operation. However, no regional effects on carnivores are expected due to noise generation.

The presence of humans will result in changes to carnivore distribution as carnivores will typically vacate the immediate area around humans.There is a potential for negligible to minor changes in carnivore distribution and/or behaviour while the camps are in operation. However, no regional effects on carnivores due to the presence of humans are expected.

Presence of buildings. Carnivores are opportunists and will typically investigate any new structures in their ranges to determine if they represent a potential food source. As such, there may be negligible to minor changes in carnivore distribution and/or behaviour when new structures (e.g. outpost camps) are introduced into their ranges. However, due to the limited number of potential structures and the fact that carnivores will ignore structures once they have been investigated and found not to be sources of food, no regional effects on carnivores are expected.

Use of winter road to transport materials to some camps during winter resulting in possible carnivore mortality (collisions). Due to the limited number of camps that are accessible by the winter road and the fact that the majority of carnivores (particularly wolves) follow the caribou into the treeline, there will be negligible carnivore mortality because of collisions. Thus, there will be no regional effects on carnivores.

- ***Breeding Birds/Habitat***

Noise generation resulting in changes to bird distribution and/or behaviour. Birds will vacate an area when a new noise is identified, but upon cessation of that noise, will immediately return to their previous locations. Furthermore, if the same noise is identified repeatedly and no obvious negative consequences are associated with it, birds will become habituated to the noise and it will not affect their distribution or behaviour. Thus, no regional effects on breeding birds are expected due to noise generation.

Presence of humans. Initially, human presence will cause birds to vacate an area. However, once the birds become habituated to them, humans do not affect their distribution or behaviour (except momentarily as a result of unexpected noises, *e.g.* gunshot). As a result, no regional effects on breeding birds are anticipated due to the presence of humans.

Presence of buildings resulting in changes to bird distribution, behaviour and/or habitat. The presence of buildings adds new habitat to an area for birds to exploit but there are a limited number of structures associated with the camps so no regional effects are expected.

- ***Fish/Aquatic Habitat***

Fishing resulting in fish (lake trout, northern pike, grayling, whitefish) mortality. Most outfitters specialize in hunting and offer fishing only as a side activity. Therefore, the number of fish mortalities due to fishing is expected to be extremely limited and localized to specific fishing lakes and no regional effects on fish are expected.

- ***Groundwater***

Disposal of sewage and waste and potential seepage into groundwater resulting in potential faecal coliform contamination and reductions in water quality. Due to the

limited number of camps, their relatively small size and their wide distribution throughout the region, it was determined that potential groundwater contamination related to sewage and waste disposal will be negligible and no regional effects on groundwater are anticipated.

APPENDIX G –
BHP DIAMONDS INC. NEWSLETTER

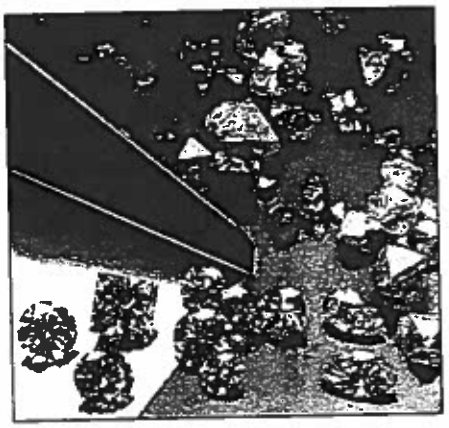
BHP
BHP Diamonds Inc.

Newsletter

Bringing news from EKATI™ to you

Issue 2 September 1999

Published by BHP Diamonds Inc., Yellowknife, NT, Canada



Rough and cut EKATI™ Diamonds.

Employee Purchase Program for Polished Diamonds

As we near the anniversary of EKATI™'s opening, the EKATI™ joint venture partners will introduce an Employee Purchase Program (EPP), giving their employees the opportunity to purchase a polished EKATI™ diamond. The intention is to have a series of Offers, until demand is satisfied. Full program details will be distributed shortly before the Initial Offer.

The stones on offer will have the word EKATI™ laser inscribed on the girdle, and where appropriate, stones will be accompanied by a GIA (Gemological Institute of America) grading certificate or dossier, setting out the quality characteristics of the particular stone.

The EPP offer will include a price list of polished stones available for purchase, with details of the carats, color, clarity and cut.

Continued on page 2

New **Logo** Launched for **EKATI™ Diamonds**

The new EKATI™ Diamonds Logo.

"We believe EKATI™ diamonds can help generate new excitement in the marketplace."

A "crystal" maple leaf, overprinted with EKATI™ Diamonds, will soon become synonymous with diamonds from Canada's first diamond mine. The maple leaf, an internationally recognized Canadian symbol was chosen to represent EKATI™ diamonds in the global marketplace.

The new logo was unveiled on June 22, 1999 at a gala black-tie event, part of the Third International Gemological Symposium in San Diego. The logo forms the keystone of a worldwide marketing plan to launch EKATI™ as a reliable and dependable source of high quality diamonds.

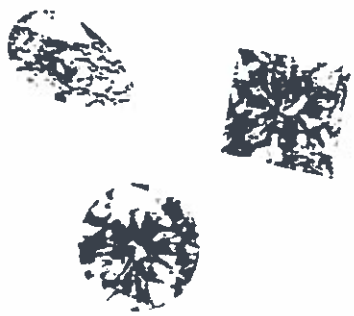
"Canadian rough diamonds have become a permanent feature of the world diamond business, " said James Rothwell, President of BHP Diamonds Inc. Jim Eccott, President and CEO of Dia Met Minerals Ltd., is enthusiastic about the prospects for a Canadian diamond industry. "We believe EKATI™ diamonds can help generate new excitement in the marketplace," he said. "Although we are new to the business, we are committed to the long term success and health of the diamond industry."

The new logo was presented to 2,000 Symposium attendees and invited guests at the "Nature of Diamonds" evening at San Diego's Natural History Museum, sponsored by BHP Diamonds Inc. and Dia Met Minerals Ltd.

The EKATI™ logo will be appearing in a series of double page advertising layouts in industry publications.

Employee Purchase Program for Polished Diamonds

Continued from page 1



Employees will be able to view the stones at the Yellowknife Sorting & Valuation Facility.

Employees of BHP Diamonds Inc. and its Joint Venture partners, will be eligible to purchase diamonds under this program.

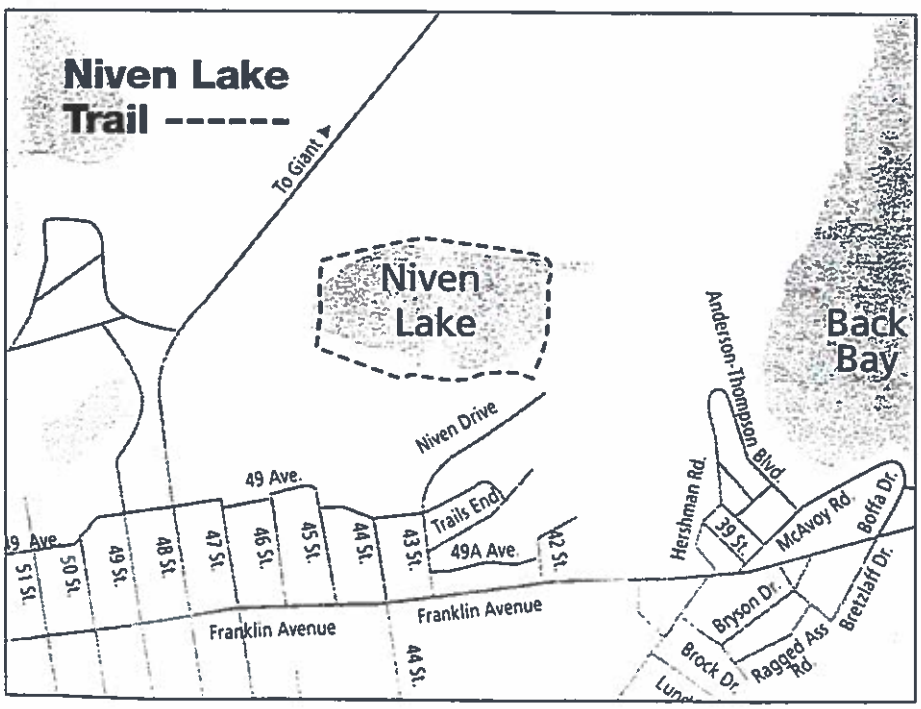
The stones will be offered at the wholesale market price of polished plus transport, GIA costs, excise tax (10%) & GST (7%). The net return to the joint venture partners will approximate the price received had the rough been sold to our customers in Antwerp. The stones will range in price from around C$300 per stone to over C$5,000 per stone.

Prior to the announcement of the EPP, you may wish to understand more about diamond quality and prices. Accessing diamond websites provides an idea of what is available in the market, in terms of price ranges for stones of various sizes, colours, clarities and cuts. These sites offer diamonds to the public through the internet, and are usually more competitive than buying directly through a retail outlet. They also provide background information on diamonds (such as – carats/colour/clarity/cut, terminology, certification). However, BHP Diamonds cannot vouch for the professionalism and credibility of any of these sites. Just a few of the available sites are:

www.internetdiamonds.com
www.mondera.com
www.diamonds-usa.com

Following the announcement of the Initial Offer, employees will be able to view the stones at the Yellowknife Sorting & Valuation Facility within certain specified times. The stones will also be transported to the mine site for viewing. Employees will be asked to list their first, second and third choice of stone, in case the original is not available. Where more than one request is received for a certain stone, allocation will be on the basis of first preference to those employees with special circumstances (e.g., planning a marriage), followed by drawing names out of a hat. Those employees who are successful in purchasing a diamond will not be eligible for subsequent rounds, until it is ascertained that all employees who wish to purchase a diamond have been successful. Payment will be by cash, bank cheque or personal cheque. The stone can be collected by the employee after payment has been made (in the case of a personal cheque, after funds have been cleared). Stones not paid for within one month will be used for the next EPP. Company loans will not be made available, nor will salary deduction be considered as a means of payment.

BHP Employees **Adopt-a-Trail**



When asked if the employees of the Yellowknife Office were interested in participating in the City of Yellowknife's "adopt-a-street" program, they said "no"! No – they didn't want to adopt just a street – they wanted to adopt the Niven Lake Trail.

What does adopting-a-street mean to our employees? It means that the City of Yellowknife will provide us with garbage bags and work gloves in order to maintain the cleanliness of the trail and signage that reads "This trail sponsored by BHP Diamonds Inc." at both entrances to the trail.

BHP Diamonds employees, by adopting the Niven Lake Trail, will demonstrate to both the citizens of and visitors to the City of Yellowknife, their dedication and commitment to this scenic trail.

30 Years with BHP
- Claude Jones

Terry Jones, Marketing Manager, Europe

On June 2, Claude Jones, Administrative Manager for the Antwerp office, celebrated his 30th anniversary with BHP. This date 30 years ago was an important decision time for Claude, not only for starting his long career with BHP, but two days previously he was married to Lola Ann – both "relationships" are still going strong.

Claude has worked at a number of mine sites in North America. Antwerp is his 9th posting:

- Cedar City, Utah
- Lucky Mc, Wyoming
- Big Eagle, Wyoming
- Springer, Nevada
- Eastern Coal, Kentucky
- Western Coal, New Mexico
- Island Copper, British Columbia
- BHP Diamonds Inc., Northwest Territories
- BHP Diamonds Inc., Belgium.

He says that "a moving van pulls up to his house every three years now, whether he orders it or not". Moving to Antwerp has allowed him to return to Europe for the first time since an early army assignment in Germany. Claude's roots are in the Western US, where he eventually plans to retire. Lola Ann and Claude have a son and three grandchildren back in Utah.

Claude has the reputation of being at operations when they are in their final stages and ready for closure. At BHP Diamonds Inc. however, he has been part of the building process and a valuable contributor from the early stages.

Claude Jones

ULU Cleanup

Herman Perry, Logistics

The old Ulu gold project was sold to Echo Bay Mines several years ago and the site was substantially moved toward production before it was shut down in 1996. BHP unfortunately still retained the responsibility of cleaning up the old mess that was left there from the exploration days.

Ulu is located 300 km north of EKATI™. In August it was decided to bite the bullet and make arrangements to get Ulu empty barrels and other old supplies and drill steel moved out to EKATI™ for disposal. After several earlier discussions between Chris Hanks and I, we booked a twin otter and went up to look at the airstrip, the general area, and see the number of barrels and other supplies involved.

It was determined there would be between 600 and 800 barrels and about another 20 tons of waste material involved in the move.

One of the contractors at site, Nuna Logistics, was approached to see if they were interested in handling the cleanup at Ulu. It was felt Nuna was our best candidate since they still had some of their equipment in storage up at site from the time when the Ulu project was shut down. The old EBM camp was fired up and the small crew lived with some element of convenience for their short stay. The DC4 was chartered to do the haulage from Ulu since the runway, at 4000 feet was too short for a Herc.

Arrangements were made to get an EBM representative involved in the activities as well. The project took 4 days and all went well. The airstrip and the access road had to have some minor repairs. The group was startled by a grizzly which wandered into the area on one occasion during the cleanup, but that was the extent of the surprises. The DC4 made 6 trips from Ulu to EKATI™ and finished the last load into EKATI™ before having to return and fight fires in Rae-Edzo.

The barrels are being backloaded on the Herc and moved to YK soon. The rest of the material is being buried or stored at EKATI™.

Human Resources

Here is a list of new BHP Diamonds Inc. employees. Welcome to the EKATI™ team!

Nick Adjun
Sylvia Andrejek
Don Arnault
Terri Badry
John Brosnan
David Bruce
Helen Butler
Renee Camsell
Jon Carlson
Brent Carr
Laura Chin
Mary Corrigal
Sam Drybones
Darren Dyck
Edward Farrell
Marek Gatkiewicz
Antonio Gonzales
Curtis Hagen
Wendy Harris
John Hwong
Yvon Jeannotte
Allan Johnson
Michael Kaatsch
Angele Kuliktana
Grant Lockhart
Lex Lovatt
Greg Lyons
Peter Mackenzie
Sam Mantla
Brian Marshall
Chris Martin
Ross McElroy
Regina Menendez
Jim Millard
Steven Norn
Bernhard Pesch
Ward Phillips
Ingrid Piefke
Ken Pon
John A. Quitte
Keith Sangris
Mark Steinwand
Brian Tobie
Patrick Tom
Tracy Williams
Carmen Wong
Charlie Zoe
Louie Zsoldos

BHP Charter

"It should provide the basis for conversations in all our workplaces about what we do and how we behave."

In my letter of 12 February to all employees I referred to the work being undertaken on a BHP Charter. I have now finalized this work. I would like to thank the wide range of people at different locations, and different levels in the company, who put forward their views and helped me in putting the Charter together.

The members of the Management Committee have unanimously endorsed it, and understand that the Charter must be matched by actions and behaviours. It is important that the Charter not be a document that is scanned in a cursory manner and filed away or framed and hung on our walls. Rather, it should provide the basis for conversations in all our workplaces about what we do and how we behave, and it should be regularly revisited. This is a task I have asked the Management Committee, and beyond them, a broader group of key communicators in the company, to take responsibility for, and they will be provided with some communication tools to assist them.

You should read it carefully and expect to have the opportunity to discuss it in your workplace in the near future.

Paul Anderson

BHP Charter

Moving into the 21st Century

We are BHP, an Australian based global company, founded in 1885, which is undergoing fundamental change as we adjust to a highly competitive global business environment.

Our purpose is to create shareholder value through the discovery, development, and conversion of natural resources.

To survive and prosper we must:

- Re-establish a foundation for future growth by eliminating under-performing assets and rebuilding margins.
- Create a high performance organization in which every individual accepts responsibility and is rewarded for results.
- Earn the trust of employees, customers and shareholders by being forthright in our communications and consistently delivering on commitments.

We value:

Integrity - Doing what we say we will do.

High Performance - The excitement and fulfilment of achieving superior business results and stretching our capabilities.

Win-Win Relationships - Having relationships which focus on the creation of value for all parties.

The Courage to Lead Change - Accepting the responsibility to inspire and deliver change in the face of adversity.

Respect for Each Other - The valuing of diversity, enriched by openness, sharing, trust, teamwork and involvement.

Safety and the Environment - An overriding commitment to safety and environmental responsibility.

We are successful when:

- Our shareholders are realizing a superior return on their investment.
- Our customers are benefiting from the use of our products and services.
- The communities in which we operate value our citizenship.
- Every employee starts each day with a sense of purpose and ends each day with a sense of accomplishment.

Award Winning Mine

To date, there have been the following achievements:

◆ **EBA Engineering Consultants Ltd.** – EKATI™ Diamond Mine Frozen Core Dam. Award of Excellence for Resource Development. Award of Merit for Technology Innovation

◆ **A.D. Williams Engineering Inc.** – EKATI™ Diamond Mine Permanent Camp Facility & Truck Maintenance Facility – Award of Merit for Resource Development, Award of Merit for Technology Innovation

◆ **H.A. Simons / BHP Diamonds Inc.** – EKATI™ Diamond Mine – Canadian Council of Canadian Engineers, National Award for Engineering Excellence

◆ **Special Award Certificate** by the John T. Ryan safety trophies Committee.

Committee's Comment: "your mine has earned a Special Award Certificate in recognition of its outstanding achievements in safe production in 1998. Through the construction phase and the early stages of production, Canada's first diamond mine is building its own high safety standards. Congratulations to you and the people at your operation for this accomplishment"

◆ **Alberta Chamber of Resources** – Resource Person of the Year Award of 1998 – Mr. Jim Excell, Vice-President of Operations.

◆ **1999 Mine Rescue Team** – Best Team Overall, NWT Mine Rescue Competition, 1st place, Underground Fire Fighting, 1999 National Western Regional Mine Rescue Competition. Best Team Captain (Joe Nicholson). Team members: Bruce Budgell, Ryan Schimmelman, Don Radovitch, Kevin Foster, Rob McLean, Andrea Minault. Mike Cooper (coach).

◆ **1999 First Aid Team** – First in WCB / St. John's Ambulance annual first aid competition. Team members: Barb Pennington, Lloyd Benson, Ryan Schimmelman, Andrea Minault and Dianne Betsina. Team coaches: Lloyd Gould, Dave Main and Mike Cooper.

Mine Rescue Team member, Kevin Foster, checking a piece of equipment.

"Canada's first diamond mine is building its own high safety standards."

New Dedicated **Waste Management Building**

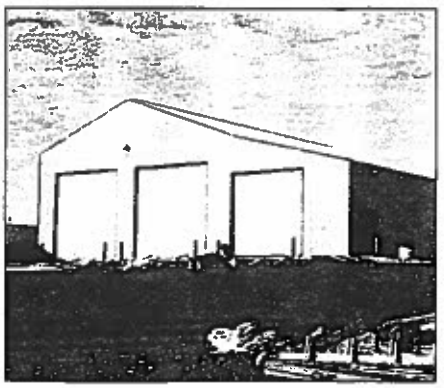
Derek Chubb, Environmental Specialist

BHP maintains a strong commitment to protect and safeguard the environment. This commitment has been clearly illustrated once again with the construction of a dedicated Waste Management Building. Construction is well underway, with a scheduled completion date during the fall of 1999.

The Waste Management Facility will serve to process all waste materials that are sent off-site for recycling or disposal. Materials currently recycled include lead-acid batteries, used grease, used oil, used fuel, solvents, waste paint, oil filters, fuel filters, plastic pails, empty drums, and pallets. Any waste material not suitable for the on-site solid waste landfill will be prepared for shipping off-site to a licensed disposal facility.

With the opening of the Waste Management Building, used oil generated on-site will be recycled for use in used oil furnaces. Used oil furnaces have been installed in the Waste Management Building, the Warming Shed, and the Site Services Building. By re-using the oil for heating purposes, we will be reducing the volume of waste materials produced, thereby helping the environment.

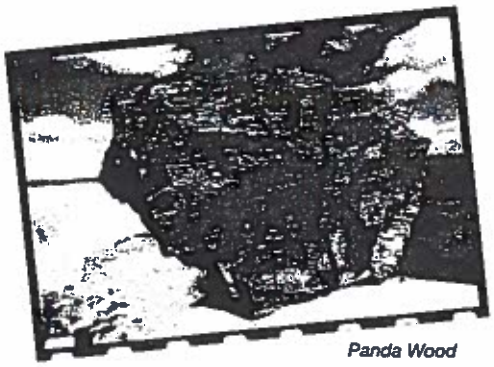
The Waste Management Building is a facility of which we are proud!



The NWT's only waste management facility.

52 Million Year Old Wood Found

Jody Todd, Mine/Geotech Geologist



Panda Wood

This specimen of wood is approximately 52 million years old and is not fossilized. This fragment was recovered during the early mining phase of Canada's first commercial diamond mine, the EKATI™ Diamond Mine, located approximately 200 kilometers south of the Arctic circle in Canada's Northwest Territories. During early diamond drilling exploration, abundant Cretaceous (66 to 144 million years old) and Tertiary (16 to 66 million years old) fossils were being recovered, which enabled the geologists to place important age constraints on the kimberlite pipe formation and the paleogeography of the region. From a few of the diamond pipes rare leaves, turtle bones and fish parts have been recovered. The age of the kimberlite pipes on the BHP–DiaMet property are considered to range from 47 to 74 million years (as determined from Rb-Sr dating of a mineral phologopite found within the kimberlite.) Abundant wood specimens have been recovered during the mining of the first diamond pit – Panda pit. Many specimens are in various states of carbonization (cooking and burning of the wood). They became charred when they were buried in hot ash and exposed to low thermal temperatures of 150 to 200 °C (302 to 392 °F). Some specimens have not been exposed to any burning and look like normal cedar logs. The wood is believed to be from a Redwood forest containing Sequoia and Metasequoia, which was one of the most common swamp plants of the Eocene (a geological period between 37 and 58 million year ago). The presence of such fossils indicate a humid and temperate climate 52 million years ago; a drastic contrast to the barren and cold tundra that now exists in the sub-Arctic of the Northwest Territories of Canada.

How did the wood and other fossils get buried 400 metres (1300 feet) and deeper within the pipe?

Diamond pipes are formed by rising gaseous magma originating deep within the earth, usually 150 to 200 Km or 93 to 125 miles, but some examples have been determined to originate as deep as 300 Km (186 miles) down. As the magma approaches surface the gases within the magma expand and pressure increases until an explosive eruption causes expulsion of the granite (our host rock), creating an open carrot shape pipe that can be as deep as 400 metres or greater. Any organic matter (trees, plants, animals) living at surface would get mixed with the hot falling ash and be buried and burned by it. Other trees and fossil would later be buried in layers of cold ash near the rim of the crater of the pipe and fall back in.

Processed Kimberlite Revegetation Experiments

Helen Butler, Environmental Specialist

BHP is committed to progressive reclamation. That is, we will reclaim areas no longer needed for mining as soon as they become available. One such area is part of the Long Lake Containment Area where processed kimberlite is stored. BHP proposes to turn this area into wetlands. But before this can be done, experimental plant research needs to be carried out, and there's no better place to do this than the indoor greenhouse at EKATI™. The reason for this is that before reclamation efforts proceed at the Long Lake Containment Area, controlled experiments are necessary to determine the best choice of plants to grow in processed kimberlite.

Kimberlite is the type of rock being mined and processed at EKATI™. It is not unlike the rocks and soils found in Hawaii, Iceland and other volcanic islands in the Atlantic and Pacific Oceans. What is common to these volcanic islands is that plants are plentiful and under the right conditions, grow quite well. Our thought is that if plants grow so well on the rocks and soils of volcanic islands and seeing kimberlite is similar in nature, why can we not grow plants on processed kimberlite? Already, without our assistance we are seeing plants growing on the processed kimberlite in the Long Lake Containment Area. This is a good indication of favorable growing conditions for vegetation. The indoor research program will help us to find the right conditions and the best local plants to grow.

The questions we are trying to answer at EKATI™ include:

- *"What are the right conditions for growing local plants in kimberlite?"*
- *"What are the best plants to grow?"*
- *"What can we do to encourage plant growth on processed kimberlite?"*
- *"How can we assist a natural process and create a productive wetland habitat in the Long Lake Containment Area?"*

So far the greenhouse studies have been encouraging. Willows, grasses, and legumes have all been grown in various soil (kimberlite), nutrient, and moisture conditions and with this work we are getting to know "the right conditions" and "the right plants". The next step is to move from greenhouse studies to the actual growing of plants on processed kimberlite in the Long Lake Containment Area.

If greenhouse and field studies prove successful at EKATI™, BHP will lead the way for future processed kimberlite reclamations in other areas. The Long Lake Containment Area will also become a stable and productive wetland habitat – an area frequented by ducks, geese, caribou and other wildlife – it will again be an integral part of the tundra ecosystem.

Green House Experiment

Additions to Kimberlite Resource

-Sable, Pigeon and Beartooth Pipes

Tina Markovic, Senior Resource Planning Coordinator

BHP currently holds permits to mine Panda, Koala, Misery, Fox and Leslie pipes. The projected mine life is 23 years (to year 2021). At this time however, the Leslie pipe is not economical to mine. The mine life without the Leslie pipe is estimated to be 15 years or until 2013.

In December of 1998, BHP applied to DIAND for amendments to existing permits and new permits to develop new kimberlite pipes. The addition of Sable, Pigeon and Beartooth kimberlite pipes will extend the mine life to 18 years, or roughly until the year 2016.

When BHP went through the original permit process, the company made it clear that more kimberlite pipes would be added to the ore reserve. The Environmental Impact Statement (EIS) and subsequent Environmental Assessment Review Process (EARP) included a hypothetical future development of three additional kimberlite pipes – 2 under lakes and 1 land-based. As it turns out, this is the actual case that we are facing now.

The EARP Panel "*...concludes that the cumulative environmental effects of additional development by BHP on the Lac de Gras claim block are unlikely to be significant*".

The resource additions are currently undergoing environmental assessment by the newly created Mackenzie Valley Environmental Impact Review Board (MVEIRB) for the Sable Kimberlite Pipe, Pigeon Kimberlite Pipe (land based) and the Beartooth Kimberlite Pipe. The Board has advised BHP that the review process will take approximately 18 months.

With the addition of the Sable pipe the mine life would be extended to 17 years or to the year 2015. Add Pigeon and Beartooth and the mine life would be extended to 18 years or to the year 2016.

Development of the Sable pipe will include:

- an all weather road from the present facilities to Sable (this may require a quarry on the Ursula Esker)
- an equipment maintenance building and fuel storage at Sable
- an emergency shelter
- waste rock storage area near the pit
- temporary drainage of Sable Lake
- drainage control including sedimentation pond

Development of Pigeon will include:

- upgrade of the existing road from the facilities
- waste rock storage area near the pit
- temporary re-route of a stream around the pit

Development of Beartooth will include:

- a short all weather haul road from Panda pit
- expansion of the Panda waste rock storage area
- temporary drainage of Beartooth Lake including a pipeline around the pit

The additional pipes will <u>not</u> require:

- changes to the workforce or accommodations
- changes to the mining method or equipment
- changes to the processing method or facilities
- changes to the Impact and Benefit Agreements or changes to the Environmental Agreement

The additional pipes <u>will provide</u>:

- prolonged employment opportunities
- prolonged economic development opportunities
- prolonged tax revenues
- prolonged benefits under the Impact and Benefits Agreements

Consultations with the communities identified by the previous EARP Review (Yellowknife, Dettah, N'dilo, Lutsel K'e, Rae Edzo, Gameti, Wekweti, Wha Ti and Kugluktuk) will be conducted.

IBA Contact Information

Questions about your Impact and Benefit Agreement?

Dogrib Treaty 11 Council
PO Box 412
Rae-Edzo, NT X0E 0Y0
Tel: (867) 392-6381
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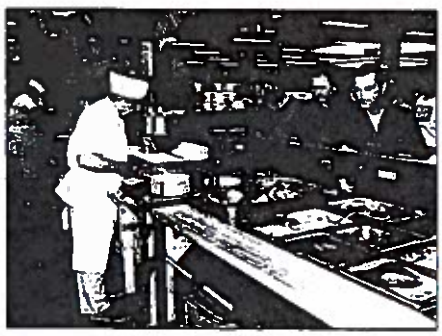
Sodexho Marriott Takes over Catering at EKATI™

Herman Perry, Logistics Superintendent



"Crossroads Cuisine" proved to be a well-received and delicious addition to the daily menus.

As well, a facelift to the sandwich room and dining room, including new tables and chairs is in the works!

As of September 4th, Sodexho took over the catering contract at EKATI™, and a number of changes will soon be visible at the camp. Some will be enacted immediately and others will be phased in over a number of weeks.

In addition to the regular breakfast menu, a special feature will be offered daily.

The *Crossroads Cuisine* which was well presented and received by employees, will be implemented quickly. It will consist of a number of modules in addition to the three daily menus on the main line. The modules will be on the second line and will consist of the following:

Fresh Inspiration: There will be a different layout for the salad bar, including eight different types of salads, three dressings and one calorie wise dressing.

La Vincita: Two types of pasta, one with spaghetti meat sauce and one with specialty sauce; and two types of pizza.

Copper Pot: Two choices of soup with a variety of croutons and scones.

Selona Grill: For this module, Sodexo will be offering daily: one type of burger, one chicken breast sandwich, one specialty sandwich and the special feature of the day.

Bagel Avenue: Different types of bagels and cream cheese spreads.

Viva Bica: At this station, the following will be offered daily: French continental coffee, Mocha Java coffee, decaffeinated coffee and one flavoured coffee.

In addition to the above, country foods (caribou, muskox, arctic char) are incorporated into the weekly menus.

Recreation News

2nd Annual BHP Employee Golf Tournament

On June 25, the 2nd annual BHP Employee Golf Tournament was held at the City of Yellowknife Golf Course. Open to BHP employees and their families, a record number of participants enjoyed a sunny day of golf and a BBQ afterwards. Prizes were donated by a number of local businesses and suppliers.

Thanks to the many volunteers who made this day happen.

Editor: Denise Burlingame / Senior Public Affairs Officer

If you have any questions or comments about the BHP NEWSLETTER, or would like to submit stories, story ideas or photos, please feel free to contact Denise Burlingame at Tel: (867) 669-6107, Fax: (867) 669-6724 or e-mail: burlingame.denise.da@bhp.com.au. BHP Diamonds Inc., #1102 4920 – 52nd Street, Yellowknife, NT, Canada X1A 3T1

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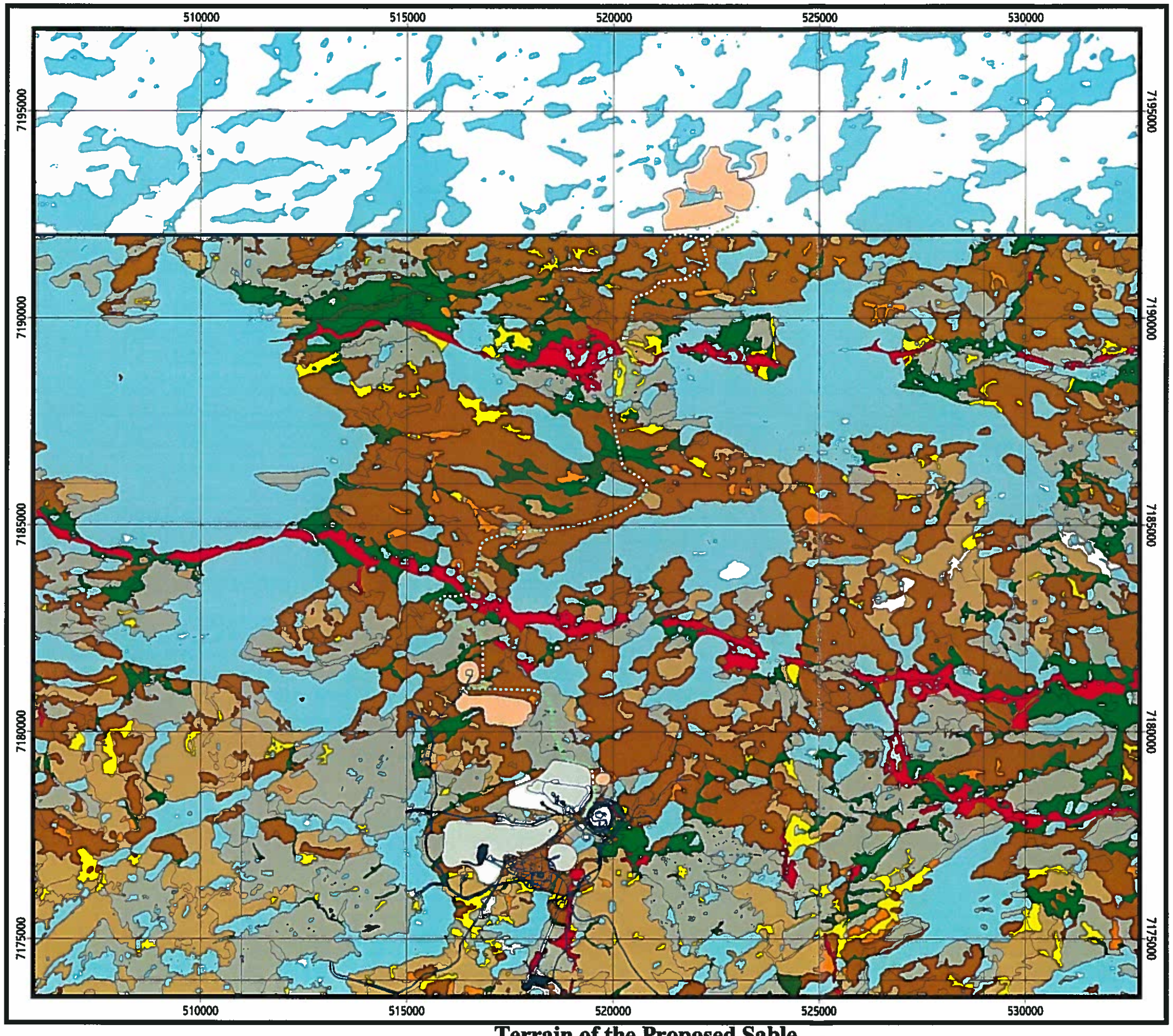
Fax 32-3-213-08-46

BHP website address: www.bhp.com.au/minerals/diamonds/index.htm



GENERAL LEGEND

- BHP Claim Block
- Ecosystem and Terain Mapping of Claim Block Area (BHP 1995a)
- Proposed Development
- Existing Development
- Permitted Development
- Proposed Sable Road
- Existing Infrastructure
- Lakes
- Land

TERRAIN LEGEND

- No Data or Doesn't Fit
- Bedrock Controlled
- Bouldery
- Morainal Blankets
- Eskers
- Other Glacio-Fluvial Deposits
- Lacustrine Deposits
- Active Fluvial
- Organics

Datum: NAD83
Scale: 1:100,000
Date: January 28, 2000
Drawn By: LLL
Checked By: SM

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Metres

Terrain of the Proposed Sable Road Area, Lac de Gras, NWT

FIGURE 3.6-3

BHP

Ekati diamond mine