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Macroeconomic Impact and Benefit/Cost Analysis of Transportation and Mining Developments in the Northwest Territories

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ABSTRACT

This paper summarizes the results of two studies undertaken to quantify the macroeconomic impact and the benefits and costs associated with transportation and mineral development scenarios in the Northwest Territories.

Each development scenario involves investment in a transportation corridor extending north from Yellowknife towards the Arctic Coast, and the staged development of various mineral deposits. The region north of Yellowknife, known as the Slave Geologic Province, is a storehouse for numerous gold, base metal and diamond reserves and is recognized as the premier new mineral region in Canada. At the present time land-based transportation infrastructure consists of a privately constructed winter road extending from Yellowknife to the Lupin gold mine, approximately two-thirds of the distance to the Arctic Coast.

In terms of the macroeconomic impact, the development scenarios analyzed would have a significant, positive impact on the economy. This impact would be significant not only in the Northwest Territories but also in southern Canada, since most of the goods and services consumed in the Northwest Territories are produced in other parts of Canada. The analysis indicates that approximately one-third of the GDP impacts and three-quarters of the employment impacts would occur outside of the Northwest Territories, mainly in the provinces of Ontario, Alberta, Quebec and British Columbia.

The benefit-cost analysis indicated a positive Net Present Value for each of the development scenarios. For the most optimistic scenario, the benefits exceeded the costs by $3 billion over the 20 year study period. The benefits are dominated by the value of the mineral output resulting from new mineral developments.

Mining holds the best prospects for economic development in the North. Transportation infrastructure is essential for the development of mineral deposits. While a causal

relationship between transportation infrastructure and mining activities was not assumed, the two studies reported here have demonstrated that providing transportation infrastructure for the development of mines produces significant macroeconomic impacts and that the benefits would exceed the costs. This information would be useful in discussions about funding transportation infrastructure projects in support of mineral developments.

INTRODUCTION

An investment in transportation infrastructure can have a number of positive impacts on the economy. The investment can create direct employment, both during and after construction, and can increase productivity. An investment in new transportation infrastructure can also be a catalyst for the development of new resources, within areas that were previously not accessible.

Transportation infrastructure is particularly important for the growth of economies that are dependent on natural resources.

The Northwest Territories holds considerable potential for mineral resource developments. However, many known deposits are currently undeveloped due to the lack of adequate transportation infrastructure. Individual resource developments simply cannot afford the expenditure required to develop the required infrastructure.

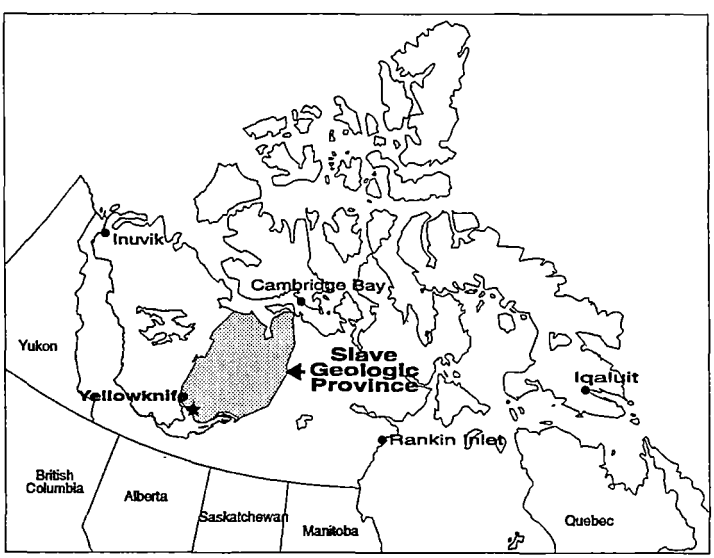


Figure 1: The Slave Geologic Province

The region with the greatest potential for mineral developments in the Northwest Territories is known as the Slave Geologic Province[1]. This geologic region, illustrated in Figure 1, extends from Yellowknife to the Arctic Coast, a distance of 600 kilometres, in a band approximately 300 kilometres wide. There are five active mines in this region. Canada's first diamond mine, currently under environmental review, may soon join this list. Many other significant gold, base metal and diamond deposits have been identified and there is considerable potential for new mineral deposits to be discovered. The region has been favourably compared to the Abitibi region of Quebec[2], in which over 100 mines have been developed since 1906.

As illustrated in Figure 2, all-weather roads access the southern reaches of the Slave Geologic Province. A privately constructed winter road extends two-thirds of the way from Yellowknife to the Arctic Coast. This road, constructed by Echo Bay Mines, is used to resupply the Lupin gold mine. The winter road will also be used by BHP Diamonds Inc. to resupply their proposed diamond mine.

The provision of improved land-based transportation into the Slave Geologic Province would provide the necessary impetus to encourage new mineral developments by securing a less costly, more reliable means of access for both exploration, development and operational activities, and for the transportation of base metal concentrates to market. Alternatively, mineral developments themselves may require a certain level of transportation infrastructure for operations.

To determine the potential economic impact of transportation and mineral developments in the Slave Geologic Province, the Northwest Territories Department of Transportation commissioned The Conference Board of Canada to undertake a study to quantify the macroeconomic impacts of transportation and mineral development scenarios in the Slave Geologic Province[3]. Quantifying the macroeconomic impact of regional development projects provides useful information in determining the impact of the development. However, to rank this project with others which may be competing for funding the benefits and costs should also be considered. A second study was therefore commissioned to conduct a benefit/cost analysis for the same transportation and mineral development scenarios[4]. This paper presents a summary of the two studies.

DEVELOPMENT SCENARIOS

Four transportation and mineral development scenarios were created for analysis. These scenarios each included the development of transportation infrastructure in the Slave Geologic Province and the staged development of mineral deposits. The scenarios were developed through a collaborative effort of Northwest Territories government departments. A 20 year time frame was used.

Each of the development scenarios, summarized in Table 1, is comprised of a transportation component and a mineral development component. The assumption in the development of the scenarios was that the type and level of transportation infrastructure

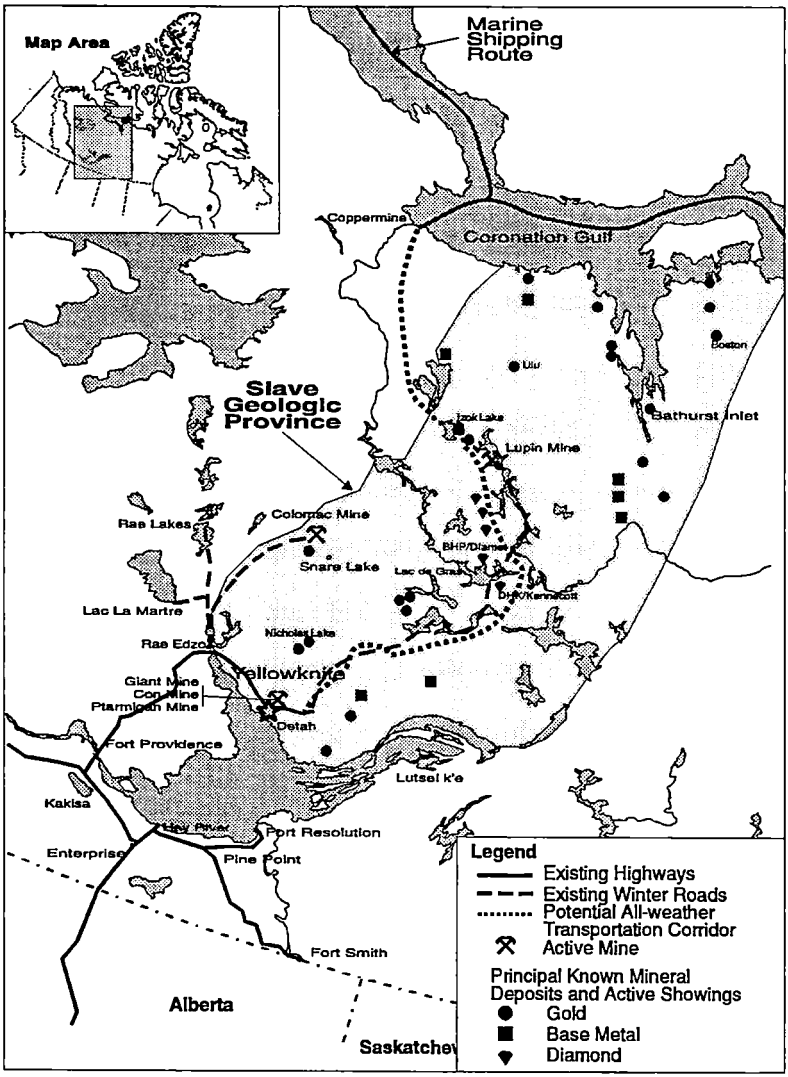


Figure 2: Potential Transportation Corridor and Known Mineral Showings in the Slave Geologic Province

and the number and type of mineral developments are inter-dependent. That is, it was assumed that improved transportation infrastructure would prompt the development of certain mineral deposits, or that a given number of mineral developments would require a certain standard transportation infrastructure.

It is noted that the scenarios were developed to bound the range of potential future activities and not necessarily to forecast actual future events.

Transportation Infrastructure

Each development scenario included an investment in transportation infrastructure. The investment ranged from simply opening and maintaining the current winter road corridor in Scenario 1, to the construction of an all-weather corridor from Yellowknife to a new deep-water port on the Arctic Coast in Scenario 4. Scenario 2 and 3 fall between these two bounds. It is noted that the deep-water port would be used to bring resupply materials into mines located in the northerly portion of the Slave Geologic Province, and to ship base metal concentrates to smelters in Europe and the Pacific Rim.

Table 1: Summary of Development Scenarios

Scenario	Transportation Infrastructure Infrastructure	Mine Developments
Scenario 1	Winter Road Yellowknife to Lupin Mine	One Diamond Mine One Gold Mine
Scenario 2	Winter Road Yellowknife to Izok Lake All-weather road Izok Lake to the Arctic Coast Deep water Port on the Arctic Coast	One Diamond Mine One Gold Mine One Base Metal Mine Extension to Lupin Mine
Scenario 3	All-weather road Yellowknife to Lac de Gras Winter Road Lac de Gras to Izok Lake All-weather road Izok Lake to the Arctic Coast Deep water Port on the Arctic Coast	Two Diamond Mines Three Gold Mines One Base Metal Mine Extension to Lupin Mine
Scenario 4	All-weather road Yellowknife to the Arctic Coast Deep water Port on the Arctic Coast	Three Diamond Mines Four Gold Mines Three Base Metal Mines Extension to Lupin Mine

Note: For the benefit-cost analysis, additional costs quantified include municipal infrastructure and training programs. Additional benefits quantified include transportation safety improvements, transportation efficiency improvements, reduced resupply costs for remote communities and tourism benefits.

Mineral Developments

Mineral developments are a very important aspect of each of the development scenarios. Investment in new transportation infrastructure is assumed to make the development of certain mineral deposits economically viable. New transportation infrastructure is also assumed to increase mineral exploration activities, thus increasing the likelihood for the discovery and development of other deposits.

For Scenario 1, which assumes no new transportation infrastructure, mineral developments include the development of one new diamond mine and one new gold mine over the 20 year study period. For Scenario 4, which assumes an all-weather transportation corridor to a port on the Arctic Coast, mineral developments include the development of three new diamond mines, four new gold mines and three new base metal mines. Scenario 4 is the most optimistic scenario.

ECONOMIC IMPACT ANALYSIS

Methodology[5]

The economic impact analysis quantified the direct, indirect and induced effects of the development scenarios on the economy. Direct impacts result from expenditures made on goods and services that are directly consumed by the project. Indirect impacts occur as a result of expenditures made by firms and government agencies that are directly involved in the project. Induced impacts result from the spending of household income earned by labour involved in the provision of goods and services for the direct and indirect inputs to the project.

Gross Domestic Product (GDP) and employment were quantified to determine the economic impacts of the development scenarios on the economy. GDP and employment were quantified for each Province and Territory[6].

Two tools were used to quantify the economic impacts. Input-Output models were used to determine the direct and indirect economic impacts and the induced impacts for the Northwest Territories. Macroeconomic models were used to determine the induced economic impacts for all provinces.

The first step in estimating the economic impacts of the development scenarios involved estimating the value of output for the various components of the scenarios. For transportation components this involved determining the initial capital investment required and the annual operation and maintenance costs. Mineral developments required an estimate of the initial capital investment in the mine and an estimate of the value of mineral output. As noted previously, a 20 year time period was used for the evaluation.

Once the total expenditures were determined, the Northwest Territories Bureau of

Statistics Input-Output Model for the Northwest Territories and Statistics Canada Inter-Provincial Input-Output model for the rest of Canada were used to translate the initial expenditures into the final demand for goods and services for the affected industries. Tracing of the initial expenditures into the final demand for goods and services defined the direct impacts of the individual projects. The models were also used to estimate the indirect impacts associated with each scenario.

The Northwest Territories Bureau of Statistics Input-Output Model is a "closed" model, and therefore was able to trace the spending of labour income derived from the direct and indirect impacts and thus quantify the induced impacts on the Northwest Territories. Since Statistics Canada Input-Output Model was "open", The Conference Board of Canada's Provincial Medium-Term Forecasting Model was used to determine the induced impacts for the rest of Canada.

Results of the Economic Impact Analysis

GDP and employment were quantified to determine the economic impact of the development scenarios. GDP impacts are expressed in constant 1993 dollars. Employment is expressed in terms of person-year equivalents. All impacts presented are the incremental impacts associated with the development scenarios over the 20 year study period. Both GDP and employment were quantified for all provinces and territories, since economic activity in the Northwest Territories has a significant impact on other parts of Canada.

A summary of the economic impacts associated with each development scenario is provided in Table 2. General conclusions are summarized below.

- The impact of the developments scenarios on GDP and employment are significant.

- GDP impacts range from a minimum of $14.7 billion with Scenario 1 to $50.6 billion with Scenario 4 over the 20 year study period.

- Employment impacts range from 110,000 person-years for Scenario 1 to 395,000 person years for Scenario 4 over the 20 year study period.

- The increase in GDP and employment impacts from Scenario 1 to Scenario 4 is directly related to the increased transportation and mineral activity assumed in the Scenarios.

- The distribution of GDP impacts across Canada for Scenario 4 is illustrated in Figure 3. The largest GDP impacts occur in the Northwest Territories, capturing 63 percent of the total. However, since the Northwest Territories imports many goods and services, 37 percent of the GDP impacts occur outside of the Northwest Territories. The largest portion of these impacts occurs in the provinces of Ontario, Alberta, Quebec and British Columbia.

Table 2: Total Economic Impacts By Province

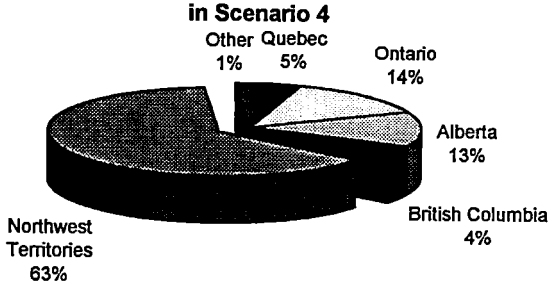
Total Gross Domestic Product Impacts (millions of 1993 dollars)

	QUE	ONT	ALTA	BC	Other	Sub-Total	NWT	National Total
SCENARIO 1								
Gross Domestic Product	759	2,039	1,675	561	192	5,227	9,500	14,727
Share of National Total (%	*5.2*	*13.8*	*11.4*	*3.8*	*1.3*	*35.5*	*64.5*	***100.0***
SCENARIO 2								
Gross Domestic Product	999	2,822	2,595	790	280	7,487	13,136	20,623
Share of National Total (%	*4.8*	*13.7*	*12.6*	*3.8*	*1.4*	*36.3*	*63.7*	***100.0***
SCENARIO 3								
Gross Domestic Product	1,852	5,411	4,591	1,438	505	13,797	23,655	37,452
Share of National Total (%	*4.9*	*14.4*	*12.3*	*3.8*	*1.3*	*36.8*	*63.2*	***100.0***
SCENARIO 4								
Gross Domestic Product	2,429	7,049	6,448	1,973	687	18,586	32,062	50,649
Share of National Total (%	*4.8*	*13.9*	*12.7*	*3.9*	*1.4*	*36.7*	*63.3*	***100.0***

Total Employment Impacts (person-year equivalents)

	QUE	ONT	ALTA	BC	Other	Sub-Total	NWT	National Total
SCENARIO 1								
Employment	15,719	35,192	19,846	9,354	3,540	83,651	26,646	110,297
Share of National Total (%	*14.3*	*31.9*	*18.0*	*8.5*	*3.2*	*75.8*	*24.2*	***100.0***
SCENARIO 2								
Employment	20,437	48,440	31,770	13,116	5,104	118,867	41,700	160,566
Share of National Total (%	*12.7*	*30.2*	*19.8*	*8.2*	*3.2*	*74.0*	*26.0*	***100.0***
SCENARIO 3								
Employment	37,785	91,219	55,432	23,788	9,199	217,424	73,924	291,348
Share of National Total (%	*13.0*	*31.3*	*19.0*	*8.2*	*3.2*	*74.6*	*25.4*	***100.0***
SCENARIO 4								
Employment	49,377	118,956	78,734	32,632	12,494	292,194	103,071	395,265
Share of National Total (%	*12.5*	*30.1*	*19.9*	*8.3*	*3.2*	*73.9*	*26.1*	***100.0***

Figure 3: Distribution of Total GDP Impacts in Scenario 4

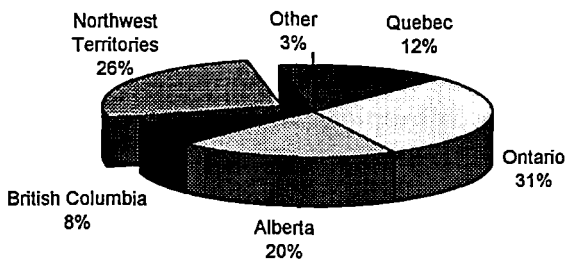


- For Scenario 4, GDP impacts are $1.6 billion per year. This is 74 percent of the actual GDP in the Northwest Territories in 1993. For Scenario 4, national GDP is $2.5 billion per year or 0.4 percent of Canada's actual GDP in 1993.

- The distribution of employment impacts across Canada for Scenario 4 is illustrated in Figure 4. Unlike GDP, the majority of employment impacts occur outside of the Northwest Territories. For Scenario 4, the Northwest Territories accounts for 26 percent of the employment. Substantial employment impacts would occur in Ontario, Alberta, Quebec and British Columbia.

- For Scenario 4, the employment impacts in the Northwest Territories represents approximately 25 percent of actual 1993 employment. For Canada, the person-year estimate represents 0.2 percent of Canada's actual employment in 1993. Of the employment impacts for Scenario 4, direct employment is 179,942 person-years or 45 percent of the total.

Figure 4: Distribution of Total Employment Impacts in Scenario 4



BENEFIT-COST ANALYSIS

The benefit-cost analysis followed guidelines outlined by the Treasury Board[7] and Transport Canada[8], but differed from Transport Canada's prescribed format in one important aspect. The purpose of this analysis was to quantify the economic impact associated with the construction of new transportation infrastructure. Transport Canada's guidelines focus specifically on replacement or upgrading projects, as would be the case for most transportation projects in Canada. However, there are still many areas of the North in which there is no transportation infrastructure. This study examined the effects of introducing new transportation infrastructure into a region previously accessible only by winter road. Since the assumption stated previously was that transportation and mineral developments are inter-dependent, it was appropriate to include the economic impacts of mineral developments in this benefit-cost analysis. In fact, the principal benefit arising from the corridor construction is the development of natural resources

that would otherwise be uneconomic to develop or whose development will be hastened as a result of the investment.

Benefit-cost analysis requires the consideration of a realistic base case. All results are then expressed as incremental to the base case. Since it was determined to be unrealistic to assume no new mineral developments over the next 20 years without transportation infrastructure improvements, Scenario 1 was chosen as the base case. All results reported are incremental to this scenario.

All costs and benefits are considered from a societal perspective. The study did not consider who would receive the benefits or incur the costs. Results are reported in constant 1993 dollar values.

Scenarios used in the benefit-cost analysis are similar to the economic impact analysis in terms of the transportation infrastructure and mineral development components. To be comprehensive in the analysis several additional benefits and costs were quantified. These additional benefits and costs are summarized below.

Costs

Costs quantified in the analysis include:

- transportation corridor construction and operation and maintenance,
- deep water port construction and operation and maintenance,
- mineral resource development including mine site preparation and operation and maintenance, excluding exploration costs (all costs were varied as a function of winter or all-weather road access),
- municipal infrastructure (operation and maintenance costs for existing facilities and construction and operation and maintenance for new facilities), and
- labour force training programs.

Costs not quantified in the analysis relate to environmental considerations. These include items such as disruption of caribou migration, destruction of habitat and point source pollution. Quantification of these costs was beyond the financial ability of the project.

The capital (purchased inputs) and labour components for each cost were determined. These components were treated separately due the differences in the methodology to calculate them. The general approach for both components, however, was to use their opportunity cost, or the dollar value of the next best alternative use. For this analysis, a shadow wage was applied to the labour component to account for unemployed resources in the labour market while the capital costs were estimated as the actual money cost, excluding taxes and subsidies.

Benefits

Benefits quantified in the analysis include:

- the value of minerals extracted,
- transportation safety improvements,
- transportation efficiency improvements,
- reduced resupply costs for remote northern communities, and
- incremental tourism expenditures.

The principal benefit considered in this study was the value of minerals extracted. These benefits were included in the analysis since it was assumed that transportation infrastructure and mineral developments are inter-dependent.

In terms of the other benefits, transportation safety improvements were assumed to result from the replacement of the existing winter road with an all-weather road. Transportation efficiency benefits were the result of improvements to the existing transportation infrastructure, namely reductions in vehicle operating costs from winter road to all-weather roads and reduced resupply costs for northern communities resulting from the construction of a deep-water port on the Arctic coast. Tourism expenditures were assumed to result from the construction of an all-weather corridor to the Arctic Coast.

Economic multiplier benefits associated with each of the scenarios were not included in the analysis and a discount rate of ten percent was used in keeping with Treasury Board Guidelines.

Benefit-Cost Analysis Results

Results of the benefit-cost analysis are presented in Table 3. It is noted that for the benefit-cost analysis, Scenario 1 is assumed to be the base case. The results noted in Table 3 are all incremental to the base case. General conclusions are noted below.

- All scenarios have a positive benefit-cost ratio

- Scenario 4 has the largest net present value at over $3 billion. This means that the benefits associated with this scenario would exceed that costs by over $3 billion dollars.

- The increase in the benefit/cost results from Scenario 2 to Scenario 4 is directly related to the increased transportation and mineral activity assumed in the Scenarios.

- For all scenarios, benefits and costs are dominated by the mineral activity accounting for 99 percent of the benefits and 85 percent of the costs for Scenario 2, with the percentages increasing for Scenarios 3 and 4.

Table 3: Summary of Benefit-Cost Results

Benefit-Cost Criteria	Scenario 2	Scenario 3	Scenario 4
Net Present Value (1993 $ million)	$356.4	$2,167.4	$3,076.9
Internal Rate of Return (Percent)	19.5%	30.8%	29.3%
Benefit-Cost Ratio	1.3	1.55	1.52

- The unquantified environmental costs would result in a reduction in the net present value for each scenario. The unquantified economic multiplier benefits, the result of indirect economic activity and from labour income, would result in an increase in the net present value if they were included in the analysis.

- Sensitivity analysis of key input parameters was conducted. Results are sensitive to changes in the discount rate and the output from mining activities. Results are much less sensitive to changes in the transportation infrastructure costs.

SUMMARY AND CONCLUSIONS

This report has summarized the results of two studies undertaken to quantify the macroeconomic impact and the benefits and costs associated with transportation and mineral development scenarios in the Northwest Territories.

In creating the development scenarios an inter-dependence between the provision of transportation infrastructure and the level of mineral activity was assumed. That is, it was assumed that improved transportation infrastructure would prompt the development of certain mineral deposits, or that a given number of mineral developments would require a certain standard of transportation infrastructure.

In terms of the macroeconomic impact, the development scenarios analyzed would have a significant, positive impact on the economy. This impact would be significant not only in the Northwest Territories but also in southern Canada, since most of the goods and services consumed in the Northwest Territories are produced in other parts of Canada. The analysis indicates that approximately one-third of the GDP impacts and three-quarters of the employment impacts would occur outside of the Northwest Territories, mainly in the provinces of Ontario, Alberta, Quebec and British Columbia.

The benefit-cost analysis differed from the format prescribed by Transport Canada for transportation projects in one important aspect. The purpose of this analysis was to

quantify the economic impact associated with the construction of new transportation infrastructure. Transport Canada's guidelines focus specifically on replacement or upgrading projects, as would be the case for most transportation projects in Canada. However, there are still many areas of the North in which there is no transportation infrastructure. This study examined the effects of introducing new transportation infrastructure into a region previously accessible only by winter road. Since the study assumed an inter-dependence between transportation and mineral developments, it was appropriate to include the economic impacts of mineral developments in this benefit-cost analysis. In fact, the principal benefit arising from the corridor construction is the development of natural resources that would otherwise be uneconomic to develop or whose development will be hastened as a result of the investment.

The benefit-cost analysis indicated a positive Net Present Value for each of the development scenarios. For the most optimistic scenario, the benefits exceeded the costs by $3 billion over the 20 year study period. The benefits are dominated by the value of the mineral output that is assumed to result from the improved transportation infrastructure.

Mining holds the best prospects for economic development in the North. Transportation infrastructure is essential for the development of mineral deposits. While a causal relationship between transportation infrastructure and mining activities was not assumed, the two studies reported here have demonstrated that providing transportation infrastructure for the development of mines produces significant macroeconomic impacts and that the benefits would exceed the costs. This information would be useful in discussions about funding transportation infrastructure projects in support of mineral developments.

ACKNOWLEDGEMENTS

The analysis was undertaken by The Conference Board of Canada. Considerable input was provided by the Department of Transportation and the Bureau of Statistics of the Government of the Northwest Territories. Other Government of the Northwest Territories departments that contributed to these studies included the Department of Energy Mines and Petroleum Resources, Department of Finance, and the Department of Economic Development and Tourism.

ENDNOTES

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2. G. Riverin and I. Morrison, Metall Mining Corporation, Gold and Base Metal Potential of the Slave Province versus Abitibi. Summary of a presentation at the 1994 Geoscience Forum, 1994.

3. The Conference Board of Canada, Slave Province Transportation Corridor Economic Impacts and Taxation Revenue, 1994 (Unpublished report).

4. The Conference Board of Canada, Slave Province Transportation Corridor Benefit-Cost Analysis. 1995 (Unpublished report).

5. Additional information on the models used are provided in the project report noted in endnote number 3.

6. The induced economic impacts were not quantified for the Yukon due to model constraints. These impacts are not considered to be significant.

7. Treasury Board Secretariat, Benefit-Cost Analysis Guide. Minister of Supply and Services Canada, 1982.

8. Transport Canada, Guide to Benefit-Cost Analysis in Transport Canada. Transport Canada (TP 11875 E), 1994.