The Conference Board of Canada
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The Slave Geologic Province

Transportation and Economic Development: Benefit-Cost Analysis

November 2001

WHAT'S INSIDE

The purpose of this study is to assess the impact of investment in transportation infrastructure in the Slave Geologic Province.

The study is divided into four phases: Scenario Development; Benefit-Cost Analysis; Economic Impact Analysis; and Taxation Revenue and Fiscal Impact Analysis.

This phase of the study is the benefit-cost analysis. This analysis compares the quantified benefits and costs to society as a whole of three proposed development scenarios with those of a base case scenario.

For each of the development scenarios the sum of the discounted incremental costs outweighed the sum of the discounted incremental benefits. In other words, society would be worse off if the development scenarios were to go ahead rather than the base case.

The Conference Board of Canada

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ACKNOWLEDGEMENT

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Executive Summary

- This study quantifies the economic benefits and the economic costs of a base case and three development scenarios for the Northwest Territories over a 20-year period.
- The Conference Board and the Government of the Northwest Territories have developed the current report in conjunction with additional studies on the economic impact and taxation revenue implications of the base case and development scenarios.
- The first phase of this study describes how the base case and scenarios were developed. The Northwest Territories Department of Transportation developed the transportation infrastructure components of the scenarios. Other parts of the Government of the Northwest Territories, with the advice of the Conference Board, then joined in to help determine the resulting mineral and other economic developments. While attempting to provide a realistic assessment of future activities in the Slave Geological Province, the uncertainty associated with this forecasting exercise is acknowledged.
- With the exception of the base case, each scenario involves investment in a transportation corridor through the Slave Geological Province, construction of a deepwater port on the Arctic coast and development of various mineral deposits (see Exhibits 1 and 2).
- Mineral development ranges from the inclusion of five diamond mines and a gold mine, in the base case, to seven diamond mines, a gold mine and three new base-metal mines in Scenario 3, the scenario with the highest and most rapid degree of investment in transportation infrastructure.
- The benefits and costs that are considered in the analysis of each scenario are measured from society's perspective. The benefits and costs to society that result from the scenario under consideration are assessed — including indirect (or external) benefits and costs. The study did not explicitly consider who would receive the benefits or incur the costs.
- The costs quantified in the study include the costs of construction and maintenance of the transportation infrastructure and the development and extraction costs for the mining activity.
- Environmental costs that result from the new transportation infrastructure and mineral development activity were not quantified in the study. Possible environmental impacts are discussed along with their effects on the quantified results.

Exhibit 1

Source: Northwest Territories Department of Transportation

Exhibit 2

Development Scenarios

	Transportation Infrastructure	Diamond Mines	Gold Mines	Base-metal Mines	Tourism
Base Case	Winter Road (Yellowknife to Lupin)	Ekati	Lupin		
		Diavik			
		Snap Lake			
		Jericho			
		One new mine			
Scenario 1	Winter Road (Yellowknife to Lupin)	Ekati	Lupin	Izok Lake	
	All-Weather Road (Contwoyto Lake to Arctic Coast)	Diavik		Hackett River	
	Deepwater Port on Coast	Snap Lake		One new mine	
	All-Weather Road (Extension from the North to Ekati/Diavik)	Jericho			
		One new mine			
Scenario 2	Winter Road (Yellowknife to Lupin)	Ekati	Lupin	Izok Lake	Increased expenditures
		Diavik		Hackett River	
	All-Weather Road (Yellowknife to Arctic Coast)	Snap Lake		One new mine	
		Jericho			
	Deepwater Port on Coast	Two new mines			
Scenario 3	Winter Road (Yellowknife to Lupin)	Ekati	Lupin	Izok Lake	Increased expenditures
		Diavik		Hackett River	
	All-Weather Road (Yellowknife to Arctic Coast)	Snap Lake		One new mine	
		Jericho			
	Deepwater Port on Coast	Three new mines			

Source: Scenario Development Report, Current Study

- The costs of construction and maintenance of municipal infrastructure required as a result of the migration of workers and their families to the Northwest Territories have not been quantified in this study. Similarly, the costs of operating training programs for local workers have not been quantified.
- The value of minerals extracted from the new mining activity form the largest category of benefits quantified in this study. Other benefits include user benefits for the new transportation infrastructure — reduced operating expenses and safety - and lower re-supply costs for some coastal communities. Tourism expenditures that result from improved transportation infrastructure have also been quantified.
- Following the recommended practice of the Treasury Board for benefit-cost analyses, economic “multipliers” were not quantified as benefits in the study.

Multiplier benefits are discussed as an unquantified benefit along with their probable effect on the quantified benefit-cost results.

- The principal measure of economic worth used to evaluate the scenarios is the Net Present Value in constant (i.e., net of inflation) 2000 dollars. The scenario’s Internal Rate of Return and Benefit-Cost Ratio were also calculated for completeness.
- The benefit-cost results were analysed with respect to the uncertainty associated with key variables and assumptions. This was accomplished through conducting Monte Carlo risk analysis.
- The benefit-cost results are presented in Table 1. Without taking the unquantified benefits and costs into account, the Net Present Value (NPV) for Scenario 1 is -$57 million. This implies that society will be worse off by $57 million if the projects of Scenario 1 are undertaken compared to the base case. The NPV for Scenario 2 is -$200 million and is -$364 million for Scenario 3.

Table 1

Summary of Benefit-Cost Results

Benefit-Cost Criteria	Scenario 1	Scenario 2	Scenario 3
Net Present Value ($ millions)	-56.8	-200.3	-364.3
Internal Rate of Return (per cent)	8.7	5.3	0.0
Benefit-Cost Ratio	0.97	0.92	0.90
Undiscounted Benefits ($ millions)	6277.0	7236.4	9730.1
Undiscounted Costs ($ millions)	5414.4	6694.4	9041.0
Discounted Benefits ($ millions)	2118.1	2304.5	3235.1
Discounted Costs ($ millions)	2175.0	2504.7	3599.4

Source: The Conference Board of Canada.

- Although all the scenarios result in a negative NPV, the magnitude of the Benefit-Cost Ratios (ranging from 0.90 to 0.97) indicate that the sizes of these losses to society are not unduly large.
- Table 1 also shows that for each scenario the undiscounted benefits outweigh the undiscounted costs, while the reverse is true in terms of the discounted benefits and costs. Most of the costs are incurred in the early years of the projects as “up-front” investments in infrastructure. By contrast, most of the benefits are only felt when the new mines (those not included in the base case) start production in the later years of the project. As a result, these benefits are subject to relatively greater discount factors and so the sum of the discounted benefits falls below that of the total discounted costs.
- The unquantified environmental costs will vary by scenario and include habitat destruction, point-source pollution including spills of hazardous materials and disruption of caribou migration.
- The unquantified economic multiplier benefits result from indirect economic activity and from the labour income generated by the projects that define each of the scenarios. These benefits, although not officially quantified in the study, would significantly improve the benefit-cost results. Results from the Economic Impact Analysis report of the current study support this. However, these benefits have to be balanced against the unquantified costs of the scenarios.

- Analysis of uncertainty confirmed the basic findings of the benefit-cost exercise. It also indicated that the findings were relatively sensitive to changes in the price of gold and base metals and the output from diamond mines. The results are much less sensitive to changes in labour costs and transportation infrastructure construction costs.

Glossary of Terms

All-Weather Road	A road constructed with a loose or stabilized gravel surface open to two-way traffic year-round.
Benefit-Cost Ratio	A measure of economic worth composed of the present value of benefits of a project in the numerator and the present value of costs of the project in the denominator.
Constant Dollars	Dollar values that are adjusted for inflation (i.e., the effects of inflation have been netted out).
Direct Economic Impacts	The economic impacts associated with the direct expenditures or output of a project.
Discount Rate	The interest rate to be used in present value calculations.
Gross Domestic Product (GDP)	A measure of the total value of goods and services produced by the economy over a specified time period (usually one year).
Indirect Economic Impacts	The economic impact associated with expenditures made by firms and government agencies that produce goods and services that are consumed by a project.
Induced Economic Impacts	The economic impacts associated with the spending of labour income from both the direct and indirect economic expenditures on a project.
Multiplier	The ratio of the total economic impacts associated with a project to the initial expenditures on the project.
Internal Rate of Return (IRR)	A measure of economic worth which defines the discount rate which is required so that the Net Present Value of a project is exactly equal to zero.
Net Present Value (NPV)	A measure of economic worth which is defined as the present value of a project's benefits less the present value of a project's costs.
Operations and Maintenance (O&M)	The expenditures (capital and labour) associated with the ongoing operations and/or maintenance of a machine, facility, etc.
Opportunity Cost	Also known as an economic cost — defined as the value of productive economic resources in their best alternative use.
Winter Road	A road constructed annually on ice over water bodies and/or compacted snow over frozen terrain. Commonly open to traffic from early January until late March.

1 Introduction

Over the past 10 years, the Conference Board has undertaken a number of studies on transportation-related issues in the Northwest Territories. These studies examined various aspects of the transportation infrastructure and economic development in the Slave Geologic Province. A number of potential projects have been examined to date as part of the government's overall transportation strategy. One currently being assessed is a transportation corridor through the Slave Geologic Province and a port situated on the Arctic coast in the Nunavut Territory.

One potential impact of making improvements to existing transportation infrastructure or the construction of new transportation infrastructure is the stimulation of economic development. However, the development of new or improving existing transportation infrastructure can also have significant social and environmental impacts. Thus, it is important to critically examine all of the impacts of proposed investments in transportation infrastructure before proceeding.

The current study is an assessment of transportation and economic development in the Slave Geologic Province. The study comprises four phases as follows:

1. Scenario Development;
2. Benefit Cost Analysis;
3. Economic Impact Analysis; and
4. Taxation Revenue and Fiscal Impact Analysis.

The second phase— Benefit Cost Analysis —is the focus of this report. The report describes the methodology and results of the benefit-cost exercise conducted for the scenarios developed in the first phase of the report. The end product is an assessment of the economic costs and benefits of the three development scenarios together with an analysis of the unquantified impacts of the scenarios.

1.1 Approach

Investment in transportation infrastructure can have a number of positive effects on the economy. From a macroeconomic perspective, such investment can create employment and increase productivity. With improvements to the existing transportation network, users may experience lower operating costs and improved safety. New infrastructure can also be a necessary condition for, or act as a catalyst in, the development of resources within areas that were previously not accessible.

Transportation infrastructure is particularly important for the growth of economies that are heavily dependent on the development of their natural resources. The Northwest Territories has rich sources of both non-renewable and renewable resources but, in many cases, lacks the transportation infrastructure necessary to make these resources viable. This problem is exacerbated by the great distances involved and the lack of proximity to major markets.

Determining the possible future course of economic development in the Slave Geologic Province is a highly uncertain exercise. As a result, a base case and three development scenarios were developed in Phase I of the study to embrace a wide range of possible outcomes. Underlying each is an assumed level of investment in transportation infrastructure composed of possible investments in new roads and a deepwater port on the Arctic coast. These investments are assumed to spur additional economic activity including the activity associated with construction and maintenance of the transportation infrastructure itself, an increase in mining activity and economic spin-offs such as increased tourism and new investment in municipal infrastructure.

This study assesses the economic benefits and costs of the increase in economic activity associated with the three development scenarios. While the analysis contained in this report was guided by the practices recommended by the Treasury Board's *Benefit Cost Analysis Guide*[1] and Transport Canada's *Guide to Benefit-Cost Analysis in Transport Canada*[2], this report does differ from other benefit-cost studies in one principal aspect. Here the most important aspects of this analysis are the benefits and costs of the mineral development activity that the new transportation network is assumed to generate rather than those of the transportation network itself. This approach was taken as the main rationale behind the proposed transportation investment is to spur economic development rather than to improve safety, efficiency or other transportation-related factors.

Several departments of the Government of the Northwest Territories contributed data and other information to this study. They include the Department of Transportation, Bureau of Statistics and the Department of Resources, Wildlife and Economic Development.

1.1.1 Benefit-Cost Analysis

Benefit-cost analysis provides a structured and consistent framework for assessing the relative merits of competing development scenarios. This assessment is done by comparing the benefits and costs of development scenarios to those of a base case.

The benefits and costs that are considered in the analysis of each scenario are measured from society's perspective. The benefits and costs to society that result from the scenario under consideration are assessed — including indirect (or external) benefits and costs. The study did not explicitly consider who would receive the benefits or incur the costs. These issues are addressed in the third and fourth phases of the project.

In general, however, the direct costs of the transportation infrastructure will be borne primarily by the public sector while the mine development costs will be borne primarily

[1] Treasury Board Secretariat, *Benefit-Cost Analysis Guide, Draft 1998*., http://www.tbs-sct.gc.ca/fin/sigs/revolving_funds/bcag/bca_e.html.

[2] Transport Canada, *Guide to Benefit-Cost Analysis in Transport Canada*. Transport Canada (TP 11875 E), 1994, http://www.tc.gc.ca/bca/Guide_e.htm.

by the mine operators. Similarly, the quantified benefits will also accrue mostly to the mine operators. Mine operators, and other road users, will also benefit from reduced operating costs and safety improvements with the construction of the all-weather road. In addition, communities in the western Arctic will benefit from reduced re-supply costs with the construction of the deepwater port. Broader (unquantified) benefits will be felt throughout the Northwest Territories, Nunavut and the rest of Canada as a result of the additional output and employment generated by the projects associated with the scenarios. Similarly, territorial and other governments will benefit from the higher tax revenues generated by these activities. However, it is likely that broader (unquantified) economic costs will also be incurred as a result of the impact on the environment and traditional lifestyles brought about by the new mineral and other developments.

Comparison of the benefits and costs requires that they must be expressed in common units. The usual practice in benefit-cost analysis is to estimate the economic value for the benefits and costs of a scenario in terms of dollars. If some costs and/or benefits cannot be quantified in this manner, the results of the analysis using quantified benefits and costs are examined in light of the probable impact of the unquantified benefits and costs.

To net out the effects of inflation over time, constant dollar values are employed for both the benefits and costs. Unless otherwise noted, constant 2000 dollars were used in this study.

1.2 Layout of the Report

The report is presented in 7 chapters. After this introduction, Chapter 2 provides brief descriptions of the base case and three development scenarios in terms of the transportation infrastructure investments and economic and other impacts. These scenarios were developed in Phase I of the study, where a fuller description of the methodology and results of the scenario development exercise is available.

Chapter 3 provides an overview of the benefit-cost methodology used in this study while Chapters 4 and 5 discuss in more detail the methodology used to estimate the economic costs and benefits, respectively. Chapter 6 presents the results of the benefit-cost analysis for each scenario and Chapter 7 examines the robustness of these results through Monte Carlo risk analysis.

2 Base Case and Scenario Descriptions

This chapter summarises the base case and three development scenarios which form the basis of the benefit-cost analysis. The scenarios were developed by the Northwest Territories Department of Transportation, with the assistance of the Conference Board of Canada, and are more fully described in the first phase of this study. While attempting to provide a realistic assessment of future activities in the Slave Geological Province, the uncertainty associated with this forecasting exercise is acknowledged. It should also be noted that the scenarios were developed to describe a range of potential future activities in the Slave Geological Province and not to forecast actual future events.

The summary starts with a general overview of the components that went towards developing the base case and other scenarios. This is followed by a description of the individual components that define each of the base case and development scenarios.

2.1 Overview

The scenarios are comprised of some or all of the following four general components. Each of these four components is composed of one or more individual projects. The four components are:

1. Construction of a land transportation corridor (or portion thereof) through the Slave Geological Province between Yellowknife and the Arctic coast (except for the base case which involves the use of an existing winter road);
2. Construction of a deepwater port on the Arctic coast;
3. Assumed non-renewable resource development;
4. Assumed renewable resource development;

The costs and benefits examined in the study are all associated with one or more of these components.

2.1.1 Land Transportation Corridor

The base case and scenarios in this report consider a number of alternatives for the development of a land transportation corridor in the Slave Geological Province (the only existing infrastructure is a winter road from Yellowknife to the Lupin gold mine). These alternatives range from no new investment in transportation, in the base case, to a permanent, gravel-surfaced, all-weather road over the entire route from Yellowknife to a proposed new port on the Arctic coast. The capital and annual maintenance cost estimates for the transportation corridors were developed by the Northwest Territories Department of Transportation.

2.1.2 Deepwater Port

The construction of a deepwater port on the Arctic Coast is common to all scenarios except the base case. The timing of this project, the investment expenditures required and the maintenance costs of the port are identical for all three scenarios. Construction will begin in 2003 (one year earlier in Scenario 3) and will be completed two years later when the port begins operations.

The port would be used to re-supply mines such as the Izok Lake base-metal mine and the Lupin gold mine. The port would also be used to ship base-metal concentrate from the Izok Lake and other mines to markets in Europe and the Pacific Rim. The port facility may also be used to supply nearby coastal communities.

2.1.3 Non-Renewable Resource Development

The investments in transportation infrastructure in each scenario are assumed to have a significant impact on the mining industry, both in terms of promoting new activity and facilitating existing operations. Recent years have seen intense exploration activities that have confirmed the presence of diamonds and other minerals in the region. Indeed, these have already resulted in the opening of Canada's first diamond mine at the Ekati site near Lac de Gras. This study assumes that the construction of new transportation infrastructure will make some of these known deposits economically viable as well as spurring additional exploration activities. In turn, this increased exploration is assumed to hasten the discovery and development of new deposits.

Estimates of the capital investment required for the various mines and the value of annual output were developed by the Northwest Territories Department of Resources, Wildlife and Economic Development (RWED) in consultation with a number of key mining companies operating in the region.

2.1.4 Renewable Resource Development

Apart from its effect on the mining industry, this study looks at the impact of transportation corridors on renewable resource development. There is potential for the development of industries such as tourism, commercial fishing, related processing activities and hydro-electric power generation. Due to data constraints, however, the only renewable resource that has been quantified in this study is the purchase of goods and services by tourists. It is assumed that the presence of an all-weather road from Yellowknife to the Arctic coast is necessary to attract new visitors to the region and encourage these additional expenditures.

Exhibit 3 summarises the components that define the base case and other scenarios.

Exhibit 3

Development Scenarios

	Transportation Infrastructure	Diamond Mines	Gold Mines	Base-metal Mines	Tourism
Base Case	Winter Road (Yellowknife to Lupin)	Ekati	Lupin		
		Diavik			
		Snap Lake			
		Jericho			
		One new mine			
Scenario 1	Winter Road (Yellowknife to Lupin)	Ekati	Lupin	Izok Lake	
	All-Weather Road (Contwoyto Lake to Arctic Coast)	Diavik		Hackett River	
	All-Weather Road (Extension from the North to Ekati/Diavik)	Snap Lake		One new mine	
		Jericho			
	Deepwater Port on Coast	One new mine			
Scenario 2	Winter Road (Yellowknife to Lupin)	Ekati	Lupin	Izok Lake	Increased expenditures
		Diavik		Hackett River	
	All-Weather Road (Yellowknife to Arctic Coast)	Snap Lake		One new mine	
		Jericho			
	Deepwater Port on Coast	Two new mines			
Scenario 3	Winter Road (Yellowknife to Lupin)	Ekati	Lupin	Izok Lake	Increased expenditures
		Diavik		Hackett River	
	All-Weather Road (Yellowknife to Arctic Coast)	Snap Lake		One new mine	
		Jericho			
	Deepwater Port on Coast	Three new mines			

Source: Scenario Development Report, Current Study

2.2 Scenario Descriptions

2.2.1 Base Case

The base case presents a scenario in which there is no new investment in transportation infrastructure. Indeed, the only expenditures on the transportation corridor are those on operating and maintaining the existing winter road between Yellowknife and Lupin. Nonetheless, the base case does assume that some mineral development goes ahead using the existing infrastructure. The timetable of components included in the base case is shown in Exhibit 4.

The base case assumes that production at the existing Ekati mine continues until the end of 2016, as well as including the development of the Diavik mine, currently under construction. With various mineral exploration reports indicating that there are several other promising diamond-bearing kimberlite pipes in the Slave Geological Province, the base case also assumes that three further diamond mines will be developed during the forecast period. These include the deposits at Snap Lake and Jericho. In addition, production is set to continue at the Lupin gold mine, which was brought back into commission in 2000, until the end of 2007.

Exhibit 4

Base Case Development Scenario

		Territory	Component	Year																			
				2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Transportation Infrastructure	Winter Road (Yellowknife to Lupin)	NWT	Construction																				
			Operation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Nunavut	Construction																				
			Operation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mineral Developments	Ekati (diamond)	NWT	Construction																				
			Production	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
	Diavik (diamond)	NWT	Construction	■	■	■																	
			Production			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Snap Lake (diamond)	NWT	Construction	■	■	■	■																
			Production				■	■	■	■	■	■	■	■	■	■	■	■					
	Jericho (diamond)	Nunavut	Construction		■	■	■																
			Production					■	■	■	■	■	■	■	■								
	New Diamond Mine	NWT	Construction										■	■	■								
			Production													■	■	■	■	■	■	■	■
	Lupin (gold)	Nunavut	Construction																				
			Production	■	■	■	■	■	■	■													

Source: Scenario Development Report, Current Study

2.2.2 Scenario 1

In this scenario an all-weather road between Contwoyto Lake and the Arctic coast with a deepwater seaport at its terminus is built in conjunction with the development of the Izok Lake base metal mine. In addition, the all-weather road is extended to the Lac de Gras region. This will enable the diamond mines in the region to take advantage of costs savings from all-weather road access to the north. The all-weather road between Contwoyto Lake and the Arctic coast and the deepwater seaport will be built in 2003 and 2004 and will be open to traffic in the following year. The extension of the all-weather road from Contwoyto Lake to the Ekati and Diavik mines is to be built between 2005 and 2006. The winter road between Contwoyto Lake and Yellowknife will continue to operate and will require annual operations and maintenance expenditures.

The construction of the transportation corridor is assumed to be a prerequisite for the development of the base metal deposits at Izok Lake and Hackett River. Construction work for both is set to take three years, beginning at Izok Lake in 2003 and Hackett River in 2006. The scenario assumes that production at Izok Lake will last for twelve years from 2006 to 2017. In addition, the opening of the transportation corridor is assumed to act as a spur to the development of an additional base metal mine. Again construction will take three years (2009 to 2011) with production beginning in 2012.

The construction and production scenarios for the Ekati, Diavik, Snap Lake, Jericho, Lupin and new diamond mines are the same as those laid out in the base case (see Exhibit 5). However, some of these mines will benefit from reduced operating costs as a result of the construction of the all-weather road. From 2005 the Lupin and Jericho mines will have all-weather road access to the North. In summer these two mines will have a barge connection running from the mine area to the southern end of Contwoyto Lake, while the existing winter road will be used over the remainder of the year. The Ekati and Diavik mines will have direct road access to the Arctic coast from 2007. The

Exhibit 5

Development Scenario 1

		Territory	Component	Year																			
				2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Transportation Infrastructure	Winter Road (Yellowknife to Lupin)	NWT	Construction																				
			Operation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Nunavut	Construction																				
			Operation	■	■	■	■																
	All-Weather Road (Contwoyto Lake to Arctic Coast)	Nunavut	Construction			■	■																
			Operation					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Deepwater Port on Coast	Nunavut	Construction			■	■																
			Operation					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	All-Weather Road (Extension from the North to Ekati/Diavik)	NWT	Construction					■	■														
			Operation							■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mineral Developments	Ekati (diamond)	NWT	Construction																				
			Production	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
	Diavik (diamond)	NWT	Construction	■	■	■																	
			Production			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Snap Lake (diamond)	NWT	Construction	■	■	■	■																
			Production				■	■	■	■	■	■	■	■	■	■	■	■					
	Jericho (diamond)	Nunavut	Construction		■	■	■																
			Production					■	■	■	■	■	■	■	■								
	New Diamond Mine	NWT	Construction										■	■	■								
			Production													■	■	■	■	■	■	■	■
	Lupin (gold)	Nunavut	Construction																				
			Production	■	■	■	■	■	■	■													
	Izok Lake (base metal)	Nunavut	Construction			■	■	■															
			Production						■	■	■	■	■	■	■	■	■	■	■	■			
	Hackett River (base metal)	Nunavut	Construction						■	■	■												
			Production									■	■	■	■	■	■	■	■	■	■	■	■
	New Base Metal Mine	Nunavut	Construction									■	■	■									
			Production												■	■	■	■	■	■	■	■	■

Source: Scenario Development Report, Current Study

additional new diamond mine will also incur lower capital and running costs as a result of its connection to the transport corridor.

Overall, Scenario 1 results in an additional thirty-three years worth of base metal production over the forecast period compared to that in the base case.

2.2.3 Scenario 2

Scenario 2 builds on the previous scenario by gradually extending the all-weather road from the Arctic coast past Contwoyto Lake and Lac de Gras all the way to Yellowknife. The construction and operation of the deepwater port and the all-weather road between the Arctic coast and Lac de Gras are the same as in Scenario 1. The southern segment of the road between Lac de Gras and Yellowknife will be built between 2007 and 2012,

Exhibit 6

Development Scenario 2

		Territory	Component	Year																			
				2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Transportation Infrastructure	Winter Road (Yellowknife to Lupin)	NWT	Construction																				
			Operation	■	■	■	■	■	■	■	■	■	■	■	■								
		Nunavut	Construction																				
			Operation	■	■	■	■																
	All-Weather Road (Yellowknife to Arctic Coast)	NWT	Construction					■	■	■	■	■	■	■	■								
			Operation													■	■	■	■	■	■	■	■
		Nunavut	Construction			■	■																
			Operation					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Deepwater Port on Coast	Nunavut	Construction			■	■																
			Operation					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mineral Developments	Ekati (diamond)	NWT	Construction																				
			Production	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
	Diavik (diamond)	NWT	Construction	■	■	■																	
			Production			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Snap Lake (diamond)	NWT	Construction	■	■	■	■																
			Production				■	■	■	■	■	■	■	■	■	■	■	■					
	Jericho (diamond)	Nunavut	Construction		■	■	■																
			Production					■	■	■	■	■	■	■	■								
	New Diamond Mine	NWT	Construction										■	■	■								
			Production													■	■	■	■	■	■	■	■
	New Diamond Mine	NWT	Construction													■	■	■					
			Production																■	■	■	■	■
	Lupin (gold)	Nunavut	Construction																				
			Production	■	■	■	■	■	■	■													
	Izok Lake (base metal)	Nunavut	Construction			■	■	■															
			Production						■	■	■	■	■	■	■	■	■	■	■	■			
	Hackett River (base metal)	Nunavut	Construction						■	■	■												
			Production									■	■	■	■	■	■	■	■	■	■	■	■
	New Base Metal Mine	Nunavut	Construction									■	■	■									
			Production												■	■	■	■	■	■	■	■	■
Other	Tourism Expenditures		Nunavut													■	■	■	■	■	■	■	■
			NWT													■	■	■	■	■	■	■	■

Source: Scenario Development Report, Current Study

replacing the existing winter road.

The construction and production scenarios for those mines included in Scenario 1 carry over to Scenario 2 (see Exhibit 6). The extension of the transportation corridor will, however, lead to some reductions in the mines' operating costs. The Snap Lake mine will have all-weather road access to Yellowknife from 2009 on, while the Ekati and Diavik mines will have all-weather road access to the South four years later.

Scenario 2 includes the development of an additional new diamond mine as a result of the improved access to the region brought about by the completion of the transportation corridor between Contwoyto Lake and Yellowknife. This mine will benefit from lower construction and operating costs due to the new road. The mine will be built between 2013 and 2015 with production taking place during the final five years of the forecast period.

Scenario 2 also includes the effects of additional tourist expenditures not included in either the base case or Scenario 1. It is assumed that the completion of the all-weather road from Yellowknife right through to the Arctic coast will attract visitors from other parts of Canada and overseas. In the scenario, tourist expenditures begin in 2013 with the completion of the all-weather road.

2.2.4 Scenario 3

This scenario provides no additional extensions to the transportation corridor contained in Scenario 2. However, Scenario 3 does assume that the transportation corridor is built as soon and as rapidly as possible. The port and the all-weather road linking it to Contwoyto Lake are built a year earlier than in Scenario 2. In addition, construction work on the Yellowknife to Contwoyto Lake segment also begins in 2002 and in this scenario only takes five years to complete rather than eight. As a result, the entire transportation corridor is open at the start of 2007.

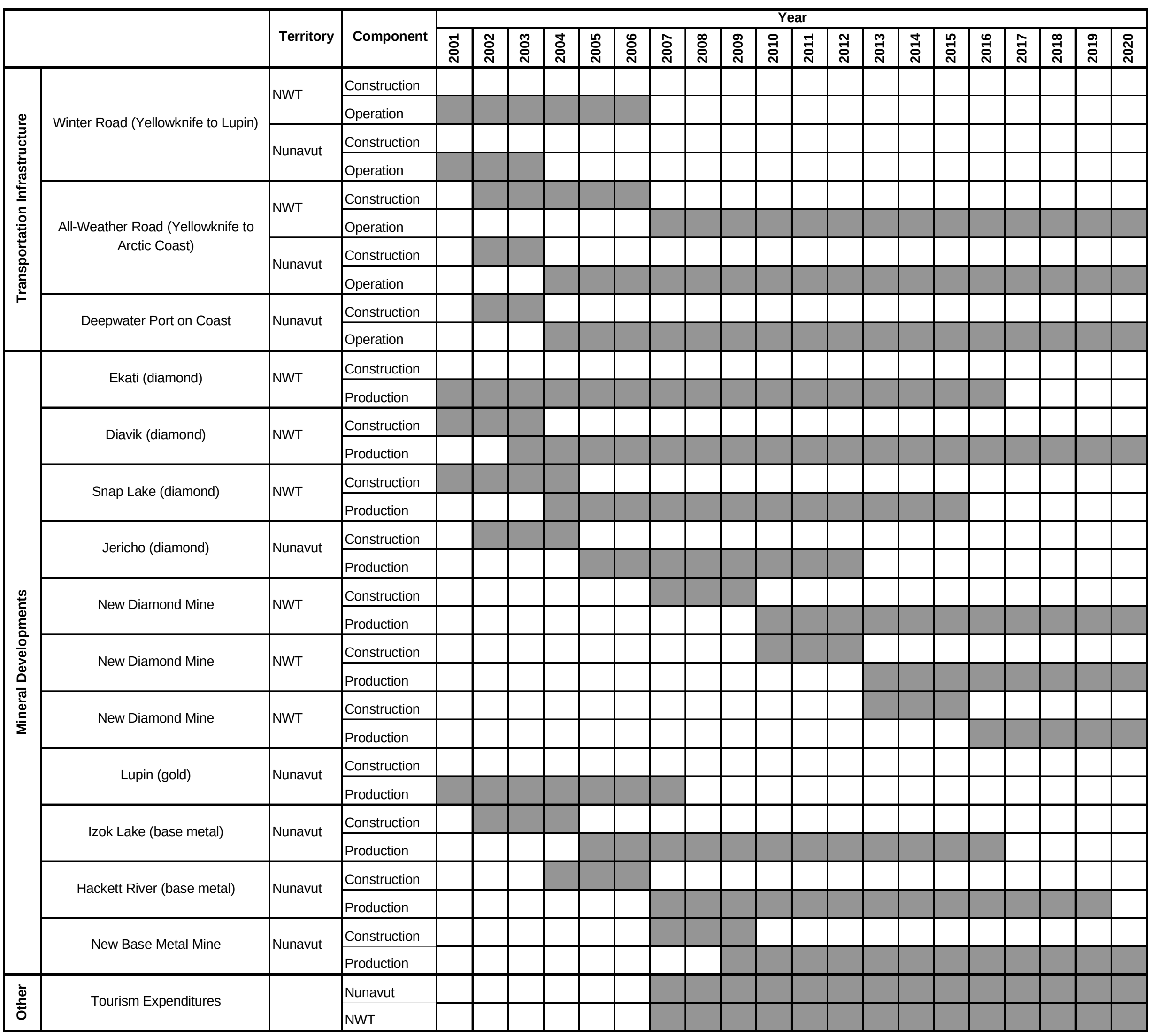
The timing of the construction and production scenarios for the Ekati, Diavik, Snap Lake, Jericho and Lupin mines remain unchanged from the base case and the previous two scenarios (see Exhibit 7). However, the accelerated construction of the transportation corridor does bring these mines all-weather road access to Yellowknife and the coast faster and, consequently, delivers costs savings earlier. The Lac de Gras region now has all-weather road access to the north as early as 2004 (as does Jericho) and to the south from 2007 on. The Lupin mine now has all-weather road access to the north from 2004 while the Snap Lake mine is connected to the south in 2005.

Scenario 3 also assumes that the faster completion of the transportation corridor speeds up the development plans for the other mines included in Scenario 2. The timing of construction and production at the two new diamonds is brought forward by three years, those at Hackett River and the new base metal mine by two years and that at Izok Lake by one year. This means that production at Hackett River will cease at the end of 2018 when the mine's working life comes to an end. The improved access to the region brought by this more rapid development scenario also leads to the development of a further new diamond mine. As with the other diamond mines, construction is assumed to take three years starting in 2013. Production will begin in 2016.

Overall, Scenario 3 results in an additional eleven years worth of diamond production

Exhibit 7

Development Scenario 3



Source: Scenario Development Report, Current Study

and two years of base metal production over the forecast period compared to that in Scenario 2. In addition, tourism expenditures start an extra six years earlier with the opening up of the all-weather road in 2007.

3 Benefit-Cost Framework

This chapter presents a description of the benefit-cost framework used to assess the benefits and costs of the development scenarios.

This study differs from most other benefit-cost analyses of improvements in transportation infrastructure conducted in Canada in one important way. Rather than solely examining the effects of replacing or improving existing facilities, this study also looks at the introduction of new transportation infrastructure. This has important implications for the types of benefits that are quantified in the analysis. The principal benefit arising from the new transportation infrastructure in this study results from the development of natural resources that were previously considered uneconomic to develop or whose development will be hastened as a result of the investment.

3.1 Discounting

Since the benefits and costs of a project frequently evolve over an extended time period, a technique is needed to compare time series of benefits and costs. By discounting, the benefits and costs of a project are converted to a common base year and can then be summed and compared. As recommended by the Treasury Board guidelines, a discount rate of 10 per cent will be used in this study.

3.2 Costs

The costs considered in this study can be divided into quantified and unquantified costs. Quantified costs include the following:

1. transportation corridor;
2. deepwater port;
3. mineral resource development;

The costs of the transportation corridor include operation and maintenance (O&M) costs for the existing winter road and all of the costs associated with the construction and O&M of the new all-weather road. The costs associated with the deepwater port are similarly divided into construction and O&M components.

Mineral resource development costs include the costs required to prepare the mine sites, construct the mines and then the annual O&M costs thereafter. Exploration costs are not included in the analysis.

The unquantified costs considered in this study include:

1. environmental costs, such as the disruption of caribou migration, destruction of habitat, and point-source pollution;
2. training costs which involve the operations and maintenance costs of programs using existing facilities;

3. the costs of municipal infrastructure which include O&M costs of using existing facilities. In addition, the construction costs of new facilities and associated O&M costs are excluded.

There are also potential social and cultural costs, such as the effects on traditional cultures and lifestyles through increased exposure to outside influences as a result of new transport links.

The numerical results of the benefit-cost analysis will be re-examined in light of the probable effects of these unquantified costs in Chapter 6.

3.3 Benefits

The benefits that were quantified in the study include:

1. minerals extracted;
2. transportation safety;
3. transportation efficiency; and
4. tourism expenditures.

As indicated previously, the value of minerals extracted is the principal benefit considered in the study. The minerals extracted include diamonds, gold and base metals (zinc, lead, silver and copper).

Transportation safety benefits only occur with the replacement of the existing winter road from Yellowknife to Contwoyto Lake with an all-weather road.

Transportation efficiency benefits ensue from improvements in transportation infrastructure. In this study, there are two sources of transportation efficiency benefits. The first involves quantifying the reduction in vehicle operating costs that result from the replacement of the existing winter road from Yellowknife to Contwoyto Lake with an all-weather road. Further transportation efficiencies occur with the completion of the deepwater port on the Arctic coast. The new port is assumed to reduce the re-supply costs for coastal communities located near the port.

The incremental tourism revenue that results from completing an all-weather road from Yellowknife to the Arctic coast is also included as a benefit in Scenarios 2 and 3.

3.4 Benefit-Cost Criteria

There are a number of summary statistics or benefit-cost criteria that can be used to assess the relative economic merits of competing development scenarios. The three criteria that are presented in this study are:

1. Net Present Value;
2. Internal Rate of Return; and
3. Benefit-Cost Ratio.

The Net Present Value (NPV) is calculated by subtracting the sum of the discounted costs from the sum of the discounted benefits. Expressed in constant dollars, a positive NPV means that the sum of the discounted benefits exceed the sum of the discounted costs. Society is better off by the dollar amount of the NPV. In choosing between competing scenarios, the one with the highest NPV is preferred from society's standpoint.

The Internal Rate of Return (IRR) provides the economic return of a scenario by calculating the discount rate at which the NPV is exactly equal to zero. By selecting a "hurdle" rate (e.g., 10 per cent) scenarios can be judged as economically viable if the IRR exceeds this rate.

The Benefit-Cost Ratio (BCR) is the sum of the discounted benefits divided by the sum of the discounted costs. If the ratio is greater than 1.0, then the project is deemed economically viable.

There are a number of technical problems with using the IRR or the BCR for determining the economic viability of competing scenarios. As a result, the Treasury Board guidelines for conducting benefit-cost analysis recommend that the scenario with the highest NPV should be selected as the preferred option. Nevertheless, the IRR and BCR for each scenario are included for completeness.

The benefit-cost criteria say nothing, however, about the distribution of the benefits and the costs of the scenarios. A positive NPV, for example, says nothing about who are the scenario's "winners" and "losers" but only that society will be better off if the scenario takes place.

3.5 Accounting for Uncertainty

The data estimates used in the analysis represent the "best guess" of the expected future result. As with any forecast, there will be some element of uncertainty in the estimate. The results of the benefit-cost analysis should be analysed in light of this uncertainty.

There are a number of standard techniques for dealing with uncertainty in benefit-cost analysis. In this study, key variables were subjected to Monte Carlo risk analysis both individually and jointly to assess the robustness of the results.

Often in the past sensitivity analysis was used to assess sensitivity of the results to variations in the values of key variables by a set amount (e.g., ± 25 per cent). However, Monte Carlo risk analysis goes a step further by taking into account a much wider range of potential variation in these variables. Computer software can be used to select a random value of the variable from its specified distribution and this value used to recalculate the NPV. This process is then repeated many times to generate an entire distribution of the NPV with respect to changes in the key variable being examined. If there is significant sensitivity, the variable in question should be subjected to further scrutiny.

This analysis can be extended further to take into account changes in all the key variables simultaneously. This technique can be used make an assessment of the overall level of risk inherent in the project as a whole.

In this study, the following factors were subjected to Monte Carlo risk analysis:

1. the prices of gold and base metals;
2. the discount rate;
3. the quantity of diamond output;
4. labour costs;
5. capital costs; and
6. transportation construction costs.

4 Estimation of Costs

This chapter presents the methodology for calculating the economic costs that are associated with the base case and each of the scenarios. As indicated previously, all quantified costs are presented in constant (i.e., net of inflation) 2000 dollars. Unquantified costs are discussed in the last section of this chapter. As discussed previously, the analysis did not address the distribution of these costs.

A list of costs that were quantified in the study is presented in Exhibit 8. The largest quantified costs are those associated with the construction of transportation infrastructure and the mines. The main costs not quantified in this study are

Exhibit 8

Quantified Costs

Transportation Corridor
- Construction
- Operations and Maintenance

Deepwater Port
- Construction
- Operations and Maintenance

Mineral Resource Development
- Construction
- Operations and Maintenance

environmental in nature (see Section 4.4).

All of the quantified costs have a construction or development phase and an operations or maintenance phase. Both of these phases can be reduced to a capital (or purchased input) component and a labour component.

The capital and labour components were treated separately because of differences in the methodology used in calculating them. Nevertheless, the general approach in costing both labour and capital was to use their opportunity cost — that is, the dollar value in their next best alternative use. This approach provides an objective measure of the cost to society in terms of foregone resources.

4.1 Labour

Labour costs refer to all of the actual labour inputs that are purchased by the projects. Average wages were derived for each component of the scenarios and multiplied by total labour requirements to give the overall labour cost for each component. Wages vary depending on the type of activity (construction and operations) and development (transportation infrastructure, diamond mine, gold mine, base metal mine).

The previous study conducted for the Government of the Northwest Territories used a measure of labour costs known as the “shadow wage”. This measure was designed to take into account potential divergences between the market cost of labour and the resource cost to society as a result of distortions in the marketplace caused by taxes, subsidies, monopoly power or the lack of a well-defined market. However, the present study makes use of a range of potential values of labour costs up to 25 per cent above or below the market wage in the analysis of uncertainty (see Chapter 7). This range was felt sufficient to take into account any potential distortions caused by using the market wage and so using a shadow wage measure would be redundant.

4.2 Capital

Capital costs refer to all of the non-labour inputs that are purchased by the projects. The capital costs were estimated as the actual money cost of the capital good or purchased input. All indirect taxes (e.g., the Goods and Services tax) and subsidies were excluded from these estimates[1].

4.3 Quantified Costs

Details on the quantified costs are provided below. All cost estimates are presented without any discounting. The input data used for calculating these costs are presented in Appendix A.

4.3.1 Transportation Infrastructure

The O&M costs for the existing winter road were based on actual operating expenditure data for the entire length from Yellowknife to Lupin. To determine the O&M costs for each of the two road segments that make up this length, the total cost of $6.5 million per year was apportioned according to the ratio of the road segment’s length relative to the total winter road distance from Yellowknife to Lupin.

Construction and annual O&M costs for each of the three all-weather road segments from Yellowknife through to the Arctic coast are presented in Table 2.

[1] Due to the unavailability of forecasts for capital utilisation, shadow pricing capital costs using the shadow wage methodology was not possible.

4.3.2 Deepwater Port

It is estimated that the deepwater port on the Arctic coast will cost $47.4 million to construct. Annual O&M costs are expected to be $2.9 million.

Table 2

Transportation Corridor Costs (millions of 2000 dollars)

All-Weather Road Segment	Construction Costs	Annual O&M Costs
Yellowknife to Ekati/Diavik	207.4	3.9
Ekati/Diavik to Contwoyto Lake	67.3	1.3
Contwoyto Lake to Arctic Coast	157.1	3.9

Source: The Northwest Territories Department of Transportation

4.3.3 Mineral Resource Development

Construction costs for the generic diamond mine differ according to whether the mine is serviced by a winter road or an all-weather road. A diamond mine serviced by an all-weather road is assumed to incur initial construction costs of $538 million. Winter road access requires the construction of additional storage facilities at the diamond mine site, raising the construction cost to $554 million. The annual O&M costs for a diamond mine served by an all-weather road are estimated to be $147 million ($5.7 million more in the case of winter road access only) when running at full capacity[1]. Table 3 provides a further illustration of the potential savings in the construction and operation of diamond mines provided by all-weather road access. It should be noted that these data refer to the entire period over which the mine sites are developed, the mines built and operations conducted rather than the 2001-2020 period of the benefit cost analysis.

The construction of the all-weather road is deemed a pre-requisite for the development of the base-metal mines. Construction costs for the Izok Lake mine are $449 million with O&M costs estimated at $137 million per year. Hackett River and the other generic base-metal mine are assumed to cost a total of $360 million to develop with annual O&M costs estimated at $110 million per year.

Table 3

Diamond Mine Construction and Operation Costs (millions of 2000 dollars)

Mine		Base Case	Scenario 1	Scenario 2	Scenario 3
Diavik	Capital[1]	2,300	2,300	2,300	2,300
	Operating[2]	162	159	156	154
Ekati	Capital	1,531	1,531	1,531	1,531
	Operating	131	130	129	127
Jericho	Capital	74	74	74	74
	Operating	29	28	28	27
New	Capital	1,146	1,146	1,131	1,131
	Operating	131	131	124	124
Snap Lake	Capital	398	398	398	398
	Operating	125	125	120	116

1 Capital costs include development, initial construction, additional construction, and equipment purchases.
2 Operating costs are annual averages over the life the of mine.

Source: The Northwest Territories Department of Resources, Wildlife and Economic Development

[1] The costs for the development and operations of the generic diamond mine were based on a mine production model developed by the Northwest Territories Department of Resources, Wildlife and Economic Development.

The annual O&M costs for the Lupin gold mine are estimated at $54 million per year.

4.4 Unquantified Costs

4.4.1 Environmental costs

The unquantified environmental costs have been summarised below for each scenario.

Base case

Under the base case, more traffic can be expected on the existing winter road to serve the Snap Lake, Jericho and new diamond mines. Increased traffic will raise the risk of damage resulting from spills of hazardous materials as more hazardous materials are transported, and may result in disruption of the migration of caribou herds. In addition, localised destruction of terrestrial and freshwater habitat can be expected at each new mine site to allow for infrastructure development and disposal of tailings and other wastes. Local fish and wildlife populations may be eliminated or forced to relocate as a result of the loss of habitat.

Scenario 1

In addition to the potential environmental impacts described under the base case, additional destruction of terrestrial, freshwater and marine habitat can be expected to result from construction work at the Izok Lake, Hackett River and new base metal mine developments. The building of additional transportation infrastructure under this scenario will also affect the environment. The all-weather road will require significant amounts of aggregate (e.g., sand, gravel) which, for the most part, can be found in eskers along the route. Withdrawal of material from these eskers could reduce the amount of denning habitat available to grizzly bears and may disrupt the use of the eskers by other wildlife. Use of the road by non-mine vehicles is expected to be minimal as the new road will not connect to any existing roads. Ships serving the deepwater port will create additional traffic through the Northwest Passage and extend the length of the current shipping season. Increased shipping may affect migratory patterns and usage of certain habitats as well as causing changes to the ice regime along the route.

Scenario 2

The inclusion of an additional diamond mine will cause more localised destruction of habitat. While the potential impacts resulting from aggregate extraction to build the additional all-weather road link will result in habitat destruction and attendant impacts on wildlife, the potential impacts resulting from unrestricted vehicular use can be expected to be a major concern. With all-weather road access to the Arctic Coast and increased tourism, the road can be expected to draw additional traffic compared to the other scenarios. Increased traffic will increase the risk of spills of hazardous materials; may disrupt caribou migration; may cause an increase in impacts to fish and wildlife and their habitat; and will likely result in increased harvesting of fish and wildlife.

Scenario 3

With the more rapid completion of the transportation infrastructure, the potential environmental impacts described in Scenario 2 will be felt correspondingly sooner. In addition, the construction of an additional diamond mine will cause more localised destruction of habitat as described in previous scenarios.

4.4.2 Municipal Infrastructure

The costs of new municipal infrastructure required to meet the needs of new workers and their families moving to the Northwest Territories have not been quantified in the study. The two major components are health and education. However, these costs are relatively small and it is felt that they would have had relatively little impact on the overall results of the benefit-cost analysis had they been included.

4.4.3 Training Programs

The costs of training and skills upgrading required for those working in the new mines and other developments were not quantified for this study. As in the case of municipal infrastructure, these costs are believed to be relatively small. Nonetheless, both types of cost have been noted in the assessment of unquantified costs in Section 6.5.

5 Estimation of Benefits

This chapter presents the methodology for calculating the economic benefits that are associated with the base case and each of the scenarios. Similar to the costs described in the previous chapter, all quantified benefits are presented in constant (i.e., net of inflation) 2000 dollars. Unquantified benefits are discussed in the last section of this chapter. As discussed previously, the analysis did not address the distribution of benefits.

A list of benefits that were quantified in the study is presented in Exhibit 9. The largest quantified benefits are those associated with the output of the various mining projects.

Exhibit 9
Quantified Benefits
Value of Mineral Output Value of Tourism Expenditures Reduced Operating Expenses from Winter Road Replacement Safety Costs from Winter Road Replacement Reduced Re-supply costs for Coastal Communities

In keeping with the approach recommended by Treasury Board's benefit-cost guidelines, the economic multiplier benefits associated with each of the scenarios have not been quantified in this study. Instead, these multiplier benefits are discussed as an unquantified benefits in Section 5.7.

5.1 Value of Mineral Output

The output of the mines that are developed in the base case and in the scenarios form the largest benefit category in this study. The value of mineral output has been included as a benefit since it is assumed that the development of a new transportation corridor would be the catalyst for much of the new mining activity.

The inclusion of mineral development benefits in this manner is not commonly associated with transportation sector benefit-cost studies — at least those conducted in the developed world. The principal benefits of upgrading existing transportation infrastructure (the usual scenario in the developed world) result from user benefits such as reduced operating expenses or safety benefits. With new roads opening up areas that previously did not have access to year-round land-based transportation, the new road is assumed to result in the development of mineral properties.

The general methodology for quantifying the output for each of the mines involves multiplying the quantity of minerals extracted from the mines by the price of the mineral in 2000. The revenue from the base-metal mine involves four minerals — lead, silver, zinc and copper.

5.2 Value of Tourism Expenditures

A new all-weather road from Yellowknife to the Arctic coast is assumed to encourage tourists to explore these regions of the Northwest Territories that were — for all intents and purposes — inaccessible. In addition, the opening of the road is assumed to lead to increased levels of activity by hunters and trappers, both resident and non-resident. The completion of the entire all-weather road from Yellowknife to the Arctic coast was assumed a necessary pre-requisite for the generation of significant tourist activity. As a result, tourist expenditures are only included in Scenarios 2 and 3.

Expenditures of both resident and non-resident tourists were quantified. The initial number of resident tourists was estimated at 200 per year, each making expenditures of $300, while an equal number of hunters and trappers are assumed to make expenditures of $200 each. The expected number of non-resident tourists and hunters was estimated at 700 with each assumed to spend $453. The number of resident and non-resident tourists was assumed to increase slowly over the study period.

5.3 Traffic Forecasts

Forecasts of vehicular traffic using the transportation corridor are required to quantify the reduced operating expense benefit.

The traffic on the existing winter road is almost exclusively composed of heavy trucks transporting fuel and dry cargo to re-supply the diamond mines and Lupin gold mine. Other trucks using the road are involved in mineral exploration. There are additional vehicles that use the road for recreational purposes but these traffic volumes are very small relative to the truck traffic. Therefore, in constructing the traffic forecasts for the scenarios, a single, generic truck category was used and the recreational vehicle traffic was excluded.

Traffic forecasts for both existing and generated traffic were estimated for the 20-year period of the study. The forecasts were based on the estimated supply requirements for the various mines of each scenario. Truck traffic involved in exploration was based on historical trends. Because of the distances and freight involved, no diverted traffic was included in the forecast.

5.4 Reduced Operating Expenses

Reduced operating expenses accrue to both existing and generated traffic with the replacement of the winter road from Yellowknife to Contwoyto Lake with an all-weather road. The number of vehicles (heavy trucks) is multiplied by the per-vehicle operating costs of the road. If the operating costs associated with the base case are greater than that of the scenario under examination, an operating expense benefit occurs.

A winter road is constructed primarily over frozen bodies of water — a feature that imposes a number of restrictions that affect vehicle-operating costs. The existing winter road from Yellowknife to the Lupin gold mine is approximately 640 kilometres in length. The planned all-weather road is estimated to be 520 kilometres in length, a saving of 120 kilometres. A second restriction of the existing winter road is the reduced speed which vehicles are required to observe due to safety considerations.

The specific operating expenses that were examined in the study include the operator's salary, fuel and lubricants, tire wear and insurance. Combining these factors resulted in an estimated vehicle operating cost for both the winter road and the all-weather road. In keeping with Transport Canada's guidelines for benefit-cost analysis, the benefits to generated traffic were reduced by 50 per cent.

5.5 Safety Costs from Replacement of Winter Road

The methodology for calculating safety benefits is also tied to vehicle traffic forecasts. The number of vehicles (heavy trucks) is multiplied by the probability of an accident occurring. The resulting product is then multiplied by the economic cost of the accident to give the total accident cost. If the accident costs associated with the base case are greater than those of the scenario under examination, a safety benefit occurs. However, in this study the probability of an accident was assumed to increase with the replacement of the winter road by an all-weather road as a result of higher operating speeds and higher traffic volumes. Thus, an increased number of accidents and their associated costs result in negative safety benefits.

Using guidelines published by the Transportation Association of Canada (TAC), three accident categories were used in the study: property damage accident, injury accident and fatal accident[1][Can NWT Department of Transportation confirm source?]. The probabilities for each type of accident occurring were estimated for both the winter road and the all-weather road, based on historical accident information. The cost of a property damage accident was also based on historical accident information whereas the costs of the injury and fatal accident types were taken from the TAC report. The accident costs were assumed to be the same for winter roads and all-weather roads.

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[1] Transportation Association of Canada, *Highway User Cost Tables - A Simplified Method of Estimating User Cost Savings for Highway Improvement*, 1993.

5.6 Reduced Re-Supply Costs

With a new port on the Arctic coast the re-supply costs for nearby coastal communities are assumed to fall. The cost estimates — with and without the port — included both dry cargo and petroleum products. The annual re-supply costs without the port is estimated at $19.2 million. The corresponding figure with the new port is $16.9 million, a savings of about $2.3 million per year.

5.7 Multiplier Impacts

The multiplier impacts for each scenario have not been quantified in this study since their inclusion would be contrary to the practice recommended by the Treasury Board. Previous studies conducted by The Conference Board of Canada for the Government of the Northwest Territories have quantified economic impacts for transportation infrastructure. The most recent study, completed in June 2001, quantified the economic impacts for four development scenarios that correspond to the base case and the three scenarios considered in this study.

If the multiplier impacts were to be included in the current study, the direct impacts would be excluded, only the indirect and induced impacts would be considered. The sum of the indirect and induced Gross Domestic Product (GDP) measured at factor cost would be included as a benefit[1].

[1] Gross Domestic Product measured at factor cost is an aggregate measure of economic output which includes wages and salaries, supplementary labour income, net income from unincorporated businesses and other surpluses.

6 Benefit-Cost Results

The results of the benefit-cost analysis are presented in this chapter for each of the scenarios. The results for each scenario are incremental to the base case. That is, the results for the scenarios represent the difference between the scenario and the base case.

As indicated previously, the proper criterion for comparison purposes is the Net Present Value or NPV. A positive NPV indicates that the scenario is justified on economic terms. The scenario with the highest NPV is usually the preferred option. The Benefit-Cost Ratio and the Internal Rate of Return are also presented for completeness.

6.1 Scenario 1

The results for the first scenario are given in Table 4. The general results are as follows. With a discount rate of 10 per cent, the NPV for this scenario is -$57 million dollars. The IRR is 8.7 per cent and the BCR is 0.97.

The largest component on the cost side is the construction and operations of the various mines. Undiscounted, these costs total $5,051 million over the 20-year study period. The undiscounted total costs for this scenario are $5,414 million. Discounted back to 2000 with a 10 per cent discount rate, total costs are reduced to $2,175 million.

The benefit side is even more dominated by the mining sector. The incremental value of mining output (without discounting) is $6,352 million. It is worth noting that the incremental transportation benefits (undiscounted) are estimated at -$111 million. Although there is a small reduction in average operating expenses, overall traffic volumes increase and the safety benefits for the all-weather road turn out to be negative — a dis-benefit. This means that the higher operating speeds on the all-weather road and higher traffic volumes will result in an increase in accidents and their associated costs. These operating and safety cost dis-benefits outweigh the other non-mining related quantified benefits and, as a result, the undiscounted total benefits for this scenario stand at $6,277 million. Discounted at 10 per cent, the total benefits are reduced to $2,118 million.

With total discounted benefits of $2,118 million and total discounted costs of $2,175 million, the NPV for this scenario is -$57 million. This result means that even without taking into account the unquantified costs and benefits, society would be worse off by $57 million if the projects in Scenario 1 were undertaken. Although, the undiscounted benefits outweigh the undiscounted costs most of the costs are incurred in the early years of the project as “up-front” investments in infrastructure. By contrast, most of the benefits are only felt when the new mines not included in the base case start production in the later years of the project. As a result, these benefits are subject to relatively greater discount factors and so their sum falls below that of the total discounted costs.

Table 4

Incremental Costs and Benefits of Scenario 1

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Costs																					
Transportation Corridor	0.0	0.0	78.5	78.5	37.5	37.5	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	270.1
Port	0.0	0.0	23.7	23.7	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	93.2
Mining	0.0	0.0	149.7	149.7	149.7	251.8	251.7	251.7	361.2	361.2	361.7	351.4	351.6	351.7	351.9	352.3	353.4	216.7	216.7	217.0	5,051.1
Total Costs	**0.0**	**0.0**	**251.9**	**251.9**	**190.1**	**292.1**	**257.3**	**257.3**	**366.8**	**366.8**	**367.3**	**357.0**	**357.2**	**357.3**	**357.4**	**357.9**	**358.9**	**222.3**	**222.3**	**222.6**	**5,414.4**
Benefits																					
Transportation	0.0	0.1	-1.2	-1.2	-1.0	-4.2	-0.8	-1.2	-6.1	-6.2	-6.5	-10.8	-10.3	-9.8	-9.7	-10.2	-10.9	-7.0	-7.1	-7.2	-111.4
Mining Output	0.0	0.0	0.0	0.0	0.0	296.1	296.1	296.0	429.6	429.5	429.4	562.8	562.7	562.6	562.5	562.4	562.3	266.6	266.5	266.5	6,351.5
Reduced Re-Supply	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	36.8
Tourism	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Benefits	**0.0**	**0.1**	**-1.2**	**-1.2**	**1.3**	**294.2**	**297.6**	**297.1**	**425.7**	**425.6**	**425.2**	**554.3**	**554.7**	**555.1**	**555.1**	**554.5**	**553.7**	**261.9**	**261.8**	**261.6**	**6,277.0**
Total Costs	**0.0**	**0.0**	**251.9**	**251.9**	**190.1**	**292.1**	**257.3**	**257.3**	**366.8**	**366.8**	**367.3**	**357.0**	**357.2**	**357.3**	**357.4**	**357.9**	**358.9**	**222.3**	**222.3**	**222.6**	**5,414.4**
Total Benefits	**0.0**	**0.1**	**-1.2**	**-1.2**	**1.3**	**294.2**	**297.6**	**297.1**	**425.7**	**425.6**	**425.2**	**554.3**	**554.7**	**555.1**	**555.1**	**554.5**	**553.7**	**261.9**	**261.8**	**261.6**	**6,277.0**
Total Benefits less Total Costs	**0.0**	**0.1**	**-253.1**	**-253.1**	**-188.8**	**2.1**	**40.3**	**39.8**	**58.9**	**58.8**	**57.9**	**197.3**	**197.4**	**197.8**	**197.7**	**196.6**	**194.8**	**39.6**	**39.5**	**39.0**	**862.6**
Present Value (PV) of Costs	**0.0**	**0.0**	**208.2**	**189.3**	**129.8**	**181.4**	**145.2**	**132.0**	**171.1**	**155.6**	**141.6**	**125.1**	**113.8**	**103.5**	**94.1**	**85.7**	**78.1**	**44.0**	**40.0**	**36.4**	**2,175.0**
Present Value (PV) of Benefits	**0.0**	**0.1**	**-1.0**	**-0.9**	**0.9**	**182.7**	**168.0**	**152.5**	**198.6**	**180.5**	**163.9**	**194.3**	**176.7**	**160.8**	**146.2**	**132.7**	**120.5**	**51.8**	**47.1**	**42.8**	**2,118.1**
PV Benefits less PV Costs	**0.0**	**0.1**	**-209.2**	**-190.2**	**-128.9**	**1.3**	**22.7**	**20.4**	**27.5**	**24.9**	**22.3**	**69.2**	**62.9**	**57.3**	**52.1**	**47.1**	**42.4**	**7.8**	**7.1**	**6.4**	**-56.8**

Evaluation Criteria	**Value**
Net Present Value (millions of 2000 doll	-$56.8
Internal Rate of Return (percentage)	8.7%
Benefit-Cost Ratio	0.97

Discount Rate (percentage)	**10.0%**

Source: The Conference Board of Canada

The IRR for this scenario is 8.7 per cent. When compared to a “hurdle” discount rate of 10 per cent, this scenario appears not to be worthwhile from society’s standpoint. This result is confirmed with a BCR of 0.97, another way of showing that the discounted benefits of this scenario are less than the discounted costs. Nonetheless, this value of 0.97 indicates that the relative size of the loss to society is not unduly large

6.2 Scenario 2

The results for the second scenario are given in Table 5. The general results are as follows. With a discount rate of 10 per cent, the NPV for this scenario is -$200 million dollars. The IRR is 5.3 per cent and the BCR is 0.92.

The largest component on the cost side is the construction and operations of the various mines. Undiscounted, these costs total $6,124 million over the 20-year study period. The undiscounted total costs for this scenario are $6,694 million. Discounted back to 2000 with a 10 per cent discount rate, total costs are reduced to $2,505 million.

The benefit side is even more dominated by the mining sector. The incremental value of mining output (without discounting) is $7,286 million. It is worth noting that the incremental transportation benefits (undiscounted) are estimated at -$90 million. Although there is a small reduction in average operating expenses, overall traffic volumes increase and the safety benefits for the all-weather road turn out to be negative — a dis-benefit. This means that the higher operating speeds on the all-weather road and higher traffic volumes will result in an increase in accidents and their associated costs. These dis-benefits outweigh the other non-mining related quantified benefits and, as a result, the undiscounted total benefits for this scenario stand at $7,236 million. Discounted at 10 per cent, the total benefits are reduced to $2,305 million.

With total discounted benefits of $2,305 million and total discounted costs of $2,505 million, the NPV for this scenario is -$200 million. This result means that even without taking into account the unquantified costs and benefits, society would be worse off by $200 million if the projects in Scenario 2 were undertaken. Although, the undiscounted benefits outweigh the undiscounted costs most of the costs are incurred in the early years of the project as “up-front” investments in infrastructure. By contrast, most of the benefits are only felt when the new mines not included in the base case start production in the later years of the project. As a result, these benefits are subject to relatively greater discount factors and so their sum falls below that of the total discounted costs.

The IRR for this scenario is 5.3 per cent. When compared to a “hurdle” discount rate of 10 per cent, this scenario is clearly not worthwhile from society’s standpoint. This result is confirmed with a BCR of 0.92, another way of showing that the discounted benefits of this scenario are less than the discounted costs. Nonetheless, this value of 0.92 indicates that the relative size of the loss to society is not unduly large

Table 5

Incremental Costs and Benefits of Scenario 2

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Costs																					
Transportation Corridor	0.0	0.0	78.5	78.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	36.5	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	477.0
Port	0.0	0.0	23.7	23.7	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	93.2
Mining	0.0	0.0	149.7	149.7	149.7	251.8	251.7	251.7	315.9	361.2	361.7	351.4	488.0	514.1	518.3	393.3	454.6	352.5	403.9	404.9	6,124.2
Total Costs	**0.0**	**0.0**	**251.9**	**251.9**	**190.1**	**292.1**	**292.0**	**292.0**	**356.2**	**401.5**	**402.0**	**390.7**	**493.5**	**519.6**	**523.8**	**398.8**	**460.1**	**358.0**	**409.4**	**410.4**	**6,694.4**
Benefits																					
Transportation	0.0	0.1	-1.2	-1.2	-1.0	-4.5	-0.8	-1.2	-6.1	-6.2	-6.5	-10.8	-6.4	-5.4	-5.5	-6.8	-8.7	-5.7	-5.9	-5.9	-89.7
Mining Output	0.0	0.0	0.0	0.0	0.0	296.1	296.1	296.0	429.6	429.5	429.4	562.8	562.7	562.6	562.5	648.9	735.3	491.5	491.5	491.4	7,285.8
Reduced Re-Supply	0.0	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	36.8
Tourism	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	3.5
Total Benefits	**0.0**	**0.1**	**-1.2**	**-1.2**	**1.3**	**294.0**	**297.6**	**297.1**	**425.7**	**425.6**	**425.2**	**554.3**	**559.0**	**559.9**	**559.7**	**644.8**	**729.4**	**488.5**	**488.3**	**488.2**	**7,236.4**
Total Costs	**0.0**	**0.0**	**251.9**	**251.9**	**190.1**	**292.1**	**292.0**	**292.0**	**356.2**	**401.5**	**402.0**	**390.7**	**493.5**	**519.6**	**523.8**	**398.8**	**460.1**	**358.0**	**409.4**	**410.4**	**6,694.4**
Total Benefits	**0.0**	**0.1**	**-1.2**	**-1.2**	**1.3**	**294.0**	**297.6**	**297.1**	**425.7**	**425.6**	**425.2**	**554.3**	**559.0**	**559.9**	**559.7**	**644.8**	**729.4**	**488.5**	**488.3**	**488.2**	**7,236.4**
Total Benefits less Total Costs	**0.0**	**0.1**	**-253.1**	**-253.1**	**-188.8**	**1.8**	**5.5**	**5.1**	**69.5**	**24.1**	**23.1**	**163.6**	**65.5**	**40.3**	**36.0**	**245.9**	**269.3**	**130.5**	**78.9**	**77.8**	**542.0**
Present Value (PV) of Costs	**0.0**	**0.0**	**208.2**	**189.3**	**129.8**	**181.4**	**164.8**	**149.9**	**166.2**	**170.3**	**155.0**	**136.9**	**157.3**	**150.5**	**137.9**	**95.5**	**100.1**	**70.8**	**73.6**	**67.1**	**2,504.7**
Present Value (PV) of Benefits	**0.0**	**0.1**	**-1.0**	**-0.9**	**0.9**	**182.5**	**168.0**	**152.5**	**198.6**	**180.5**	**163.9**	**194.3**	**178.1**	**162.2**	**147.4**	**154.4**	**158.7**	**96.7**	**87.8**	**79.8**	**2,304.5**
PV Benefits less PV Costs	**0.0**	**0.1**	**-209.2**	**-190.2**	**-128.9**	**1.1**	**3.1**	**2.6**	**32.4**	**10.2**	**8.9**	**57.3**	**20.9**	**11.7**	**9.5**	**58.9**	**58.6**	**25.8**	**14.2**	**12.7**	**-200.3**

Evaluation Criteria	**Value**
Net Present Value (millions of 2000 doll	-$200.3
Internal Rate of Return (percentage)	5.3%
Benefit-Cost Ratio	0.92

Discount Rate (percentage) **10.0%**

Source: The Conference Board of Canada

6.3 Scenario 3

The results for the third scenario are given in Table 6. The general results are as follows. With a discount rate of 10 per cent, the NPV for this scenario is -$364 million dollars. The IRR is 4.5 per cent and the BCR is 0.90.

The largest component on the cost side is the construction and operations of the various mines. Undiscounted, these costs total $8,468 million over the 20-year study period. The undiscounted total costs for this scenario are $9,041 million. Discounted back to 2000 with a 10 per cent discount rate, total costs are reduced to $3,599 million.

The benefit side is even more dominated by the mining sector. The incremental value of mining output (without discounting) is $9,804 million. It is worth noting that the incremental transportation benefits (undiscounted) are estimated at -$119 million. Although there is a small reduction in average operating expenses, overall traffic volumes increase and the safety benefits for the all-weather road turn out to be negative — a dis-benefit. This means that the higher operating speeds on the all-weather road and higher traffic volumes will result in an increase in accidents and their associated costs. These dis-benefits outweigh the other non-mining related quantified benefits and, as a result, the undiscounted total benefits for this scenario stand at $9,730 million. Discounted at 10 per cent, the total benefits are reduced to $3,235 million.

With total discounted benefits of $3,599 million and total discounted costs of $3,235 million, the NPV for this scenario is -$364 million. This result means that even without taking into account the unquantified costs and benefits, society would be worse off by $364 million if the projects in Scenario 2 were undertaken. Although, the undiscounted benefits outweigh the undiscounted costs most of the costs are incurred in the early years of the project as “up-front” investments in infrastructure. By contrast, most of the benefits are only felt when the new mines not included in the base case start production in the later years of the project. As a result, these benefits are subject to relatively greater discount factors and so their sum falls below that of the total discounted costs.

The IRR for this scenario is 4.5 per cent. When compared to a “hurdle” discount rate of 10 per cent, this scenario is clearly not worthwhile from society’s standpoint. This result is confirmed with a BCR of 0.90, another way of showing that the discounted benefits of this scenario are less than the discounted costs. Nonetheless, this value of 0.90 indicates that the relative size of the loss to society is not unduly large.

Table 6

Incremental Costs and Benefits of Scenario 3

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Costs																					
Transportation Corridor	0.0	112.2	112.2	72.2	72.2	71.2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	477.0
Port	0.0	23.7	23.7	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	96.0
Mining	0.0	149.7	149.7	269.6	256.7	251.8	496.6	523.4	522.9	377.2	435.5	469.8	686.7	712.8	665.6	538.8	529.4	564.3	439.9	427.7	8,467.9
Total Costs	**0.0**	**285.6**	**285.6**	**344.6**	**331.8**	**325.8**	**502.1**	**528.9**	**528.4**	**382.7**	**441.0**	**475.3**	**692.2**	**718.3**	**671.1**	**544.3**	**534.9**	**569.8**	**445.4**	**433.2**	**9,041.0**
Benefits																					
Transportation	0.0	-1.1	-1.2	-3.0	-6.6	-6.3	-2.7	-3.3	-3.6	-6.9	-8.4	-8.8	-10.1	-9.3	-9.4	-10.5	-8.7	-9.4	-4.7	-4.6	-118.7
Mining Output	0.0	0.0	0.0	0.0	296.2	296.1	429.7	429.7	429.6	649.6	735.9	787.7	787.6	787.5	787.4	870.9	661.7	713.6	580.2	560.0	9,803.5
Reduced Re-Supply	0.0	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	39.1
Tourism	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	6.2
Total Benefits	**0.0**	**-1.1**	**-1.2**	**-0.7**	**291.9**	**292.1**	**429.8**	**429.1**	**428.7**	**645.4**	**730.3**	**781.6**	**780.3**	**780.9**	**780.7**	**863.2**	**655.8**	**706.9**	**578.3**	**558.1**	**9,730.1**
Total Costs	**0.0**	**285.6**	**285.6**	**344.6**	**331.8**	**325.8**	**502.1**	**528.9**	**528.4**	**382.7**	**441.0**	**475.3**	**692.2**	**718.3**	**671.1**	**544.3**	**534.9**	**569.8**	**445.4**	**433.2**	**9,041.0**
Total Benefits	**0.0**	**-1.1**	**-1.2**	**-0.7**	**291.9**	**292.1**	**429.8**	**429.1**	**428.7**	**645.4**	**730.3**	**781.6**	**780.3**	**780.9**	**780.7**	**863.2**	**655.8**	**706.9**	**578.3**	**558.1**	**9,730.1**
Total Benefits less Total Costs	**0.0**	**-286.7**	**-286.8**	**-345.4**	**-39.9**	**-33.7**	**-72.3**	**-99.8**	**-99.7**	**262.7**	**289.3**	**306.4**	**88.0**	**62.6**	**109.6**	**318.9**	**120.9**	**137.2**	**132.8**	**124.9**	**689.1**
Present Value (PV) of Costs	**0.0**	**259.6**	**236.0**	**258.9**	**226.6**	**202.3**	**283.4**	**271.4**	**246.5**	**162.3**	**170.0**	**166.6**	**220.6**	**208.1**	**176.7**	**130.3**	**116.4**	**112.7**	**80.1**	**70.8**	**3,599.4**
Present Value (PV) of Benefits	**0.0**	**-1.0**	**-1.0**	**-0.6**	**199.4**	**181.4**	**242.6**	**220.2**	**200.0**	**273.7**	**281.6**	**274.0**	**248.6**	**226.2**	**205.6**	**206.6**	**142.7**	**139.9**	**104.0**	**91.3**	**3,235.1**
PV Benefits less PV Costs	**0.0**	**-260.7**	**-237.0**	**-259.5**	**-27.2**	**-20.9**	**-40.8**	**-51.2**	**-46.5**	**111.4**	**111.5**	**107.4**	**28.0**	**18.1**	**28.9**	**76.3**	**26.3**	**27.1**	**23.9**	**20.4**	**-364.3**

Evaluation Criteria	Value
Net Present Value (millions of 2000 doll	-$364.3
Internal Rate of Return (percentage)	4.5%
Benefit-Cost Ratio	0.90

Discount Rate (percentage) **10.0%**

Source: The Conference Board of Canada

6.4 Ranking of Scenarios

With the results summarised in Table 7, the ranking of the scenarios can be quickly established. Scenario 1 has the highest NPV at -$57 million and has the highest ranking. Scenario 2 has the second highest NPV at -$200 million and is ranked second. The scenario with the lowest ranking is Scenario 3 with an NPV of -$364 million.

Table 7

Summary of Benefit-Cost Results

Benefit-Cost Criteria	Scenario 1	Scenario 2	Scenario 3
Net Present Value ($ millions)	-56.8	-200.3	-364.3
Internal Rate of Return (per cent)	8.7	5.3	0.0
Benefit-Cost Ratio	0.97	0.92	0.90

Source: The Conference Board of Canada.

6.5 Unquantified Benefits and Costs

The unquantified environmental costs will clearly reinforce these quantified results. The environmental impacts of the road and mine construction will occur relatively early in each of the scenarios. This means that with discounting, these unquantified costs will have a greater effect on the results than if the costs were incurred later. The unquantified training costs and costs of having to build additional municipal infrastructure will also have an impact, although these costs are assumed to be relatively small.

The effects of the unquantified benefits — the economic multiplier impacts — can be more readily assessed since the scenario definitions between the current study and the previous study are nearly identical. The total incremental multiplier benefits (undiscounted) for Scenario 1 are estimated at $2,100 million; for Scenario 2 they are $2,873 million; and for Scenario 3 they are $3,895 million. Discounting these results using a discount rate of 10 per cent lowers these values to $821 million, $1,002 million and $1,488 million, respectively. Adding these multiplier benefits (even with discounting) to the existing benefit stream would make the scenarios more attractive.

In order to properly assess the scenarios, decision makers must decide if the balance between the discounted environment costs and the discounted multiplier benefits is sufficient to make the scenarios economic (i.e., result in a NPV of greater than zero).

7 Analysis of Uncertainty

In this chapter, the results of the benefit-cost analysis are analysed as to their uncertainty. This will answer the question of how robust the results are to changes in the critical assumptions used in the analysis. The chapter is composed of two parts: the first conducts a simultaneous Monte Carlo risk analysis for all the uncertain variables in the model; the second contains supplementary analyses of the impact of the individual variables on the results of the benefit-costs analysis.

In the previous study sensitivity analysis was used to assess the sensitivity of the results to variations in the values of key variables by a set amount (e.g., ± 25 per cent). However, Monte Carlo risk analysis goes a step further by taking into account a much wider range of potential variation in these variables. Computer software can be used to select a random value of the variable from its specified distribution and this value used to recalculate the NPV. This process is then repeated many times to generate an entire distribution of the NPV with respect to changes in the key variable being examined (for this study, the process was repeated until the distribution of the NPV for each of the scenarios changed by less than 1.5 per cent). The results can also be presented in the form of a cumulative probability distribution function which shows the probability that the NPV will be above a certain value, say zero. If there is significant sensitivity, the variable in question should be subjected to further scrutiny.

This analysis can be extended further to take into account changes in all the key variables simultaneously. This technique can be used make an assessment of the overall level of risk inherent in the project as a whole.

In this study, the following factors were subjected to Monte Carlo risk analysis:

1. the prices of gold and base metals (lead and zinc);
2. the discount rate;
3. the quantity of diamond output – the quantity is determined by two variables, namely, the amount of diamonds in the reserve and the quality of these diamonds;
4. labour costs – these comprise ten wage rates for the construction and operation of the transportation corridor and the mines;
5. capital costs – these comprise forty-seven capital cost estimates for the construction and operation of the transportation corridor and the mines; and
6. transportation construction costs – these comprise the wage rates and capital cost estimates for the construction of the transportation corridor.

Treasury Board guidelines point out that when carrying out such an exercise it is important to take into account the covariance of the key risk variables. For example, a high NPV value might result from simultaneous random selections of relatively high values of both the price and quantity of, say, diamonds. Such an NPV might be outside a plausible real world range. Unfortunately, the resources required to develop a correlation matrix not only between the contemporaneous values of the risk variables but also between their values over time were beyond the scope of this study.

7.1 All-Variable Risk Analysis

Table 8 shows the principal results from the Monte Carlo risk analysis when all the key variables were allowed to vary simultaneously (3100 iterations were required to obtain these results). The mean NPV values are reasonably close to those of the basic benefit-costs analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV and the highest chance of having a positive NPV. Nonetheless, there is only about a 3 in 10 chance of the NPV turning out to be greater than zero. It is worth noting that the probability of a positive NPV is greater for Scenario 3 than it is for Scenario 2, despite Scenario having a higher average NPV.

Table 8

Summary of All-Variable Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-48.8	-195.9	-369.5
Standard Deviation of NPV ($2000 millions)	106.7	138.3	414.0
Probability NPV Greater Than Zero	30.5%	8.4%	18.4%

Source: The Conference Board of Canada.

Appendix B contains charts showing the distributions of the NPV for each scenario together with their cumulative probability distribution functions.

7.2 Individual Variable Risk Analysis

This section contains supplementary information on the results of the risk analysis carried out when only one set of variables was permitted to change at any one time.

7.2.1 Price of Gold and Base Metals

Table 9 shows the principal results from the Monte Carlo risk analysis when just the prices of gold, lead and zinc were allowed to vary simultaneously (1100 iterations were required to obtain these results). The mean NPV values are again reasonably close to those of the basic benefit-cost analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV and the highest chance of having a positive NPV. Indeed, Scenarios 2 and 3 have virtually no

Table 9

Summary of Gold and Base Metal Prices Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-56.0	-199.3	-364.1
Standard Deviation of NPV ($2000 millions)	78.9	78.9	91.4
Probability NPV Greater Than Zero	24.3%	0.4%	0.0%

Source: The Conference Board of Canada.

chance of achieving a positive NPV. It is worth noting that the standard deviation of the NPV for Scenarios 1 and 2 are the same. This is because each has the same base metal production profile.

7.2.2 Discount Rate

Table 10 shows the principal results from the Monte Carlo risk analysis when just the discount rate was allowed to vary (1600 iterations were required to obtain these results). The mean NPV values are again reasonably close to those of the basic benefit-cost analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV and the highest chance of having a positive NPV. Indeed, Scenarios 2 and 3 again have virtually no chance of achieving a positive NPV. In fact Scenarios 1, 2 and 3 require discount rates of 8.6 per cent, 5.3 per cent and 4.5 per cent, respectively, to achieve a positive NPV.

Table 10

Summary of Discount Rate Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-50.1	-194.8	-356.7
Standard Deviation of NPV ($2000 millions)	48.5	33.9	51.3
Probability NPV Greater Than Zero	14.0%	0.1%	0.0%

Source: The Conference Board of Canada.

7.2.3 Quantity of Diamond Output

Table 11 shows the principal results from the Monte Carlo risk analysis when just the quantity of diamond output of the generic diamond mines was allowed to vary (800 iterations were required to obtain these results). The mean NPV values are again reasonably close to those of the basic benefit-cost analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV. It is important to note that the diamond output profiles for Scenario 1 and the Base Case are the same. This means that the NPV for Scenario 1 is exactly the same as in the basic benefit-cost analysis and so there is no distribution around the NPV and, hence, no possibility of a positive value.

Table 11

Summary of Diamond Output Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-56.8	-202.6	-375.2
Standard Deviation of NPV ($2000 millions)	N/A	89.0	383.7
Probability NPV Greater Than Zero	0.0%	18.8%	2.8%

Source: The Conference Board of Canada.

7.2.4 Labour Costs

Table 12 shows the principal results from the Monte Carlo risk analysis when only wage rates were allowed to vary (600 iterations were required to obtain these results). The mean NPV values are again reasonably close to those of the basic benefit-cost analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV. The standard deviations are relatively small indicating that the distributions of the NPVs are clustered relatively tightly around their mean values. This explains why there is zero probability of obtaining a positive NPV. In fact Scenarios 1, 2 and 3 require wage rates to fall by an average of 9.3 per cent, 30.7 per cent and 39.1 per cent, respectively, to achieve a positive NPV.

Table 12

Summary of Labour Cost Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-55.6	-198.7	-363.6
Standard Deviation of NPV ($2000 millions)	13.1	13.4	16.6
Probability NPV Greater Than Zero	0.0%	0.0%	0.0%

Source: The Conference Board of Canada.

7.2.5 Capital Costs

Table 13 shows the principal results from the Monte Carlo risk analysis when only wage rates were allowed to vary (1800 iterations were required to obtain these results). The mean NPV values are again reasonably close to those of the basic benefit-cost analysis. The mean NPV values are again reasonably close to those of the basic benefit-costs analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV and the highest chance of having a positive NPV. Nonetheless, there is not much more than a 1 in 10 chance of the NPV turning out to be greater than zero. Moreover, Scenarios 2 and 3 again have virtually no chance of achieving a positive NPV. Nonetheless, Scenarios 1, 2 and 3 require capital costs to fall by an average of just 3.6 per cent, 10.8 per cent and 13.7 per cent, respectively, to achieve a positive NPV.

Table 13

Summary of Capital Cost Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-55.0	-198.0	-365.3
Standard Deviation of NPV ($2000 millions)	43.9	50.6	68.8
Probability NPV Greater Than Zero	11.5%	0.0%	0.0%

Source: The Conference Board of Canada.

7.2.6 Transportation Construction Costs

Finally, Table 14 shows the principal results from the Monte Carlo risk analysis when only the labour and capital costs of building the transportation infrastructure were allowed to vary (1000 iterations were required to obtain these results). The mean NPV values are again reasonably close to those of the basic benefit-cost analysis. The ranking of the mean values of the scenarios remains unchanged with Scenario 1 having the highest NPV. The standard deviations are relatively small indicating that the distributions of the NPVs are clustered relatively tightly around their mean values. This explains why there is zero probability of obtaining a positive NPV. Moreover, Scenarios 1, 2 and 3 require capital costs and wage rates for the transportation infrastructure to fall by an average of 28.6 per cent, 66.9 per cent and 97.4 per cent, respectively, to achieve a positive NPV.

Table 14

Summary of Transportation Construction Cost Risk Analysis Results

Risk Analysis Criteria	Scenario 1	Scenario 2	Scenario 3
Mean NPV ($2000 millions)	-56.7	-200.1	-363.6
Standard Deviation of NPV ($2000 millions)	8.8	9.4	12.3
Probability NPV Greater Than Zero	0.0%	0.0%	0.0%

Source: The Conference Board of Canada.

Appendix A: Assumptions

Appendix A1: Data Constants

This sub-appendix contains data constants used in calculating the benefits and costs. Although most of the data entered directly in the benefit or costs calculations (e.g., discount rate) some were used in intermediate calculations (e.g., the uncertainty factors used in the risk analysis).

Appendix A2: Multi-Year Data (Date Dependent)

This sub-appendix contains multi-year data that occur in specific years over the 20-year study period. This can be contrasted with Appendix A3 which contains multi-year data which may be repeated several times over the 20-year study period (see description of Appendix A3 for further details). The years 2001 to 2020 run across the top of the table.

Appendix A3: Multi-Year Data (Non-Date Dependent)

This sub-appendix contains multi-year data that which may be repeated several times over the 20-year study period. For example, Scenario 3 contains three new diamond mines that all use the same three-year development cost profile. As a result, the dates that run across the top of the table have been replaced by year numbers.

Appendix A1

Data Constants

#	Data Element Name	Units	Value
1	discount rate (mean)	per cent	10.0%
2	discount rate (standard deviation)	per cent	1.25%
3	price of copper (mean)	$2000/tonne	$2,693.27
4	price of silver (mean)	$2000/ounce	$7.36
5	price of diamonds for generic diamond mine	$2000/carat	$ 101.19
6	grade for diamonds - generic diamond mine (mean)	carats/tonne	1.82
7	grade for diamonds - generic diamond mine (standard deviation)	carats/tonne	1.10
8	quantity of kimberlite extracted - generic diamond mine (mean)	million of tonnes	33.50
9	quantity of kimberlite extracted - generic diamond mine (standard deviation)	million of tonnes	23.00
10	expenditures by tourists - non-residents	$2000	$ 453
11	expenditures by tourists - residents	$2000	$ 250
12	initial number of tourists - non-residents	number	700
13	initial number of tourists - residents	number	400
14	winter road distance from Yellowknife (YK) to Ekati/Diavik	kilometers	420
15	winter road distance from Ekati/Diavik to Lupin	kilometers	220
16	all-weather road distance from Yellowknife to Ekati/Diavik	kilometers	410
17	all-weather road distance from Ekati/Diavik to Contwoyto Lake	kilometers	110
18	all-weather road distance from Contwoyto Lake to Artic Coast	kilometers	265
19	average vehicle operating costs - winter road	$2000/vehicle-kilometer	$ 3.00
20	average vehicle operating costs - all-weather road	$2000/vehicle-kilometer	$ 1.50
21	probability of a property damage accident - winter road	accidents/million vehicle-kilometers	0.2000
22	probability of a property damage accident - all-weather road	accidents/million vehicle-kilometers	0.8500
23	probability of an injury accident - winter road	accidents/million vehicle-kilometers	0.1300
24	probability of an injury accident - all-weather road	accidents/million vehicle-kilometers	0.5300
25	probability of a fatal accident - winter road	accidents/million vehicle-kilometers	0.0070
26	probability of a fatal accident - all-weather road	accidents/million vehicle-kilometers	0.0300
27	cost of a property damage accident - winter road	$2000/accident	$ 12,700
28	cost of a property damage accident - all-weather road	$2000/accident	$ 12,700
29	cost of a injury accident - winter road	$2000/accident	$ 100,000
30	cost of a injury accident - all-weather road	$2000/accident	$ 100,000
31	cost of a fatal accident - winter road	$2000/accident	$ 2,900,000
32	cost of a fatal accident - all-weather road	$2000/accident	$ 2,900,000
33	uncertainty in gross annual wage data	per cent	25.0%
34	average gross annual construction wage (most likely) - base metal mine	$2000/worker/year	$ 90,000
35	average gross annual construction wage (most likely) - diamond mine	$2000/worker/year	$ 90,000
36	average gross annual construction wage (most likely) - all-weather road	$2000/worker/year	$ 55,000
37	average gross annual construction wage (most likely) - port	$2000/worker/year	$ 62,000
38	average gross annual operations wage (most likely) - base metal mine	$2000/worker/year	$ 75,000
39	average gross annual operations wage (most likely) - gold mine	$2000/worker/year	$ 70,000
40	average gross annual operations wage (most likely) - diamond mine	$2000/worker/year	$ 73,200
41	average gross annual operations wage (most likely) - winter road	$2000/worker/year	$ 62,000
42	average gross annual operations wage (most likely) - all-weather road	$2000/worker/year	$ 62,000
43	average gross annual operations wage (most likely) - port	$2000/worker/year	$ 60,000
44	cost of re-supply for coastal communities - without port	$2000 millions	$ 19.2
45	cost of re-supply for coastal communities - with port	$2000 millions	$ 16.9
46	uncertainty in transportation infrastructure	per cent	25.0%
47	uncertainty in mining infrastructure	per cent	25.0%

Appendix A2

Multi-Year Data (Date Dependent)

Data Element Name	Units	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
forecast traffic on winter road from YK to Ekati/Diavik (base case)	vehicles/ year	5,395	6,062	5,291	6,724	8,510	9,472	9,778	8,912	8,637	10,133	9,113	9,074	8,714	9,496	9,305	7,637	5,969	5,531	5,495	5,391
forecast traffic on winter road from Ekati/Diavik to Lupin (base case)	vehicles/ year	560	681	626	627	774	1,024	1,054	508	508	508	263	184								
forecast traffic on winter road from YK to Ekati/Diavik (Scenario 1)	vehicles/ year	5,395	6,062	5,924	7,358	9,056	10,047	6,070	5,204	5,426	7,002	6,255	6,236	5,338	5,654	5,574	4,697	4,011	3,308	3,293	3,418
forecast traffic on winter road from Ekati/Diavik to Lupin (Scenario 1)	vehicles/ year	560	560	1,193	1,193	1,193	1,067														
forecast traffic on all-weather road from Ekati/Diavik to Contwoyto Lake (Scenario 1)	vehicles/ year							5,177	5,177	5,673	5,594	5,438	5,431	6,049	6,519	6,414	5,642	4,699	4,168	4,148	3,926
forecast traffic on all-weather road from Contwoyto Lake to Arctic Coast (Scenario 1)	vehicles/ year					89	7,864	12,146	12,146	21,772	21,693	21,439	31,045	30,971	30,824	30,349	29,577	28,634	20,823	20,823	20,602
forecast traffic on winter road from YK to Ekati/Diavik (Scenario 2)	vehicles/ year	5,395	6,062	5,924	7,358	9,056	10,047	6,070	5,204	5,426	7,002	6,255	6,236								
forecast traffic on winter road from Ekati/Diavik to Lupin (Scenario 2)	vehicles/ year	560	560	1,193	1,193	1,193	1,067														
forecast traffic on all-weather road from Yellowknife to Ekati/Diavik (Scenario 2)	vehicles/ year													6,524	6,420	6,594	5,133	4,917	4,475	4,674	4,799
forecast traffic on all-weather road from Ekati/Diavik to Contwoyto Lake (Scenario 2)	vehicles/ year							5,177	5,177	5,673	5,594	5,438	5,431	6,049	6,519	6,414	6,241	5,896	5,726	5,705	5,483
forecast traffic on all-weather road from Contwoyto Lake to Arctic Coast (Scenario 2)	vehicles/ year					89	7,864	12,146	12,146	21,772	21,693	21,439	31,045	30,971	30,824	30,349	30,176	29,832	22,381	22,381	22,159
forecast traffic on winter road from YK to Ekati/Diavik (Scenario 3)	vehicles/ year	5,395	6,695	5,924	7,800	9,265	10,047														
forecast traffic on winter road from Ekati/Diavik to Lupin (Scenario 3)	vehicles/ year	560	1,193	1,193																	
forecast traffic on all-weather road from Yellowknife to Ekati/Diavik (Scenario 3)	vehicles/ year							7,759	6,474	6,450	7,398	7,134	7,375	7,896	7,778	7,729	6,253	5,912	5,870	5,293	5,316
forecast traffic on all-weather road from Ekati/Diavik to Contwoyto Lake (Scenario 3)	vehicles/ year				3,745	5,149	5,361	5,878	5,878	5,875	6,388	6,732	7,066	7,592	8,043	7,927	7,733	6,986	7,215	6,695	6,334
forecast traffic on all-weather road from Contwoyto Lake to Arctic Coast (Scenario 3)	vehicles/ year				3,238	11,922	12,134	21,781	21,781	21,778	31,928	32,272	32,606	33,132	33,583	33,467	33,273	25,246	25,475	15,825	15,464
price of lead (mean)	$2000 per tonne	564	567	566	564	562	559	556	554	551	548	545	543	540	537	535	532	529	527	524	521
price of lead (standard deviation)	$2000 per tonne	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123
price of zinc (mean)	$2000 per tonne	1,092	1,091	1,091	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090	1,090
price of zinc (standard deviation)	$2000 per tonne	238	238	238	238	238	238	238	238	238	238	238	238	238	238	238	238	238	238	238	238
price of gold (mean)	$2000 per tonne	305	306	306	306	306	306	306	306	306	306	306	306	306	306	306	306	306	306	306	306
price of gold (standard deviation)	$2000 per tonne	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49

Source: Northwest Territories Department of Transportation, The Conference board of Canada

Appendix A3

Multi-Year Data (Non-Date Dependent)

Data Element Name	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
growth rate for tourists - non-residents	per cent/ year		0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
growth rate for tourists - residents	per cent/ year		1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
number of tourists - residents	number	400	405	411	416	422	428	433	439	445	451	457	464	470	476	483	489	496	502	509	516
number of tourists - non-residents	number	700	706	713	719	725	732	738	745	752	759	765	772	779	786	793	801	808	815	822	830
quantity of lead extracted - Izok Lake	tonnes/ year	16,500	16,500	16,500	16,500	16,500	16,500	16,500	16,500	16,500	16,500	16,500	16,500								
quantity of lead extracted - Hackett River	tonnes/ year	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000								
quantity of lead extracted - generic base metal mine	tonnes/ year	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000								
quantity of zinc extracted - Izok Lake	tonnes/ year	171,000	171,000	171,000	171,000	171,000	171,000	171,000	171,000	171,000	171,000	171,000	171,000								
quantity of zinc extracted - Hackett River	tonnes/ year	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000								
quantity of zinc extracted - generic base metal mine	tonnes/ year	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000								
quantity of copper extracted - Izok Lake	tonnes/ year	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000								
quantity of copper extracted - Hackett River	tonnes/ year	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000								
quantity of copper extracted - generic base metal mine	tonnes/ year	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000								
quantity of silver extracted - Izok Lake	thousand ounces/ year	1,584	1,584	1,584	1,584	1,584	1,584	1,584	1,584	1,584	1,584	1,584	1,584								
quantity of silver extracted - Hackett River	thousand ounces/ year	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955								
quantity of silver extracted - base metal mine	thousand ounces/ year	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955	3,955								
quantity of diamonds extracted - generic diamond mine	per cent	3.00	6.00	7.80	7.80	7.80	7.80	7.70	7.70	7.70	7.70	7.00	7.00	7.00	5.00	3.00					

Sources: Northwest Territories Department of Wildlife, Resources and Economic Development, Northwest Territories Department of Transportation

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Appendix A3, cont.

Multi-Year Data (Non-Date Dependent)

Data Element Name	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
annual capital cost of construction - Izok Lake with winter road	$2000 millions/ year	$120.0	$120.0	$120.0																	
annual capital cost of construction - Izok Lake with all-weather road	$2000 millions/ year	$120.0	$120.0	$120.0																	
annual capital cost of construction - Hackett River	$2000 millions/ year	$96.0	$96.0	$96.0																	
annual capital cost of construction - generic base metal mine	$2000 millions/ year	$96.0	$96.0	$96.0																	
annual capital cost of construction - generic diamond mine with winter road	$2000 millions/ year	$139.3	$177.2	$177.4	$0.0	$0.0	$0.0	$47.0	$47.0	$0.0	$0.0	$60.7	$60.7	$0.0	$0.0	$0.0	$37.0	$0.0			
annual capital cost of construction - generic diamond mine with all-weather road (north and south)	$2000 millions/ year	$135.6	$172.5	$172.6	$0.0	$0.0	$0.0	$47.0	$47.0	$0.0	$0.0	$60.7	$60.7	$0.0	$0.0	$0.0	$37.0	$0.0			
number of mine construction workers - Izok Lake with winter road	workers/ year	330	330	330																	
number of mine construction workers - Izok Lake with all-weather road	workers/ year	330	330	330																	
number of mine construction workers - Hackett River	workers/ year	265	265	265																	
number of mine construction workers - generic base metal mine	workers/ year	265	265	265																	
number of mine construction workers - Jericho with winter road	workers/ year	20	39	20																	
number of mine construction workers - Jericho with all-weather road	workers/ year	20	39	20																	
number of mine construction workers - generic diamond mine with winter road	workers/ year	300	184	184	0	0	0	49	49	0	0	63	63	0	0	0	38				
number of mine construction workers - generic diamond mine with all-weather road (north and south)	workers/ year	285	174	174	0	0	0	48	47	0	0	61	61	0	0	0	38				
annual capital cost of operations - Lupin with winter road	$2000 millions/ year	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0													
annual capital cost of operations - Lupin with all-weather road (north access)	$2000 millions/ year	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0	$25.0													
annual capital cost of operations - Izok Lake (north access)	$2000 millions/ year	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0								
annual capital cost of operations - Izok Lake (north and south access)	$2000 millions/ year	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0	$90.0								

Sources: Northwest Territories Department of Wildlife, Resources and Economic Development, Northwest Territories Department of Transportation

Appendix A3, cont.

Multi-Year Data (Non-Date Dependent)

Data Element Name	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
annual capital cost of operations - Hackett River (north access)	$2000 millions/ year	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0								
annual capital cost of operations - Hackett River (north and south access)	$2000 millions/ year	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0								
annual capital cost of operations - generic base metal mine (north access)	$2000 millions/ year	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0								
annual capital cost of operations - generic base metal mine (north and south access)	$2000 millions/ year	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0	$72.0								
annual capital cost of operations - Ekati with winter road	$2000 millions/ year	$77.8	$104.2	$104.2	$104.2	$104.2	$104.2	$104.2	$104.2	$104.2	$104.2	$93.3	$93.3	$93.3	$88.6	$77.8	$46.7				
annual capital cost of operations - Ekati with all-weather road (north access)	$2000 millions/ year	$77.8	$104.2	$104.2	$104.2	$104.2	$102.7	$102.7	$102.7	$102.7	$102.7	$92.0	$92.0	$92.0	$87.4	$76.6	$46.0				
annual capital cost of operations - Ekati with all-weather road (north and south access - Scenario 2)	$2000 millions/ year	$77.8	$104.2	$104.2	$104.2	$102.7	$102.7	$102.7	$102.7	$102.7	$102.7	$92.0	$92.0	$86.8	$82.5	$72.4	$43.4				
annual capital cost of operations - Ekati with all-weather road (north and south access - Scenario 3)	$2000 millions/ year	$77.8	$104.2	$104.2	$102.7	$102.7	$102.7	$97.0	$97.0	$96.3	$96.3	$86.8	$86.8	$86.8	$82.5	$72.4	$43.4				
annual capital cost of operations - Diavik with winter road	$2000 millions/ year	$49.9	$99.8	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$142.5	$123.5	$114.0	$114.0	$97.9		
annual capital cost of operations - Diavik with all-weather road (north access)	$2000 millions/ year	$49.9	$99.8	$142.5	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$121.0	$111.7	$111.7	$95.9		
annual capital cost of operations - Diavik with all-weather road (north and south access - Scenario 2)	$2000 millions/ year	$49.9	$99.8	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$139.6	$132.3	$132.3	$132.3	$132.3	$114.6	$105.8	$105.8	$90.8		
annual capital cost of operations - Diavik with all-weather road (north and south access - Scenario 3)	$2000 millions/ year	$49.9	$99.8	$139.6	$139.6	$132.3	$132.3	$132.3	$132.3	$132.3	$132.3	$132.3	$132.3	$132.3	$132.3	$114.6	$105.8	$105.8	$90.8		
annual capital cost of operations - Winspear with winter road	$2000 millions/ year	$42.1	$84.3	$105.3	$105.3	$105.3	$105.3	$94.8	$94.8	$94.8	$94.8	$84.3	$42.1								
annual capital cost of operations - Winspear with all-weather road (south access)	$2000 millions/ year	$42.1	$84.3	$105.3	$105.3	$105.3	$105.3	$94.8	$94.8	$94.8	$94.8	$84.3	$42.1								
annual capital cost of operations - Winspear with all-weather road (north and south access - Scenario 2)	$2000 millions/ year	$42.1	$84.3	$105.3	$105.3	$105.3	$93.9	$84.5	$84.5	$84.5	$84.5	$75.1	$37.6								
annual capital cost of operations - Winspear with all-weather road (north and south access - Scenario 3)	$2000 millions/ year	$42.1	$75.1	$93.9	$93.9	$93.9	$93.9	$84.5	$84.5	$84.5	$84.5	$75.1	$37.6								
annual capital cost of operations - Jericho with winter road	$2000 millions/ year	$11.3	$24.2	$25.8	$25.8	$25.8	$25.8	$12.9	$9.7												
annual capital cost of operations - Jericho with all-weather road (north access)	$2000 millions/ year	$11.3	$23.6	$25.2	$25.2	$25.2	$25.2	$12.6	$9.4												

Sources: Northwest Territories Department of Wildlife, Resources and Economic Development, Northwest Territories Department of Transportation

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Appendix A3, cont.

Multi-Year Data (Non-Date Dependent)

Data Element Name	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
annual capital cost of operations - Jericho with all-weather road (north and south access - Scenario 2)	$2000 millions/ year	$11.0	$23.6	$25.2	$25.2	$25.2	$25.2	$12.6	$9.4												
annual capital cost of operations - Jericho with all-weather road (north and south access - Scenario 3)	$2000 millions/ year	$11.0	$23.6	$23.7	$23.7	$23.7	$23.7	$11.9	$8.9												
annual capital cost of operations - generic diamond mine with winter road	$2000 millions/ year	$42.6	$85.2	$110.8	$110.8	$110.8	$110.8	$109.4	$109.4	$109.4	$109.4	$99.4	$99.4	$99.4	$71.0	$42.6					
annual capital cost of operations - generic diamond mine with all-weather road (north and south access)	$2000 millions/ year	$40.4	$80.9	$105.2	$105.2	$105.2	$105.2	$103.8	$103.8	$103.8	$103.8	$94.4	$94.4	$94.4	$67.4	$40.4					
number of mine operation workers - Lupin with winter road	workers/ year	325	325	325	325	325	325	325													
number of mine operation workers - Lupin with all-weather road (north access)	workers/ year	325	325	325	325	325	325	325													
number of mine operation workers - Izok Lake	workers/ year	625	625	625	625	625	625	625	625	625	625	625	625								
number of mine operation workers - Hackett River	workers/ year	500	500	500	500	500	500	500	500	500	500	500	500								
number of mine operation workers - generic base metal mine	workers/ year	500	500	500	500	500	500	500	500	500	500	500	500								
number of mine operation workers - Ekati with winter road	workers/ year	457	613	613	613	613	613	613	613	613	613	549	549	549	521	457	274				
number of mine operation workers - Ekati with all-weather road (north access)	workers/ year	457	613	613	613	613	613	613	613	613	613	549	549	549	521	457	274				
number of mine operation workers - Ekati with all-weather road (north and south access)	workers/ year	457	613	613	613	613	613	613	613	613	613	549	549	549	521	457	274				
number of mine operation workers - Diavik with winter road	workers/ year	228	456	652	652	652	652	652	652	652	652	652	652	652	652	565	521	521	448		
number of mine operation workers - Diavik with all-weather road (north access)	workers/ year	228	456	652	652	652	652	652	652	652	652	652	652	652	652	565	521	521	448		
number of mine operation workers - Diavik with all-weather road (north and south access)	workers/ year	228	456	652	652	652	652	652	652	652	652	652	652	652	652	565	521	521	448		
number of mine operation workers - Winspear with winter road	workers/ year	248	496	619	619	619	619	558	558	558	558	496	248								
number of mine operation workers - Winspear with all-weather road (south access)	workers/ year	248	496	619	619	619	619	558	558	558	558	496	248								
number of mine operation workers - Winspear with all-weather road (north and south access)	workers/ year	248	496	619	619	619	619	558	558	558	558	496	248								

Sources: Northwest Territories Department of Wildlife, Resources and Economic Development, Northwest Territories Department of Transportation

Appendix A3, cont.

Multi-Year Data (Non-Date Dependent)

Data Element Name	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
number of mine operation workers - Jericho with winter road	workers/ year	66	142	152	152	152	152	76	57												
number of mine operation workers - Jericho with all-weather road (north access)	workers/ year	66	142	152	152	152	152	76	57												
number of mine operation workers - Jericho with all-weather road (north and south access)	workers/ year	66	142	152	152	152	152	76	57												
number of mine operation workers - generic diamond mine with winter road	workers/ year	222	444	577	577	577	577	569	569	569	569	518	518	518	370	222					
number of mine operation workers - generic diamond mine with all-weather road (north and south access)	workers/ year	222	444	577	577	577	577	569	569	569	569	518	518	518	370	222					
annual capital cost of construction - ContwoytoLake to Arctic Coast all-weather road (Scenarios 1 & 2)	$2000 millions/ year	$70.0	$70.0																		
annual capital cost of construction - Ekati/Diavik to Contwoyto Lake all-weather road (Scenarios 1 & 2)	$2000 millions/ year	$30.0	$30.0																		
annual capital cost of construction - Yellowknife to Ekati/Diavik all-weather road (Scenario 2)	$2000 millions/ year	$31.0	$31.0	$31.0	$31.0	$31.0	$30.0														
annual capital cost of construction - ContwoytoLake to Arctic Coast all-weather road (Scenario 3)	$2000 millions/ year	$70.0	$70.0																		
annual capital cost of construction - Ekati/Diavik to Contwoyto Lake all-weather road (Scenario 3)	$2000 millions/ year	$30.0	$30.0																		
annual capital cost of construction - Yellowknife to Ekati/Diavik all-weather road (Scenario 3)	$2000 millions/ year	$62.0	$62.0	$61.0																	
annual capital cost of construction - deepwater port on the Arctic Coast	$2000 millions/ year	$19.3	$19.3																		
number of road construction workers - Contwoyto Lake to Arctic Coast all-weather road (Scenarios 1 &2)	workers/ year	155	155																		
number of road construction workers - Ekati/Diavik to Contwoyto Lake all-weather road (Scenarios 1 & 2)	workers/ year	66	66																		
number of road construction workers - Yellowknife to Ekati/Diavik all-weather road (Scenario 2)	workers/ year	68	68	68	68	68	68														
number of road construction workers - Contwoyto Lake to Arctic Coast all-weather road (Scenario 3)	workers/ year	155	155																		
number of road construction workers - Ekati/Diavik to Contwoyto Lake all-weather road (Scenario 3)	workers/ year	66	66																		
number of road construction workers - Yellowknife to Ekati/Diavik all-weather road (Scenario 3)	workers/ year	136	136	136																	
number of road construction workers - deepwater port on Arctic Coast	workers/ year	72	72																		

Sources: Northwest Territories Department of Wildlife, Resources and Economic Development, Northwest Territories Department of Transportation

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Appendix A3, cont.

Multi-Year Data (Non-Date Dependent)

Data Element Name	Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
annual capital cost of operations - Yellowknife to Ekati/Diavik winter road	$2000 millions/ year	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7	$3.7
annual capital cost of operations - Ekati/Diavik to Lupin winter road	$2000 millions/ year	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3	$2.3
annual capital cost of operations - Contwoyto Lake to Arctic Coast all-weather road (Scenarios 1 & 2)	$2000 millions/ year	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7
annual capital cost of operations - Ekati/Diavik to Contwoyto Lake all-weather road (Scenarios 1 & 2)	$2000 millions/ year	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9
annual capital cost of operations - Yellowknife to Ekati/Diavik all-weather road (Scenario 2)	$2000 millions/ year	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7
annual capital cost of operations - ContwoytoLake to Arctic Coast all-weather road (Scenario 3)	$2000 millions/ year	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7
annual capital cost of operations - Ekati/Diavik to Contwoyto Lake all-weather road (Scenario 3)	$2000 millions/ year	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9
annual capital cost of operations - Yellowknife to Ekati/Diavik all-weather road (Scenario 3)	$2000 millions/ year	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7	$2.7
annual capital cost of operations - deepwater port on the Arctic Coast	$2000 millions/ year	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2	$2.2
number of road operations workers - Yellowknife to Ekati/Diavik winter road	workers/ year	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
number of road operations workers - Ekati/Diavikto Lupin winter road	workers/ year	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
number of road operations workers - Contwoyto Lake to Arctic Coast all-weather road (Scenarios 1 & 2)	workers/ year	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
number of road operations workers - Ekati/Diavik to Contwoyto Lake all-weather road (Scenarios 1 & 2)	workers/ year	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
number of road operations workers - Yellowknife to Ekati/Diavik all-weather road (Scenario 2)	workers/ year	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
number of road operations workers - Contwoyto Lake to Arctic Coast all-weather road (Scenario 3)	workers/ year	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
number of road operations workers - Ekati/Diavik to Contwoyto Lake all-weather road (Scenario 3)	workers/ year	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
number of road operations workers - Yellowknife to Ekati/Diavik all-weather road (Scenario 3)	workers/ year	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
number of road operations workers - deepwater port on the Arctic Coast	workers/ year	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11

Sources: Northwest Territories Department of Wildlife, Resources and Economic Development, Northwest Territories Department of Transportation

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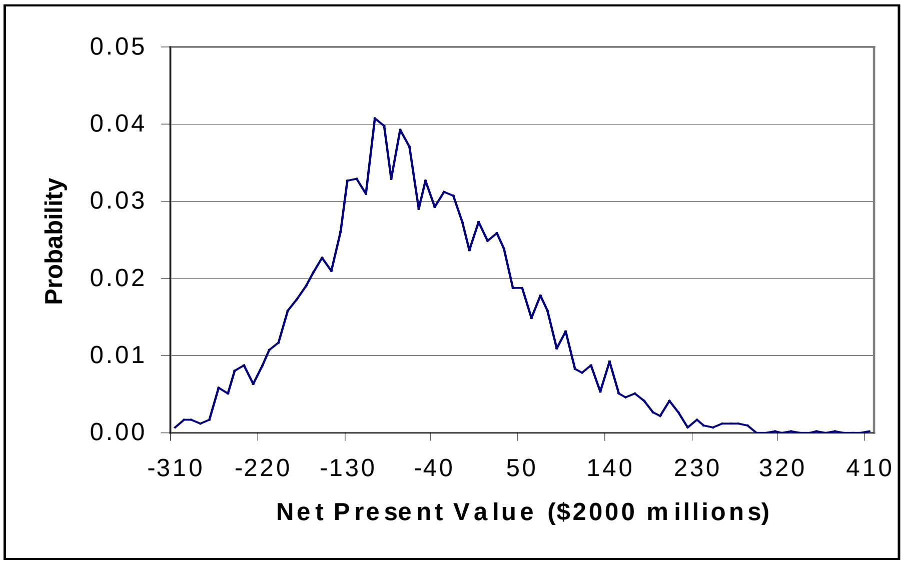
Appendix B: Sensitivity Analysis Results

This appendix contains information on the results obtained when the benefit-cost model was subjected to Monte Carlo risk analysis for all the key variables of interest (price of gold and base metals; quantity of diamond output; discount rate; labour costs; capital costs; and transport construction costs), as described in Chapter 7. Charts B-1, B-2 and B-3 show the distributions of Net Present Value (NPV) in millions of 2000 dollars for the three scenarios. Charts B-4, B-5 and B-6 show the cumulative probability distribution functions of the NPV for each scenario.

Chart B-1

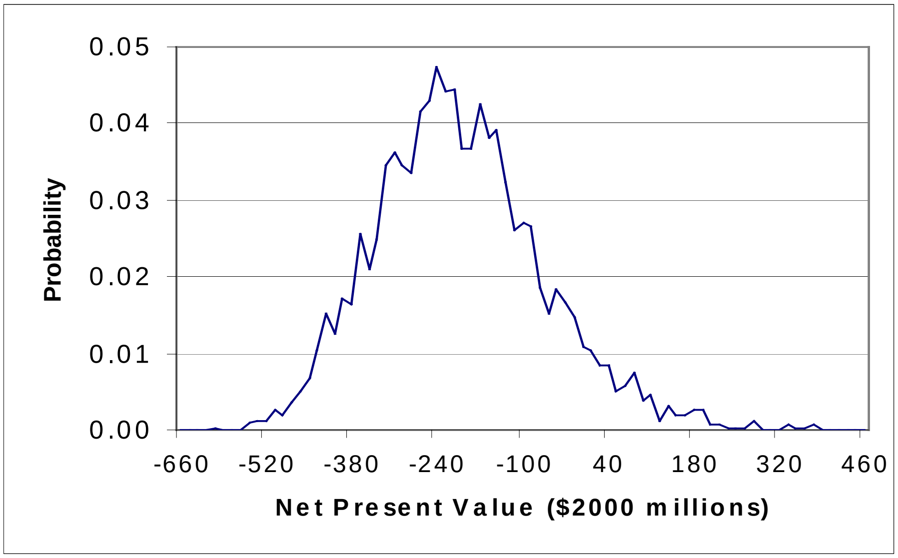
Scenario 1: Distribution of NPV



Source: The Conference Board of Canada

Chart B-2

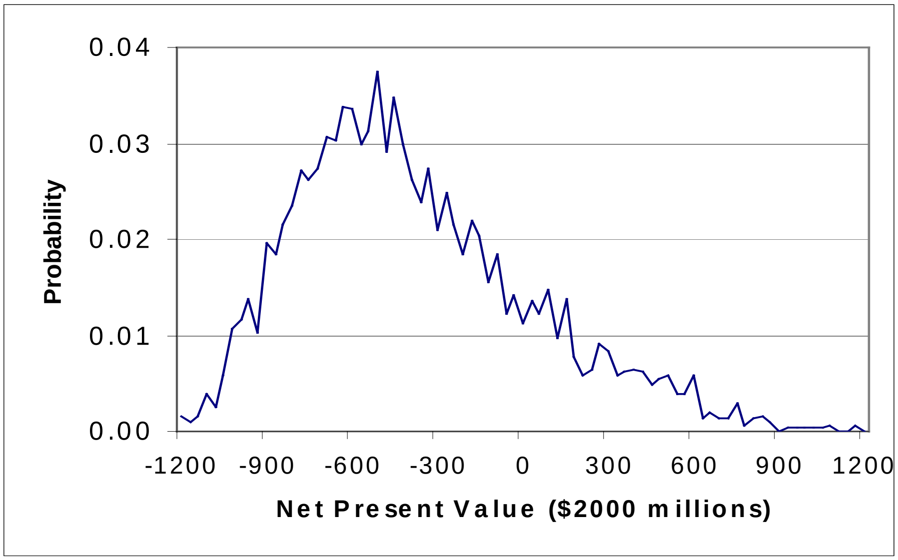
Scenario 2: Distribution of NPV



Source: The Conference Board of Canada

Chart B-3

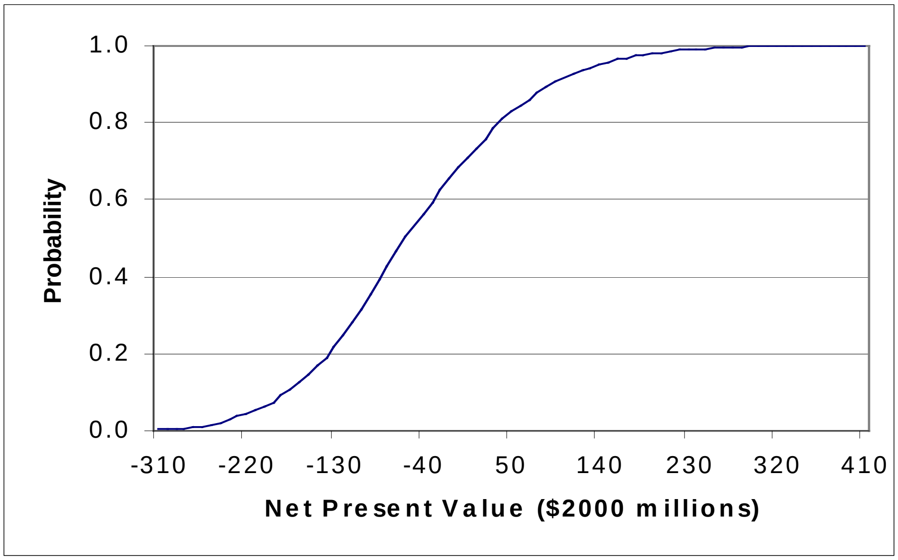
Scenario 3: Distribution of NPV



Source: The Conference Board of Canada

Chart B-4

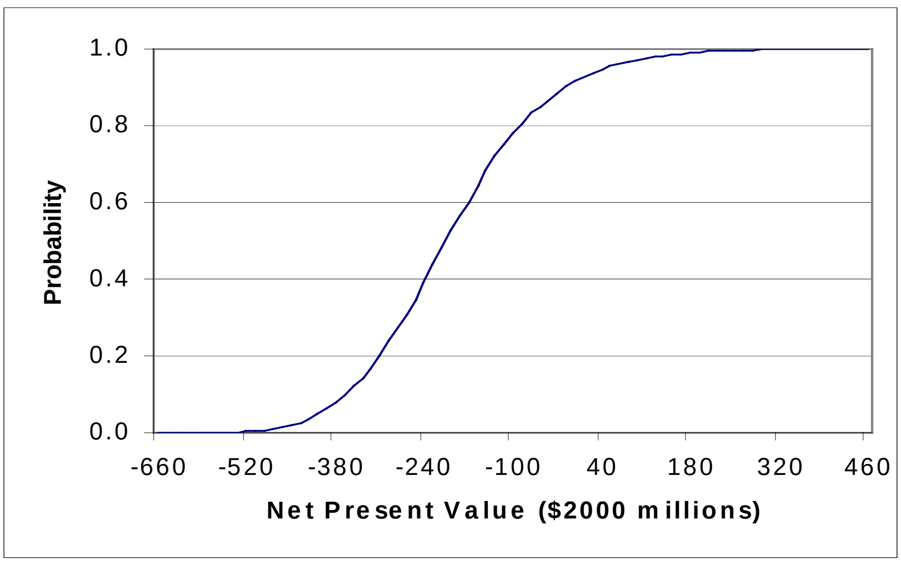
Scenario 1: Cumulative Probability Density Distribution of NPV



Source: The Conference Board of Canada

Chart B-5

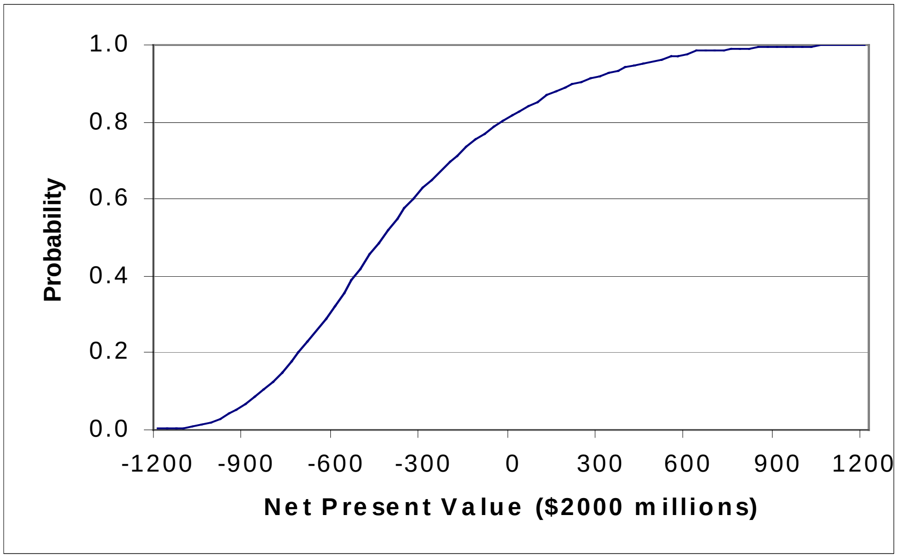
Scenario 2: Cumulative Probability Density Distribution of NPV



Source: The Conference Board of Canada

Chart B-6

Scenario 3: Cumulative Probability Density Distribution of NPV



Source: The Conference Board of Canada